INTERVIEW WITH R. CHRISTIANSEN, PIONEER IN WIND POWER AND HYDROGEN
As a turn-key solution, the H-TEC ME series of electrolyzers are impressive thanks to their compact design, high power density and low operating costs. With an efficiency of 95% thanks to heat extraction, they are also extremely cost-effective. The individual performance guarantee sets new standards and opens up new opportunities for the industrial use of hydrogen. H-TEC electrolyzers are an immediately available and effective integrated energy solution.
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 applications to its fleet of electric delivery vehicles (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 H2Zwei and H2-International

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 EON until the company decided to split operations.

BEE’s president, Fritz Brickwede, 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. ||

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ALPIQ BUYS DIAMOND LITE

Diamond Lite, a Swiss engineering firm founded by Hansjörg Vöck in Herisau in 1982, was acquired by Alstom. 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. ||

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. ||

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 Electricité de France became the parent company’s majority 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. ||

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NEW MANAGER AT H-TEC EDUCATION

Dr. Thorsten Schmidt (Quelle: GP Joule)

Last November, H-Tec Education, based in Lubeck, Germany, was put under new management. Parent company GP Joule elevated Thorsten Schmidt, 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 Kütter, 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 H₂ and fuel cell community, he has since been advising the key account management and the marketing department at GP Joule in Reuenkofge, 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 Lubeck. The sole CEO of H-Tec Education is Ove Petersen, who is also chief executive at GP Joule, alongside Heinrich Gänster and Andre Hirsich. ||

NIKUTTA NEW HEAD OF ALSTOM GERMANY

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. ||
The Hydrogen Council [...] 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 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 many 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.||


### FUTUREE’S SURPRISE RESUSCITATION
Heliocentris again files for bankruptcy – this time, as part of Odasco

Siegfried Limmer

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 jobs. Some of Heliocentris’ former staff had already indicated in previous conversations with H2-international that the takeover of Heliocentris 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 media technology, is the head of 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 know-how to set up “200 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 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 an investment of coming online, the two companies 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.”

### FCP FOUNDED IN CHEMNITZ

New-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. Hoes said that its non-tangible assets, such as the software tools for the P21 Energy Manager, would be sold off very soon.

Last November, Thomas Melzer and Achim Loecher were appointed CEOs at newly founded FCP – Fuel Cell Powertrain, a joint venture between Melzer’s PITT Power group, headquartered in Düsseldorf, and the DeWe Group Holdings from Beijing. They share the role with Professor Thomas von Unwerth, director of the Advanced Powertrain 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 Ventitechnik.

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 the sales market to be China, where it has set up a subsidiary for local manufacture. Melzer and Loecher used to sit on the board of Proton Motor, a fuel cell manufacturer they both left in July two years ago.

### H2-INTERNATIONAL NOW WELL ESTABLISHED

Hydrogen Verlag’s most recently added information service, H2-international.com, 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 more than 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 Museumschenchenmuseum in Munich, and the High Performance Center at the University of Stuttgart, the hydrogen was the Global Renewable Energy Solutions Showcase trade show for COP23 delegates, international organizations and NGOs in the Bundeskunsthalle, Nov. 7 through 8.

Tab: Investmenten im Energiesektor

<table>
<thead>
<tr>
<th>Estimated H2 Investment</th>
<th>USD 20 to 25 billion per year</th>
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<tr>
<td>Oil and gas</td>
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<td>Renewable energies</td>
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<tr>
<td>Automotive industry</td>
<td>USD 300 billion per year</td>
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<tr>
<td>Total</td>
<td>USD 1.7 trillion per year</td>
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H2-international 01 | 18

H2-international 01 | 18
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 hydrogen-fuel-cell 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 days leading up to the event, that official registration had to stop. In all, according to the official count, there were 353. For these 3 days, the German city of Stuttgart could have been the world capital of electric transportation.

Stay ing Disruptive Through Electrification

The organizers used that you might call an oversized auditorium, 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 Haage, president of the World Electric Vehicle Association, affirmed that the industry was on board and on course. He also said that 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. 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 that 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. Meanwhile, 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 Weber reported that around 40 charging points, fed by a giant battery, were temporarily set up on the show grounds.

ALTERNATIVE FUELS

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 that 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?”

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"The life cycle assessment has already turned out positive, despite the difficulties of making a clean product in a dirty economy," said the global CO2 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 Haage, president of the World Electric Vehicle Association, explained at the podium.

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, Henrik Kagermann, said that more marketing would help.

An A i r b u s f o r B a t t e r i e s

Maros Šefčovič, vice president of 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-supported aircraft manufacturer, the chance to compete and succeed on the market. Now, Šefčovič would like to see the same happening in the battery sector.

Ple a 4 e t e k 4 e t h e C o m b u s t i o n E n g i n e R u n n i n g

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 that 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?”

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NO D O O M A N D G L O O M

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.

For the first time, the Asahi Kasei Group, a Japanese chemical company, showed its systems for producing ammonia, which supply 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 h2utenberg 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 on-site into methanol and dimethyl ether. With EUR 15 million in support from the European Union, six industrial centers in Europe are to be developed into economically strong, low-carbon regions by 2025. A total of 31 European countries and more than 40 companies from five European countries have been involved in this pursuit, which started Nov. 7, 2017.

Even Bosch, which primarily demonstrated its electric vehicle design and 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.

The first Electric Transportation Day, ATem, was conducted under the auspices 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 Sauter said, was also to be offered during the f-cell 2018 to promote and strengthen ties within the hydrogen and fuel cell community.

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Infrastructure Costs

The Jülich research center used the show as an opportunity to present its study, commissioned by H2 Mobility, on the cost of infrastructure for hydrogen- and battery-powered cars. During a press conference, the authors of the study, Detlef Holten and Martin Robinus, 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.
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 some advancements made in fuel cell technology, from the use of important raw materials for e-cars, but also mentioned the challenges of electric transportation. He referenced minister for the environment, Franz Untersteller, certainly made clear where he stands on the issue of fuel 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 Organisation Hydrogen and Fuel Cell Technology?

**WHO’S LOOKING AFTER HYDROGEN?**

During the EVS30 press conference, Hannig 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 complimentary 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 Organisation Hydrogen and Fuel Cell Technology?

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 9. The electric transportation alliance called elect! had been established under the name eCarTec is no more. In October 2017, changes since 2017. The auto show in Munich that originally started under the name eCarTec and left its Battery+Storage event in the past. Instead, the 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 in one large hall at the Mandalay Bay Convention Center. It attracted many interested visitors.

**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.

**VING FOR VISITORS**

Competition among trade show organizers in Germany is now raging as well as in other electric transportation arena. More and more event providers want to establish hubs of emerging technologies and draw industry-wide attention 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, eCarTec took place instead. It had a new concept and significant additions. It will run parallel to Intersolar Europe; ees Europe, the 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.

**HYDROGEN FUEL CELLS**

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, eCarTec took place instead. It had a new concept and significant additions. It will run parallel to Intersolar Europe; ees Europe, the --- Hydrogen + Fuel Cells North America event will be held 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.

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 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 plausible 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 American 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 Internationa Oct. 8 through 10, 2018. This may detract from emove360°, which was held Sept. 24 through 27 in Anaheim, California. The opportunity to learn about the practical applications of 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 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, H2 Fuel and Fuel Cells North America. Also supporting the function were the California Fuel Cell Partnership, California Hydrogen Business Council and Canadian Hydrogen and Fuel Cell Association.

**GREAT POTENTIAL**

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Tobias Renz, who also organizes the shared exhibitions 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 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, H2 Fuel and Fuel Cells North America. 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.

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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.

SOLIDPOWER PARTNERS WITH MICROSOFT

Fuel cells for 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.

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 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 concept 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 Ravaggi, CEO of SOLIDpower

FREUDENBERG BOUGHT ECORE

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 positive mood and is looking ahead,” he said. Stefener, who was presented with the European Inventor Award in 2012, believed until very late 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 Ampfeler explained, “The crucially important was the question of investing and 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, “because decisions have been made,” he said.

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 Ergas initiative by Germany’s energy industry said that the national KfW Development Bank had meanwhile been offering EUR 7,200 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 Ergas 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

Langwedl 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 Meting. During the groundbreaking ceremony in Langwedl 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.”
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 binders 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 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 H2 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.

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. 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. 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 now wants to use the gas to transform the transportation sector. “It can’t be that hard,” says Christiansen.

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At present, it seems that the electrolyzer planned will be installed at the E.ON Netz substation in Haurup, so H2 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.

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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 Ellhoff, 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 wind 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 of 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.

Christiansen: We generate so much energy here in Schleswig-Holstein, it is different. In this, politicians have set the right course.

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.

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.

Christiansen: 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 the 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.

Christiansen: 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, not just 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.

Christiansen: 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.

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.

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.

Christiansen: 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.

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 receiving electricity as any example, any revenue from selling the hydrogen produced would accordingly reduce the amount of possible EEG surcharge relief. In our case, there would be no relief.

Christiansen: 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.

Christiansen: Could you elaborate on that?

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Christiansen: I see. So, what are you planning on doing next?

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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 zero-emissions 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 50 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 Vanhoutrydt, 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 H2 production byway. 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 Falkenhausen, 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 setting 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 and physical product flow. For example, green hydrogen produced in the wind-rich north of Germany doesn’t have to be transported to 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, and a new, important criterion for bio-synthetic 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. It 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. For example, on what the hydrogen is used for, what 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 GreenX, based in Finland.

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TALK ABOUT DISRUPTIVE TECHNOLOGY

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 Bühl, representing the Städterweck 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. Policy makers, on the other hand, seemed to be preventing rather than promoting the switch 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 citizens-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 credits, or “solar coupons.” Right now, estimating the concrete impact of digital technologies such as blockchain systems and artificial intelligence is difficult.

Johanna Gumpen, a lecturer at the University of Kassel, held a session to discuss which hype 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.

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 integration between energy sectors, determined prior to the event through an analysis of possible 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 an integration of markets, which required cooperation at all levels, and that it was time to start taking measurable steps toward it.

FUEL CELL CAR & RIDE SHARING

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 30 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 ride-sharing 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 Hörch, 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 Hamburg, the business has purchased 15 Mirai cars, whose keys changed hands when the hydrogen station by mineral oil company Allguth was opened on Kreßstraße 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 Mobilitätsysteme, 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.
MAYORS SEARCHING FOR FUEL CELL BUSES

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

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 companies planning to switch from diesel to hybrid or electric vehicles. But he also expressed his discontent, a spokeswoman for Berlin’s mass transit company, told biz-energy.com: “You just don’t find any buses on the European market. We’d buy in bulk and promote them, but there aren’t any on the market, at least in Germany.”

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.”

Some had been working on hydrogen buses for years before it abandoned its activities in the sector altogether.

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 currently there was no single battery or fuel cell bus meeting the company’s expectations for a series product. A year later, his opinion seems unchanged.

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 HyFlyCute, 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.

The situation wasn’t any different with the bus market. Still, Müller said that the heavily criticized German manufacturers for not offering a single electric cab. 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 currently there was no single battery or fuel cell bus meeting the company’s expectations for a series product. A year later, his opinion seems unchanged.

Germany’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 more than 40 years. But in fall 2016, Daniel Bäuerle from the product planning department of Daimler Buses said that currently there was no single battery or fuel cell bus meeting the company’s expectations for a series product. A year later, his opinion seems unchanged.

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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 economics 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 aimed the investigation of applications, costs and GHG emissions to fuel cell electric vehicles, or PCEVs 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 agriculture and dairy, and a considerable part of the 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 PCEVs 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 [3]. The widespread use of electric vehicles in materials handling and instead of internal combustion engines 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 bar, 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 refill 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.

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 replacement and recycling, as well as waste material, 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 H1 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 H1 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, from eco-beacon of hope to economically viable alternative.
it is recommended that regulatory privileges be granted to have 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.

Despite 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. Undertaking launched NewBusFuel, a project focused solely on the design of the relevant infrastructure. 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).

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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 using redundant capabilities to achieve synergies and distribute the work. Hydrogen is an ideal candidate for 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 NIF 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 H₂, 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].

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...
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 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 Julich research center in Germany as part of an AVL-Plansee collaboration, which dates back to 2015. Onboard supply is typically the center in Germany as part of an AVL-Plansee collaboration, which dates back to 2015. Onboard supply is typically the 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. 

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The 117-page report regards heavy-duty vehicles powered by compressed or liquified natural gas as the biggest competitive edge, the authors said. Another example is the hydrogen-powered Frigovan H1 Zero Emission. Lambert, a French supplier of vehicle refrigeration systems, presented the new model at the Solutrans show, zeroing in on outdated information that did not account for the hydro- 

gen 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.

“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

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.

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 hydro-

FUEL CELL WORKHORSES
Great promise in heavy-duty applications
supplier Hexagon Lincoln. Last August, the Japanese auto-
maker also showcased a hydrogen-powered refrigeration ve-
hicle 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-interna-
tional). The San Pedro Bay Ports Hybrid & Fuel Cell Elec-
tric Vehicle Project funded by the US government has de-
ployed class 8 trucks, type Kenworth T800, to run between
the two biggest ports of the country, Los Angeles and Long
Beach. Ballard’s 85-kilowatt FCEvoCity®-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
solutions in certain use cases [see also p. 46].”
In Belgium and the Netherlands, fuel cells have been
employed in garbage truck trials. The company that convert-
ed the trucks owned by Geesinknorba was Belgian-Dutch
company E-Trucks. At the A1 and A5 freeway, with around EUR 18
million in throughput, and create economies of scale, a company con-
sortium intends to deploy about 100 of these kinds of vehi-
cles in northern Holland until 2028. Wind power plants are
said to be used for the eco-friendly production of the fuel
they need. Jan Willem Langeraat, CEO of Hydro, 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 Nether-
lands, 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 Askö from Scan-
dinavia announced their entry to the fuel cell truck market.
The partnership is comparable to the Coop collaboration in
Switzerland, since Askö, 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 deliv-
er four HyPM™-HD90 systems to Asko. The converted ve-
hicles 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.

**FUEL CELLS VERSUS CATEMATIC 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 eight highway 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 mar-
ket 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. Re-
garding 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 run-
ing 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 Clau-
dia Kemfert said, “In the opinion of the SRU, the rec-
ommendation to develop catenary trucks is not meant
to diminish the importance of a fuel cell option. Faced
with an ever-growing heavy-duty transportation mar-
ket and the call for a short-term slash of carbon di-
oxide emissions, it does make sense, however, to give
priority to overhead lines.”

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H2-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 H2 refueller (developed by Wystrach).

H2-Share will develop a joint roadmap for zero-emission heavy-duty trucks (or a market share of 0.7%) by 2025 and the development of production capacity for 500 to 1,500 trucks. Furthermore, the long term aims of H2-Share involve embedding hydrogen technology to make the heavy-duty logistic sector more sustainable.

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 CO2 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 the 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.

As a committed end-user, Colruyt Group will test case the truck in its day-to-day logistic 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 CO2 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 Slabbeekoon, 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% CO2 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 Slabbeekoon.
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 in Wolfsburg’s main station, Alstom’s staff was joined by the state’s transportation ministers, and also several representatives from other businesses and many reporters. Their goal: to catch a glimpse of the Coradia iLint trains in the future.

Of all places, Alstom, a government-owned rolling stock manufacturer from France, chose a site close to the headquarter 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 NLVG about 14 fuel cell trains and a 30-year maintenance contract. Both were inked by the compa-
nies’ heads on-site. While Alstom will reportedly produce the railroad vehicles, Linde would provide the hydrogen for operating them.

During the event, Lies presented NLVG with a notice of award promising over EUR 83.3 million from the state’s budget. The money will be used to purchase the locomotives and rent them out to railroad operators, while Alstom will conduct inspections in the maintenance facility of mass transit company evh in Bremermende. In addition, 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.”

**Nothing to Rail Against**

**Avid interest in fuel cell trains**

**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 Breit, the designated operator of the vehicle, said that he could drive in the same way engineers were used to from other models.

**FROM GREY TO GREEN HYDROGEN**

Plans are to have two prototypes, manufactured in Salzgitter, transport passengers between Cuxhaven and Buxtehude starting in December 2018 (see also October 2017 issue of H2-international) and to now, the only trains serving this line have been evh’s diesel locomotives. Soon, power will not run along overhead lines but be supplied on board through hydrogen.

The initial refueling station will be movable 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 hydrogen on-site with an electrolyzer that will reportedly be hydrogen on-site with an electrolyzer that will reportedly be hydrogen on-site with an electrolyzer that will reportedly be hydrogen on-site with an electrolyzer that will reportedly be hydrogen on-site with an electrolyzer that will reportedly be hydrogen on-site with an electrolyzer that will reportedly be hydrogen on-site with an electrolyzer that will reportedly be hydrogen on-site with an electrolyzer that will reportedly be hydrogen on-site with an electrolyzer that will reportedly be hydrogen on-site with an electrolyzer that will reportedly be hydrogen on-site with an electrolyzer that will reportedly be hydrogen on-site with an electrolyzer that will reportedly be hydrogen on-site with an electrolyzer. Power will be supplied on board through hydrogen. The electric power will be provided by a fuel cell.

**H2-international 01 | 18**
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 missiles 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 long-term 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 oftseated did the manufacturer 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.

ELECTRIC TRANSPORTATION

SOBERING PRODUCT PRESENTATION AT FRANKFURT’S INTERNATIONAL MOTOR SHOW

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 presages 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.

NEW ELECTRIC PRODUCT FAMILIES

The van could become part of Daimler’s recently created EQ brand, the company’s automotive version of emotional intelligence. Like 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 display grounds, nor an outdoor exhibition area of its own making this time. The German automaker also didn’t want to say exactly how many kilometres its journey was. 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.

ELECTRICIZED 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 2018. 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 made some 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 didn’t include the New Mobility World exhibition, 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, around 120 were left last year. To save face, the organizer said that “overall, the exposition involved more than 230 [exhibitors, partners, sponsors, and the like], and 200’000 visitors, changing 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 was 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, Chryl- ler, Fiat, Peugeot and Volvo, had already said before the show 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. ||
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 230-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 Chambery. 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 mail 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 Sebaldbrücke 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 26 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.
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 2018. 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 the aftermath 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.

SMES RULES NEED TO IMPROVE Some in the industry also believe that the current funding environment needs to change. NIP I 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, Julich, had sometimes asked for up to 24 months in secured financing, some said. Small businesses are often the drivers of new technologies that haven’t been able to provide. H2-international has learned that a lack of financial backing had already prompted Julich 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 withheld 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 better to meet SMEs’ halfway.

INCENTIVES FOR ELECTROLYzers

On Nov. 14, 2017, the National Organization Hydrogen and Fuel Cell Technology extended the list of eligible technologies to include electrolyzer technology, capable of 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 foerdertop.de.

TIGHTNESS TESTS AT MOTEK

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 neighbouring hall. The Cetates 605 attracted many to the company’s booth, where employees demonstrated its capability to detect very small leaks (Q > 10⁻⁸ millibars · l·s⁻¹). 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.”

NEW HYDROGEN MONITORING UNIT

Last September, SI TechH2 unveiled a portable hydrogen monitoring unit, including a power disconnect Cevtech CHV 08. The switchboard-like H₂ control cabinet MWS-01 was specially designed to suit the facilities of one of its customers, where it is being used to produce fuel cells and fuel. The hydrogen also serves as a fuel cell power source to provide electricity to a 500-square-meter house. The 10-staff Cevtech team, based in Munich, Germany, uses the Cevtech for both commercial and research applications. The company has 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.”

SAFE AND SOUND REFUELING

At the 30th Electric Vehicle Symposium in Stuttgart, UST Umweltensorechtk, based in the German state of Thüringen, exhibited its patented Senicor® sensor technology 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 10-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 can be built in redundancies.

期间，“绿色”仍是一个可供探索的选择。Werner Diwald，该机构的经理，表示，该机构已经在准备氢和燃料电池项目的后期发展。例如，该机构已经准备了相关的授权文件。不过，该机构也注意到，燃料电池的开发仍面临许多挑战，包括技术难度大、成本高、市场接受度低等问题。因此，该机构建议政府应继续支持氢和燃料电池项目的发展，以推动这些技术的商业化和产业化。

源：November 2017, H2-international, H2-International 01 | 18 H2-international 01 | 18

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Source: UST Umweltensorechtk
Sustainable Material Flow

Fuel cell use in the logistics industry

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 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 state-side 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 ever before,” he stressed that Nacco Materials Handling Group, whose products are mainly marketed under the 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 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 300 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 Lille, 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.”

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 Fromius, Profactor and others is planned to result in a completely scalable product line to manufacture fuel cell systems at a faster pace.
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.

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 industry 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 is 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 fuel cell investors no confidence in the technology’s 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 is currently valued on the Nasdaq Stock Market only about 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 values. As soon as the technology 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. But shareholders were mistaken, celebrating too early. The company spreading the risk across a pool of customers, but large corporations are stating load and know 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.

Rolling stock and ships

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 interval over 25-kilometer-long tracks.

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 load and know 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 factors in license revenues, rail and bus fuel cell bus deliveries and the potential of several markets in which Ballard plays a lead role and is in a bright spot, technologically. On the other hand, 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 and this 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 its growth at the competition offered by lower-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. 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
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 panics, 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 investors 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 H2 retailing 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. 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 investors over the next years.

TOYOTA TO PRODUCE ITS OWN H2, 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. Hogos 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 stock price, 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 H2-filling stations went operational during the quarter, marking the biggest investment in the United States with the most refueling sites in the States. Bookings are said to have added up to around USD 44 million in the quarter. Plug Power’h, however, will only be reached by 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 calculations, 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 wouldn’t 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 on the profit front. While generally very forward in cell shares, but businesses such as Ballard Power, whose extensive know-how may land it a partnership with another forklift truck manufacturer, is certainly still in its infancy. It will take a long time for Plug to make its substantial know-how available 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: 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 revenue USD 671 million 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. You should be 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 CFO 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 1,800 and 3,000 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 in 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 pay at the same period, bringing 2017’s total to USD 160 million while its partners to find a remedy to the H2 infrastructure issue.

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. It may also surpass its 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 be >>

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

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

Fig. 5: Concept study of the new Tesla roadster

Fig. 6: ITM Power system at Thogga in Frankfurt am Main, Germany

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be even higher. I find predictions of a quarterly loss in excess of USD 1 billion to be overly dramatic. It's not an unimagi-
nable scenario, though, should Tesla implement all its plans, as they will require large-scale investment and massive ex-
penditures. 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 of its subsidiary which gave the business a billion dollars in credit. On top of this, there is a window for paying back cer-
tain 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 technology to the market.

What should never be overlooked is that battery technol-
y is evolving too, in terms of materials and construction. Toyota's solid-state version is only one such example. Lavi-

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

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 industries. Currently, only high-speed 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 Nor-
way’s fjords or between its many islands. The default fuel, however, is still diesel, despite its effects on the climate and the environment.

Since the early 2000s, Norway’s government and leading companies have been building up a hydrogen economy, particularly in the North Sea region. 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 nowhere else they were sup-
posed to be. The reason was that fuel cells were considered inferior by the local administration of Floroe, three companies
that were originally driving hydrogen forward gradually backed away from the technology with the unclear future.

Two such companies, Statoll 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 hydro-
ergy systems more flexible. The subsequent use of the gas as fuel in vehicles is a logical part of the discussion. The
original plan to build a large green hydrogen facility in the county comes from ships. Fast ferries with a travel speed of up to 30 knots, which is approximately 56

In 2015, however, after intensive lobbying from the Norwegian Hydrogen Forum and associated groups, the govern-
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are ready for it. In order not to miss any important developments, many in recent years have been heavily in-
volved 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 is expected to become energy independent by 2030. A special focus is on renewable electricity from hydropower. It also produces a significant amount of sur-
plus 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, Fin-
land 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 increase from 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 ac-
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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.
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 consultant that has been providing insight into the hydrogen and fuel cell industry since 2004. 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 59 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, with roughly 5,000 more fuel cell vehicles being brought to market by companies in Japan. This is expected to have significant influence on the number of sales starting in 2018.

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 cell. The number of units shipped up with each month, as more and more factories 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 projects in China.

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 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 this sector of the industry was growing almost exclusively 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, although this segment of the industry was growing almost exclusively in Asia.

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 installments from the ence.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 many automotive 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.
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 CO₂ 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 2021 to 2025. The administration has proposed a tariff on Chinese solar cells and solar panels, generally of 30%-35%, 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 being restored 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 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 too 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 Walmart 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 advertising featuring their relationship 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: http://www.youtube.com/watch?v=Rk1P6By0Ql

TRUMP ADMINISTRATION UPDATE

US-Update by Bob Rose

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. 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.

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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 Walmart 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 meaning-

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 Yen million. The target

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.

BUS UPDATE Several companies are developing SOFC units for small and medium size commercial applications, however, with government support. Stations 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. ||

Tab: Financial Year 2018 - Fuel Cell and Hydrogen Budget Request

<table>
<thead>
<tr>
<th>Program</th>
<th>FY 2018 Request (Yen Billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENE-FARM and Small Commercial</td>
<td>8.9</td>
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<tr>
<td>Hydrogen Station Deployment</td>
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<tr>
<td>Hydrogen Supply Demonstrations</td>
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<tr>
<td>Vehicle R&amp;D</td>
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<tr>
<td>Fueling Station R&amp;D</td>
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<tr>
<td>Renewable Hydrogen R&amp;D</td>
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<tr>
<td>Total</td>
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<tr>
<td>Vehicle Purchases Subsidies (FDV's included)</td>
<td>13.0</td>
</tr>
</tbody>
</table>
We discuss challenges and opportunities for an innovative hydrogen age and business cases for fuel cells.

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