THE HYDROGEN MAGAZINE

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H2int.

H2 filling stations: Sensors for everything that matters

Plasma pyrolysis: H2 and carbon black from methane

Production technology: Precise placement in fuel cell stacking

Big plans in Germany

Offshore hydrogen production, H2 power plants and Hamburg's hydrogen hub – making progress?

Is there more to come?

The year 2025 is entering the home stretch. Everyone wants to quickly check off their to-do lists: complete projects, submit funding applications, process accounts. In German politics as well, several projects are supposed to be finished “by the end of the year,” or at least by early 2026.

It is said that the draft law for the greenhouse gas reduction quota for road transport is supposed to be introduced to the Bundestag, the Federal Parliament of Germany, before the end of the year. The quota is part of the third Renewable Energy Directive (RED III) and should actually have been anchored in German law since May.

A step forward was made in Germany in mid-December regarding power plants. The government agreed on an installed capacity and also on the requirement that new power plants must be H2-ready in the long term. This requirement is more than one might expect.

That there will be an obligation to operate them with hydrogen as soon as possible seems, according to previous statements by Energy and Economy Minister Katherina Reiche, rather unlikely. But apart from hydrogen, the economic basis for power plant tenders would also have to be created – because at some point they will simply be needed, and you cannot just order finished gas-fired power plants by express delivery on the internet.

This mood of tense waiting was also present at the Hydrogen Technology World Expo in Hamburg, where the H2international editorial team was on site – even though the trade fair was larger than ever before and many projects are finally being implemented.

Just a few years ago, climate protection was clearly humanity’s most pressing mission. The physics have not changed, only the awareness. And so we are treading water, and the water is rising. Not only literally on the coasts, but also figuratively for companies and people who invested money and time in the sector. And then, all of a sudden, the electrolyzer manufacturer Sunfire announces an unexpected new customer: Rheinmetall wants to produce e-fuels in decentralized plants. That is certainly not cheap and is certainly not a business field that can save the whole hydrogen sector. But what matters is that, in an emergency, e-fuels shall allow a certain amount of independence and functionality to be maintained. With this, Rheinmetall is putting an advantage of local energy production back on the agenda that had already been forgotten: resilience. It is never cheap – but priceless when it matters.

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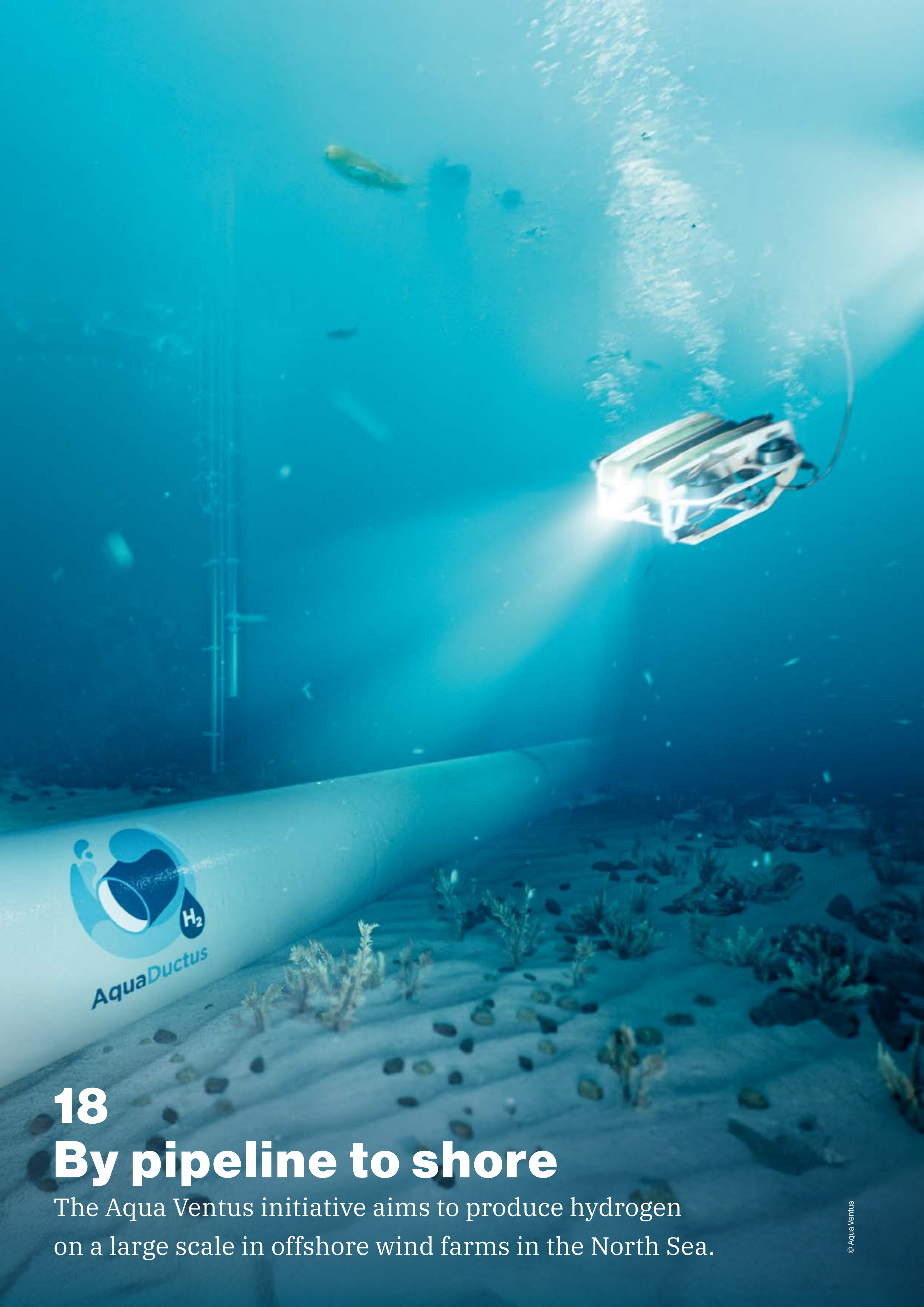

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By pipeline to shore

The Aqua Ventus initiative aims to produce hydrogen on a large scale in offshore wind farms in the North Sea.

Content


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COVER IMAGE: The Aqua Ventus rendering illustrates what offshore hydrogen production could look like in the future. © Aqua Ventus

What's up, Hyfindr?

WHO PAYS CALLS THE SHOTS

Hyfindr CEO Dr. Björn Lüssow
shares insights and encounters from the international hydrogen community.

Every two weeks, I experience a déjà vu. After recording the podcast for The Hydrogen Leader, I sit in the studio, my headphones lying on the table – and I keep asking myself: What are we actually doing here?

I speak with people who are building the global hydrogen industry, like Driss Berraho from ACWA Power in Saudi Arabia. He is planning to supply Europe with green hydrogen on a large scale in just two years, mainly in the form of ammonia. Other companies are planning the same thing in Brazil, Chile, and North Africa.

The world is investing to provide Europe – especially Germany – with green hydrogen. And we are talking about hydrogen being too expensive.

We discuss reports, such as that of the German Federal Audit Office (see article on the right side of this page), which questions the effectiveness of Germany's hydrogen strategy. We attend trade fairs and reassure ourselves that the sector's growth is still manageable.

To be honest, something else is on my mind: What we are not doing. We are missing the opportunity that is presenting itself to us. Other countries believe in us. They invest because they trust that Europe – and in particular Germany – is serious about the energy transition. And what are we doing with this trust? Not enough, and that's to our own detriment. We are not making enough use of our role as the buyer of hydrogen. The customer is king. Every entrepreneur knows this.

Whoever pays, calls the shots – this is not an empty phrase, but a call to action for policymakers.

Industry demands regulatory clarity. Why aren't we providing it? The more I talk to professionals, the more I am convinced: Without hydrogen, a comprehensive energy transition will not succeed.

If we act now, we will set the rules for tomorrow. This requires not money, but courage. We are already building hydrogen pipelines. We should now also ensure that they are used when completed. So let's call the shots – now is the time. ○

Rebuke from the Federal Audit Office

The Federal Audit Office of Germany has sharply criticized the implementation of the national hydrogen strategy and called for a reality check. "Despite billions in subsidies, the federal government is failing to achieve its ambitious targets for ramping up the hydrogen economy," said the President of the Federal Audit Office, Kay Scheller, on the occasion of the publication of a special report on the implementation of the federal hydrogen strategy. "The responsible Federal Ministry for Economic Affairs has itself recognized that it needs to adjust its approach. Now it must also act consistently."

According to the report, the federal government has already made available more than 7 billion euros in 2024 and 2025, primarily as subsidies. There are commitments amounting to billions of euros until the end of the decade. The Federal Audit Office sees both the future of Germany as an industrial location and the achievement of climate neutrality by 2045 at risk.

The original demand was expected to come mainly from the steel industry and from hydrogen-ready power plants. For gas-fired power plants, however, the Federal Audit Office no longer expects this, as there is currently no obligation to convert to hydrogen. As supply and demand are both shrinking, the plans for the hydrogen core network are now considered oversized.

At the same time, supply is lacking. Neither domestic supply nor imports are expected to be achievable by 2030 as planned. According to the report, there are so far worldwide investment decisions for the production of 63 TWh of green hydrogen. Germany alone would need between 47.5 and 91 TWh per year.

Because green hydrogen will remain permanently more expensive than fossil energy carriers, the federal government would have to subsidize it with billions every year for the foreseeable future. The report assumes that the price difference between hydrogen and natural gas in 2030 will be between 70 and 275 euros per megawatt hour, including emissions certificates. The financing mechanism for the hydrogen core network is also considered risky. If the ramp-up does not succeed, the federal government would be left with costs amounting to a double-digit billion sum.

Despite the high costs, the contribution of hydrogen to climate neutrality remains uncertain. The Federal Audit Office is now calling on the government to develop supply, demand, and infrastructure "hand in hand." At the same time, the federal budget must not be overstretched. However, simply waiting is also not an option: "If it cannot find solutions to the existing challenges, it will need a plan B in good time to achieve climate neutrality by 2045 without a permanently subsidized hydrogen economy," writes the Federal Audit Office. ○


© Eternal Power

Hamburg-based hydrogen start-up awarded for large-scale projects

The company Eternal Power, a pioneer in green hydrogen scaling, has been awarded the German Sustainability Award 2026 in the category of the fuel industry. The jury particularly commends the rapid development of a project pipeline of over six gigawatts for green hydrogen and derivatives.

With its role as a project developer for scalable large-scale plants for the production of green hydrogen and hydrogen derivatives, Eternal Power convinced the jury. The focus of the evaluation was the company's transformation performance. Within a short time, it has built a project pipeline with a planned production capacity of over six gigawatts (GW). This could avoid more than four million tonnes of CO2 emissions annually.

“This volume can be increased tenfold by the end of the decade – an impressive proof of the ambitious scaling strategy,” the jurors write on their website. According to its own statements, Eternal Power pursues an international scaling strategy with partnerships in Europe, Chile, the Middle East, and Africa. The goal is to create gigawatt-scale capacities that can replace fossil fuels in industrial applications.

The business model is based on an integrated one-stop-shop approach. This includes the development, generation of renewable energies, and production of hydrogen derivatives along the entire value chain. The projects are designed to integrate into existing port and industrial infrastructures.

The German Sustainability Award, one of Europe's most prestigious honours for corporate sustainability and transformation, is given annually to companies that, in the opinion of a panel of experts, make particularly effective contributions to sustainable transformation. Among other things, innovation strength, scalability, development potential, and long-term responsibility are evaluated. ○

Representatives of Sonplas and Zhejiang Filter, who are now cooperating in the field of electrolysis. © Monika Rößiger

Modular test bench for hydrogen components

The Lower Bavarian special machine manufacturer Sonplas presented a new test bench for alternative fuels at the hydrogen trade fair in Hamburg. The facility is designed for hydrogen, methanol, and ammonia and was presented in a scaled-down version including container infrastructure. The test bench allows customers to test components under realistic conditions – for example, in the context of functional and durability tests with hydrogen.

For this purpose, it offers, among other things, flow measurements, dynamic pressure measurements, and leakage tests.

The new test bench concept is modular and can represent various electrolysis technologies – including Proton Exchange Membrane Electrolysis (PEM), Alkaline Electrolysis (AEL), and Anion Exchange Membrane Electrolysis (AEM). The systems can be configured for different performance classes and metrological requirements. Target groups include both research institutions and industrial companies in pre-series and series development.

On the first day of the trade fair, Sonplas Managing Director Michael Frankl also sealed a new partnership with the Chinese company Zhejiang Filter Technology. The manufacturer of electrolysis stacks plans to install a demonstrator in Germany with the support of Sonplas. This is intended to convince potential European customers of the performance of the products. ○ **Monika Rößiger**

Import terminal for green ammonia planned

A central import terminal for green ammonia is to be established in the Port of Hamburg. The company MB Energy plans to build new infrastructure for this purpose at the Blumensand tank farm. The core of the project is a tank for the interim storage of imported ammonia. According to the company, the terminal is expected to go into operation in 2028. In close proximity to the planned ammonia tank, the US corporation Air Products is planning a hydrogen production facility. There, the imported ammonia will be split into hydrogen and nitrogen and prepared for distribution. "We believe that hydrogen has good prospects in the heavy-duty sector in the future," says Philipp Kroepels, Director New Energy. For example, to transport tomatoes over long distances such as from southern Spain to northern Europe. "This cannot be done with battery trucks." MB Energy therefore describes its project as a "practical entry into the hydrogen economy." The existing mineral oil tank on the site, centrally located in the port, is to be replaced by the new ammonia tank. It offers logistical connections for both the import and further processing of energy carriers. With the project "New Energy Gate Hamburg," MB Energy aims to develop the site for sustainable H2 products and renewable energies. ○ **Monika Rößiger**

Philipp Kroepels, Director New Energy, explains the plans for the ammonia terminal in Hamburg.
© Monika Rößiger

AI-supported laser welding technology to replace precious metals

The Fraunhofer Institute for Laser Technology (ILT), together with iGas energy and the manufacturing specialist dLS LichtSchneiderei, is developing new methods for the production of PEM electrolysers. The focus is on eliminating costly precious metal coatings by using laser-welded titanium expanded metal with high electrical conductivity. The project, titled "AI-supported welding and cutting of expanded metal for efficient electrolyser production" (KISSSEs), started in October 2025 and is scheduled for three years.

Researchers at Fraunhofer ILT are relying on artificial intelligence (AI) to identify optimal welding points in complex lattice structures. This precise welding reduces electrical contact resistance and makes expensive precious metal coatings unnecessary. Additionally, AI-supported laser cutting processes improve the edge quality of the grids, which is expected to further increase the efficiency of the electrolysers.

Zhiheng Ye, doc. candidate at Fraunhofer ILT, works on new technologies for electrolysers without precious metals.

© Fraunhofer ILT, Aachen

"Our AI models identify the optimal welding points even in irregular expanded metal geometries, enabling reproducible contacts with lower resistance," explains Zhiheng Ye, hydrogen expert at Fraunhofer ILT. "This lays the foundation for scalable and resource-efficient electrolyser production."

The project focuses on proton exchange membrane electrolysis (PEM), where a membrane electrochemically separates water into hydrogen and oxygen. PEM systems are considered particularly suitable for operation with fluctuating renewable energies, as they offer high power density, short response times, and good partial load capability.

The PEM stacks used in the project are supplied by iGas energy. They produce up to 260 normal cubic meters of hydrogen per hour and can be scaled by coupling. iGas energy also contributes electrochemical system expertise, develops flow and cell models, and tests the components in operation. ○

Trade fair report

Hydrogen and Whisky

By Monika Rößiger

Towards evening at the fair, it becomes clear that the H2 industry not only offers catalysts, compressors, and sensors but can also enjoy itself. Dutch exhibitors hoist a large cheese wheel onto the reception counter and offer the ten-year-old specialty in small bites on wooden skewers.

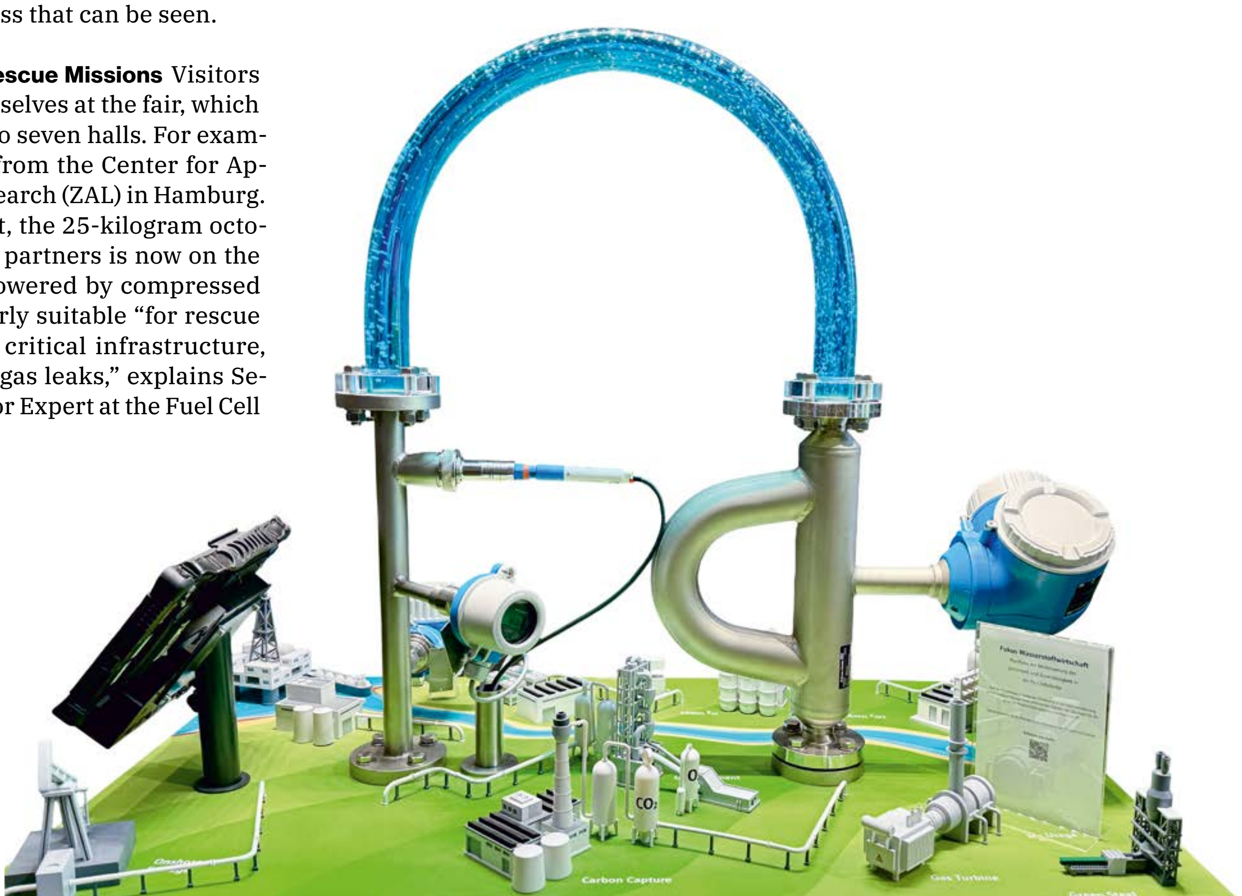
The representatives of Scotland pour their guests even older single malt; the Japanese serve sushi, and the North Germans currywurst. Apart from the country-specific cuisine, the more than a thousand exhibitors are likely united by the hope that now, in light of the delayed hydrogen ramp-up, things can only get better.

After reports of postponed or canceled projects had accumulated in recent months, neither pioneers nor established companies, whose business model is not solely based on hydrogen, let their spirits be dampened at the Hydrogen Technology World Expo. After all, there are hundreds of hydrogen projects in Europe, and they rely on their own successes; large and small progress that can be seen.

Hydrogen Drone for Rescue Missions Visitors could see this for themselves at the fair, which expanded from three to seven halls. For example, the H2PM drone from the Center for Applied Aeronautical Research (ZAL) in Hamburg. Last year still a project, the 25-kilogram octocopter developed with partners is now on the market. The drone, powered by compressed hydrogen, is particularly suitable “for rescue missions, monitoring critical infrastructure, and detecting fires or gas leaks,” explains Sebastian Altmann, Senior Expert at the Fuel Cell Laboratory at ZAL.

H2 Octocopter Replaces Helicopter With a payload of up to five kilograms, it can stay in the air for two to three hours and cover up to 150 kilometers. In comparison, a battery-powered drone only achieves a good half-hour flight time.

The hydrogen drone is also capable of replacing a helicopter flight – at a fraction of the cost. The latter costs between 1,000 and 3,000 euros per hour, depending on the provider; the H2 drone, on the other hand, 50 to 100 euros. It is actually intended for use in industry or the civilian sector. “But given the geopolitical situation, military interest in powerful drones for surveillance purposes is noticeably increas-



Installation at the Endress + Hauser stand

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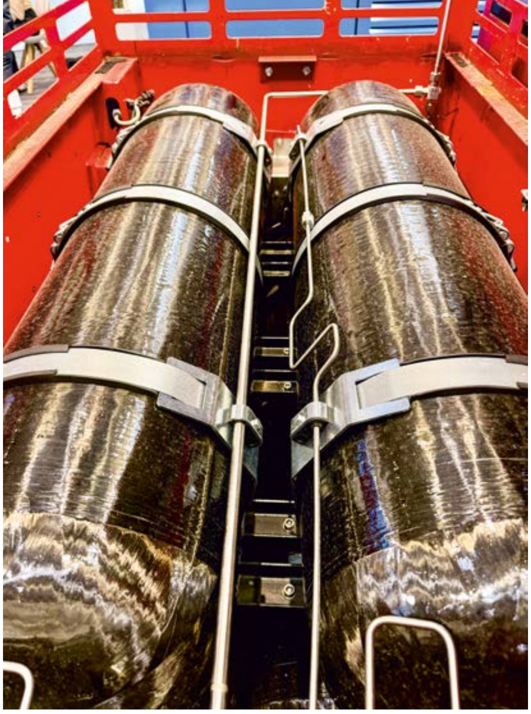

LEFT: Pressure Tanks for a Baggage Tug Converted from Natural Gas to Hydrogen Propulsion.
© Monika Rößiger

RIGHT: Flying Test Laboratory for Testing Climate-Compatible Technologies: The Research Aircraft UpLift of the DLR.
© Monika Rößiger

ing," says Altmann when asked by H2international. However, ZAL excludes the development of weapon-carrying drones. On the contrary, research is now increasingly focused on defending against military and espionage drones.

H2 Baggage Tug in Practical Test for the First Time In any case, a red vehicle in Hall B5 comes across as harmless, which has been in test operation at Hamburg Airport since July 2025: A baggage tug that Hydro Technology Motors (HTM) from Bingen am Rhein has converted from natural gas to hydrogen propulsion. This concept was recently nominated in the "Hydrogen Innovation of the Year" category for the "German Renewable Energy Award," which is presented by the cluster Renewable Energy Hamburg.

Two carbon fiber-reinforced pressure tanks (350 bar) on the loading area are filled on demand via a mobile refueling unit from Ryze Power directly at the airport. According to HTM, converting existing vehicles is a "cost-effective and environmentally friendly alternative to new battery or fuel cell vehicles." Ten kilograms of hydrogen are enough for a three-shift operation.

The first practical test of a baggage tug converted to hydrogen combustion was deliberately conducted during the particularly busy summer months. The EU-funded project BSR HyAirport is scientifically accompanied as part of the energy transition joint project Northern German Real Laboratory.

Important for European Airports The results regarding technical and economic feasibility are important not only for the further approximately 60 natural gas-powered baggage tugs in Hamburg but for airports throughout Europe. Because the collected data is shared with the operators. Hamburg Airport is already convinced "that hydrogen will play a significant role in the future of aviation on the ground and, of course, in the air."

Electrolysis Without Platinum A "real boost in performance" for electrolyzers is promised by José Manuel Sanchis Bernat at the stand of Matteco, a spin-off from the University of Valencia. "Our next-generation electrodes and catalysts increase the hydrogen yield of AWE and AEM electrolyzers," says Iker Marcaide, co-founder and CEO of Matteco.

This is due to the enlarged catalytic surface. Advanced materials – without platinum – increase the efficiency of H2 production and thus contribute to the scaling of hydrogen technologies overall. "With our nickel-iron catalysts, the LCOH decreases by up to 20 percent. And that with minimal degradation."

In addition to more sustainable catalysts, there were other innovative products, processes, and materials. For example, the Federal Institute for Materials Research and Testing (BAM) is investigating the use of glass fiber-reinforced plastic pipes as an alternative to conventional steel pipes for hydrogen. The goal is to develop new pipeline systems that remain efficient even under high pressures and reduce costs compared to previous solutions.

Asia at the Waterkant Northern Germany presented itself in Hall 6 with its concentrated hydrogen expertise, both in terms of research and companies. Delegations from Japan and South Korea showed particular interest in the projects of this region, including employees of the Japanese Ministry of the Environment, ▷

the Fukushima Energy Agency, and foreign trade representatives.

A group of journalists from seven EU countries, who were researching in the metropolitan region, also visited the fair. The Hanseatic city aims to become a leading location for hydrogen. This concerns both the production and import of green hydrogen and its use in industry, business, and transport.

Go Big or Go Home Central projects for this are the construction of a 100-megawatt electrolyzer ("Hamburg Green Hydrogen Hub") at the site of the former Moorburg coal-fired power plant and a 60-kilometer hydrogen pipeline network for large industrial companies. In addition, the construction of the first large import terminal in Germany for hydrogen and its derivatives in the port.

Thus, Hamburg's First Mayor Peter Tschentscher also took the time during his tour of the fair to ask entrepreneurs in the industry, for example, where there are bottlenecks and what politics can do about it.

Champagne for the Hydrogen Fans "Overall, the mood at the fair was quite positive," summarizes Jan Rispens, head of the the cluster Renewable Energy Hamburg, which organized and managed the joint stand with 15 companies. "Some significant projects are progressing in Europe, technology development has gained momentum, and investors are still interested in project development." At the end of the second day, the champagne corks popped at HZwei and H2international: Together with the German Hydrogen Association, the publisher invited to a reception. ○

ABOVE: A Look Under the Hood of the Hydrogen Baggage Tug. The Baggage Tug is in Practical Test at Hamburg Airport.

© Monika Rößiger

LEFT: Hamburg's First Mayor Peter Tschentscher Informs Himself About the Progress of the Hydrogen Projects.

© Monika Rößiger

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Round table for hydrogen rules

By Dennis Klein

The "Standardization Roadmap for Hydrogen Technologies" in Germany is scheduled to be completed this year. This initiative is an inventory of the existing regulatory frameworks – and at the same time, a list of standardization issues yet to be clarified. The aim is to enable a rapid and smooth ramp-up of the hydrogen market.

Standards (in Germany: Normen) provide legal certainty. For example, they can be referenced in laws as an option for compliance. Standards define interfaces between individual sectors and strengthen international trade by granting market access for products and services. Through cooperation with science and research in standardization committees, standards enable early strategic decisions for the implementation of new technologies. They also contribute to consumer safety by setting minimum standards and safety requirements and updating them as necessary to reflect current knowledge – often voluntarily, before laws come into effect.

In the gas supply industry, German standards regulate, for example, the quality of the energy carrier and define interfaces. This benefits trade and cooperation among companies. Standards also improve consumer safety by setting requirements for climate-friendly operation of pipeline systems or for inspection cycles and the quality of components.

In this context, the collaborative project "Standardization Roadmap for Hydrogen Technologies", funded by the German Federal Ministry for Economic Affairs and Energy (BMWK), actively supports the ramp-up of the hydrogen market by helping to develop a comprehensive technical regulatory framework for hydrogen technologies in Germany.

Launched in January 2023, the project provides an overview of the status quo of standardization in the field of hydrogen technologies in Germany, records the requirements and challenges for the entire value chain of the hydrogen economy, and derives necessary actions for future technical regulations. Based on these recommendations, concrete standardization projects are initiated and implemented.

Everyone at one table "With the standardization roadmap, transparency has been created in the field of technical regulation for hydrogen technologies. It constitutes a round table for all stakeholders," says Dennis Klein, Head of the Standardization Roadmap at DVGW (German Technical and Scientific Association for Gas and Water). Together with the German Institute for Standardization (DIN), DVGW is project leader and initiator of the initiative. Also participating are the German Commission for Electrical, Electronic & Information Technologies (DKE) in DIN and VDE, the Association for Standardization and Advancement of Railways (NWB), the German Association of the Automotive Industry (VDA), the Association of German Engineers (VDI), and the German Engineering Federation (VDMA).

"All relevant stakeholders and rule-setters worked together on a cross-sectoral, coherent and coordinated roadmap that covers the entire value chain from production to application," Klein explains, highlighting the advantages of the concept. This collaborative approach is characteristic of Germany's technical rulemaking and ensures that the multitude of ongoing activities, initiatives and projects in the field of hydrogen technologies related to standardization are integrated. In addition, duplication of work is avoided as a far-reaching standardization network is established at the European and international levels.

Funding accelerates standardization The basis for this was initially a joint analysis of the existing regulatory frameworks for hydrogen that can already be used in Germany, which is made publicly and freely available in a continuously updated database (see note at the end of the article). Building on this, a gap analysis was carried out to identify the necessary standardization needs, which were then consolidated into recommendations for action in a roadmap. These recommendations were developed in 40 working groups of the standardization roadmap in close coordination with experts from the relevant standardization committees. On this basis, the latter were able to apply to the BMWK for funding for the implementation of a standardization project. "A large number of projects only became possible thanks to this funding, which otherwise would not have been carried out at all or only with significant delays under normal circumstances," emphasizes DVGW staff member Klein.

In the meantime, 191 standardization projects have been launched and 312 recommendations for action have been issued. Sixty-nine so-called implementation projects received funding, of which six have already been completed. By the end of the year, it is expected that 27 implementation projects will be completed.

Of the 69 funded standardization projects, around 47 are at the national level, 14 at the European level and eight at the international level. Thirteen address the topic of production, eighteen infrastructure, eighteen application, fifteen quality infrastructure, and five continuing education, safety, and certification.

The concrete benefit of the standardization work lies in the fact that it is transparent and publicly accessible to all users. A standardization roadmap prevents duplication, builds on each other efficiently and in a coordinated manner, and defines the best state of information made possible by the exchange and sharing of knowledge among experts. For example, as a result of project funding, findings from German research on safety requirements for pressure vessels, pipelines, and components have been incorporated into the standards. This integration of national research into standardization is a hallmark of ▷

Project meeting for the standardization roadmap for hydrogen.

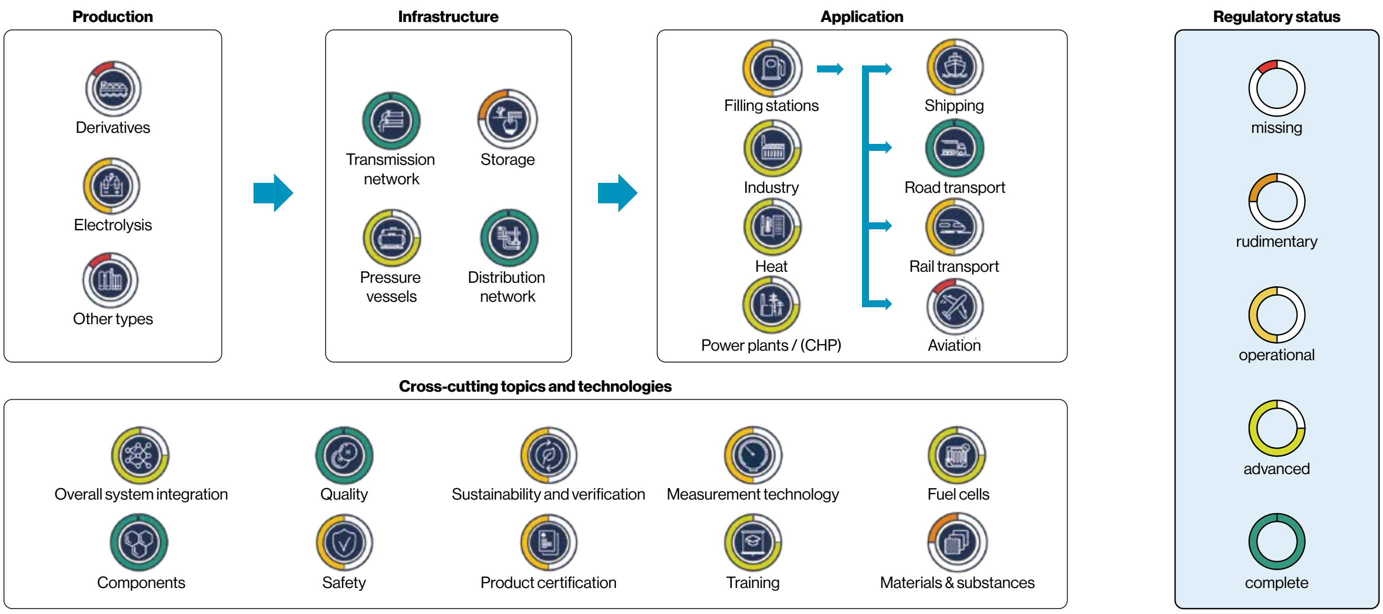
the German approach. This was made possible by funding experts who invested their time in this implementation.

"This will greatly accelerate coordination and hydrogen projects in the future," standardization expert Klein is certain. For example, in the case of pipeline networks, it will no longer be necessary to test every material individually for hydrogen suitability. A standard provides the assessment for the material to be used and replaces individual tests that previously took several days. This, in turn, reduces time and costs for each application and also facilitates the work of manufacturers such as steel producers. The background here is that standardized instructions for planning, construction, and maintenance are already available and also provide relief in the event of damage.

Valuable input from the Hydrogen Innovation Program Thanks to its expertise in the field of hydrogen, DVGW and its members in Germany have made a significant contribution of knowledge and helped to complete the H2 regulatory framework, says Klein. Thirty of the 69 implementation projects alone have benefited from this. Key regulatory frameworks, especially in the area of pipeline infrastructure, storage, and applications, fall under the responsibility of DVGW and its DIN Standards Committee NAGas.

Valuable input is provided here, among other things, by the DVGW Hydrogen Innovation Program, launched in 2020 in Germany with a budget of 15 million euros. Various findings from this program have been incorporated into the development of regulations and standards. Klein cites two examples: one is H2 safety, specifically hazardous areas at pipeline outlets to the atmosphere, in connection with the implementation project G 442 "Explosion Hazard Areas at Pipeline Outlets to the Atmosphere." The second concerns standardization projects on the molecular H2 tightness of valves as well as the H2 tolerance of valves in general and of shut-off valves in particular. These standards form the basis for the new DVGW technical bulletin G 405 "Conversion of Existing Valves to Hydrogen," which helps professionals convert existing systems to hydrogen.

National, European and international standards Depending on complexity and need for discussion, the development of a standard or regulatory framework takes between one and three years, expert Klein explains. In Germany, it is recognized that the need for coordination is usually greater at the European or international level. The first step is to define the right framework. For example, an electrolyzer is an international product and therefore requires an international standard. "With regard to exports, there is no point in writing a rule or standard just for Europe or Germany," Klein points out. The same applies to quality criteria for hy-



Development status of the technical regulatory framework for hydrogen technologies.

drogen. After all, hydrogen is not produced only in Germany, but throughout Europe and is also likely to be imported from around the world.

It is different in the case of infrastructure. With regard to the hydrogen backbone, Klein states: “This is a European project. Accordingly, we need European and national regulations here.” After all, there will be no hydrogen pipelines to China or the USA.

Internationally, DVGW sees Europe, and particularly Germany, as pioneers in hydrogen. An additional effect is expected from the standardization roadmap. “Thanks to this funding, Germany is in a position to take a leading role in European and international projects and to advance standards specifically in line with the National Hydrogen Strategy,” Klein emphasizes.

Focus also on training and continuing education

An important part of the standardization work is the topic of training and continuing education. This was addressed by Working Group 5 (Continuing Education, Safety, Certification) of the German standardization roadmap. Among other things, DVGW and its DIN Standards Committee NAGas are preparing a technical report. This is intended to help qualify professionals for the safe handling of hydrogen so that they are prepared for the transformation to a climate-neutral future with hydrogen. The insights gained are also to be reflected in DVGW's vocational training activities. DVGW’s vocational training branch in Germany already offers an extensive program of courses and seminars on hydrogen. These include, for example, the certification course “H2 Competence” or the “H2 Academy by DVGW”, which is run in cooperation with Siemens.

Overall, DVGW in Germany praises the efficient work within the framework of the “Standardization Roadmap for Hydrogen Technologies”. Of the total of 40 working groups, 35 have already completed their work, reports standardization expert Klein. The efficiency is also reflected in the total costs for the standardization project, which amount to just under 10 million euros. “Standardization is important, but it also has to be kept in a healthy balance,” Klein says. With regard to the sometimes high bureaucratic effort in the construction sector, he emphasizes: “A hydrogen economy must function safely, but at the same time must also be lean.” ○

Dennis Klein
Head of the standardization roadmap at DVGW

The North Sea as a Hydrogen Source for Europe

By Monika Rößiger

The core message of a new analysis by Aqua Ventus is that green hydrogen could be produced profitably right on the doorstep. It deals with the systemic integration of offshore wind energy and H2 production in the North Sea by the year 2045.

The Aqua Ventus (AV) initiative aims to build an offshore production capacity of 10 gigawatts (GW) for green hydrogen in the North Sea. To realize this large-scale project along the entire value chain – from production through transport to utilization – more than a hundred companies, associations, and research institutes have joined forces. They come from various sectors, from the gas and offshore wind industry to hydrogen production and maritime logistics.

The AV consortium sees itself as an industry-driven platform for the development and scaling of H2 production at sea. It includes several sub-projects, including infrastructure projects like Aqua Ductus, which envisions a hydrogen pipeline from the North Sea to Germany. Additionally:

- **Aqua Primus:** Pilot plants for offshore electrolysis
- **Aqua Campus:** Training and further education for specialists
- **Aqua Navis:** Development of hydrogen-powered ships for offshore use
- **SEN-1:** Pioneer projects for testing technologies under real conditions

The North Sea as an eco-power plant for Europe Through international networking with similar initiatives in neighboring countries, Aqua Ventus aims to create a European hydrogen economy throughout the North Sea region. This would significantly contribute to Europe's supply security, industrial competitiveness, and climate protection. The analysis now published by the European consulting firm Frontier Economics is related to the current spatial development plan (FEP). The responsible Federal Maritime and Hydrographic Agency (BSH) discusses a possible overplanting of offshore wind farms in zones 4 and 5 of the German North Sea. These zones are more than 300 kilometers from the coast and are referred to as the “Duck’s Beak.”

Current discussion on overplanting Specifically, it concerns whether the installed capacity of the wind farms may exceed the capacity of the power cables to the coast. This so-called “overplanting” would mean that not all generated energy can be transmitted during power peaks. However, since peak performance is rarely reached and larger amounts of electricity can be transported by cable through overplanting, the costs for grid connection would be reduced.

The focus of the investigation by Frontier Economics is on two scenarios: an expansion to 70 gigawatts (GW) according to the legal target and a more conservative scenario with 55 GW. Various technical configurations were examined for both: a baseline scenario with equally sized wind turbines and power cables and onshore electrolysis, an overplanting scenario with more turbine capacity than cable capacity and also onshore electrolysis, and thirdly, an offshore sector coupling with overplanting, offshore electrolysis, and hydrogen pipelines. The results show: The latter reduces grid integration costs the most.

Offshore sector coupling saves up to 1.7 billion euros annually “The combination of offshore hydrogen production and a hybrid line system for electricity and hydrogen leads to the lowest system costs in all scenarios examined,” explains Robert Seehawer, Managing Director of AquaVentus. “Compared to energy transport exclusively via power lines, around 1.7 billion euros per year can be saved on the 70 GW expansion path and 0.5 billion euros annually in the 55 GW scenario.” In contrast, electrical overplanting combined with onshore electrolysis would only reduce costs by 0.7 or 0.1 billion euros per year according to modeling.

More efficient use of infrastructure minimizes system costs Basically, it is cheaper to transport green electricity generated at sea far from the coast in the form of hydrogen via pipeline ▷

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EXPANSION TARGETS FOR OFFSHORE WIND AND ELECTROLYSIS

Germany plans an offshore wind capacity of 30 gigawatts (GW) by 2030. By 2040, it should be 50 GW and finally 70 GW by 2045. Parallel to this, an expansion of electrolysis capacity to 10 GW by 2030 is planned. Independent of these political goals, the discussion about overplanting and offshore electrolysis is in the context of how these goals can be achieved cost-effectively.

> "Overplanting is good, but sector coupling at sea is better. Expansion costs can be more effectively reduced through hybrid connection concepts."

Robert Seehawer, Managing Director of AquaVentus

Robert Seehawer (left) moderates a panel discussion on H2 production in the North Sea at the "Hydrogen Technology World Expo." © Monika Rößiger

to land than via high-voltage transmission. An analysis by the consulting firm E-Bridge in 2024 showed this. Alone, this would reduce the expansion costs for energy from the North Sea over a 25-year horizon by 31 billion euros.

"The study showed that overplanting is good, but sector coupling at sea is better. By this, I mean that expansion costs can be more effectively reduced through hybrid connection concepts," says Seehawer. However, it is most effective to consider both measures.

Therefore, the offshore electrolysis model is also worthwhile, even though the investments for it are higher than for onshore electrolysis. The option to flexibly use electricity or hydrogen depending on the market price increases returns in operation. Offshore wind farm operators then produce electricity and hydrogen in a market-integrated and profit-maximizing manner. Additionally, losses during electricity transport on the mainland decrease due to curtailment, which would otherwise have to be compensated by redispatch with fossil power plants – which is very expensive.

Robust against price and technology risks

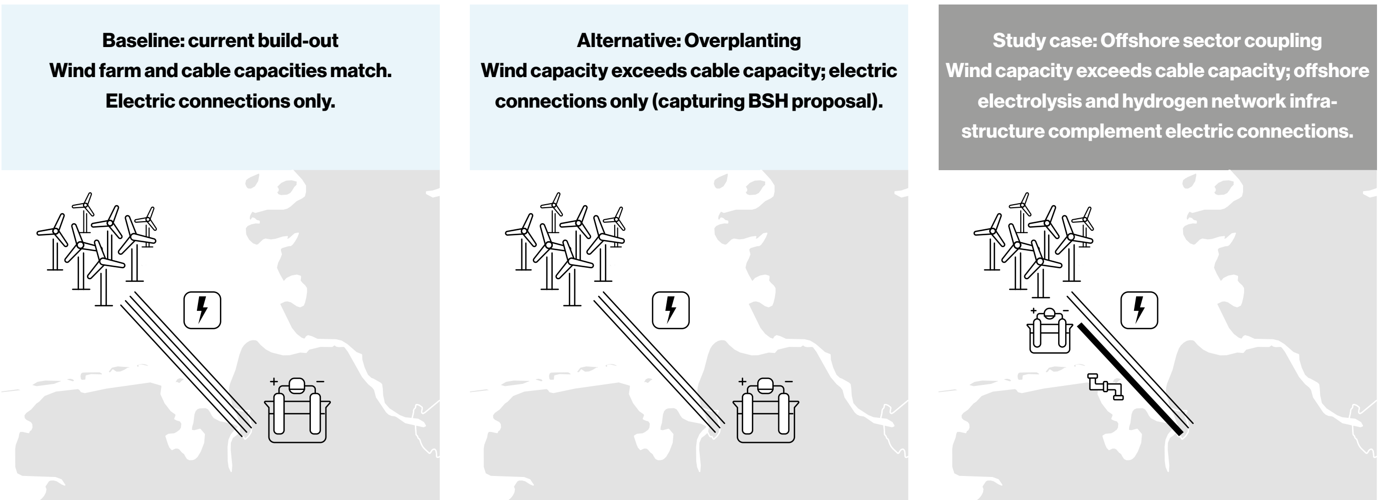
The advantages of offshore sector coupling remain even with changed price and model assumptions, according to another result from Frontier Economics. Even if offshore electrolysers were twice as expensive as their onshore counterparts, this configuration would still be profitable. And fluctuating electricity prices of ±20 percent or different electrolyser capacities would not change the economic advantages of this concept according to the analysis. These could be further optimized if the project duration were extended from 25 to 35 years. According to Frontier Economics, this could reduce system costs by around another seven percent.

Legal and planning adjustments necessary

"To exploit the potential of offshore sector coupling, however, regulations must be adjusted," says Robert Seehawer. "This primarily includes a change in the Offshore Wind Energy Act (WindSeeG) so that offshore electrolysis can be combined with overplanting." So far, the either-or principle applies: The BSH prescribes to offshore wind farm operators whether they should connect to a power or hydrogen line. Combined grid connections are not yet possible. Significant synergy potentials would result from this: The grid expansion could be correspondingly smaller and cheaper and also implemented faster.

Aqua Ventus proposes treating offshore electrolysis equally by law and giving offshore wind developers the opportunity in the spatial development plan (FEP) to reduce economic system costs and increase their own returns through combined electricity and hydrogen production.

In addition to the economic and resilience benefits that building a pipeline compared to power lines in the North Sea would have, there is also the issue of nature conservation. In the long-overused habitat of the North Sea, fewer interventions in the marine environment would be necessary. This is certainly desirable: After all, the entire European Wadden Sea from Denmark through Germany to the Netherlands is considered a World Heritage Site. ○



All configurations assume identical capacities for wind farms and electrolysis. In the "Baseline" and "Overplanting" scenarios, the electrolyser is located on the coast, whereas in offshore sector coupling it is near the wind farms. © Frontier Economics

Risen from Ruins

By Monika Rößiger

Even if it sometimes looks like there has been an earthquake at the site of the former Moorburg coal power plant, the construction of the Hamburg hydrogen factory is progressing as planned. From the second half of 2027, 10,000 tons of green hydrogen are to be produced here annually.

LEFT: At the former Moorburg coal-fired power station, old facilities are being demolished to make way for an H2 factory.
© Monika Rößiger

RIGHT: View into a gas pressure control station for the decompression of hydrogen.
© Monika Rößiger

Relentlessly, excavators rumble over an area of about 16,000 square meters, tearing down one concrete wall after another. They are preparing the ground for a major transformation: the construction of a 100 MW electrolysis plant. In Moorburg, where the first steam engine of the Hanseatic city stood in 1911, one of the first large electrolysis projects in Germany is being created today with the Hamburg Green Hydrogen Hub (HGHH). The foundation stone was laid on December 1, 2025. From the second half of 2027, 10,000 tons of green hydrogen are to be produced here annually.

From Coal Power Plant to Hydrogen Factory The operators Hamburg Energie and Luxcara are relying on PEM electrolysis, where the green gas is produced at atmospheric pressure and then compressed to 25 to 30 bar. The stacks for the electrolysis plant are manufactured at Siemens Energy's gigafactory in Berlin and assembled at the Mülheim site in North Rhine-Westphalia, explains Christoph Cosler, Head of Corporate Development at Hamburger Energiewerke and HGHH Managing Director. “A separate hall is being built for the new plant, where electrical technology and the gas side are cleanly separated.”

From Past to Future Previously, the distinctive structures of the coal power plant, including the almost 140-meter-high twin chimney and the two boiler houses, were demolished. Nevertheless, the operators assure that as much of the existing infrastructure as possible will continue to be used. For example, the 380-kilovolt connection will be retained, and the water treatment will be converted for Elbe water for electrolysis.

In mid-October this year, HGHH commissioned the Munich-based company Kraftanlagen Energies & Services to implement the so-called balance-of-plant infrastructure for its electrolyser. This includes, among other things, power distribution, water treatment, cooling and compressor stations, as well as the connection to the hydrogen network.

Flexibility is at the heart of the concept Additionally, a truck loading station will be built. According to HGHH, this provides additional flexibility in the transport of hydrogen, as not only potential industrial customers in the port but also filling stations and commercial enterprises can receive the certified green gas if needed.

Since no stationary hydrogen storage is planned, trailers serve as mobile buffer storage. Each trailer holds one to two tons of hydrogen at a pressure of 380 to 500 bar. A 10–20 megawatt battery storage is intended to provide additional flexibility. The hydrogen reaches a trailer loading station via a pipeline and then continues to the gas transfer station for the Hamburg hydrogen industrial network HH-WIN. ▷

THE “HAMBURG GREEN HYDROGEN HUB”

The HGHH is an Important Project of Common European Interest (IPCEI) of the EU. The federal government and the state are funding it with more than 154 million euros. The city of Hamburg repurchased the Moorburg power plant from its former owner Vattenfall due to a referendum. The Hamburger Energiewerke are 100 percent owned by the Hanseatic city.

Use in the Port, Industry, and Mobility It is, of course, regrettable that Arcelor Mittal is not initially converting its wire rod mill in the Port of Hamburg to hydrogen, despite an existing direct reduction plant, admits Cosler. "But there are other steelworks in Germany that will need green hydrogen."

The connection of the Hamburg hydrogen factory to the European Hydrogen Backbone is also planned for 2027. "From 2030, we see an immense demand for green hydrogen," says Cosler. "Not only in the Port of Hamburg but throughout Germany." Therefore, he also assumes that the already planned scaling of the electrolysis plant will be realized; up to 800 MW are possible according to the current state.

The Hamburg Hydrogen Industrial Network (HH-WIN) forms the basis for the future H2 infrastructure of the Hanseatic city. "By 2027, the first expansion stage of 40 kilometers is to be completed," reports project manager Elisabeth Ziemann from the Hamburger Energienetze. Then the operation and the linking of local and regional markets will start. By 2031, the network is to be expanded to 60 kilometers.

The water treatment plant at the Moorburg site will be retained and used for the electrolyser in the future. © Monika Rößiger

The first phase is already under construction It includes 33 kilometers of new construction and seven kilometers of converted existing lines. These were previously cleaned with so-called magnetic resonance and ultrasonic pigs and checked for their condition. A former power plant line also proved to be well-suited for hydrogen transport. The use of existing lines reduces both investment costs and the necessary construction work.

The diameter of the pipelines varies between 200 and 500 millimeters at pressure levels of 25 or 70 bar. Over a distance of 4.5 kilometers, hydrogen and power lines are currently being laid together to minimize the impact on nature conservation and residents.

1.4 million tons less CO2 per year The decarbonization potential of HH-WIN is significant: Currently, according to Ziemann, 15 to 21 terawatt-hours of natural gas are transported through the network. About a third of this could be decarbonized, saving 1.4 million tons of carbon dioxide annually. The targeted connection of energy-intensive companies in the Port of Hamburg supports the city on its way to climate neutrality.

"Hamburg Future Decision" In October 2025, the people of Hamburg voted to bring forward the city's climate neutrality by five years, now to 2040. "This decision poses great challenges for the Hamburger Energienetze, but also for construction companies and trades," says Bernd Eilitz, spokesman for the Hamburger Energienetze. Now it is important to explore all possibilities to further increase the already high pace of network expansion.

If households are to do without gas heating from 2040, the power infrastructure must be expanded by then so that electric heat pumps can be used everywhere where there is no connection to the district heating network. The referendum, however, has no impact on HH-WIN due to its already earlier commissioning.

European Integration The Hamburg industrial network is also part of the IPCEI projects of the European Union and will be connected to the German hydrogen core network and the European Hydrogen Backbone. This allows Hamburg to feed the green gas into the core network and also draw from it. European integration also facilitates the import and export to and from Northern and Southern Europe and overall strengthens the security of supply on the continent. ○

CAPACITY RESERVATIONS IN PREPARATION

Industrial customers can reserve the required capacities for their future connection from the beginning of 2026 and thus gain planning security. A fee is charged for reservation contracts, which is later offset against the core network fee to be paid for the actual capacity booking.

RIGHT: The cation exchanger is part of the water treatment plant. Elbe water will later be converted into high-purity water for the electrolyser there. © Monika Rößiger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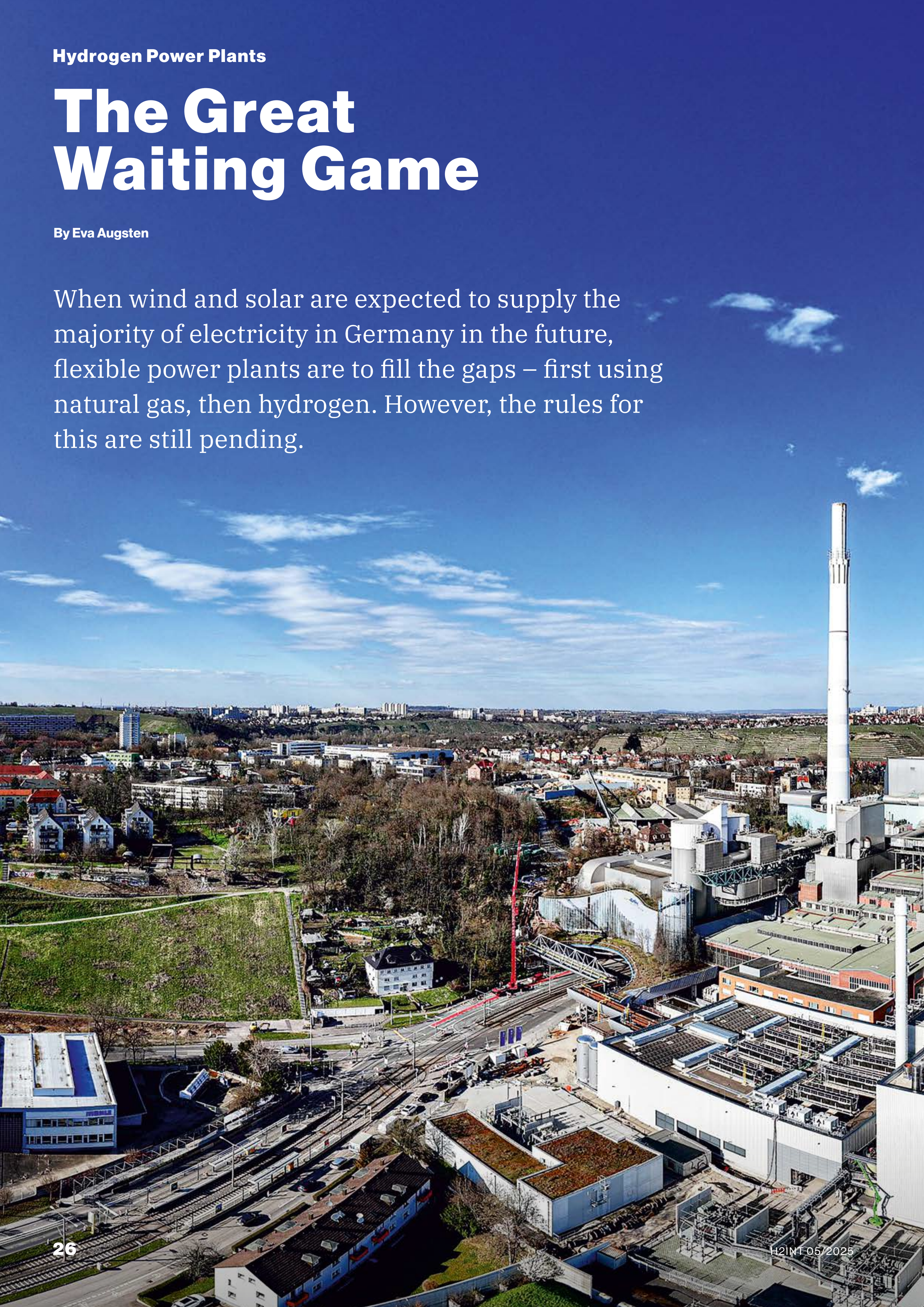
Hydrogen Power Plants

The Great Waiting Game

By Eva Augsten

When wind and solar are expected to supply the majority of electricity in Germany in the future, flexible power plants are to fill the gaps – first using natural gas, then hydrogen. However, the rules for this are still pending.



The new H2-ready fuel-switch power plant by EnBW in Stuttgart-Münster is already in operation. © EnBW

They have reached an agreement. In mid-November, the German government, made up of the Social Democratic Party (SPD) and the Christian Democratic Union (CDU), announced that it had produced a joint results paper on the national power plant strategy. Ten gigawatts of new power plant capacity are to be built quickly, and all plants are to be made convertible to hydrogen in the future.

The agreement was long overdue. Germany urgently needs quickly available power plant capacity. Even after the agreement, the goal of actually launching tenders for this in early 2026 remains extremely ambitious. Here are the main threads of the debate on Germany's power plant strategy, which has been ongoing for many years.

Why have a power plant strategy at all? At the end of the previous coalition government, which consisted of the Social Democratic Party (SPD), Alliance 90/The Greens, and the Free Democratic Party (FDP), in November 2024, there was a draft bill from the Federal Ministry for Economic Affairs and Climate Action of Germany (Bundesministerium für Wirtschaft und Klimaschutz) for the so-called Power Plant Security Act, abbreviated as KWSG. The idea of minister Robert Habeck (Alliance 90/The Greens) was: gas-fired power plants that can be converted to hydrogen in the future are to serve as backup for electricity generation from wind and solar. In a liberalized electricity market, however, such gas-fired power plants have ▷

been an unpopular business model for decades. Whenever wind and solar power are abundantly produced, they are also inexpensive and push gas power plants out of the market. Gas power plants would therefore have to finance themselves with fewer and fewer operating hours, since only generated electricity is traded on the electricity market and not capacity held in reserve – so capacity is really not profitable here. This brings existing gas power plants to the brink of economic viability, not to mention new builds. The problem has been known for well over ten years, and many experts have been calling for a so-called capacity market. This means that the government tenders secured capacity and offers power plant operators a kind of basic income for keeping their plants available.

The draft bill from the ministry under Robert Habeck was the first legislative initiative to address this problem. Various technologies were to be allowed to compete. A requirement, however, was prospective climate neutrality – so for gas-fired power plants, it was essential from the outset that they could be converted to hydrogen. In total, 12.5 gigawatts of power plant capacity were to be secured in this way. Legal questions regarding state aid with the European Union had, after lengthy preliminary talks, been largely resolved. The German Association of Energy and Water Industries (BDEW) therefore called for this draft law to be used as a basis, even though some changes would still be necessary from the perspective of power plant operators.

What changes with Katherina Reiche?
The Federal Ministry for Economic Affairs and Energy of Germany, now under Katherina Reiche of the CDU, initially assumed that Germany needs not 12.5 gigawatts of flexible power plant capacity, but 20 gigawatts – explicitly in the form of gas-fired power plants and despite a lower projected electricity demand than before. She is relying on a "pragmatic" approach, as she emphasizes. This means: first, the power plants should be built; whether and how they can be converted to hydrogen will be decided later. However, this resets the state aid discussion with the EU to zero, because the EU requires technology and climate neutrality.

Reiche initially relied on a "fast-track program" with direct subsidies for five to ten gigawatts of power plant capacity. She was quoted in business media as saying that the EU had given positive signals for "significantly more than half" of the planned 20 gigawatts. In mid-November, the coalition committee then agreed on the ten gigawatts and on making the power plants hydrogen-ready. What the EU will say about this is not yet known, and the concrete tender rules are also still outstanding.

First H2-ready power plants from EnBW
Various power plant operators are already planning, building, and operating gas-fired power plants that could at least partially be fired with 20 to 30 percent hydrogen, if it were available.

In October 2025, EnBW put one of the first hydrogen-capable gas turbine power plants in Germany into commercial operation in Stuttgart-Münster. In southern Germany, secured generation capacity is particularly urgently needed, as there is both high energy demand from industry and little wind power generation. The reason EnBW took the investment risk, even though

ABOVE: With up to 50 percent, the possible hydrogen share in the planned gas-fired power plant in Voerde is particularly high.
© RWE

BELOW: Economics Minister Katherina Reiche visiting LEAG in August: tenders for early 2026 promised
© LEAG

the Power Plant Security Act is not yet complete, is also due to another subsidy – the Combined Heat and Power Act of Germany (Kraft-Wärme-Kopplungsgesetz). Under this scheme, the company received a grant. This "fuel switch" alone is expected to reduce CO2 emissions by 60 percent.

This is not only for Stuttgart-Münster, but also for replacing the coal-fired power plants Altbach/Deizisau and Heilbronn. Together, all three are to provide a generation capacity of around 1.5 gigawatts. Strictly speaking, Stuttgart-Münster is not a standalone gas-fired power plant, but rather an addition to a waste incineration plant, which was previously supplemented by three coal-fired boilers. The new facility is to deliver 124 MW of electrical and 370 MW of thermal output. EnBW is targeting the switch to hydrogen for the second half of the 2030s. For this, changes to the gas turbine's fuel supply as well as a complete hydrogen logistics system would of course be necessary.

The other two hydrogen-capable power plants from EnBW are not as far along. Construction in Altbach-Deizisau has been underway since November 2023, with completion currently scheduled for the first quarter of 2027. In Heilbronn, construction began in February 2024, with commissioning planned for the second half of 2027. All three plants also supply heat and are therefore subsidized under the Combined Heat and Power Act of Germany.

Hamburg: CCGT power plant scheduled to go into operation in 2026 The municipal energy supplier Hamburg Energiewerke are also under considerable time pressure. They are currently building a new combined gas and steam turbine plant in the port area. This plant is to be able to burn up to 30 percent hydrogen. If higher shares are required in the future, adjustments are to be made as part of normal "product maintenance" during routine overhauls.

Hamburg's decision to build the hydrogen power plant was also driven by political pressure. Amid fierce controversies and two citizens' initiatives, one of which went to a referendum, the people of Hamburg secured the conversion of the district heating network.

The new hydrogen-capable power plant is to replace the dilapidated Wedel heating plant, which is now only operating with special exemptions. However, as it is essential for district heating supply in the west of the city, it must keep running until the replacement is complete – including a new pipeline under the Elbe to bring heat from the port into the city. Construction work, including on the pipelines, is in full swing.

The power plant is to receive funding under the Combined Heat and Power Act of Germany (KWKG), just like the EnBW plants. It is still unclear whether and to what extent a capacity market will be relevant, as the plant is to be operated based on heat demand and is intended to have the shortest possible operating hours in order to give priority to renewable heat sources – at least, that is the current plan. This is also reflected in the performance data: the electrical output is only 180 MW, while the plant can supply up to 290 MW of heat. This also includes a power-to-heat system, which generates heat from electricity when there is an abundance of power on the market. Since electricity and heat generation are not always needed at the same time, a heat storage unit with a capacity of 50,000 cubic meters of water is also planned.

According to Hamburg Energiewerke, the CCGT plant is now 85 percent complete, even though installing some pipelines has proven to be more laborious than expected. To ensure completion by the end of 2026, 100 additional fitters have been deployed, according to the municipal energy supplier.

RWE wants to make Voerde site a hydrogen hub RWE, one of Germany´s largest utility companies and mainly active in the federal state of Northrhine Westphalia, is working on three projects. They would like to build a hydrogen-capable gas power plant at their existing site in Werne-Stockum, but the project is on hold. The plan is for 800 MW of electrical output, up to 50 percent of which could be produced from hydrogen. The permitting process is complete, according to the press release. In another town, Weisweiler, RWE also announced in 2023 that it had begun the permitting process. At the end of October this year, RWE also announced its intention to reactivate their Voerde power plant site. Until 2017, a hard coal power plant operated by STEAG was in operation there, but it was no longer profitable. RWE took over the site in 2021 to develop hydrogen projects there. An announcement from 2023 mentioned a 400 MW electrolyzer. Now, a new gas-fired power plant is being discussed, with 850 MW of capacity and also up to 50 percent hydrogen-capable. In 2024, RWE commissioned an American-Spanish consortium consisting of GE Vernova and Tecnicas Reunidas to handle planning, and the permitting process "based on proven technologies" is complete. According to current plans, the plant in Voerde could start producing electricity in 2030. RWE is determined to participate in the German government's tenders – and is calling on the government to announce the conditions.

LEAG pushes for decisions on Schwarze Pumpe & Co The Lausitz Energie Kraftwerke AG (LEAG) also wants to make its Schwarze Pumpe site ready for the energy transition. Schwarze Pumpe is one of the largest lignite energy generation sites in Germany. A hydrogen-capable gas power plant with up to 850 MW could be built here, based on the existing infrastructure of the large coal-fired power plant. By 2030, 3,000 MW of coal-fired power plants are to be taken offline. This will only work if the secured capacity is replaced.

New build projects for H2-ready power plants with a combined capacity of around 2,000 MW are planned for the Schwarze Pumpe, Lippendorf, and Leipheim sites. Some of these already have partial permits, press spokesman Thoralf Schirmer explained upon request from H2international. However, he said no more detailed technical information could be provided yet.

"Now it is up to policymakers to resolve the investment backlog for future power plants with clear regulations and fair tender conditions," said Adi Roesch, chairman of the board of LEAG, during a visit by Reiche to the Schwarze Pumpe power plant site. Reiche assured that "a significant share of the planned 20 gigawatts of gas power plant capacity will be put on the market and auctioned off this year." This announcement remained the status quo as of early November, the editorial deadline for this issue.

Of course, the power plants can only run on hydrogen if it is available. Economics Minister Reiche has already stated in connection with the energy transition monitoring that the core network and import corridors should be built up step by step and depending on demand – which she, in turn, does not particularly want to accelerate. In any case, the technology and the power plant operators would be ready. ○

Green iron even from low-grade ores

By Jens Peter Meyer

The climate-friendly production of iron and steel is expected to become an important application area for hydrogen. The Finnish company Metso is introducing a technology that also enables the reduction of lower-grade iron ores with hydrogen.

In order to turn iron ore into iron, the oxygen must be removed from the ore – a process known in chemistry as the reduction of iron. The classic method for this is the blast furnace. Pure carbon removes the oxygen from the ore, producing iron and CO2. The alternative is so-called direct reduction in a shaft furnace, as operated by Arcelor Mittal for many years in Hamburg, Germany using natural gas. In several steps, hydrogen and carbon monoxide are first produced from the natural gas, and then these gases remove the oxygen from the ore. Since natural gas contains carbon, CO2 is also produced during direct reduction with natural gas – although significantly less than in the blast furnace process. If green hydrogen were used instead of natural gas, CO2 emissions could be reduced even further.

While Arcelor in Hamburg, Germany, decided after much back and forth against iron production with green hydrogen, the company Stegra is currently building such a plant on an industrial scale in northern Sweden. So far, the shaft furnace process has only been used for iron-rich ores. For ore with lower iron contents, direct reduction in a circulating fluidized bed is considered an economically attractive alternative.

The Circored pilot plant in Frankfurt, Germany is intended to produce sample material on a ton scale for potential customers © Metso

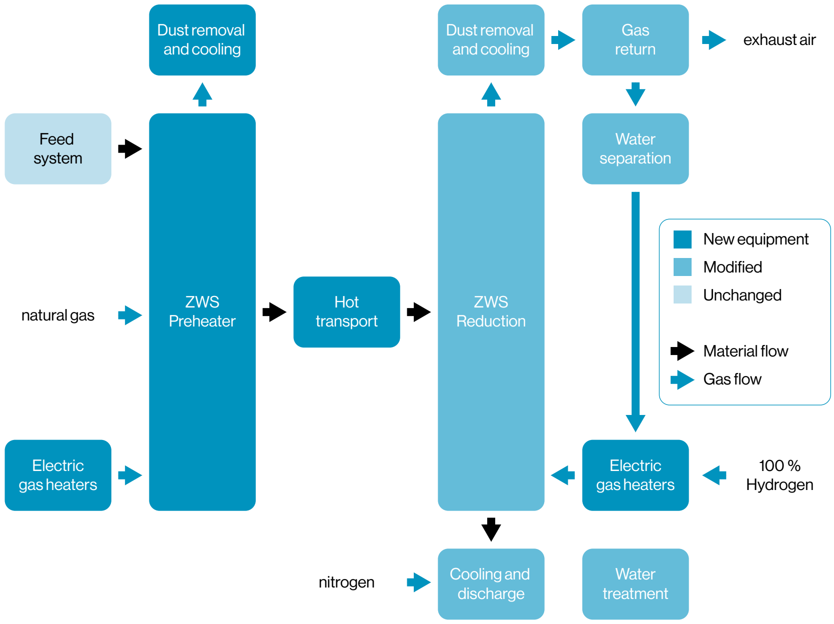
Many ores contain too little iron for shaft furnace processes. Metso, a Finnish manufacturer of metal processing technologies, inaugurated a so-called Circored pilot plant in Frankfurt am Main, Germany in September. The pilot plant for iron production is based on a circulating fluidized bed (CFB). Compared to the shaft furnace process, the CFB process offers an important advantage. It can also process iron ores with an iron content of less than 60 percent, which, according to Sebastian Lang, head of research and development in Metso's "Ferrous and Heat Transfer" division, is not common in the shaft furnace process. About 95 percent of the world's iron ore deposits contain only lower iron fractions, so the CFB technology could be a key to decarbonizing the steel industry, according to Metso.

In addition, the CFB process is said to be able to process fine ore directly, which arises in mining after ore preparation. Pelletizing, as is common in traditional steel production, is not required. On the contrary, particle sizes of less than 2 millimeters are well suited for fluidization in a gas medium. In the fluidized bed process, nozzles ensure that the fine material is kept in a turbulent flow and circulates through the reactor. It is a continuous process in which fresh material is constantly fed in and reduced iron ore is removed. The residence time determines the degree of reduction. About 30 minutes are sufficient.

Process requires heat supply. In contrast to ore reduction with CO, direct reduction with hydrogen is an endothermic process. Therefore, a large amount of heat energy must be supplied. In Metso's CFB process, the fine ore is first preheated to about 900 degrees Celsius. In this CFB reactor, combustion in addition to electric gas heaters introduces extra heat into the process. This also leads to oxidation of the iron ore. This is necessary, for example, with the ore magnetite. “Magnetite is not very reactive,” says Lang. “The dense mineral structure means that hydrogen cannot penetrate well.” Therefore, preheating converts the ore into the fully oxidized and more reactive form of hematite.

Pilot plant receives no hydrogen. In the pilot plant, natural gas and not hydrogen is used for preheating. This is not due to process technology but to availability at the Frankfurt location in Germany. Because there are difficulties in obtaining sufficient hydrogen, Metso is focusing on the core process in the reduction reactor. In this step, reduction of the preheated material takes place in the circulating fluidized bed at about 650 degrees Celsius. The pig iron produced in this process has a metallization degree of about 80 percent. The shaft furnace achieves 95 percent.

Further processing into steel in the smelter. Therefore, further reduction must take place during the processing of iron into steel. This is not possible in the electric arc furnace, the melter. In addition, current electric arc furnace technology is not able to separate the large amounts of slag that occur with ores of low iron content. However, a new technology is currently being introduced. A so-called smelter can further reduce the pig iron, separate the impurities present via the slag, and enrich it with carbon. SMS Group from Mönchengladbach, Germany, a manufacturer of lines for metal processing, is currently building such a smelter in Duisburg, Germany, for Thyssenkrupp to process directly reduced pig iron from the shaft furnace. Metso also has smelter technology in its portfolio. For the first quarter of 2026, it is planned that SMS Group will take over Metso's metals division and combine the development work on technologies for green steel under one roof.



Flow diagram of the Circored pilot plant: The fine ore first passes through the CFB preheater before being transferred in a hot state to the actual CFB reduction reactor. © Metso

Pilot plant is intended to convince customers. Metso developed the CFB technology in the 1970s and has long used it for various material processing applications. For iron production, the company already built a demonstration plant in Trinidad at the end of the 1990s with a production capacity of 0.5 million tons of iron per year. Plants with an annual production of 1.25 million tons are now technologically mature, according to Lang. So why a pilot plant? The pilot plant in Frankfurt is intended to gain further experience with the electric heaters. The actual purpose, however, is to produce sample material on a ton scale. Potential customers can use this to test whether the pig iron is suitable for further process steps, such as melting furnaces.

Economic viability within reach. The first Circored plant in Trinidad was not able to establish itself on the market and was shut down, even though the plant built by Metso was able to achieve stable operation. The production capacity was too low for economic operation under the conditions at that time. Whether the CFB technology has a chance in the market depends largely on CO2 pricing and the price of hydrogen. If the CO2 price rises in the coming years as expected and hydrogen costs as much as current estimates predict, the CFB technology would be as expensive as traditional iron production in blast furnaces, according to Metso. Compared to the shaft furnace, it is even said to be significantly cheaper, since the cost for the pelletizing step can be eliminated. This has been demonstrated by calculations from Metso. In addition: “We are very efficient in hydrogen utilization,” says Lang. This can also be an advantage for the new process, as long as the cost and availability of hydrogen remain a bottleneck for carbon-free technologies. ○

Jens-Peter Meyer
Jens-Peter Meyer holds a doctorate in chemistry and is a freelance journalist. He has been reporting for over twenty years for technical publications on topics related to the energy transition and climate protection.

Hydrogen region H2Ostwürttemberg

Skeptics not wanted

By Leonhard Fromm

In the town Schwäbisch Gmünd, the currently largest hydrogen production facility of the French company Lhyfe began operation in October. The prominent guests from the state government who attended the event demonstrated their determination to drive the technology forward.

Matthieu Guesné, founder and CEO of Lhyfe, explains to the distinguished guests how hydrogen is produced from electricity here. © Lhyfe

Baden-Württemberg's State Premier Winfried Kretschmann does not want "skeptics" when it comes to green hydrogen. © Lhyfe

The plant in Schwäbisch Gmünd, inaugurated by Winfried Kretschmann (Green Party), Minister-President of the Federal State of Baden-Württemberg in the Southwest of Germany, on October 14, can produce up to four tonnes of hydrogen per day. However, the 30-million-euro facility, funded with 4.3 million euros from the EU and 2.1 million euros from the state, is still in the ramp-up phase. This is due not only to technical coordination in the initial phase but also to demand, which is only gradually increasing. The heart of the 10 MW facility is the electrolyzer, which receives its electricity from the public grid. Certificates ensure that the electricity is generated from renewable sources and that the hydrogen is therefore "green." Four tonnes of this are enough to allow 100 trucks to travel 400 kilometers each.

The operator is Lhyfe, founded in France in 2017 and listed on the stock exchange. The company has already realized three facilities in its home country and now operates its first German site on one hectare in the Ostalb region, built from containers, each with five stacks.

Until the facility is expected to be connected to the supra-regional natural gas network in 2032, customers from the mobility and industrial sectors as well as suppliers of this fuel cell technology will be supplied by trailers. H2 Mobility, the operator of hydrogen fueling stations nationwide, intends to supply its planned stations in southern Germany with energy from Gmünd, explained Pascal Louvet, Head of Sales for Lhyfe Germany, during a press tour before the inauguration. In the long term, the site in East Württemberg is also expected to feed into the hydrogen core network, which is to be established from 2032.

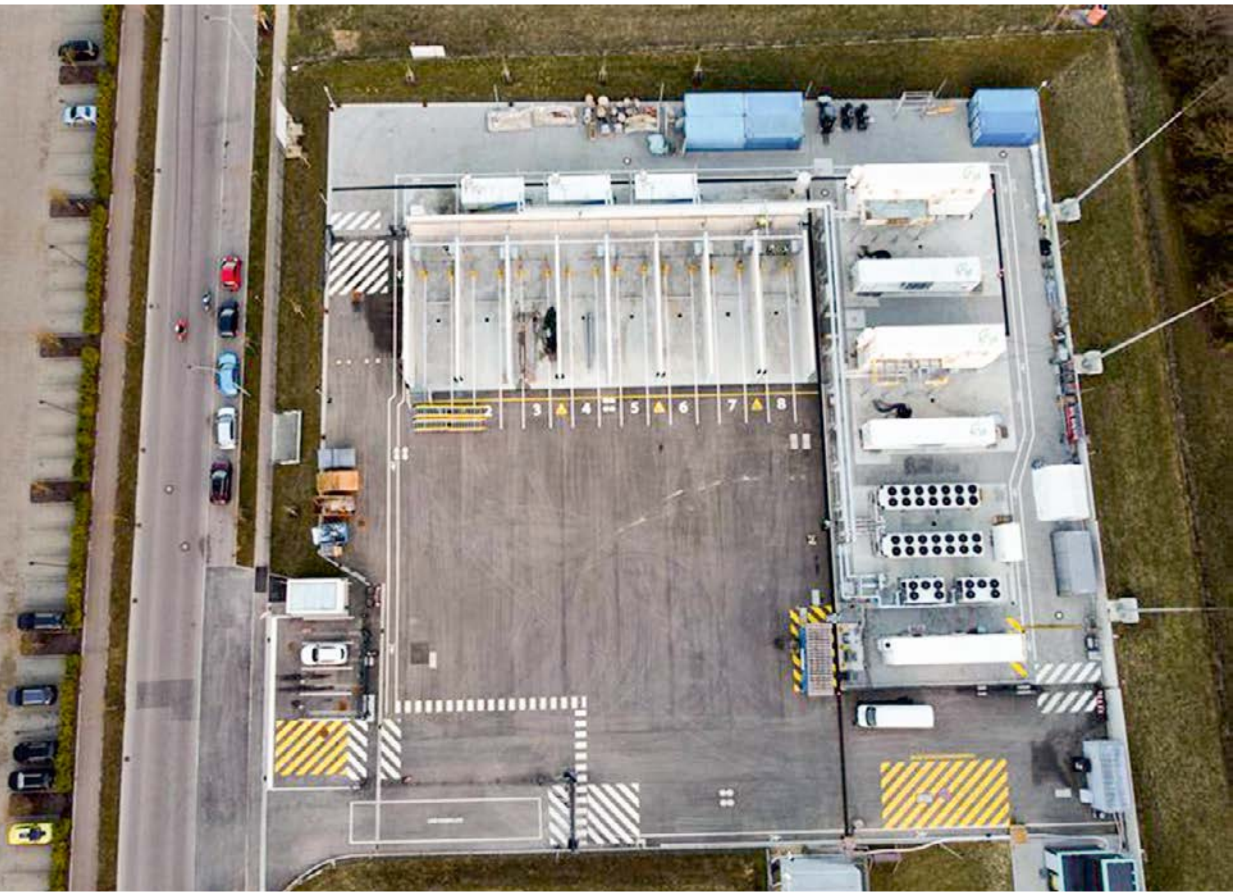
Approval at record speed Potential customers in the region would then include energy-intensive companies such as Schwenk Zement in Herbrechtingen, the Palm paper mill in Aalen, and a district heating network in Ellwangen. At full capacity, Lhyfe aims to produce hydrogen at a price "significantly below ten euros" per kilogram. Since revenues from CO2 certificate trading could be taken into account, this alone would reduce the price by three to six euros, according to Louvet. The basis for this is the RFNBO certification (Renewable Fuel of Non-Biological Origin) of the Gmünd plant.

The sales manager: "Our green hydrogen is particularly a CO2-free alternative to gray hydrogen and fossil natural gas in the chemical, steel, and glass industries." Schwäbisch Gmünd's Lord Mayor Richard Arnold (CDU) is hoping the facility will attract such companies to the planned industrial park "H2-Aspen," which is also to have a hydrogen fueling station. Arnold expressly praised those responsible at the Stuttgart regional authority, who approved the facility in just four months in accordance with the German Federal Emissions Control Act, "for which there was no precedent." This gives hope for the transformation that the country urgently needs.

Minister-President Kretschmann also praised the facility as a "lighthouse project" that had been significantly supported by the H2-Wandel association in Ulm and the Center for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW), also in Ulm. Kretschmann: "It takes courage and pioneers like the partners involved here to get the hydrogen economy up and running." The political sphere provides the legal framework and funding, "but we do not need skeptics."

Nationwide, electrolysis capacity is currently at 170 MW. In Schwäbisch Gmünd alone, a further 10 MW is being added. The state will invest another 125 million euros in electrolyzers.

Environment Minister Thekla Walker (Green Party) added: "Hydrogen production is industrial policy, because we need a resilient energy supply and technological leadership in this field." China is moving at a rapid pace in this area, but with Lhyfe, the southwest has a strong French partner. Nicolas Gibert-Morin from Brussels recalled decisions made in 2020 that the EU wants to produce ten million tonnes of hydrogen annually by 2030. The funding, as in Gmünd, would directly benefit the municipalities. ▷



The containers for actual hydrogen production require little space – above all, the trailers for transporting the hydrogen must be able to maneuver on site. © Lhyfe

Just the beginning "Gmünd is only the beginning of Lhyfe in Germany," company founder and CEO Matthieu Guesné called out to the audience. Of around 200 Lhyfe employees, 30 are active in Germany, not only at the headquarters in Cologne but also distributed across the country. What motivates him, Guesné says, are his children – they have a right to a future worth living.

In France, the company already operates three facilities at onshore and offshore wind parks. Currently, Lhyfe operates 70 trailers to supply its 50 customers. Each trailer holds between 380 and 1,000 kilograms of hydrogen, depending on the pressure level. The company is building additional onshore and offshore sites in Europe and aims to establish itself as a major hydrogen producer.

In Lubmin, in the Federal State of Mecklenburg-Vorpommern, the French are planning an 800 MW project on the site of a former nuclear power plant, which is to be connected to the future European hydrogen network. Other sites are planned in the Saarland for a steelworks and in Lower Saxony at a port for refueling ships.

Before the electrolyzer could be put into operation in the southwest, the hydrogen region H2Ostwürttemberg carried out some preliminary work, also with the help of HyLand funding from the National Organization Hydrogen and Fuel Cell Technology (NOW), which belongs to the Federal Ministry of Transport.

In a 2022 survey, 40 companies in East Württemberg reported an annual demand totaling 200,000 tonnes of hydrogen. This corresponds to an energy quantity of 7 TWh. The main customers would therefore be the Palm paper mill in Aalen and Schwenk Zement in Heidenheim.

The South German Natural Gas Pipeline (SDL) crosses the district of Heidenheim; it is to be H2-compatible from 2032. In parallel, a regional distribution network is being built, 84 kilometers long and costing up to 185 million euros. To make all this viable, the offtake volumes must be organized via H2Ostwürttemberg. The state, federal government, and EU must co-finance the network expansion. The decision that the 60 billion euros from the coronavirus aid package cannot be used for climate protection has not made this any easier.

Nevertheless, progress continues. In the HyLand program, the H2Ostwürttemberg region has completed vision development as a "HyStarter" and planning as a "HyExpert." It is now in the third and final phase. As a "HyPerformer," it continues to receive grants from NOW, which now no longer flow into plans but into the actual implementation of the projects. ○

Comparison of utilization pathways

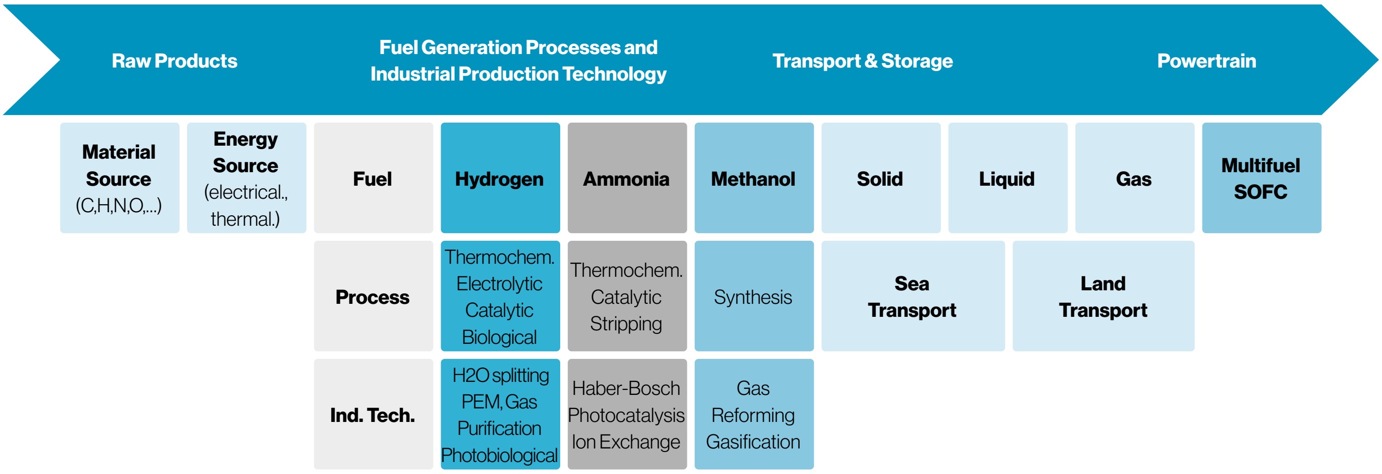
By Jana Reiter, Christoph Höfer

Ammonia, methanol and hydrogen – all of them can serve as fuels for solid oxide fuel cells. However, comparing the key figures of fuel and technology pathways has so far proven difficult. The EU project Fuelsome aims to change this.

Container ships could become an application area for SOFC fuel cells in multi-fuel operation.

Global maritime trade is increasing. In 2018, shipping already accounted for around 2.9 percent of anthropogenic greenhouse gas emissions, with a rising trend. To date, more than 99 percent of the international shipping sector's energy demand is met by petroleum-based fuels. As a climate-friendly propulsion technology, the solid oxide fuel cell (SOFC) is particularly promising for container ships. It operates with ammonia, methanol or hydrogen – the latest models can even switch between these fuels. However, it is still unclear what concrete usage pathways will look like. Consequently, the basis for statements on key figures such as costs, greenhouse gas emissions, overall process chain efficiency, land requirements and technology readiness level is also lacking. The EU project Fuelsome has defined possible future supply pathways for alternative fuels to facilitate this.

The Fuelsome project as a whole comprehensively investigates and develops a multi-fuel system with SOFC fuel cell, with the aim of reaching technology readiness level 4. A total of eight international partners are involved: the technology group AVL List, the research consortium Atena Scarl, the software company eBOS Technologies Ltd, the fuel cell manufacturer Elcogen Oy, the Technical University Politechnika Warszawska, the Zurich University of Applied Sciences and the Austrian research institute AEE Intec. AEE Intec is investigating how the key performance indicators (KPIs) of the usage pathways can be made comparable. ▻



Structure diagram as a framework The first part of the project has now been completed. The initial results are comprehensive structure diagrams that serve as a framework to investigate specific fuel pathways. They were created in an iterative and transdisciplinary process. The representation begins with the question of where the feed stock for fuel production comes from – in the physico-chemical sense, these are chemical elements such as carbon, hydrogen, nitrogen. The subsequent process steps are then processed: transport, storage and provision. Each usage pathway ends with the generation of propulsion energy on the ship, thus mapping the entire chain (well to wheel).

After defining the pathways, the challenge was to parameterise the individual process steps. For example, the researchers included the volumetric and gravimetric energy density of hydrogen and ammonia in gaseous and liquid states, the purity requirements necessary for operating the fuel cell, and all cost models for scaling. This enables calculation, scaling and optimisation in a specific computational model.

ABOUT AEE INTEC

AEE – Institute for Sustainable Technologies (AEE INTEC) was founded in 1988 and is now one of Europe's leading institutes for applied research in the field of renewable energy and resource efficiency. In the three target group areas "Buildings", "Cities & Networks" and "Industrial Systems", as well as three technology workgroups "Renewable Energies", "Thermal Storage" and "Water and Process Technologies", the range of R&D projects carried out extends from basic research projects to the implementation of demonstration plants. Since 2015, AEE INTEC has been a member of Austrian Cooperative Research – ACR.

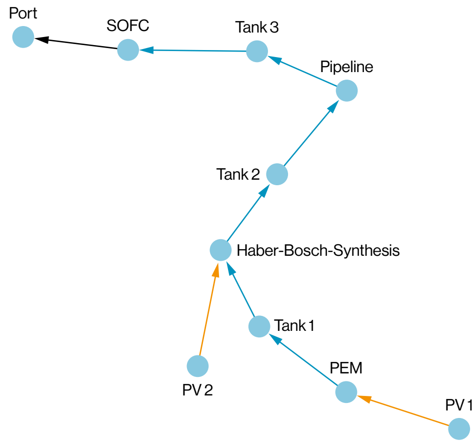
To link the previously theoretical pathways with practice, the researchers defined concrete use cases – exemplary applications of the usage pathways involving a specific combination of technologies.

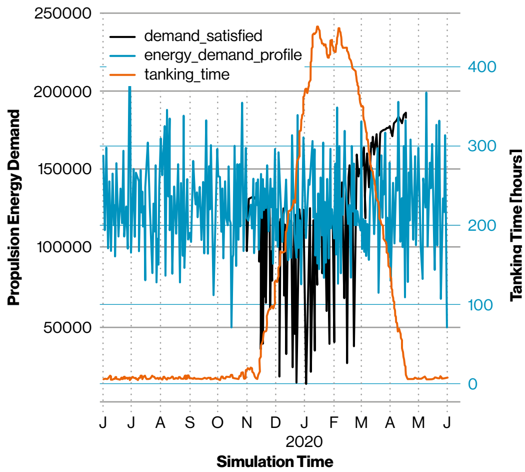
The use cases are fundamentally independent of location. However, modelling in different case studies is to be based on real port locations, as these have a major influence on the results. The AEE INTEC team has created case studies for two ports of key importance in Europe: Rotterdam, Netherlands, and Valencia, Spain. For each location and its technological conditions, the respective KPIs are calculated and all data are evaluated with regard to important acceptance criteria. Three use cases relevant to practice are in focus and are outlined below.

Use Case 1: Hydrogen production via PEM electrolysis This use case considers the production of hydrogen using proton exchange membrane (PEM) electrolysis, powered by electricity from wind and solar energy. The PEM technology was chosen due to its good compatibility with fluctuating renewable energies. However, the model can also be applied to alkaline electrolysis or any other technology, provided corresponding data are available. Prior to electrolysis, water treatment is required, with key parameters also included in the model. The water demand in the model is not a fixed restriction, but an input parameter – interpretation is therefore left to the user.

The hydrogen produced in this use case is stored locally in a depleted natural gas reservoir. The gaseous hydrogen is then transported via pipeline to the port, where it is again stored in a former natural gas reservoir, ensuring that sufficient hydrogen is always available for refuelling. Geological storage was assumed, as such sites are generally available at many locations and often also near the coast. The data situation from studies is also relatively good. How-

From costs to emissions, the key figures for each fuel depend on its exact usage pathway. AEE INTEC is developing a tool to map these pathways.





Progression of propulsion energy demand (blue), progression of covered propulsion energy demand (green), and the waiting time of ships in port until complete refuelling (red) in the case of a supply chain that cannot meet demand in the winter months due to reduced electricity supply from the photovoltaic system required for hydrogen production. Between November and March, supply is consistently below demand. Effective design optimisation for a supply pathway exhibiting this behaviour would involve increasing electricity supply from alternative sources such as wind or hydropower.

ever, there are hardly any large-scale technical high-pressure storage facilities, and a simple extrapolation from small storage units does not lead to meaningful results. Fundamentally, as with the electrolysis technology: if parameters are known, other storage technologies can also be incorporated into the model.

Use Case 2: Ammonia production via Haber-Bosch process Ammonia (NH_3) scores over hydrogen with its high volumetric energy density and easier storability, as it is already liquid at ambient pressure at temperatures below -33 °C. It can be produced on an industrial scale from hydrogen and nitrogen using the Haber-Bosch process.

This second use case initially involves the same steps as use case 1. However, after the hydrogen has been transported to the port, ammonia synthesis takes place there, also powered by renewable energies. The required nitrogen is obtained from ambient air using a cryogenic separation process.

Use Case 3: Methanol from hydrogen and biogas The third use case focuses on the fuel methanol. Like the first two use cases, this one also begins with hydrogen production and transport to the port. There, biogas is also produced via anaerobic digestion. The raw materials for this can include biogenic residual or waste materials or manure. The biogas then needs to be purified: CO_2 and CH_4 (methane) from the biogas are required for methanol synthesis, while components such as hydrogen sulfide or ammonia must be removed. Methanol can then be synthesised from green hydrogen and the mixture of CO_2 and methane.

Simulation tool currently under development Preliminary calculations and evaluations of the usage pathways already exist, but they are still quite rough. The direct use of hydrogen has the advantage of requiring fewer conversion steps, which increases efficiency and reduces investment costs. However, the technology readiness level is lowest for direct hydrogen use, primarily due to the lack of infrastructure. In methanol production from biogas, on the other hand, the costs of CO_2 capture have a very strong impact on fuel costs. However, these initial data are not yet robust enough for concrete comparisons between use cases or even for decisions.

The researchers are currently working on developing a reliable and more precise simulation tool, which will also be able to calculate fuel pathways with temporal resolution. The software tool will be completed by the end of 2025 and will also be accessible to experts outside the project. In a workshop, the project results as well as the tool are expected to be presented to interested port companies in April 2026. This will enable them to use a consistent computational model to map the potential at their specific locations, taking their resources into account. Interested parties can already register with AEE INTEC for the workshop. ○

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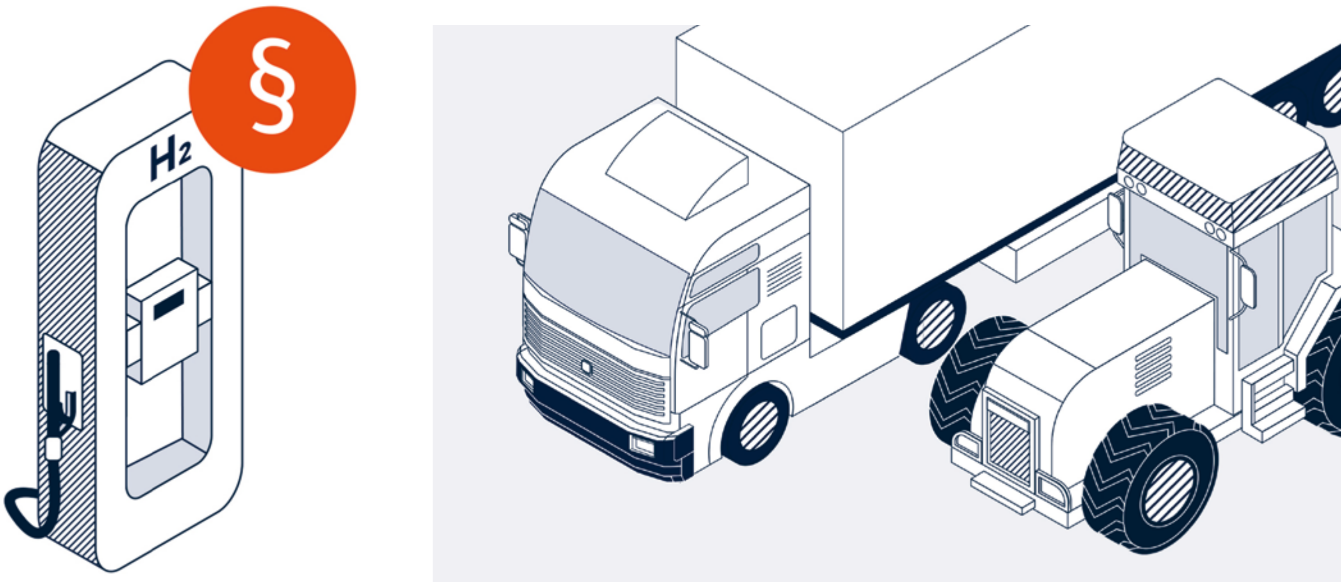
Same fuel, different tax

By Sybille Riepe

Several manufacturers are opting for hydrogen combustion engines instead of fuel cell drives. What is hardly known to the public: in Germany a different taxation applies to these. If the problem is not solved quickly at the political level, a technical workaround will be needed to ensure legally compliant refueling of H2 combustion engines.



© CEP

Hydrogen mobility is facing a new hurdle: at the filling station, tax law in Germany differentiates between fuel cell vehicles and hydrogen combustion engine vehicles. This regulation could slow down the development of hydrogen combustion engine technology if no solution is found in tax law.

Pitfall of the German Energy Tax Act The unequal treatment arises implicitly. The German Energy Tax Act does not explicitly mention hydrogen as an energy carrier. Therefore, the similarity principle applies: hydrogen used in combustion engines is taxed like natural gas. The tax rate is currently 0.90 euro per kilogram and will rise to about 1.25 euro in 2027. An administrative regulation from the German Federal Ministry of Finance, however, exempts hydrogen used in fuel cells from the energy tax. So the rule is: no tax for fuel cell vehicles, but hydrogen combustion engine vehicles have to pay.

Refueling ban for H2 combustion engines This different taxation presents operators of hydrogen filling stations with a technical challenge: they have to distinguish between vehicle types in order to invoice the hydrogen correctly. However, this information is not requested during refueling. This leads to complicated procedures and individual arrangements with the main customs offices, resulting in a patchwork across Germany: while some filling stations exclude hydrogen combustion engine vehicles in their general terms and conditions, others allow them, and still others require official approval for every refueling.

Communication interface as a quick solution To provide a remedy as quickly as possible, the International Organization for Standardization (ISO), with

HYDROGEN COMBUSTION ENGINES: MANUFACTURERS AND APPLICATIONS

H2 combustion engines are mainly used in agricultural and construction machinery, in logistics transport, and in motorsport. They complement fuel cells and expand the possibilities of hydrogen mobility. Some manufacturers and suppliers are already relying on this technology – here is a selection:

HEAVY-DUTY TRANSPORT

- **Deutz is producing the TCG 7.8 H2 engine, a six-cylinder hydrogen combustion engine with 220 kW power and 1,000 Nm torque, already in series production.**
- **MAN is testing H2 trucks based on the TGX model.**
- **Volvo Trucks is developing trucks with combustion engines; on-road tests are to start from 2026, with commercial market launch towards the end of the decade.**
- **Komatsu is testing a co-development with Keyou: a 92-ton dump truck (model HD785) with a hydrogen combustion engine as a proof of concept, with refueling system and components.**
- **Keyou has delivered the first 18-ton hydrogen combustion engine truck to EP-Trans, based on an Actros chassis with a converted Deutz 7.8-liter cylinder. Keyou also plans to deliver 40-ton vehicles with H2 combustion engines from 2026.**
- **Cummins has presented an H2 combustion engine in Europe and also showcased the H2-ICE engines (X10, X15H) and related technologies at the IAA.**
- **Ashok Leyland is cooperating with Reliance to develop H2 engines for trucks in the 19–35 ton segment.**

CONSTRUCTION MACHINERY AND AGRICULTURE

- **JCB produces H2 excavators and telehandlers for construction and agriculture; field tests and near-series prototypes are ongoing.**
- **CNH Industrial is developing H2 tractors under the New Holland and CASE brands.**

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“We urgently need a solution that puts all hydrogen drive concepts on an equal footing and gives filling station operators legal certainty.”

Florian Brandau, board member of the Clean Energy Partnership (CEP)

support from the Clean Energy Partnership (CEP), is working on technical solutions – including a communication interface (“Advanced Communication”) that enables automated data transfer between vehicle and filling station, including information on vehicle type and drive system. This will make hydrogen for fuel cells and combustion engines technically distinguishable, provide legal certainty for filling station operators, and allow the first hydrogen combustion engines to be refueled easily, even at public hydrogen filling stations.

A political solution is needed Regardless of a technical solution: the unequal tax treatment of hydrogen vehicles with combustion engines and fuel cells needs to be reviewed. Both technologies use climate-friendly hydrogen and contribute to the decarbonization of transport. Given the urgency to reduce CO_2 emissions, such differentiation is neither appropriate nor expedient. The decisive factor is the emissions advantage – and this applies to both concepts if green hydrogen is used. A uniform tax regulation would foster innovation, secure investments, and accelerate the market ramp-up of climate-friendly mobility. Florian Brandau, board member of the CEP, therefore calls for: “We urgently need a solution that puts all hydrogen drive concepts on an equal footing and gives filling station operators legal certainty.”

Future perspectives and need for action The resolution of the tax law conflict is crucial for the future of hydrogen mobility. Legislators, industry, and research must work together to develop practical solutions that meet the requirements of tax law and the needs of the market. Different law, similar problem: the definition of the supplier of hydrogen currently depends on the legal framework (for example, Energy Tax Act, BImSchV/RED III) and the specific application. This leads to legal uncertainty and practical hurdles in the market. CEP therefore calls in its statement on the draft of the Second Act to Further Develop the Greenhouse Gas Reduction Quota for a harmonization of this definition. The dilemma at the hydrogen filling station shows that the regulatory framework must keep pace with technology. Efficiency debates aside: parallel developments must not be slowed down by bureaucracy. Only if legal barriers are removed can hydrogen realize its potential as the key to a sustainable transformation of transport. ○

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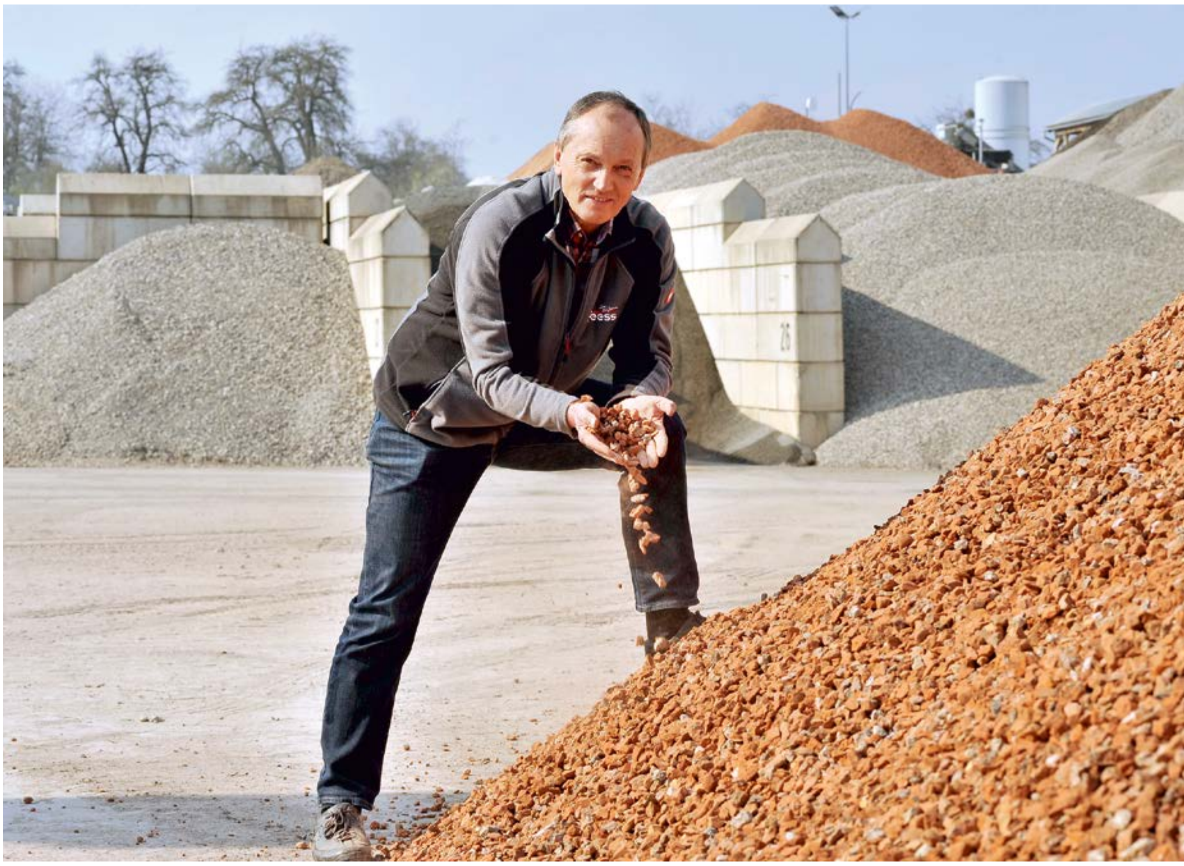
Hydrogen is expensive and hard to obtain

By Leonhard Fromm



The introduction of hydrogen-powered construction machinery is faltering. This is due to progress in electrification even in the heavy-duty sector, the low availability of hydrogen, and high costs. Yet despite adverse circumstances, there is still interest.

In logistics, the transformation towards zero-emission vehicles (ZEV) based on hydrogen is underway. In the case of construction machinery, the change started later – now it has come to a standstill. One reason is the cost. In 2025, one kilowatt hour for commercial customers in Germany costs about twenty-five cents, but one kilogram of hydrogen cost ten to fifteen euros. This means that, in terms of usable energy, electricity is significantly cheaper.

Availability: a common problem for electricity and hydrogen And then you have to obtain the hydrogen in the first place. “Above all, due to the lack of availability, the topic of hydrogen is still a long way off for us,” says Sonja Reimann, press spokesperson at the construction machinery dealer and Caterpillar distribution partner Zeppelin Baumaschinen. Currently, announcements and planned investments in this area are being withdrawn again. Caterpil-

lar may present a prototype at the Bauma trade fair in 2028. So far, the company has focused in the ZEV context on battery-electric drives for large machines such as wheel loaders with fifty tonnes.

But this gives rise to another challenge: the power supply at construction sites is often critical, according to Reimann. Nevertheless, customer interest in this topic is surprisingly high. That is why the company is monitoring this market, for example, to see which solutions for charging infrastructure at construction sites are being discussed or how the power supply on mobile construction sites can generally be improved. For these applications, it would basically be an advantage if construction machinery were operated with hydrogen and thus did not place an additional burden on the power supply.

Hydrogen concepts among construction machinery manufacturers At least, companies and research institutions continue to devote themselves to the development and testing of hydrogen-powered construction machinery. For example, Liebherr already presented prototypes of two hydrogen combustion engines at Bauma in 2022. In 2024, the prototype of the L566 H wheel loader was presented at the Liebherr plant in Bischofshofen. In October of the same year, it went into test operation in a quarry operated by Strabag. It is refueled at a specially established filling station in the quarry. However, there was no further word on the series production originally announced for 2025. This is not surprising, as the test operation is scheduled to continue until October 2026.

In addition, the industry is exploring the possible uses of fuel cells. For example, General Motors and construction machinery manufacturer Komatsu are working together on a hydrogen fuel cell module for an electric dump truck, as reported at this year's Bauma. Komatsu has also developed, as a concept machine, a medium-sized hydraulic excavator with a hydrogen fuel cell system. Companies such as Strabag SE, one of the largest construction companies in Europe, are ensuring that there is enough pressure in the innovation pipeline. The Austrian company, which also includes Züblin in Stuttgart, aims to become climate neutral across its entire value chain by 2040. This also includes the operation of construction machinery.

Many manufacturers and dealers are skeptical but prefer not to express this publicly. A dealer of construction machinery from well-known manufacturers, who wishes to remain anonymous, states: “Hydrogen is a technology topic for the future. It will probably take a very long time before it finds widespread acceptance and becomes commercially usable on a large scale. Reasons for this include, for example, the current lack of scalability, the lack of supply infrastructure, and the high electricity price.” And at Sennebogen, a well-known manufacturer of electric cranes in Straubing, it is said, upon explicit request: “Hydrogen concept engines that are presented at trade fairs are individual concept solutions that work under laboratory conditions, but are anything but ready for the market. At the moment, they therefore function more as marketing tools, intended to demonstrate the innovative strength of individual manufacturers and the industry.” Achieving market maturity will still take a lot of time, as the industry is still at the very beginning of the learning curve.

Expensive powertrains as a risk for users On the user side, demolition waste recycler Feess in Kirchheim/Teck, who received the German Environmental Award in 2016, wants to set a trend with its fleet of vehicles and machinery. The company owns around one hundred construction machines such as excavators and wheel loaders as well as more than fifty trucks. Senior manager Walter Feess has therefore also looked into hydrogen. He believes the time is not yet ripe. First, he wants to invest in stationary electric cranes at his recycling yards, which should ideally be powered by self-produced PV electricity. His forecast: “In the long run, it will probably come down to a broad spectrum of drive solutions depending on the specific application, i.e., electric, battery, hydrogen, and diesel in parallel.” In any case, the current investment climate in the construction industry is unfavorable, and passing on additional costs for significantly more expensive drivetrains beyond the conventional combustion engine in offers endangers competitiveness. ○

LEFT: Currently sees little financial leeway for alternative drives in construction machinery: demolition waste recycler and environmental pioneer Walter Feess in Kirchheim/Teck. © FEESS

RIGHT: A seventy-tonne crusher in use during demolition. For such heavyweights, hydrogen engines could be a solution – from a technical point of view. © FEESS

Measuring what matters

By Jens Peter Meyer

Highly specialized sensors suitable for hydrogen are used to monitor safety-relevant parameters at hydrogen refueling stations. If malfunctions or anomalies occur, control systems can automatically take measures to prevent hazards.

Hydrogen refueling stations require a range of sensors to ensure safe operation. In particular, it is important to reliably detect the temperature and pressure of the hydrogen during the refueling process. Determining the hydrogen concentration in the ambient air is also a safety-relevant measurement. In the future, measuring hydrogen purity could also play an important role.

An external coating with gold slows the diffusion of hydrogen through the membrane of a pressure sensor.

© Vega

Kälte- und Systemtechnik GmbH (Kustec) from Austria specializes in cooling systems for hydrogen refueling stations. During refueling, hydrogen heats up as a result of the pressure drop – unlike most other gases. Since the temperature in standard hydrogen tanks is limited to 85 °C, the gas must be cooled before refueling. For monitoring the refueling process, precise sensors are necessary to monitor pressure and temperature. For this, Kustec uses sensors from the Swiss manufacturer Trafag AG, which are suitable for hazardous areas.

A special feature: Trafag's temperature sensors are certified for multiple Ex zones. When designing a hydrogen refueling station, the supplier defines the Ex zones. Previously, it was customary to designate Ex zone 1 at hydrogen refueling stations, says Trafag Managing Director Markus Degasperi. In Ex zone 1, explosive hydrogen-air mixtures can occur during normal operation. Therefore, the sensors must be intrinsically safe, and isolation switches are required in the control cabinet. Today, suppliers try to use zone 2, in which no explosive atmosphere can occur during normal operation, allowing the isolation switches to be omitted. However, to offer suppliers flexibility regarding Ex zones, Trafag sensors are suitable for both zone 1 and zone 2. Trafag offers the temperature sensors in numerous versions. Customers can choose between different measurement technologies and cable assemblies. Kustec uses intrinsically safe temperature sensors with 20 m long cables in its pre-cooling units in the dispensers.

Thin-film-on-steel sensors for pressure measurement The pressure sensors used by Kustec also come from Trafag. These are thin-film-on-steel sensors. In thin-film pressure measuring cells, several electrical resistors are located on the reverse side of the thin-film membrane, away from the medium, and are connected to form a Wheatstone bridge. Under pressure, the membrane deforms and the resistors are compressed or stretched depending on their position. The resistance changes proportionally to the pressure.

The challenge is to develop a membrane material that is hardly permeable to hydrogen and does not become brittle when in contact with hydrogen. Over time, hydrogen atoms can diffuse through the membrane of a thin-film-on-steel sensor and cause signal drift. Particularly high temperatures intensify the drift.

“What's important is how reliable a sensor is,” says Degasperi. Accuracy and long-term stability are crucial. In particular, the drift of the sensor signal must be prevented. Hydrogen pressure sensors must measure up to 1,000 bar. For releasing the refueling process, they must also be able to reliably detect 0 bar. If the zero point has drifted, there is a problem. “Then it is no longer possible to start,” says Degasperi.

Titanium nitride coating reduces hydrogen diffusion Signal drift is also an issue for sensor manufacturer Alexander Wiegand (Wika). An external coating with gold can help, as the diffusion coefficient of hydrogen through gold is orders of magnitude lower than through steel. But gold is expensive. In addition, “the front is easily scratched from the outside,” says Christian Wirl, Portfolio Manager Hydrogen at Wika. Every scratch reduces the effect of the gold or even completely eliminates it.

Wika has therefore developed an alternative to gold coating. The company uses a titanium nitride coating only a few nanometers thick to protect the sensor from hydrogen. The sensor body itself is made of the cobalt-chromium-nickel alloy Elgiloy, which is sufficiently elastic. The titanium nitride coating is located on the back of the sensor body between an insulation layer and the actual resistor layer. In this position, the protective layer is shielded from mechanical stress and scratches. The titanium nitride coating also has the advantage of being less expensive than a gold coating. According to Wirl, these pressure sensors can be completely metal-sealed. This eliminates the need for an elastomer seal, which is more permeable to atomic hydrogen than a metal one.

Wika developed and tested the new sensor in its laboratory at its main site in Klingenberg, Germany. The tests showed that the titanium nitride coating prevents signal drift almost as effectively as a gold coating. In terms of robustness, however, the design is said to offer significant advantages and is also suitable for high temperatures. The new technology can be used for pressure sensors with a measuring range from 0 to 1,000 bar. Wika has already started to implement the titanium nitride coating in its end products. The first to feature it are electronic pressure sensors for explosion-proof areas. For temperature measurement, Wika uses thermocouples, which, according to Wirl, are more resistant to pressure and vibration and react more quickly to temperature changes compared to platinum resistance sensors (see H2international 03/2025, page 37).

Vega Grieshaber KG also offers metal thin-film sensors for hydrogen pressure measurement up to 1,000 bar. "We preferably manufacture these measuring cells dry, that is, without oil filling as a transmission medium, to avoid the negative effects of hydrogen diffusion on the oil," says Vega sales engineer Nils Springmann. For its oil-filled metallic measuring cells, the company optionally uses gold or gold-rhodium coatings. Piezoresistive measuring cells with oil filling and gold coating are used in the low-pressure range up to 40 bar. In these sensors, pressure acts on a stainless steel membrane and the oil filling behind it. In the oil, there is a semiconductor element that responds to deformation with a change in resistance. According to Springmann, gold coatings are useful for such piezo sensors. They prevent hydrogen molecules from diffusing through the thin membrane and interfering with the measurement signal.

For pressures up to 100 bar, dry ceramic-capacitive measuring cells have proven themselves.

© Vega

Ceramic capacitive pressure measurement for the low-pressure range For pressures of less than 100 bar, Vega relies on ceramic capacitive measurement. "All measuring points with lower pressures, from 100 bar downwards, we measure using ceramic capacitive technology with a dry ceramic measuring cell. So far, we have had very positive experiences with this," says Springmann. According to Springmann, dry ceramic measuring cells have advantages in terms of robustness and long-term stability. "The leak rates are negligibly small for most applications," says Springmann. ▷

Neoxid manufactures sensors for detecting hydrogen purity and hydrogen concentration.

© Neoxid

With ceramic capacitive pressure sensors, the pressure acts on a ceramic membrane, resulting in a change in capacitance. The capacitive ceramic sensor works like a plate capacitor. Due to the pressure, the distance between the electrodes decreases and the capacitance increases.

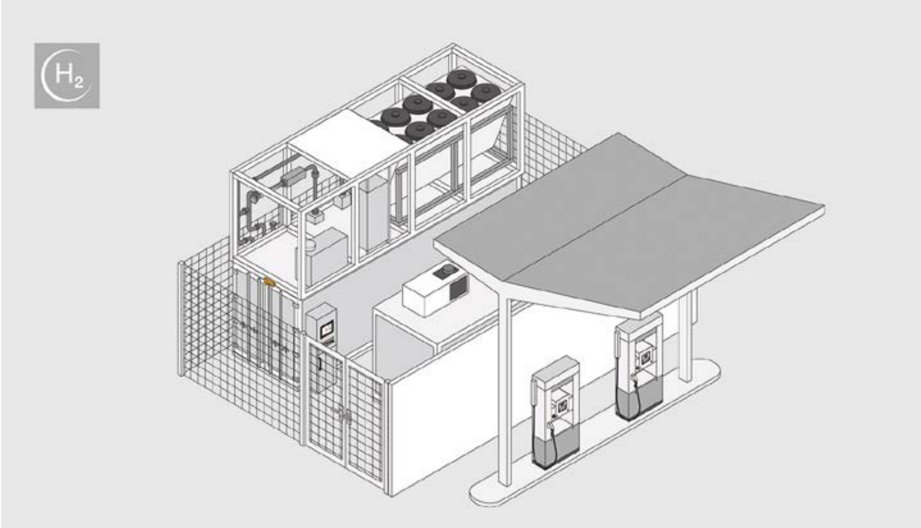
Determining hydrogen purity Pressure and temperature are important parameters during hydrogen refueling, but not the only ones. Neoxid Hydrogen AG focuses on sensors for detecting hydrogen purity and hydrogen concentration. The company uses the thermal conductivity of a gas mixture as the measurement parameter. The measurement signal can accurately detect impurities in hydrogen down to the ppm range. The purity of hydrogen is an important factor when the gas is used as fuel in a fuel cell. Impurities such as carbon monoxide or oxides of sulfur or nitrogen act as catalyst poisons and can significantly reduce the performance and service life of the fuel cell. Therefore, hydrogen 3.7 is used for fuel cell drives, which has a purity of more than 99.97%.

At today's refueling stations, which obtain hydrogen from nearby PEM electrolyzers, purity is not a problem, says Neoxid Managing Director Dieter Ostermann. However, this will change as more and more stations source gas from the hydrogen core network. Then it will not be possible without purity sensors. This is because the pipelines, which also include sections repurposed from natural gas operation, must be expected to contain impurities in the range of 1%. Ostermann expects that sensors will be installed in cars to stop the refueling process if the quality is not right. But purity sensors will also become unavoidable in the stations themselves.

According to Ostermann, Neoxid is the only supplier that can measure hydrogen concentration in operation at high pressures without complex sample preparation and measurement in a gas chromatograph. The measurement of thermal conductivity does not change the gas composition and the measurement signal is compensated for pressure, temperature, and humidity. This allows the proportion of water vapor to be distinguished from other impurities.

Sensors for hydrogen concentration in the air Another application for Neoxid sensors is measuring hydrogen concentration in the air. Gas warning devices can use them to detect leaks and warn of explosive hydrogen-air mixtures. For this application, not only is thermal conductivity measurement suitable. Usually, pellistors are used, which are based on the principle of catalytic combustion. In the sensor, hydrogen burns and, depending on the concen-

Safety functions at a hydrogen refueling station include the detection of hydrogen leaks, flames, and smoke, as well as the monitoring of temperature and pressure.



To prevent explosive atmospheres at hydrogen refueling stations, detecting and quickly locating leaks is crucial. Control systems automatically initiate safety measures.

tration, generates an additional amount of heat that can be detected. The electronics evaluate the temperature change at the sensor surface and determine a gas concentration from it. The sensitivity of pellistors reaches below 5% of the lower explosive limit. According to the Fraunhofer Institute for Physical Measurement Techniques IPM, the advantages of catalytic sensors lie in their simple operating principle, uncomplicated installation, and reliable calibration. However, modern pellistors also have some disadvantages. Above all, high operating temperatures, high power consumption, and susceptibility to catalyst poisons have a negative impact.

Control systems use sensor signals for error detection Accurate sensors that reliably record the actual state are one thing. The other are control systems that detect errors and react automatically based on the measured values. Pilz supplies control systems that detect gas leaks by analyzing gas detectors and monitor temperature, pressure, fill level, voltage, and current. They detect errors in the millisecond range and initiate predefined safety responses if the limit values for filling and emptying set by the hydrogen tank manufacturer are not met. If malfunctions occur during refueling of a vehicle, the control system switches an electronic safety valve to, for example, trigger an emergency stop of the process or reduce the power of a compressor.

The Pilz control system monitors the critical limit values for pressure, temperature, and the hydrogen charging and discharging rates. It also analyzes the pressure gradient to detect anomalies or errors at an early stage. A rapid drop in pressure can indicate leaks. The safety system achieves an accuracy of 1%. If it monitors the pressure range of a hydrogen refueling station from 0 to 1,000 bar, the measurement deviation is 10 bar. According to Pilz, this enables compliance with safety level SIL 3 in accordance with IEC 62061.

In addition to monitoring pressure and temperature during the refueling process, hydrogen refueling stations also require the detection of hydrogen leaks, flames, and smoke. The monitoring system from Pilz is already used at several stations in France.

An important aspect of control systems is cybersecurity. Unauthorized access to control systems in the hydrogen sector can pose a major safety risk. Pilz therefore also offers systems for access and authorization management, which support data and network security, user authentication, and access management.

This ensures that, through the interaction of sensor technology and monitoring electronics, both people and hydrogen installations are well protected. ○

The turquoise promise

Text: Fabian Kauschke

Methane plasma pyrolysis produces low-CO2 hydrogen at high temperatures and – it is hoped – at low cost. The Berlin-based company Graforce is testing the process in Austria, but sees the main market outside Europe.

Green hydrogen is considered too expensive, too energy-intensive, and therefore not competitive. With this statement, critics often deny the gas its future viability. However, companies are already planning projects with a total capacity that exceeds Germany's National Hydrogen Strategy target of ten gigawatts (GW). According to the industry association "Die Gas- und Wasserstoffwirtschaft", 11.3 GW have been announced. However, the reality is that only a fraction of the planned projects will be completed on time, or at all. According to a study by the Potsdam Institute for Climate Impact Research, less than ten percent of the originally announced green hydrogen production was realized in 2023. This is reason enough to focus on technologies that undercut electrolysis in terms of energy intensity while still producing low-emission hydrogen.

> Plasma pyrolysis requires twelve kilowatt-hours to produce one kilogram of hydrogen.

Currently, forty to eighty kilowatt-hours (kWh) of renewable electricity are required to produce one kilogram of green hydrogen. Plasma pyrolysis promises to significantly undercut this value and produce one kilogram of H2 with less than twelve kWh. The Berlin-based company Graforce holds five patents for the application of various plasma processes and builds plants for methane and ammonia plasma pyrolysis.

From methane to H2 and carbon black Methane plasma pyrolysis decarbonizes methane (CH4) to produce hydrogen, solid carbon, and industrial-grade heat. If you take 200 kilograms of methane and 500 kWh of renewable energy and process them via plasma pyrolysis, you get 50 kilograms of hydrogen, 150 kilograms of carbon black, and 150 kWh of industrial heat. Carbon black is a raw material used in industry, for example in the production of paints, high-performance coatings, plastics, tires, concrete, or asphalt. As activated carbon, carbon black is used in water treatment (fourth purification stage) and for gas separation. In agriculture, it is used to improve soil quality, especially in sandy soils (by increasing water adsorption). Low-carbon carbon black can replace petroleum coke while reducing CO2 emissions and, in the form of graphite, is used in lithium-ion batteries, for example.

The by-product, which occurs here in triple the quantity compared to hydrogen, is already integrated into a wide range of industrial processes. Until now, it has been produced in a CO2-intensive manner by burning oil or natural gas. The waste heat generated by the plasma pyrolysis process can also be used industrially at various temperature levels.

When biomethane is used and the resulting carbon black is stored in product form (C-steel) for the long term (> 35 years), the process acts as a CO2 sink. If raw biogas (consisting equally of biomethane and CO2) is used, the same process can produce CO2-neutral syngas, which, after processing into SAFs (Synthetic Air Fuels), will contribute to the decarbonization of aviation in the medium term. To do this, the methane must first be separated from the other components of the biogas.

Splitting in the reactor The plasma pyrolysis reactor is three meters long and one meter in diameter. It is mainly filled with thermal insulation. Inside is a graphite tube 2.5 meters long.

Temperatures between 1,300 and 1,500 degrees Celsius prevail in the plasmolysis reactor.

© Graforce

Within this graphite reactor is a plasma torch, which, with the supply of hydrogen, generates a thermal hydrogen plasma that quickly and energy-efficiently brings the reactor to high temperatures. The required H2 is initially supplied via an external gas bundle and remains after the splitting process.

> "What unites companies is the necessity to drastically reduce their CO2 emissions as quickly as possible."
>
> **Marc Dünow, Project manager at Graforce**

In the reactor, in the absence of oxygen, methane splits at temperatures between 1,300 and 1,500 degrees Celsius into hydrogen and carbon, which is then removed. After the process, the hydrogen has a purity of approximately 98 percent and can therefore be used directly, for example, in an H2 combustion engine (Keyou), an H2 combined heat and power plant, or H2 turbines. However, for applications such as fuel cells, a higher degree of purity is required. To achieve this, pressure swing adsorption is connected downstream of the plasmolysis. This brings the hydrogen to a purity level of nearly 100 percent.

Not green, but climate-friendly? A plasmolysis reactor has a capacity of 0.5 megawatts. The systems can be combined modularly, making production facilities with 30 megawatts possible. When connected to an industrial operation, all three products – hydrogen, carbon, and waste heat – can be used. In Kremsmünster, Upper Austria, a methane plasmolysis plant has been established in cooperation with Rag Austria, which exploits these characteristics. The hydrogen produced is stored by the project partner in the region and used in a combined heat and power plant or for industrial purposes. The carbon obtained is used in agriculture to enrich the soil.

"We are in discussions with steel mills, energy suppliers, pigment manufacturers, and companies in the oil and gas sector in order to produce significant quantities of hydrogen and carbon from natural gas in the near future. What unites these companies is the need to drastically reduce their CO2 emissions as soon as possible," says project manager Marc Dünow about the current developments at Graforce.

Hydrogen from methane plasmolysis is defined as low carbon hydrogen according to the regulation to be ratified at the EU level in 2025, taking into account all upstream emissions, and can be certified, subsidized, and traded on this basis. "This enables the breakthrough for our H2 bridging technology," says the project manager. According to current European legislation, only hydrogen from water electrolysis produced with renewable energy may be referred to as green. The hydrogen produced in plasmolysis is classified as turquoise. Nevertheless, the technology helps to decarbonize industrial processes. Due to the currently limited availability of proven green H2, plasmolysis – like the use of blue hydrogen – could serve as a transitional solution until the electrolysis technology market is fully established. However, it is questionable whether methane plasmolysis will be included in federal funding programs in the future. For this reason, Graforce is also turning its attention to the USA, Saudi Arabia, Australia, Thailand, and Korea, due to increased international demand. ○

AMMONIA PLASMOLYSIS

Ammonia plasmolysis is another technology for producing hydrogen. It is used, for example, in the treatment of wastewater in sewage treatment plants. In this process, nitrogen compounds contained in the water (such as urea and ammonium) are broken down into individual N and H atoms. These subsequently recombine to form green hydrogen and nitrogen. What remains is purified water. Using membrane technology, the gases are separated and stored in gas tanks for further use. This technology already represents an energy-efficient method for splitting the future hydrogen carrier ammonia (NH3) and is ready for large-scale industrial implementation today.

Stacking at high speed

By Magdalena Helmle, Matthias Fischer

Every second, the high-speed stacker from VAF positions a membrane electrode assembly and a bipolar plate. The fact that fuel cell stacks can be produced so quickly and precisely is primarily due to a workpiece carrier individually adapted to the product.

At Hannover Messe 2022, the high-speed stacker from VAF was presented for the first time. It enables the production of up to 70,000 stacks per year and thus set new standards for large-scale manufacturing of PEM fuel cell stacks. Since then, VAF has continuously optimized and further developed the performance of the system with customers from around the world for every new project. The core components are the patented stacking process and the workpiece carrier adapted for each product. This makes the process flexible and suitable for many products.

High speed stacker in operation © VAF

Components are aligned against a stop The cell components are precisely mechanically aligned in the workpiece carrier by being positioned against a fixed stop using a patented push technology – similar to how you align a stack of paper by tapping the edges on a desk. This achieves the required accuracy. The challenge of this process lies in executing it in such a way that no damage occurs. This can only be achieved through precise process optimization and the appropriate selection of materials for the parts that come into contact with the workpiece.

As a result, it becomes possible to achieve higher speeds in the upstream pick-and-place process, since the robot does not have to position the cell components as precisely.

Gripping technology limits the speed High demands are placed on gripping technology in both electrolyzer and fuel cell manufacturing. For the high-speed stacker, VAF uses flow grippers that pick up the cell components using vacuum. These are specially adapted to the components. However, it is also a matter of using the right process parameters to determine whether and how the grippers function. Factors such as holding times during pick-up, the suction power of the gripper, and the behavior of the component determine the cycle time.

Challenging are the increasingly larger cell areas and thus larger and heavier components that come with advancing technology. Their inertia makes these highly dynamic processes more difficult. A low weight of the gripper therefore has a positive effect on the processes. At the same time, the gripper must retain a certain stiffness, since some membrane electrode assemblies are floppy and the outer contours are delicate. In order to place such components precisely, the gripping technology and process parameters must be finely tuned.

Basically, this technology developed for PEM stacks could also be transferred to other types of fuel cells, but PEM technology receives the most attention due to automotive applications.

Between special-purpose machines and series production The main advantage of a special-purpose machine is that the system is fully adapted to customer requirements. However, completely new systems always involve a risk, and only after completion is the system's functionality proven. In highly dynamic processes such as stack production, the risk is significantly higher that issues will only become apparent afterwards. In addition, new designs are considerably more expensive than systems that can be built multiple times. Therefore, the high-speed stacker is a combination of both. The basic concept of the systems is the same. Only the key elements – such as the gripping process and the workpiece carrier – are customized for each case. In addition, VAF offers its customers the possibility to carry out comprehensive test series in advance on its own pilot plant and to incorporate the information gained into the customization of the customer's system. This saves engineering hours and at the same time reduces risk.

Electrolyzers are more specialized The stacking process for electrolyzers differs in several respects from that for a fuel cell. Most fuel cells now consist of a maximum of two different components – the membrane electrode assemblies and the bipolar plates. In electrolyzers, the components are more varied, larger in area, and often more challenging in geometry for automation.

Electrolyzer manufacturing is not yet as advanced in scaling as fuel cell manufacturing. As a result, the requirements for the systems are in other areas. The entire system is larger due to the outer dimensions of the components. Due to the higher variety of cell designs, the different materials, and the tight tolerances, the demands on the stacking concept and the innovative gripper are high. Even small adjustments to the cell design can significantly reduce the complexity of the systems and thus lower costs accordingly. The experience gained from building the first systems for stack assembly can be used for many concepts and processes in the next generations of systems.

Close cooperation is necessary The reputation for reliability, durability, and precision continues to give German mechanical engineering companies an advantage, especially in fuel cell and electrolyzer production. However, increasing competition from Asia is clearly noticeable. This leads not only to strong price pressure but also to technical competition at a high level.

However, German companies can score with their trustworthy cooperation. Stack manufacturers maintain close exchanges with mechanical engineers regarding their technologies. The aim is to develop tailored solutions for production and to optimize products in order to reduce the complexity of the machines and the costs. This approach is based on a solid foundation of trust, as the manufacturers must disclose extensive expertise for the machine builders to find and provide innovative solutions. This exchange has contributed to the machines achieving a high level of process stability and meeting quality requirements, so that stack manufacturers receive a reliable production line. ○

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Gas flows under control

Purem by Eberspächer is leveraging its experience from automotive exhaust technology to develop new products for hydrogen and fuel cells. One innovation is the hydrogen recirculation blower (HRB). Its purpose is to improve hydrogen utilization in the fuel cell stack by recirculating unused hydrogen. The development is based on side channel blower technology and has been adapted to the requirements of hydrogen. This includes increased tightness and optimized materials. Initial practical tests with customers are planned for the end of 2025. According to the company, production is scheduled to start in 2027.

Recirculation blower

© Purem by Eberspächer

Another innovation is a modular exhaust system for fuel cells. It consists of several individual components that can be combined into a complete system. An important function is the reduction of noise emissions. Although electricity generation in the fuel cell itself is almost silent, unpleasant high-frequency noises occur, for example, through the compressor or purge processes. The silencers are tailored to the requirements of fuel cell vehicles and are resistant to high humidity and water condensate.

Another task is the separation of water from the exhaust gas. Depending on the outside temperature, varying amounts of water would otherwise condense. If puddles form on the road in winter, for example when waiting at traffic lights, this could lead to black ice. According to the manufacturer, the water separators are designed for high mass flows and offer low back pressure as well as high separation efficiency.

For the balance of plant, Purem offers new, production-ready valve solutions. The gas control valve regulates air flows and pressure in the system and can be used as either a bypass or throttle valve. The cathode isolation valve provides hermetic sealing of the cathode path and protects against leaks. Both components are designed for various applications and use suitable materials as well as customer-specific connections. ○

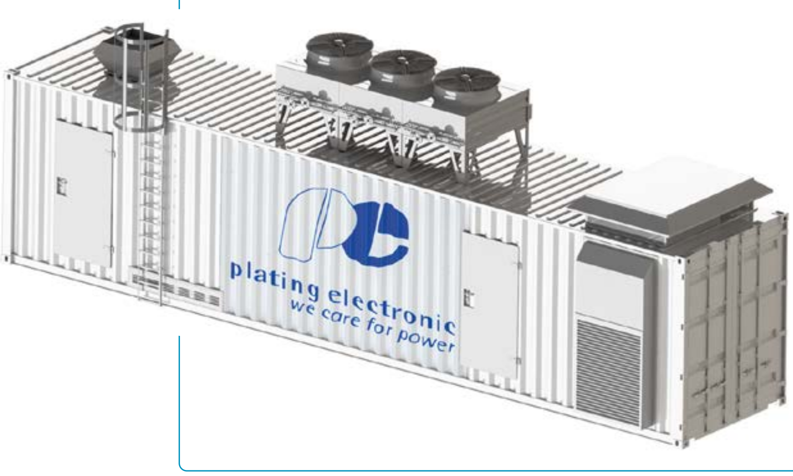
www.purem.com

Direct current from the container

Plating Electronic has developed "turnkey" direct current supply systems in skid or container design for electrolyzers. The models of the Power Station series are intended to be suitable for direct current outputs from 100 kW up to 5 MW. In addition to the rectifier itself, control cabinets, subdistribution cabinets, compensation systems, and cooling units are pre-installed on the skid. The container serves as optional protection. With the container, the system achieves protection class IP21; higher protection classes are possible, according to the company.

The technical specifications are flexible. Depending on requirements, customers can choose between switch-mode power supply and thyristor technology. The DC output ranges from 1 to 1,000 volts and 0.5 to 50 kA, with other currents and voltages available on request. Cooling with water or air is integrated, and the system is designed for ambient temperatures up to 35 degrees Celsius as standard. More is possible upon request here as well. The direct current supply features remote monitoring via an industrial fieldbus system and is intended for round-the-clock operation (24/7, 100%). ○

www.plating.de



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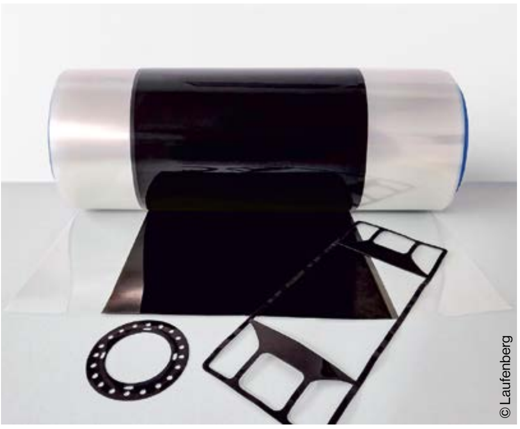
Flat gaskets from the roll

Laufenberg and Wevo-Chemie promise to make flat gaskets for fuel cells and electrolysers more cost-effective with a new manufacturing process.

In the new process, specially developed two-component elastomers from Wevo-Chemie are applied in liquid form onto a carrier film. The coating is performed using the roll-to-roll technique from Laufenberg. Curing takes place in a multi-zone tunnel oven, the temperature zones of which can be individually adjusted to the material. Optionally, pre-curing with infrared emitters can be carried out in order to shorten the curing time and remove air inclusions. The production speed can be scaled and ranges from 0.5 to 50 meters per minute.

This process allows the production of pure elastomer gaskets with layer thicknesses from 20 micrometers to 2 millimeters. In combination with carrier films, hybrid gaskets with a total thickness from 70 micrometers to 4 millimeters are possible. The selection of elastomer and carrier film depends on the respective application area. The gaskets are supplied either as roll goods or as precisely cut individual parts. ○

www.laufenberg.info
www.wevo-chemie.de



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Modular test systems

Sonplas has developed a test stand in container design for alternative fuels such as hydrogen, methanol, and ammonia. This test stand is intended to give customers the opportunity to test their components in a safe environment – for example, with hydrogen. In this way, function and service life can be verified so that the products meet the requirements and operate safely in later series deployment. In addition to flow measurement and flow characterization, dynamic pressure measurements and leakage tests, among others, are also offered. Sonplas can expand the test stand modularly if required.

For individual electrolysis cells and stacks, Sonplas offers a concept together with IAV that can be adapted to customer-specific requirements. The new test stand concept makes it possible to test different technologies – including proton exchange membrane electrolysis (PEM), alkaline electrolysis (AEL), and also anion exchange membrane electrolysis (AEM). This system is also modular in design. It can be adapted to different power ratings of the test specimens. The measurement technology can be more or less comprehensive depending on customer requirements. According to Sonplas, the application is intended both for research institutions for basic development and for industrial customers in pre-series and series development.

For this purpose, IAV contributes expertise in the development and operation of electrolysis systems, and Sonplas brings competence in special machine construction. According to the partners, they are already working together on a first customer project. ○

www.sonplas.com

Bipolar Plates

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Electrolyzers

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Deutsche Zentrum für Luft- und Raumfahrt (DLR) / German Aerospace Center, Institute of Engineering Thermodynamics, Energy System Integration, Pfaffenwaldring 38–40, 70569 Stuttgart, Germany, Phone +49-(0)711-6862-672, Fax -747, *www.dlr.de/tt*

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Organizations

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Organizers (Events)

ees Europe – International Exhibition for Batteries and Energy Storage Systems / Solar Promotion GmbH, P.O. Box 100 170, 75101 Pforzheim, Germany, Phone +49-7231-58598-0, Fax -28, *www.ees-europe.com*

European Fuel Cell Forum, Obgardihalde 2, 6043 Luzern-Adligenswil, Switzerland, Phone +41-(0)4-45865644, Fax 35080622, *forum@efcf.com, www.efcf.com*

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