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H2 international

THE E-JOURNAL ON HYDROGEN AND FUEL CELLS

→ BUSES, TRUCKS AND TRAINS – NEW NASCENT FUEL CELL MARKETS

→ INTERVIEW WITH R. CHRISTIANSEN, PIONEER IN WIND POWER AND HYDROGEN

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E-JOURNAL ON HYDROGEN AND FUEL CELLS

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NEWFOUND OPTIMISM

Dear readers,
There is a noticeable feeling of change in the air, and it is not mere hype this time. A current of hope runs through the hydrogen and fuel cell industry. No, there's no euphoria, but also no longer the sense of discouragement, resignation sometimes, that frequently pervaded the community in past years. The general opinion coming out of the sector is that hard work is finally paying off. It goes without saying that these technologies are not yet market staples, but we see that fuel cells will have a place in energy conversion and hydrogen will have a place in energy storage.

A noticeable boost in application occurred at the beginning of last year, when it became apparent that transportation of loads of goods or people offered much more potential for fuel cells than the passenger car market (**see cover story, pp. 22 to 37**). Great innovations have been made for trains in recent years, which will benefit trucks and buses. Larger vehicles also need larger amounts of hydrogen to refuel them, so high-throughput stations that fill this need could quickly become profitable.

Another new and noteworthy innovation is being implemented by DHL. The courier is said to be adding fuel cell cars produced by StreetScooter to the fleet of electric delivery vehicles the subsidiary already provides for day-to-day operations (**see p. 41**).
With these novelties comes an ever-growing demand for clean hydrogen. Its production in the energy-rich north of Germany could be multiplied. For example, in Schleswig-Holstein, there are more and more who recognize that the vast amounts of renewable electricity can be used to generate green hydrogen and are seizing the opportunity (**see interview, pp. 14 to 17**). In northern Friesland, these prospects have created an air of expectation, which is bound to spread to other regions of the country.

All these individual happenings can be considered part of a larger development that was whispered about in the mid-1990s and gained real momentum around the turn of the millennium, when the world began serious research into hydrogen and fuel cells. Over the years, a great deal of new materials, components and technologies came into being, along with a whole new industrial sector. With more time and effort, these systems could become economically viable very soon.

Fifteen years is how long it took for many technologies, including the ones above, to enter the market. According to American trend researcher and futurist John Naisbitt, this is the timespan for establishing a megatrend (**see p. 46**).

Lastly, a look at the stock charts of notable fuel cell companies reveals that there is a significantly rising interest in this technology. This trend goes not only for American but also German businesses, such as SFC Energy. However, the upswing cannot hide the fact that those stocks currently trade far below their issue prices.

In conclusion, we begin this year with hope, keeping in mind that the road to progress has been long and still stretches ahead.

Best wishes,

Sven Geitmann
Editor of HZwei and H2-International

BEE GETS NEW CEO IN PETER RÖTTGEN

Peter Röttgen [Quelle: BEE]

On Aug. 1, 2017, Peter Röttgen became the new CEO of Germany's Federal Renewable Energy Federation, or BEE for short. He replaced Harald Uphoff, who served as interim CEO after Hermann Falk left BEE in 2016. Röttgen had previously served as deputy head at the State Office of Mining, Energy and Geology in the German state of Lower Saxony and later as manager of the Energy Storage Innovation Center at E.ON until the company decided to split operations.

BEE's president, Fritz Brickwedde, said, "Mr. Röttgen and his wealth of expertise in public service and the energy industry will prove a crucial addition to BEE when the market is transformed in the years ahead."

BEE is an umbrella organization representing the interests of 49 associations and businesses in Germany. By its own account, it speaks for 330,000 employees and is dedicated to turning the goal of fully renewable heat, power and transportation into a reality. ||

ALPIQ BUYS DIAMOND LITE

Diamond Lite, a Swiss engineering firm founded by Hansjörg Vock in Herisau in 1982, used to be something of a European office for products by American electrolyzer manufacturer Proton OnSite. That changed last summer, when it was purchased by Swiss energy services provider Alpiq Holding, based in Lausanne, on June 30. With the acquisition of Diamond Lite, Alpiq has made a strategic investment in its growth markets. The deal expands its portfolio to include turnkey power-to-gas production systems, which it will design, install and market for customers in Europe's industry. The sale of Diamond Lite came on the heels of Proton's takeover by Norwegian manufacturer Nel Hydrogen in early 2017. ||

AREVA GERMANY RENAMED FRAMATOME

The nuclear products division of the French Areva group has restructured its German subsidiary. On Nov. 1, 2017, it transferred all operations of Areva Germany, based in Erlangen, to New NP. After French energy supplier Électricité de France became the parent company's major shareholder at the beginning of 2018, the name was changed to Framatome. On Nov. 1, 2016, exactly one year prior to the transfer, a financially weak Areva NP had entered into a binding agreement with EDF to allow the latter to become a major shareholder for EUR 2.5 billion. ||

NEW MANAGER AT H-TEC EDUCATION

Dr. Thorsten Schmidt [Quelle: GP Joule]

Last November, H-Tec Education, based in Lübeck, Germany, was put under new management. Parent company GP Joule elevated Thorsten Schmidt to head of the teaching materials division. Åke Johnsen, who had worked for H-Tec's marketing department since 2001 before becoming part of the board in 2016 after the exit of company founder Uwe Küter, left the subsidiary to join its parent company, where he could lead the hydrogen business at both GP Joule and H-Tec to new levels of success. Because of his great number of contacts in the H_2 and fuel cell community, he has since been advising the key account management and the marketing department at GP Joule in Reußenköge, Germany. By his own account, the situation had been a win-win scenario for everyone involved.

Schmidt has many years of experience in managing branch offices from his time as H-Tec Education's sales manager. Granted authority to act on the company's behalf, he has since been overseeing day-to-day operations in Lübeck. The sole CEO of H-Tec Education is Ove Petersen, who is also chief executive at GP Joule, alongside Heinrich Gärtner and André Hirsch. ||

NIKUTTA NEW HEAD OF ALSTOM GERMANY

Dr. Jörg Nikutta [Quelle: Alstom]

On Sept. 1, 2017, Jörg Nikutta became responsible for Alstom's operations in Austria and Germany. The same day, he was also appointed spokesman for the board of management at Alstom Transport Deutschland. Nikutta used to work at Deutsche Bahn and now follows in the footsteps of Didier Pfleger, who has since been in charge of Alstom's Middle East business. ||

TÖPLER & LEHMANN'S GUIDEBOOK REVISED

It's been three years since publisher Springer Verlag released the first edition of its guidebook "Wasserstoff und Brennstoffzellen - Technologien und Marktperspektiven" written by Johannes Töpler and Jochen Lehmann. In late 2017, an extended and updated version hit the shelves, again comprehensively informing readers about hydrogen and fuel cell technologies. Taking account of recent debates, this second edition in German grew by more than 80 pages to include a new chapter on hydrogen storage in underground caverns and one about power-to-X. To make up for the somewhat high price tag, it comes with a non-transferrable coupon that a buyer can use to download the e-book version. The first edition is also available in English ("Hydrogen and Fuel Cell – Technologies and Market Perspectives"). ||

Töpler, Lehmann (Ed.), Wasserstoff und Brennstoffzellen – Technologien und Marktperspektiven
Publisher: Springer Vieweg, Berlin, September 2017,
368 pages, Language: German
ISBN 978-3-662-533359-8; store price: EUR 79.98

H_2 INVESTMENTS TO PAY OFF

The Hydrogen Council used the COP23 climate change conference to present a new report titled "Hydrogen, Scaling up." Featuring contributions by consulting firm McKinsey, it describes a roadmap for advancing the large-scale introduction of hydrogen and assessing its impact on transforming the energy sector. According to the study, the gas could help cut carbon dioxide emissions by nearly 20 percent of the 2050 targets, or around 6 gigatons. Its authors see the potential in transportation at up to 15 million hydrogen-powered cars and 500,000 trucks, and they believe that the industry could create more than 30 million jobs altogether. Yearly revenue was estimated at around USD 2.5 trillion.

Takeshi Uchiyamada, chairman of Toyota and co-chair of the Hydrogen Council, explained: "Hydrogen is an indispensable resource to achieve this transition because it can be used to store and transport wind, solar and other renewable energies to power transportation and many other things. The Hydrogen Council […is…] encouraging governments and investors to give it a prominent role in their energy plans. The sooner we get the hydrogen economy going, the better, and we are all committed to making this a reality."

Benoît Potier, chairman of Air Liquide and the other co-chair of the council, agreed: "This study confirms the place of hydrogen as a central pillar in the energy transition, and encourages us in our support of its large-scale deployment. Hydrogen will be an unavoidable enabler for the energy transition in certain sectors and geographies. The sooner we make this happen the sooner we will be able to enjoy the needed benefits of hydrogen at the service of our economies and our societies.

"Solutions are technologically mature and industry players are committed. We need concerted stakeholder efforts to make this happen; leading this effort is the role of the Hydrogen Council."

Given the right circumstances, the authors believe that the total investment could be as high as USD 280 billion by 2030. ||

→ http://bit.ly/2hNZXKN

Quelle: Hydrogen Council

Estimated H_2 investment	USD 20 to 25 billion per year
Oil and gas	USD 650 billion per year
Renewable energies	USD 300 billion per year
Automotive industry	USD 300 billion per year
Total	USD 1.7 trillion per year

Tab.: Investitionen im Energiebereich

H2-INTERNATIONAL NOW WELL ESTABLISHED

H2 international E-JOURNAL ON HYDROGEN AND FUEL CELLS

Hydrogeit Verlag's most recently added information service, H2-international, has become a fixture of the international hydrogen and fuel cell community. Since its foundation in the summer of 2015, the e-Journal on Hydrogen and Fuel Cells has been offering translations of articles published in the German trade journal HZwei. Its reach is steadily growing. Last year, h2-international.com recorded 55,000 page views, twice as many as in 2016. The website was accessed from 152 countries, with the United States taking the lion's share. 2018 will see some major changes. From now on, the English-language magazine will be published four times a year, just like its German counterpart. A print version will be available each April and October. The yearly subscription fee has been cut to EUR 35. ||

→ www.h2-international.com

HYDROGEN FEATURED AT CLIMATE CONFERENCE

Proponents of hydrogen and fuel cell solutions had something to look forward to at COP23, the 23rd UN climate conference, which took place in Bonn, Germany, Nov. 6 through 17 last year. Until the beginning of December, the Deutsches Museum featured a special exhibition on "Hydrogen – The unlimited energy source," supported by the Hydrogeit Verlag publishing house. Additionally, some of the buses transporting attendees around the grounds during the summit were CleanShuttle battery, hydrogen and hybrid versions from all over Germany. The event also offered opportunities to ride in fuel cell vehicles to a hydrogen refueling station for a closer look at the installation. The high point of the conference, however, was the Global Renewable Energy Solutions Showcase trade show for COP23 delegates, international organizations and NGOs in the Bundeskunsthalle, Nov. 7 through 8. ||

Theme: News | **Author:** Sven Geitmann

FUTUREE'S SURPRISE RESUSCITATION

Heliocentris again files for bankruptcy – this time, as part of Odasco


[Quelle: J. Holzwarth]

Siegfried Limmer

The takeover of Heliocentris by Odasco nearly a year ago was meant to save the ailing business, but it is now clear that the attempt at a turnaround has failed. When newly founded Odasco Heliocentris Europe filed for bankruptcy on Aug. 3, 2017, work at both company locations, Wendlingen and Munich, had already halted. Proceedings were opened on Sept. 1 last year.

Throughout 2017, the fuel cell manufacturer had to deal with a shortage in liquidity, which reportedly led to employees either going on strike or quitting their job. Some of Heliocentris' former staff had already indicated in previous conversations with H2-international that the takeover had not brought about any fundamental change in the way the company was run. Many experienced people left Odasco Heliocentris, making it impossible to keep the business afloat.

During last year's Supplier Marketplace on Sept. 20 in Berlin, Hartmut Kordus told the hydrogen and fuel cell community that he had acquired the assets of the Wendlingen location. Kordus, an electrical engineer specializing in telecommunications and renewable energies, is the head of both adKor, based in Wildau, and an engineering firm located in Zeuthen, near Berlin. He has been involved in the design and installation of cell phone towers, among other things. By his own account, his company has the "most fuel cell units for BOS radio towers on the market," around 120 systems (see also November 2015 issue of H2-international).

Despite a temporarily suspended phone line, the Heliocentris' Wendlingen location has since become home to the development of fuel cell-based uninterruptible power supply. Last November, it was reported that employees at the site had resumed their work, although under entirely new management. Kordus had been able to convince one of the three former CEOs of FutureE Fuel Cell Solutions, Siegfried Limmer, to join the company. Together with a small team, Limmer intends to shore up support for existing systems and set up new installations. On Aug. 21, 2017, he founded a new company called FutureE.

Kordus told H2-international that adKor and FutureE had signed a cooperation agreement, which had allowed the company to finish fulfilling an order by the Stadtwerke Düsseldorf utility for the manufacture and installation of five UPS fuel cell systems. The order was placed in as early as last May, but Odasco Heliocentris no longer had the resources to complete it. Instead, more than 50 percent of the contract value had subsequently been paid by Kordus to Odasco Heliocentris to cover outstanding bills, he said.

With these five new units coming online, the two company heads intend to signal to existing customers and to prospects that the business can guarantee long-term reliable support for UPS systems. Asked about the business's outlook, Limmer said that the aim was to "eventually grow again with the expected influx of orders." ||

Düsseldorf-based lawyer Jan-Philipp Hoos from White & Case Insolvenz was appointed the trustee in the bankruptcy case. He is collaborating with his Berlin-based colleague Joachim Voigt-Salus, the trustee during the previous Heliocentris proceedings.

Now-defunct P21, based in Munich, used to serve as a second business location. It has since been shut down, and all employment contracts have been terminated. Hoos said that its non-tangible assets, such as the software tools for the P21 Energy Manager, would be sold off very soon.

FCP FOUNDED IN CHEMNITZ

Last November, Thomas Melczer and Achim Loecher were appointed CEOs at newly founded FCP – Fuel Cell Powertrain, a joint venture between Melczer's PTT Power Train Technology based in the German state of Saxony and Dewei Group Holdings from Beijing. They share the role with Professor Thomas von Unwerth, director of the Advanced Powertrains department at Chemnitz University of Technology, which works in close partnership with FCP. The fourth and last CEO is Wolfgang Heil, also CEO of TTS Technology Transfer & Supply and formerly employed in the same position at GSR Ventiltechnik.

FCP's objective is to develop and manufacture state-of-the-art battery and fuel cell hybrid systems as well as powertrains. The company plans to invest "EUR 120 million in establishing a visionary infrastructure and installing and creating the first systems and products over the next 36 months."

So far, FCP has a staff of 16, a number that is said to be growing to 100 eventually. Besides the department on system development, the university will reportedly receive a testing environment and a low-volume production facility. Financial support will come from the federal state's economic development agency among others. The new company considers its main sales market to be China, where it will set up a subsidiary for local manufacture. Melczer and Loecher used to sit on the board of Proton Motor, a fuel cell manufacturer they both left in July two years ago. ||

Fig. 1: Daimler wants to first electrify the internal combustion engine, thus creating a hybrid.

Theme: Trade shows | **Author:** Sven Geitmann

ELECTRIFICATION HAS BEGUN

30th Electric Vehicle Symposium in Stuttgart

"The biggest EVS yet," Thomas Walter, part of the team that manages Messe Stuttgart, exclaimed when he opened the 30th Electric Vehicle Symposium on Oct. 9, 2017. At this point, he thought that he was dealing with 5,000 conference participants and trade show visitors, but the actual number was closer to 9,500. For these 3 days, the German city of Stuttgart could have been the world capital of electric transportation.

Even the organizers were surprised by the rush of people eager to attend EVS, the Electric Vehicle Symposium & Exhibition, in 2017. There were so many requests, especially in the 3 days leading up to the event, that official registration had to be stopped. In all, according to the official count, about 1,700 attendees, from 53 countries, flocked to last year's EVS conference to update themselves on recent developments in electric transportation at the International Congress Center Stuttgart. And instead of the 250 exhibitors initially anticipated, there were 353.

STAYING DISRUPTIVE THROUGH ELECTRIFICATION The organizers used what you might call an oversized auditorium to publicly declare that Stuttgart was to usher in a "new era of clean transportation." Alluding to the Bonn climate summit, COP23 (see p. 6), the declaration was meant to spread "a message of hope, a true assessment of feasibility and a call to action." Espen Hauge, president of the World Electric Vehicle Association, affirmed that the industry was on board and that the only question remaining was when, exactly, would electric vehicles make up most of the transportation sector. He said that electric engines required 50 percent to 80 percent less energy compared to internal combustion engines, mainly thanks to the greater efficiency of electric motors. He also stressed that disruptive technology, as innovative as it may be, could have a brutal impact on a country or region.

> "The life cycle assessment has already turned out positive, despite the difficulties of making a clean product in a dirty economy [...] The global CO_2 emissions of an electric vehicle can be up to 13 times lower than that of a comparable combustion engine car. This figure includes emissions for producing the vehicle if renewable energy is used to generate the electricity."
>
> *Espen Hauge, World Electric Vehicle Association*

There were also admonishing voices. Winfried Kretschmann, governor of the German state of Baden-Württemberg, explained that a lot was at stake. He said, "Our role as pioneers in technology, our economic power, our jobs and our natural environment must be protected from the consequences of a changing climate. The challenges are great." He added, "It's clear that in Baden-Württemberg we will have to shift into high gear." In the same vein, the chair of the National Platform for Electric Mobility, Henning Kagermann, said that more marketing would help.

AN AIRBUS FOR BATTERIES Maroš Šefčovič from the European Commission called for a strong commitment to electrification and clear guidelines for better planning security. Addressing carmakers, he said, "Now is the time to deliver." He also stated that Europe was better equipped than any other region in the world to take the next step into a new era of transportation. Then, he referenced similar challenges the aviation industry had when it was faced with structural changes in the 1960s. They were overcome when Germany and France started working together and gave Airbus, a government-shared aircraft manufacturer, the chance to compete and succeed on the market. Now, Šefcovic would like to see the same happening in the battery sector.

PLEA TO KEEP THE COMBUSTION ENGINE RUNNING Daimler's answer to the emissions problem in the transportation sector couldn't have been more contradictory. Ola Källenius, board member and head of research at the automaker, showed a highly polished presentation including emotionally charged video clips and a bombastic musical score. The basic message was that Daimler would continue with internal combustion engines. For several minutes and without a glance at any notes, Källenius, who is to succeed Dieter Zetsche as chairman of the board in 2019, went on about the merits of conventional technologies. He showed the audience combustion-based racecar engines to be implemented in high-end vehicles by AMG for the road. Then, he asked, "Why did I tell you all this at a conference about electric transportation?"

His answer was that even in 2025, according to the German National Platform for Electromobility, only every fourth vehicle sold on the market is expected to be powered by electricity. The remaining 75 percent would rely on internal combustion engines, which Daimler aims to make as efficient and clean as possible by hybridizing them in cars, vans, trucks and buses.

He only briefly talked about the GLC F-Cell and said that Daimler's new fuel cell passenger cars would go on the market in 2018 but would be manufactured in low volumes. Later, the number of fuel cell engines might increase, but their implementation was more likely in commercial vehicles.

Although his presentation was anything but encouraging for the electric transportation sector, it was met with a great deal of applause, perhaps partly related to its being delivered in Daimler's home city.

> The fact that a booming electric vehicle market could bring about new challenges was evident by the amount of energy needed for the many e-cars arriving in Baden-Württemberg's capital. Thomas Walter reported that around 60 charging points, fed by a giant battery, were temporarily set up on the show grounds.

NO DOOM AND GLOOM The first exhibition hall was well filled by over 350 exhibitors, and even during the conference sessions, it wasn't boring at the booths. Although at first glance, the companies dealing with hydrogen and fuel cell technology seemed rather small in numbers, more than 40, along with their latest offerings, could be discovered by consulting the program for the event.

Espen Hauge

For the first time, the Asahi Kasei Group, a Japanese chemical company, showed its systems for producing ammonia and hydrogen to the German hydrogen community. Founded in 1922, it started manufacturing chloralkali electrolyzers in 1975. This February, its German subsidiary, Düsseldorf-based Asahi Kasei Europe, is said to begin testing a newly developed electrolyzer at the h2herten Application Center and get it certified for the European market. The corporation is participating in the international European project ALIGN-CCUS, which among other things, is aiming to convert carbon dioxide as well as hydrogen produced onsite into methanol and dimethyl ether. With EUR 15 million in support from ERA-Net for Accelerating CCS Technologies, six industrial centers in Europe are to be developed into economically strong, low-carbon regions by 2025. A total of 31 companies, research institutes and universities from five European countries have been involved in this pursuit, which started Nov. 7, 2017.

Even Bosch, which primarily demonstrated its electric vehicle designs, presented some fuel cell technology. However, Harald Fischer said that his company hadn't yet decided on whether it would develop its own stack. Instead, Bosch had entered into partnership with several manufacturers, for example, Hydrogenics, ElringKlinger, PowerCell and Ballard.

INFRASTRUCTURE COSTS
The Jülich research center used the show as an opportunity to present its study, commissioned by H_2 Mobility, on the cost of infrastructure for hydrogen cars and battery-powered cars. During a press conference, the authors of the study, Detlef Stolten and Martin Robinius, and other experts discussed the cost-effectiveness of Germany expanding both its electrical and hydrogen infrastructure. More on this in the April 2018 issue of H2-international.

CONNECTING PEOPLE The organizers also indicated their satisfaction with the networking event running parallel to the exhibition. Around 200 industry specialists signed up for altogether 500 one-on-one talks. This service, Peter Sauber said, was also to be offered during the f-cell 2018 to promote and strengthen ties within the hydrogen and fuel cell community.

The first Electric Transportation Day, AtEm, was considered a success as well. The day before EVS30, several car manufacturers had a wide range of electric vehicles at both Karlsplatz and Bahnhofsvorplatz in Stuttgart available for test drives. The state's minister for transportation,

Winfried Hermann, was pleased with the curiosity and goodwill many people had for the new technologies. He also reminded everyone that it was important to pay attention to where the electricity needed for these new cars came from. Hermann said that the use of fossil energy should be left in the past and the brown coal, or even uranium, in the ground.

WHO'S LOOKING AFTER HYDROGEN?
During the EVS30 press conference, Henning Kagermann made clear where he stands on the issue of fuel cell cars and why they're barely considered in recommendations coming from his association. "There are enough complementary organizations that take care of hydrogen," he said. Exactly which ones he meant, however, wasn't so clear. For example, has the task of creating a roadmap for the introduction of fuel cell cars been assigned to NOW, the National Organization Hydrogen and Fuel Cell Technology?

F-CELL AWARDS The f-cell awards of the year were presented in a convention hall on the show grounds. Since many symposium participants were invited, the ceremony was rather large, yet every award felt special. The state's minister for the environment, Franz Untersteller, certainly knew how to give a speech stressing both the advantages and challenges of electric transportation. He referenced some rather inhumane practices involved in the mining of important raw materials for e-cars, but also mentioned some advancements made in fuel cell technology, from both ElringKlinger and Bosch, for example.

The winner in the Products & Market category once again came from Freudenberg. The corporation's Filtration Technologies division in Weinheim, Germany, received an award for its innovative air intake filter. This fuel cell filter system helps to reduce flow resistance, increasing efficiency. In the Research & Development category, the University of Augsburg's Institute of Textile Technology and RWTH Aachen University's Institute of Applied Microbiology received EUR 10,000 in prize money for their collaboration during TexKoMBZ. The research groups jointly designed a new electrode for microbial fuel cells. The bio-anode might make it possible to obtain electricity from wastewater (see article in the April 2018 issue of H_2-international).

ADVANCING ELECTRIFICATION Overall, EVS30 showed that the transportation sector has undergone a major change in trajectory over the past few months. The automotive industry seems to have come to the realization that it's only a matter of time before electric alternatives replace conventional engines. It's understandable that for big players such as Daimler or Volkswagen, overhauling their businesses won't be as easy as pushing a button. But the advance of electrification cannot be reversed. The cautious steps taken by automobile companies have given way to practical strides: For them, it's no longer about whether to pursue the idea of electrification at all, but how and how fast. Evidence of this are the numerous suppliers poised to switch to electric transportation. And since the Frankfurt motor show, IAA 2017, they've been knocking on the doors of car manufacturers to make them switch too. ||

ELECT!
In June 2017, Messe Stuttgart announced that an electric transportation alliance called elect! had been established. During EVS30, Thomas Walter said that the platform would be turned into a trade show called elect!, to be held Oct. 8 through 10, 2018.

Theme: Trade shows | **Author:** Sven Geitmann

VYING FOR VISITORS

Competition among trade show organizers in Germany is now ramping up in the energy storage as well as the electric transportation arena. More and more event providers want to establish hubs of emerging technologies and draw industry-wide interest to their locations. The most recent example of this type of effort is the cooperation between Messe Düsseldorf and Stuttgart-based Peter Sauber Agentur.

The electric transportation expos have undergone some changes since 2017. The auto show in Munich that originally started under the name eCarTec is no more. In October 2017, emove360° took place instead. It had a new concept and significantly fewer exhibitors. In 2018, Power2Drive Europe, an event built around electric transportation and charging infrastructure, will be competing for visitors when it is held for the first time on the same show grounds, June 19 through 22. It will run parallel to Intersolar Europe; ees Europe, the electrical energy storage event established in 2014; and EM-Power, the new exhibition for smart building automation and management. All four will be gathered under the umbrella of The smarter E.

In Stuttgart, elect!, an independent e-transportation fair, intends to establish itself as an autumn event (see October 2017 issue of H2-International). In 2018, it will take place Oct. 8 through 9. This may detract from emove360°, which will be held a week later in Munich. Meanwhile, the double feature of Battery Show Europe and Electric & Hybrid Vehicle Technology Europe, held in Sindelfingen in 2017, will be found in Hannover, May 15 through 17, in 2018, at the same location where Hannover Messe, one of the world's largest trade shows, will take place toward the end of April.

After the 30th Electric Vehicle Symposium & Exhibition, Peter Sauber Agentur has ended its foray into electric cars and left its Battery+Storage event in the past. Instead, the agency will focus on hydrogen and fuel cells, hosting f-cell in Stuttgart, Sept. 18 through 19. It will also feature these themes at Energy Storage Europe, in cooperation with Messe Düsseldorf, March 13 through 15, after talks with the owner of the Munich show grounds were unsuccessful. With the agency's involvement, Messe Düsseldorf hopes to attract even more active players in the hydrogen and fuel cell industry to its event by the Rhine and take "the product portfolio of the leading trade fair for energy storage systems to the next level," as Bastian Mingers, head manager of the exhibition, put it. ||

Theme: Trade shows | **Author:** Sven Geitmann

H2 IN THE DESERT

First hydrogen and fuel cell show in Las Vegas

The leap over the big pond has been made. Tobias Renz Fair and Deutsche Messe organized the first Hydrogen + Fuel Cells North America, which took place in Las Vegas, Nevada, Sept. 10 through 13, 2017. The hydrogen and fuel cell trade show ran alongside Solar Power International and Energy Storage International in one large hall at the Mandalay Bay Convention Center. It attracted many interested visitors.

Tobias Renz, who also organizes the shared exhibition space for hydrogen and fuel cells every year during Hannover Messe, was thrilled even before the opening with the exhibitors he was able to muster. When they arrived and set up the trade show, the first of its kind in North America, he was pleased to find that everything was going as planned.

A total of 30 exhibitors, some coming from Europe and some from within North America, presented their products in the 1,000-square-meter, or nearly 11,000-square-foot, space in the dry, desert-like climate of Nevada. Among them were such prominent companies as Air Liquide, Ballard, Hydrogenics, ITM Power, Nel Hydrogen and Proton OnSite. Also supporting the function were the California Fuel Cell Partnership, California Hydrogen Business Council and Canadian Hydrogen and Fuel Cell Association.

GREAT POTENTIAL Similar to Hannover Messe, the trade show was designed to include a forum space where exhibitors could display their products or prototypes (see fig. 1). During presentations, this area was usually well filled, since there were many Solar Power International attendees taking the opportunity to learn about the practical applications of hydrogen and fuel cells.

The individual booths prepared for the event were fairly typical from the point of view of the locals but plainer than one is used to in Germany. This was Tobias Renz's intention, as he didn't want a replica of the shared space in Hanover but a hydrogen and fuel cell trade show of its own, as is the American way. Benjamin Low, Deutsche Messe's manager of the Energy Show in Hanover, who was also present, has been supporting Renz in his North America venture and is already contemplating bringing the show to China.

According to Stephen Miner, CEO of Solar Energy Trade Shows, organizer of Solar Power International, "This year's event was a true testament to the growth and strength of this industry. A record crowd of 20,000 attendees saw an even bigger and better show that included Energy Storage International, Hydrogen + Fuel Cells North America and the Smart Energy Microgrid Marketplace – a complete integration of these renewable technologies all in one place. We're excited to continue the expansion and integration of these components in Anaheim for Solar Power International and Energy Storage International 2018."

All the exhibitors and visitors were impressed by the first Hydrogen + Fuel Cells North America. Even though the booths, set up at the edge of the spacious convention center, weren't always crowded, their messages reached plenty. As a result, several companies declared on the spot that they wanted to be there for the next show. ||

Fig. 2: Arno A. Evers

Arno A. Evers, who established the booth for hydrogen and fuel cells in Hanover in 1995, personally and proudly attended the event and was impressed with the way his vision from 2000 had been brought to life.

In total, 700 exhibitors showed their products at the event in Las Vegas. At Energy Storage International alone, 160 organizations were represented. In 2018, the Solar Power International, Energy Storage International and Hydrogen + Fuel Cells North America event will be held Sept. 24 through 27 in Anaheim, California.

Theme: Stationary systems | **Author:** Sven Geitmann

SOLIDPOWER PARTNERS WITH MICROSOFT

Fuel cells for Seattle data center

Fig. 1: Top: Complex voltage conversion from borehole to server; below: direct path from gas pipe to server

While SOLIDpower's core business is the supply of energy to residential and commercial buildings, it has recently branched out into IT. As a German-Italian manufacturer of high-temperature fuel cells, it will now provide units to businesses that need to keep servers running. The most well-known partner it has signed a cooperation agreement with is Microsoft. On Oct. 25, 2017, the first generator came online at the American software giant's Seattle data center.

State-of-the-art data centers require an immense amount of energy and, to a large extent, are driving the demand for efficient energy supply solutions. The yearly savings potential is correspondingly high, adding up to hundreds of millions of dollars.

So far, the cooperation has resulted in the delivery of 10 solid oxide fuel cells. The units were installed near Microsoft's headquarters last fall. They are only hooked up to the servers and have no connection to the internal power grid. SOLIDpower said in a press release that "the devices, which are based on the BlueGen fuel cell generator distributed in Europe, are installed right above each server rack, and generate power directly at the rack [see image]."

The units replace commonly used systems that distribute power from a central location outside the actual server rooms. In addition to being more efficient and less expensive, fuel cell setups remove the need for diesel emergency backup generators to keep servers online during a power outage.

Source: SOLIDpower

Fig. 2: Fuel cell units on top, servers directly below

GAS BEATS POWER HOOKUP For years, Microsoft has been trying to improve its energy supply efficiency and switch over to renewable-based production. The company is now taking the next step by setting up a gas-powered data center in cooperation with McKinstry and Cummins. The servers in this new building will connect to gas pipes instead of power lines, while the fuel cell will supply electricity to each server individually. "What makes this project so disruptive is how radically it simplifies the process of powering servers and how this could almost double the energy efficiency of data centers – all while reducing costs and improving reliability," said Christian Belady, general manager of Cloud Infrastructure Strategy and Architecture at Microsoft.

He added that "right now, data centers are powered by the electrical grid, which flows from a power plant through multiple substations and transmission lines, and then must be converted into the right voltage for a data center before we can use it. With fuel cells powered directly from the natural gas line, we cut out all those steps, and remove the energy losses that occur through this long transmission process [see fig. 1]."

Today's fuel cell units are usually set up parallel to the grid, but Microsoft's new approach requires fewer electrical components and does not involve the power distribution network. The idea for the project was conceived in 2013 while Microsoft was testing prototype versions of in-rack fuel cells in partnership with UC Irvine's National Fuel Cell Research Center. Those tests were followed one year later by a biogas pilot in Cheyenne, Wyoming.

"The technology will soon be deployed at a much larger scale. We will then use systems that are specifically designed for this purpose based on the reliable and highly efficient technology of our BlueGen system."
Alberto Ravagni, CEO of SOLIDpower

NEW INVESTOR Those new fuel cell opportunities prompted a globally operating corporate investor to pour around EUR 40 million into SOLIDpower's bank accounts. Consequently, the makeup of the board was changed to reflect the new majority stake. The next investment the company is planning consists of a new 7,000-square-meter or 75,000-square-foot production facility in Italy, which is likewise said to be leading to an increase in the number of staff members from 71 to 150 by 2020. At that point, yearly production capacity is expected to have grown from today's 1,500 to up to 16,000 micro-CHP units. ||

FREUDENBERG BOUGHT ELCORE

On Oct. 8, 2017, both Elcomax and its wholly owned subsidiary Elcore requested a preliminary bankruptcy hearing at the district court in Munich, Germany. If nothing else, it allowed for business to continue until the end of last year, as wages and salaries were paid through the federal employment department in those three months. In mid-January 2018, it was reported that the Freudenberg corporate group, or, more specifically, Freudenberg Sealing Technologies, had bought the struggling business.

Manfred Stefener, CEO of Elcore and Elcomax told H2-international that company management was "greatly optimistic about getting the financing worked out," even though it would take some time. Stefener, who also co-founded Smart Fuel Cell in 2002, said that some business partners had already pledged their support. He added that product development had made considerable advances and that market prospects were looking good.

He explained that Elcore had been in a bit of a "growth trap," which might have prompted some risky decisions that had put the company in this unfortunate situation. A recent and, in his eyes, necessary financing round had not been as successful as had been hoped. "Still, everyone is in a good mood despite the difficulties," he said. Stefener, who was presented with the European Inventor Award in 2012, had believed up until the very last minute that the company could prevent an exodus of personnel and avoid having to lay off most of its 100 staff members.

Interim trustee Hubert Ampferl explained, "The crucial factor will be how potential investors evaluate the prospects for growth in the fuel cell market." His law firm, Dr. Beck & Partner, published a press release on Oct. 11, 2017, to look for suitable candidates. *His colleague, Ulf Pechartscheck, said,* "Comprehensive government funding makes the group's products a particularly appealing option for *residential building owners*." He, too, was confident that the company could attract the right kind of investor, meaning one that would continue to develop the technology and establish it on the market. Sales partner Thermondo, however, has already removed the Elcore 2400 from its website.

As recently as last March, energy supplier E.ON had announced that it had entered into a distribution agreement with Elcore to focus on clean and economic fuel cells for residential heat supply.

With a plan for everyone, E.ON would provide enough carbon-neutral, eco-friendly natural gas – and, if needed, electricity – to more than just meet the demands of Elcore customers. In late September, the Munich-based manufacturer had even showcased a new design for its Elcore 2400.

The Zukunft Erdgas initiative by Germany's energy industry said that the national KfW Development Bank had meanwhile been offering EUR 7,000 to EUR 28,000 for the installation of residential fuel cells for over a year. Timm Kehler, chair of the initiative, explained, "There is demand for these funds. The fuel cell has caught the interest of the market. The program works." Zukunft Erdgas estimates that 1,500 residential fuel cells were installed last year. "That was just the beginning. We've been very pleased with the results so far," he said. ||

FUEL CELLS TO POWER ENTIRE RESIDENTIAL AREA

Langweid am Lech is the first-ever place in Germany where residential fuel cells will meet all energy needs. Regional energy utility Erdgas Schwaben, based in Augsburg, has joined forces with developer Michael Dumberger and heating system supplier Viessmann to install Panasonic fuel cells in each of the 62 duplex and row houses under construction in a new residential zone. Another 43 will reportedly be part of a similar project in Mering. During the groundbreaking ceremony in Langweid last July, Gerhard Failer, sales manager at Dumberger, said that "fuel cells are perfect for supplying our highly insulated buildings with safe and inexpensive heat and power." HAnd his boss, Michael Dumberger, added, "We don't build for ourselves but for generations to come." ||

COMMERCIAL INSTALLATIONS NOW ELIGIBLE FOR GRANTS

At first, the veritable amount of grant money supporting fuel cell purchases in Germany had only been available to individuals owning residential buildings. Last July, the government changed the eligibility criteria of its technology rollout program to allow applications from SMEs, energy service companies and municipalities planning to install non-residential systems. State secretary Rainer Baake from Germany's federal economy ministry explained, "The decision to extend eligibility to commercial premises is an important milestone that will create broad and lasting opportunities for this highly efficient and future-proof technology." ||

Theme: Energy storage | **Author:** Sven Geitmann

REINVENTING TRANSPORTATION CAN'T BE THAT HARD

20 H_2 Stations for Schleswig-Holstein

For a long time, the wind power industry had no interest in energy storage, because it was much more lucrative to feed the power generated directly into the public grid. However, the end of the 20 years of guaranteed feed-in payments for the first turbines in Germany is in sight. Because of this, operators and planners, including Reinhard Christiansen, are looking for alternatives. Christiansen has been increasingly focusing his attention on wind power storage. However, it is still unclear whether returns from power-to-X or from methanization could be as high as what his wind farms generated in the past, that is, up to 12 percent. They could be with a suitable renewable energy policy.

Reinhard Christiansen's office is in the former milling and mixing facility of his farm. Countless folders fight for space on the shelves. The different colored bindings stand for different companies, and since Christiansen leads several of these, the small room is a whirl of colors, all revolving around wind power.

Christiansen stopped his agricultural business in 1991. At the time, he was volunteer district chair for BUND, a national NGO focused on nature preservation and environmental protection, and realized that he could not put in the time to profit from farming if he wanted to make strides in renewable energy. He then got into the insurance business and, at the same time, dedicated himself to promoting and improving the use of wind energy.

Inspired by the booming industry in Denmark, he started work on creating his own wind farm and got the citizens of his village in northern Friesland on board. Although he was one of the first wind farm builders, he does not see himself as a pioneer, though he considers Hans-Detlef Feddersen, CEO of ee-Nord, to be one. Christiansen declares, "We have built on the knowledge of others."

Although he, his fellow villagers and the nearby municipalities are now doing well financially, Christiansen is still working to optimize energy supply. It is not only the high excess capacity in the wind sector that is frustrating him.

Image: D. Geitmann

Reinhard Christiansen (middle) and Marko Bartelsen (right) at the interview

He is also highly critical of the politics surrounding the industry. For example, he says that electricity is being routed from Denmark instead of Germany to France because of long-term supply contracts, while the power produced locally is being throttled by German regulators. That network operators can then pass down substantial costs to consumers bothers him. Christiansen says, "We must, as an industry, show that we also don't like it."

TRANSFORMING TRANSPORTATION THROUGH HYDROGEN The wind farmer is now turning to hydrogen technology, again as one of the first in the region, though he points out that others before him had already demonstrated the feasibility of storing wind power in the form of hydrogen. He now wants to use the gas to transform the transportation sector. "It can't be that hard," says Christiansen.

For this purpose, he, together with 55 businesses, founded Energie des Nordens in 2015. In December 2016, he secured the funding for his wind-to-hydrogen project. The project's manager, Marko Bartelsen, has since been leading the effort to get both H_2 refueling stations and fuel cell cars to the region (see December 2017 issue of H2-International). There is now a promise from H2 Mobility that a refueling station will be built west of Flensburg toward the end of 2018. The hydrogen for the station could come from Christiansen's wind farm in Ellhöft. According to him, enough could be generated to fill 3,200 fuel cell cars, or 13 to 14 railcars, a year. Together, the amount that could have been produced had the wind power plants in Schleswig-Holstein not been shut down temporarily to stabilize the grid would be enough for 274,000 cars.

At present, it seems that the electrolyzer planned will be installed at the E.ON Netz substation in Haurup, so H_2 can be fed into the gas network and electricity can be drawn directly from the substation. In this way, wind-sourced energy could be used before an imminent grid overload causes so-called EisMan signals to be relayed and turbines to switch off.

Einspeisemanagement, the German word for feed-in management, evens out fluctuations in grid supply generated from renewable sources as well as CHP and landfill gas.

So far, the response to the project has been positive, because all approvals from administrative bodies were obtained early on, according to Bartelsen. Therefore, he intends to continue with it and erect 20 to 30 H_2 stations within the next 2 to 3 years. "But now we need the first," adds Christiansen. He plans to set up his own station in the neighboring village of Westre as early as September this year. This location, in addition to Haurup, would guarantee a sufficient supply of fuel for hydrogen-powered electric vehicles in the region. ||

Theme: Energy storage | **Author:** Sven Geitmann

GREEN ELECTRICITY IS FACING NUMBERS DEEP IN THE RED

Interview with Reinhard Christiansen, pioneer in wind power

Reinhard Christiansen is the best person to ask about green electricity. By the late 1980s, he had already made significant contributions to wind power in Germany. In 1995, he started designing the first wind farm together with the other people in Ellhöft, a village with a population of 113. After getting the farm running in 2000, Christiansen started four others like it, set up an electrical substation and founded several companies to manage the power systems. These projects, along with his consulting services, yielded him not only personal wealth but also the respect of the energy industry. Now, at over 60 years, he is set on bringing a new idea to life: the production of hydrogen from wind-generated electricity (see October 2017 issue of H2-International). We visited Christiansen at his estate in the small community, set directly on the border of Germany and Denmark, and talked to him about his visions, old and new.


Image: D. Geitmann

Reinhard Christiansen

H2-international: Mr. Christiansen, here in the far north, there's almost always a stiff wind blowing. One can imagine wanting to bottle it. Could you tell us about the exact moment at which you thought to start your first community wind farm?
Christiansen: At that time, I was a district chair for BUND, a national NGO dedicated to environmental protection, and had established an energy working group. We had to figure out why wind power business was booming in the neighboring country of Denmark but not in Germany. We couldn't let it stay that way.

H2-international: Overall, it took 5 years for all the environmental concerns and assessments to be addressed and for the six wind power plants to go into operation. What were the main obstacles at that time?
Christiansen: The former head of the district council of northern Friesland, Olaf Bastian, made it clear that he was completely against wind power and made sure his colleague on the Danish side would discourage its use south of the border.

H2-international: Did you ever consider giving up?
Christiansen: No, not ever! When you have goals set and you run into walls on the way there, you have to tunnel, skip, bypass or tear them down.

H2-international: If I may, how did you bridge these 5 years financially?
Christiansen: In the beginning, we were just 28 citizens from the community. When the money was about to run out, we asked friends and acquaintances to help out. Eventually, 23 joined our ranks and refreshed our funds.

H2-international: The planning of subsequent wind farms went at a much brisker pace. What was different?
Christiansen: There was the Renewable Energy Law, the EEG, which guarantees demand and prices over 20 years. That was a good basis for planning. But the difficulties were no less. Many new problems cropped up during the planning process.

H2-international: I remember that at the time, I doubted that the offers of 8 percent or, even, 12 percent return could be taken seriously. Were there indeed such successful projects?
Christiansen: When things aligned in your favor, it certainly did happen. Also, why shouldn't it? Only through this system can taxes be paid. In addition, it was common to get double the return with conventional methods of energy production.

H2-international: So, from today's point of view, can it be said that the success of the wind power industry would not have been possible without the Renewable Energy Law?
Christiansen: That must be acknowledged. In this, politicians have set the right course.

H2-international: The time of funding for the first wind turbines is now gradually starting to run out. Does this mean the end for these windmills?
Christiansen: If their operational safety is guaranteed and the machines have high uptime, you could keep them running as long as possible. But to support the upkeep, you then have to go to market or process the power into something profitable.

H2-international: It is in fact already the case today that power from wind is available at about 4 euro cents, for example, in the United States. In Germany, grid parity has partly been achieved, or has it not?
Christiansen: Unfortunately, producing electricity is considerably more expensive for us as a result of grid balancing fees, a high number of regulations, the required inspections and the cost of approval. The price cannot realistically be less than 5 cents per kilowatt-hour if the communities and citizens involved want to live comfortably.

H2-international: Still, you've been pursuing a new project for 3 years now, namely the storage of power from your wind farms in the form of hydrogen. Why do this, if the investment has long been past breakeven and there are newer turbines that can compete on the market?


Image: D. Geitmann

Christiansen: We generate so much energy here in Schleswig-Holstein yet still burn heating oil, gasoline and diesel. This makes no sense! We could be getting power from the land and putting the savings back into the country.

H2-international: In 2011, you founded Energie des Nordens, with the initial purpose of establishing a regional energy grid in the north of Germany. Since 2015, this company has been pursuing the goal of producing hydrogen directly at the nearby substation. How did you come up with the idea of using hydrogen as a storage medium for wind energy?
Christiansen: Hydrogen technology is being used all over the world, just not by us, even though our power grids can only hold so much. Processing electricity into hydrogen at wind farms that would normally temporarily be down to prevent grid overload is an appropriate solution.

H2-international: Do you see yourself again as pioneering a new technology, as you did with wind power?
Christiansen: With wind power, there were many paving the way before I started. With hydrogen technology, it's the same, as determined people and groups from all corners of the country are applying themselves to the cause.

H2-international: Marko Bartelsen assumed leadership of this project at the start of 2016. How far has it come since then?
Christiansen: We were very close to launching the project. The guidelines of SINTEG, a government program to fund so-called Smart Energy Showcases, and in particular the conditions of the Experimental Clause were not designed for economic viability. They've had quite the opposite effect.

H2-international: Could you elaborate on that?
Christiansen: The Experimental Clause provides for a relief from the EEG surcharge by 60 percent. This type of relief would be great, but the guidelines of SINTEG also stipulate that revenue is considered in the calculation. So, taking our case of storing and reusing electricity as an example, any revenue from selling the hydrogen produced will accordingly reduce the amount of possible EEG surcharge relief. In our case, there would be no relief.

H2-international: Does that mean it's no longer worth it in your case?
Christiansen: Yes, the difficulties are exacerbated in our case, since operating costs may only be set at 50 percent. This means that grants and earnings made economic operation of the Haurup hydrogen project possible. We broke even. However, as SINTEG support will only offset 50 percent of the cost, profit looks better in the books. Since it reduced the amount of funding and the Experimental Clause makes relief very difficult to qualify for, our numbers will end up deep in the red. If they don't change these eligibility criteria, not only our project, but every project invested in this funding program, is doomed.

H2-international: I see. So, what are you planning on doing next?
Christiansen: There are many projects that I want to move forward. Expansion of the network of hydrogen refueling stations. Supplying them with green hydrogen. Establishing a community purchasing cooperative interested in acquiring fuel cell vehicles.

H2-international: When could we expect your first hydrogen fueling station and the first fuel cell cars?
Christiansen: At this point, the third quarter of 2018. For hydrogen, the possibilities for refueling need to come before the car. In the realm of e-cars equipped with batteries only, it is different, since there's electricity everywhere.

H2-international: In 2016, the first Grünstrom Event took place in Enge-Sande, which is around here. Could it be said that a hydrogen community has sprung up in northern Germany, specifically in the Flensburg area?
Christiansen: Yes. Here, citizens will soon awaken to a region-wide establishment of hydrogen facilities. When the first two fueling stations are in operation, the clean energy transformation of the transportation sector will have taken its course.

H2-international: Thank you for these insights.

Grünstrom Event will take place June 1 through 3, 2018 in Enge-Sande, Germany.

Theme: Energy storage | **Author:** Matthias Altmann

SUSTAINABLE H_2 PRODUCTION AND SUPPLY

CertifHy-ing green hydrogen

EU project CertifHy has started implementing a certificate of origin system for green hydrogen. Pilot tests are said to be conducted in the next 9 to 15 months.

Many see great promise in hydrogen as a fuel for zero-emission transportation and a raw material in the industrial sector. Not only has the number of hydrogen-powered fuel cell vehicles been steadily on the rise. The fulfillment of COP climate targets will eventually require large quantities of the compound, for example, in refineries, steel processing and the basic chemical industry. What is needed is a reliable system to track and certify exactly where the green hydrogen comes from and how it is produced.

A Guarantee of Origin, or GO for short, is currently being devised by a consortium on behalf of the Fuel Cells and Hydrogen 2 Joint Undertaking, a public-private partnership made up of the European Commission and several of the continent's businesses and research organizations. The pilot was named CertifHy and is headed by Hinicio, a strategy consulting firm.

The company in charge of drawing up the documentation and procedures based on the first project stage from 2014 to 2016 is LBST. "Together with 14 industrial suppliers and 500 interested stakeholders, we used the first CertifHy project stage to create a solid foundation for our system. Now, we can begin to discuss its implementation. As many as 650 people will be involved in creating a de facto harmonized European guarantee of origin," Hinicio's Wouter Vanhoudt, CertifHy's project leader, said. Uwe Albrecht, LBST's managing director, added that "green hydrogen has shown great potential in past years' energy scenarios and environmental analyses to thoroughly and sustainably transform the transportation and industrial sector. And with CertifHy, stakeholders will soon have a reliable tool to guarantee its origin."

STAKEHOLDER PLATFORM On Nov. 20 last year, the consortium set up a stakeholder platform. Its first plenary session attracted more than 100 partners from business, industry, politics, standardization committees, associations and research organizations in Europe. It also established four working groups to start tackling issues such as the creation of a system to track hydrogen production, certify manufacturers and pilots, provide user guidance and devise a policy framework. The overall objective of the stakeholder platform is to offer a forum for discussions about how to structure the system and manage the pilot stage. Bart Biebuyck, executive director of the Fuel Cells and Hydrogen 2 Joint Undertaking, said at the start of the session that the intent was to have a "self-sustaining" system by the end of the project.
Once this system is set up successfully, plans are to popularize CertifHy among institutions in Europe and incorporate it into European regulations and technical standards starting in 2019.

PILOT STAGE To test and improve the procedures and the system itself, the consortium selected four pilots at locations throughout Europe, each using a different type of H_2 production pathway. In France, industrial gas supplier Air Liquide produces hydrogen through steam reforming natural gas, with subsequent carbon capture and storage. In the Netherlands, chemical company AkzoNobel creates it as a byproduct of chloralkali electrolysis. Belgian retail chain Colruyt, on the other hand, produces the gas on-site to refuel its fleet of vehicles. And energy utility Uniper's wind-sourced electrolysis generated green hydrogen in Falkenhagen, Germany.

These power plants and their low-carbon or zero-emission products will be inspected and certified by TÜV Süd, so long as they meet CertifHy's requirements. Expressing his delight, Konrad Tausche, head of Carbon Management Service at TÜV Süd Industrie Service, said that "we are seeing the implementation of a uniform European certification system. The standardized production and tracking of eco-friendly hydrogen provides yet another contribution to meeting climate change targets."

HOW IT WORKS Guarantee of origin is a well-known and established concept in green power production. CertifHy will soon provide the industry with a similar system to track hydrogen. The gas can then be certified wherever it meets the requirements for eco-friendly production, with certificates being traded through an electronic registry apart from physical product flow. For example, green hydrogen produced in the wind-rich north of Germany doesn't have to be transported to meet demand in the south, where grey hydrogen may be the only option. The certificate will be transferred instead, turning the grey hydrogen green. Consequently, the green hydrogen total in the north will be reduced by the amount stated on the certificate – a reliable and efficient way to make an eco-friendly alternative available to customers throughout Europe.

The first project stage concluded with a broad consensus on establishing two levels of hydrogen quality. The first designates green hydrogen that is produced from renewables and releases no more than a set amount of carbon dioxide, an important criterion for bio-sourced energy. The second points to non-renewable but low-carbon hydrogen that releases no more carbon dioxide than the first method.

HOW IT CAN BE USED Introducing a guarantee of origin for green hydrogen is intended to provide gas users with reliable information about how environmentally friendly it is. There is more than one conceivable scenario in which guaranteeing the origin of the gas can prove beneficial.

GOs could be acquired for hydrogen quantities received or generated on-site. This option is of special interest to large-scale consumers, for example, in industry. They could advertise the use of green hydrogen in production to their customers and the public.

If a much smaller amount of hydrogen is involved, for example, when people refuel their private fuel cell vehicles, it is the gas station operators who may want to offer a guarantee of origin. This guarantee can either be obtained separately from the supplier of the physical product or by requesting hydrogen supply that has already been certified.

Commercial fleet managers could choose to get the guarantee themselves. It will ensure that they can demonstrate carbon-neutral fleet operation to customers and the public alike.

Another option would be automakers offering their vehicles with a certain number of GOs and maybe fuel at the point of sale. More scenarios are possible, depending on what the hydrogen is used for, what the relevant supply chain looks like and which regulations need to be observed.

HOW LONG IT WILL TAKE The organizations participating in CertifHy are currently in the process of setting up the GO system. It will then be tested and improved upon during the previously mentioned pilots. If this article has piqued your interest in green hydrogen certificates, please contact the CertifHy consortium as soon as possible, so you can get a head start to prepare for its implementation. This year will see the creation of the first product certificates based on project outcomes and their inclusion in the electronic registry for trading and purchase.

Green hydrogen manufacturers can likewise get in touch with CertifHy. Once the pilots end, the procedures will have become established and validated enough to be used to certify additional production facilities and quantities and create GOs. ||

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CERTIFHY CONSORTIUM
Consortium members are the international inspection and certification services provider TÜV SÜD from Munich; green energy and transportation consulting firm Ludwig-Bölkow-Systemtechnik from Ottobrunn, near Munich; consortium leader and strategy consulting firm Hinicio, based in Belgium; Dutch research institute ECN and IT systems provider Grexel, based in Finland.
→ www.CertifHy.eu

Theme: Energy storage | **Authors:** Annika Linke and Sven Geitmann

TALK ABOUT DISRUPTIVE TECHNOLOGY

6th Barcamp Renewables in Kassel

Disruptive innovations – What are they and what effect could they have on the energy industry? This was the theme of the sixth Barcamp Renewables, held Oct. 26 through 27, 2017, in and around Kassel, Germany. More than 120 people participated in a lively debate around current projects to promote renewable energy use.

Last year's Barcamp started with a panel discussion, in which industry experts attempted to come up with an answer to the question: In what form will the next disruptions in the industry come? According to Martin Rühl, representing the Stadtwerke Union Nordhessen, "Renewables are now the future." Daniel Bannasch, there for MetropolSolar, was also sure that the reign of renewables would no longer be held back, saying that with a 1 m² photovoltaic cell, an electric car could run for 1,000 kilometers, or 621 miles, per year. This potential had been the fascination of big players on the market for a long time. The goal of fully renewable energy was looking like a real possibility, as evident in the creation of new business fields. Policymakers, on the other hand, seemed to be preventing rather than promoting the switchover to renewables, especially in Germany, a point that clearly resonated with the audience.

After establishing that they did not expect the clean energy transformation to occur from the top down, the participants discussed how the clean energy transformation could be achieved at the level of the people. Julian Kretz, from Next Kraftwerke, pointed out that a great deal of responsibility for making it happen lay with regional utility providers and citizen-financed renewable energy cooperatives. These players especially should keep up with the increasing complexity of our age and work more with programmers and start-ups to create digital solutions for real-world problems.

FROM BLOCKCHAIN TO SOLAR COINS On the second day of the Barcamp, Bitcoin consultant Britta Aufermann shed some light on the mysterious concept of a blockchain. Her basic message was "Germany has been sleeping when it could have been taking part in the global activity of bitcoin trading." There is a huge opportunity for the energy industry to improve itself through digital extension. One possibility would be the introduction of solar coins, or, especially, the coupling of blockchain technology with photovoltaics, which would significantly lower consumption of the energy resources being used.

In addition, the effects of the new German law to establish a digital energy infrastructure were addressed. Marek Seeger, information security manager at SMA, said that the law was, in principle, up to standard in terms of security, but forcing the use of Smart Meter Gateways would be detrimental to the implementation of similar technologies in the future. Indeed, the biggest complaint has been that the regulation on the gateways is not sufficiently clear. Right now, estimating the concrete impact of digital technologies such as blockchain systems and artificial intelligence is difficult.

Johanna Gampe, a lecturer at the University of Kassel, held a session to discuss which hypes in the digital world could be taken advantage of to promote renewables and, more importantly, how. One of her examples was the use of viral marketing through social media, which could allow renewable energy cooperatives to reach many more people of all different ages. ||

ENERGIEBLOGGER
Despite being a registered association, Energieblogger sees itself as a loosely connected group of active bloggers who inform the internet about anything related to renewable energy. They also co-organized this Barcamp. H2-international represents the hydrogen and fuel cell division of Energieblogger.
www.energieblogger.net

Disruptive technology: A disruptive technology or disruptive innovation is an innovation that displaces an existing, highly successful technology, product or service. [retrieved and translated from the German-language Wikipedia, Jan. 29, 2018]

Blockchain: A blockchain [...] is a continuously growing list of records, called blocks, which are linked and secured using cryptography. Each block typically contains a hash pointer as a link to a previous block, a timestamp and transaction data. [...] Blockchains are secure by design and are an example of a distributed computing system with high Byzantine fault tolerance. Decentralized consensus has therefore been achieved with a blockchain. [...] The first blockchain was conceptualized in 2008 by an anonymous person or group known as Satoshi Nakamoto and implemented in 2009 as a core component of bitcoin, where it serves as the public ledger for all transactions. [retrieved from Wikipedia, Jan. 29, 2018]

Bitcoin: Bitcoin is a cryptocurrency and worldwide payment system. It is the first decentralized digital currency, as the system works without a central bank or single administrator. The network is peer-to-peer and transactions take place between users directly, without an intermediary. [retrieved from Wikipedia, Jan. 29, 2018]

Clean Disruption of Energy and Transportation: How Silicon Valley Will Make Oil, Nuclear, Natural Gas, Coal, Electric Utilities and Conventional Cars Obsolete by 2030, by Tony Seba [ISBN: 9780692210536]

Theme: Electric transportation | **Author:** Sven Geitmann

FUEL CELL CAR & RIDE SHARING

Fleet operators go electric

Fig. 1: Hydrogen-powered ridesharing cars

The main group of customers currently driving demand for electric as well as hydrogen vehicles isn't consumers but fleet operators. One prominent example is BeeZero, a Linde subsidiary. In April 2016, it became the first carpooling service in Germany to add 50 Hyundai ix35 Fuel Cell vehicles to its task force in Munich. Since last September, BeeZero has been receiving competition from a rival that is going in a different direction. With financial support from NOW, a start-up called CleverShuttle, partly owned by Deutsche Bahn and Daimler, bought fuel cells for its rideshare service. It offers exclusively electric and plug-in hybrids in several German cities, such as Berlin, Dresden, Frankfurt am Main, Leipzig and Stuttgart.

CleverShuttle's fleet in Hamburg is made up of only hydrogen-powered vehicles, 20 Mirai cars to be exact. According to Frank Horch, the city's senator in charge of economic, transportation and innovation policy, "These eco-friendly fuel cell vehicles not only provide a viable and efficient means of transportation, they also cut down on the amount of harmful emissions. It's the reason why we, the city of Hamburg, have supported the project with around EUR 200,000."

In Munich, the business purchased 15 Mirai cars, whose keys changed hands when the hydrogen station by mineral oil company Allguth was opened on Kreillerstraße in October 2017.

Late last year, another player joined the table: Alphabet Deutschland, BMW's leasing service. In the next 3 years, some of the transportation provider's big customers are said to get 30 Mirai cars in total, supported with EUR 0.5 million by NIP 2, Germany's technology rollout program.

One more competitor is book-n-drive Mobilitätssysteme, which has had a Mirai among its carshare vehicles since last September. CEO Udo Mielke said that the car could be booked at the regular price of EUR 4 per hour.

But progress isn't confined to Germany. In California, StratosFuel is planning to offer a carshare service this year, with an initial fleet of 15 fuel cell vehicles. ||

The decision on carshare or rideshare will determine who drives the vehicle. With carshare, the customer gets behind the wheel and with rideshare, a trained driver transports passengers. Rideshare is not unlike a cab service, the difference being that other customers can be picked up along the way, reducing the price for kilometers travelled.

NEW INTEGRATED ENERGY STUDY

At the end of September 2017, the Fraunhofer Institute for Wind Energy and Energy System Technology and Swiss consulting firm E4tech held a forum on how to transform the energy industry through sector integration. The purpose of the gathering was to discuss the legal, financial and technical barriers to greater interaction between energy sectors, determined prior to the event through an analysis of possibly interrelated factors, and to come up with solutions. The proposed strategy focuses on pushing forward short- and long-term measures that will have an impact on the market and the industry during the upcoming legislative period.

The authors of the study presented at the conference maintained that the best path to change "does not lie in the radical electrification of the heat and transportation sectors or in switching all industries over to hydrogen as the sole energy carrier, but rather in a sensible merger of the two technologies, taking into account efficiency and sustainability." They stressed that the key to achieving the clean energy transformation was this integration of markets, which required cooperation at all levels, and that it was time to start taking measurable steps toward it. ||

Theme: Electric transportation | **Author:** Sven Geitmann

MAYORS SEARCHING FOR FUEL CELL BUSES

Diesel summit: The money's available, the vehicles aren't

Fig. 2: Remains a vision – 2009 concept study of the Citaro F-Cell

If there was one thing that the Diesel Summit made abundantly clear, it was the lack of zero-emission, or even low-emission, cars on the German market. The 28 mayors who met with interim chancellor Angela Merkel in Berlin, Nov. 28, 2017, were faced with a dilemma. They would like to purchase electric buses and promote electric cabs, but there aren't any on the market, at least in Germany.

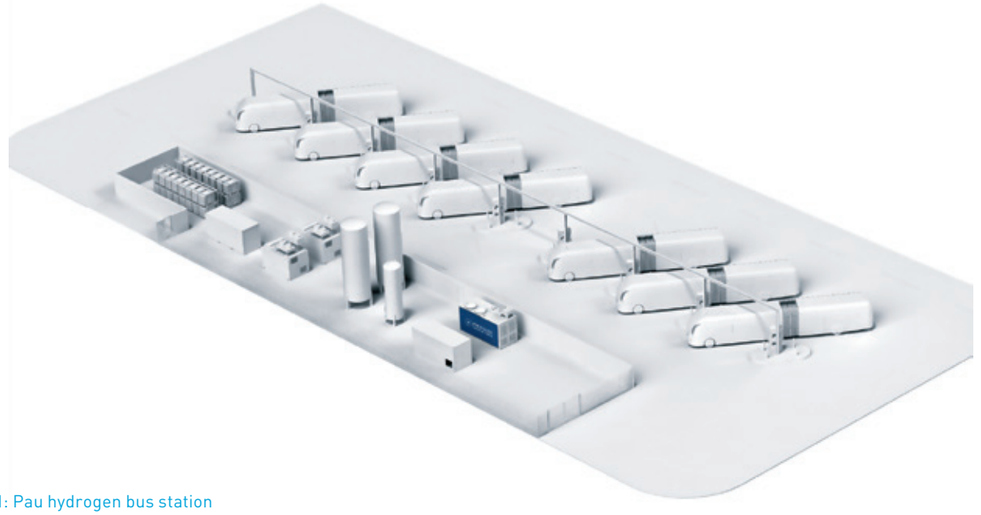
Some made it seem as if the looming driving bans came as a total surprise that no one could have prepared for. But it has long been known that the air quality in big European cities is deteriorating while there is no viable low-emission car market to speak of (see March 2017 and July 2017 issue of H2-international). Several attendees renewed their criticism of the purpose of these Diesel Summits, stressing that those eleventh-hour attempts were too little too late.

The German government pledged to make EUR 1 billion available in federal and state aid to provide support in the short term, giving administrators at both governmental levels the option to combine those incentives for their programs. In response, the acting mayor of Berlin, Michael Müller, announced that the city would, in some cases, double its EUR 4,000 incentive for cab companies planning to switch from diesel to hybrid or electric vehicles. But he also heavily criticized German manufacturers for not offering a single electric cab. The situation wasn't any different with the bus market. Still, Müller said that the city would follow Hamburg's example and starting in 2020, would buy electric buses – if necessary, from manufacturers abroad.

Expressing her discontent, a spokeswoman for Berlin's mass transit company told bizz-energy.com:
"You just don't find any buses on the European market. We'd buy in bulk and hope that the industry realizes they're missing out on a big moneymaker. Someday, we'll need much more than a thousand."

During the Busworld 2017 show, the head of Daimler's bus division, Hartmut Schick, told eurotransport.de:
"There are still buses that need to be on the road for more than 350 kilometers [217 miles] a day and cannot be refueled anywhere during that time. It is those buses for which we're contemplating a fuel cell solution in the form of a range extender. So, the focus has shifted, away from fuel cells as the only energy supply on board, as we had previously thought."

MANUFACTURERS DRAW A BLANK A few years back, German automakers certainly had the guts to push ahead on some promising ventures, not just in electric buses but especially in fuel cell vehicles. Take Daimler for example. As part of Cute and HyFleet:Cute, the corporation had 36 fuel cell Citaro buses running for 12 mass transit companies on three continents. Those Citaro FuelCell Hybrid versions were based on NeBus, a design that Daimler developed, with much government support, in parallel to the fuel cell-powered NeCar. MAN, too, had been working on hydrogen buses for years before it abandoned its activities in the sector altogether.



Source: Daimler

Fig. 1: Pau hydrogen bus station

Daimler itself said that by 2030, 70 percent of all transit buses sold in western Europe would be zero-emission vehicles. It even advertised the fact that its subsidiary Daimler Buses had been developing alternative engine systems for more than 40 years. But in fall 2016, Daniel Bäuerle from the product planning department of Daimler Buses said that there currently was not one battery or fuel cell bus meeting the company's expectations for a series product. A year later, his opinion seems unchanged.

RHINELAND'S 30 FUEL CELL BUSES It's not as if there aren't any efforts being made, but those projects will rely on vehicles manufactured abroad. For example, Cologne's regional transportation provider RVK announced that 30 fuel cell buses will be driving in and around the city starting in 2019. After being told in late September last year that its funding application to the federal transportation ministry had been successful, it can expect to receive EUR 13 million to purchase fuel cell hybrid buses and to have two additional hydrogen stations, one in Meckenheim and the other in Wermelskirchen, installed by the end of 2018. One such station just came online at the Cologne Bonn Airport a few months ago (see p. 41) and the site in Hürth will reportedly be expanded as well. Ten more vehicles that are said to come into operation in 2020 at the latest will be supported with an additional EUR 5.6 million from the EU's Joint Initiative for Hydrogen Vehicles across Europe. It is the biggest fuel cell bus project in Europe, with the aim to put 144 hydrogen buses on the roads of five countries.

The council of the Rheinisch-Bergischer Kreis district has meanwhile agreed to cover the yearly O&M costs of all 15 buses. To the left of the Rhine, it is the Rhein-Sieg-Kreis and Rhein-Erft-Kreis districts where respectively 10 and 5 buses are said to go into operation, with the latter using them as part of the transportation network in Hürth and Brühl.

THE FUEL CELL'S 8 IN FRANCE In France, a comparable project is being undertaken in Pau Béarn Pyrénées, where altogether 8 buses are planned to start driving in fall 2019. The vehicles, 18 meters or 59 feet long, are said to be manufactured by Dutch bus producer Van Hool and operated by regional transportation providers Syndicat Mixte des Transports Urbains – Pau Porte des Pyrénées and Société de Transport de l'Agglomération Paloise. The hydrogen to power those buses will come from electrolyzers by British manufacturer ITM Power (see fig. 2). The EUR 20 million project is being supported financially by the EU's hydrogen initiative.

Jan Van Hool, the bus manufacturer's director of design, said that his company had already sold around 50 fuel cell vehicles, 32 in Europe and 21 in North America.

Even Costa Rica had its first fuel cell bus in operation by late November last year. The hydrogen for this first-of-a-kind vehicle in central America is being produced at zero emissions through wind turbines and solar systems. It's not exactly a surprising development, considering that the country's renewable share in power production was at 98 percent in 2016. In the city of Liberia, the Hydrogen Ecosystem project led to the design of the Nyuti hydrogen bus, which is being funded by Ad Astra Rocket, the Texas-based company of former astronaut Franklin Chang Díaz. ||

Theme: Electric transportation | **Author:** Dr. Stefan Eckert, Dr. Michael Faltenbacher, Dr. Benjamin Reuter, Alex Auf der Maur, Sven Altenburg, Alexander Labinsky

ZERO EMISSIONS IN COMMERCE

From eco-beacon of hope to economically viable alternative

Policies aimed at decarbonizing the transportation sector have so far focused on cars, buses and delivery vans. But there are other types of commercial vehicles, such as light- and heavy-duty trucks as well as construction, agricultural and special purpose equipment, which almost exclusively run on diesel and contribute a great deal to emissions in transportation. The study described in this article investigated the regulations on commercial vehicle emissions and the economic and environmental relevance of different industry segments. Based on five case studies, it also analyzed the total cost of ownership and the GHG emissions during the manufacture of eco-friendly engines.

Commercial vehicles are responsible for more than one-third of all GHG emissions in transportation [1]. On top of this, combustion engines create headaches for urban planners due to the amount of nitrogen oxide and fine dust particles they produce. Whereas trucks and semitrucks are the major polluters among commercial vehicles because of their high mileage, the continuous operation of, for example, construction equipment is no less of a concern, especially inside buildings or in densely populated areas close to these construction sites. It has been reported that 25 percent of the soot found in urban areas and caused by the transportation sector can be traced back to construction equipment [2].

The objective of the study was to show the potential for (locally) zero-emission engines in place of diesel ones in the commercial vehicle sector. This aim limited the investigation of applications, costs and GHG emissions to fuel cell electric vehicles, or FCEVs for short, and battery electric vehicles, or BEVs.

EMISSIONS REGULATIONS Commercial vehicles constitute a strongly heterogeneous market of high import. The manufacture of the vehicles alone employs nearly 12,000 people in the German state of Baden-Württemberg. Crucial industry segments are agricultural equipment and buses. Despite high economic and environmental relevance, these markets show a penetration rate of renewables approaching zero, except for materials handling, where most vehicles run on electricity. There are several regulatory instruments, such as tolls, vehicle taxes and drive restrictions, that classify cars based on their emission output. However, apart from taxation, BEVs and FCEVs are often subject to the same requirements as diesel cars that need to comply with the Euro 6 standard.

The above means that current regulations provide little incentive for switching to zero-emission engines. Only workplace safety standards, which compared to environmental regulations put much stricter emission limits on vehicles and machines, expressly stipulate that in closed spaces, diesel-run equipment either be exchanged for a zero-emission system or a costly analysis and removal of emissions be done in its place [5]. The widespread use of electric vehicles in materials handling shows that workplace safety is an important tool to advance zero-emission capabilities.

SUITABLE ZERO-EMISSION ENGINES Vital factors to consider in zero-emission engine design are the volume and weight of traction batteries and hydrogen tanks. The higher energy density of hydrogen leaves FCEVs with less of a disadvantage. To offer a comparable range, tanks pressurized at 700 bars, or 10,000 psi, need 5 times the volume and 3 times the weight of a diesel tank, whereas batteries need to be 15 times as large and will weigh about 20 times as much [4]. Those specifications point to the severe constraints of battery use in continuous operation and for distances greater than 200 kilometers, or 124 miles, in some applications. Another factor that needed to be part of the analysis was the charging time of BEVs and the infrastructure required to charge or refuel vehicles. As public infrastructure measures have proven insufficient, companies are forced to develop their own solutions. Apart from their cost, these ventures pose challenges for a business's organizational structure, a factor that should not be underestimated.

TOTAL COST OF OWNERSHIP Five case studies covering as much of the commercial sector as possible were selected to determine the total cost of ownership as well as GHG emissions. Comparisons were drawn between the most suitable zero-emission variant and a conventional diesel engine (see table).

The total cost of ownership includes expenses associated with the vehicle purchase, fuel and energy, operation and maintenance, taxation and tolls, and the resale value at the end of the vehicle's economic life. Currently, the traction battery or the fuel cell makes up a considerable part of the investment, even more so in the commercial segment, where low-volume production and much customized equipment means that buyers will not be able to enjoy the same kind of cost benefits available to consumers. Nevertheless, the commercial sector is expected to see battery and fuel cell prices fall by around 60 and 88 percent, respectively. Operating costs, however, are most closely associated with fuel prices and the consumption values of individual use cases. Hydrogen has not yet become competitive, but prices were assumed to end up 49 percent lower at 2030, while diesel would rise by 27 percent and electricity by 28 percent.

Type of vehicle	Conventional engine	Zero-emission option
Heavy-duty vans	Diesel	Battery electric
Large trucks	Diesel	Fuel cell
Transit buses	Diesel	Fuel cell range extender
Wheel loaders	Diesel	Battery electric
Garbage trucks	Diesel	Fuel cell range extender

Table: Vehicle and engine examples

Those assumptions will result in total costs of zero-emission versions of as much as 60 percent to 180 percent above diesel cars in almost all the categories investigated. One exception is the wheel loader. Even today, its engine costs only 8 percent more than a conventional one thanks to a comparatively inexpensive lead-acid battery. In conclusion, zero-emission engines are not yet competitive in any of the vehicle categories when focusing only on the total cost of ownership.

In the future, however, costs will start to decrease until they are 1 percent to 6 percent lower than for conventional vehicles in 2030, i.e., these engines can be competitive under certain conditions (see fig. 1). The only zero-emission option that will continue to cost around 20 percent more is the garbage truck equipped with a fuel cell range extender.

GHG EMISSIONS Environmental effects were analyzed based on GHG emissions throughout the vehicle life cycle. This analysis considered emissions during vehicle production and maintenance, for example, possible battery replacements and upstream supply chains for producing materials, components and energy carriers, and during operation. To demonstrate the GHG reduction potential of zero-emission engines, it was assumed that the technology will have made significant advances until 2030 and power will be sourced entirely from renewables, which will also be used to produce hydrogen through electrolysis. The biofuel share in B11 diesel was set to 10.8 percent [3], resulting in GHG emissions of 48 grams of carbon dioxide per kilowatt-hour of electricity, around 2.98 kilograms of carbon dioxide per kilogram of hydrogen and about 2.82 kilograms of carbon dioxide per liter of B11 grade diesel.

The amount of energy consumed by zero-emission vehicles is much lower than for diesel cars because of the greater efficiency of an electric engine (see fig. 2). As the engine does not produce any emissions, the major portion of pollutants in its life cycle is associated with manufacture and supply. The production of the high-voltage battery and the hydrogen tank initially lead to increased GHG emissions, but their operation will offset this in a matter of 5 to 12 months, depending on the type of vehicle. Over the life cycle, the decrease in GHG emissions is between 67 percent and 87 percent compared to diesel engines (see fig. 3).

Here, too, the exception is the wheel loader. The production of the electric model shows GHG amounts comparable to diesel car manufacture, making this one beneficial starting in the first hour of daily operation. At 87 percent, it also shows the greatest reduction in GHG emissions across all categories.

RECOMMENDATIONS The growth of the zero-emission vehicle segment could be supported by removing certain financial impediments or by offering incentives. Likewise, >>

Source of all figures: thinkstep

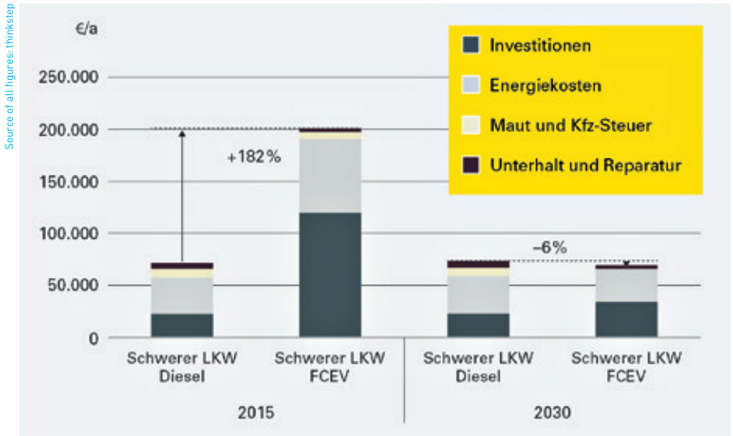


Fig. 1: Total cost of ownership for diesel and FCEV heavy-duty truck in 2015 and 2030

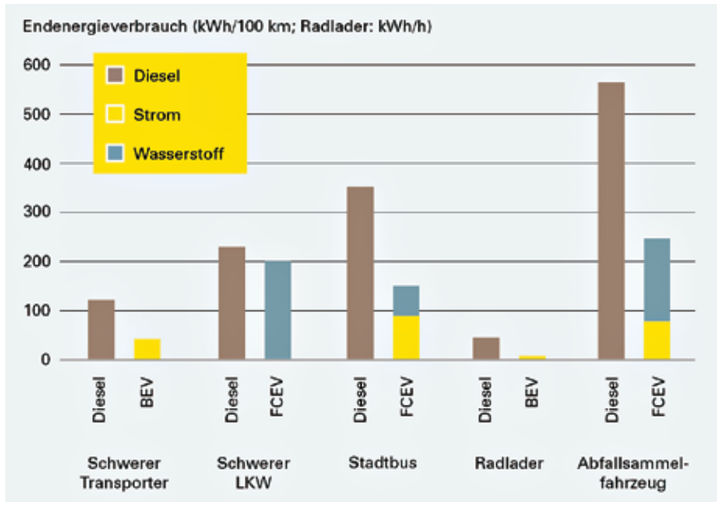


Fig. 2: Energy required by the diesel and zero-emission sample vehicles

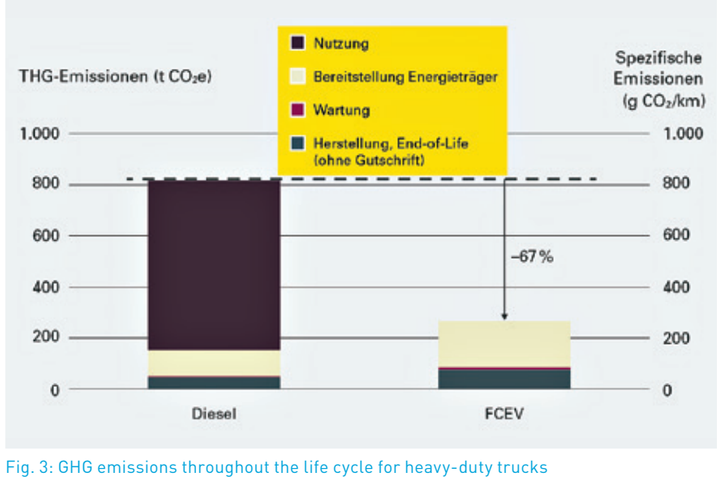


Fig. 3: GHG emissions throughout the life cycle for heavy-duty trucks

it is recommended that regulatory privileges be granted to heave them into a stronger position than Euro 6 vehicles. To make full use of available measures, zero-emission engines should receive their own classification.

Despite moderate demand in some parts of the economy, practical solutions are often few and far between. Examples such as StreetScooter, a successful DHL Group product, are proof of the discrepancy between the points of view of established manufacturers and the specific needs of users. To better align customer demands and manufacturer-side innovations, both suppliers and users need to initiate a broader dialog about the benefits of fuel cells and hydrogen. ||

This study was commissioned by e-mobil BW. It is available for download at http://bit.ly/2ygS5U3

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REFUELING FUEL CELL BUS FLEETS

NewBusFuel – economically sustainable hydrogen supply

Source: WSW, Hydrogenics (1)

Fig. 1: Hydrogen refueling station with on-site electrolyzer; maximum production rate: 6 tons / day

Fuel cell buses have many advantages over their diesel counterparts, making them an attractive option for mass transit companies. A few examples are the complete absence of local emissions, the greater flexibility in choosing a primary energy carrier and, depending on the source of the hydrogen and the use of renewables, considerable potential for reducing carbon dioxide levels.

The many years spent on research and development and extensive trial periods in demonstration projects such as CUTE, HyFleet:CUTE, CHIC and HyTransit have turned up several holes in our knowledge about large-scale bus refueling. To fill in these gaps, the Fuel Cells and Hydrogen Joint Undertaking launched NewBusFuel, a project focused solely on the design of the relevant infrastructure.

Filling up buses is different from refueling cars. Not only do they need greater quantities and storage capacity, but they also require highly reliable and spacious installations, especially in urban areas, where most bus garages offer little room for additional equipment.

For a comprehensive analysis of infrastructure requirements and technological solutions, 13 teams made up of bus operators, hydrogen technology suppliers and other stakeholders channeled their activities during NewBusFuel to devise a plan for each of the 12 partner cities from 7 countries (see fig. 2).

The result was a wide variety of technology choices, from on-site production through electrolysis (see fig. 1) and steam reforming to near-site and off-site methods. Approaches ranged from pipeline use to the delivery of compressed and cryogenic hydrogen (see fig. 3).

The aim was to devise best practice guidelines that follow up on the requirements and solutions identified during the project, and offer guidance to bus operators, manufacturers and the public. These guidelines include lists of specifications, for example, to determine the space needed for a refueling station (see fig. 4), as well as economic figures, such as the cost of capital for modules and the entire system, always based on daily hydrogen throughput. They also give information about environmental factors, such as the greenhouse gas emissions caused by individual hydrogen production pathways.

Subsequent interviews provided opportunities to smooth out the details of the solutions offered, avoid stumbling blocks and give timely feedback on practicality. This feedback was later turned into a number of recommendations >>

Fig. 2: Case studies and project partners

for the targeted and efficient implementation of hydrogen infrastructures (see [2]).

Requirements and settings may contrast sharply from region to region, which means that the findings should be considered goalposts and not definite targets for real-word application. Nevertheless, they offer robust estimates for any kind of hydrogen station as early as the conceptual stage. More data will have to be gathered by studying each scenario individually.

THE COST OF HYDROGEN A second objective of the project was to calculate hydrogen costs at the fuel pump, including their share in the construction and operation of the equipment. The authors of each case study had set their own cost targets, typically based on diesel use cases, which came to EUR 4 to EUR 6 per kilogram.

In three of those, the employment of several technologies led to estimates matching outcomes. Three other solutions resulted in EUR 6 to EUR 8 per kilogram of hydrogen, while the total cost in the remaining studies far exceeded cost limitations. To respect the confidential nature of the information, this article will refrain from listing which stations did or did not meet expectations.

RECOMMENDATIONS Success or failure notwithstanding, all comparisons, and all methods used to optimize cost effectiveness proved useful for providing guidance on how to achieve cost reductions in hydrogen bus refueling (see [1]).

For example, some bus operators were not used to such a close alignment of infrastructures and fleets. This alignment, however, is vital for preventing or limiting excess capacity and keeping down costs. Likewise, changes needed to be made to the strategies for guaranteeing supply. One example is the recommendation that spare parts critical to operation be held in store. Additionally, contracts should state service response times, and modular systems could provide redundant capabilities. Whereas bus operators aimed for relatively high storage capacity early in the project, figures were, in most cases, later lowered, not least because of cost and space constraints.

Similar recommendations have been devised for technology suppliers in the hydrogen industry, for example, to improve the reliability and efficiency of their components.

In the end, it is smart policy which will have the most impact on infrastructure development. Taxes levied on electricity to produce hydrogen through electrolysis add a substantial price tag to production. Revising the rules, and bringing them into line globally, could make hydrogen much more economically viable throughout Europe and remove impediments to its consumption. For municipalities, this translates into a focus on clean air solutions. And the use of a coherent set of regulations to grant privileges to zero-emission transportation is an effective tool to strengthen the position of fuel cell buses in mass transit.

Other factors, such as European and national rules, were analyzed in conjunction with their impact on a country's infrastructure costs. For example, the stringent regulations on safety distance and the placement of firewalls between components had increased the total cost of the concept system in Italy by around EUR 500,000.

CONCLUSION NewBusFuel has shown that hydrogen can be an economically viable and competitive option, depending on the design of the supply infrastructure. But, of course, hydrogen is not diesel. One may not need a reminder, but it is important to point out the drawbacks and benefits of the gas. They are crucial to arriving at a technologically and economically sensible solution, which is required not only when building vehicles, but also – or even more so – when designing new infrastructures. The more hydrogen a system will consume, the earlier it will pay off, for example, when using redundant capabilities to achieve synergies and distribute the work. Hydrogen is an ideal candidate for powering zero-emission buses that need to travel medium to long distances. In turn, the buses can become a secure and reliable source of large-volume sales.

Economic viability can be improved further through strict adherence to development and research cost targets, e.g., as part of NIP 2 and FCH2 JU. Recently, Ballard and Solaris had announced that they would offer buses at EUR 450,000 under certain conditions, namely acquiring more than 100 of the 12-meter-long vehicles. Their running costs of EUR 5 per kilogram of H_2, consumption of 7 kilograms per 100 kilometers, or per 62 miles, and an additional EUR 0.35 for each kilometer are merely 12 percent above the ones for conventional diesel buses and are fast approaching their levels [3]. ||

NewBusFuel was funded by the Fuel Cells und Hydrogen Joint Undertaking under grant agreement no. 671426.

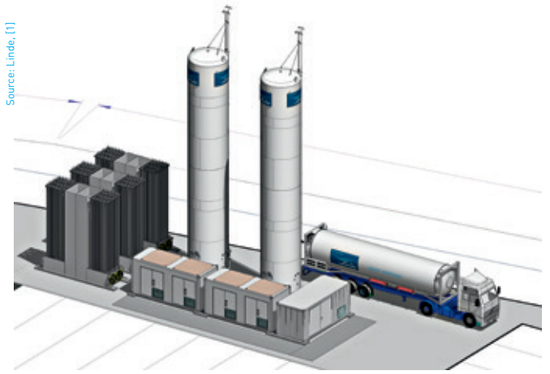
Source: Linde, [1]

Fig. 3: Filling station supplied with liquid hydrogen; throughput: 2.25 tons / day

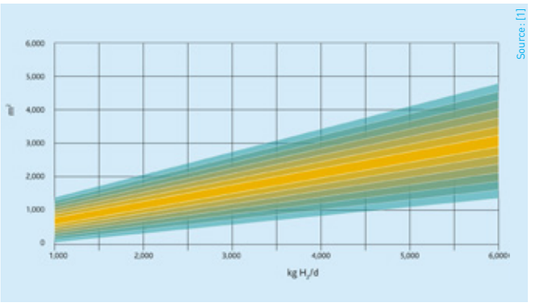

Fig. 4: Space requirement of a bus station with on-site hydrogen production

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For more information, please visit
→ www.newbusfuel.eu/publications

ELECTRIC TRANSPORTATION

Theme: Electric transportation | **Author:** Sven Geitmann

FUEL CELL WORKHORSES

Great promise in heavy-duty applications

Source: E-Trucks

Fig. 1: Fuel cell garbage truck

The hydrogen and fuel cell units deployed in heavy-duty applications have been mostly test systems for onboard energy supply. Even those systems are far from being finished products. The shared opinion among research and development laboratories is that the technologies could be used to power cars and trucks, but only up to a certain weight or load. Ever since Alstom's trains have proven to the vehicle sector that it is possible to design traction units with several hundred kilowatts of power, developers have begun to zero in on heavy-duty transportation.

It all started with fuel cell systems such as the ones built and tested by Austrian automotive supplier AVL List since 2002. Its high-temperature 5- to 10-kilowatt fuel cells are designed for powering both the sleeper and driver's cab in a truck during long-distance drives. One of these units is being tested in the Christian Doppler laboratories at the Jülich research center in Germany as part of an AVL-Plansee collaboration, which dates back to 2015. Onboard supply is typically the domain of small combustion motors that achieve 10 percent efficiency, less than a third of what a solid oxide fuel cell could achieve.

Another example is the hydrogen-powered Frigovan H_2 Zero Emission. Lamberet, a French supplier of vehicle refrigeration systems, presented the new model at the Solutrans show, which took place Nov. 21 through 25, 2017, in Lyon, France.

FEDERAL TRANSPORTATION MINISTRY PUBLISHES FUEL CELL TRUCK REPORT While auxiliary power unit designs such as the ones above have already been investigated and tested in RD&D projects, there has been little research on fuel cells supplying power to a vehicle's engine. Consequently, Germany's federal transportation ministry commissioned a group made up of the Fraunhofer Institute for Systems and Innovation Research, the Fraunhofer Institute for Material Flow and Logistics and PTV Transport Consult to create a report on "Fuel Cell Trucks: Critical Barriers to Development, Research Demand and Market Potential" as part of the government's Mobility and Fuels Strategy.

The study was published in August 2017 and found that up to 20 percent of all trucks weighing between 3.5 tons and 7.5 tons, which corresponds to classes 2 to 4 in the United States, could run on hydrogen one day. The total weight of many trucks, however, is above 12 tons, a segment where the authors of the study see fuel cells at 2 percent or 3 percent by 2030.

The 117-page report regards heavy-duty vehicles powered by compressed or liquified natural gas as the biggest competition to hydrogen trucks in the long run, as they showed a similar cost structure throughout their life cycle. Which technology would come out on top would depend on future fuel prices, over which taxes and fees wielded considerable influence, the authors said.

> "Aside from the United States and Germany, the lead countries in fuel cell R&D are China and Japan. While the number of publications on fuel cell trucks in the first two has stagnated, China has seen a notable increase in scientific papers in the field in recent years."
>
> *Excerpt from a transportation ministry report on the truck market*

The creators of the study, Professor Martin Wietschel and his colleagues, give a rather cautious estimate of how many years fuel cell trucks were behind passenger cars. What they did not factor in when putting the figure at 10 to 15 years was that it is relatively easy to integrate into commercial vehicles two tried-and-proven fuel cell systems from the passenger car market. Their estimate seems to have been based in part on outdated information that did not account for the hydrogen trucks in operation today and the ones planned for tomorrow (see subsequent projects).

Likewise, the conclusions and recommendations of the research team headed by Till Gnann are very general in nature (see box). One example: "Expectations are that the availability of low-cost, low-temperature fuel cell systems and an expanding hydrogen infrastructure will speed up development and market deployment in the truck industry."

FUEL CELLS FROM SCANDINAVIA What growth could look like in concrete terms is on display at two businesses that have been working on fuel cell truck engines in Europe, the United States and Asia. Just recently, in mid-November 2017, Nikola Motor Company said that, as had been the case with Swiss retail chain Coop, PowerCell would deliver the fuel cells for a prototype (see October 2017 issue of H2-international). This time, they would supply a Bosch engine of more than 300 kilowatts of power. In all, 5,000 hydrogen trucks will reportedly be produced at Fitzgerald Glider Kits in Tennessee. Nikola is looking into setting up its own factory, though it has yet to say where the facility will be located. Shortly thereafter, Nel from Norway announced that, at least initially, it would supply the hydrogen for the vehicles.

Nel CEO Jon André Løkke said about the USD 3.6 million deal that the "initial two demo stations will provide 1 ton of hydrogen to Nikola Motor's prototype trucks and serve as the design verification for Nel's mega-scale concept." The megastations consist of eight of Nel's A-485 electrolyzers, integrated into one unit to be more cost-effective. From 2019 to 2021, these systems will reportedly be installed at 16 locations. An expansion to 32 electrolyzers per unit could make it possible to produce 32 tons of hydrogen a day.

NEXT UP, ASIA AND THE USA Toyota, too, is developing fuel cell systems for the commercial vehicle market, both for buses and trucks (see July 2017 issue of H2-international). The hydrogen tanks for the truck the corporation unveiled in April 2017 will reportedly come from Norwegian >>

RECOMMENDATIONS
Learn from past fuel cell truck and bus projects
Give proper consideration to competing technologies
Take advantage of but don't rely on spillover effects from the passenger car market
Reduce consumption by improving efficiency
Consider fuel cell truck requirements when implementing a hydrogen refueling infrastructure

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supplier Hexagon Lincoln. Last August, the Japanese automaker also showcased a hydrogen-powered refrigeration vehicle whose fuel cell powers the engine and the cold-store unit. Meanwhile, Toyota has entered into partnership with 7-Eleven Japan to set up a pilot for sourcing the energy for hydrogen production from available solar fields.

Ballard, a Canadian fuel cell manufacturer, is heading in the same direction (see July 2017 issue of H2-international). The San Pedro Bay Ports Hybrid & Fuel Cell Electric Vehicle Project funded by the US government has deployed class 8 trucks, type Kenworth T680, to run between the two biggest ports of the country, Los Angeles and Long Beach. Ballard's 85-kilowatt FCveloCity®-HD units feed power directly into a lithium ion battery that drives the electric motor at the twin axle in the back. The range of the electricity-only mode is said to be 45 kilometers, or 28 miles. Adding the fuel cell will make energy supply last the entire day.

Rob Campbell, CCO of Ballard, said, "We see significant market interest in the complementary addition of fuel cell systems to address the range limitations of stand-alone battery solutions in certain use cases [see also p. 46]."

BENELUX COUNTRIES: WASTE DISPOSAL, THE FUEL CELL WAY In Belgium and the Netherlands, fuel cells have been employed in garbage truck trials. The company that converted the trucks owned by Geesinknorba was Belgian-Dutch company E-Trucks Europe. Fully charged and filled up with 7 to 12 kilograms of hydrogen, the vehicles can be operated for 12 to 16 hours straight. John van Roon from E-Trucks said, "A purely battery-run garbage truck isn't going to work. The peak load frequency is too great. A battery would need too many recharges."

The vehicles, which tout their fuel cell use in Dutch with "Ik rijd op waterstof" written on their sides, are currently being refueled at mobile stations. To increase hydrogen throughput, and create economies of scale, a company consortium intends to deploy about 100 of these kinds of vehicles in northern Holland until 2020. Wind power plants are said to be used for the eco-friendly production of the fuel they need. Jan Willem Langeraar, CEO of Hygro, remarked that "of course, 100 hydrogen trucks aren't enough. But they prove that this kind of business is viable."

A comparable project, also undertaken in the Netherlands, is H2Share. Coordinated by WaterstofNet, it uses 27-ton trucks by VDL to get the job done (see report on p. 34).

SCANIA AND ASKO In 2016, Scania and Asko from Scandinavia announced their entry to the fuel cell truck market. The partnership is comparable to the Coop collaboration in Switzerland, since Asko, a Norwegian wholesaler, has a large truck fleet of its own. The partnership is said to be focused initially on substituting fuel cells for diesel in four triple-axle 27-ton Scania vehicles. All other components are expected to be sourced from the standard portfolio of Scania hybrid and electric vehicles.

In June 2017, news broke that Hydrogenics would deliver four HyPM™-HD90 systems to Asko. The converted vehicles could be operational at the end of 2018. The manager of the project, Hedvig Paradis, said, "Different customers in different regions around the world will need different solutions, and hydrogen fuel cell technology can be one of those solutions."

UPS FAVORS RANGE EXTENDERS Another option is the use of fuel cells as range extenders. A main target market for this application is package delivery, where it could be useful to increase the range offered by an electric engine. American logistics company UPS is currently testing converted class 6 vans as part of a collaborative effort together with the U.S. Department of Energy and other partners. A prototype was said to be available in the second half of 2017 in Sacramento, California. The vehicle is equipped with a 32-kilowatt fuel cell connected to a 45-kilowatt-hour battery. Fuel is stored in a 10-kilogram hydrogen tank. ||

Fig. 2: Fuel cell system based on UPS' delivery van platform

FUEL CELLS VERSUS CATENARY TRUCKS

In April 2017, the Club of Logistics lobbying association clearly stated their dislike of the German government's intention to invest in truck overhead lines during two demonstration projects and called for an expansion of the hydrogen infrastructure instead. Shortly before, the federal environment ministry had announced that it would fund two eHighway field tests, FESH and ELISA, at the A1 and A5 freeway, with around EUR 18 million each. The trials would involve the setup of catenary wires over a length of 6 kilometers, or 3.7 miles, in both directions of travel.

The association's president, Peter Voß, said that fuel cells running on renewably sourced hydrogen were more economic and environmentally friendly than the proposed alternative. He added, "We've had tried-and-proven technology available on the passenger car market for years. It could easily be adapted for trucks as part of a hybrid design."

ENVIRONMENTAL COUNCIL CALLS FOR COMMERCIAL VEHICLE ELECTRIFICATION

The team of advisers on environmental issues, SRU, shared its point of view in a November 2017 report. Regarding long-distance, heavy-duty truck applications, they wrote, "Travel on roads off the electrified freeway network could be sustained by using batteries with limited range or by means of a hybrid design, adding in a combustion engine or a fuel cell. It is not yet clear which technology will ultimately succeed, whether it will be a battery, fuel cell or a combustion engine running on synthetic fuel. Long-term market prospects also depend on the way the cars are being driven. For these reasons, it may be prudent to create a wide range of incentive policies."

Asked by H2-international, co-author Professor Claudia Kemfert said, "In the opinion of the SRU, the recommendation to develop catenary trucks is not meant to diminish the importance of a fuel cell option. Faced with an ever-growing heavy-duty transportation market and the call for a short-term slash of carbon dioxide emissions, it does make sense, however, to give priority to overhead lines."

Theme: Electric transportation | **Author:** Sven Geitmann

H2 AS OPTION FOR HEAVY-DUTY TRANSPORT

H_2-Share – Cooperation in the logistic sector

WaterstofNet, a non-profit organisation operating in Flanders and the Netherlands which develops sustainable hydrogen projects, has embarked on its *H2-Share* project. *H2-Share* stands for *Hydrogen Solutions for Heavy-duty transport Aimed at Reduction of Emissions in North-West Europe*. The project will run until March 2020 and its objective is to facilitate the development of a market for low-carbon heavy-duty vehicles, run on hydrogen, for logistic applications. It will develop practical experience in different regions in North-West Europe (NWE), creating a transnational living lab. This will form a basis for the development of a zero-emission heavy-duty vehicle industry in this area. It will build and test a 27 ton rigid truck (developed by VDL) fuelled by hydrogen with a mobile H_2 refueler (developed by Wystrach).

H2-Share will develop a joint roadmap for zero-emission heavy-duty trucks in NWE, based upon demo's and strong cooperation with sector-related associations. It aims to realise knowledge sharing between regions and stimulate technology and market development. The project will demonstrate the readiness of hydrogen technology for heavy-duty applications in real life conditions. In doing so it will produce a 27 ton heavy-duty rigid truck working on TRL 7 (Technology Readiness Level – operational environment) instead of level 5 (technical development). It aims to achieve a reduction in CO_2 output of 75 ton during two years of testing. Furthermore, the long term aims of H2-Share involve the development of production capacity for 500 to 1,500 heavy-duty trucks (or a market share of 0,7 %) by 2025 and some 5,000 by 2030.

Research from the logistic sector shows a strong growing interest in zero-emission vehicles as a means of mitigating negative environmental impact. This is particularly the case in the EU where it contributes 25 % of total transport sector CO_2 emissions. While electric trucks can operate efficiently in urban areas, hydrogen technology has a key role to play in zero-emission logistics over longer distances and with heavier payloads. Heavy-duty vehicles with a fuel cell range extender – while not yet commercially available in het EU – have huge potential.

This is acknowledged by the involvement in the project of several well-known names within the logistics industry. In 2018, Cure (waste processing), Colruyt Group/Codifrance (food retailer), Breytner (inner city logistics) and DHL/Deutsche Post Group (postal service logistics) will carry out tests with the vehicle. The variation in context (loads, trajectories, …) and location (flat or hilly, distances, …) that these companies provide will allow for testing in a wide range of operating conditions. The tests will take place at six separate locations in Germany, The Netherlands, Belgium and France.

Source: Shutterstock, WaterstofNet

Fig. 1: Truck with logos adjusted

As a committed end-user, Colruyt Group will testcase the truck in its day-to-day logistical operations in Belgium and France. Because of the diversity of the group, it will be able to test a variety of cases. The group has been a pioneer in hydrogen for many years, as Tijs Hanssens, communications manager Technics, Real Estate & Energy, explains: "Our aim is to gain knowledge and experience in order to prove that hydrogen technology can be used efficiently in heavy-duty logistics. We strongly believe in the important role of green hydrogen as a sustainable option: renewable and without CO_2 emissions. We are very enthusiastic about this European test project that wants to embed hydrogen technology to make the heavy-duty logistic sector more sustainable."

Another enthusiastic end-user is DHL which will test the truck in Germany and the Netherlands, especially in long-haul transport (from gateway to service centre) and last mile transport (from service centre to customer). Marijn Slabbekoorn, GoGreen Program manager at DHL, tells: "Our cooperation with this project fits well with the GoGreen Program of DHL. We have the ambition to be 100 % emission free in our whole network by 2050. Also, by 2025 we want to attain a 50 % CO_2 reduction compared to 2017. And 70 % of our last mile routes have to be emission free by 2025." The company already uses a lot of electrical transport, bikes and street scooters to attain this goal. "But we believe in hydrogen and see a lot of opportunities. Therefore, this project closes the gap," concludes Slabbekoorn. ||

H2-SHARE-CONSORTIUM
Partners: VDL ETS (The Netherlands), Wystrach GmbH (Germany), VDL Bus Chassis (The Netherlands), AutomotiveNL (The Netherlands), TNO (The Netherlands), Hydrogen Europe (Belgium), e-mobil BW (Germany) and WaterstofNet (Belgium)
Subpartners: Municipality of Helmond (The Netherlands) and VIL (Belgium)
Associated partners: Deutsche Post DHL Group (Germany) & DHL International BV (The Netherlands), Ministry of Infrastructure and Environment (The Netherlands), BREYTNER BV (The Netherlands), CURE (The Netherlands) and Colruyt Group (Belgium)
The project is approved and subsidized (Đ 1.69 million from a total budget of Đ 3.52 million) by the European transnational cooperation Interreg NWE.

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Theme: Electric transportation | **Author:** Sven Geitmann

NOTHING TO RAIL AGAINST

Avid interest in fuel cell trains

Fig. 2: The new head of Alstom's business in Germany and Austria, Jörg Nikutta (see p. 4) giving one of many interviews

Fuel cell offerings for rolling stock are gaining traction these days. The number of regions debating investments in fuel cell trains is steadily growing. During a Nov. 9 press conference last year, Alstom – Europe's only supplier of rolling stock powered by the technology – held a press conference in Wolfsburg to boost demand even further.

Of all places, Alstom, a government-owned rolling stock manufacturer from France, chose a site close to the headquarters of Europe's largest automaker, Volkswagen, for its media event about the switchover of regional trains from diesel to fuel cells. Where only the Aller river separates the VW factory site in the German state of Lower Saxony from Wolfsburg's main station, Alstom's staff was joined by the state's minister for the environment and energy, Olaf Lies, several representatives from other businesses and many reporters. Their goal: to catch a glimpse of the Coradia iLint on display.

The reason for the gathering was a purchase agreement with Lower Saxony's regional transportation provider LNVG about 14 fuel cell trains and a 30-year maintenance and energy supply contract. Both were inked by the companies' heads on-site. While Alstom will reportedly produce the railroad vehicles, Linde would provide the hydrogen for operating them.

During the event, Lies presented LNVG with a notice of award promising over EUR 81.3 million from the state's budget. The money will be used to purchase the locomotives and rent them out to rail operators, while Alstom will conduct inspections in the maintenance facility of mass transit company evb in Bremervörde. In addition to state funds, the project is being supported with EUR 8.4 million from NIP 2 (see box).

The event was closely followed by the media, as it basically kicked off another gathering, the meeting of the German states' transportation ministers, also held in Wolfsburg, Nov. 9 through 10. It was the reason why Lies called the new agreement an important step forward for the industry and the economy as a whole. With pride in his voice, he said, "From now on, there will be a real alternative to diesel trains in non-electrified rail transport," adding that the state's goal was to "fund innovative technologies and make a sustainable contribution to the energy revolution in the transport sector."

TECHNOLOGY INSIGHTS

From the inside, the train looks like any other. Even the driver's compartment contains no unusual controls or equipment. The technology doesn't make itself noticeable, neither to the railroad engineer nor to the passengers. Marco Brey, the designer and operator of the vehicle, said that it could be driven in the same way engineers were used to from other models.

NIP 2

As part of the second stage of NIP, the National Innovation Program Hydrogen and Fuel Cell Technology, the federal transportation ministry put up in July 2017 a call for applications meant to advance fuel cell use in trains and ships. Through the program, the ministry aims to improve the competitiveness of mature products and their refueling infrastructures.

FROM GREY TO GREEN HYDROGEN Plans are to have two prototypes, manufactured in Salzgitter, transport passengers between Cuxhaven and Buxtehude starting in December 2021 (see also October 2017 issue of H2-international). Up to now, the only trains serving this line have been evb's diesel locomotives. Soon, power will not run along overhead lines but be supplied on board through hydrogen.

The initial refueling station will be moveable and process grey hydrogen from the chemical industry. The next stage, planned to be activated within two years, is to generate green hydrogen on-site with an electrolyzer that will reportedly be installed at the route's final stop in Bremervörde. One fill-up is said to be enough for travelling about 1,000 kilometers, or 621 miles, up from the range of 800 kilometers, or 497 miles, stated previously.

Alstom estimated that Germany had around 20,000 kilometers, or 12,427 miles, of non-electrified tracks. Hansjoachim Menn, spokesman for LNVG's board, said that diesel trains would prove to be an economically unsound solution for these parts of the railroad system. In his opinion, they would eventually disappear from the market altogether. The trend toward alternative engine solutions had prompted Alstom to seek reassurance that it could order more fuel cell trains in the future.

Fig. 3: A thin stainless-steel pipe instead of a wide, dirty exhaust

Jens Sprotte from Alstom Transport Deutschland told H2-international that the manufacturer had signed blanket agreements with suppliers such as Hydrogenics and xperion to meet growing demand. Gian Luca Erbacci, senior vice president of Alstom's European business operations, was confident that the technology could also be successfully exported to Norway and North America.

HYDROGEN-POWERED HEIDEKRAUTBAHN Alstom certainly can't complain about a lack of interest in its product portfolio. As early as 2015, four German states had announced their intention to jump on the fuel cell bandwagon. In early October 2017, they were joined by another state, Brandenburg, where the so-called RB27 Heidekrautbahn may be adapted for hydrogen use. Thanks to wind farms in the Uckermark region, there's plenty of green power available. Together with Enertrag, railroad company Niederbarnimer Eisenbahn and energy utility Barnimer Energiegesellschaft, Alstom is planning to file an application for a fuel cell pilot which promises a total investment of around EUR 35 million. If the application is submitted and approved quickly, Brandenburg state could steal the spotlight from Lower Saxony. Alstom was ready to deliver trains as early as the end of this decade, Nikutta confirmed when asked by H2-international.

The CEO of Niederbarnimer Eisenbahn, Detlef Bröcker, said that "zero-emission transportation along the Heidekrautbahn route is perfect for a region as popular as this one is with many tourists from Berlin." Jörg Müller, CEO of Enertrag, added he was confident that "this project will have a ripple effect far beyond the region. Only 50 percent of Germany's railroad system is electrified, and green hydrogen is the perfect option for these tracks."

BALLARD PARTNERS WITH SIEMENS One competitor to watch is Ballard Power Systems, a Canadian manufacturer enjoying a favorable market position. In mid-November 2017, the Canadian business and Siemens signed an agreement to develop a zero-emission fuel cell system for powering regional and commuter trains based on Mireo, Siemens' new and disruptive innovation in the railroad sector. The USD 9 million deal will see Ballard design a 200-kilowatt fuel cell system to get the train up to 160 kilometers, or 99 miles, per hour. Thanks to lightweight construction and an onboard smart grid, energy demand is expected to be 25 percent lower than in other railroad vehicles carrying the same number of passengers. Trains based on that design could be ready for the market in 2021 and replace currently used diesel versions.

Randy MacEwen, Ballard's CEO, said that his company had been observing rapidly growing demand for clean energy fuel cell technology in a range of applications, including trains, streetcars, buses and trucks. He added that fuel cells used in railroad vehicles "enable electrification with range, without the need for costly catenary wire infrastructure."

In Asia, development hasn't come to a standstill either. On Oct. 26, 2017, a fuel cell train by CRRC Tangshan started running between the Chinese cities of Tangshan and Xugezhuang. ||

"We've always been faced with that chicken-and-egg dilemma. [...] This development will push the establishment of a hydrogen society and will create new solutions for the storage and transport of energy. For the first time, the coupling of this sector to hydrogen infrastructure will be realized within a significant scope and in an economically viable manner."

Bernd Eulitz, Linde board member

"Emission-free, energy-efficient and cost-effective – trainsets with fuel cell drive are an environmentally friendly alternative to diesel locomotives."

Enak Ferlemann, parliamentary state secretary at the federal transportation ministry

"Basically, we didn't replace anything besides the traction unit. [...] Lint is a German acronym and is short for light innovative rail vehicle for local transportation."

Tanja Kampa, Alstom's head of communications for the German-speaking region

THE NEXT FRENCH-GERMAN PARTNERSHIP

What has worked in the aviation industry for years, namely the Airbus cooperation between Germany and France, could now become a reality in the railroad sector. Siemens Mobility and Alstom may have been thinking along the same lines when they jointly announced late last September that Siemens would integrate its train division with its French counterpart. Both signed a memorandum of understanding to put the transportation business under shared management in a so-called merger of equals. Soon, the two most important European railroad vehicles, the ICE and the TGV, will come from the same company.

The heads of both businesses agreed to new headquarters in the greater metropolitan area of Paris, a new chief executive in Alstom's CEO Henri Poupart-Lafarge and a 50 percent Siemens stake in Alstom on a fully diluted basis. The transport solutions division will reportedly go to Germany, the one for railroad products will be in France. Joe Kaeser, CEO of Siemens, said, "We put the European idea to work and together with our friends at Alstom, we're creating a new European champion in the rail industry for the long term." First, however, Alstom's shareholders will have to approve of the merger at an extraordinary general meeting to be held by July 31, 2018.

The next International Hydrail Conference will take place June 6 through 8, 2018, in Rome, Italy.

Theme: Electric transportation | **Author:** Sven Geitmann

NO MORE FIREWORKS

Sobering product presentation at Frankfurt's International Motor Show

There were no marketing fireworks this time at the 67th International Motor Show in Frankfurt, Sept. 14 through 24, 2017. In contrast to 6 years prior, the trade show wasn't bent on zero-emission stickers and lush green isles but focused on simple product presentations instead.

Attendees could spot a handful of electric models and their charging points when visiting the celebration hall, the longtime site of Mercedes' range of vehicle exhibits. All of those, however, were hybrids, including the S 560 e, E 350 e, C 350 e and GLE 500 e 4Matic, except for the GLC F-Cell. While the latter may have been touted as a world premiere, the fact remains that there was no commercially available car running on electricity alone.

When touring the 3-story building, it quickly became obvious what Daimler was proud of. A super-sized Maybach SUV and several luxury cars were the pinnacle of its booth. Only offstage did the automaker offer a glimpse into the future: the Vision Van, a concept study of a battery-powered vehicle that can drive autonomously and has a drone on its roof for package delivery.

NEW ELECTRIC PRODUCT FAMILIES The van could become part of Daimler's recently created EQ brand, the corporation's automotive version of emotional intelligence. Like BMW's i series, it is said to be used to market new electric products. Aside from the van, available in the next decade at the earliest, the automaker plans to bring an electric passenger car to the market in the first half of 2019. Called EQC, it will supposedly be a mix of today's EQ concept study and the GLC. But Daimler also showcased a concept study named EQA, whose design could ultimately prevail.

After years of one announcement following another, the GLC F-Cell was finally unveiled at the show in Frankfurt (see fig. 1). This preseries car will be available this year, albeit for lease only. The carmaker's strategy in electric transportation is to put hybrids first and develop battery models later, while it sees potential for the fuel cell in trucks and buses. Anyone wanting to buy an electric-only Daimler these days will have to make do with a Smart car.

VW'S NEW I.D. FAMILY Volkswagen did put a bit more on the table. In the back part of its booth, the automaker exhibited its available battery electric models, e-up and e-Golf, and the plug-in hybrids Golf GTE and Passat Variant GTE. But those combined didn't attract nearly as many attendees as the new I.D. family. Like BMW and Daimler, Volkswagen has created its own electric vehicle brand. The I.D. compact car is said to be for sale in 2020, just as the SUV crossover I.D. Crozz, and the minibus I.D. Buzz in 2022. They all use

Fig. 1: World premiere of the GLC F-Cell

GLC F-CELL
Daimler's newest addition is a plug-in fuel cell vehicle, equipped with a 13.8-kilowatt-hour lithium ion battery. The battery can be charged at any electrical socket, while the carbon tanks incorporated into the underbody have enough space for 4.4 kilograms of hydrogen and can be filled at a gas station within 3 minutes. By the manufacturer's account, the combined range had been measured as 500 kilometers, or 311 miles, based on the New European Drive Cycle. The GLC's power output through an asynchronous 147-kilowatt engine was 40 percent above the B F-Cell model, while its fuel cell system was around 30 percent smaller. The use of platinum in production had been reduced by 90 percent.

the company's MEB Platform, a new modular system created specifically for vehicle electrification.

Jürgen Stackmann, board member for sales and marketing at Volkswagen, said that the e-Golf would be discontinued in 2019 and the new Golf 8 line wasn't going to move beyond a plug-in hybrid option. He added that the similar-type I.D. would cost no more than a diesel model. Currently, however, it wasn't planned to be equipped with a fuel cell unit.

Among Volkswagen group companies, it is Audi, based in Ingolstadt, that now drives fuel cell development. Still, it didn't have a car powered by the technology on the show grounds, nor an outdoor exhibition area of its own making this time. The German automaker also didn't want to say exactly where its fuel cell journey was going. The only two electric models it had on-site were the Q7 e-tron quattro and the A3 e-tron as well as two concept studies, Aicon and Elaine, which may point the way forward in electric and autonomous driving. Scott Keogh, president of Audi America since 2012, said around the time the show was taking place that fuel cells were of little importance to the brand. He told Automotive News Europe that the worst thing one could do was to divide attention between electric and fuel cell drive systems now and later jump to a completely different technology altogether. By contrast, the new head of Audi's R&D department, Peter Mertens, said that he intended to pour more resources into fuel cell and CNG engines. He told the auto motor und sport magazine, "When I use a fuel cell, say, to extend the range, I can install a smaller battery. The battery is indeed the biggest cost factor these days."

Porsche displayed even less love for the technology, exhibiting only two hybrids, the Panamera Turbo S E-Hybrid and the Panamera 4 E-Hybrid Sport Turismo.

ELECTRIFIED TO THE CORE BMW, on the other hand, had comparatively many electric vehicles to show attendees. The BMW i Vision Dynamics is planned as an offer to customers for whom an i3 is too small and an i8 too big. Likely called i5, it will contribute as a 3 Series model "to electrifying the heart of the BMW brand," as Harald Krüger, the automaker's CEO, put it. The model, type Gran Coupé, is said to have a range of 600 kilometers, or 373 miles. And then there was the world premiere of the sportier version of the i3, the i3s. BMW's Mini brand had another world first in the new Electric Concept. Its booth also featured the Countryman as a plug-in hybrid.

Surprisingly enough, there was no fuel cell car at Hyundai's booth. It was said to have been made part of the shuttle service transporting attendees around the grounds, but no one had reported spotting it. Hyundai-owned Kia had only two hybrids and one battery electric vehicle at its booth despite the claims of company representatives that the automaker had market-ready fuel cells available.

By contrast, Honda had the Clarity on-site and unveiled its new Urban EV Concept, whose series production is said to start in Europe in 2019. And Toyota had placed its Mirai to the front of its booth, as it had done in 2015, followed by several hybrids. It didn't have any battery-only cars, though. Renault did, presenting both the Twizy and its Formula One racing car in Frankfurt.

To make the list complete, it should be noted that Opel brought its Ampera along, while Ford didn't have anything electric to present.

CES FOR IAA Overall, the International Motor Show again couldn't keep what had been promised. The German Automotive Industry Association had made some bold statements about an "amazing electric transportation event," but the truth is that, at least during the days the show was open to visitors, there was not much to see. The first few days did include the New Mobility World exposition, which heavily featured electric transportation. But it wasn't a mind-blowing occasion either. From the around 180 organizations that exhibited their products in 2015, only around 120 were left last year. To save face, the organizer said that "overall, the exposition involved more than 250 [exhibitors, partners, sponsors, media organizations and others]." Still, it didn't change the fact that people seem to be losing interest in the entire show. While in 2013, the auto show had 1,098 exhibitors from 35 countries present 159 world premieres to around 900,000 attendees, last year's numbers had dwindled down around 10 percent to 1,000 and 810,000 respectively.

Some European automakers, such as Alfa Romeo, Chrysler, Fiat, Peugeot and Volvo, had already said before the show took place that they wouldn't attend and Tesla, too, had declined the invitation. It surely puts a dent in the image of the motor show. Attendees, it seems, will soon find innovations rather at the Consumer Electronics Show in the United States instead of the birthplace of the automobile.

As readers probably know, another German event, Auto Mobil International, in Leipzig didn't take place in 2016, even though it would have been the 25th anniversary, because several large automakers had cancelled their bookings. It has been reported that there was a new gathering, Auto 2018, in planning at the Leipzig show grounds, but it will be packed with regional suppliers.

What remains is the feeling that automakers, especially German ones, have been in a deep slumber throughout the electrification years and that Germany needs to redefine its role in the automotive world. ||

Based on a study created by Transport & Environment, German environmental association NABU provided proof that the automotive industry has little interest in electric vehicles. Pointing to the International Motor Show, it criticized the manufacturers' meagre product offerings in electric transportation. President Leif Miller said that "the auto industry is far from implementing its widely announced electric car offensive. In Europe, there are no more than 20 electric models for sale – compared to around 420 types of combustion engine vehicles."

PRAGMA BUILDS CROWDFUNDED ELECTRIC BIKE

It took Pragma Industries, a French manufacturer of fuel cell bikes, fewer than 3 weeks to reach the EUR 300,000 goal of its early November crowdfunding campaign. The amount, which has meanwhile grown to over half a million euros, is planned to help with the construction of the first Alpha bikes in Biarritz. The Alpha 2.0, the company's second generation of hydrogen-powered pedal cycles, comes with a 250-watt electric motor by Brose and a frame-integrated 200-bar pressure cylinder offering a range of 100 kilometers, or 62 miles.

The first generation of the bike, known as Alter Bike, was unveiled in May 2013 (see July 2013 issue of HZwei). It was said to be available for lease in 2014 and for sale in 2016. Then, Pragma pushed back the schedule, announcing that it would initially offer its product only to fleet operators in Cherbourg-en-Cotentin, Saint-Lô and Chambéry. The EUR 150,000 deal would involve 10 fuel cell bikes and a refueling station, which could fill 20 to 30 bikes a day, taking only 1 to 2 minutes for each. Consumers will reportedly have to wait until 2019 to purchase a bike on the open market.

In November 2015, industrial gas supplier Linde presented a similar fuel cell model to the German public. This one, however, was only used for marketing purposes, as the company had no intention of creating its own product line (**see April 2016 issue of H2-international**). ||

FUEL CELL MAIL – POWERED BY DEUTSCHE POST

StreetScooter's battery vehicles have already proven to be a cost-effective solution for day-to-day operations in the mailing industry. Now, the business based in Aachen, Germany, is planning its next move. With the help of the city's university of applied sciences, it has designed a fuel cell vehicle that can go up to 500 kilometers, or 311 miles, on one tank. Deutsche Post, which bought StreetScooter in 2014, will reportedly use 500 of those cars in a first trial. Markus Döhn, manager of the German mail company's electric transportation business, said to H2-international, "We'll be testing fuel cells and roadside refueling over the next 2 years. We haven't yet decided on any dates or locations. Most likely, the route will include Aachen and roads that already have 700-bar filling stations." Board member Jürgen Gerdes had previously told the Spiegel that the corporation was working with one of its partners on the relevant refueling setup. Late last November, the H2 Mobility coalition reported that its CEO Nikolas Iwan and Professor Achim Kampker from StreetScooter had signed a letter of intent that would have StreetScooter vehicles refuel at the coalition's public filling stations starting in the middle of this year. ||

NO-COST LAND FOR HYDROGEN STATION

Late last November, the total number of hydrogen filling stations in Germany stood at 35, prompting a statement from NOW that the expansion of the refueling grid was making significant progress. Rhineland-Palatinate's first public hydrogen station, which had received around EUR 900,000 from the federal transportation ministry, had just been inaugurated in Koblenz, Nov. 21. Operated by Air Liquide, the easily accessible installation is located at a truck stop called BolzPlatz, close to the A61 freeway. Carina Bolz, the truck stop's general manager, said that offering the plot at no cost had been the right thing to do. The company had always been strongly committed to helping eco-friendly alternatives gain a foothold in the market.

When the Koblenz station was inaugurated, another EUR 400,000 project had already been in operation in Munich. This one features a new generation of Linde's cryopump and ionic compressor and is equipped with a 400-kilogram tank to store liquid hydrogen (**see also p. 29**). And as part of the NIP 2 rollout program, EUR 900,000 was invested in a system near the freeway entrance at Bremen's Sebaldsbrück suburb (**see October 2017 issue of H2-international**).

October 2017 also saw stations in Bad Rappenau and at the Cologne Bonn Airport coming online, with the latter having received about EUR 800,000 in government funds. The total grew to a bit over 40 at the end of 2017, although not all systems were operational. Meanwhile, Air Liquide has opened a refueling site in Dubai, the first of its kind in the United Arab Emirates.

When Ludwig-Bölkow-Systemtechnik recently analyzed the global market, it found that the number of hydrogen stations will increase by a factor of 20 over the next years if all of Europe's current installation targets are met. The worst-case scenario would still see the number rise by a factor of 9. The bad news is that in global comparison, Europe is expected to lose considerable ground to other markets, especially Asia. ||

Fig. 1: Uncomplicated hydrogen refueling with the type of nozzle used for gasoline

Theme: Funding | Author: Sven Geitmann

GERMAN COALITION AGREEMENT ON HYDROGEN AND FUEL CELLS

What will happen after 2019?

The second stage of the German National Innovation Program on hydrogen and fuel cells is designed to support the market introduction of both technologies. Launched in 2016, NIP 2 was devised with a 10-year duration in mind, but so far funding for only 3 years has been approved. Germany may still be searching for a new government, but once it is formed it will have to decide at some point how to continue the program. There has been no information yet on whether hydrogen and fuel cell funding will be part of a new coalition agreement.

So far, the federal transportation ministry has set aside EUR 250 million to encourage market adoption until 2019. But what then?

The coalition talks will prove crucial to providing a sense of direction. Only if hydrogen and fuel cells are listed in the agreement to form a new government will there be a budget plan to allocate reasonably sized funds.

Considering the importance of these talks, several organizations had gotten involved even before Germany had its general election. Their hope was to have hydrogen and fuel technology become part of the agreement early on. Last summer, Hamburg's Wasserstoff-Gesellschaft association drew up a list of demands to remind everyone that hydrogen would, in the long run, need to play a key role "as the most effective option for the chemical storage of energy from volatile renewables."

One of those demands was that "the fees and charges imposed on electricity for renewable hydrogen production need to go." Likewise, the association called for green hydrogen that is used in refineries to produce fuel to receive the same type of carbon credits as biofuels. The document also put a spotlight on northern Germany, where "underground caverns need to be adapted for hydrogen storage and available gas grids need to be revamped, at least partly, to transport the gas."

When a so-called Jamaica coalition made up of the Christian Democratic Union, the Social Democrats and the Greens was still an option to be explored, Werner Diwald, spokesman of Performing Energy, wrote an open letter to the government. One of the things he referenced in it were the outcomes of several ministry meetings that had provided proof of the enormous potential of sector integration and power-to-X. Exploiting this potential would require Germany to rethink its approach toward the Renewable Energy Directive II, he said. "Only power-to-X technologies will help us achieve comprehensive sector integration that will lead to efficient and sustainable decarbonized heat, power and transportation." Diwald also called on the future government to ensure that in the concluding talks on RED II, green power-to-X sources would be treated equally to others in terms of their potential to lower carbon dioxide emissions.

SME RULES NEED TO IMPROVE Some in the industry also believe that the current funding environment needs to change. NIP 1 has shown that the requirements for grants are not always SME-friendly. Specifically, small businesses had considerable trouble with all the bureaucratic red tape those applications involved, they said. And the agency distributing the funds and overseeing project implementation, Jülich, had sometimes asked for up to 24 months in secured financing, something that many – especially the small businesses that are often the drivers of new technologies – hadn't been able to provide. H2-international has learned that a lack of financial backing had already prompted Jülich to put promising ventures on the chopping block. However, startups and small businesses just don't have the same cash available as large corporations.

It may be preferable in this case to emulate the Fuel Cells and Hydrogen Joint Undertaking, which initially withholds a portion of its EU grants, payable only if the project is successful. This kind of deposit could be set, for example, at 5 percent. In exchange, some requirements for approval could be lowered to meet SMEs halfway. ||

> "A lot of small businesses are being sidelined because they don't have much to show for on their balance sheet. It's surreal."
>
> *Unnamed source*

INCENTIVES FOR ELECTROLYZERS

On Nov. 14, 2017, the National Organization Hydrogen and Fuel Cell Technology extended the list of eligible technologies in the NIP 2 rollout program to include electrolyzers producing hydrogen at gas stations. These new incentives could mark an important milestone in the country's infrastructure buildup. Their implementation was a response to the drumbeat of criticism levelled at the authors of NIP 2, who were said to have ignored the technology altogether. The grants from the revised funding guideline, which makes explicit mention of electrolyzers for green hydrogen production, will help to recover up to 60 percent of the investment in a publicly accessible gas station. Asked by H2-international, the organization explained that "operators can get up to 40 percent of the difference in cost between their electrolyzer installations and conventional units to produce hydrogen. The manager of the gas station doesn't have to be the one who runs the electrolyzer." However, the program administrators will only accept applications submitted to the federal transportation ministry by March 31, 2018. The money for the new funding opportunity comes from the EUR 250 million budget allocated for Market Activation Measures up to 2019. Applications can be submitted online at foerderportal.bund.de/easyonline. ||

TIGHTNESS TESTS AT MOTEK

Source: CETA

Ceta Testsysteme based in Hilden, Germany, used last October to present a new mass flow meter and a hydrogen leak detector to attendees at Motek 2017, the international trade show on automated production and assembly, which ran in parallel to the 30th Electric Vehicle Symposium in the neighboring hall. The Cetatest 615 attracted many to the company's booth, where employees demonstrated its capability to detect very small leaks ($Q > 10^{-6}$ millibars · L/sec). Ceta's sales manager, Joachim Lapsien, said that the business had been in talks with prospects from industries as varied as automotive, electric bikes, electric transportation, explosion protection, shipbuilding and renewables. He added, "Nearly every industry has an interest in testing and confirming the tightness of components and systems." ||

HYPOS SUPPORTS HYDROGEN SENSOR DEVELOPMENT

At the 30th Electric Vehicle Symposium in Stuttgart, UST Umweltsensortechnik, based in the German state of Thuringia, exhibited its patented Semicon® sensor equipment to analyze combustible gases. One possible use for its system is the highly selective detection of hydrogen concentrations of up to 10 percent – or, optionally, up to as much as 100 percent. In fuel cell units, it can be used, for example, to detect exhaust gas leakage at pipes, stacks and membranes. The sensor can also be employed to monitor chemical processes, ensure the safe operation of plants in manufacturing and facility management, and discover accidental gas release in portable and stationary systems. Last May, the 100-staff business became a member of Hypos, a research project created by middle Germany's hydrogen initiative to develop highly sensitive sensor equipment for measuring hydrogen concentrations in fuel gas mixtures. The sensors to be designed during the project will consist of components from a variety of manufacturers and contain built-in redundancies. ||

Source: UST

NEW HYDROGEN MONITORING UNIT

Last September, SL TecH2 unveiled a portable hydrogen monitoring unit, including a power disconnect option. The switchboard-like H_2 control cabinet MWS-01 was specially designed to suit the facilities of one of its customers, where it is being used in vehicle testing and repair. It can not only be configured to meet all common input and output voltages, but, thanks to a cable length of up to 20 meters, also match the number of explosion-proof H_2 metering sites that need to be positioned in the hazardous zones. SL TecH2's CEO, Stefan Liphardt, told H2-international that "if there's a leak releasing hydrogen into the atmosphere during tests or remodeling, the control cabinet will cut off power to the high-voltage components to prevent the gas from igniting." If preset threshold values are exceeded, the device will trigger an acoustic and a visual alarm signal. Although the output voltage will be cut off, the hydrogen detection sites will continue to be supplied with power. The system is also available for outdoors, where it can operate within a temperature range of –25°C to +40°C. ||

Source: SL TecH2

SAFE AND SOUND REFUELING

During last October's emove360° and 30th Electric Vehicle Symposium, Stäubli Fluid Connectors showcased its CHV 08 hydrogen equipment for refilling fuel cell cars. According to the manufacturer, this robust yet lightweight nozzle offers a reliable mechanical interlock and provides a vital safety feature for refueling at 350 bars or 5,000 psi. It comes with a stainless-steel housing and a polyurethane sleeve and is suitable for any type of vehicle equipped with an SAE J2600 or ISO 17268 compliant receptacle. Stäubli also offers a reusable breakaway called BRH. Integrated into the hose, it will immediately disconnect and seal the line if a customer accidentally drives off while the pump is still attached, regardless of whether the system is pressurized.

Additionally, the company's subsidiary, Stäubli Electrical Connectors, presented its new high-voltage connector PerforMore. It transmits high continuous current at minimal energy loss, making it an excellent choice in electric vehicles and when fast-connecting batteries, inverters, electric motors and other electric powertrain components. ||

Source: Stäubli

Theme: Research & Development | **Author:** Sven Geitmann

SUSTAINABLE MATERIAL FLOW

Fuel cell use in the logistics industry

Fig. 1: Toyota forklift trucks (Source: Toyota)

The good news is that fuel cells for materials handling equipment are no longer confined to a niche market. Entire warehouses in North America are currently being served by hydrogen-powered forklift trucks. This type of fuel cell application is also becoming increasingly popular in Asia and Europe, but their logistics industries will have some catching up to do.

Plug Power, based in Latham, New York, is one of the leaders in the development of fuel cell equipment for the materials handling market. From the United States, it delivers forklift trucks powered by the technology to all corners of the globe. For example, in late October 2017, it received an order from Toyota Material Handling Norway to ship GenDrive systems to Trondheim, where Nel ASA electrolyzers produce solar-sourced hydrogen at Norwegian wholesaler Asko. And Asko is thinking about whether to retrofit its fleet of trucks as well (see p. 32).

Other manufacturers are planning to create similar product lines. Another stateside supplier, Hyster, announced last fall at TOC Europe in Amsterdam, Netherlands, that it would soon be able to supply a heavy-duty forklift truck for loads of up to 48 tons. This kind of lifting capacity has always been a diesel-only domain, but that is about to change. Jan Willem van den Brand, Hyster's director of Big Truck Product Strategy & Solutions, said that "initial introductions are likely to be based on lithium-ion batteries." However, the company would eventually offer three options – a small or medium battery combined with a Nuvera fuel cell or a battery-only solution. "This truck is being developed in response to the evolving needs of customers, who are increasingly demanding zero-emission trucks to support their environmental goals, while still specifying the right truck for their particular application needs," he said.

At the LogiMAT show in Stuttgart, Germany, the vice president of Hyster-Yale Group, Ian Melhuish, told the Logistik Heute magazine that "fuel cell-powered forklift trucks will be playing a more vital role in intralogistics than some people think." He stressed that Nacco Materials Handling Group, whose products are mainly marketed under the Hyster and Yale brands, had made the right strategic decision when buying fuel cell manufacturer Nuvera in 2014. Hyster had been receiving many requests for fuel cell forklifts both from the United States and Europe and particularly from automotive customers.

TOYOTA LEADS THE WAY – AGAIN Additionally, several Japanese corporations, including Iwatani, Toshiba, Toyota Motor, Toyota Industries, Toyota Turbine and Systems, and Japan Environment Systems, have created a coalition to launch a comprehensive program for hydrogen supply in Yokohama and Kawasaki. The objective is to implement and evaluate a low-carbon supply chain that creates renewable hydrogen in power plants along the Tokyo Bay for running a total of 12 fuel cell forklift trucks. The project is expected to cut their carbon dioxide emissions by around 80 percent.

In Yokohama, the energy of a wind power plant called Hama Wing (see fig. 1 on p. 55) is used to produce hydrogen in a Toshiba-made electrolyzer, type H2One™, at 10 normal cubic meters per hour. It is then compressed and stored before being delivered by truck inside two 300-liter tanks at 450 bars, or 6,500 psi, to a fruit and vegetable market, to a factory and to warehouses, where it powers the 12 fuel cell forklifts (see fig. 1). Energy that isn't immediately required will go into a stationary accumulator made from 180 discarded batteries that used to supply energy in Toyota Mirai models. Project start was July 12, 2017.

As early as March 2016, Toyota had already showcased a fuel cell forklift design. Since January last year, two trucks of this type have been roaming the halls of the Motomachi Plant in Toyota City. They are part of an initiative by the Japanese environment and transportation ministries to promote fuel cells for use in industrial vehicles. Toyota's management is planning to have up to 180 fuel cell forklifts in operation by 2020.

South African platinum producer Implats is yet another business intent on switching over to fuel cells. It has been using forklift trucks equipped with the technology since 2016 and has likewise been testing a load haul dump loader for underground mining activities. It was reported that a working prototype of the new vehicle would be used in day-to-day operations as early as last year. Compared to their diesel-powered counterparts, electric load haul dump loaders produce no emissions and only half as much heat, making it possible to install a less sophisticated ventilation system in the tunnels. This project is part of the Impala Fuel Cell Development Roadmap, a collaborative effort supported by South Africa's government.

EU PROJECTS In past years, it was HyLift-Europe that provided the biggest impetus for forklift truck development across the continent. Around a dozen companies entered into collaboration in 2013 to implement about 200 fuel cell systems, and their refueling infrastructure, at 10 to 20 materials handling sites.

So far, the biggest success stories coming out of this EUR 9.3 million project have been the 46 vehicles operating at Prelocentre in Saint-Cyr-en-Val, near Orléans, in France, and a binding agreement about another 35-strong fleet of vehicles, a number that is expected to rise to 150. HyLift's coordinator, Hubert Landinger from Ludwig-Bölkow-Systemtechnik, told H2-international that the project hadn't led to as many sites as planned because interim results had shown that, if at all, only large-scale fleet operation made economic sense.

"Right now, you can't be competitive without some sort of financial support. We will need new funding measures to promote the technology until the market can continue on its own." He had been in talks with government officials before the end of last year to try to persuade them to extend HyLift-Europe for another 12 months.

A second EU venture to develop and scale forklift fuel cell components is Inline. Its EUR 3.2 million budget is said to be used for the design of a fuel tank and a control valve. Both components are still difficult to manufacture and are currently preventing further advances in production. The collaboration between Fronius, Profactor and others is planned to result in a completely scalable product line to manufacture fuel cell systems at a faster pace. ||

Theme: Stock market | **Author:** Sven Jösting

MEGATREND LOOMING AFTER 15 YEARS OF GETTING BY

Sven Jösting's stock market analysis

At the dawn of the new millennium, the shares of fuel cell companies had gone through the roof. Fuel cells were thought of as the next big breakthrough technology, and it seemed as if large, new growth markets were just waiting to be exploited. But shareholders were mistaken, celebrating too early. The industry's leading businesses stumbled over the immense cost to develop and introduce new technologies. Likewise, a lot of them were spread too thin, trying to serve too many markets with too many products at once. Instead of concentrating research on a few promising segments, some allocated resources to several – regardless of their potential.

Fig. 1: Past years' share prices of the six businesses depicted in these articles (* Historical prices as of Dec. 23, 2017)

Millennium Cell, an American business founded in 1998, was one of those businesses said to have a bright future. With the development of intriguing fuel cell technologies, for example, to power drones, it became worth billions of dollars before tumbling to rock bottom and into bankruptcy. However, Millennium Cell's rise and fall didn't put a stop to the market altogether. Others had no doubt about their success either, but they were clever enough to focus research on a few markets to become a force to be reckoned with.

> Here's the irony: Two businesses that had worked together closely during that time were Millennium Cell and Protonex. While the former has gone bankrupt, the latter has become a wholly owned subsidiary of Ballard Power.

15 YEARS TO BREAKTHROUGH It was to take about 15 years before the industry's stakeholders felt sure enough last year that the fuel cell had again grabbed the attention of the market. They believe that the technology could soon prove to be a vital asset in meeting global demand for electricity, heat and cooling, and energy in transportation, for example, to power private and commercial vehicles, trains and ships.

According to futurist John Naisbitt, the time's ripe for a new direction. On average, it takes 15 years for a megatrend to emerge. There will be highs and lows, but the core message will remain: "The trend is your friend." What may have given the fuel cell its new – and especially, long-term – prospects were developments in electric transportation, but also rising oil prices and the discussion about carbon dioxide emissions and climate change.

There has been a shift in the mindset of investors, although it may still take a while to persuade them of the technology's rosy outlook. Most fuel cell businesses have lost a considerable portion of their market value over the years, some up to 99 percent. Research and development have made capital raises at unfavorable terms a frequent occurrence, which has diluted the stock of existing shareholders. For example, Ballard Power, currently valued at USD 5, would need to grow by 2,000 percent to regain the USD 120 footing it had in 2000.

Still, it is becoming increasingly clear that all those years spent on researching system designs and finding ways to produce and store hydrogen will be paying off, a development that is certain to have a positive impact on stock market prices. As soon as the new megatrend takes off, there will be no holding back, as everyone will want their piece of the pie.

Industry experts such as Toyota's chairman and inventor of the Prius, Takeshi Uchiyamada, see 2020 as the dawn of the fuel cell age, particularly in transportation. Other experts go as far as to say that from 2020 on, the technology will show growth akin to the 1990s boom in the solar and wind industry.

BALLARD POWER'S VISION: 30 PERCENT FCEVS BY 2030

As the then market leader, Ballard Power (Nasdaq: BLDP) determined soon after taking up its fuel cell activities that there was no way it could compete in the transportation sector. The upfront investment that such a move required was just too great.

Fig. 2: Mireo - New concept in rail transportation

A decision was made to outsource these activities to AFCC, a Daimler-Ford joint venture and Ballard spin-off, which signed a three-way agreement with Nissan in 2013 to develop the next generation of fuel cells. Nevertheless, it continues to regard both Nissan and Ballard as partners to the endeavor.

To show how times have changed, let me quote Ballard's CEO MacEwen, who recently described the fuel cell as a disruptive technology that could "uniquely position" his company. He recommended a "30 by 30" policy of having 30 percent of all commercial vehicles equipped with fuel cells by 2030. The company has only twelve years left to meet that target. Batteries and fuel cells would make a good match in a hybrid, with the latter greatly alleviating the limitations of the former and offering more route flexibility. MacEwen, however, is already thinking ahead. He explained during the third-quarter conference call in late September that he wants to help make fuel cells the technology of choice in heavy-duty truck applications (see also August 2017 issue of H2-international).

There is mounting pressure from all sides. Countries such as China and India have made fuel cells a requirement and 40 leading cities in the world have announced to ban fossil fuel vehicles from their streets by 2030, with twelve planning to implement their policies as early as in 2025. Those targets alone offer potential equivalent to around 60,000 busses – all the more reason for taking a closer look at fuel cell businesses and their stock market development.

In 2018, Ballard is said to be involved in the manufacture of around 20,000 bus stacks in China, upward from the 6,000 per year previously. It puts the Canadian business in the most favorable position to advance bus electrification through fuel cells. Considering the market's prospects for growth, it cannot be overstated what kind of competitive advantage this represents.

On to the number crunching: The company reported a notable 54 percent increase in total revenues at a gross margin of 32 percent. Third-quarter earnings added up to USD 31.9 million. The net loss is getting ever smaller and amounted to USD 1 million during the same three months (that's minus USD 0.01 per share). Again: The trend is your friend. Quarter after quarter shows constant improvement. The continued high investment in R&D is the reason why the company hasn't broken even yet. Total liquidity fell to USD 60.1 million, but that's still a very healthy number. Order backlog reached a record-breaking USD 236.8 million, according to Ballard.

PROTONEX, THE PORTFOLIO'S CROWN JEWEL Meanwhile, the U.S. Army has approved the use of fuel cell systems for drones and other military equipment. Starting in 2018, this public-sector customer is said to be placing orders worth USD 150 million to USD 250 million over 5 years, making Protonex, a Ballard subsidiary, the crown jewel in the parent company's portfolio. Its outlook is extremely positive, and one may assume that the profit margin from the deal won't be a small one either. Those USD 150 million to USD 250 million over 5 years will also mean that Ballard could rake in USD 30 million to USD 50 million annually in this segment alone. That's no small change considering total revenues estimated at USD 100 million, and it serves to underscore the minimum 30 percent growth Ballard expects to see this year – without even looking at the company's other segments, such as bus stack manufacture in China.

ROLLING STOCK AND SHIPS CRRC, the world's largest rolling stock manufacturer, has been collaborating with Ballard on developing a hydrogen-powered tram to transport 336 passengers at up to 70 km/h or 44 mph in a 40-kilometer or 25-mile range. Its H_2 capacity is said to be 12 kilograms. Even if this and other projects have not yet left the pilot stage, they could lead to a great many bookings. And which business is in a better position than Ballard to benefit from this growing market?

There are other pieces of good news that will capture the imagination. Ballard has supplied ABB with a fuel cell system for a cruise ship and has partnered with Siemens for a USD 9 million research project on railroad technology. Not only is the company spreading the risk across a pool of customers, but large corporations are stating loud and clear how much they appreciate the fuel cell manufacturer as a collaboration partner in technology development. These pilot orders can later serve as a template to generate bookings that will be anything but small.

GOOD PROSPECTS I'm hypothesizing here: Why couldn't Ballard be worth several billion dollars in a few years' time? It's not like the market capitalization hasn't been above USD 11 billion before, in 2002 to be precise (see chart). But today, this kind of market valuation would be based on a well-reasoned analysis of medium- to long-term prospects and factor in license revenues, fuel cell bus stack deliveries and the potential of several markets in which Ballard plays a lead role and is in a bright spot, technologically. On the other end of the spectrum, there is Tesla, whose market cap of more than USD 50 billion is beginning to look increasingly unsustainable, with the great downfall only being a matter of time.

Ballard is moving in quite the opposite direction. After many years of posting big losses, the Canadian company is now expected to not only break even, but increase profits at a rapid pace. The stock market will respond in kind and anticipate the business growth of this rising star. Now is the time to harvest what has been sown during years and years of research. The fuel cell – and with it, Ballard – is ready to take the market by storm. >>

> "Looking forward, a key business driver will continue to be the compelling value proposition offered by zero-emission fuel cell electric vehicles, or FCEVs, in numerous heavy-duty motive use cases. This is particularly true where vehicles must deal with long range or long hours of operation. In these situations, FCEVs can deliver key financial and operational benefits while also addressing the limitations of a battery-only design, through extended range, rapid refueling and full route flexibility."
>
> *MacEwen, CEO of Ballard*


Quelle: FuelCell Energy

Fig. 3: SureSource 3000, consisting of two 1.4-megawatt units

FUELCELL ENERGY – FALLING SHARES PRESENT NEW OPPORTUNITIES

FuelCell Energy's shares have experienced a sharp drop for seemingly no reason. It may have been a tactic intended to push down the price, for example, to profit via short sale in anticipation of the fall and convert warrants later. That is pure speculation, of course, but people say these things have happened before. In any case, the most recent investment decisions seem to be an unmistakable sign that institutional investors believe in the company's prospects and its technology. ExxonMobil is drowning papers, such as the German Handelsblatt business magazine and the Financial Times, in ads that make explicit mention of FuelCell Energy's carbon capture technology. I don't believe that their actions could be classified as greenwashing, a designation that would apply if Exxon were only parading around carbon capture to polish its eco-friendly image and has no intention of following through with its implementation. I would even go as far as saying that if that were the case, the competition wouldn't stand idly by and, I believe, would push ahead with the same ideas. In short, FuelCell Energy (Nasdaq: FCEL) will be one of the most promising candidates for investing over the next years.

In a recent Handelsblatt interview, VW's brand manager, Herbert Diess, had few good things to say about the fuel cell. In his opinion, the cost of constructing H_2 refueling stations was extremely high and hydrogen production required substantial amounts of energy, while the technology itself had been plagued by comparatively low efficiencies. Toyota, on the other hand, believes in the fuel cell's potential and is more than willing to prove it. It is also becoming ever more likely that countries such as China will start shifting the focus of their electric transportation strategies from batteries to fuel cells and green hydrogen. VW has yet to open its eyes to see the writing on the wall, but it won't have much of a choice considering the sheer size of the Chinese market. The German carmaker is relying on charging points while Toyota is collaborating with its partners to find a remedy to the H_2 infrastructure issue.

TOYOTA TO PRODUCE ITS OWN H_2 SOON On Nov. 30, it was announced that Toyota had commissioned FuelCell Energy to erect a fuel cell system called SureSourceTM at the Port of Long Beach in California. Biogas conversion will make the system a production facility for fully renewable hydrogen to be used for the port's delivery trucks. Once it is set up, the system is also said to be producing electricity for 30,000 homes. Naturally, shareholders were delighted when the news broke. I expect more bookings to follow in its wake.

PLUG POWER – EXPECTATIONS VS. REALITY

Plug Power's third-quarter results proved disappointing. The company said that the figures didn't have any influence on its great prospects, considering a customer base which includes corporations as large as Walmart and Amazon. Their bookings are expected to top USD 600 million in the coming years. During the reporting period, Plug delivered 2,753 GenDrive systems for forklift retrofits, which generated USD 61.4 million in revenue. Current production capacity is at 15,000 systems per year, with 95 percent of them manufactured in-house. Ballard's contribution has been reduced to a minimum.

Nine H_2 filling stations went operational during the third quarter, making Plug Power (Nasdaq: PLUG) the business with the most refueling sites in the States. Bookings are said to have added up to around USD 44 million in the same period, bringing 2017's total to USD 160 million while the year-end figure is expected to reach USD 300 million. I recommend a closer look at the numbers, considering the somewhat complicated process of issuing warrants in combination with capital raises. Based on my unproven assumption, their taxation will create losses on the books. However, should Amazon and/or Walmart convert warrants, that would be a horse of a different color. While it would make them shareholders, it would also provide Plug with capital – there's really nothing bad to say about such a scenario.

The fourth quarter is said to deliver a boost in revenue and bookings. However, I am a bit cautious, even if Plug's big customers promise good business. Some predictions made throughout 2017 had to be retracted. Surely, Plug will continue to benefit from a generally very positive attitude toward fuel cell shares, but businesses such as Ballard Power, whose extensive know-how may land it a partnership with another forklift truck manufacturer soon, seem to have much greater potential to reach breakeven and enter growing fuel cell markets.

Let's wait for the fourth-quarter results and see whether the predictions by management will come true. Plug's market cap is decent. Its relatively aggressive advertising is just a bit too much for my taste. First, the company should prove that – like Ballard – a good gross margin is not a lofty goal and that estimates match up to reality.

ITM POWER – SHARE RALLY PROMPTS PROFIT TAKING

The dust has settled on a rally to the top and a share price that nearly tripled temporarily. Stock market experts like to call it chart consolidation and profit taking. ITM (London:


Quelle: ITM Power

Fig. 4: ITM Power system at Thüga in Frankfurt am Main, Germany

ITM) was successful in raising EUR 120 million in fresh capital. Now, the British manufacturer's market capitalization is above long-term expectations despite its bright outlook. I think investors should put this one on the watchlist, but look for other, more promising options in the meantime. ITM Power does have a strong order pipeline, with around GBP 42 million in contracted orders and other recently projected bookings of about GBP 5.9 million. But compared to similar businesses, EUR 120 million seems a bit optimistic, given the backlog and revenue the company has been able to generate – say, in comparison to Hydrogenics (Nasdaq: HYGS).

TESLA – LOSSES CONTINUE TO PILE UP

Tesla's third-quarter figures didn't merely point to poor performance – the USD 671 million loss in particular was way more than anything most analysts had predicted. Based on non-GAAP accounting, including adjustments, shares lost USD 2.92 each. GAAP, which has the more relevant figures in my opinion, showed minus USD 3.70 per share at a revenue of USD 2.98 billion, which includes SolarCity's.

What shouldn't sit well with investors either is that the production of the immensely important Model 3 has been far behind schedule. Right now, we are talking about no more than a few hundred vehicles, 260 to be precise. It will take a long time before CEO Elon Musk's predictions and targets – initially 5,000 and later 10,000 per week – could come true. The schedule calls for their fulfillment at the end of 2018's first three months. However, the massive investment in production facilities will again require more capital during the last quarter of 2017 and the first of this year.

MORE SMOKE AND MIRRORS On the other hand, the media couldn't be more captivated, as Musk recently presented new Tesla options in the form of a semitruck and a roadster. But it's anyone's guess when they can be produced, let alone delivered. The introduction of the electric truck, for which big corporations such as Walmart and DHL have already placed initial orders, is scheduled for 2019. The roadster – priced at USD 250,000 – may not enter series production before 2020, but can be pre-ordered through a USD 50,000 deposit. There are said to be between 1,000 and 5,000 Tesla fans who have deep enough pockets to be persuaded to become part of a select group of electric roadster pioneers. Tesla (Nasdaq: TSLA) couldn't be happier about this, as it would rake in a good USD 250 million – basically, as an interest-free loan. But does this amount of cash make up more than a drop in the ocean?

OPTIMIST OR PESSIMIST? Those investors who firmly believe in Tesla's success see a glass that's half full. They are convinced that the corporation's high losses stem from necessary investments in the automaker's future and that the heavy capital drain is a logical prerequisite for increased Model 3 and battery production capacity. The dramatic rise in revenue that they expect in 2018 and the highly profitable line of business they feel developing over the coming years are their reasons for pouring that much money, and more, into the company.

On the other side of the fence, there are the pessimists, whose more than 30 million short sales reveal their skepticism about the company's progress. Perpetually increasing capital demand and delays in Model 3 production are reasons enough for them to consider Tesla a doomed enterprise. The worse the company's financials get – something that even rising revenues can't compensate for – the more difficult it will be for Tesla to raise capital. In other words, the next time the corporation asks for money by issuing shares, it may have to offer a high discount compared to the price at which it is quoted on the stock market. Institutional investors will certainly expect some compromise, which is not a good sign at all. And then there are the debts Tesla will have to refinance over the next years, SolarCity's among them. It could offer asset-backed securities, but that would eat away at the business's substance.

MEGABATTERY FINISHED IN TIME The aim was no more than 100 days, and it has taken fewer than that for Tesla to complete the world's largest lithium-ion battery system in South Australia. As you may recall, it was a bet between Musk and Australian billionaire Mike Cannon-Brookes, which Musk won. What remains unknown to me is the precise amount of the investment and who paid or will pay for the battery. It's certainly good news, although when it comes to Tesla, such things are no more than an entertaining sideshow.

SHARE RANGE: USD 400 TO USD 200 My prediction is in line with JP Morgan's, which anticipates a range of USD 400 tops and USD 200 bottom in the coming months. I think it's safe to assume that the fourth quarter of 2017 will not be unlike the third regarding losses, which may prove to >>

Fig. 5: Concept study of the new Tesla roadster

be even higher. I find predictions of a quarterly loss in excess of USD 1 billion to be overly dramatic. It's not an unimaginable scenario, though, should Tesla implement all its plans, as they will require large-scale investment and massive expenditures. They would initially lead to exorbitant costs and, logically, substantial losses.

All in all, I expect more capital raises to follow. Aside from the battery factory and Model 3 production, there will be another cost hike if Tesla were to offer a semitruck and a roadster. Let's not even talk about the financial obligations to its suppliers, which gave the business billions of dollars in credit. On top of this, there is a window for paying back certain debts, for example, the SolarCity bonds. In my opinion, Tesla's market cap above USD 50 billion already factors in any possible positive development. Likewise, one should not lose sight of the fact that Tesla's pioneer image will age the more other automakers put new electric models and fuel cell hybrids on the market.

What should never be overlooked is that battery technology is evolving too, in terms of materials and construction. Toyota's solid-state version is only one such example. Lastly, the fuel cell will give electric transportation a run for its money over the coming years. As you may know, Musk has called it a "fool cell" – but what if it turns out that he might be the fool in the end? Who knows? My take: a share price that more easily approaches USD 200 than USD 400. ||

RISK WARNING
Share trading can result in a total loss of your investment. Consider spreading the risk as a sensible precaution. The fuel cell companies mentioned in this article are small and mid-cap ones, i.e., they may experience high stock volatility. This article is not to be taken as a recommendation of what shares to buy or sell – it comes without any explicit or implicit guarantee or warranty. All information is based on publicly available sources and the content of this article reflects the author's opinion only. This article focuses on mid-term and long-term prospects and not short-term profit. The author may own shares in any of the companies mentioned in it.

Theme: Global | **Author:** Alexandra Huss

NORWAY'S BET ON MARITIME APPLICATIONS

Fuel cell use in the land of the fjords

One of the most important pillars of Norway's economy, the maritime sector, is closely tied to the petroleum and natural gas industry. Using highly specialized ships and underwater equipment, offshore oil platforms are constructed, equipped and maintained as well as assembled and anchored to the seabed along the coast of Norway. The country has one of the largest merchant fleets in the world, and a large part of its public transport is done over water. Cars and passengers are ferried to neighboring countries, along the coast of Norway's fjords or between its many islands. The default fuel, however, is still diesel, despite its effects on the climate and the environment.

Fig. 1: Passenger express ferry planned for short-distance travel in Floroe

Since the early 2000s, Norway's government and leading companies have been building up a hydrogen economy, especially in the transportation segment. In 2006, the first hydrogen station for public use was opened in Stavanger. It was intended to be the first point in a chain of stations, from the city in the southern part of Norway to Oslo, along which fuel cell vehicles might drive.

A PIONEER IN HYDROGEN The "hydrogen highway" that was imagined was reduced to a small handful of stations around the capital. The fuel cell vehicles were also missing from the actual picture, as they were everywhere else they were supposed to be found. In addition, leading Norwegian companies that were originally driving hydrogen forward gradually backed away from the technology with the unclear future. Two such companies, Statoil and Norsk Hydro, started the withdrawal after their merger in 2007. The final step was to hand the electrolyzer business over to Nel Hydrogen in 2011. Since then, Nel has become one of the most experienced companies in supplying hydrogen system components.

The Norwegian government, which once fully supported the technology by presenting a strategy to implement hydrogen in 2005 and assembling a body of advisors, took the subject off its list of priorities in subsequent years. On top of this, the changes the government made to its renewable policy for establishing climate-friendly and sustainable transportation systems in 2012 led to a boom in battery electric vehicles. Today, Norway is one of the richest nations in electric means of transportation. No other country has more electric cars per capita. More than one out of every three newly registered vehicles have an electric motor. Since new electric car users are probably not looking for alternatives, the introduction of hydrogen and fuel cell technology in land transport at this time seems superfluous.

In 2015, however, after intensive lobbying from the Norwegian Hydrogen Forum and associated groups, the government put hydrogen implementation back into the white papers on energy supply. The issues arising from the changes in climate protection and renewable energy policy, that is, electricity surpluses and network bottlenecks, might be one reason why hydrogen use in Norway is back at the center of political discussion. Norwegian hydrogen and fuel cell companies are ready for it. In order not to miss any important developments, many in recent years have been heavily involved in the EU-funded projects set by the Fuel Cells and Hydrogen Joint Undertaking and in the activities of other international organizations.

A SPECIAL KIND OF CHALLENGE Unlike many other countries in Europe, Norway does not have to look hard for rich sources of renewable energy. The country has long relied on renewables and, today, generates nearly a hundred percent of its electricity from hydropower. It also produces a significant amount of surplus energy, about 10 terawatt-hours per year, which naturally varies depending on the day and season. Although the country in northern Europe considered grid connection and electricity exchange with its neighbors, that is, Sweden, Denmark, Finland and Russia, from the start, it is now increasingly testing the limits of the transmission network.

Through the implementation of the European Renewable Energy Directive, the share of renewables in Norway's total energy consumption is expected to rise from the 61 percent in 2010 to 67.5 percent in 2020. This means that the power surplus in Norway will also grow and prices will drop accordingly. With this in perspective, Norway is now seeing storage of energy in the form of hydrogen as a means of making energy systems more flexible. The subsequent use of the gas as fuel in vehicles is a logical part of the discussion.

The large quantities of green hydrogen that could be produced in Norway by means of electrolysis have attracted many players in the energy business, since new opportunities to export it might open up. In addition, Norway's maritime industry has realized that it could significantly reduce its emissions by fueling ships with hydrogen. For now, the fact is that the international shipping sector has agreed on liquid natural gas for maritime propulsion, since it is much more climate-friendly than diesel. However, hydrogen could be used to reduce emissions from ship fleets moving around the region or country all the way to zero. The focus here would be on car and passenger ferries, express ferries operating as water taxis and large excursion boats for giving tours.

AN H_2 HIGH-SPEED PASSENGER FERRY In 2015, the first purely battery electric ferry, B/F Ampere, went into use on the Sognefjord between Lavik and Ytre Oppedal. In 2016, Vision of the Fjords, a cruise ship that mainly used electricity for propulsion despite being a hybrid, was presented and sent on its path along the Naeroyfjord. It has become clear to the participants in the project that further solutions would need to be made before electric ships could cover longer distances or before more powerful vessels could run on electricity alone. For this purpose, the use of fuel cells as range extenders in battery electric ferries is now being investigated.

An initial prototype for a fuel cell high-speed passenger ferry was conceived. It is to be built in the coming years and go into operation in 2021. The ship will have a length of 30 meters, or 98 feet, and is designed for up to 100 passengers. A decisive factor for initiating this project was the great potential to reduce diesel fuel use and thus emissions.

Fig. 2: Hydrogen technology on board the ferry

A purely battery electric propulsion system for the high-speed ferry was not an option because of the power requirements of the ferry, about 1,500 kilowatts, and the length of its trip, 115 nautical miles, which is 213 kilometers or 132 miles. Moreover, the efficiency of a carbon fiber ship was not meant to be offset by the high weight of the batteries that would have to be installed. The planned hydrogen fast ferry would replace the current diesel-powered one, which consumes around half a million liters of fuel each year.

In order to meet hydrogen demand for the new ferry, an electrolyzer and a new gas station at corresponding capacities will be built with the support of the local government in Floroe. It can also provide the current required for electrolyzer operation; of the nearly 16 terawatt-hours of electricity produced in the administrative district using water and wind power, there is today more than 8 terawatt-hours in surplus. Since construction of the whole infrastructure is not possible at the current pier for high-speed ferries, an entire facility is being built on an island opposite it. This island will be further expanded to accommodate the new system.

The large-scale project is being funded by the regional government and the participating municipalities. Coordinated by the local administration of Floroe, three companies from the region have joined forces to work on the project: Broedrene Aa, in Hyen, specializing in the manufacture of carbon fiber fast ferries; Mancraft, in Bergen, an expert in boat propulsion systems manufacture; and Skyssbat, the public transport company that will operate the ferry around Floroe starting in 2021.

Floroe is located in the county of Sogn og Fjordane, in the west of the country. Norway's largest fjord, the Sognefjord, is also in this area. Fifty-five percent of public transport emissions in the county comes from ships. Fast ferries with a travel speed of up to 30 knots, which is approximately 56 kilometers or 35 miles per hour, are an important means of transportation in the region. They not only connect the archipelagos to the mainland; they can also be used to reach the cities and municipalities along the coast and the fjord much faster than with cars and intercity buses. Regarding the project, the regional government is concerned with not only the technical feasibility and working demonstrations, but also the value added to its economy and any new opportunities that could come from it. ||

Theme: Global | **Author:** Alexandra Huss

CHINA SHINES IN FUEL CELL INDUSTRY REVIEW

Fuel Cell Industry Review by E4tech

At the beginning of December, market data and analyses for the fuel cell industry were published by E4tech in The Fuel Cell Industry Review 2017. E4tech is an international consultancy that has been providing insight into the hydrogen and fuel cell industry since 2014. To prepare the review, a team at E4tech contacts fuel cell companies worldwide and aggregates their delivery figures. The result is an independent commentary on the state of the hydrogen and fuel cell sectors. Some excerpts are presented below.

The fuel cell sector continued to grow in 2017. With nearly 700 megawatts, it shipped 30 percent more capacity than in 2016. Growth in units came to about 15 percent. New projects, collaborations and industry alliances were announced almost each day, it seemed, in the last few months of the year. Because of this, it was a challenge, gladly taken, to cover as many developments in the annual report as possible.

The preliminary market data for 2017 is based on fuel cell system shipments up until October and on estimates from individual businesses for the last months of the year. Note that in the chapter on transportation, only vehicles are counted as systems, not simply fuel cell units.

Over 100 companies were contacted for the survey. The responses were compared with publicly available data and missing information was filled in wherever necessary. As usual, conclusive numbers for 2017 and preliminary figures for 2018 will be published in The Fuel Cell Industry Review at the end of this year.

Considering that the fuel cell sector is still a somewhat nascent industry, growth in 2017 was remarkably high, especially in the transportation segment. The analysis shows that last year, about 5,000 more fuel cell vehicles were shipped than in 2016. In all, fuel cell use in transportation grew around 50 percent, as measured by electrical output, and now contributes over 450 megawatts of power to the whole fuel cell sector.

To an outsider, however, it looks as if companies in this sector had mixed feelings about promoting fuel cell application in vehicles. For one thing, many more are investing much more in battery electric vehicles, which far outnumbered the 3,000 new fuel cell automobiles on the market in 2017. Another thing is that although several industry coalitions waved the banner of hydrogen mobility, with the Hydrogen Council seeming most vigilant in this duty, there are still only modest plans, with the exception of Toyota's, to drive up the number of cars in the coming years.

China was clearly ahead in 2017. There, it has set in that battery electric vehicles alone can hardly solve the emissions problem in the transportation sector. Since 2016, the country has had the most attractive incentives for various classes of fuel cell vehicles. Virtually overnight, they triggered a boom in investments in class 5, or around 7.5-ton, trucks and buses running on combined battery and fuel cells. The number of units shot upward with each month, as more and more factories were opened. Up to this point, fuel cell innovations have mainly been imported via various cooperation agreements with North American manufacturers and then implemented in vehicles by Chinese companies specializing in fuel cell assemblies.

In the preliminary totals for 2017, about 2,500 new fuel cell vehicles were counted for China. Many are not yet running daily, as too many regulations and too few hydrogen refueling stations impede progress. The greater stack and module inventory, which is not considered in the given totals, will enable the fuel cell vehicle market in the country to grow even more strongly in 2018.

Interest in the application of fuel cells for heavy load transport outside of China also rose, notably in Europe and North America. Even though these markets are not growing as rapidly as China, the projects kicked off by businesses or users have the potential to become larger than the primarily government-funded programs.

Looking at the distribution over fuel cell markets by region, a familiar pattern is immediately apparent: Asia is clearly in the lead at 80 percent of all shipped systems, a number that is still being driven by Japan's Ene-Farm program for micro-CHP systems. However, the percentage of solid oxide fuel cells greatly increased, which had something to do with the withdrawal of Toshiba from this field (see also p. 55). Supported by subsidies since April 2017, commercial small-capacity CHP systems are currently being brought to market by companies in Japan. This is expected to have significant influence on the number of sales starting in 2018.

There is also an apparent trend in fuel cell capacity. Asia and North America, just as in previous years, were head-to-head, sharing 95 percent, or 670 megawatts, of the worldwide market. An in-depth analysis, however, shows a rather significant difference for 2017. Companies based in Asia have shifted their market focus to new applications and regions. For one thing, Toyota, Honda and Hyundai sold only about 1,000 automobiles on the continent, whereas they sold 1,500 in 2016. It was obvious that in 2017, these companies had tried to get more vehicles on the American market, especially in California. For another, fuel cell use in transportation has increased in Asia, prompted by the developments in China described above. At the same time, somewhat fewer large stationary systems, especially in South Korea, were sold. This may only be temporary, since operation of Doosan's new factory for producing phosphoric acid fuel cell systems in South Korea, started in mid-2017, could even things back out this year.

In North America, the sales from large stationary facilities continued to rise in the low double-digit percentage range. Since nearly 2,000 fuel cell cars from Asian automobile manufacturers, significantly more than in the previous year, were shipped to the United States, the megawatt total for this region of the world again strongly increased. Not to be overlooked is the contribution of Plug Power, which established its significance in the field of intralogistics in 2017, albeit this segment of the industry was growing almost exclusively in North America.

Europe is still a relatively overlooked market, but it noticeably shot up at the low end of the scale in 2017. Compared to the previous year, it grew 40 percent more by capacity, primarily through the distribution of nearly 300 fuel cell cars, that is, 50 percent more of these vehicles, although they were provided by Asian OEMs. Despite efforts to expand the continent's refueling infrastructure, the number of cars on the road continues to lag significantly behind that of Japan and California. Europe has now turned its attention to other applications of fuel cells. The success of Alstom's hydrogen-powered trains has motivated increased fuel cell use in the rail industry.

The optimism involved in several projects and initiatives for fuel cell trucks and equipment has been carried over by those in logistics and materials handling to ships. Today, fuel cell technology can be used for not only onboard power supply but also propulsion. All these exciting developments, however, contributed little to the number of units counted for 2017. The rise in this sector was a result of about 1,500 new systems supported by the KfW433 program in Germany as well as the latest installations from the ene.field project.

Setting aside the detailed, thoroughly positive market numbers, in 2017, the concept of making green hydrogen through ever cheaper electricity from wind and sun on a large scale became important across the board. Somehow, it has made it into the agenda of decision makers in business and politics. The idea is that fuel cells will serve as a clean link for emission-free conversion of hydrogen into usable energy. Support to carry this vision out to the end will eventually come. In the meantime, the fuel cell industry has the challenge of asserting itself on the market bit by bit. ||

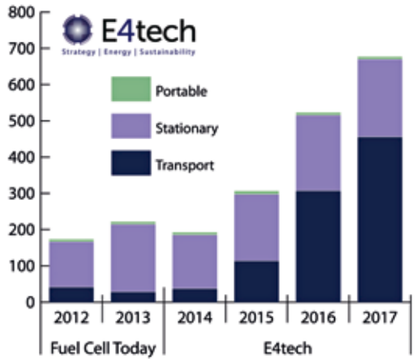

Fig. 1: Yearly fuel cell capacity delivered according to application for 2012 to 2017 (in megawatts)

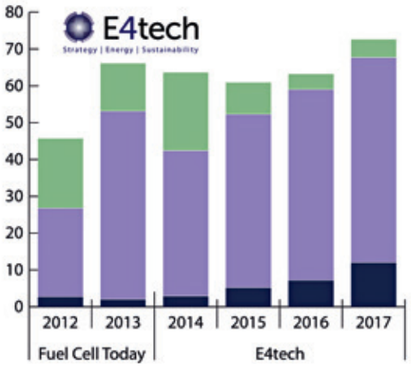

Fig. 2: Yearly unit shipments by application for 2012 to 2017 (1,000 units)

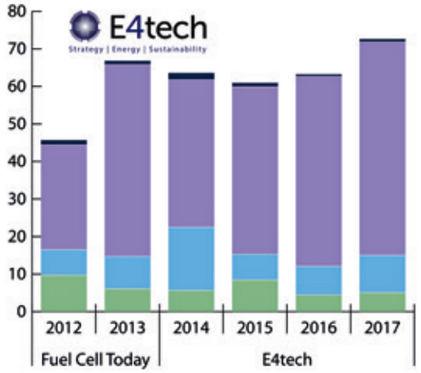

Fig. 3: Yearly unit shipments by market region for 2012 to 2017 (1,000 units)

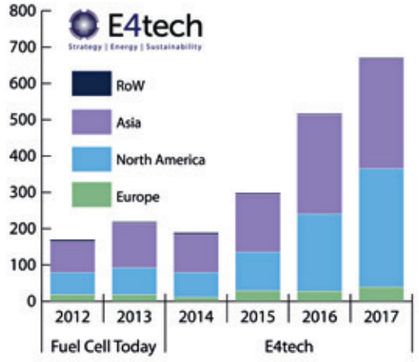

Fig. 4: Yearly fuel cell capacity by market region for 2012 to 2017 (in megawatts)

Download the full report, along with shipment numbers, data tables, analyses and commentary on the growth of individual companies, free of charge:
→ www.FuelCellIndustryReview.com

Reference(s)
D. Hart, F. Lehner, R. Rose, J. Lewis, M. Klippenstein (2017, December). The Fuel Cell Industry Review 2017. E4tech: Lausanne.

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Theme: Global | **Author:** Robert „Bob" Rose

TRUMP ADMINISTRATION UPDATE

US-Update by Bob Rose

The trump government's move towards fossil fuels has intensified in the fourth quarter. The Energy Information Center is primarily intended for power plants that are to receive a certain electricity price in order to be able to guarantee base load protection. The Environmental Protection Agency (EPA) is committed to revamping and eliminating the clean power plan. The Clean Power Plan was in place to meet US-led CO_2 reductions. Exceptionally, the government will reverse fuel consumption regulations for the period from 2021 to 2025.

President Trump removed nearly 2 million acres of federal land from wilderness protection in part to allow oil and gas extraction. (The oil and gas industry is not particularly interested in new leases at the moment but the symbolism is obvious.)

The administration has proposed a tariff on Chinese solar cells and solar panels, generally of 30%-35%, which would which would drive up the cost of small and large solar installations.

It is unlikely that these and other measures will have a significant impact on the US energy mix, even if all the changes are implemented, as larger forces are at play, including a glut of low cost natural gas and increasingly competitive renewable options, even with the tariff.

In the case of vehicle fuel economy, the current regulations are buttressed by the State of California's. California has the authority to set its own vehicle emission rules and while the details are complicated and open to some debate, California has extended emission standards to, in effect, include fuel economy. There have been rumblings of a repeal of California's authority, but no serious effort has emerged so far.

All this is important for fuel cells for two reasons: California's vehicle standards are driving the deployment of fuel cell vehicles, and any low-CO_2 regulations or incentives have at least the potential to encourage the adoption of fuel cell power generation systems.

Fig. 1: Ad by ExxonMobil and FuelCell Energy

A more concrete impact on fuel cells is seen in the DOE vehicle related fuel cell and hydrogen research budget. As we have reported, the Administration has proposed to cut spending from $102 million in FY 2017 to $45 million in FY 2018, and to cut the SOFC research budget from $30 million to $2 million. At least some of these cuts will be restored, but the final decision is bound up in a larger debate over federal spending, immigration policy, and other matters. The issues will not be settled until late in December, and possibly later. SOFC likely will be fully restored but a cut of at least 15% and possibly much more is anticipated in the vehicle related budget.

FUEL CELL TAX CREDIT There has been progress in the effort to restore the Business Investment Tax Credit for fuel cells and various other advanced and renewable energy generating technologies, which was allowed to expire last December 31. An extension, with a five-year phase-down, was included in the massive tax bill approved by the House of Representatives. There was no similar provision in the Senate. The two versions are being reconciled with an eye toward final approval before January 1. The credit carries a price tag of $1 billion so final approval is not guaranteed, but it is likely.

ITC IMPACT Fuel cell companies have said the expiration of the ITC is a blow to their business prospects. Bloom Energy told the State of Delaware late in October the expiration was "stifling Bloom's growth" and "negatively impacted our business growth plans." Under the terms of a 2012 grant agreement, Bloom promised to create 900 jobs in Delaware in return for a state grant, certain income guarantees, rent-free facilities and other enticements. Bloom reported only 302 workers and has returned $1.5 million to the State.

FuelCell Energy and Plug Power (purchasers can claim the credit for its forklift systems) also were affected. Both took steps to lessen the impact. FuelCell Energy is moving to a Power Purchase Agreement model, telling shareholders it can make more money with that approach than with simply selling units. Plug struck purchase agreements with Wal-Mart and Home Depot, as previously reported, that swap sales for stock warrants. The first bill for this arrangement came due last quarter: Plug reduced revenue by $26.1 million and warned investors in November of much more to come.

BUS UPDATE The longstanding California effort to encourage fuel cells for buses appears finally to be taking hold, at least in a modest way. The Department of Energy reported in November that the fuel cell bus fleet in California is expected to more than double in the next year or two. Four transit agencies in California are collectively operating 19 buses in 2017; two of these fleets will add a total of 33 more units. The bus fleet in Ohio will expand from five to 12, while three other transit agencies will each be operating one bus. This would bring the grand total of fuel cell buses operating in the US to 48. While California has adopted regulatory incentives, and offers some financial support for demonstrations, in general US cities and states have not yet stepped up with meaningful support. Despite decades of effort and technical progress, fuel cell buses are still in "demonstration mode" in the US.

EXXON-MOBIL Exxon-Mobil is running television advertisements featuring their research partnership with FuelCell Energy to develop a low cost carbon capture technology for power generation. Exxon-Mobil has had a longstanding interest in fuel cells and in reforming gasoline, though its recent official position has been that carbon fuels will be with us for a long time. With Shell's entry into the hydrogen fueling market in California, it is possible Exxon is reassessing. They certainly feel good enough about their relationship with FCE to develop the new ads. They were seen during American football games, a premium time slot. ||

The ad may be viewed here:
→ https://www.youtube.com/watch?v=9i41P68YgOI

Theme: International | **Author:** Robert „Bob" Rose

FORCING THE SOFC TECHNOLOGY

Japan-Update by Bob Rose

Building a hydrogen economy is one of Japan's success stories, despite high costs and lack of demand. That's why the country is now focusing on cost cutting. In June 2017, significant changes were made in the regulatory framework for the construction of H2 stations, which were previously considered industrial plants. The new regulations now regulate all questions relating to safety checks, quality controls, unattended operation and a variety of other technical issues.

Fig. 1: Hama system in Yokohama

HYDROGEN STATIONS There are 91 public hydrogen refueling stations operating in Japan (as of October 2017), with another 10 in development, putting the country well on its way to its short term goal of 160 stations by 2020. The deployment of stations has been one of Japan's hydrogen/fuel cell success stories, despite daunting costs and a lack of initial demand for hydrogen.

Average station costs are Yen360 million, with operating costs of Yen40 million, driven in large part by the strict regulatory regime. The goal is a roughly 50% reduction in both, via the regulatory changes, R&D, information sharing, design standardization and other means.

ENE-FARM The other success story, at least so far, is Ene-farm, the cooperative program to market residential fuel cells. More than 220,000 units have been installed since the program began in 2009 and the price for PEM units has been cut by two-thirds to a little over Yen1 million. The target is Yen800,000. The government is considering ways to improve the uptake in multi-family housing units, where only a handful of units have been installed. About 40% of Japanese homes are in multi-family buildings.

A surprising phenomenon has been the growth of SOFC units in the Ene-farm product mix; more than 10% of the installed units ae now SOFC. While the technology has superior electrical efficiency, SOFC has struggled with cost and durability issues. Ten-year durability has been achieved and costs are coming down. The government's estimate is that SOFC unit costs have declined by about half since 2011 with another 30% reduction needed to meet government targets.

Toshiba decided to stop offering its PEM units in 2017, certainly a blow to the program. Toshiba is scrambling to recover from the bankruptcy of its nuclear power division. The decision leaves, at least temporarily, only one PEM and one SOFC vendor in Ene-farm.

Several companies are developing SOFC units for small and medium size commercial applications, however, with government support. Units ranging from 3kW to 250 kW have been tested or are in development and a few early units are on offer. This appears to be Japan's new fuel cell frontier.

BUDGET Japan's FY 2018 budget request is in line with FY 2017, and includes support for vehicles and stations, Ene-farm, SOFC research and research into hydrogen production, delivery and utilization. ||

Program	FY 2018 Request (Yen Billion)
ENE-FARM and Small Commercial	8.9
Hydrogen Station Deployment	5.7
Hydrogen Supply Demonstrations	9.4
Vehicle R&D	2.9
Fueling Station R&D	2.4
Renewable Hydrogen R&D	0.9
Total	30.2
Vehicle Purchase Subsidies (FCEVs included)	13.0

Tab.: Financial Year 2018 – Fuel Cell and Hydrogen Budget Request

EVENTS 2018

JANUARY 31ST TO FEBRUARY 1ST, 2018
EL-MOTION, 8. AUSTRIAN ELECTRIC MOBILITY CONGRESS
in Vienna, Austria, www.elmotion.at

FEBRUARY 28TH TO MARCH 2ND, 2018
FC EXPO – INTERNATIONAL HYDROGEN & FUEL CELL EXPO
Tokyo Big Sight, in Tokyo, Japan, www.fcexpo.jp

MARCH 13TH TO 15TH, 2018
ENERGY STORAGE EUROPE
in Düsseldorf, Germany
www.energy-storage-online.com

MARCH 13TH TO 15TH, 2018
IRES – INTERNATIONAL CONFERENCE AND EXHIBITION FOR THE STORAGE OF RENEWABLE ENERGIES
in Düsseldorf, Germany
www.eurosolar.de

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

APRIL 23TH TO 27TH, 2018
HANNOVER MESSE – GROUP EXHIBIT "HYDROGEN, FUEL CELLS, BATTERIES" AND MOBILITEC
Hannover, Germany, Hannover Messe, www.h2fc-fair.com

MAY 9TH TO 11TH, 2018
EV EXPO –INTERNATIONAL EV INDUSTRIAL ECOLOGY CHAIN EXPOSITION & GLOBAL ELECTRIC VEHICLE LEADERSHIP SUMMIT
in Guangzhou International Sourcing Center, China
www.evexpovip.com

MAY 14TH TO 15TH, 2018
5TH RESIDENTIAL ENERGY STORAGE FORUM ORGANIZED BY DUFRESNE
in Berlin, Germany, www.energystorageforum.com

MAY 15TH TO 17TH, 2018
THE BATTERY SHOW
in Hanover, Germany,
www.thebatteryshow.eu

MAY 16TH TO 18TH, 2018
11TH ENERGY STORAGE WORLD FORUM
organized by Dufresne
in Berlin, Germany, www.energystorageforum.com

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

JUNE 19TH TO 21ST, 2018
ELECTRIFY EUROPE
Messe Wien, in Vienna, Austria
www.electrify-europe.com

Conference in Munich:
JUNE 19TH TO 20TH, 2018,
Fair: JUNE 20TH TO 22ND, 2018,
in Munich
EES EUROPE & POWER2DRIVE EUROPE – EUROPE'S LARGEST EXHIBITION FOR BATTERIES AND ENERGY STORAGE SYSTEMS
The exhibition for charging infrastructure and e-mobility
www.ees-europe.com,
www.powertodrive.de

JULY 24TH TO 27ST, 2018
HYPOTHESIS XIII – HYDROGEN POWER THEORETICAL & ENGINEERING SOLUTION INTERNATIONAL Symposium in Singapore
www.hypothesis.ws

JULY 26TH TO 28TH, 2018
CHINA INTERNATIONAL HYDROGEN AND FUEL CELL EXHIBITION (CHFCE)
China International Exhibition Center organized by China Machinery Industry Federation, in Beijing, China
http://en.chfce.com

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Hydrogen + Fuel Cells NORTH AMERICA
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