2002–2016

CLEAN ENERGY PARTNERSHIP

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HYDROGEN – WHAT KEPT US MOVING 2002–2016

CONTENT

FOREWORD

We are currently experiencing the greatest mobility revolution since the invention of the automobile. Automated, connected driving is about to take off, and the switch to alternative drives has begun. This means that in the next five to ten years, mobility will change more than it has in any previous decade.

Fuel cell technology, too, can become a key driver for the mobility of the future – with crucial competitive advantages over other drive trains: fast refuelling, extensive range and optimum technology for large vehicles. It can help us take a real quantum leap forward in the area of climate protection in the transport sector.

In order to seize our opportunities for growth and prosperity through mobility, we have a clear aim: to develop and produce top-notch alternative drives and establish our technologies in the market. To achieve this, I have launched a comprehensive hydrogen strategy – with three key points:

- We continue the success story of the first National Innovation Programme Hydrogen and Fuel Cell Technology (NIP). In NIP II, we will invest around 250 million euros by 2019.

- We work with the private sector to create a nationwide network of 400 filling stations by 2025 – and invest a total of 350 million euros into constructing the world's first nationwide network for refuelling fuel-cell vehicles with hydrogen. After all, a technology can only prevail if drivers can trust in being able to refill their car anytime and anywhere.

- We promote innovations and put them on the road. The aim is to introduce innovative products of hydrogen and fuel-cell technology for use in various fields. These include: hydrogen buses in city traffic, vehicles in logistics and commercial traffic, and rail vehicles in public transport.

The Clean Energy Partnership (CEP) is indispensable in providing momentum for our hydrogen strategy and is an important lighthouse project into which we have invested 118 million euros to date. This public–private partnership contributes crucially to the development of uniform technical standards and the development of a filling-station network. I would also like to take this opportunity to thank the National Organization for Hydrogen and Fuel Cell Technology (NOW), which coordinates and implements NIP.

The future belongs to alternative drives. Germany is a trailblazer and pioneer in this field, bringing together more mobility with fewer emissions!

Your's Alexander Dobrindt MdB
Federal Minister of Transport and Digital Infrastructure

Photo: federal government / Kugler

Alexander Dobrindt MdB
Federal Minister of Transport and Digital Infrastructure

funded by:
Federal Ministry of Transport and Digital Infrastructure
coordinated by:
NOW National Organisation Hydrogen and Fuel Cell Technology

FOURTEEN YEARS OF HYDROGEN MOBILITY

AT THE END OF PHASE 3 OF THE PROJECT, THE TIME HAS COME FOR AN INTERIM STOCKTAKING. WHAT HAVE WE ACHIEVED IN THE CLEAN ENERGY PARTNERSHIP, AND WHAT STILL LIES AHEAD?

We can say with some pride that we have achieved our main goal: hydrogen has become a fuel that will make a significant contribution to the energy revolution, including the mobility sector. The project partners have contributed to this achievement with industrial research and development in a wide range of fields. They tested the suitability and system capabilities of cars, filling stations and logistics for everyday use, and developed processes and technologies for the entire supply chain. Here are some examples:

- In 2003, the four car manufacturers BMW, Daimler, Ford and Opel first began testing hydrogen in their vehicles. Volkswagen joined them in 2006. In 2004, 16 vehicles underwent demonstration and trial operations. Today, there are more than 400 vehicles, most of them customer owned.

- We integrated the first hydrogen station in an existing filling station on Messedamm, Berlin, in 2004. In March 2006, the second CEP hydrogen filling station went into operation in the Spandau district of Berlin where hydrogen refuelling at 700 bar was technically tested for the first time. This pressure rating, which the CEP was instrumental in promoting, is now considered the global standard for cars.

- At the same location, an electrolysis plant was installed in 2004, which produced hydrogen from renewably generated electricity. Compressed and stored, it was available for fuelling on-site without additional supply logistics. Today, half of the hydrogen at our filling stations is produced using renewable energy – an important contribution to lowering CO_2 emissions caused by road transport.

Since 2008, the CEP has been the biggest lighthouse project of the National Hydrogen and Fuel Cell Technology Innovation Programme (NIP) and is coordinated by the National Organisation for Hydrogen and Fuel Cell Technology (NOW). Over time, its activities have been extended to other lighthouse regions: in Hamburg and Berlin, new sites were built where entire fleets of cars and buses can refuel. The state of North Rhine-Westphalia's first public hydrogen filling station opened in Düsseldorf. In Baden-Wuerttemberg, the establishment of the network began with sites in Stuttgart and Karlsruhe, and hydrogen filling stations now exist in Hesse and Bavaria as well.

Where do we stand at the end of 2016?

The first hydrogen-powered vehicles are now on the market for private users, and others are being added. Fuelling and logistics have been tested to such an extent that H2 Mobility Deutschland – a joint venture between the CEP partners Air Liquide, Daimler, Linde, OMV, Shell and Total – can take over the operation of the filling stations from 2017 and expand the Germany-wide network in the years ahead.

The Clean Energy Partnership, too, will continue to take on important tasks, albeit to a modified extent: they range from further developing technologies and standards, to serving as the independent knowledge platform for the German hydrogen industry through to increasing international cooperation. We're going places with hydrogen – join us!

Your's Thomas Bystry
Chairman of the Clean Energy Partnership

AIR LIQUIDE · BMW Group · BOHLEN DOYEN · DAIMLER · EnBW · HYUNDAI · Linde · OMV · Shell · SIEMENS · Ford · GM · Opel · H2 MOBILITY · HOCHBAHN · HONDA · SSB · TOTAL · TOYOTA · VOLKSWAGEN · Westfalen

Established in 2002 and managed by the German Federal Ministry of Transport and Digital Infrastructure (BMVI), the Clean Energy Partnership (CEP) has steadily grown. Today, it unites 20 partners from different sectors – energy, technology, automotive and transport – in the world's leading association of its kind.

KNOWLEDGE AND PROJECT MANAGEMENT

THE NERVE CENTRE OF THE CEP IS IN THE WORKING GROUPS.

Since 2008, the individual activities are recorded and processed in a comprehensive project and knowledge management. The so-called overarching module forms the basis for a seamless backing of research and development processes. Using measures data, results are worked out and consistently translated into action.

Developing solutions together

The continuous exchange among industry partners as well as international networking with technology initiatives and standardisation bodies worldwide were at the centre of these activities. Within the CEP, various thematic working groups dealt with specific questions in the areas of mobility, infrastructure, production and communication. The working groups discussed matters of technical detail as well as related topics. Several groups of experts dealt with the practical challenges that had to be mastered on the path to market maturity for the new technology.

On the basis of their joint work, the expansion of the service station network was made concrete and a comprehensive evaluation of the vehicle and facility operation data was undertaken. The energy data collection now installed at most CEP service stations, for example, grants a differentiated insight into the system's efficiency given the interaction of all components and under varying operating conditions. This gives protagonists valuable knowledge about the efficiency and optimisation potential of the current generation of service stations. With this internationally appreciated expertise, the partnership has contributed to the development of the uniform fuelling standard for 700-bar pressurised gas fuelling, SAE TIR J-2601, among other things. Today, the CEP has a globally unparalleled database on the performance and efficiency of available technologies.

The focus is on customer friendliness

The partnership has also made it possible for customers to easily access the newly built hydrogen pumps. Though initially the focus here was on technical testing, today the pumps are as easy to use as conventional gas filling stations. To make life with a hydrogen car easier for users from the start, an authorisation process for customers including a card and billing system for hydrogen fuelling was introduced. A reporting system on service station availability was also established, which can be accessed online and provides live information about CEP hydrogen filling stations.

The representatives at the CEP plenary assembly

What we are talking about

In addition to these tasks, the CEP has engaged in intensive public relations work since 2008, with the aim of effectively anchoring hydrogen in the public consciousness as a fuel and energy store. The project's PR working group developed a long-term communication strategy to inform the defined target groups about hydrogen mobility and get them excited about it. Traditional print products, an informative and interactive web presence (www.cleanenergypartnership.de) and regular appearances at trade fairs were supplemented by viral films, social media activities, and special informative events for the trade press as well as Campus Days at selected universities. The importance of hydrogen as a storage medium and emission-free fuel in the age of decarbonisation was the central starting point for CEP's communications. Thanks to the extensive experience and sources of knowledge jointly acquired by the partners, the CEP's public relations work was able to illustrate the many uses of technology for specific target groups and make them accessible. The CEP test drive events, where the technology of hydrogen-powered fuel cell vehicles could be experienced live, accompanied by experts, were especially popular.

PRODUCTION AND STORAGE

Hydrogen (H_2) has been used in industrial processes for more than 100 years. Because it occurs in so many natural compounds, it can be produced in a number of ways. One of the CEP's concerns was and still is to generate hydrogen as sustainably as possible, so as to minimise CO_2 emissions even before it is used in the vehicle. And so, over time, different methods of hydrogen production were tested by the CEP: electrolysis, the reforming process, and crude glycerol pyrolysis.

Another major topic that the partnership dealt with was the question of the most appropriate storage method. Within the CEP, two techniques were tested: gaseous H_2 storage under high pressure and the storage of cryogenic, liquefied hydrogen at a temperature of –253 °C.

The CEP now focuses on gaseous storage for vehicles, while both methods are used for storage at service stations.

HYDROGEN FROM RENEWABLE SOURCES ENABLES HIGH CO_2 REDUCTIONS. WHICH PRODUCTION METHODS AND STORAGE OPTIONS EXIST TODAY?

Crude glycerol pyrolysis

Since 2012, the Linde pilot plant in Leuna has supplied hydrogen sustainably produced from crude glycerol, which is certified as green by the German Association for Technical Inspection (TÜV). The plant has thus helped to meet the CEP's voluntary commitment to supply at least 50 per cent renewable hydrogen. Crude glycerol pyrolysis was discontinued in 2015 for economic reasons. Also since 2012, Leuna has been testing another green production method using bio-methane.

Air Liquide successfully completed the certification of the 'Blue Hydrogen' production process as green hydrogen, according to CEP requirements / the TÜV SÜD CMS 70 standard. 'Blue Hydrogen' is centrally produced in an Air Liquide steam reformer in Dormagen by reforming bio-methane, and can be supplied to the service stations via various Air Liquide filling plants using a mass balancing system. As with green energy, the balancing means that the service stations are indirectly supplied with green-certified hydrogen.

Reforming process

Steam reforming is a proven and cost-effective method for producing the large quantities of hydrogen that are needed particularly in refineries and industrial applications. A hydrogen-containing synthesis gas is initially produced from natural gas to which steam and heat is added, which is then split until pure hydrogen forms. The gas has to be very pure in order for the fuel cell to work properly. Hydrogen is also produced as a by-product in chemical industry processes. Even hydrogen produced from natural gas can serve to reduce carbon dioxide emissions: used in fuel cell vehicles, it generates up to 30 per cent fewer CO_2 emissions than modern diesel vehicles (comparison value 120 g/CO_2/km).

If bio-methane instead of natural gas is used for the steam reforming, CO_2 is reduced not only during use, but also during production. The sustainably produced biogas comes from certified sustainable sources registered with the German Energy Agency (dena). The proportion of processed organic methane in the feed gas can be increased as needed, theoretically up to the plant's maximum capacity.

HARD FACTS!

At –423.17 °F, hydrogen condenses into a colourless liquid. The melting point of hydrogen is –434.45 °F – only that of helium is lower. When hydrogen changes from a gaseous to a liquid state in extremely low temperatures, its volume is reduced by 99.9 per cent.

Water electrolysis

Water electrolysis makes zero-emissions hydrogen production possible if the electricity needed for the electrolysis is produced from renewable energy sources such as wind energy. In water electrolysis, water (H_2O) is mixed with a liquid that improves the ion transport. Using electrical energy applied at two electrodes, the water is split into its components, hydrogen (H_2) and oxygen (O). The electrical energy used is converted into chemical energy and stored in the hydrogen. Electrolysis can be carried out directly at the service station ('on-site') or centrally at bigger power-to-gas plants and subsequently transported to the filling station. Both options have been tested by the CEP. In decentralised generation, the H_2 stations essentially operate self-sufficiently and produce their hydrogen on-site, so there are no transport costs. However, the production of large amounts of hydrogen at centralised plants is usually the more economical solution. Above all, this option makes it easier to achieve cost-efficient economies of scale, which can positively affect the pricing of green hydrogen.

When the first CEP hydrogen station was being built on Messedamm in Berlin in 2004, an electrolyser with a capacity of 60 Nm/h was already installed by the then project partner StatoilHydro. To avoid CO_2 emissions that would affect the success of the project, only renewable electricity certified by Vattenfall was used to operate the plant.

Over the years, the CEP refined the electrolysis technique, adapted it to requirements and improved it. Energiepark Mainz, a joint project by Siemens, Linde, Stadtwerke Mainz and RheinMain University of Applied Sciences, started operation in July 2015. This 'power to gas' plant uses eco-friendly electricity, among other things from neighbouring wind turbines, to generate up to 200 tons of green hydrogen a year by electrolysis – enough to power around 2,000 fuel cell cars for a year.

Meanwhile, water electrolysis using renewable electricity is relevant not only for the production of hydrogen as a fuel; it also represents an option for storing surplus electricity, which we will have more and more of as Germany's power industry switches to renewable sources. Large amounts of volatile energy can be stored long-term in the form of hydrogen, and then be converted back into electrical energy or fed into the natural gas grid as needed.

One flagship project in this connection is the world's first hydrogen-wind-biogas hybrid power plant in Prenzlau. It consists of three 2.3 MW Enercon E-82 E2 wind turbines and a 500 kW electrolysis plant. Two CHP plants can be run on a mixture of hydrogen and biogas.

PATRICK SCHNELL
VORSITZENDER CEP
2008–2015

For me, the combination of storing wind energy in form of hydrogen and its use as fuel in fuel cell vehicles is a trailblazer. With it, we resolve social, economic and ecological problems all in one go.

Both CHP plants and the wind turbines supply electricity which can be fed into the grid. When there is an oversupply of electricity, this can be used to produce the gases oxygen and hydrogen from water by electrolysis; the gases are then stored in pressurised tanks. These tanks act as a store for periods when the wind is not strong enough to cover consumers' energy needs with 'RE' gas. Some of the CEP service stations in Berlin are supplied with hydrogen produced there.

Storing hydrogen

Hydrogen is the lightest known element – 14 times lighter than air. Its low density poses particular challenges for its storage in vehicles and at filling stations as well as for its transport. When storing larger quantities at service stations and during transport, hydrogen is stored in gaseous form under high pressure, or as cryogenic liquid hydrogen at –253 °C. The appropriate option is selected based on logistical, economic and energy aspects. Underground storage tanks are particularly suitable for relatively confined spaces. For road distribution, 500-bar trailers are currently the state of the art, and reduce the number of trips necessary (vs. the conventional 200-bar technology).

For storage in the vehicles, the CEP is focusing on gaseous storage at 350 bar in buses and 700 bar in cars. Major progress has been made in the energy-efficient realisation of these high pressures over recent years. For instance, thanks to modern compression technology, e.g. an ionic compressor, specific energy consumption and space requirements have been reduced considerably.

Since mid-2015, cryo-compressed storage technology has also been tested, which works with liquid hydrogen. Compression using cryogenic liquid hydrogen requires only 10–20 per cent of the energy of a gas compressor.

Journalist event in 2014 in Baden-Wuerttemberg: "A look behind the scenes – hydrogen as fuel and energy storage"

INFRASTRUCTURE: A FILLING STATION NETWORK FOR GERMANY

Since its inception in 2002, the CEP has been blazing the trail for the construction of a hydrogen fuelling infrastructure in Germany. While the filling stations were initially used mainly for testing and demonstration purposes, the last phase of the project was increasingly guided by the practical needs of the market.

Besides ongoing research and development, the focus today is mainly on improving the H_2 supply.

FROM THE FIRST RESEARCH STATION TO THE CUSTOMER-FRIENDLY FILLING STATION NETWORK

At the end of 2004, the first CEP hydrogen filling station went into operation on Messedamm in the Charlottenburg district of Berlin after several years of preparation. It was a milestone in many respects: it was the world's first full integration of hydrogen at a conventional filling station, a choice which had deliberately been made even at this early stage. Rather than being pumped in an area separate from the regular forecourt, hydrogen was included in the range as another product, alongside the conventional fuels. Two H_2 fuel pumps were installed to test different fuelling technologies. While Opel and BMW opted for super-cooled liquid hydrogen in the vehicle in the interest of a high-energy density – and thus a greater range – Daimler and Ford tested pressurised-gas fuelling at 350 bar. In the further course of the CEP, liquid fuel was eventually abandoned entirely in favour of pressurised gas fuelling.

700-bar compression

From 2007, preparations began for the introduction of 700-bar compression, which was successively adopted by all car and filling station manufacturers in the CEP as the industry standard in the further course of the project. Today, 350-bar pressure is used almost exclusively by buses.

700-bar: refuelling within three minutes

The first vehicles in front of the filling station on Messedamm, Berlin, 2004

Liquid hydrogen is still used for storing large volumes at service stations. An advantage of this is that the energy-intensive pre-cooling of hydrogen, which is required at 700-bar fuelling in the interests of quick fuelling, can be dispensed with.

In parallel to the liquid hydrogen pumps, the project partner StatoilHydro built an electrolysis plant at the Messedamm site, which produced hydrogen on-site with renewable electricity. Pressurised and stored, the hydrogen was available for fuelling without additional supply chain logistics.

2006, the CEP partner Total opened the second CEP hydrogen filling station on Heerstrasse in the Spandau district of Berlin. The opening was attended by the then German and French Transport Ministers, Wolfgang Tiefensee and Dominique Perben. During the inauguration, Mr Tiefensee announced the launch of an unprecedented research and development programme – the National Hydrogen and Fuel Cell Technology Innovation Programme (NIP).

This second filling station, too, offered hydrogen at 350 bar and in liquid form alongside conventional fuels. Later, an additional fuelling option for compressed hydrogen at 700 bar was added, making this the first 700-bar filling station in Germany. In addition to the publicly accessible petrol pumps at the Total station, the filling-station technology also supplied another complete fuelling system at the adjacent premises of the Berlin Transit Authority (BVG), which has fuelled its fleet of 14 hydrogen buses here since 2006. Both facilities initially obtained their hydrogen from Linde, from a 17,600-litre liquid hydrogen storage tank. The evaporation quantities were harnessed to operate two stationary fuel cells that supplied electricity and heat for the service station.

DR. KLAUS BONHOFF
CEP CHAIRMAN
2005–2007

In recent years, we have seen a cost reduction in the fuel cell drives by 75 per cent and in the hydrogen filling stations by 50 per cent. At the same time, the technology has proven its suitability for everyday use.

It is foreseeable that fuel cell drives with hydrogen as fuel are more economical for mobility with large operating ranges and fast refuelling times than other alternatives – and with zero emissions!

Starting in June 2006, gaseous hydrogen was supplied from steam reforming using propane and butane (liquid gas), which was already stocked at the site for LPG fuelling anyway. However, extensive testing showed that an economically sustainable production of hydrogen is not possible using this method.

So from 2010, concepts for a supply of renewably produced hydrogen from the Uckermark region were developed and implemented together with the wind farm operator Enertrag.

The H_2 infrastructure is growing

Thanks to the experience gained with the available fuelling technologies and various production and supply paths, the expansion of the infrastructure gained considerable momentum from 2010.

First, the filling station on Holzmarktstrasse in Berlin opened in May 2010, a collaboration project between the CEP partners Linde, Total and StatoilHydro. As a 'multi-energy service station', alongside conventional fuels, natural gas, and LPG, it also supplies customers with hydrogen in all available forms and pressures (LH_2, GH_2 350 bar, GH_2 700 bar).

At Holzmarktstrasse, various technical innovations were tested in research operations during the project phase up to 2014. For instance, Statoil used a next-generation prototype of its electrolysis technology at the site, designed with the idea of optimising it for use with volatile renewable energy. The electrolyser was to react very flexibly to a changing energy supply at short notice. For the first time, the storage was moved underground, to test solutions for filling stations with limited space. Total commissioned the development and operation of a mini-CHP to use the evaporation quantities occurring in the LH_2 tank; it now supplies the filling station with energy and heat.

Cryopump technology

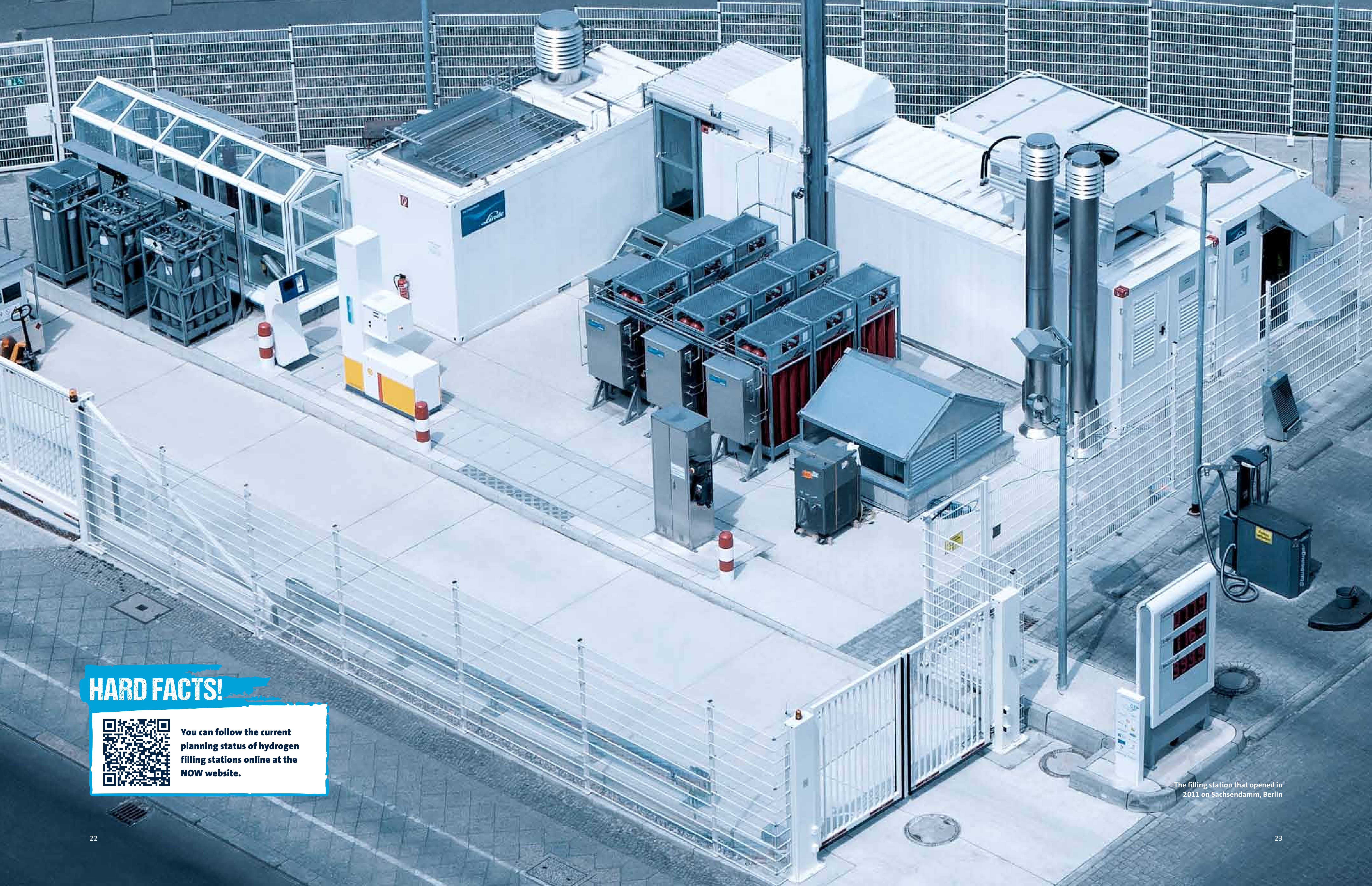
In a second stage of expansion from 2014, the facility was retrofitted and equipped with the latest filling station technology, using cryogenic pump technology from Linde to supply hydrogen at 700 bar.

In June 2011, Shell opened its first hydrogen filling station in Germany – the world's highest-capacity hydrogen filling station to date – on Sachsendamm in the Schöneberg district of Berlin. Equipped with a cryogenic pump system, it supplies up to 1,200 kg of GH_2 per day. It offers pressurised hydrogen at 350 bar and 700 bar, so that both cars and buses can be fuelled.

The car fuel pump is fully integrated into the forecourt. The generous system capacity was essentially owed to the Berlin Transit Authority (BVG) plans to substantially expand its test fleet. However, these plans had to be abandoned after the bus manufacturer MAN discontinued the further development of its hydrogen combustion engine technology. The hydrogen for the Sachsendamm filling station was initially supplied by the Linde pilot production plant in Leuna, where hydrogen was sustainably produced based on crude glycerol and thus certified as green by TÜV. As a result, the station makes a substantial contribution to meeting the CEP's voluntary commitment to supply at least 50 per cent renewable hydrogen.

On-site production

Also in 2011, EnBW joined the CEP and built filling stations on Durlacher Allee in Karlsruhe and Talstrasse in Stuttgart in the CEP region Baden-Wuerttemberg. The energy supplier was especially motivated by the question of how renewable power can be usefully and efficiently stored in hydrogen by means of on-site electrolysis and sold as a fuel.



HARD FACTS!

You can follow the current planning status of hydrogen filling stations online at the NOW website.

The filling station that opened in 2011 on Sachsendamm, Berlin

The hydrogen station in Hamburg's HafenCity has an electrolysis plant for the on-site production of green-certified hydrogen.

Similar interests led Vattenfall to build the technologically ambitious hydrogen filling station in Hamburg's HafenCity in cooperation with Shell. Its redundant construction made it one of the most reliable service stations in Germany. Not only is it very sophisticated from an architectural point of view, it also has an unusually prominent location in the centre of the Hanseatic city, directly opposite the SPIEGEL building on Oberbaumbrücke and a stone's throw away from Hamburg's main railway station. Its on-site electrolytic hydrogen production uses certified electricity from wind turbines that are less than six years old. Up to 20 buses and several cars can be fuelled with a delivery capacity of approximately 750 kg of GH_2 (at 350 bar and 700 bar). This is where Hamburger Hochbahn fuels its hydrogen buses, which have been in service since 2003.

In September 2012, the first site in North Rhine-Westphalia went into operation. The construction of the Air Liquide public hydrogen filling station on Höherweg in Düsseldorf was funded by the federal state of North Rhine-Westphalia – the third region after Berlin and Hamburg to become involved in the CEP. The capacity of the H_2 filling station (about 200 kg/day) is enough to fuel up to 50 cars a day. The gaseous hydrogen is stored at a medium pressure of 200 bar in a 200 kg tank. The station has two dispensers at pressures of 350 & 700 bar. This site is the first in a series of other sites currently being set up by Air Liquide.

In Berlin, other sites were built at the future Berlin Brandenburg Airport and on Heidestrasse within sight of the main railway station.

The network expansion also progressed rapidly in the CEP region of Baden-Wuerttemberg. With the opening of the OMV station in Metzingen in autumn, the federal state inaugurated its eighth hydrogen filling station. In North Rhine-Westphalia, the CEP partner company Westfalen recently built a H_2 station in the Amelsbüren district of Münster.

Filling station network for Germany

With the agreement regarding the implementation of a 50-service station programme by the end of 2016, signed in June 2012 by the CEP partners Air Liquide, Air Products, Daimler, Linde, Total and the Federal Transport Minister Dr Peter Ramsauer, 2012 also marked the start of the market preparation phase, at the end of which Germany should have a basic nationwide supply. Major challenges accompanied the network expansion over the years. While the first sites were largely standalone developments, the need to simplify the further network and fleet construction through extensive standardisation of technologies, components and processes very soon became apparent – a process the plant manufacturers, operators and automotive industry were equally involved in. By bringing all interest groups together around the same table, the CEP offered excellent conditions for effectively supporting the necessary standardisation processes.

PATRICK SCHNELL
CEP CHAIRMAN
2008–2015

For me as a Frenchman, it thrilled me to see that the French economy minister Macron visited the filling station on the Heidestrasse together with the German economy minster Gabriel. I was very pleased to witness the prominent support given in our field of hydrogen.

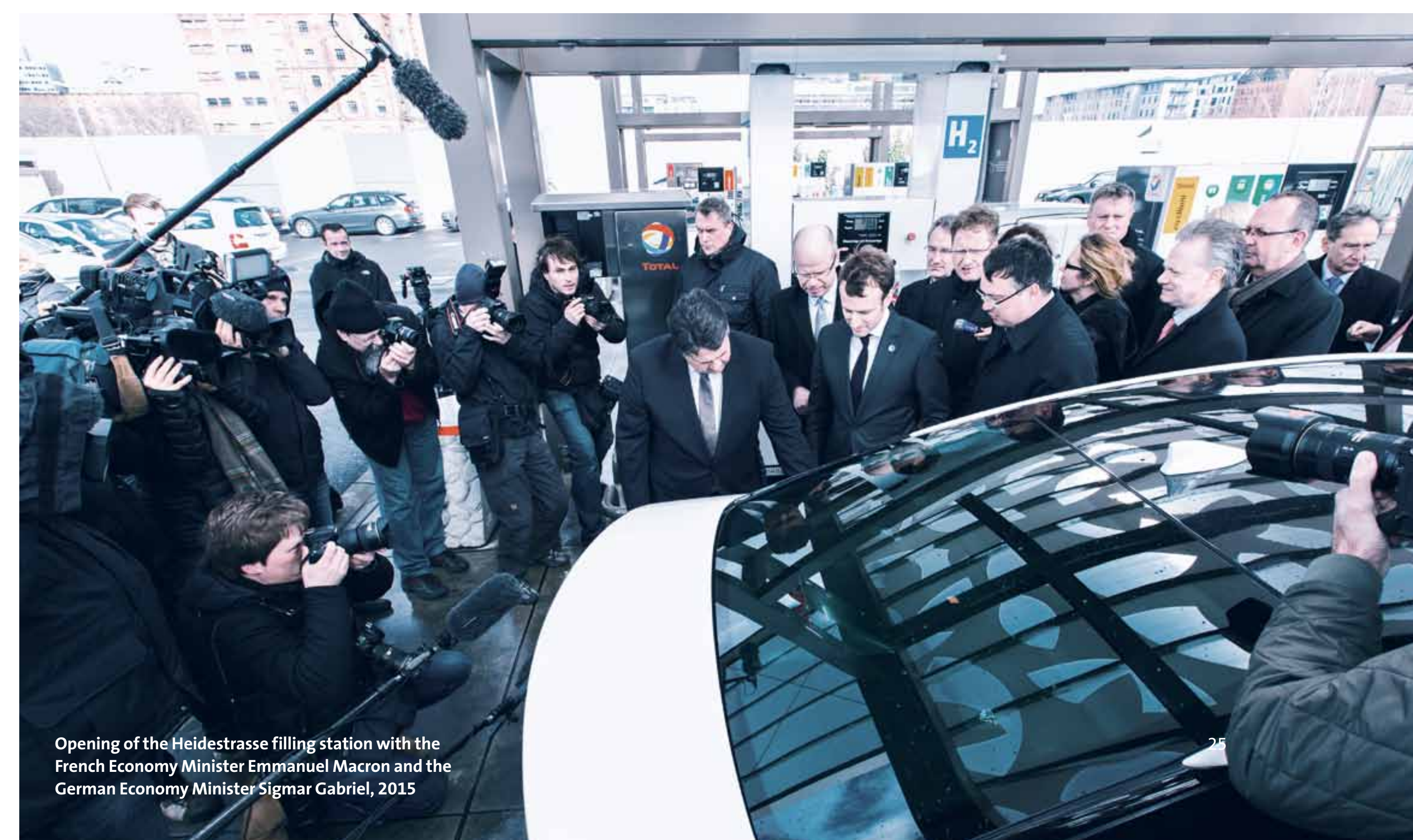
Standardisation, efficiency and cost optimisation were also the order of the day in the manufacturing of compressor stations – the technical heart of every H_2 filling station. The progress in all three areas was evident, among other things, by the fact that Linde began the world's first small-series production of H_2 filling stations in 2014.

Global fuelling standard

After members of H2 Mobility Deutschland had already formulated requirements for the dimensioning of fuelling equipment in advance of the company's founding, the establishment of a fuelling standard for 700-bar pressure hydrogen fuelling was essential.

The CEP took over practical testing at selected locations. The findings eventually culminated in the publication of the current revision of SAE TIR J2601 (2014). It would have been impossible without the field testing conducted by the CEP.

From 2017, H2 Mobility Deutschland will manage the infrastructure's further expansion. By 2018, there will be 100 stations in six major metropolitan areas and along the axes connecting them. By 2023, H2 Mobility plans a network of up to 400 service stations, depending on the increase in the number of fuel cell vehicles.



Opening of the Heidestrasse filling station with the French Economy Minister Emmanuel Macron and the German Economy Minister Sigmar Gabriel, 2015

Hydrogen filling station, Holzmarktstrasse, Berlin

Go-ahead for the energy transition – State Secretary Reiche opens the large-scale hydrogen plant in Berlin-Schönefeld, 2014

H2 Mobility Congress with Federal Minister of Transport and Digital Infrastructure Alexander Dobrindt and representatives of the industry, Berlin, 2016

Opening of the filling station on Sachsendamm, Berlin, 2011

Dr P. Blauwhoff, Chairman of the Managing Board at Deutsche Shell Holding GmbH, P. Schnell, CEP Chairman, O. Reckenhofer, MD of Linde Gas Deutschland, Dr K. Bonhoff, MD of NOW GmbH, 2012

Tim Heisterkamp, Manager Public Affairs at The Linde Group explains the site on Sachsendamm in Berlin, 2011

Hesse joins CEP, 2011: Hesse's Minister for Environment L.Puttrich with K.-F. Stracke, Chairman of the Board at Adam Opel AG

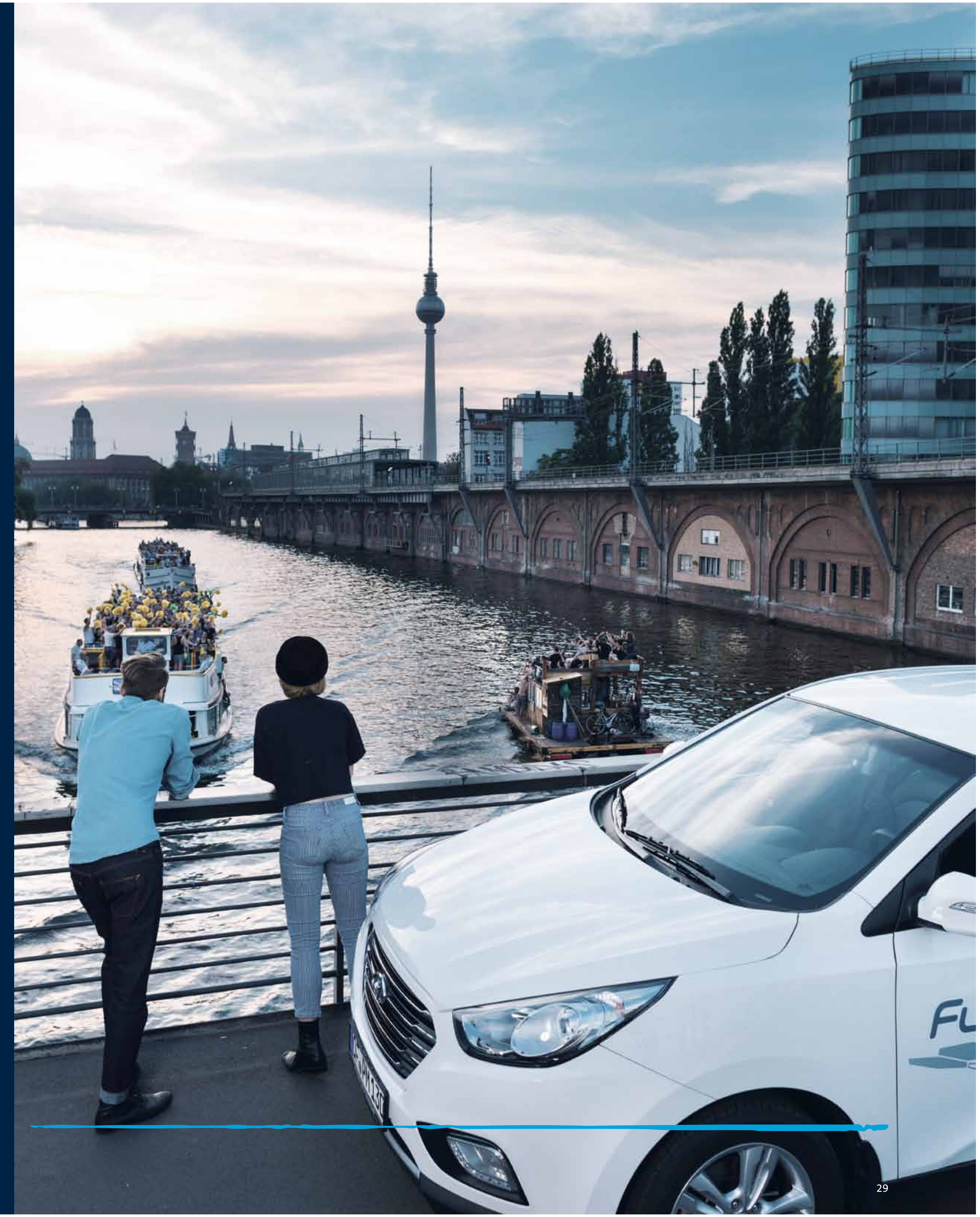
Photo shoot at the first petrol station in North Rhine-Westphalia, 2012

Wolfgang Tiefensee at the opening of the filling station on Holzmarktstrasse, Berlin, 2010

MOBILITY

The overriding objective of the energy revolution is to significantly reduce greenhouse gases. As road transport is indisputably a major emitter, industry and government have great hopes in the potential of hydrogen. Accordingly, the aim of the Clean Energy Partnership (CEP) was clearly defined: to prepare the ground for a clean mobility of the future, emissions-free, silent, and without restrictions on range.

Through their dedicated research and development and with the support of Germany's federal government, the partner companies have been true trailblazers in creating an impressive fleet of fuel-cell vehicles.



HYDROGEN – DIFFERENT STORAGE AND DRIVE CONCEPTS

In 2003, the four car manufacturers BMW, Daimler, Ford, and Opel began experimenting with hydrogen as an alternative fuel. In early 2006, before the first phase of the project had ended, a fifth automotive group joined: Volkswagen. From the end of 2004, as many as 16 vehicles were driving through Berlin's streets in demonstration and trial operations. Shortly afterwards, in 2007, hydrogen-powered vehicles were also handed over to customers including Deutsche Telekom, Vattenfall, the Federal Chancellery, Hermes, Berlin's urban waste management, IKEA and various ministries – thereby impressively demonstrating their technical maturity even at this early stage of the project.

In the early days of the CEP, the partners still worked on very different drive and storage concepts. Over the course of the project, the use of hydrogen in internal combustion engines was abandoned in favour of fuel-cell propulsion, which had better energy efficiency, and has now reached technical market maturity. The alternative storage of liquid hydrogen in the vehicle, as was tested by Opel and BMW, is no longer carried out in the vehicle itself, but only for larger quantities, i.e. at the service stations. Across all brands, compressed gaseous hydrogen has prevailed for use in vehicles with fuel-cell propulsion.

Hydrogen vehicles in everyday use

In 2004, Ford joined the fuel-cell demonstration project for the CEP with its Focus. The vehicle was already the fifth generation of Ford fuel-cell vehicles and is still undergoing long-term endurance tests to this day. A battery provides additional thrust during acceleration by boosting the overall system performance and allows for recuperation during braking. What has proceeded to become the doyen of the CEP vehicle fleet has been driven by royals like Prince Charles and Prince Haakon of Norway. Movie buffs may also know that the Ford Focus was featured in the James Bond movie 'Quantum of Solace', even if only as the engine sound used to dub the Bond girl's car. With the Explorer Hydrogen, Ford sent a second fuel cell vehicle out onto the road. The SUV had two powerful electric motors for the front and rear axes, enabling four-wheel drive.

Prince Haakon of Norway with rally pro Henning Solberg on the Viking Rally, Norway, 2009

BMW was also on board from the beginning, with the Hydrogen 7, a saloon based on the 7 Series with a modified petrol engine that let it run on liquid hydrogen (LH_2) as well as petrol. The bivalent-drive vehicle was powered with LH_2 cooled to –253 °C, stored in a highly insulated tank, and was considered from the outset suitable for everyday use.

BMW ceased operating the Hydrogen 7 in 2011, and turned its focus to developing the drive system and hydrogen storage. In 2015, this resulted in a model based on the BMW 5 GT, which relies entirely on fuel-cell technology. BMW is also testing a new storage technology in this vehicle, cryo-compressed (CCH_2) technology, where cryogenic liquefied hydrogen is directly compressed and fuelled at –40 °C, giving it a greater capacity and range. Unlike in LH_2 technology, there are no evaporation losses with CCH_2.

The fuel cell prevails

In 2004, Daimler introduced the A-Class F-Cell into the CEP. 60 units of this small-series fuel cell vehicle were built, representing the sixth generation of Daimler's fuel cell vehicles. This vehicle was tested as part of various international collaboration projects in Europe, the United States, Japan and Singapore. The F-Cell hydrogen used compressed gas at 350 bar; its fuel consumption was equivalent to 4 litres of diesel per 100 kilometres. The fuel-cell system is housed in the 'sandwich floor' of the Mercedes-Benz A-Class's long wheel base.

In 2007, the next generation arrived – the B-Class F-Cell, operated worldwide in a small series run of about 200 units. Up to 90 vehicles were on the road in the CEP regions of Berlin, Baden-Wuerttemberg and Hamburg. This generation of the F-Cell in particular contributed significantly to increasing the CEP fleet stock to well over 100 vehicles by the end of 2013. Daimler used 700-bar technology here for the first time. In 2011, three of these cars travelled around the world as part of the F-Cell World Drive, each covering distances of about 30,000 km in 125 days. On the road, Linde's specially-built mobile refuelling unit served almost 400 hydrogen refuellings.

In 2017, Daimler will launch a fuel cell plug-in vehicle on the market with the Mercedes-Benz GLC F-Cell.

Opel added the HydroGen3 fuel-cell vehicle to the CEP fleet in 2004. Based on the Opel Zafira, it was already close to series production. The HydroGen3 liquid ran on cryogenic liquid hydrogen and coped with all requirements without an additional back-up battery thanks to its dynamically optimised fuel-cell system.

In 2008, the HydroGen3 was followed by the HydroGen4, a vehicle based on the Chevrolet Equinox. This model was driven by customers mainly in Berlin, but also in other CEP regions. Well-known customers such as ADAC, Allianz, Coca-Cola, Hilton, Linde, Schindler, Axel Springer, Total and Veolia ensured high visibility for the vehicle on Berlin's roads.

In 2006, the Volkswagen Group became the fifth vehicle manufacturer to join the CEP, initially contributing the Touran HyMotion to the project. The HyMotion3 successor generation with the vehicle models VW Tiguan HyMotion, VW Caddy HyMotion and Audi Q5 HFC had greater ranges from 2008, thanks to 700-bar tank technology. Performance peaks are covered by a lithium-ion battery beneath the cargo floor of the boot, and the energy released during braking is harnessed to recharge the battery. The fourth-generation HyMotion, the fuel-cell variant of a US Passat, also runs on gaseous hydrogen at 700 bar. In 2016, the Audi brand took over VW Group's fuel-cell activities, making it the Volkswagen Group's interface to the CEP. At the Los Angeles Auto Show 2014, Audi presented the A7 Sportback h-tron. This plug-in hybrid model combines the fuel cell with two electric motors for all-wheel drive. The battery installed below the boot space stores the recuperation energy from the braking process, enabling an increase in performance.

The CEP fleet continues to grow

After 2008, the Clean Energy Partnership became more and more internationally relevant, as evidenced by other mobility partners coming on board, among other things. In 2011, for instance, two global Japanese companies joined the project for the first time: Toyota and Honda. Shortly thereafter, the Korean carmaker Hyundai also joined the CEP.

In Toyota's fuel-cell hybrid vehicle FCHV-adv, a vehicle developed close to series production-readiness, which was introduced in 2008 after having undergone several stages of development since 1992, the CEP gained a 700-bar vehicle that already had all the main elements of market and series-production readiness. The vehicles were not available for customers at first, but were used for test and trial drives. This was the last generation of trial vehicles for Toyota.

The Toyota Mirai has been available as a series production vehicle since 2014 in Japan, and since 2015 in the United States and Germany. With the launch of the Toyota Mirai, an essential step on the way to the final establishment of hydrogen as an alternative fuel was made.

Honda brought several units of the Honda FCX Clarity, which it had introduced in 2008, to Germany and is now setting new standards in terms of range. The FCX Clarity saloon is a 350-bar vehicle concept with a PEM fuel cell installed in the centre tunnel. Honda presented the successor model, the Clarity Fuel Cell, in 2015 and its European market launch took place in 2016. Thus Honda has succeeded in offering the world's first production-model saloon where the entire drivetrain including fuel cell is housed in the engine compartment. Equipped with a 700-bar tank system, the vehicle has a lithium-ion battery and is suitable for everyday use without restrictions.

Asia's second-largest automotive group Hyundai was already on the brink of entering the market the year it joined the CEP. In 2013, the ix35 Fuel Cell was added to the Group's product range on an equal footing alongside conventional series-production vehicles. Since mid-2015, this vehicle can also be purchased by private customers. By the end of 2015, there were around 120 vehicles on the road in Germany. The Hyundai ix35 Fuel Cell is also the fleet car of the world's first car-sharing project with fuel cell vehicles that Linde initiated in the summer of 2016: 50 emission-free vehicles are currently on the road in Munich under the BeeZero brand.

The CEP vehicles and explainers in front of the hybrid power plant in Prenzlau, where green hydrogen is produced

H_2 in public transportation

In addition to cars, the CEP vehicle fleet also includes hydrogen buses. At the beginning of the project the development of technical maturity and suitability for everyday use was the focus of the collaboration with partner companies. In June 2006, MAN hydrogen buses were handed over to the Berlin Transit Authority (BVG) in the presence of Environment Minister Sigmar Gabriel. They were the first buses in the CEP's fleet. During the Football World Cup, the buses were used as shuttles between the airport and the press centre at the Olympic Stadium for a great publicity boost.

After the launch of the hydrogen-powered bus service, large-scale pilot projects in public transport followed in other CEP regions. For instance, on the 109 'Innovation Line' in Hamburg, vehicles with innovative propulsion technologies were used to test different ones under comparable conditions. In addition to pure fuel-cell buses, battery-powered buses equipped with fuel cells as range extenders have been part of the Hamburg bus fleet since December 2014, for example.

From 2002 to 2016, the new buses in the city on the banks of the river Elbe travelled a stretch of about half a million kilometres. In Cologne, articulated buses with fuel-cell drives have been on the road since 2011. In 2013, Baden-Wuerttemberg launched scheduled services with the second generation of fuel-cell hybrid buses. Two buses have served as shuttles between the Karlsruhe Institute of Technology (KIT) campuses since June 2013. Also in Stuttgart, fuel-cell buses have been on the road again since 2013 – the continuation of a fleet trial that already successfully tested the everyday viability of the buses in hilly topography from 2003 to 2005.

The 'newcomers' to public transport deliver high productivity and flexibility as well as a good energy balance. Progress continues to be made on the standardisation of filling stations, bus depots, the establishment of a more cost-effective infrastructure, and the further technical development of existing offers. The equipment of garages that work on fuel-cell vehicles has been standardised, concepts for stronger sector networking are being drawn up, and the CEP has made advances in the field of after-sales as well. Further key steps were taken towards market maturity with the easy availability of spare parts, as well as the development of reliable diagnostic tools for analysing technical defects. The level of acceptance by passengers and the interest among high-ranking international visitors is already high. The Swedish royal couple, Princess Victoria and Prince Daniel, for example, expressed their enthusiasm about the sustainable technology during a visit to Hamburg. Virtually silent and producing zero emissions, the buses are especially suitable for use in city centres or residential areas.

Hydrogen bus in public transportation at Stuttgart Airport

VEHICLE DATA

AUDI H-TRON

BMW 5ER GT HYDROGEN FUEL CELL

FORD EXPLORER FUEL CELL

FORD FOCUS FUEL CELL

HONDA FCX CLARITY

HYUNDAI IX35 FUEL CELL

MERCEDES-BENZ B-KLASSE F-CELL

TOYOTA FCHV-ADV

VW PASSAT HYMOTION

CITARO FUELCELL-HYBRID
FROM DAIMLER BUSES

CITARO FUELCELL-HYBRID
FROM DAIMLER BUSES

M.A.N. BUS
FROM BVG

KIT MERCEDES-BENZ CITARO
FUELCELL HYBRID

PHILEAS FUEL CELL-HYBRIDBUS

RVK VAN HOOL A330FC

CAR	POWER UNIT	REFUELLING	POWER	TOP SPEED	RANGE
Audi Q5 HFC	Fuel Cell	gaseous hydrogen, 700 bar	100 kW	160 km/h	ca. 250 km
Audi A7 h-tron quattro	Fuel Cell	gaseous hydrogen, 700 bar	170 kW	200 km/h	beyond 500 km
BMW Hydrogen 7	Otto- / combustion engine	liquid hydrogen, petrol	191 kW	230 km/h	200 + 500 km
BMW GT 5 FCEV	Fuel Cell	cryogenic hydrogen, 350 bar	> 150 kW	180 km/h	ca. 700 km
BMW GT 5 FCEV	Fuel Cell	gaseous hydrogen, 700 bar	> 150 kW	180 km/h	ca. 500 km
Ford Focus Fuel Cell	Fuel Cell	gaseous hydrogen, 350 bar	65 kW	137 km/h	280 km
Ford Focus Fuel Cell	Fuel Cell	gaseous hydrogen, 700 bar	65 kW	137 km/h	400 km
Ford Explorer Fuel Cell	Fuel Cell	gaseous hydrogen, 350 bar	100 kW	160 km/h	400 km
Mercedes-Benz A-Klasse F-Cell	Fuel Cell	gaseous hydrogen, 350 bar	65 kW	140 km/h	160 km
Mercedes-Benz B-Klasse F-Cell	Fuel Cell	gaseous hydrogen, 700 bar	100 kW	170 km/h	380 km
GM/Opel HydroGen3 liquid	Fuel Cell	liquid hydrogen	60 kW	160 km/h	400 km
GM/Opel HydroGen4	Fuel Cell	gaseous hydrogen, 700 bar	94 kW	160 km/h	320 km
Honda FCX Clarity	Fuel Cell	gaseous hydrogen, 350 bar	100 kW	160 km/h	460 km
Hyundai ix35 Fuel Cell	Fuel Cell	gaseous hydrogen, 700 bar	100 kW	160 km/h	ca. 600 km
Toyota FCHV-adv	Fuel Cell-Hybrid	gaseous hydrogen, 700 bar	90 kW	155 km/h	ca. 600 km
Volkswagen Touran HyMotion	Fuel Cell	gaseous hydrogen, 350 bar	80 kW	140 km/h	ca. 160 km
Volkswagen Tiguan HyMotion	Fuel Cell	gaseous hydrogen, 700 bar	100 kW	140 km/h	ca. 230 km
Volkswagen Caddy Maxi HyMotion	Fuel Cell	gaseous hydrogen, 700 bar	90 kW	140 km/h	ca. 500 km
Volkswagen US Passat	Fuel Cell	gaseous hydrogen, 700 bar	100 kW	160 km/h	ca. 500 km

BUS					
Citaro FuelCell-Hybrid from Daimler Buses	Fuel Cell	gaseous hydrogen, 350 bar	120 kW	80 km/h	ca. 350 km
Solaris Urbino 18,75 Electric	Fuel Cell	gaseous hydrogen, 350 bar	100 kW	80 km/h	ca. 350 km
M.A.N. Buses with combustion engine BVG	Otto- / combustion engine	gaseous hydrogen, 350 bar	150 kW	80 km/h	ca. 200 km
Phileas Fuel Cell-Hybridbus from APTS	Fuel Cell	gaseous hydrogen, 350 bar	150 kW	80 km/h	ca. 300 km
A330 FC from Van Hool	Fuel Cell	gaseous hydrogen, 350 bar	150 kW	80 km/h	ca. 350 km

CREATING AWARENESS FOR CLIMATE PROTECTION

The Clean Energy Partnership. Whoever came up with the name must have been a visionary, because who would have thought in the noughties that ten years later 'clean energy' would be a dictum in the energy sector.

The 'Clean Energy Partnership' is more than a name, it is the promise to redefine our world's energy supply. The partners are collaborating to make transport, heat and electricity clean. The not-very-associative word hydrogen is not even mentioned. And when fuel cells are brought up, the atmosphere is usually laden with question marks. These have been the communication challenges of the Clean Energy Partnership since the beginning. How do you communicate an invisible gas? Project communications were called for that would synthesise the results from research and development context and present these to the public in a way both technically correct and easy to understand.

Target group-specific appeal

In the early years, communications were mainly focused on the target group of government and decision-makers, who were only too happy to come to the first public filling stations to be shown the 'cars of the future' and later reported with pride that they were allowed to witness a historic moment. From 2011, the CEP's public relations work was broadened and the communication concepts focused on future customers and the wider public as well. The full range of modern communication instruments was employed. We made the first films in which hydrogen-powered cars represent zero-emission mobility. The project film, which explains the work and goals of the CEP in 90 seconds, was created with the participation of all partners. In the most elaborate scene, all the vehicle models drive on a road in the Uckermark under rotating wind turbines. No one who was involved in the filming will ever forget the surprised faces of villagers who watched behind half-open curtains as unfamiliar vehicles rolled from matt black low-loaders and then silently drove down the road in a convoy.

Active on all communication channels

With the videos 'Crime Scene: The Garden Shed', 'A Blonde Comes into the Library' and 'The Power-Full Neighbours' we virally disseminated the simple benefits of emissions-free hydrogen mobility, garnering lots of clicks and fans on the social platforms. When Germany's federal government proclaimed the energy revolution, the communication requirements changed. The public wanted to know how the transition from fossil fuels to the fluctuating renewables was going to be achieved. We showed the entire cycle of the hydrogen economy, with hydrogen mobility as an important building block in a changing energy economy based on renewable sources. Such complexity cannot be explained in one sentence; to do so properly, we needed placements in interviews, background reports and advertorials. At integrated events, we showed journalists what sector interlinking meant. The world's first hybrid power plant in Prenzlau was the starting point of a route at the wheel of various hydrogen-powered cars through the enchanting landscape of the Uckermark to the hydrogen filling station on Heidestrasse in Berlin. There, at the destination, the cars were refuelled with green wind-powered hydrogen from the very production plant in Prenzlau from where the tour began.

All of this took place in the company of the partnership's experts who were happy to answer the media representatives' questions. In this manner and with similar events in other regions, a solid network of dedicated journalists who believe in the topic's urgency and relevance was built up over the years. Other forms of knowledge transfer included easy-to-understand explanatory videos about the technology, a comprehensive interactive website, lectures and workshops at universities, as well as events for the general public, complete with test drives in fuel-cell vehicles.

Explaining the bigger picture: energy transition with hydrogen

Almost all the mainstream media that now report on hydrogen mobility stop in at the CEP communications office for in-depth knowledge, experience and evaluations. A growing number of service providers in photography, film, the online and design sectors, as well partners on the PR committee who have shown willing cooperation have helped to support joint, credible communications that tailored relevant and appropriate information to fit their target groups – even when their own company logo was not in the foreground.

In this way, the CEP grew into a highly acclaimed institution of knowledge, in which it was possible for the individual partners to work together – beyond their business objectives and selling intentions – to further the success of hydrogen as an alternative fuel. In the foreseeable future of its market activation, there will still be a need for a reliable source of information that handles the increasing number of enquiries and supports further progress with appropriate communication measures until the market ramp-up.

When the public perceives hydrogen as a storage medium and fuel equal to other technologies – that is when CEP communications will have achieved its goal.

Hannes Jaenicke, German actor, author and environmentalist tests the fuel cell technology, Berlin, 2016


Exciting hydrogen – Long Night of Sciences, Berlin, 2011


Alba contest – away with CO_2 emissions, Berlin, 2013


CEP in conversation with Salaheddine Mezouar, Foreign Minister of Morocco, at the Climate Change Conference of the United Nations, 2016


50 hydrogen filling stations for Germany, press conference, Berlin, 2012

Parliamentary evening with the German Hydrogen Association (DWV), Berlin, 2014


ADAC driver safety training, Linthe, 2012


Making-of explanatory films "Fuel Cell" & "Electrolysis", 2015


The naked truth – the making-of "Tatort Gartenlaube", 2012

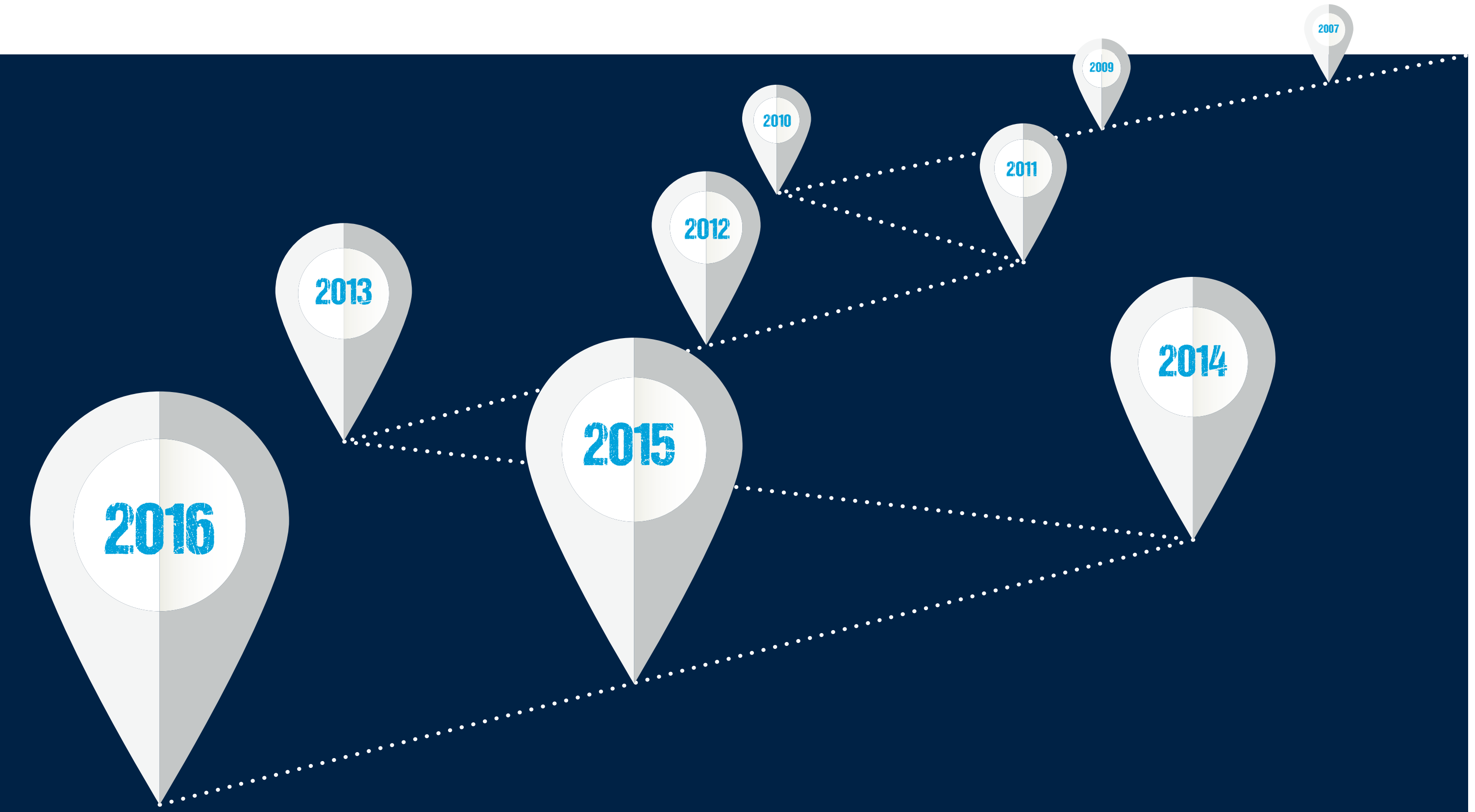
Initiative "Wasserstoff Brennstoffzelle Deutschland" ("Hydrogen fuel cell Germany") launches a campaign for hydrogen with prominent support, Berlin, 2016

Memorandum of Understanding between Dr Hyun Soon Lee, Vice Chairman of Hyundai Motor Company, Dr Klaus Bonhoff, Managing Director of NOW GmbH, Patrick Schnell, Chairman of CEP, Seoul, 2011

MILESTONES

The EU, together with China, Japan, Canada, Russia, and the USA, has set the target of reducing CO_2 emissions by 80 per cent compared to 1990 by the year 2050. To achieve this, experts believe that 95 per cent of road traffic must be switched to alternative drive systems. The Clean Energy Partnership's research and development work is based on the belief that hydrogen as a fuel and energy store can be an important contributor to decarbonisation and thus the energy revolution. This is our path.

There were many challenges to overcome and achievements to celebrate during our collaboration. Here are some of the milestones we like to look back on.



2002

December 2002: In December 2002, the Clean Energy Partnership (CEP) was established as a joint initiative of government and industry under the lead management of the Federal Ministry of Transport and Digital Infrastructure (BMVI).

2003

At the beginning of 2003: Start of fuel cell bus trials in Hamburg.

2004

November 2004: The first CEP filling station opens on Messedamm in Berlin with on-site production using water electrolysis. The hydrogen is condensed to a pressure of 350 bar in a compressor; refuelling with cryogenic liquid hydrogen is also possible.

The CEP launches its fleet of fuel-cell vehicles. From the end of 2004, as many as 16 vehicles are on Berlin's streets in demonstration and trial operations. Soon thereafter, in 2007, commercial enterprises start testing additional hydrogen-powered vehicles.

2006

In the presence of German Environment Minister Sigmar Gabriel, the first hydrogen buses with internal combustion engines are sent out on Berlin's roads. During the Football World Cup, they are used as shuttles between the airport and the press centre at the Olympic Stadium.

2007

May 2007: After 250,000 kilometres covered and 1,700 refuellings in 2006, the CEP is honoured by the 'Germany – Land of Ideas' initiative. Federal Minister of Transport Wolfgang Tiefensee and Federal Minister of Economics Michael Glos each add a hydrogen car to their respective ministries' fleets.

2008

2008–2016: The CEP becomes a beacon project of the National Hydrogen and Fuel Cell Technology Innovation Programme (NIP), an alliance of the German government, industry and science funded by the Federal Ministry of Transport and Digital Infrastructure for demonstrating hydrogen and fuel cell technology that is coordinated by the National Organisation for Hydrogen and Fuel Cell Technology (NOW).

September 2008: The first car 700-bar hydrogen fuel pump goes into operation in the Spandau district of Berlin. The ceremonial first refuelling uses the world's first infrared interface for data communication between vehicle and filling station at a public filling station.

2009

March 2009: The CEP and the California Fuel Cell Partnership (CaFCP) form a transatlantic alliance. The partners' declared goal is to coordinate and accelerate joint projects in the field of hydrogen and fuel cell technology through joint technology projects such as the introduction of a common standards for fuelling.

May 2009: At the Viking Rally, the CEP get royal backing: under the slogan 'Zero emissions', Prince Haakon of Norway also started in a fuel cell vehicle with his team-mate, the racing driver Henning Solberg, to open the HyNor Hydrogen Highway from Oslo to Stavanger.

2010

The next generation of fuel cell hybrid buses is introduced in Hamburg.

May 2010: In the run-up to the World Hydrogen Energy Conference (WHEC) in Essen, the H_2 filling station on Holzmarktstrasse in Berlin is opened. At the same time, the CEP launches its first integrated event: after technical discussions at the Norwegian Embassy, a journalists' rally starts from Berlin to Hamburg via Stolpe.

2012

February 2012: In Hamburg's HafenCity, an H_2 station opens that has the largest production capacity anywhere in Europe. The facility is able to supply up to 750 kg of hydrogen a day, at least half of which is produced on-site by electrolysis using renewable energy.

April 2012: The hybrid power plant in Prenzlau begins supplying filling stations in the capital Berlin with green wind hydrogen. CEP vehicles are powered here with environmentally friendly fuel from wind energy.

June 2012: A joint declaration of intent is signed by the German Federal Ministry of Transport and Digital Infrastructure (BMVI) and by the CEP partners Air Liquide, Air Products, Daimler, Linde, and Total to expand the network of public hydrogen filling stations in Germany to at least 50.

2013

July 2013: The CEP and the Scandinavian Hydrogen Highway Partnership (SHHP) launch an international collaboration at the 'International workshop on H_2 infrastructure and transportation' hosted by NOW. The goal is to expand the filling-station infrastructure towards the region of Scandinavia.

The CEP vehicle fleet has covered a lot of ground – two million kilometres since 2005, with about 100 fuel-cell vehicles.

2014

From 2014, the CEP regularly organises Campus Days at universities and colleges to give students a better understanding of the wide range of applications of hydrogen and fuel-cell technology through lectures and test drives.

The current version of the standard refuelling protocol SAE TIR J2601 is published. With its extensive field testing, the CEP played a major role in its development.

2015

Battery-powered buses with fuel cells as range extenders operate on the new no. 109 'Innovation Line' in Hamburg with its strong visible presence.

May 2015: Germany's first motorway hydrogen filling station is officially opened at the motorway service area in Geiselwind. The new H_2 filling pump along the A3 between Würzburg and Nuremberg links the existing filling facilities in the metropolitan regions of Frankfurt am Main, Stuttgart, and Munich.

2016

April 2016: The CEP exhibits for the sixth time at the Hannover Trade Fair, the most visited industry fair in the world. CEP partners offer test drives of fuel cell vehicles in the outdoor area. Linde supplies the H_2 via a mobile refuelling unit.

The 'H2 Mobility Congress' is held in Berlin. Under the heading 'Fuel Cell Electromobility in Germany and throughout the World', Federal Minister of Transport Alexander Dobrindt meets with high-ranking politicians and industry representatives to discuss ways of getting the technology of the future onto the roads.

May 2016: At the UN Climate Change Conference in Bonn, the CEP presents its fleet and provides information on the development of hydrogen mobility, as well as its potential as an important element in an energy and transport revolution.

December 2016: The world's first car-sharing project with fuel-cell vehicles is launched in Munich; the filling station network continues to grow. The stage is set for market activation: the first series production vehicles are now available in Germany, with more to follow in 2017.

Clean Energy Partnership
CEP

A lighthouse project within the National Hydrogen and Fuel Cell Technology Innovation Program

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