NOW
National Organisation Hydrogen and Fuel Cell Technology

ANNUAL REPORT 2014

NOW MAGAZINE 2014

TABLE OF CONTENTS

Foreword by Alexander Dobrindt

The integration of power from renewable sources into our energy supply system provides us with significant economic, environmental policy and social opportunities. In this regard, I envisage the area of transportation providing decisive impulses for the advancement of the energy turnaround. After all, besides the reduction of CO_2 emissions in the sector, using renewable energy in the battery or filling the fuel tank with wind hydrogen can result in the establishment of a new value-added chain with secure jobs and a reduced reliance on the import of raw materials for Germany: from energy production and its storage, to use in vehicles. For us as a centre of knowledge and technology, this represents an overwhelming incentive.

NIP – National Innovation Programme Hydrogen and Fuel Cell Technology

My department has therefore provided industry support over several years with comprehensive programmes to promote the market preparation of suitable products. Since 2006, the Federal Ministry has supported hydrogen and fuel cell technology in the areas of mobility and in the stationary supply of energy. In the National Innovation Programme Hydrogen and Fuel Cell Technology, the Federal Ministry for Transport and Digital Infrastructure (BMVI – Bundesministerium für Verkehr und digitale Infrastruktur) has allocated funds totalling 500 million euros until 2016 to support the testing of the technology under day-to-day conditions. The funding is supplemented by 200 million euros from the Federal Ministry for Economic Affairs and Energy (BMWi – Bundesministerium für Wirtschaft und Energie), which places its focus on the support of general research and development of the technology.

Electromobility Model Regions and Electromobility Showcases

The aim of having one million electric vehicles on the roads by 2020 is a great challenge. But we are holding on to this target – even if doubts may have been raised from time to time. It is clear that we need electric drives if we wish to unite climate protection and mobility. With targeted support through the structures of the BMVI Model Regions and the Showcases together with the BMWi, BMUB and BMBF, we have supported industry since 2009 and 2011, respectively, to create a foundation for the market success of electromobility. Besides supporting the recharging infrastructure, the

development of CO_2-reduced personal and commercial transportation as well as alternative drives for buses and rail applications are all areas of focus. In terms of implementing the NIP and Electromobility Model Region programmes, the federally owned NOW has established itself as a reliable partner to government and industry.

Overarching mobility and fuel strategy

The mobility and fuel strategy (MKS – Mobilitäts- und Kraftstoffstrategie) is a key instrument of the Federal Government to implement the energy turnaround in the transport sector. With the decision of the Federal Cabinet on 19 June 2013 on the MKS, the Federal Government presented a comprehensive overview of technologies and alternative fuel options for the transport sector, for the first time, in respect to the energy turnaround.

Upon this basis, the MKS is currently being further developed with the following objectives:

↗ The market maturity of alternative drives and fuels should be attained as quickly as possible in order to meet the Federal Government's energy efficiency and climate protection goals.

↗ The demands of the EU guideline for alternative fuels infrastructure ("Clean Power for Transport" or CPT guideline) are to be fulfilled through specific steps for action.

The successful inclusion of affected parties from society and business will be continued in the form of workshops and comprehensive specialist dialogues. A national plan for the implementation of the CPT guideline is to be presented by November 2016.

In collaboration with partners

It is important that government, industry and science continue to work closely together in the future on both a domestic and international level when dealing with the subjects of the energy turnaround and electromobility. A tight-knit and effective network has been able to be established thanks to the NIP and Electromobility Model Region programmes. Not least, I also consider the establishment of a pan-European infrastructure for hydrogen and battery power together with our neighbouring countries is a priority. As only with widespread public acceptance and the willingness of society to adopt new technologies can battery or fuel cell-based mobility or other applications using this technology become successful in the market.

Alexander Dobrindt, MdB

Federal Minister for Transport
and Digital Infrastructure

Foreword by Dr. Klaus Bonhoff

Electricity and hydrogen from renewable sources of energy are the way forward for modern energy buildings. They allow energy from fluctuating sources like from wind or the sun to be stored and used flexibly. A key focus: electricity and hydrogen can in future become the drivers of the energy turnaround if used as CO_2-free fuels in the transport sector.

The development of new technologies for the supply of energy is of great importance socio-politically – and for Germany as an industrial nation as a whole. As such, the government has therefore supported the market preparation of hydrogen and fuel cell technology as part of the National Innovation Programme (NIP) since 2006, and the establishment of electromobility in Model Regions since 2009 and in Showcases since 2011. The National Organisation for Hydrogen and Fuel Cell Technology (NOW), was assigned to oversee the implementation of the NIP and Model Region programmes. NOW works at the crossroads where industry, research and politics intersect. In NOW Steering Committees, representatives from the aforementioned areas work together to discuss and jointly align the government funding support strategically with the research and development activities being undertaken.

Achievements in the NIP and Electromobility Model Regions

In the NIP, which was established as a 10-year programme in 2006, the coordinated approach of industry, research and politics has enabled several decisive achievements to be recorded in regard to market preparation. For example, following successful tests under everyday conditions in the NIP, the first fuel cell vehicles (see Clean Energy Partnership, p. 010) and stationary fuel cell systems for the production of heat and power (see Callux, p. 050) are today available on the commercial market. The technology is today also deployed in numerous so-called Special Markets, including the uninterruptible power supply for digital radio networks of public authorities (see Clean Power Net, p. 064) or in the area of industrial trucks such as forklifts – and today represents a real viable alternative to conventional technology. In addition, due to the challenge of storing renewable energy, hydrogen technology has recently gained even further importance.

In the Electromobility Model Regions, work has continuously been undertaken since 2009 to push the expansion of electromobility forward. Not least for this reason were 17 models from German vehicle manufacturers available on the market at the end of 2014. On the infrastructure side, the standardised type of plug has now been defined: Combined Charging System (CCS) with Type 2 Plug for alternating current recharging and Combo2 DC Plug for direct current recharging. Here too, the project work undertaken within the Model Regions formed a basis for decisions. The challenge now is to lead electromobility to broader successes. The key players in this step are municipalities. Their sphere of influence extends from environmental and transportation concepts to the public recharging infrastructure and the deployment of electric vehicles in the municipal fleet. Supporting the entry of new players to electromobility, which besides municipalities includes local public transport authorities and fleet operators, is a key goal of the accompanying research to the Model Regions (see from p. 078). Together with experts from the demonstration projects, the appointed research institutions are delivering general, overarching findings to key issues and are organising the transfer of knowledge to the relevant target groups in close cooperation with NOW and the BMVI.

Expansion of infrastructure in Germany and Europe

New infrastructure must be established for the fuels hydrogen and electricity. The testing of hydrogen refuelling stations under day-to-day conditions within the NIP-funded Clean Energy Partnership (CEP) was instrumental in ensuring that today the first 50 such refuelling stations are being built across Germany – also within an NIP/CEP context. Research and development continues to be a priority in these refuelling stations, while the expansion is already taking strategic aspects into account, such as the coverage of metropolitan areas or main arterial roads and motorways. The big step, with up to 400 refuelling stations, will be taken on by H_2 Mobility – a joint undertaking of the key industrial players in this field.

The expansion of battery and hydrogen infrastructure not only requires concerted, integrated efforts on a national level – it demands this from all players across the whole of Europe. Only with mutual support between politics and industry can the increasingly important goal of market activation be assured while maintaining a high standard of research and development in the very socio-politically important field of hydrogen, fuel cell and battery technology.

International cooperation and acceptance

Complementing the technical aspects of the programmes, NOW also views its role in ensuring international coordination and cooperation among all relevant partners. As such, NOW is actively involved and assumes key roles in various international committees such as the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) on a global level, or the Governmental Support Group (GSG) on a European level. It is furthermore also imperative to keep additional players and groups continuously informed and up to date on the technologies and programme results, to promote acceptance and to also incorporate these players in ongoing developments. Among these communication activities is certainly not least this NOW Annual Report 2014 you are reading now.

I wish you an enjoyable and insightful read, and together with my team am available to answer your questions at any time.

Dr. Klaus Bonhoff

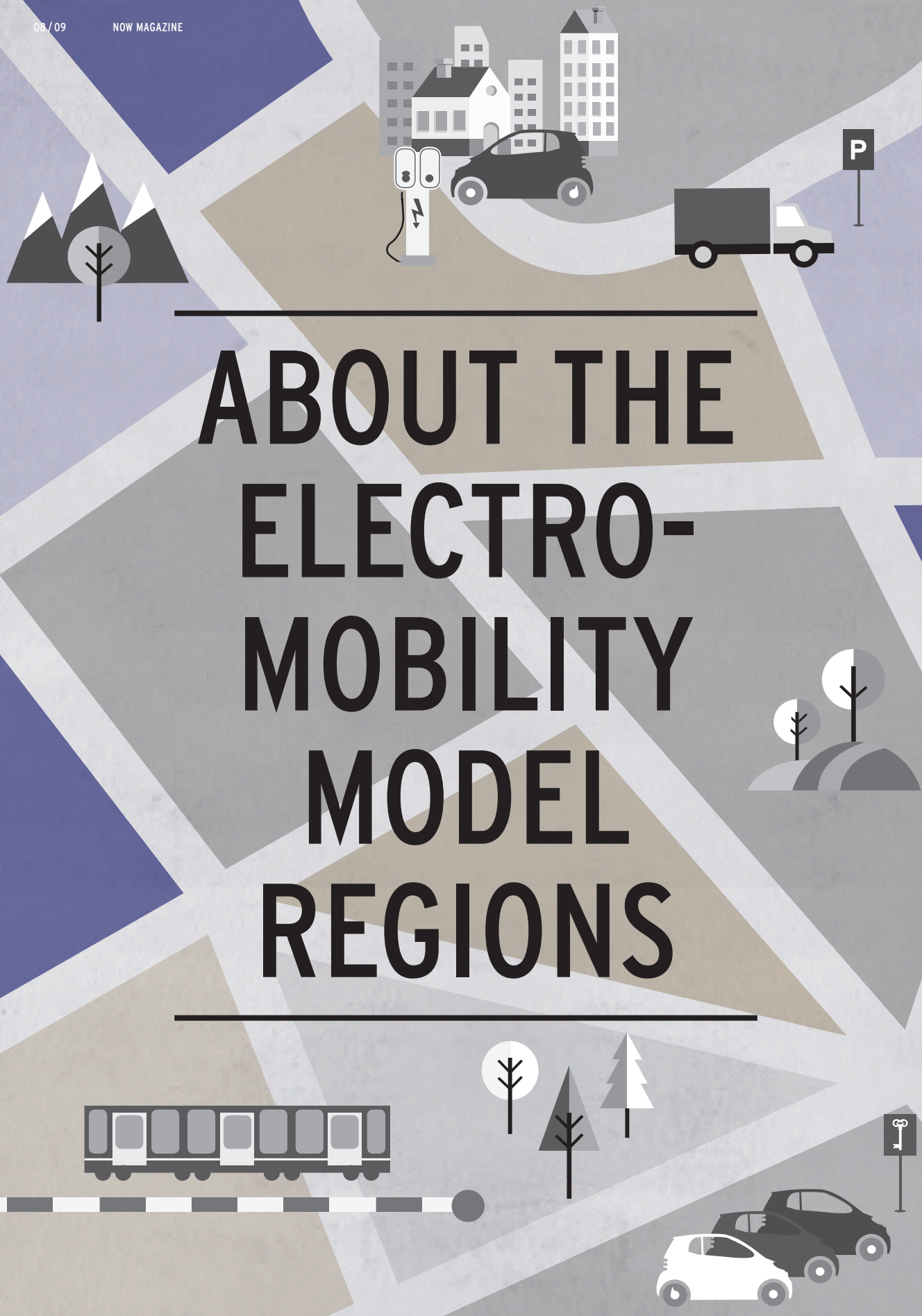
Managing Director (Chair) NOW GmbH
National Organisation Hydrogen and
Fuel Cell Technology

ABOUT NOW

NOW GmbH (National Organisation Hydrogen and Fuel Cell Technology) was founded in 2008 by the Federal Government, represented by the Federal Ministry of Transport, Building and Urban Development (today the Federal Ministry of Transport and Digital Infrastructure – BMVI). The task of NOW involves the coordination and management of two federal development programmes – the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP) as well as the Electromobility Model Regions of the BMVI. Both programmes serve to advance the market preparation of the corresponding technologies to ensure that mobility and the supply of energy in the future is efficient and environmentally friendly. Support focuses on research and development activities as well as demonstration projects that present the deployment of the technologies under everyday conditions.

NOW is responsible for the evaluation and bundling of projects within the respective programmes and acts as the interface between government and the involved partners from research and industry. Central coordination of the projects enables the exchange experiences within the framework of an integrated process and to exploit existing synergies. The project administrator Jülich (PtJ) undertakes the concrete handling of the BMVI funding. Besides targeted market preparation activities of electromobility as well as hydrogen and fuel cell applications via various demonstration and research projects, NOW undertakes active public relations activities to raise awareness and acceptance of these technologies among users.

Representatives from politics, industry and science are a part of NOW committees. The Advisory Board counsels the organisation regarding the implementation of the NIP. Because the changeover to a sustainable mobility and energy industry represents a global challenge, NOW also promotes cooperation on an international level. NOW is a member of the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), which brings 17 nations and the European Commission together under one roof in order to advance the development of hydrogen and fuel cell technologies throughout the world.



ABOUT THE ELECTRO-MOBILITY MODEL REGIONS

Model Regions Electromobility

Federal Ministry of Transport and Digital Infrastructure

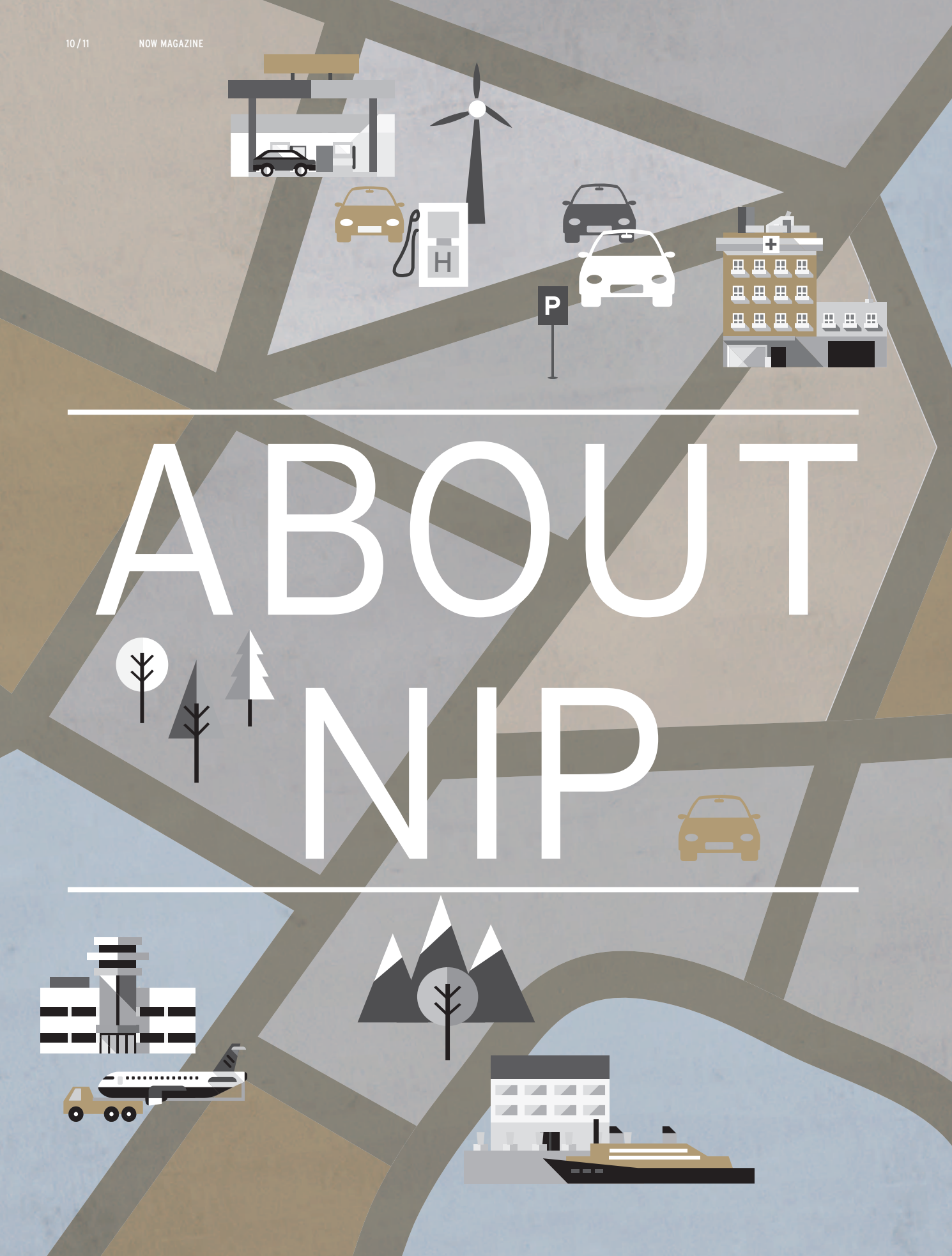
With the Electromobility Model Regions funding programme, the Federal Ministry of Transport and Digital Infrastructure (BMVI – Bundesministerium für Verkehr und digitale Infrastruktur) supports cross-sector cooperation between industry, research and the public sector to promote and entrench electromobility in day-to-day life. Supplementing the federally funded Showcases, the regional context is a predominant issue due to the involvement of municipalities. Support is provided for technology open research and development for battery electric vehicles as well as projects demonstrating the suitability of electromobility applications in the public domain for everyday use and user-orientation while integrating these in contemporary mobility, spatial and urban developments. Through the participation of local players from relevant industries, research and the public sector, electromobility is tested and evaluated in accordance with prevailing local demands and conditions. The support of electromobility extends across all key fields of action. The individual projects are therefore complemented through accompanying scientific research on overarching topics. All aspects of electromobility are considered here, including user perspectives, the continued development of drive and vehicle technology, the subjects of safety and infrastructure, the integration of electromobility in public and commercial vehicle fleets, as well as questions dealing with regional and urban development along with the regulatory framework.

Further information on the programme is contained in the attached programme report.

Electromobility Model Regions – Sectors of Application
(As at December 2014*)

SECTOR OF APPLICATION	BUDGET IN THOUSANDS OF €	FUNDING IN THOUSANDS OF €
ORGANISATION/PROJECT HQS	5,736	3,157
INTERNATIONALISATION	3,376	3,026
ERA-NET	3,330	3,133
PUBLIC TRANSPORT – RAIL	19,019	7,633
DRIVE/TECHNOLOGY TESTING	15,736	7,817
AIR TRANSPORT	13,436	6,982
ACCOMPANYING RESEARCH	8,232	7,688
INFRASTRUCTURE	17,622	10,837
PUBLIC TRANSPORT – BUSES	18,673	10,481
PUBLIC TRANSPORT – INTERMODAL	30,911	20,212
COMMERCIAL TRANSPORTATION	62,451	31,180
PERSONAL TRANSPORTATION	70,181	42,874
TOTAL	268,702	155,020

* Figures refer to BMVI funding for projects from 2009 onwards.



ABOUT NIP

National Innovation Programme
Hydrogen and
Fuel Cell Technology

As part of a strategic alliance, government, industry and research initiated the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP) in 2006 for the promotion and market preparation of associated technologies, which is scheduled to run over a course of ten years. Total programme funding volume amounts to 1.4 billion euros. The Federal Government – the Federal Ministry of Transport and Digital Infrastructure (BMVI – Bundesministerium für Verkehr und digitale Infrastruktur) together with the Federal Ministry of Economic Affairs and Energy (BMWi – Bundesministerium für Wirtschaft und Energie) – provide half the funds, with the balance made up by participating industry. The NIP continues to be supported by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB – Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit) and the Federal Ministry of Education and Research (BMBF – Bundesministerium für Bildung und Forschung). All four of the federal departments are represented in both the NOW Advisory and Supervisory Boards.

The NIP is divided into four programme areas in order to advance the possibilities for various products and applications of hydrogen and fuel cell technology in equal measure and to address market-specific challenges in a targeted manner. Research and development activities as well as demonstration projects are thereby implemented according to the areas of Transport and Infrastructure, Hydrogen Provision, Stationary Applications or Special Markets. The respective technologies are tested under real day-to-day conditions and competencies bundled in so-called Lighthouse Projects together with several partners. The Lighthouses bridge the gap between R&D and the future markets, and also ensure that the products and services connected with the topic of hydrogen and fuel cells are made more widely known to the public. Furthermore, the strengthening of the supplier industry is also explicitly promoted in all programme areas to pave the way for future series production.

The total share of BMVI funding in the NIP amounts to 500 million euros. Further funding will be made available by the BMWi to support application-based R&D projects that will contribute to improve components and systems as well as for other essential studies. The following diagrams show the distribution of funding across the various application sectors.

Further information on the details of individual NIP projects can be found in the attached programme report.

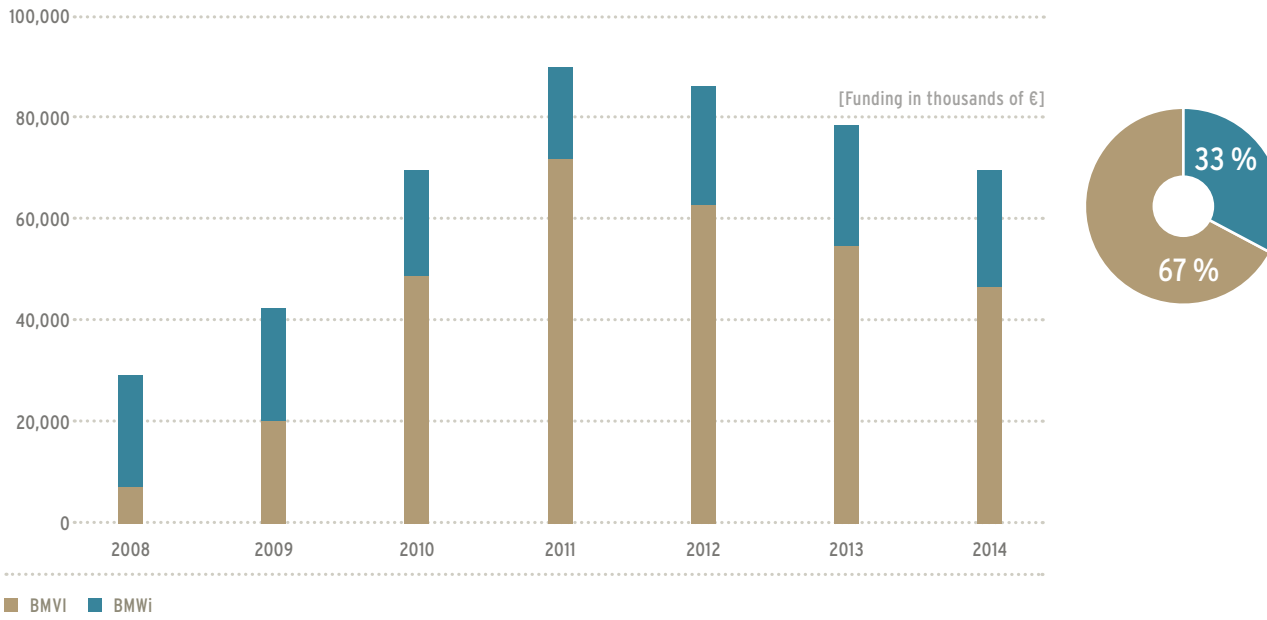
Federal Ministry
of Transport and
Digital Infrastructure

Federal Ministry
for Economic Affairs
and Energy

Federal Ministry for the
Environment, Nature Conservation,
Building and Nuclear Safety

Federal Ministry
of Education
and Research

NIP – Source of Funding
Demonstration (BMVI) and R&D (BMWi) *



Energy Storage Funding Initiative

The growing share of renewable energies in the production of electricity must go hand in hand with the development of efficient energy storage. The Federal Ministry of Economic Affairs and Energy (BMWi – Bundesministerium für Wirtschaft und Energie), together with the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB – Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit) and the Federal Ministry of Education and Research (BMBF – Bundesministerium für Bildung und Forschung) commenced a joint initiative in 2011 to promote R&D in the area of storage technologies. Projects on the development of a large range of storage technologies for electricity, heat and other energy carriers will be supported. In the process, many synergies within the field of hydrogen and fuel cell technology will arise, which will be coordinated together with NOW. Under the "Energy Storage Funding Initiative", the three ministries have allocated a funding amount of over 190 million euros to projects in an initial phase. From this, around 43 million euros are allotted to the subject of hydrogen from wind, and the funds for methanation come to almost an additional 53 million euros.

* All data refers to approved projects.

Federal Ministry
of Transport and
Digital Infrastructure

The Federal Ministry of Transport and Digital Infrastructure in the NIP

The Federal Ministry of Transport and Digital Infrastructure (BMVI) established the NIP together with the Federal Ministries of Economic Affairs and Energy (BMWi), Education and Research (BMBF) and the Environment (BMUB). The programme is part of the High-tech Strategy for Germany and is integrated in the federal government's Fuel Strategy. The total share of the BMVI in the NIP amounts to 500 million euros. The NIP offers a joint framework for numerous hydrogen and fuel cell research projects from research and industry.

NIP – Sectors of Application
(As at December 2014*)

SECTOR OF APPLICATION	BUDGET IN THOUSANDS OF €	FUNDING IN THOUSANDS OF €
TRANSPORT & INFRASTRUCTURE	519,561	248,325
HYDROGEN PROVISION	25,197	12,379
STATIONARY INDUSTRY	72,348	35,376
STATIONARY HOUSEHOLD	101,706	48,983
SPECIAL MARKETS	103,963	49,775
INTERDISCIPLINARY THEMES	11,946	6,751
INNOVATIVE DRIVES	15,439	7,411
TOTAL	850,161	408,999

*Figures refer to BMVI funding for projects from 2009 onwards.

Federal Ministry
for Economic Affairs
and Energy

The BMWi supports application-based R&D projects within the framework of the NIP

The BMWi is supporting application-based R&D projects aiming to improve components and systems in the area of hydrogen and fuel cell technology. Supplementary to this, several fundamental investigations and studies are also being financed.

The scope of support spans the entire application area of the technology: transport and infrastructure, stationary fuel cells for household energy supply as well as for industrial applications in addition to special markets for fuel cell technology.

NIP – Sectors of Application
(As at December 2014*)

SECTOR OF APPLICATION	BUDGET IN THOUSANDS OF €	FUNDING IN THOUSANDS OF €
TRANSPORT & INFRASTRUCTURE	131,849	66,382
HYDROGEN PROVISION	16,425	10,132
STATIONARY INDUSTRY	12,160	9,145
STATIONARY HOUSEHOLD	44,643	20,168
SPECIAL MARKETS	20,310	11,182
INTERDISCIPLINARY THEMES	21,488	14,508
TOTAL	246,875	131,517

* The information refers to BMWi funds for projects since 2009.

International Cooperation

There were many occasions in 2014 where the foundations were laid for continued development and market introduction of hydrogen and fuel cell technology in an international context. In Japan, a long-term approach for its transition into a hydrogen society was announced. Meanwhile, in the USA, eight states joined forces to combine their efforts for the promotion of electromobility and decisions on important funding instruments. In Europe too, clear signals were given towards the market introduction of hydrogen and fuel cell technology with the resolution of the Clean Power for Transport guideline, the extension of the Fuel Cell and Hydrogen Joint Undertaking (FCH-JU) until 2020 and the first hydrogen projects within the TEN-T programme.

Against this backdrop it is essential to continue the close cooperation and exchange with leading nations in this area. The past year saw many activities, which are presented on the following pages.

For the future – and on an international level – it is essential to ensure that Germany remains among the leading nations. This can only occur if efforts continue to create a positive market environment to initiate the hydrogen and fuel cell technology market and remain internationally competitive in the long term and not lose innovative technologies.

Europe

Especially in respect to the Ukraine crisis, in 2014 it was clearly shown how dependent the European Union is on commodity imports and to what extent this can be influenced by geopolitical developments. Political sovereignty means independence, and this equally applies in the energy sector.

With the ambitious goals of the EU in terms of renewable energy in the electricity sector, Europe is on the right track in this area. Bigger challenges lie ahead, however, in the transport sector. But it is precisely in this area where there are significant potentials to decrease the dependence on raw material imports while also strengthening the domestic European economy. Only with the increased electrification of personal transport can these potentials be exploited. The technologies in question – be it pure battery-electric or fuel cell vehicles – enable renewable energies to be integrated in the transport sector, thereby decreasing the dependence on the import of resources.

In view of this, the extension of the FCH-JU into a second phase with a horizon of 2020 to 2024 was an important signal to all member states. With an overall budget of 665 million euros, the FCH-JU 2 will continue to be in a position to support research and demonstration activities in Europe.

A further milestone was the announcement of the Clean Power for Transport (CPT) guideline by the European Commission in 2014. This represents a significant step in the right direction. The CPT outlines important standards for alternative fuels and creates the necessary foundation to initiate a coordinated development of corresponding infrastructure for alternative fuels across Europe.

The Governmental Supporting Group (GSG) was established in 2013 to jointly discuss the implementation of the CPT and exchange experiences. The GSG currently comprises seven member states (Austria, Netherlands, Denmark, Sweden, France, England, Germany). It is anticipated that further interested countries will join next year. NOW supports the Federal Ministry of Transport and Digital Infrastructure (BMVI – Bundesministerium für Verkehr und digitale Infrastruktur) in content-related tasks in this area. Among its activities, the GSG organised the First Dialogue on European Hydrogen Refuelling Infrastructure in Berlin. For the first time, all involved parties such as the national industry initiatives (H_2 Mobility, UK H_2 Mobility, etc.), representatives of the respective national ministries and European funding programmes (FCH-JU, TEN-T) came together at one table to discuss a common approach. This dialogue will be set forth in 2015 in order to support continued joint developments.

As well as its efforts in the GSG, NOW was also involved in shaping and coordinating European activities in many bilateral meetings such as a partner of the FCH-JU in the Distributed Generation Study that it conducted. NOW continues to work closely with the FCH-JU in further studies on the subjects of storage and hydrogen buses.

Japan

With the adoption of the Energy Plan in April 2014 and the associated roadmap to becoming a hydrogen society, an important foundation was laid in Japan for the market introduction of hydrogen and fuel cell technology. The roadmap covers the issues of energy conversion, energy security, environmental aspects and business development, setting out milestones until the year 2040. This represents a logical step forward for the Japanese government's support scheme, which has proven very successful to date.

Evidence of this success is, for example, commencement of commercial production of the "Mirai" FCEV by Toyota and the breaking of the 100,000 unit sales barrier in September 2014 for fuel cell systems for household energy.

Within the framework of the existing MoU between the New Energy and Industrial Technology Development Organization (NEDO) and NOW, this year also saw continued lively exchanges on national developments and experiences being made in current projects. In addition, close cooperation existed in the International Workshop of HRS Infrastructure, the accompaniment of the IEA H_2 Roadmap and within IPHE activities. This cooperation is set to continue in the future.

USA

Eight US states signed the Zero Emission Vehicle (ZEV) Action Plan on 29 May 2014. As part of the action plan, the signatory states (California, Connecticut, Maryland, Massachusetts, New York, Oregon, Rhode Island, Vermont), which account for around 25 percent of the US car market, resolved to bring more than three million electric vehicles onto the roads by 2025. Besides this goal, the plan also includes further measures in the area of market preparation and standardisation.

In addition, the California Energy Commission awarded funding valued at 46.6 million dollars for the establishment of 28 hydrogen refuelling stations. With this support together with other existing activities, in the coming years California will boast a hydrogen refuelling station network of around 54 sites.

The positive market environment is also affecting the commercialisation of the first fuel cell vehicles. In 2014, the Hyundai Tucson became the first publically available fuel cell vehicle in California for lease. Toyota plans to follow suit in autumn 2015 when it will offer its Mirai model to the public.

As part of the cooperation with the Department of Energy (DoE), NOW again participated as an expert at the Annual Merit Review as well as at various other specialist workshops. Furthermore, cooperation in the trilateral projects, together with NEDO in Japan, also continued throughout the year.

China

Building on the existing joint declaration between the Federal Ministry of Transport and Digital Infrastructure (BMVI – Bundesministerium für Verkehr und digitale Infrastruktur) and the Ministry of Science and Technology (MOST) in the People's Republic of China for cooperation in the areas of sustainable mobility, energy efficiency, reduction of emissions and innovative transport technologies, a declaration of cooperation was signed on 10 October 2014 to intensify and expand cooperation in the area of innovative drive technologies and corresponding infrastructure. Besides the existing collaborative activities of the Electromobility Model Regions (Shenzhen – Hamburg; Wuhan – North Rhine-Westphalia; Dalian – Bremen/Oldenburg), the joint declaration was expanded to incorporate hydrogen. The importance of China as a fast-growing market is common knowledge. It is therefore necessary to enter into cooperation with China at this early point in order to jointly discuss aspects including certification, regulation, standardisation as well as safety issues. The signed declaration of cooperation is a good basis from which discussions with relevant partners from China can be initiated in the future.

2nd International Workshop on H_2 Infrastructure

A part of the trilateral cooperation with NEDO in Japan and the Department of Energy (DoE) in the USA, the 2nd International Workshop of H_2 Infrastructure took place in 2014 in Los Angeles. Besides the organising countries, experts from Scandinavian countries, the European Commission and the FCH-JU were also represented. Building on the results of the preliminary workshop, new results could be presented. The next expert's workshop of this kind will take place in Japan in 2015. This very successful international cooperation demonstrates how common challenges can also be overcome together through mutual support.

IEA H_2 Roadmap

Following the inclusion of a dedicated chapter on the subject of hydrogen by the International Energy Agency (IEA) in its annual Energy Technology Perspective publication in 2012 for the very first time, in 2013 work commenced on the creation of its own H_2 Technology Roadmap. Various workshops took place on this subject in 2014 in the USA and Japan that were attended by representatives from industry, research and politics. NOW accompanies the work of the IEA as a stakeholder of the study.

The various IEA Roadmaps provide an important foundation for many decision makers from politics and business to form an opinion. For this reason, the inclusion of hydrogen in the IEA portfolio is an important step for enhancing global visibility of hydrogen and fuel cell technology, thereby also helping to create a greater level of awareness for the potential fields of application. The H_2 Technology Roadmap will be published in spring 2015.

IPHE

The International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) is a consortium of 17 member states and the European Commission with the goal of accompanying and promoting the commercialisation of hydrogen and fuel cell technology.

Two Steering Committee (SC) meetings took place in 2014. Besides the continuing IPHE working groups for regulation, standardisation and training, the establishment of a permanent secretarial office (PSO) was an area of focus this year. Tim Carlson (Canada) was elected as Head of the future PSO at the SC meeting in Oslo. Moreover, the formal and structural basis for the establishment of an independent PSO was also set out. The PSO is currently scheduled to be up and running in 2015 in order to provide active support to the IPHE. Japan's IPHE Chairmanship ended with the last SC meeting in Rome. France was unanimously elected as the new Chair, taking on duties from 3 December 2014.

So-called Educational Encounters also took place again this year with the active involvement of regional universities and students, parallel to the SC meetings.

↗ More information on the IPHE can be found here: www.iphe.net

Interview with Michio Hashimoto

New Energy and Industrial Technology Development Organization (NEDO), Japan

↗ Michio Hashimoto, Director General, New Energy and Industrial Technology Development Organization (NEDO)

In December 2013, the Japanese Ministry of Economy, Trade and Industry (METI) established a Council to develop a strategy for hydrogen and fuel cell technology. Since then, the council has been studying ideal approaches for the future utilisation of hydrogen energy, through collaboration between industry, research and government. On June 23, 2014, the council compiled measures to be taken by people involved in realising a hydrogen society into a Strategic Road Map for Hydrogen and Fuel Cells.

Michio Hashimoto, the Director General of the New Energy and Industrial Technology Development Organisation (NEDO), describes the central aims of the roadmap.

What role does the promotion of hydrogen and fuel cell technology in the policies of the Japanese government play these days?

By significantly expanding the application and utilisation of hydrogen in various sectors, hydrogen and fuel cell technologies can potentially contribute to energy saving, the improvement of energy security and the effect on the environment.

The Strategic Energy Plan, approved by the Cabinet in April 2014, mentioned that hydrogen is expected to play the central role as secondary energy, in addition to electricity and heat, and that it is important to accelerate the activities toward the establishment of the so-called hydrogen society.

How would you describe the current situation?

Applications like stationary fuel cells and fuel cell vehicles are already commercialised and continued efforts on the expansion of the markets are being made to lead the world.

What are the central objectives of the roadmap?

In order to ensure an affordable and stable supply of hydrogen depending on the demands, it is important to establish a comprehensive hydrogen supply chain covering production, storage & delivery, and application. Regarding the establishment of the hydrogen society, the roadmap addresses the necessity of long-term activities, which should be conducted though step-by-step processes among all stakeholders.

The market for hydrogen energy in Japan is projected to expand to ¥1 trillion in 2030 and reach ¥8 trillion in 2050. What are the main challenges until that date?

By recognising the differences of the target years to overcome technological barriers and to ensure market readiness, the roadmap indicates a step-by-step process toward the establishment of the hydrogen society:

Phase 1: By expanding the utilisation of stationary fuel cells and FCVs, to expand the market to lead the world (today).

Phase 2: By expanding hydrogen demand and expanding hydrogen sources like stranded energies, to establish a new secondary-energy structure with electricity, heat as well as hydrogen (by the late 2020s).

Phase 3: By applying CCS technology to hydrogen production, or by using renewables as hydrogen sources, to establish an overall CO_2-free hydrogen supply system (around 2040).

What is the general opinion and perception regarding hydrogen and fuel cell technologies in Japan?

As stationary FCs were commercialised in 2009 and the number of installed units reached 100,000 in last September, public awareness and acceptance of hydrogen and fuel cells is generally high. People's interest became even higher with the recent launch of FCVs.

The popularisation of FCVs brings hydrogen closer to citizen's daily life, so it is important to disseminate proper information on safety and reliability of hydrogen to the public.

As one of the interim targets, the roadmap mentions the Summer Olympic Games 2020 in Tokyo, where fuel cell vehicles are being considered to transport athletes and visitors. What effects do you expect regarding visibility of the technology?

The Tokyo Olympic games in 2020 must be a good opportunity to show the potential of hydrogen to the world. It is also expected that the Olympic Games may promote local FCH infrastructure developments, with the pre-designing of post-Olympic Games applications.

Interview with Daniela Rosca

DG Mobility & Transport, European Commission

↗ **Daniela Rosca is Head of the Clean Transport and Sustainable Urban Mobility Unit in the Directorate General for Mobility and Transport at the European Commission.**

Alternative fuels are urgently needed to break the over-dependence of European transport on oil. Research and technological development have led to successful demonstrations of alternative fuel solutions for all transport modes. Market take-up, however, requires additional policy action on a transnational level. The Clean Power for Transport directive, adopted by the European Parliament and the Council on 29 September 2014, aims to facilitate the development of a single market for alternative fuels for transport in Europe.

How is the current situation regarding charging infrastructure across Europe?

The situation of recharging infrastructure across Europe is a moving target. And it is moving into the right direction. The European Electromobility Observatory publishes a map with recharging stations which can be accessed under the following link:
www.ev-observatory.eu

The EU-funded project Green eMotion also provides a map with electric recharging points:
www.greenemotion-project.eu

We also have data for the refuelling infrastructure of fuel cell electric vehicles: at this point in time there are around 250 such stations in the EU, of which around 150 are publicly accessible. Moreover, there are concrete plans for additional stations in a number of countries, so we expect a rather sharp development over the coming years.

What are the reasons transnational cooperation is important for the development of charging infrastructure?

The reasons are twofold, and both are key for EU-wide mobility with alternative fuels: firstly, we need to avoid the creation of technological islands where the Member States develop different, incompatible technical solutions, and secondly, we need to allow for cross-border continuity of the charging infrastructure. The first issue is addressed by the Directive by prescribing a common plug for EVs and the standardization needs for all fuels recharging/refuelling infrastructure for which the Directive mandates minimum infrastructure de-

ployment. The second issue is addressed by the Directive whereby Member States should take into account, where relevant, cross-border continuity when drafting their national policy frameworks.

The directive Clean Power for Transport requires member states to install an appropriate number of publically accessible recharging points by the end of 2020. How is the situation here now?

The Member States have until mid-November 2016 to submit their national policy frameworks with clear objectives and targets. The implementation of the corresponding infrastructure is due by end 2020 for battery electric vehicles and by end 2025 for fuel cell electric vehicles. Some countries already have or are already developing rather extensive deployment plans.

Data on the geographic location of the publicly accessible recharging points shall be made available to all users in an open and non-discriminatory manner. Are there concrete ideas how to realize these plans on a transnational level?

On a transnational level we aim to make this data available through the European Electromobility Observatory which we are currently developing further.

One of the main objectives of the EU directive is to harmonize the standards and technical specifications. For example, the directive makes it mandatory to use a common plug all across the EU, which will allow EU-wide mobility. Looking at the future – what are the biggest tasks that lay ahead to realize these plans?

The Commission is currently in the process of issuing a standardization request to the European Standardisation Organisations in order to mandate the standardization work required by the Directive. The request will cover all standardization aspects derived from the Directive and for all fuels for which infrastructure is mandated.

What are the most important achievements so far?

There are several important achievements by the Directive so far. The Directive provides a political signal that there is political will at EU level to push forward the mass-market deployment of alternative fuels. The Directive provides a regulatory framework to Member States in order to develop alternative fuels in a synchronous and harmonized way and with the flexibility needed to take national specificities into consideration. Last but not least, the Directive provides confidence to all actors involved in the sector: vehicle manufacturers, energy providers and consumers. The Directive directly addresses the root problem of the development of alternative fuels: there are no vehicles because there is no infrastructure and vice-versa, i.e. the "chicken-or-egg" problem. Alternative fuels are here, and they are here to stay.

Efforts to improve charging infrastructure are not only made within the EU. Is there an exchange of experience and knowledge on an international level?

There is an agreement on the outlet shape for the EV plug between EU and US automotive manufacturers. The issue of the EV plug is also regularly dealt with in trade talks between the EU and Japan.

Which reactions do you expect from industrial partners?

Reactions to the Directive, both the initial Commission proposal and the adopted text, from industry stakeholders have been very positive, as a strong political signal in favour of kick-starting the mass-market for alternative fuels. Industry stakeholders are aware that it is now for Member States to properly implement the Directive in order to allow reaching the goals set in this legislative text.

We expect industrial partners to team up to propose projects both to the national governments and to the EU, be it through the Fuel Cell and Hydrogen Joint Undertaking or the Horizon 2020 research and innovation programme, the Juncker Investment Plan or the Connecting Europe Facility for the Trans-European Transport Networks.

Strategic Programme Management

The Advisory Board

New technologies based on hydrogen, fuel cells or batteries are necessary in order to continually reduce our reliance on fossil fuels in the future. This will not happen overnight. Rather, the continued advancement of the systems that will supply our future energy requirements will be a long-term process in which all players from industry, science and government must work together.

It is for this reason that within the NOW Advisory Board, representatives from industry, science and government are jointly working to shape the strategic direction of the National Innovation Programme Hydrogen and Fuel Cell Technology. The Advisory Board debates and determines on key areas of support upon the backdrop of a holistic approach to preparing these technologies for market readiness.

Besides fuel cell and hydrogen projects, NOW has also coordinated battery-electric mobility as part of the "Electromobility Model Regions" funding programme for several years. In addition to the Electromobility Showcases, the Model Regions with their large number of vehicles and the associated recharging infrastructure ensure a high level of visibility for electromobility.

Composition and challenges ahead

The Advisory Board is composed of representatives from the participating federal ministries: Transport and Digital Infrastructure (BMVI – Bundesministerium für Verkehr und digitale Infrastruktur), Economic Affairs and Energy (BMWi – Bundesministerium für Wirtschaft und Energie), Environment, Nature Conservation, Building and Nuclear Safety (BMUB – Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit) and Education and Research (BMBF – Bundesministerium für Bildung und Forschung), a coordinator of the federal states as well as representatives of all industry branches and research institutions related to the topic. In 2014, changes to the persons responsible occurred in three federal ministries.

Following the creation of a strategy paper in 2014 in which both the necessity and key subjects for a further development of the NIP beyond 2016 were outlined, the Advisory Board prepared a catalogue of measures. It depicts the measures and budgets for which the foundations for a continued development of the NIP have been laid, and shows the required funding amounts required from the 2016 budget and beyond.

The Advisory Board also advocated the continuation and support of international activities, such as the Fuel Cells and Hydrogen Joint Undertaking (FCH JU), the H_2 Roadmap of the International Energy Agency (IEA) and the International Partnership for Hydrogen

The Advisory Board In Detail:

The board is comprised of representatives from the following 18 interest groups:

Federal & State Government

BMVI: Stefan Schmitt (Vice-Chair)
BMWi: Dr. Georg Menzen (Advisory Board Chairman)
BMBF: Dr. Karsten Hess
BMUB: Alexander Folz
Representatives of the federal states:
Dr. Heinz Baues, Heinrich Klingenberg
(without voting rights)

Science

Education: Prof. Dr. Jürgen Garche (Vice-Chair)
Research & Development Helmholtz Association:
Prof. Dr. Ulrich Wagner
Research & Development Institutes/Universities:
Prof. Dr. Alexander Michaelis

Industry / Application:

Mobility – Passenger cars: Dr. Sabine Spell
Mobility – Commercial vehicles: Dr. Jürgen Friedrich
Domestic energy supply: Andreas Ballhausen
Industrial applications: Johannes Schiel
Specific applications:
Prof. Dr. Werner Tillmetz
Fuel cell components manufacturing:
Dr. Uwe Maier

Infrastructure

Fuel industry: Patrick Schnell
Hydrogen production: Dr. Oliver Weinmann
Hydrogen delivery: Markus Bachmeier
Network supply: Markus Seidel

and Fuel Cells in the Economy (IPHE). The activities of industry and government in Germany can thereby be thematically and organisationally linked to the plans of the EU, USA, Japan and Korea, in particular.

Dr. Georg Menzen, BMWi
(Advisory Board Chairman)

Prof. Dr. Werner Tillmetz, ZSW
(Advisory Board Chairman)

Annual Review of Events

NOW actively conducts public relations activities in order to increase the perception and public awareness of the technology and the associated products. An overview of selected events from 2014 is shown on the following pages.

Alexander Dobrindt, Federal Minister for Transport and Digital Infrastructure

January **February** March April May June July August September October November December

The conference also included a driving event, which was also attended by (from left to right): Rainer Bomba, State Secretary at the Federal Ministry for Transport and Digital Infrastructure (BMVI); Dr. Heiner Heseler, State Councillor for Economics, Labour and Ports of the Free Hanseatic City of Bremen; Prof. Matthias Busse, Institute Director, Fraunhofer IFAM.

4 – 5 February 2014
Local Electromobility – expert conference for municipal representatives by the BMVI

Municipalities take on a key role in the expansion of electromobility. On behalf of the Federal Ministry of Transport and Digital Infrastructure (BMVI), Fraunhofer IFAM and NOW invite municipal representatives to the "Local Electromobility" (Elektromobilität vor Ort) expert conference in Bremen. In various forums on the subjects of practical examples on the ground, legal framework conditions and the build-up of the charging infrastructure, speakers present results and experiences from the Model Regions and provide practical assistance to more than 200 participants from municipalities, local companies as well as economic development and state ministries.

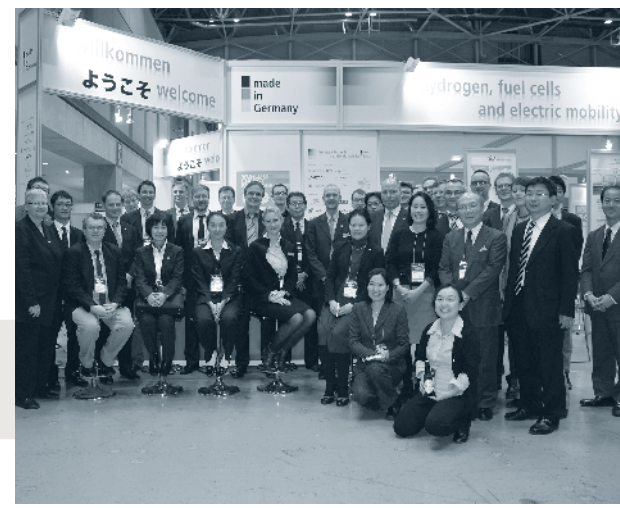
2014

19 February 2014
Secure electricity supply for police radio – commencement of NIP project "Fuel Cell Technology in Digital Public Safety Communications Systems"

As part of the NIP Clean Power Net lighthouse, the BMVI funds the implementation of fuel cell technology for digital radio for public safety authorities in Brandenburg to the tune of more than three million euros. Instead of conventional, high-maintenance diesel generators, in future 116 fuel cells will ensure the uninterruptible (emergency) power supply for digital communications of public authorities and organisations (BOS). With a total project volume exceeding six million euros, this represents the largest project in this area.

26 – 28 February 2014
FC Expo Tokyo

The largest international trade fair and conference on the subject of hydrogen and fuel cell technology, FC Expo, takes place for the tenth time in the Asian region. NOW is represented at the German pavilion.



7 March 2014
Prize for the "Morgen in meiner Stadt" (Tomorrow in my City) initiative

The "Morgen in Meiner Stadt" (Tomorrow in my City) online portal is among 100 prizewinners in the "Ausgezeichnete Orte im Land der Ideen" (Distinguished places in the land of ideas) competition. In so-called "future workshops" the project involves middle-school students developing approaches and solutions for the urban challenges of the future – including those dealing with the central topics of energy and mobility. NOW counts among the most important supporters of the initiative and was involved in both the 1.5 year-long preparations of the portal, along with its actual launch.

MORGEN IN MEINER STADT

19 March 2014
New partners in the CPN network

At its third full plenary assembly, the Clean Power Net industry and research network welcomes two new partners: Hydrogenics GmbH and Siqens GmbH join the research and industry alliance, thereby committing themselves to the promotion of fuel cell technology. The network, comprised of researchers, users and manufacturers of fuel cell systems, now counts 24 partners.

clean power net
Brennstoffzellen in Industrie und Business

26 March 2014
NOW in the Efficiency House Plus at the Electromobility Days

On the occasion of the Electromobility Days, NOW provides information for Efficiency House Plus visitors on the contribution electric drives and fuel cells can make towards the energy turnaround. With its heat pump and modern photovoltaic plant on its roof and façade, the Efficiency House produces more power than its inhabitants consume – energy that can, for example, be used for powering an electric vehicle. With test drives, offered by NOW, this is something visitors get to experience first hand.

2014

3 April 2014
FCH-JU and NOW – joint workshop for hydrogen-electrolysis

Together with the European Fuel Cells and Hydrogen Joint Undertaking (FCH JU), NOW GmbH jointly organises a workshop on hydrogen electrolysis in Brussels. Numerous speakers discuss the technological gaps still existent in the application of electrolysis and the future potential of this technology in wind-hydrogen systems and the storage of energy.

Joint NOW GmbH –
FCH JU Water Electrolysis Day
3 April 2014, White Atrium
Avenue de la Toison d'Or 56 – 60,
1060 Brüssel, Belgium

7 April 2014
Learning packs for schools

In cooperation with Hydrogeit publishing house, NOW presents a learning pack for schools entitled "Batteries and electric drives – hydrogen and fuel cells" at the Hanover Industrial Fair. Katherina Reiche, Parliamentary State Secretary at the Federal Ministry of Transport and Digital Infrastructure, speaking on NOW's new teaching materials: "I'm delighted that together with NOW and the Hydrogeit publishing house, we have developed educational material that explains simply and intelligibly the future topic of electromobility. It is very positive when we can make young people enthusiastic about new technologies. Electromobility is the topic of the future – also for education. With the teaching material we can stimulate professional interest at an early stage. Supporting the next generation is extremely important in safeguarding Germany as a technological location."

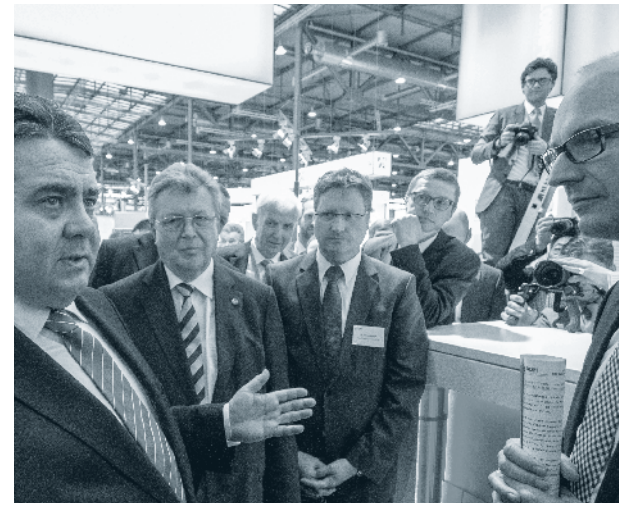
Katherina Reiche, Parliamentary State Secretary at the Federal Ministry of Transport and Digital Infrastructure, accepts a copy of the learning pack at the Hanover Industrial Fair.

7 – 11 April 2014
Hanover Industrial Fair

As part of the NOW stand, Airbus presents its fuel cell system for the on board supply of power and as the drive for the nose wheel.

7 – 11 April 2014
Hanover Industrial Fair

NOW at the Hanover Industrial Fair: topics from the NIP national funding programme are highlighted at the joint fuel cell stand; at the neighbouring MobiliTec stand NOW supports the federal government on the subject of battery-electric mobility and electromobility model regions. Test drives are on offer outside in both fuel cell and battery-electric vehicles.



Federal Minister for Economic Affairs and Energy, Sigmar Gabriel, at the Fuel Cell Initiative (Initiative Brennstoffzelle) stand, receiving information on the market entry of fuel cell devices for the supply of heat and power in single-family homes.

Claudia Fried, Clean Energy Partnership Press Officer; Werner Diwald, Spokesperson of Performing Energy; Katherina Reiche, Parliamentary State Secretary at the Federal Ministry of Transport and Digital Infrastructure; Thomas Haberkamm, Head of Public Affairs at Linde; Prof Werner Tillmetz, Chair of the Centre for Solar Energy and Hydrogen Research, and Dr. Klaus Bonhoff, Managing Director NOW (from left to right) during the handover of the declaration.

8 April 2014
Industry initiatives sign a declaration of commitment for the expansion of hydrogen mobility

The industry initiatives Clean Energy Partnership (CEP), H_2 Mobility and Performing Energy (PE) affirm their commitment to the market introduction of hydrogen and fuel cell technology. On 8 April at the Hanover Industrial Fair, the leaders of the initiatives sign a corresponding declaration to confirm this commitment and hand it over to Katherina Reiche, Parliamentary State Secretary at the Federal Ministry of Transport and Digital Infrastructure. Over the next ten years, 300 companies from the automotive and supply industry, energy supply, specialty chemicals as well as machine and equipment manufacturers, plan to invest more than two billion euro for the market activation of a sustainable, secure and profitable hydrogen mobility.


HH-HN 5321


27
HYDROGEN
FUEL CELLS
BATTERIES
Fuel
AIRBUS
ZARGES

2014

4 May 2014
GreenTec Awards

The "E-PORT AN – Elektromobilität am Flughafen Frankfurt" (E-PORT ON – Electromobility at Frankfurt airport) project wins the GreenTec Award in the aviation category. The joint project of the Lufthansa Group, Fraport AG, the state of Hesse and the Electromobility Model Region Rhine-Main combines several measures for the deployment of electromobility at Frankfurt airport: for taxiing and towing of aircraft, an electric lifting vehicle for catering and electromobility for lifting e-pallet loaders as well as further vehicles on the apron. The goal is to reduce emissions on the ground during aircraft ground handling and associated transportation at the airport. The project is supported with funds of the BMVI within the framework of the Electromobility Model Region Rhine-Main – and received the distinction of "Lighthouse Electromobility" by the federal government on 2013.

Link to the project: www.e-port-an.de

20 – 21 May 2014
Supplier marketplace

Around 100 participants from the areas of fuel cell manufacturing, automotive and supply industry, stationary electricity and heat supply as well as manufacturing and production facilities get together for an intensive cross-industry exchange on the application possibilities and synergies for the further development of fuel cell systems. The workshop is organised by NOW, together with the Fuel Cell Working Group of the German Engineering Federation (VDMA).

23 May 2014
German Hydrogen Congress

Around 150 experts followed the invitation of the Energy Agency NRW, NOW and DWV to exchange ideas on the key topic of "Hydrogen as a storage medium and fuel" at the Representation of the State of North Rhine-Westphalia in Berlin. Key players from state and federal government along with representatives from business and research speak at the congress. General summary: after almost seven years, the results of the support provided for research and development are impressive overall. It is now important to actively organise market introduction and support the market launch.

23 May 2014
State Secretary Reiche opens large-scale hydrogen facility in Schönefeld, Berlin

The TOTAL multi-energy refuelling station was officially opened with the refuelling of a fuel cell vehicle. Located at the site of Berlin's imminent new airport, the station will be supplied with hydrogen that is produced on site via electrolysis from power from wind and solar energy. Aside from supplying to emission-free fuel cell vehicles, the operation of a power facility with renewably-produced hydrogen as well as its feeding into the public gas network is planned. The project provides the opportunity of researching the energy turnaround as a whole system. The partner companies involved are investing a total of more than ten million euros until 2016, 50 per cent of which coming via the NIP funds of the BMVI.

27 May 2014
Electromobility Forum

Representatives from NOW come together with further experts in the area of electromobility in Lathen, in the north of Germany. Here they engage in a lively exchange on the subject of inductive energy transmission for electromobility applications. A highlight of the event is a visit to the approx. 25 metre test track on which 60kW of electric power can be transmitted without contact over 15cm clearance. The construction of the test track serves to enhance research and demonstration of inductive energy transmission and was supported with funds of approx. two million euros from the BMVI within the framework of the Electromobility Model Regions.

2014

23 June 2014
ElectroChemical Talks in Ulm

For the fourteenth time, the Education and Training Centre Ulm for Innovative Energy Technologies (WBZU) and the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) host the ElectroChemical Talks in Ulm. Held under the motto "Next Generation Electrochemical Energy Technologies", the conference focuses on the latest developments and insights on lithium-ion batteries, fuel cells and hydrogen. Dr. Klaus Bonhoff, Managing Director (Chair) NOW and member of the Scientific Committee presented the session: "Fuel Cell Applications".

With more than 320 participants from 21 countries and 120 poster presentation, the ElectroChemical Talks in 2014 were bigger than all such previous events.

Representing the federal government, the BMVI founded the National Organisation for Hydrogen and Fuel Cell Technology (NOW) in 2008. NOW's task involves the coordination of the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP) and the Electromobility Model Regions. For sustainable modern mobility, there is no way around battery and fuel cell power.

30 – 31 August 2014
Open Day at BMVI

On the occasion of the open day of the federal government, more than 21,000 visitors make their way to the Federal Ministry for Transport and Digital Infrastructure (BMVI) to learn more about mobility using battery and fuel cell energy. In two pavilions, representatives from NOW, CEP and Callux captivate visitors with informative discussions. They are on hand to answer questions on the NIP lighthouse projects such as e4ships from Hamburg and the projects of the Electromobility Model Regions. Interest in obtaining first-hand practical experience with the new drives is huge – the CEP breaks a record for the number of test drives being demanded.

Katherina Reiche, Parliamentary State Secretary at the Federal Ministry of Transport and Digital Infrastructure, with Roadshow guests in Teltow

Electromobility Roadshow

Municipalities are key players for the continued expansion of electromobility. It is necessary to anchor electromobility in the day-to-day lives of the population at a local level. Reason enough for NOW to take the BMVI Electromobility Roadshow to the streets.

Stops in 10 cities took place in 2014 – with an info point and test drives. Without the involvement of partners from the project headquarters and further supporters in Saarbrücken, Solingen, Löbau, Bad Waldsee, Offenbach, Teltow, Erfurt, Halle, Schwerin and Berlin, these events would not have been possible. An important part of the Roadshow was the handover of the Electromobility Startersets to the local municipal representatives. The Electromobility Startersets summarise the most important results and insights of the projects and accompanying research coming from the BMVI Electromobility Model Regions, in a user-friendly manner. They aim to serve as a practical guideline for municipalities taking their first steps in the area of electromobility.

www.roadshow-elektromobilitaet.de
www.startset-elektromobilitaet.de

Alexander Dobrindt, Federal Minister for Transport and Digital Infrastructure supports municipalities in their efforts to expand electromobility.

Dr. Veit Steinle, Director-General Department Policy Issues, at the Federal Ministry of Transport and Digital Infrastructure (BMVI), with Christian Carius, Minister for Construction, State Development and Transport in Thuringia, at the Roadshow in Thuringia

15 September 2014
Mobile Citizens (BürgerMobil) project kicks off in Meckenbeuren

The Mobile Citizens project commences in the community of Meckenbeuren. As part of the project, volunteer drivers ensure that the remote parts of the community are better connected to the local public transport network and that gaps in the timetable are closed. A full-electric passenger vehicle from the "emma – e-mobil mit Anschluss" (e-mobile with connection) project is deployed for this purpose. The vehicle, a Nissan Leaf model, is run exclusively on renewable sources of energy and is particularly environmentally friendly. As part of the Electromobility Model Regions, "emma – e-mobil mit Anschluss", is being supported with a total of 3.6 million euros of BMVI funding.

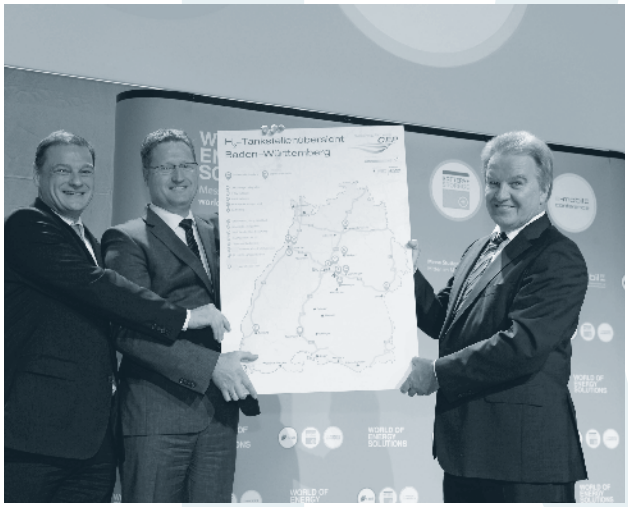
29 September 2014
Opening of the multi-energy refuelling station in Jafféstraße

Katherina Reiche, Parliamentary State Secretary at the Federal Ministry of Transport and Digital Infrastructure and Cornelia Yzer, Berlin Senator for Economic Affairs, Technology and Research, open the multi-energy refuelling station Jafféstraße. The multi-energy refuelling station represents a cooperation between TOTAL Deutschland GmbH, Daimler AG, Linde AG as well as RWE Effizienz GmbH. It can supply energy to vehicles of all different drive types: conventional combustion engines, battery-electric vehicles as well as electric vehicles that generate their electricity from a fuel cell by means of hydrogen. The Jafféstrasse location is part of the expansion programme for hydrogen refuelling stations, agreed upon by industry representatives with the Federal Transport Ministry in 2012. Under these plans, 50 refuelling stations will form the basis for a nationwide network by the end of 2015. The Federal Ministry of Transport The BMVI supports the multi-energy refuelling station within the NIP with around one million euros.

Parliamentary State Secretary Katherina Reiche, BMVI together with Berlin Economic Affairs Senator Cornelia Yzer open the multi-energy refuelling station in Jafféstraße as part of the 50 refuelling station programme

6 – 8 October 2014
World of Energy Solutions

On the occasion of the trade fair for new mobility and energy: "WORLD OF ENERGY SOLUTIONS", Dr. Klaus Bonhoff, Managing Director (Chair) of NOW, as well as Franz Loogen, Managing Director of e-mobil BW, present State Environmental Minister Franz Unterstel-ler with a map showing the locations of the hydrogen refuelling station in Baden-Wurttemberg. The hydrogen refuelling stations are part of the 50 refuelling sta-tions programme, funded within the framework of the National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP) of the federal government.



Franz Loogen, Managing Director e-mobil BW; Dr. Klaus Bonhoff, Managing Director (Chair) NOW and Franz Untersteller, Baden-Wurttemberg Environmental Minister (from left to right) at the announcement of the refuelling station locations

4 November 2014
Parliamentary Evening of the German Hydrogen and Fuel Cell Association

Moderated by Dr. Klaus Bonhoff, Managing Director (Chair) of NOW, key players from business and politics join to discuss developments in the areas of climate protection and renewable energy in Germany, Europe and on the American continent on the occasion of the Parliamentary Evening of the German Hydrogen and Fuel Cell Association (DWV – Deutscher Wasserstoff- und Brennstoffzellen-Verband), at the US Embassy in Berlin. Participants quickly emphasise the significance of hydrogen/fuel cells as being an essential part of any economically successful energy turnaround. Representatives of the Fuel Cell Technologies Office in the Department of Energy (DoE) in the USA also highlight that the German-US cooperation continues to represent a decisive element for research and development.

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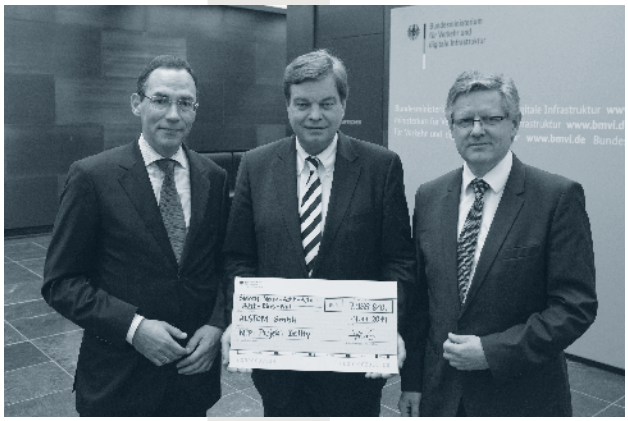


Dr. Martin Lange, Board Member Alstom Transport; Enak Ferlemann, Parliamentary State Secretary at the Federal Ministry of Transport and Digital Infrastructure; and Wolfram Schwab, Technical Director Alstom (from left to right)

12 November 2014
Fuel cell drive replaces diesel railcar – National Innovation Programme hits the rails

With 7.9 million euros, the BMVI is supporting the development of a new generation of rail vehicles with fuel cell drives from the company Alstom. This means that in the near future, conventional diesel rail cars will be able to be replaced on non-electrified routes with more energy efficient and less costly alternatives using fuel cell drives. State Secretary Enak Ferlemann hands over the notification of the funding approval and explains: "This is a pioneering project within the framework of the National Innovation Programme. It is the first application of fuel cell technology for rail transportation. If we succeed in demonstrating the suitability of the technology for everyday use, we will have a genuine emission-free drive alternative." The vehicles will be developed and manufactured in Alstom's competence centre for regional trains in Salzgitter, Germany. Trains with fuel cell drives will then go into regular passenger service in four German states: Lower Saxony, North Rhine-Westphalia, Baden-Wurttemberg and the State of Hesse.

18 November 2014
"Starterset Electromobility" online platform to simplify entry to electromobility for municipalities

With the official launch of the "Starterset Electromobility" online platform, cities and municipalities now have a digital assistant at the ready to help in their efforts to expand electromobility on a municipal level. Under five main areas – local public transport, personal transport, commercial transport, recharging infrastructure and urban development – information is provided on how and where electromobility can be assisted to reach a breakthrough point on a municipal level. An interactive list of measures aligned to the needs of the users provides additional recommendations for action and corresponding practical examples for the local expansion of electromobility. The online platform was commissioned by the BMVI and developed by NOW together with the Institute of Urban Design at the University of Stuttgart, Fraunhofer IFAM and the German Institute for Urban Studies.

Katherina Reiche, Parliamentary State Secretary at the Federal Ministry of Transport and Digital Infrastructure explains: "Cities and municipalities play a key role for the introduction of electromobility. Especially in regards to determining the urban planning and infrastructural framework conditions, they are chief points of contact and can significantly support and promote the integration of electromobility. The Starterset provides cities and municipalities concrete assistance and practical recommendations for action in order to make the switch to electromobility easier at a local level."

↗ More information on the Starterset Electromobility can be found here (German only): www.starterset-elektromobilitaet.de

26 November 2014
New hydrogen refuelling stations for North Rhine-Westphalia

At the annual meeting of the Fuel Cell and Hydrogen Network NRW, Dr. Klaus Bonhoff, Managing Director of NOW, together with Dr. Frank-Michael Baumann, Managing Director of EnergieAgentur.NRW and Patrick Schnell, CEP Chairman, hand over a map of the state of North Rhine-Westphalia showing the locations of the new refuelling stations to Johannes Remmel, Minister for Climate Protection. By the end of 2015, new sites will exist at the following locations: Aachen, Dusseldorf, Cologne/Bonn Airport, Westkreuz Cologne, Munster and Wuppertal. This means that fuel cell vehicles can be refuelled here in the future with hydrogen compressed to 700 bar. The refuelling stations are being supported within the 50 refuelling stations project by the NIP.

Dr. Ewold Seeba, BMUB; Günter Elste, Hamburger HOCHBAHN; Olaf Scholz, Lord Mayor of Hamburg; Rainer Bomba, State secretary at the Federal Ministry of Transport and Digital Infrastructure; and Frank Horch, Senator for the Economy, Transport and Innovation in Hamburg (from left to right) open the Innovation Route

18 December 2014
Innovation Route 109 in Hamburg

Hamburger HOCHBAHN opens the Innovation Route 109. To reach the goal of only having emission-free vehicles in scheduled operations in Hamburg by 2020, various drive technologies are being tested for their reliability in practice.

Besides one diesel-hybrid bus, two fuel cell-hybrid buses are also in deployment. The functionality of the drive technologies is being tested during regular public services and subsequently scientifically evaluated.

Up to 20 vehicles are simultaneously in daily service on Route 109. 15,000 passengers will therefore be transported through Hamburg's inner city in an environmentally friendly manner. The BMVI supports the Innovation Route within the framework of the NIP and Electromobility Model Regions.

»Fuel cell ready for commercialisation«

Deutsche Welle

Interview with Dr. Klaus Bonhoff

↗ Specialists at the World Hydrogen Energy Conference (WHEC) in Korea are looking optimistically to the future. Fuel cell expert Klaus Bonhoff explains in the DW interview that the technology is mature and costs must now be reduced.

Mr. Bonhoff, hydrogen can be produced from water via electrolysis and this can then be used to generate power and heat using a fuel cell. Why does this technology have such great significance?

Hydrogen is a universal energy source and may have a significant role in the energy turnaround. It is storable and can be produced using renewable energy. In a fuel cell, it efficiently converts the energy to heat and power. Cars can use hydrogen as a fuel and thereby become more efficient while also reducing emissions.

To date this is a niche technology. Is this going to change?

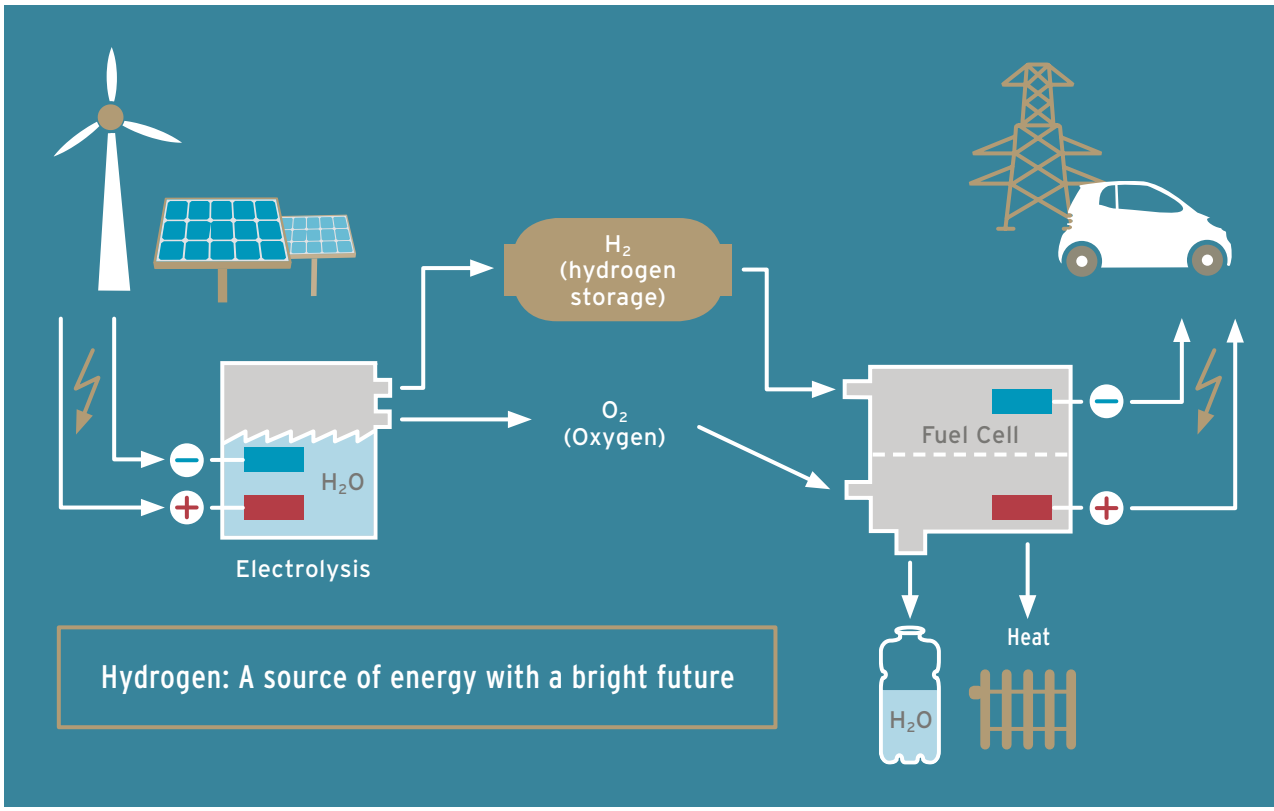
Progress has certainly been made over the past five to ten years. The technology works and there are heaters and vehicles implementing fuel cells. There are also refilling stations for hydrogen. However, it is still too costly when compared with conventional technologies. But we need hydrogen technology to achieve our climate goals. We have now reached the threshold to mass-market introduction. Costs can thereby be potentially reduced through the industrialisation of the technology – with large quantities to achieve economies of scale.

The first vehicles with fuel cell technology are now in series production. Why?

All analyses show that battery technology alone will not be sufficient to serve the broad and diverse customer base in the transport sector. That is why fuel cells, which have a larger range than batteries, are necessary. Hyundai is now delivering its first commercial customer with fuel cell vehicles in California – and other manufacturers will follow suit over the next year or two.

But isn't there more movement in area of batteries: prices keep falling. How do you see the two storage technologies in comparison to one another?

We need batteries for short-term storage. But we need hydrogen to store wind and solar energy over longer periods and in greater volumes. The power and transport sectors need to be considered together in this regard. Surplus power can be used for the production of



hydrogen. This reduces electricity grid loads in peaks and one simultaneously has hydrogen for transport purposes – and hydrogen technology will become more economical faster in the process.

Which countries are investing in this technology in particular?

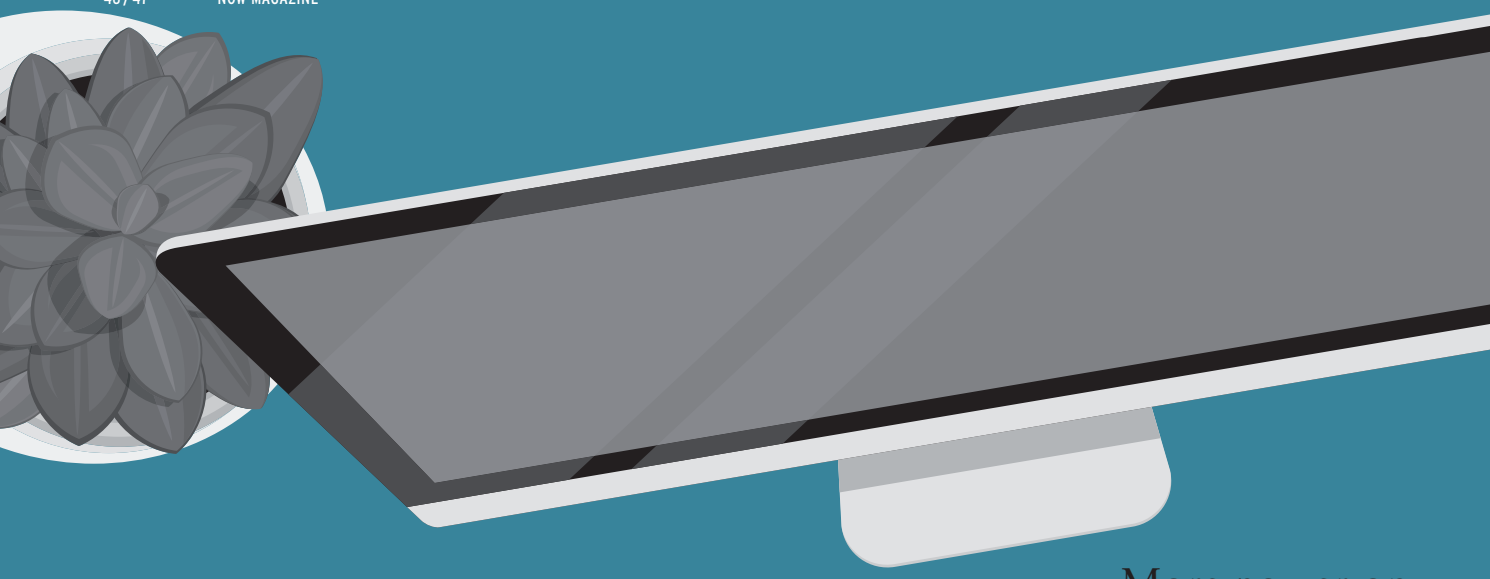
There are a handful of industrial nations, such as Germany, working very hard in the development of hydrogen and fuel cell technology, including Japan and the USA. Moreover, developments are impressive in Korea, where the World Hydrogen Energy Conference is now taking place. The largest fuel cell company is Korean and there is a clear commitment to the fuel cell for stationary applications due to its high level of efficiency and potential to reduce CO_2 emissions. It is on an equal footing with renewable energies in terms of the support it receives.

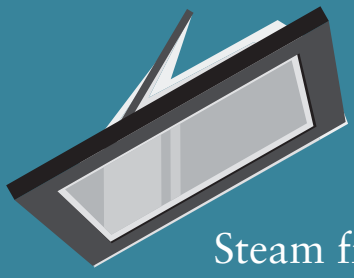
How do you see developments over the next few years?

It is clear to see that we are coming out of the phase of research and development and that we are moving into the commercialisation of the technology. Automakers such as Hyundai and Toyota have fuel cell vehicles for sale. Daimler, BMW and Volkswagen are also deeply involved in the technology. And the company Viessmann is now commencing sales of fuel cell heating plants.

Commercial readiness will be clearly recognisable by 2020. And from 2025, I anticipate the technology will be commercially viable even without public funding support.

↗ **Interview conducted by Gero Rueter.**





With the power of hydrogen

February 2014, Süddeutsche Zeitung

More power on Cologne's roads

May 2014, auto.de

Steam from the exhaust pipe – mobility in Stuttgart

March 2014, Stuttgarter Zeitung

Brandenburg police radios ecological – fuel cells help during power outages

March 2014, Der Tagesspiegel

Cleaner local public transport – hydrogen not diesel

July 2014, Westdeutscher Rundfunk

Public utilities put their money on electromobility

May 2014, Die Welt

On the road to the hydrogen age

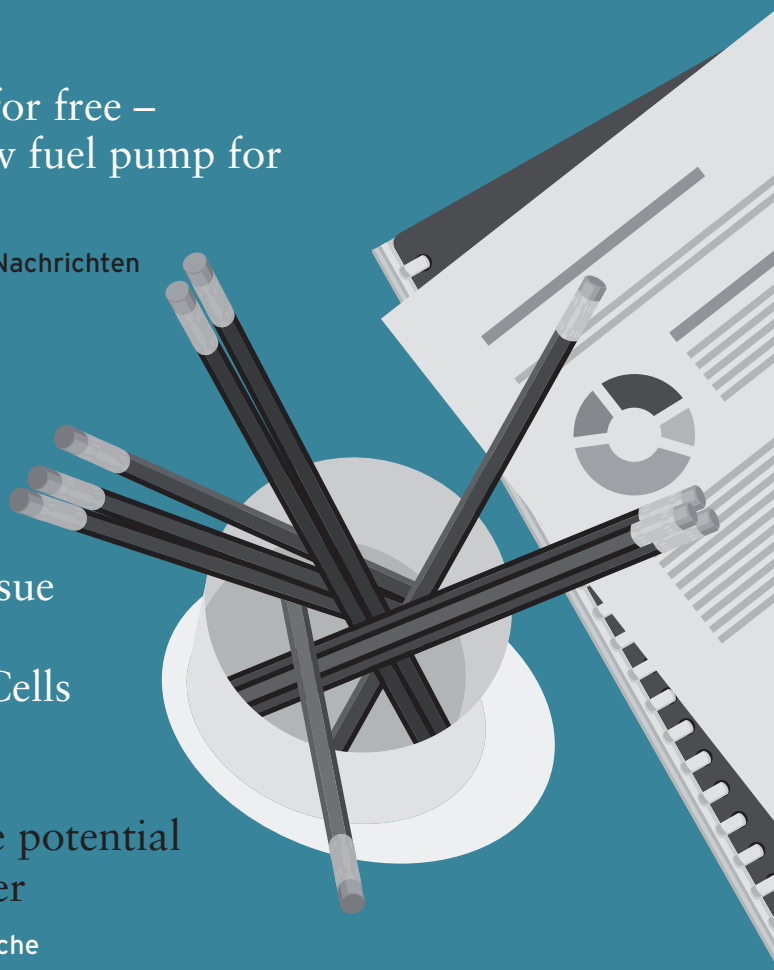
February 2014, Automobil Industrie

Fill up on electricity for free – Anita Tack opens new fuel pump for electric vehicles

May 2014, Potsdamer Neueste Nachrichten

Workshop for more e-vehicles

May 2014, Solinger Tageblatt



NOW and Hydrogeit Publishers issue new teaching materials – More Knowledge on Batteries and Fuel Cells

March 2014, Focus Online

Technology with huge potential – gas from wind power

September 2014, WirtschaftsWoche

Electromobility is the future

August 2014, Die Welt

Fuel cell: the on-grid power plant in the home

August 2014, Mitteldeutscher Rundfunk

District to assess new recharging stations for electric bikes – new federal network platform for e-mobility

November 2014, Potsdamer Neueste Nachrichten

The environmentally conscious way to get to the sights of Thuringia

January 2014, Thüringer Allgemeine

Power-to-gas – test of the new storage technology

May 2014, Die Welt

Power plant in the cellar

May 2014, Wirtschaftswoche

Funding by:

Federal Ministry
of Transport and
Digital Infrastructure

following a resolution by
the German Bundestag

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NOW coordinates the National Innovation Programme Hydrogen and Fuel Cell Technology of the federal government and the Electromobility Model Regions of the BMVI.

The following provides detailed information of projects newly approved in 2014 as well as those concluding in 2014.

Federal Ministry for Economic Affairs and Energy

THE FOLLOWING BMWi NIP PROJECTS WERE APPROVED IN 2014:

PROJECT	COMMENCEMENT	CONCLUSION
Low Cost BiP	01 May 2014	30 April 2017
Low Cost BiP	01 May 2014	30 April 2017
Low Cost BiP	01 May 2014	30 April 2017
Low Cost BiP	01 May 2014	30 April 2017
Low Cost BiP	01 May 2014	30 April 2017
Low Cost BiP	01 May 2014	30 April 2017
ALASKA	01 December 2014	31 Mai 2017
ALASKA	01 December 2014	31 May 2017
ALASKA	01 December 2014	31 May 2017
ALASKA	01 August 2014	31 May 2017
EXTRAMEA	01 August 2014	31 July 2018
H_2plus	01 August 2014	30 June 2015
Thermelin	01 December 2014	30 November 2018
Thermelin	01 December 2014	30 November 2018
Thermelin	01 December 2014	30 November 2018
MCFC-Next	01 July 2014	30 June 2017
MCFC-Next	01 July 2014	30 June 2017
MCFC-Next	01 July 2014	28 February 2015
Expansion of the fuel cell testing area	01 August 2014	31 December 2017
FOSUS	01 January 2015	31 December 2017
FOSUS	01 January 2015	31 December 2017
FOSUS	01 January 2015	31 December 2017
LPG-mKWK	01 December 2014	31 January 2017
LPG-mKWK	01 December 2014	31 January 2017
DemoHydra	01 July 2014	30 June 2017
LSSOFC	01 October 2014	30 September 2017
PRECOAT	01 January 2015	31 December 2017
PRECOAT	01 January 2015	31 December 2017
PRECOAT	01 January 2015	31 December 2017

PARTNERS	FUNDING RATIO [%]	FUNDING BUDGET [€]
Gräbener Maschinentechnik GmbH & Co. KG	42	358,194
VOLKSWAGEN AG	41	316,601
Zentrum für Brennstoffzellen-Technik GmbH	90	362,577
HARDO-Maschinenbaugesellschaft-mbH	41	36,793
Jowat AG	41	189,699
Technische Universität Carolo-Wilhelmina zu Braunschweig	90	247,371
Zentrum für Brennstoffzellen-Technik GmbH	100	395,807
Daimler AG	35	276,961
MANN+HUMMEL Innenraumfilter GmbH & Co. KG	35	163,478
Forschungszentrum Jülich GmbH	100	366,703
SolviCore GmbH & Co. KG	40	2,004,530
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V.	100	839,595
ElringKlinger AG	40	1,307,862
Viessmann Werke Allendorf GmbH	40	591,879
CeramTec GmbH	40	659,643
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V.	80	4,135,142
FuelCell Energy Solutions GmbH	48	874,538
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V.	80	4,135,142
Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW)	100	1,190,029
SunFire GmbH	50	1,697,116
Vaillant GmbH	50	208,412
KERAFOL Keramische Folien GmbH	50	341,263
Primagas Energie GmbH & Co. KG	40	141,276
Zentrum für Brennstoffzellen-Technik GmbH	100	490,876
Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLR)	90	1,346,372
Robert Bosch GmbH	40	1,658,293
Zentrum für Brennstoffzellen-Technik GmbH	100	435,959
Gräbener Maschinentechnik GmbH & Co. KG	50	456,407
Hille & Müller GmbH	50	401,752

NIP – TRANSPORT AND INFRASTRUCTURE

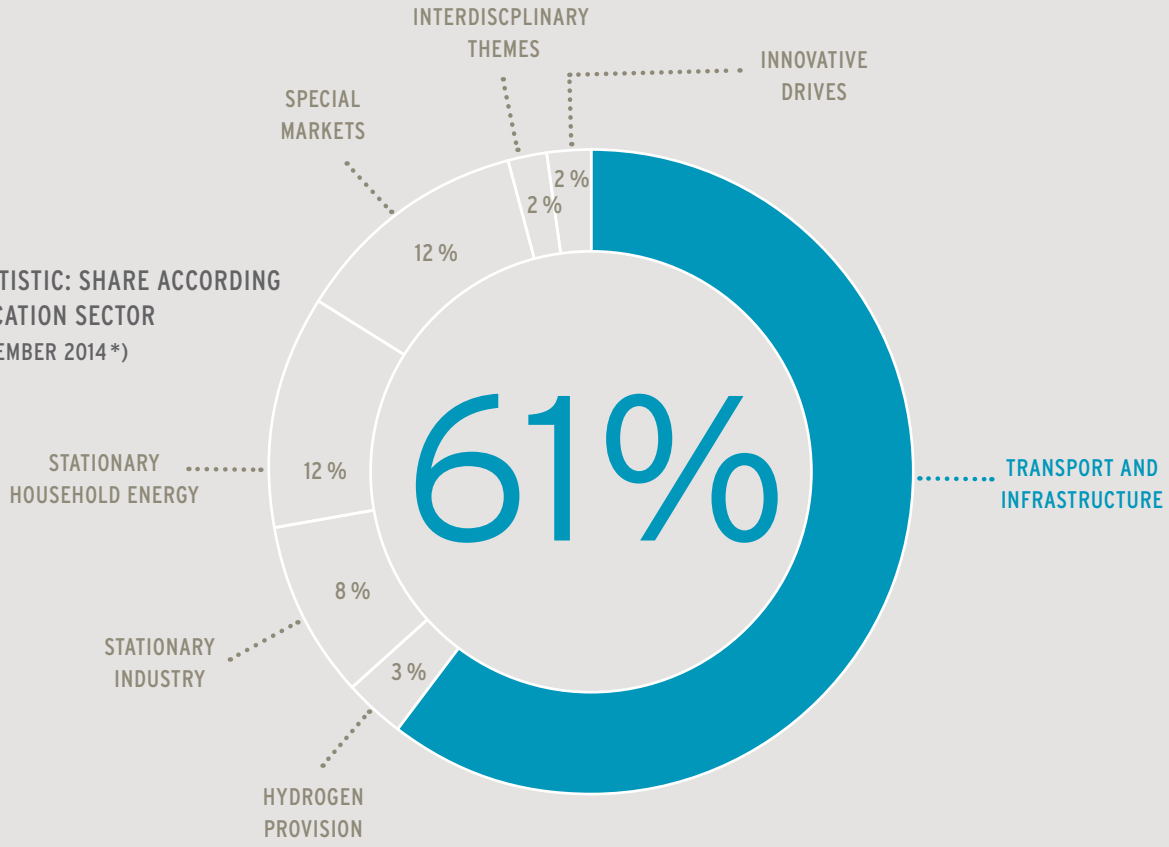
THE PROJECTS ARE LISTED I / 01 – I / 15 ON THE FOLLOWING PAGES,
COMPLETED PROJECTS ARE MARKED WITH 🏁 .

NIP – TRANSPORT AND INFRASTRUCTURE

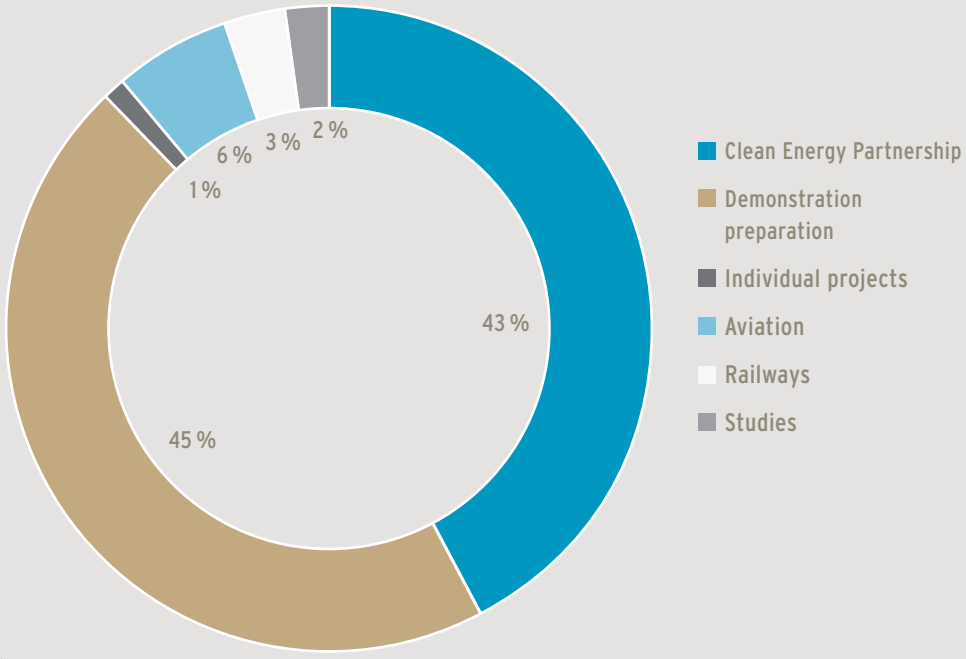
The Transport and Infrastructure programme area focuses on research and development along with demonstration activities in the areas of drive technologies and hydrogen infrastructure. Entire drive systems and key components such as polymer electrolyte fuel cells (PEMFC) and hydrogen storage are being closely examined throughout the research and development activities. A main focus is placed on reducing costs and weight, increasing service life and performance as well as enhancing reliability in day-to-day operations. In addition, efforts to improve the development of production processes of fuel cell systems are being stepped up in order to establish and enhance manufacturing expertise. In terms of infrastructure, cost reductions and improved reliability are similarly a key area of focus in the various projects and work is also continuing on the introduction of technological standards for hydrogen refuelling stations. The programme area is also examining potential areas of off road fuel cell applications, such as for the supply of onboard power in aircraft or for drivetrains in rail transportation.

The demonstration projects are an important aspect of the Transport and Infrastructure programme area as they help validate the implemented technology under everyday conditions and also assist in preparing the market by increasing user acceptance. Comprehensive accompanying research activities in these areas is initiated and coordinated by NOW. Furthermore, hydrogen-based fuel cell vehicles are being tested in comprehensive collaborative projects spanning both personal transportation as well as local public transport. The expansion of hydrogen infrastructure is also being promoted within the framework of the 50 Refuelling Stations programme, coordinated by NOW, in order to provide a basic national supply network of hydrogen refuelling stations.

NIP – STATISTIC: SHARE ACCORDING TO APPLICATION SECTOR
(AS AT DECEMBER 2014 *)



NIP – TRANSPORT AND INFRASTRUCTURE: ALLOCATION BY APPLICATION AREA
(AS AT DECEMBER 2014)



* The diagram incorporates projects at planning stage at NOW, being processed by PtJ, LOI (Letter of Intent) as well as those approved.

»Clean Mobility with Hydrogen and Fuel Cells.«


NEU 45

CLEAN ENERGY PARTNERSHIP (CEP) – CLEAN MOBILITY WITH HYDROGEN AND FUEL CELLS

In order to promote the energy turnaround and become independent of dwindling natural resources, the demand for alternative drive technologies and renewable energies is now greater than ever. An important aspect in this regard is research into alternative fuels to ensure a reduction of greenhouse gas emissions. The Clean Energy Partnership, a joint government and industry initiative, has been testing the day-to-day suitability of hydrogen as a fuel since 2002. In 2008 the CEP became a Lighthouse Project of the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP) and has now progressed to become Europe's most important demonstration project in the area of hydrogen-based mobility.

Sustainably produced, hydrogen enables fuel cells to provide virtually emission-free mobility with a range that is comparable to conventional diesel or petrol engines. But the use of hydrogen in vehicles is not the only point of focus of the CEP – solutions for the sustainable production of the fuel along with an expansion of the infrastructural network are also being jointly aspired to.

The CEP is currently in its third and final project phase, which will culminate in 2016 with market preparation. With more than 100 vehicles including the models Mercedes-Benz B-Class F-CELL, Ford Focus Fuel Cell, Honda FCX Clarity, Hyundai ix35 Fuel Cell, Toyota FCHV-adv, Opel HydroGen4, VW Tiguan HyMotion and Audi Q5 HFC, the CEP fleet of vehicles has grown to be of considerable size. For several years, the vehicles have been tested on the roads daily – free of any noteworthy incidents. Also impressive are the numbers of hydrogen buses in service in local public transport: Stuttgarter Straßenbahnen (SSB) put new hydrogen buses into scheduled service in March 2014. And at the end of 2014, the Hamburger HOCHBAHN presented two hydrogen buses to the general public, which will operate the new, so-called "Innovation Route" in the city.

EXPANSION OF THE HYDROGEN INFRASTRUCTURE

With the 50 Refuelling Station programme that is supported by the federal government, the CEP partners Daimler, Linde, Air Liquide and Total pledged to put 50 refuelling stations into operation in Germany until the end of 2015. NOW is coordinating this expansion. In May and September 2014, the CEP opened the first two refuelling stations of the programme, together with Katherina Reiche (MdB), Parliamentary State Secretary at the Ministry of Transport and Digital Infrastructure: one at Berlin's future international airport BER, the other in Jafféstraße in the west of Berlin. Both are multi-energy refuelling stations from Total, offering a rich selection of fuels. State Secretary Reiche emphasised: "The development of alternative drives remains at the top of the government's agenda: it is our goal to successively develop a nationwide supply network for electromobility – for both hydrogen-based fuel cell vehicles and battery-electric vehicles. Many strong partners are called on for the energy turnaround. I am delighted with the pledge of these companies to get involved through their expertise, investment and major commitment." For the development of infrastructure in Baden-Wurttemberg and North Rhine-Westphalia, the CEP prepared a map of future refuelling station locations in autumn. This was handed over to the Minister for the Environment Franz Untersteller at the "WORLD OF ENERGY SOLUTIONS" fair for new mobility and energy in Stuttgart, and to Climate Protection Minister Johannes Remmel a month later at the annual meeting of the Fuel Cell and Hydrogen Network NRW.

The CEP relies on having strong partners for the successful expansion of the hydrogen infrastructure. Bohlen & Doyen, the Westfalen Group and OMV joined as CEP members in 2014. The contribution of Bohlen & Doyen will be a mobile hydrogen refuelling station that is scheduled to be operational in 2015. A large refuelling station in Munster that will be equipped with hydrogen pumps for passenger vehicles and buses marks the beginning of the Westfalen Group's involvement. And OMV will commence with three hydrogen refuelling stations in Bavaria.

ACCESSING NEW TARGET GROUPS – THE CEP CAMPUS DAYS

To help ensure that the next generation of engineers is also enthusiastic about hydrogen technology, 2014 saw the inaugural CEP Campus Days take place at the Technical University Chemnitz, Ostwestfalen-Lippe University and RWTH Aachen University. The areas of focus in the CEP lectures included hydrogen production using renewable sources, the current status of refuelling station construction as well as vehicle technology. The good take up of the events, including attendance by regional members of the media, means that the CEP will continue with this successful concept in 2015.

MORE INFORMATION FOR JOURNALISTS – CEP MAGAZINE SUPPLEMENT IN "JOURNALIST" AND "WIRTSCHAFTSJOURNALIST"

Journalists often only report on the subject of hydrogen in an isolated manner. The CEP partners have therefore jointly prepared a magazine supplement that comprises a basis of information for journalists, which comprehensively shows the many and varied interrelationships existing in the hydrogen economy. The supplement has already been included in the following specialist publications for journalists in Germany: "Journalist" (issue 10/2014) and "Wirtschaftsjournalist" (issue 12/2014).

More Information on the CEP can be found at **www.cleanenergypartnership.de**


Der Stoff, aus dem die Zukunft ist.
F-CELL


B FC 5036

I / 01

» HYTRUSTPLUS – ACCOMPANYING SOCIAL-SCIENTIFIC STUDY TO THE NATIONAL INNOVATION PROGRAMME HYDROGEN AND FUEL CELL TECHNOLOGY «

With the first fuel cell vehicles going on sale soon, a decisive step towards the hydrogen economy is being made. Pilot projects are now connecting renewable energies more intensively with the hydrogen economy, such as in the area of hydrogen storage. Nevertheless, current infrastructure along with large parts of the general public and relevant stakeholders are still not adequately prepared for this step. The HyTrustPlus research project will therefore actively include the ideas, expectations and creative potentials of social players in the development of the hydrogen economy. In this way, the systemic technology change to hydrogen and fuel cell technology can be conceptually prepared and actively shaped.

To realise the intended broad participation of the social players, the project has set out two goals:

↗ Development of business and participation models for relevant stakeholders from industry, politics and associations as well as from civic society

↗ Raising of social awareness towards hydrogen mobility and the hydrogen economy as well as undertaking the associated educational measures necessary for this to occur

Overall, the project is to result in an increase of public awareness and knowledge. Furthermore, specific target groups are to be actively involved in the developments. Following the preliminary conceptual work, efforts have now already commenced on the identification of a pilot region. In addition, as part of the initial interviews with experts, experiences from hydrogen economy pilot projects were collated in order to identify drivers and obstacles for further cross-industry collaborations. The first interim results are scheduled to be available from March 2015.

The latest information on the project can be found at: www.hytrustplus.de

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Innovationszentrum für Mobilität und gesellschaftlichen Wandel (InnoZ) GmbH	1,242,086	1,242,086

COMMENCEMENT: 01 September 2014
CONCLUSION: 31 December 2016

» Pilot projects are now connecting renewable energies more intensively with the hydrogen economy, such as in the area of hydrogen storage. «

I / 02

» ACCOMPANYING RESEARCH FOR THE 50 HYDROGEN REFUELLING STATIONS PROGRAMME «

A total of 50 hydrogen refuelling stations are to be in operation in Germany by the end of 2015. This research project will scientifically accompany the operation of the existing 15 locations along with the establishment and operation of the next 35 refuelling stations along with the associated supply infrastructure.

Based on the specific experiences made throughout the establishment and operation of the refuelling stations, the accompanying research project will identify approaches for further technological development. It will focus on a broad range of research topics including ecological, economic and technological aspects of hydrogen refuelling stations as well as covering the issue of user and operator acceptance. Regulatory and energy policy framework conditions for the establishment and operation of hydrogen refuelling stations and the economic impulses along the value added chain are also topics of research. Through the work of the project consortium and the resulting networking of all relevant players in the establishment and expansion of the hydrogen refuelling station network, potentials for optimisation in many areas will be identified and may then be exploited in the establishment of future refuelling stations.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Ludwig-Bölkow-Systemtechnik GmbH	1,054,942	1,054,942

COMMENCEMENT: 01 November 2014
CONCLUSION: 31 December 2016

GOALS AND DIMENSIONS OF THE ACCOMPANYING RESEARCH

Refuelling station operation
↗ Operational data
↗ Operational experiences

Framework conditions
↗ Regulatory guidelines
↗ Energy policy

Accompanying research
↗ **Acceptance** among users, operators and operating staff
↗ Potential for improvement of the implemented **technologies**
↗ Further reduction of **greenhouse gas emissions**
↗ More **economic** construction, operation and production of hydrogen; optimised expansion strategy of the refuelling station network
↗ Continued development of the **regulatory and energy policy environment**
↗ Support of the domestic **value added chain**
↗ **Networking** of all relevant players

Goal
↗ **Practical feasibility** of the refuelling station technology
↗ **Market maturity** for commercial introduction


HAFENCITY
HAMBURG

I / 03

» SUPPLY OF HYDROGEN REFUELLING STATIONS WITH PEM ELECTROLYSIS «

The research project aims to equip a hydrogen refuelling station with an innovative PEM hydrogen electrolysis system and test the plant in operation over a one to two-year period.

In order to effectively demonstrate how surplus fluctuating wind or solar energy can be used to produce hydrogen as a fuel for vehicles, the plant is to possess a capacity of 100 to 300 kW and should be operated using renewable energy with load profiles.

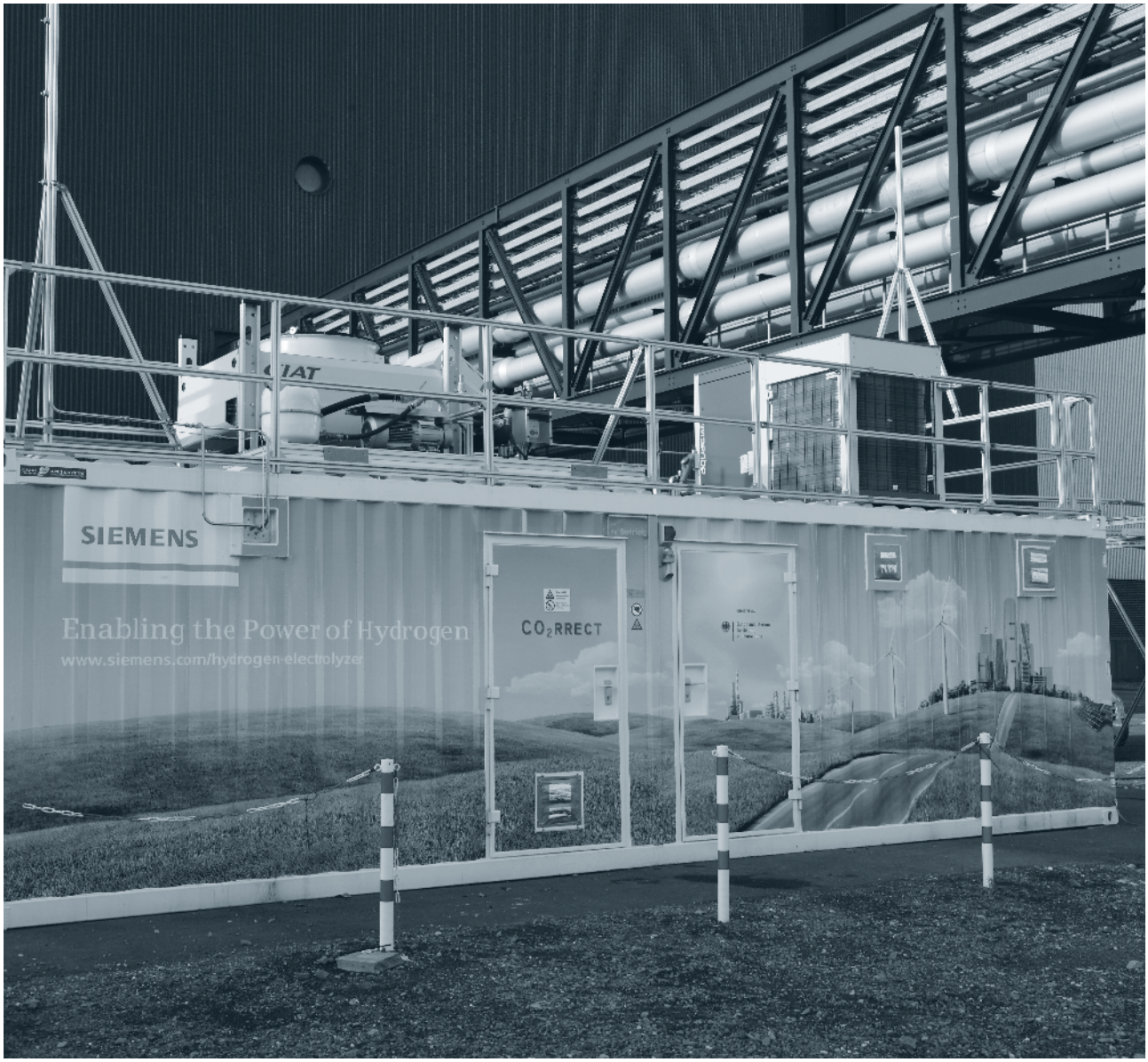
This project represents an amendment for a refuelling station yet to be established by Air Liquide. The chosen hydrogen refuelling station is to be expanded within the scope of the already proposed project, enabling the required hydrogen to be supplied dynamically through the Siemens PEM electrolyser.

Siemens will be responsible for the installation of the electrolysis plant and putting it into operation, along with the associated technical/scientific support as well as for the plant's service and maintenance needs.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Siemens AG	857,056	411,387

COMMENCEMENT: 01 August 2014
CONCLUSION: 30 June 2016

» The chosen hydrogen refuelling station is to be expanded within the scope of the already proposed project, enabling the required hydrogen to be supplied dynamically through the Siemens PEM electrolyser. «



SILYZER 100 Electrolyis System (at the Kohle Innovation Centre at the RWE power plant in Niederaussem)

REHAU Type IV Pressure Reservoir Concept for compressed hydrogen at 700 bar

I / 04

» ALTHYPTANK – EXAMINATION OF AN ALTERNATIVE PROCEDURE FOR THE MANUFACTURE OF COMPRESSED HYDROGEN RESERVOIRS «

REHAU is specialist in the processing of plastics with innovative solutions for the construction, furniture and automobile industries. A long-term company goal is the development of a fibre-reinforced compressed hydrogen reservoir for storage at 700 bar.

Until now, such reservoirs are manufactured using a wet-winding process. REHAU is taking an innovative approach in which the reinforcement is manufactured using an alternative procedure. Above all, this provides benefits in the shape of enhancing fibre efficiency and a shorter cycle period. In addition, the process ensures that the components all boast a constant high level of quality and can be manufactured in large quantities. Moreover, the current very high manufacturing costs for fibre-reinforced pressure tanks are to be significantly reduced in the future.

The proposed procedure will be closely examined in terms of its suitability for manufacturing high-pressure reservoirs within the scope of this project. This will entail the experimental assessment of the process-related parameters by means of corresponding testing facilities. To ensure a greater overall understanding, numerical simulations will be conducted for component design and the manufacturing processes will also be modelled. In order to generate input variables for the simulation of these complex components, the fibre-reinforced composites resulting in this procedure will be characterised in advance through comprehensive examinations. Finally, the demonstration components that can be manufactured by this new procedure will then be tested in compliance with the applicable EC directives.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
REHAU AG + Co	2,611,722	1,253,627

COMMENCEMENT: 01 October 2014
CONCLUSION: 30 November 2016

I / 05

» MASS PRODUCTION OF MEMBRANE ELECTRODE ASSEMBLIES (MEA): TECHNOLOGIES FOR THE INTRODUCTION TO THE (MASS) MARKET – MAS-TECH «

The path leading from market introduction to the establishment of a mass market for PEM fuel cell systems is becoming increasingly fraught with questions of costs. An important factor for the successful market penetration of fuel cell systems is therefore the establishment of less expensive and more stable manufacturing processes.

The main aim of the MAS-TECH project is to complement the existing technology platform at Solvicore with additional cost-reducing elements to thereby further cut overall manufacturing costs.

Solvicore is pursuing the following goals to enhance additional cost reduction potentials within the scope of this project:

↗ The process chain will be equipped with selected automated in-line control systems. These will be developed as part of the project and implemented with the goal of enhancing the cycle time and minimising reject rates.

↗ Further cost reductions will be achieved through the elimination or significant improvement of process steps as well as through the testing and introduction of improved quality control systems.

↗ Finally, through the development of an automated roll-to-roll assembly process together with various specialist partners from Germany, a further boost to efficiency will be possible.

As such, the project will shape a cost-optimised technology platform that enhances the international competitiveness of MEA production to therefore also strengthen German industry.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Solvicore GmbH & Co. KG	648,200	311,136

COMMENCEMENT: 01 July 2014
CONCLUSION: 30 September 2016

» An important factor for the successful market penetration of fuel cell systems is therefore the establishment of less expensive and more stable manufacturing processes. «

» In contrast to the automobile, rail infrastructure also provides an important benefit: with one centrally-positioned refuelling station it is possible to completely cover the demands of an entire regional network – a tight-knit web of refuelling stations is not required. «

I / 06

» BETHY – DEVELOPMENT OF A NEW GENERATION OF TRAINS WITH LOCAL EMISSION-FREE DRIVES FOR NON-ELECTRIFIED LINES «

The importance of rail sector has grown for many years: increasing numbers of people are discovering rail travel as a viable mobility alternative. Rail networks are currently being expanded and renewed throughout the world, with ever more comfortable trains in local and long-distance service. Rail systems represent the only chance to master the high levels of traffic in urban areas and megacities. It is particularly here where the deployment of local emission-free trains can play an important role for environmentally friendly and sustainable mobility – even on non-electrified lines. In contrast to the automobile, rail infrastructure also provides an important benefit: with one centrally-positioned refuelling station it is possible to completely cover the demands of an entire regional network – a tight-knit web of refuelling stations is not required.

Alstom is capitalising on this advantage with the development of the world's first generation of local emission-free trains for regular scheduled passenger services on non-electrified lines. It is therefore setting the course for an environmentally friendly alternative to conventional diesel trains. They provide a higher level of energy efficiency as well as lower energy costs and are being developed at the Alstom Centre of Competence for Regional Trains in Salzgitter. The German Aerospace Centre (DLR – Deutsches Zentrum für Luft- und Raumfahrt) in Stuttgart will support the company in the development of the required technology. Four German states or associated local transport authorities in Lower Saxony, North Rhine-Westphalia, Baden-Wurttemberg and the State of Hesse could also be secured to take part in the project and have signed letters of intent for the ordering of the trains.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
ALSTOM Transport Deutschland GmbH	19,972,025	7,988,810

COMMENCEMENT: 01 September 2013
CONCLUSION: 30 June 2016

I / 07

»SUCCESSFUL COMPLETION OF HYDROGEN METERING VALVE FOR THE SUPPLY OF ANODE GAS DEVELOPMENT PROJECT: BOSCH DEVELOPS TAILOR-MADE HYDROGEN FUEL INJECTION FOR CARS – MORE COMPACT, EFFICIENT AND LIGHTER MODULE FOR DEPLOYMENT IN CARS FOR THE FIRST TIME «

The fuel cell counts among the most promising technologies for emission-free mobility of the future. Fuel injection takes on a special role in this technology: sophisticated metering valves supply the cell with hydrogen. Bosch has developed these important fuel cell components from the ground up and made them more compact, lighter and significantly more efficient for the deployment in cars.

The development of these innovative components was supported with funds totalling six million euros from the Ministry for Transport and Digital Infrastructure in accordance with a resolution of the German Parliament. At the end of the five-year development process, a whole series of magnetically actuated hydrogen valves had been developed. Already today, they are suitable for use with numerous current fuel cell systems. Throughout the developmental process, the Bosch engineers already placed a special focus on ensuring that the components could be produced cost-effectively in the future in series production. "We are ready for swift market introduction," comments Hubert Stier, Head of the Project at Robert Bosch GmbH. During the manufacturing process of the components, Bosch takes into account that hydrogen is extremely volatile and can even permeate steel. For this reason, the company developed an improved manufacturing process, partly together with its suppliers, in the areas of remodelling, laser welding and vulcanisation.

From an industrial product to an automotive component

In order for its full potential as the basis for mobility of the future to unfold, fuel cell technology must be reliable, safe and inexpensive. Industry and research has primarily focused on the development and improvement of the fuel cell itself and have achieved substantial simplifications of its architecture. Meanwhile, in the area of fuel cell periphery, such as the metering of the hydrogen, industrial products or modified components from existing automotive applications were often implemented, such as natural gas fuel injectors. "For the series introduction of fuel cell systems, these parts are suited neither technically or economically. They are too big and heavy, consume too much power or were not developed to cater to the specific characteristics of hydrogen. Moreover, they also do not fulfil the functional safety that is demanded of automotive components," explains Hubert Stier.

In an initial step, Bosch constructed a fuel cell laboratory as well as a test bench for a 5 kW fuel cell system in its development centre in Schwieberdingen, Germany. With their help, the project team chose the best materials and components for the valves and could optimise the interplay of the components including control and regulation. Further areas of research included the tribological system in hydrogen, hydrogen embrittlement in steels taking various production processes into account, as well as the simulation of highly dynamic gas flows for an optimal geometric design. The research aimed to ensure the robustness, reliability and safety of the valves for vehicle use throughout the entire service life of the vehicle.

Funding support makes an important contribution

Within the framework of the publically funded NIP project, Robert Bosch GmbH could develop a technically mature and economical solution solution to produce hydrogen metering valves (Hydrogen Gas Injector – HGI) for the anode gas supply of fuel cell systems in vehicles. The research project commenced at the beginning of August 2008 and was successfully completed by the development team in December 2013 before the planned conclusion date. "The funding support was necessary to develop these important components from scratch. This valve simplifies the construction of fuel cell systems for all manufacturers," concludes Hubert Stier.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Robert Bosch GmbH	12,503,264	6,001,567

COMMENCEMENT: 01 August 2008
CONCLUSION: 30 June 2014

I / 08

» BRIST – BRENNSTOFFZELLE, INTEGRATION UND SYSTEMTEST (FUEL CELL, INTEGRATION AND SYSTEM TEST) «

Aim of the project was to increase the technological maturity of a multifunctional fuel cell system and prepare it for the future installation in commercial aircraft. The project partners see this system as one that provides an emission-free alternative to existing turbine-based solutions (APUs – Auxiliary Power Units), for the provision of energy. It has simultaneously been shown that, besides power, the working principle of the fuel cell is suitable for further uses on board. The water produced can be fed into the service water reservoir; the used low-oxygen air can be deployed to reduce the oxygen level in fuel tanks or in the cargo hold (inertisation); and waste heat can be used to avoid the build-up of ice.

The project consortium comprised, on the one hand, of companies that each are leaders in their respective fields. On the other hand, research institutions were also involved, which not only helped to raise understanding of the technology itself, but also to create new impulses, methods and ideas. The course of the project confirmed the correctness of this approach as it was repeatedly the case that original methods and approaches needed to be adapted. The high complexity of a multifunctional system is attributable to the fact the requirements are contradictory, in part. For example, a high level of surplus air (stoichiometry) is advantageous for specification-compliant electrical performance and dynamics, while for the aforementioned inertisation function a low level of air is beneficial as only in this way can the oxygen content in the respective areas be significantly reduced.

In order to gain both experience with the behaviour of such systems and also be in the position to test components, the Fuel Cell Test Centre (FCTC) was established in Hamburg. Besides the flexibility of integrating new components, e.g. water separators from AOA or power electronics from EADS-IW, the system behaviour under flight conditions was to be tested. The tank simulator was designed in such a way that the pressure conditions of an aircraft tank at cruising altitude could be replicated using a vacuum pump. Laboratory tests showed reactions between the fuel cell and the fuel tank inerting system (FTIS), which could, however, be minimised through a more suitable design of the overall system. By the end of the project, a laboratory setup was in operation that could independently reproduce the relevant aspects of a flight and thereby simulate the intended operations in an aircraft.

The BRIST project delivered new insights to all involved parties and developed knowledge for the deployment of fuel cell systems in aircraft. This has put the project partners in the position to advance industrialisation and develop new products. Future market introduction will bring about new jobs and the advancement of technology will strengthen the market position.

PARTNERS:	PROJECT BUDGET/€	PROJECT FUNDING/€
Airbus Operations GmbH	6,905,900	3,314,832
AOA Apparatebau Gauting GmbH	1,687,522	810,010
Berner & Mattner Systemtechnik GmbH	1,277,407	613,156
Diehl Aerospace GmbH	550,089	264,043
Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLR)	1,348,396	647,230
Airbus Group Innovations	3,500,516	1,680,248

COMMENCEMENT: 01 January 2010
CONCLUSION: 31 December 2014

I / 09

» THIRD GENERATION HEAVY-DUTY FUEL CELL SYSTEM FOR USE IN BUSES/ NABUZ PRE-COMMERCIAL «

As part of the overall NaBuZ (sustainable bus system of the future) project, NuCellSys together with EvoBus is pursuing the goal of demonstrating the application potential of the latest generation passenger fuel cell system in the form of a so-called double system as a fuel cell drive train suitable for series production in a city bus. By combining two fuel cell systems to form a double system, the development of an operating strategy for the double system based on that of single systems, as well as the adaptation of major components to the increased voltage level and the increased service life requirement are the main focus.

All project results will be exploited firstly for the development of subsequent, more efficient fuel cell system generations and secondly they will be incorporated in the vehicle development of city buses with fuel cell drives. Thus it will be ensured that the project results can be commercially exploited through the sale of vehicles. The scientific and technical results gained from the project can be fed into the development of future city buses with fuel cell drives.

The project goals were defined as follows:

↗ Setting-up of a dual FC test bench integrating a dual FC system

↗ Conceptual analysis and development of a performance interface between fuel cell system and hybrid system with different voltages

↗ Development and verification of an operational management strategy for the dual FC system, as well as the power management and control of the developed power electronics

↗ Optimisation and verification of suitable FC system components (humidifier and air supply) for 12,000 hours of operation

↗ Inspections of installation space and packaging of a dual FC system in a Citaro solo bus and articulated bus with respect to service and maintenance aspects

↗ Construction of a high-voltage test environment for the verification of the developed power electronics (DC/DC converter)

↗ Test operation and continuous running at the bus test bench

Because of the necessity of a suitable test environment for the future FC bus application from two passenger systems, a bus dual test bench was planned, constructed and put into operation with two FC systems within the project. Parallel to this the necessary bus-specific components like a DC/DC converter, a dual fuel cell controller as well as software management were developed and verified. This was implemented in a specially developed HV hardware-in-the-loop test bench. Control and regulation of the newly developed power electronics were the main focus. In a second step the developed and verified software and hardware in the real FC test bench was installed and functionally tested. Here the first results were achieved regarding the dynamic behaviour of the DC/DC converter in combination with the highly dynamic behaviour of the electrical turbocharger of the FC system.

A feature of the newly developed DC/DC converter is the galvanically separated design for an FC performance up to 100 kW. The galvanic isolation is required in order to securely separate the lower FC voltage from the higher bus traction voltage and to maintain the overall isolation resistance of the vehicle in the specified area, above all when a dual FC system in parallel connection is used.

The development of the DC/DC converter was carried out in two steps. The first step was a laboratory prototype, which was developed relatively inexpensively and used for proof of concept at the test bench. The results obtained were incorporated into the specifications of the A-model DC/DC converter. The A-model converter delivered at the end of the project achieved a considerably higher level of maturity and formed the basis for the desired series development.

In addition, intensive installation tests were carried out in bus rear sections for the FC system and of the bus components. The goal was to use the building space of the diesel aggregate for the operation in future of the fuel cell aggregate for the solo bus and articulated bus. Assembly in production as well as service and maintenance requirements were also taken into account. After the concept was determined, an initial A-model dual FC system was constructed in the prototype manufacture and investigations carried out regarding assembly and installation of the components. The aggregate is also available for initial test installations in the rear carriage body for Evobus.

In regard to the long service life requirements for a city bus, endurance tests for the air supply and humidification were carried out. The results show that the developed components are suitable for long service life requirements. The extension of service life is certainly doubled or tripled compared to the passenger vehicle specification. A doubled service life is expected with the FC stack module, as this faced very significant "design to cost" requirements and thus will be developed without any substantial power reserves. Instead a good maintenance and exchange concept in the use of passenger vehicle stacks will be favoured.

The development of the DC/DC converter in the galvanically separated model posed a great challenge in the project. On the one hand there was no experience with galvanically separated DC/DC converters in this performance class, and on the other hand the adjustment requirement between the FC systems and the dynamic requirements of the fuel cell air supply was very high. This necessitated intensive test phases and analyses in the laboratory that were repeatedly interrupted by component breakdowns. The converter had to be adapted very often by the manufacturer, which led to long delays in the project.

Nevertheless the operation with a dual FC system with the specific requirements could be successfully demonstrated. The results obtained were taken into account in the further development of the laboratory model to the A-model. The A-model was developed with a greatly increased maturity level for the latest FC generation and formed the basis for the next generation of Evobus FC buses.

PARTNERS:	PROJECT BUDGET/€	PROJECT FUNDING/€
NuCellsys GmbH	8,905,911	4,274,838
EvoBus GmbH	554,643	266,229

COMMENCEMENT: 01 September 2009
CONCLUSION: 31 October 2014

» The results show that the developed components are suitable for long service life requirements. «

» The new concepts were successfully implemented so that compared to current products, savings of over 65 % were made in pure material costs (in relation to stack performance). «

I / 10

» ROBUST FUEL CELL SYSTEMS FOR MOBILE APPLICATIONS WITH HIGHER PERFORMANCE REQUIREMENTS – TECHNOLOGY PLATFORM «

The motivation for the project resulted from the increasing number of enquiries from different users regarding larger capacity hydrogen-based fuel cell systems (> 100 kW) for use in stationary applications and in the rail, water and road transport areas.

In the development process special emphasis was placed on cost reduction, simple construction and long service life. In this way the material costs per kW compared with the preceding stack generation were significantly lowered while at the same time increasing performance density. At the test bench already over 5,000 operating hours were carried out with very promising results. Thus running times of well over 10,000 operating hours at a remaining performance of over 80 % of the take-off performance are expected.

In addition to the fuel cell stack the relevant system periphery was tested and implemented. Here the aim in particular was to ensure simple integration in the respective customer application as well as to reduce system complexity in terms of future product costs. The new concepts were successfully implemented so that compared to current products, savings of over 65 % were made in pure material costs (in relation to stack performance).

With the two prototypes an added value of 65% in Germany was already achieved. However, a new supplier of the membrane for the fuel cells was sourced in parallel. As a result the added value will increase significantly. We can assume that the added value of the fuel cell system in series production will be up to 90% in Germany.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Proton Motor Fuel Cell GmbH	2,533,828	1,216,237

COMMENCEMENT: 01 April 2010
CONCLUSION: 31 January 2014

I / 11

» SYSTEM VERIFICATION OF 700 BAR IONIC COMPRESSION TECHNOLOGY ACCORDING TO SAE J2601 «

The aim of the National Innovation Programme for Hydrogen and Fuel Cell Technology is to advance hydrogen technology in the mobility sector to market maturity. Aside from the fuel cell vehicles required for this, efficient refuelling of vehicles, which will be secured through appropriate effective hydrogen refuelling, is of key importance. Up to 900 bar necessary for refuelling can be compressed for storage in the pressure tanks of the vehicles from both gaseous as well as liquid phase hydrogen.

An important aspect for successful market introduction is reliable and resilient refuelling for the expected continually increasing number of fuel cell vehicles. A primary challenge for the technical components is to gather the necessary operational experience for the anticipated highly-utilised capacity of the refuelling system through many vehicles. But because already in the demonstration phase the capacity of the refuelling stations was not exploited in its entirety, comprehensive testing of the machines at test facilities is required. Within the project three machines of similar construction-type were installed on a test bench and continuously operated in parallel in an endurance test. Valuable findings could be gathered on the operational and wear resistance behaviour of components under different operational conditions, which could in part, be directly implemented in optimised construction solutions. In particular the close coordination with the supply industry enabled significant improvements in terms of downtimes of the machines.

Aside from the pure operation of the machines in continuous operation and the evaluation of the measurement protocols, a detailed fault/cause analysis was carried out on faulty elements, which delivered important additional findings for field trial facilities installed in the future.

The comprehensive test options made possible by the funding project was an important milestone on the road to commercialisation of hydrogen as a fuel. Further developed product generations are to be tested to a similar extent in so far as is possible in order to allow in advance the demands of a growing market to flow into the development process.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Linde AG	2,041,968	980,144

COMMENCEMENT: 01 December 2010
CONCLUSION: 31 March 2014

» An important aspect for successful market introduction is reliable and resilient refuelling systems for the expected continually increasing number of fuel cell vehicles. «

Compressor station with a Linde IC 90 compressor

I / 12

» FURTHER DEVELOPMENT OF THE CRYOGENIC PUMPS SYSTEM «

The aim of the procect based on "Innovative 700 bar refuelling technology for public series refuelling compliant with OEM standard release A – Fuelling Specification", was system optimisation. The underlying cryogenic pumps technology was especially developed for refuelling stations which are supplied with liquid hydrogen in order to exploit the advantages at the refuelling station, such as the higher storage density and high reachable throughputs.

The central aspects of the further development are reduced land usage and less electrical output without having to make compromises either in terms of cost or power. Furthermore, from a thermodynamic point of view, an optimised temperature management system was developed to be integrated in future systems. The most important performance data of the advanced refuelling stations are: mass flow 100 kg/h, maximum refuelling pressure 875 bar, six fuel cell vehicles per hour, compliant with SAE J 2601.

All technical adjustments facilitate the integration of the refuelling station components in existing refuelling stations and thus address experiences from earlier phases of development and demonstration. The innovation cycle could thus be successfully continued.

With development completed, a system with very high hydrogen throughputs has been created which can be easily integrated for the refuelling station operator. Aside from the hydrogen vehicle market, this can also be very well employed in the area of bus or fork lift fleet refuelling.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Linde AG	648,200	311,136

COMMENCEMENT: 01 April 2012
CONCLUSION: 31 March 2014

» The central aspects of the further development are reduced land usage and less electrical output without having to make compromises either in terms of cost or power. «

I / 13

» FUEL CELL SYSTEM DESIGN VALIDATION FOR THE MARKET INTRODUCTION OF PASSENGER VEHICLES «

Germany is facing the challenge of advancing the transition to a new era of environmentally-friendly, reliable and affordable energy provision. This also includes the securing of innovative concepts and technological progress for sustainable mobility with electrically-operated vehicles. Aside from hydrogen, fuel cell technology is an inseparable component of sustainable mobility as a storable and multi-usage secondary energy source. As it is highly efficient, it has the potential to guarantee secure, competitive and environmentally-friendly energy provision over the long term.

As a global leader in the development and production of fuel cell systems, NuCellSys is investing great effort into meeting the need for pollutant-free and sustainable mobility. In the fuel cell system design validation for the market introduction of passenger vehicles project, NuCellSys pursued the goal of improving the robustness, reliability and service life of a fuel cell system. This was achieved by improving the design validation methodology and by sustainably securing a basis for larger quantities for automotive application.

With the methodology being applied to FC technology for the first time, as well as the definition of reliability and strength processes, faults over all integration levels (components, FC system, drive train) were to be identified at an earlier stage in order to be in a position to introduce troubleshooting measures earlier.

Furthermore, for the first time a larger number of components and FC systems were to be provided at the end of every development phase to safeguard the design. Already in the development phase of this project, also at the suppliers, FC system components were to be subject to comprehensive robustness and reliability tests, which were specified in "robustness and reliability check lists". Components with interaction to other system components were to be tested on the level of components and system units (representation of interfaces or the environment of the components and sub-system units to be tested) or in overall FC systems. With early fault detection and troubleshooting all components were to be prepared with minimal fault rates and maximum potential reliability (reliability growth) for integration in an FC system and the resulting design validation. In this way considerable costs in the later phases of development through design iterations and the logistical and time resources associated with them could be avoided.

As the developed process led to very good results, early recognition of faults and malfunctions and significantly improved service life of the FC systems, this methodology then fully formed the basis of the verification and validation campaigns in the already running follow-up project.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
NuCellSys GmbH	22,805,928	9,806,549

COMMENCEMENT: 01 October 2008
CONCLUSION: 30 April 2014

I / 14

» HYMOTION4 FUEL CELL VEHICLE «

With the HyMotion4 project several NIP-relevant goals were grouped together. Firstly the maturity level of the fuel cell technology was to be improved. Secondly the aim was to increase the public visibility of fuel cell vehicles in order to raise awareness of the advantages of this new drive technology. In order to raise customer acceptance, the FC aggregate developed in another subsidised project of the Volkswagen Group was to be integrated without limitations into a combustion engine vehicle in terms of functionality, interior space and driving performance in an existing series vehicle concept of the Volkswagen Group.

Within the framework of an extension of the project, the number of vehicles was increased from one to nine in order to enhance the presence of fuel cell technology in public. Four Volkswagen vehicles on the basis of a vehicle platform for the international market (US Passat) and four top-of-the-range Audi vehicles (Audi A7) as well as an additional laboratory vehicle for internal operation and testing were built. Within the funding framework an internal hydrogen refuelling station was also established in order to be able to operate these vehicles with 700 bar.

Another priority was the development of a cost-optimised overall strategy. In order to quickly achieve scaling effects in – at first – a low number of expected fuel cell vehicles, drive trains with the same in-house-developed FC aggregate were to be constructed in different performance classes. At Volkswagen a drive train for a front-wheel vehicle with an output of 100 kW was developed. With the same FC power a second four-wheel drive train with considerably more performance on the basis of the Audi A7 was developed. This has a peak power of 170 kW, which will be generated from two electric engines at the front and rear axles. The drive power will be provided by the fuel cell and a plug-in battery that is larger than that in the Volkswagen. Unlike the purely hybrid operation in the Volkswagen, regular and fast recharging is possible with the Audi, via a standardised combo plug. Thus apart from hydrogen operation, purely electric driving is also an option.

The vehicles are incorporated in the CEP programme in Berlin. In addition they were presented to the public in a joint appearance of Volkswagen and Audi at the Los Angeles Auto Show in November 2014 and garnered great interest. Particularly impressive were the integration of fuel cell technology in high-volume series vehicles without usage limitations, the noted smoothness of battery-electric vehicles, the large range and rapid refuelling.

Apart from trial operation, the vehicles will in the future be further used in the area of technical optimisation and publicity work.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Volkswagen AG	13,290,392	6,379,389

COMMENCEMENT: 01 August 2009
CONCLUSION: 31 December 2014

Volkswagen Group models at the Los Angeles Auto Show in November

I / 15

» OPTIMISATION OF THE SYSTEM DESIGN AND FURTHER OPERATION OF A FULLY-INTEGRATED HYDROGEN REFUELLING STATION FOR PASSENGER CARS AND BUSES IN HEERSTRASSE IN BERLIN INCLUDING THE CONSTRUCTION OF A HYDROGEN TEMPORARY STORAGE FACILITY IN PRENZLAU «

Aside from the enlargement of the hydrogen vehicle fleets and the expansion of the hydrogen refuelling infrastructure in the CEP regions, the fundamental project goals of the CEP in its second phase were the development of the generation infrastructure and the wide-scale introduction of renewably-produced hydrogen for use as a fuel in passenger vehicles and buses. The project constituted an essential element in the achievement of these goals.

At the focus was the further operation one of the hydrogen refuelling stations erected in Heerstrasse in Berlin-Spandau by TOTAL Deutschland GmbH as part of the EU project HyFLEET:CUTE. At the time of the beginning of the project, this facility was the only integrated hydrogen refuelling station ready for operation in Berlin. Therefore it has for some time delivered a significant proportion of the supply services for the CEP passenger car fleet as well as for the hydrogen buses of the Berliner Verkehrsbetriebe (Berlin public transport company).

The goals of this project were respectively, the further operation, upgrading and in part optimising retrofitting of the existing facilities. At the same time renewable energies were for the first time to be substantially incorporated in the generation of the hydrogen used in the CEP and completely replace the LPG used to this point at this location. Alongside this a fundamental change of the supply concept for gaseous hydrogen was to take place, with the aim of increasing the proportion of renewably-generated hydrogen successively by 50% in line with the objectives of the CEP in the course of phase III of the CEP.

The refuelling station was put into operation in spring 2006. It had refuelling facilities for high-density gaseous hydrogen for pressure levels of 350 and 700 bar, a hydrogen reformation from LPG which was retrofitted as part of this project and an ion compressor station.

The facility was equipped with dispensing facilities for CGH_2 700 bar, CGH_2 350 bar and LH_2 in the public area as well as CGH_2 350 bar and LH_2 in the area of the adjacent bus depot of the Berliner Verkehrsbetriebe (BVG). Both LH_2 filling points were decommissioned during the project, after BMW ceased the operation of its LH_2 fleet in mid-2011.

High availability of the refuelling station was of central importance, especially because it served at the beginning of the project as the lone supplier to the Berlin bus fleet. This was valuable to the fleet in terms of real-life testing of the supply pathways with wind hydrogen. As a starting point for good infrastructural provision of services to the Berlin region, this location was to create the conditions for long-term positive customer loyalty to hydrogen as a fuel in company fleets.

ENERTRAG AG played a major role in the implementation of the overall project, which guaranteed supply to the refuelling station location using electrolytically wind-generated hydrogen from Prenzlau. For this ENERTRAG expanded the activities already running at the beginning of the project in the hybrid power station under construction in Prenzlau to include different modules. While the electrolysis facility was not a part of the project and already funded as part of the state-subsidised hybrid power station, ENERTRAG was also to build and operate a hydrogen temporary storage system including a compressor unit, a pipeline and a trailer filling station. In addition the hydrogen logistics were to be worked out and implemented between TOTAL and ENERTRAG for supplying the Berlin consumer.

PARTNERS:	PROJECT BUDGET/€	PROJECT FUNDING/€
TOTAL Deutschland GmbH	2,592,44	1,244.372
ENERTRAG AG	1,984,640	952,627

COMMENCEMENT: 01 August 2009
CONCLUSION: 31 May 2014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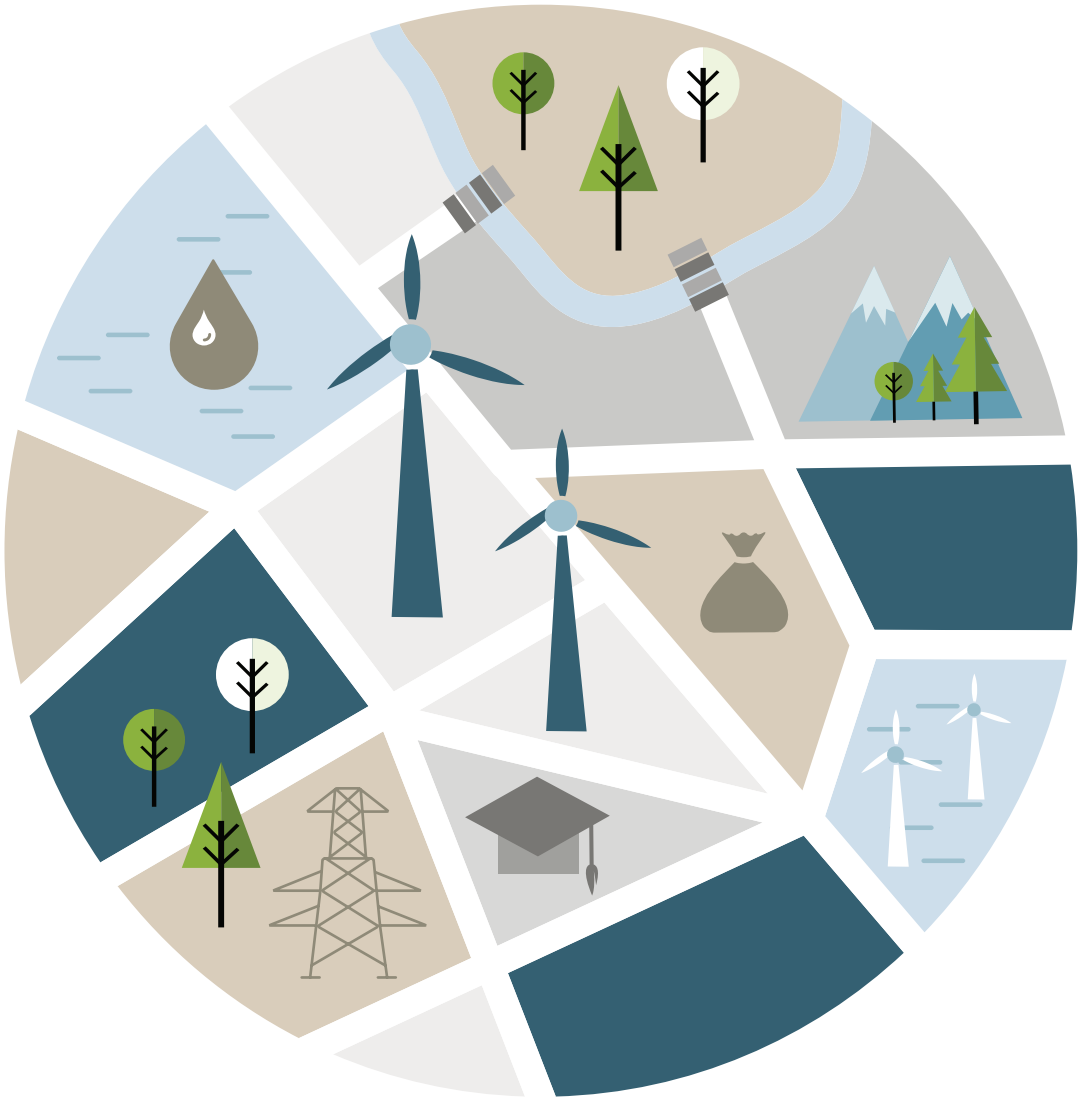
NIP – HYDROGEN PROVISION



THE PROJECT IS LISTED AS II / 01 ON THE FOLLOWING PAGES.

NIP – HYDROGEN PROVISION

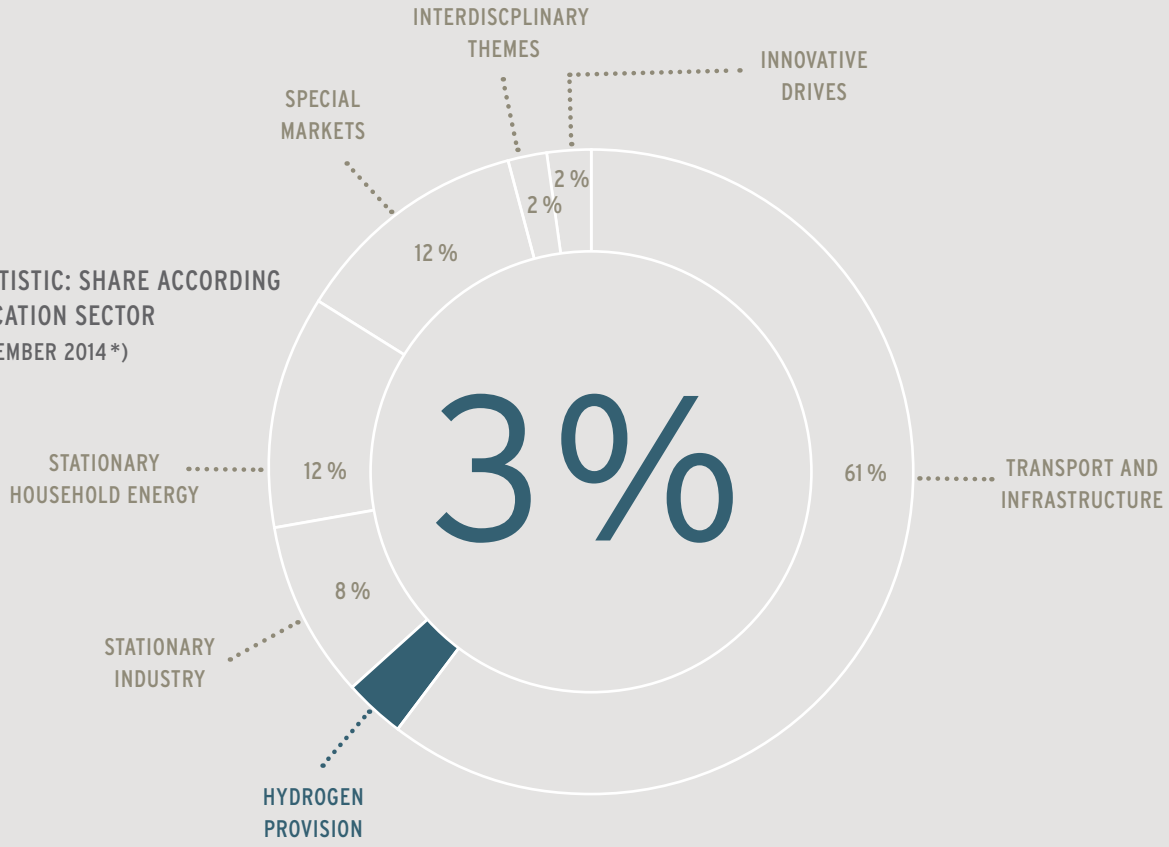
Demonstration projects and studies on the production, storage and distribution of hydrogen are conducted within the Hydrogen Provision programme area in the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP). In line with the goals of the federal government's energy concept, the hydrogen is primarily produced using renewable energy – wind, solar and biomass. The hydrogen is used to power fuel cell vehicles and as a storage medium for large amounts of fluctuating renewable energy. Specific areas of application also include stationary reconversion, the feeding-in into the natural gas network as well as for use as a climate neutral industrial gas.

The use of regenerative hydrogen can make a significant contribution to the goals of the so-called energy turnaround. Not only does it accelerate the switch from fossil-based fuels to renewable sources of energy in the transportation and energy sector – as set out in the energy concept – it also creates energy storage capacities, which are urgently required for the energy turnaround to succeed. The special economic appeal of hydrogen as a fuel enables a lead market to be established, which can pave the way for the storage of energy and other applications.

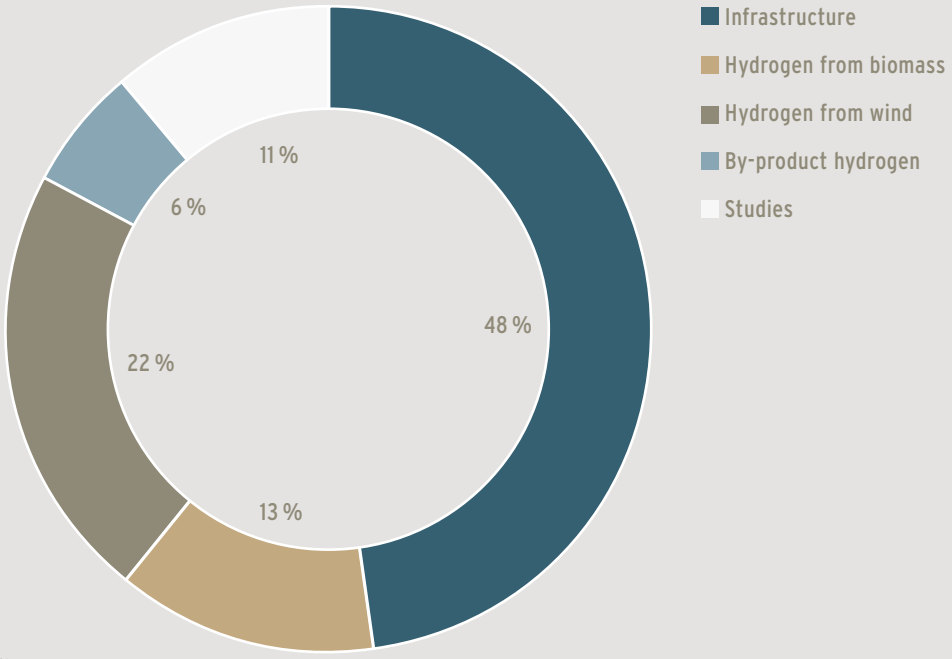
Hydrogen production via the highly efficient water electrolysis method, chiefly from excess wind energy, is at the core of the programme area. Water electrolysis is regarded as a key technology for the integration of renewable energy in the areas of transportation and energy. New and growing markets for hydrogen lay the foundation for exploiting the significant development potential that is inherent in all electrolysis technologies.

While the tried and tested alkaline electrolysis method may today still be the most common method of producing hydrogen electrolytically, the newer PEM electrolysis method is markedly gaining in importance. Demonstration projects using both technologies are being supported within the programme area. The role of hydrogen in the energy and transportation sectors is also being examined on a cross-sector level in the programme area (see following article). The potentials of hydrogen and fuel cell technologies to reach the goals set out for the energy turnaround are issues being thoroughly discussed in numerous studies and analyses. The results also serve to classify the projects and other NIP activities, or their effect, in terms of how they can support the energy turnaround.

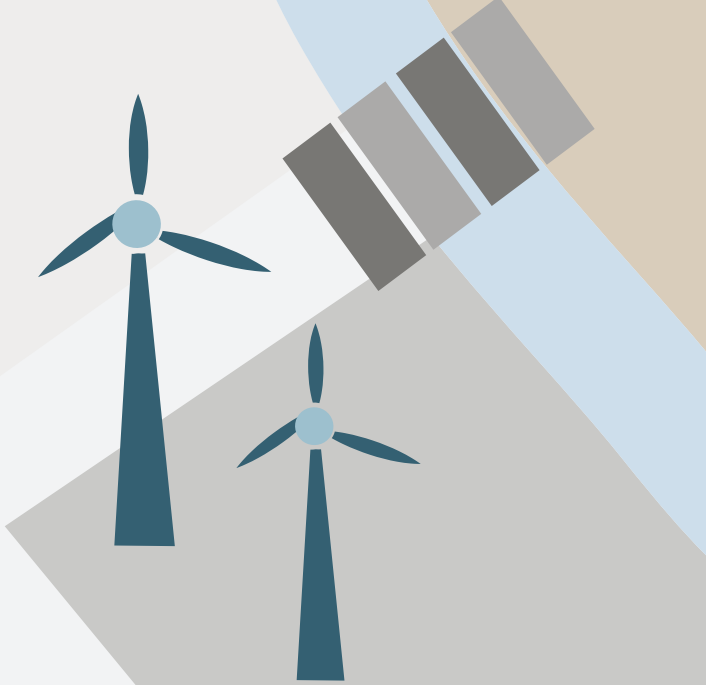
NIP – STATISTIC: SHARE ACCORDING TO APPLICATION SECTOR
(AS AT DECEMBER 2014 *)



NIP – HYDROGEN PROVISION: ALLOCATION BY APPLICATION AREA
(AS AT DECEMBER 2014)



* The diagram incorporates projects at planning stage at NOW, being processed by PtJ, LOI (Letter of Intent) as well as those approved.



HYDROGEN AS A FUEL AND ENERGY STORAGE: SUCCESS FACTORS FOR THE GERMAN ENERGY TURNAROUND

Updated and abridged version of the original article by Ehret, O., Bonhoff, K. (to be published): "Hydrogen as a fuel and energy storage: success factors for the German Energiewende", in: *Special Issue of the International Journal of Hydrogen Energy* devoted to the European Hydrogen Energy Conference 2014

THE POTENTIAL OF HYDROGEN AND FUEL CELLS TO SUPPORT THE ENERGY TURNAROUND

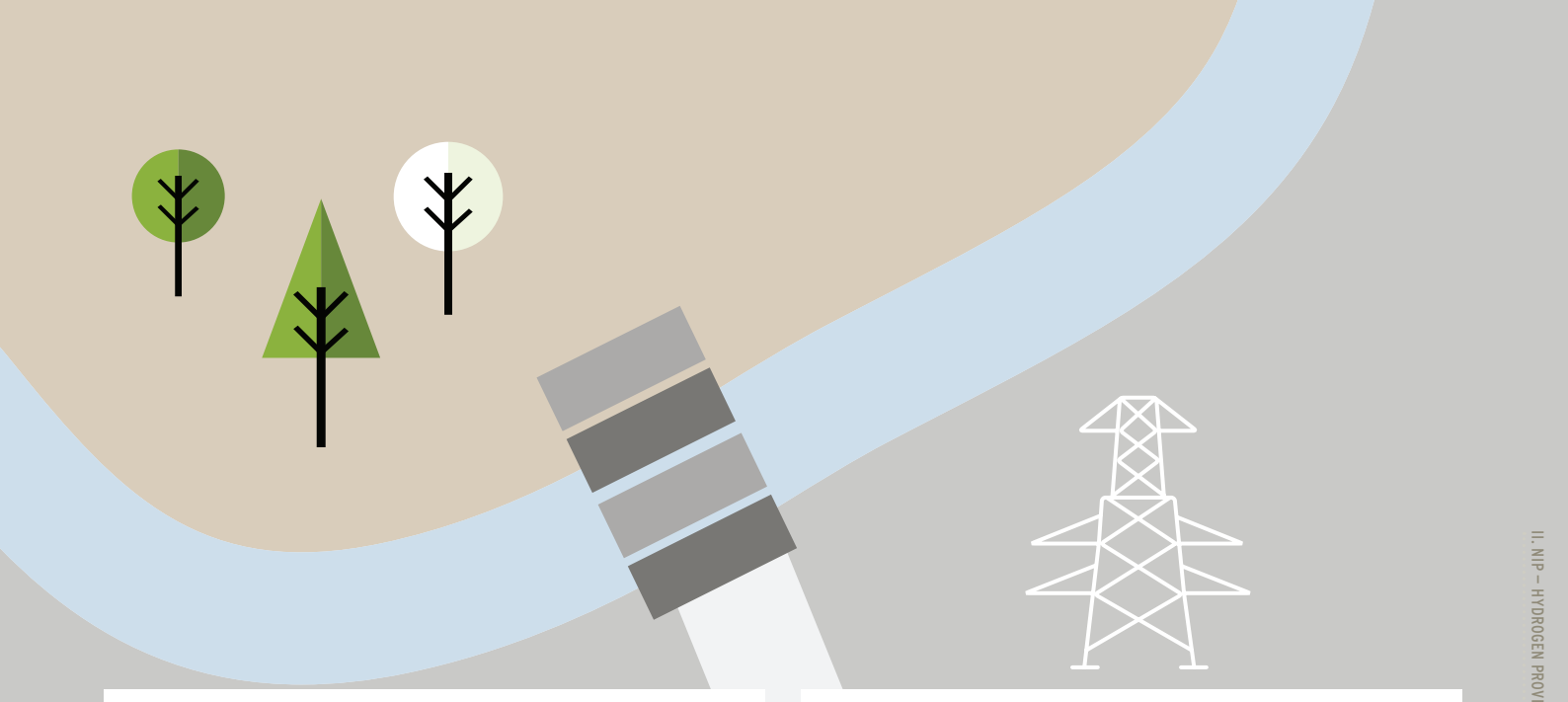
The federal government's *energy concept* aims to bring about an environmentally friendly, reliable and affordable supply of energy in both the stationary and mobile areas [1]. In essence it aspires to virtually substitute fossil fuel-based energy entirely with renewable sources of energy by 2050, with ambitious interim goals also being set. By 2020, the share of renewable energy of final energy consumption is to grow to 18 %, and to 60 % by 2050. Greenhouse gas emissions are to be reduced by 40 % until 2020 and by between 80 % and 95 % by 2050, in comparison to levels of 1990. Primary energy consumption is to reduce by 20 % until 2020 and by 50 % until 2050. In the transport sector, a 10 % reduction in final energy consumption is planned until 2020 and a reduction of 40 % is envisaged by 2050, compared to 2005.

The government's *mobility and fuel strategy (MKS – Mobilitäts- und Kraftstoffstrategie* [2]) delivers a detailed analysis of the transport sector and provides sustainable concepts for the future. At its core, the MKS aims to promote the use of renewable energy in the transport sector and strives towards its better integration within the energy and transportation sectors. The electrification of vehicle drive trains is considered as imperative. And besides pure battery and plug-in hybrid vehicles, fuel cell electric vehicles also play a key role. Electric vehicles use renewable power directly and therefore avoid the use of fossil fuels and resulting carbon emissions and, in addition, electric propulsion is more efficient and therefore results in lower energy consumption.

Given the increasing effects of climate change and other environmental impacts leading to the adoption of the energy concept, the federal government had previously already brought the *National Innovation Programme Hydrogen and Fuel Cell Technology (NIP)* into force as an important measure to promote sustainable technologies [3]. The *National Organisation for Hydrogen and Fuel Cell Technology (NOW)* was commissioned with the task of coordinating and implementing the programme content. The NIP aims to integrate renewable energy in the transport and energy sectors. Hydrogen is produced using renewable energy and converted to power via highly efficient fuel cells. In this way, compared to conventional vehicles, energy consumption can be halved, fossil fuels are replaced by renewable fuels, greenhouse gases and other pollutants cut to zero and traffic noise greatly reduced.

The expansion of renewable energies, as set out in the energy concept, provides significant benefits. But it simultaneously highlights the problem of integrating the fast-growing volume of fluctuating wind and solar power. The capacity of existing networks is increasingly being overextended in attempts to absorb peaks in supply. Besides an expansion of the network, the development of energy storage capacities is required to address this issue. As the current *Integration von Wind-Wasserstoff-Systemen in das Energiesystem (Integration of Wind-Hydrogen Systems in the Energy System)* [5] studies show, sizeable surpluses in renewable energy are to be expected in the future – for which hydrogen is exceptionally suited for providing storage capacities to exploit this energy at a later time.

Meanwhile, the *Power-to-Gas (PtG) im Verkehr (Power-to-Gas in Transportation)* 6] study shows that the use of renewably produced hydrogen as a fuel is by far the most attractive option. This means that hydrogen as a fuel could help pave the way towards a lead market for it to be used – as also examined in the study – as an industrial gas, for stationary reconversion through electrolysis, as well as for use by the natural gas industry. The common use of hydrogen production and infra-



structure components is associable with the attainment of economies of scale and synergies, which if exploited promises significant cost reductions for cross-sector applications. For example, the construction of a hydrogen pipeline with double the capacity results in costs far lower than twice the price – but it enables broader ranging demands to be satisfied. Particularly hydrogen used as a fuel enables a lead market to be created for the expansion of energy storage capacities. Such an expansion is broadly seen as an important prerequisite that will enable the energy turnaround to become successful – and is not economically viable for an independent operation to develop on its own.

HYDROGEN AS A FUEL AND FOR ENERGY STORAGE: DEMONSTRATION PROJECTS AND INDUSTRIAL ACTIVITIES

A multitude of projects on the use of hydrogen in the transport sector are being supported as part of the National Innovation Programme Hydrogen and Fuel Cell Technology. At the heart of this is the *Clean Energy Partnership* (CEP) lighthouse project, in which a steadily growing number of fuel cell vehicles and hydrogen refuelling stations have been in operation since 2003. There are now five regions, 20 companies and far more than 100 fuel cell vehicles plus 15 hydrogen refuelling stations in operation. Another 35 refuelling stations are currently in the planning stage or under construction. In accordance with policy guidelines, the hydrogen provided is largely produced using either wind energy or biomass. At five refuelling stations the hydrogen is produced "on site" via alkaline and PEM electrolysis – and experience gained here is also used for the continued development of larger electrolysers and large-scale energy storage plants.

While the various demonstrations of the technology are still being completed within the CEP, commercialisation has already commenced elsewhere. There are now several Asian fuel cell vehicle manufacturers that are offering fuel cell vehicles for sale and the market entry of German automotive firms is imminent. Parallel to this, consortia for the expansion of hydrogen infrastructure have emerged across the globe. The *H_2 Mobility* industry initiative provided an action plan in 2013 for the expansion of a nationwide refuelling station network in Germany. According to Air Liquide, Daimler, OMV, Shell and Total, around 400 refuelling stations will be operational by 2023, requiring a total investment volume of some 350 million euros. The first 100 stations are to be operation by 2017 following the establishment of a joint venture [7]. The expansion of infrastructure is occurring in close cooperation with the vehicle manufacturers, which will ensure a coordinated market introduction of fuel cell vehicles together with the required infrastructure.

Demonstration projects are also being supported within the NIP in the area of energy storage, including the integration of hydrogen in the energy sector. Among these is the *RH_2-WKA wind-hydrogen project* (from the company *Wind-projekt*), operational since September 2013, which provides the power supply of a wind farm in wind still conditions, among other things. In addition, construction work for a project by *E.ON Hanse* and partners for the feeding in of hydrogen in the natural gas network – based on highly innovative single-stack MW-PEM electrolysis technology – commenced in June 2013.

STUDIES DOCUMENT ABILITY OF NIP TECHNOLOGIES TO ATTAIN ENERGY TURNAROUND GOALS

The *Integration von Wind-Wasserstoff-Systemen in das Energiesystem (Integration of Wind-hydrogen Systems in the Energy System)* [5] study picks up on several important issues for the energy concept and mobility and fuel strategy. The amount of "surplus" wind energy expected in Germany until 2030 is quantified and the resulting storage requirements identified. A concept for a large-scale wind-hydrogen system is developed and evaluated in terms of its technical feasibility. Options for the application of hydrogen as a fuel or source of energy for stationary electrolysis and feeding into the supply network are primarily analysed from the perspective of economic feasibility. In accordance with the

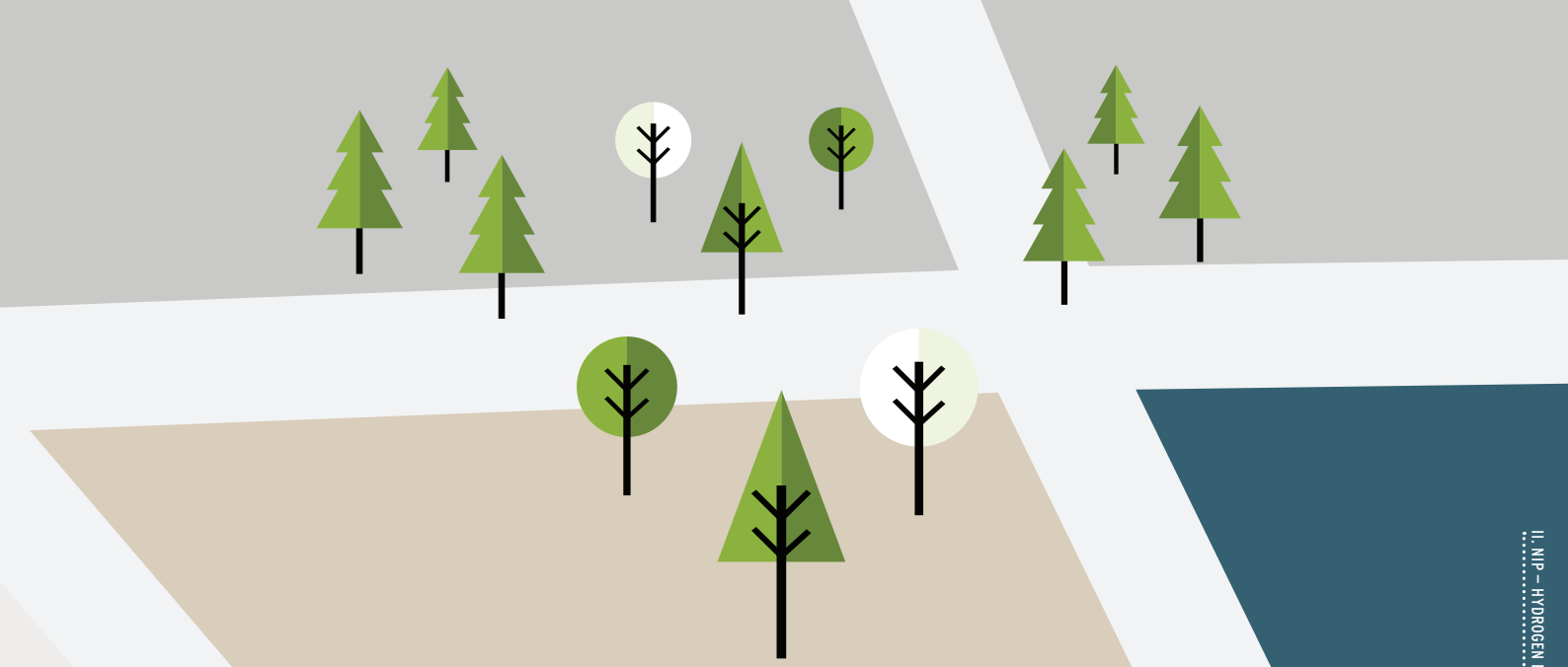
desire for greater integration in the energy and transport sectors, a cross-sector approach is pursued. The results calculate significant surpluses for 2030, enabling five wind-hydrogen systems in northern Germany – requiring only a limited amount of non-renewable energy to be purchased. In this way, the entire anticipated demand for hydrogen for fuel cell vehicles in northern Germany can be covered – and substantial environmental benefits are also to be expected due to the subsequent replacement of conventional vehicles. Wind-hydrogen systems are evaluated as being technically feasible, but require technological improvements compared with today's levels. In most of the modelled scenarios, economic competitiveness is expected even from purely surplus wind-hydrogen compared with fossil fuel-produced hydrogen. And through the purchase of only partly renewable energy, the economic viability can be improved even further. In the main scenario, the fuel market proved to be more economically feasible in 93 % of cases, compared to reconversion at just 7 %. Nevertheless, the dual system design provides substantial benefits through greater long-term security for the sale of supplies and also underlines the intended purpose of the cross-sector approach.

The *Hy-NOW: Evaluierung der Verfahren und Technologien für die Bereitstellung von Wasserstoff auf Basis von Biomasse (Evaluation of the Processes and Technologies for the Provision of Hydrogen on the Basis of Biomass)* [8] study examines options for the supply of biomass-based fuel for fuel cell vehicles, taking technological, ecological and economic criteria into account. It is shown that feasible and advantageous methods are realisable in terms of many of the listed criteria, yet that widespread application must be tempered due to the limited availability of biomass. Various highly efficient methods are capable of fulfilling the demands for the reduction of greenhouse gas emissions in accordance with relevant EU regulations [8], which clearly go beyond the generally formulated goals of the energy concept. The requirement of the *energy concept* and MKS to deploy renewable energies is – as also in the case of the previously presented study – fulfilled in any case.

The *Überleitung der Ergebnisse aus GermanHy in das Emissionsberechnungsmodell TREMOD (Transfer of results from GermanHy into the Emissions Calculation Model)* [9] study analyses the scenarios of the GermanHy study, which was originally published in 2009, and then integrates this into TREMOD. GermanHy analysed many possible paths for the production and use of hydrogen for the market introduction of fuel cell vehicles and provided many statements on emission reduction potentials. With the transfer of the data from the study into TREMOD – the official and methodically sophisticated emission calculation model of the federal government – a much more precise and reliable interpretation of the data is possible. The model confirmed and specified the GermanHy results to the extent that the widespread market introduction of fuel cell vehicles allows for significant efficiency increases as well as a substantial reduction in greenhouse and pollutant emissions to be realised. Energy consumption in the road transport sector can be reduced by around 70 % until 2050 compared with levels of 2010 – greenhouse gases can even be cut by more than 80 % [9]. As a comparison with the goals of the energy concept for the transport sector 2050 shows, the targeted 40 % reduction in energy consumption can be achieved – and exceeded – with ease. Even the overall economic objective to reduce greenhouse gas emissions by 80 – 95 % can be achieved.

SUMMARY: HYDROGEN AND FUEL CELLS CAN SIGNIFICANTLY SUPPORT THE ENERGY TURNAROUND

The studies presented clearly show that hydrogen and fuel cell technologies can make a significant contribution to reach the goals of the energy turnaround. Large amounts of otherwise not immediately usable "surplus" wind energy can be effectively exploited by being converted to hydrogen, stored and then used as either a fuel for fuel cell vehicles or later for reconversion via electrolysis and the feeding into the supply network, as required. In this way, not only is the replacement



of fossil fuels for renewable energy promoted in the transport and energy sectors – as outlined in the energy concept and the government's mobility and fuel strategy (MKS) – desperately needed energy storage capacities are thereby also created and will help to support the energy turnaround. The economic viability of both examined options for use is crucial – whereby the economic appeal of the fuel allows for the creation of a lead market, which can then pave the way for energy storage and other applications. As such, hydrogen enables the cross-sector integration and *per se* use of renewable energy across sectors and – considering the large and continuously growing share of renewable energies – can overcome the increasingly blurry delineation to the formerly purely fossil fuel-based sectors of industry.

Through the widespread introduction of fuel cell vehicles, energy consumption can be reduced by around 70 % in the transport sector by 2050 and greenhouse gases decreased by more than 80 % – respectively achieving or significantly surpassing the goals set out for the energy turnaround. In the Clean Energy Partnership of the National Innovation Programme Hydrogen and Fuel Cell Technology and the H_2 Mobility industry initiative, fuel cell vehicles and hydrogen infrastructure are being demonstrated and commercialised, respectively. According to expert committees, despite the considerable successes through the NIP and activities by industry to date, continued technological improvements and funding policy measures are still necessary. Only in this way can a widespread market entry of hydrogen and fuel cell technologies be achieved and thereby guarantee the required support to attain the goals of the energy turnaround.

Reference list

[1] BMWi, BMU (28 September 2010) *Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply* (www.bmwi.de)

[2] BMVBS (June 2013) *The Mobility and Fuels Strategy of the German Government (MFS): New pathways for Energy* (www.bmvi.de)

[3] BMVBS, BMBF, BMWi (8 May 2006) *Nationales Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie* (www.now-gmbh.de)

[4] McKinsey & Company (to be published) *Commercialization of Energy Storage in Europe*

[5] Stolzenburg, K. *et al.* (31 March 2014) *Integration von Wind-Wasserstoff-Systemen in das Energiesystem: Abschlussbericht* (www.now-gmbh.de)

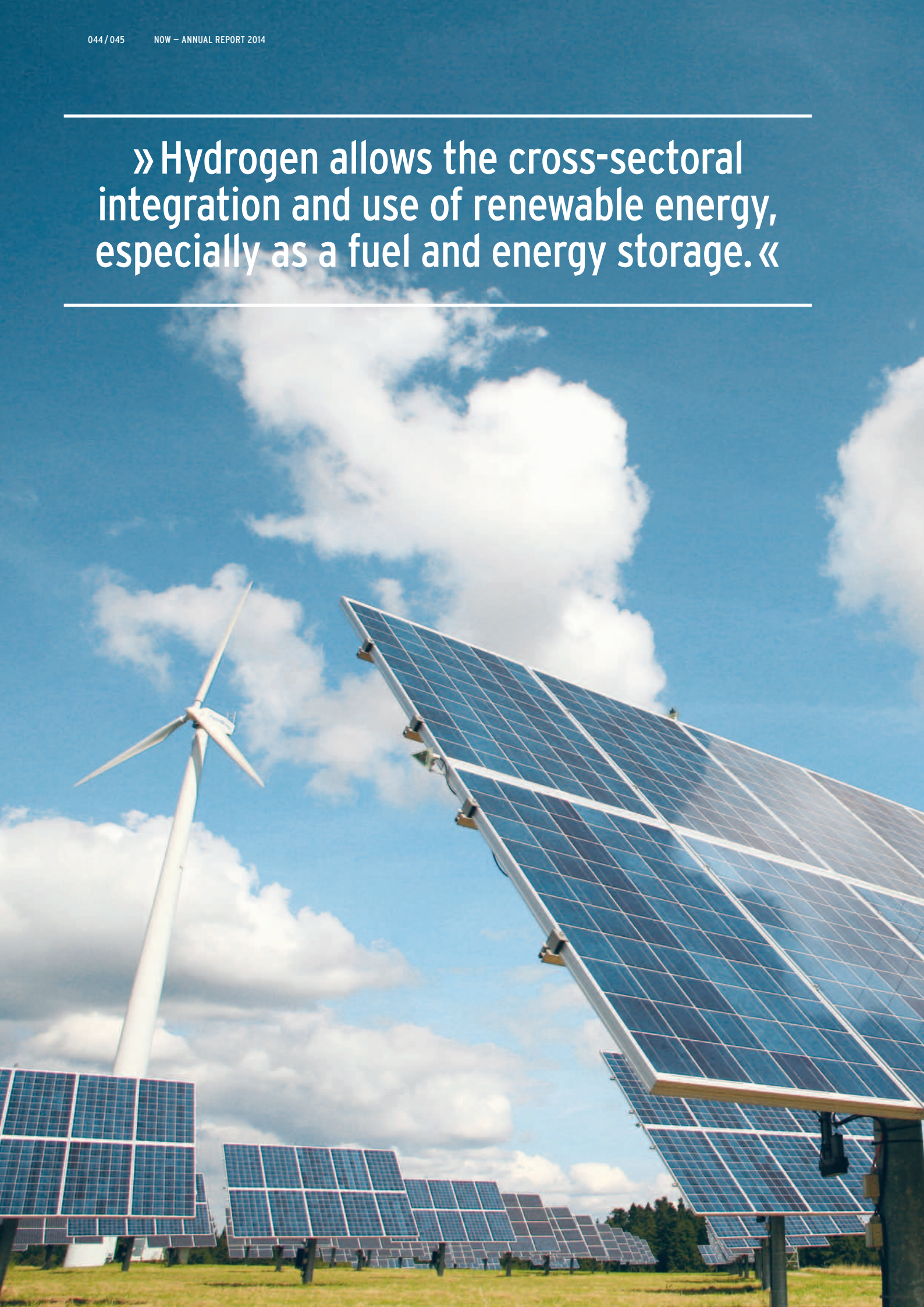
[6] DLR *et al.* (15 April 2014) *Power-to-Gas (PtG) im Verkehr: Aktueller Stand und Entwicklungsperspektiven* (www.bmvi.de)

[7] NOW (30 September 2013) *Initiative H_2 Mobility: nitiative: Leading Industrial Companies Agree on an Action Plan for the Construction of a Hydrogen Refueling Network in Germany* (www.now-gmbh.de)

[8] Zech, K. *et al.* (June 2013) *Hy-NOW: Evaluierung der Verfahren und Technologien für die Bereitstellung von Wasserstoff auf Basis von Biomasse: Endbericht* (www.now-gmbh.de)

[9] Holdik, H. *et al.* (August 2013) *Überleitung der Ergebnisse aus GermanHy in das Emissionsberechnungsmodell TREMOD: Schlussbericht Teil II* (www.now-gmbh.de)

» Hydrogen allows the cross-sectoral integration and use of renewable energy, especially as a fuel and energy storage. «



II / 01

» META STUDY ON THE USE OF RENEWABLE HYDROGEN AS BOTH A FUEL AND FOR FEEDING INTO THE NATURAL GAS NETWORK: TECHNOLOGY, EFFICIENCY, PERSPECTIVES «

The study, jointly commissioned by NOW and the German Technical and Scientific Association for Gas and Water (DVGW – Deutscher Verein des Gas- und Wasserfaches), aims to promote a better understanding of the simultaneous use of hydrogen as a fuel and its feeding into the natural gas network. In the automotive and fuel sector, hydrogen produced using renewable energy is primarily considered as a fuel for fuel cell vehicles. Meanwhile, the feeding of hydrogen into the natural gas network and the resulting multitude of implementation possibilities (heating, reconversion, gas mobility) is seen as a key possibility for implementation by the natural gas industry. The respective sectors have followed different technological and economic strategies to date, which have so far not been compared in detail or examined in terms of their potential common perspectives for utilisation. The study, being conducted by the DBI Gas- und Umwelttechnik (DBI Gas and Environmental Technology) research institute, will therefore analyse the value-added chains, technical conditions and developmental requirements as well as economic perspectives of both fields of application. Important is the identification of synergy potentials that may provide a means to optimise cost efficiency for the joint use of electrolytically produced hydrogen as both a fuel and a gas additive. The results will be consolidated in a draft concept for a demonstration project in which the simultaneous use of renewable hydrogen as a fuel and additive for natural gas will be validated from both a technical and economic perspective. NOW and DVGW are jointly funding the study with 20,000 euros each. It is expected to be completed between late 2014 and mid 2015. The execution of a demonstration project is a feasible follow-on project, but will be dependent on the results incorporated in the draft concept.

» Important is the identification of synergy potentials that may provide a means to optimise cost efficiency for the joint use of electrolytically produced hydrogen as both a fuel and a gas additive. «

NIP – STATIONARY ENERGY SUPPLY

THE PROJECTS ARE LISTED III / 01 – III / 04 THE FOLLOWING PAGES,
COMPLETED PROJECTS ARE MARKED WITH 🏁 .

NIP – STATIONARY ENERGY SUPPLY

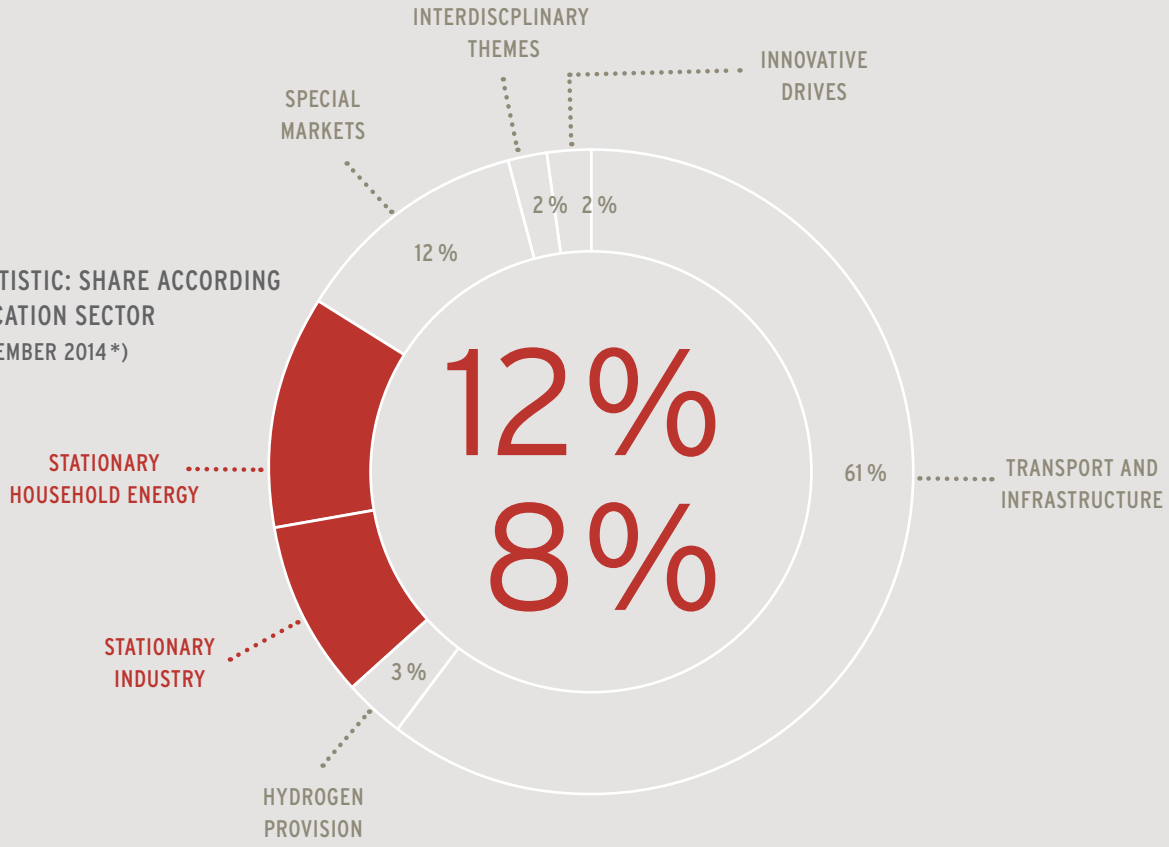
The Stationary Energy Supply programme area in the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP) includes systems from a lower capacity range of one kilowatt to five kilowatts for household energy, and extends up to plants with some ten kilowatts to a few megawatts in industrial use. The simultaneous generation of heat and power via fuel cells facilitates high overall efficiency rates of more than 85 percent. This enables CO_2 savings of between 25 and 35 percent compared with modern conventional supply systems.

The systems in household energy supply work on the principle of combined heat and power and burn natural gas from existing pipelines. In the medium term, biogas and fluid renewable energies that are fed into the natural gas network will also be used. Fuel cell devices for household energy thus have the advantage of being directly usable without requiring investment in the surrounding infrastructure. Low to high-temperature polymer electrolyte membrane fuel cells (PEMFCs) and solid oxide fuel cells (SOFCs) will be used in this area.

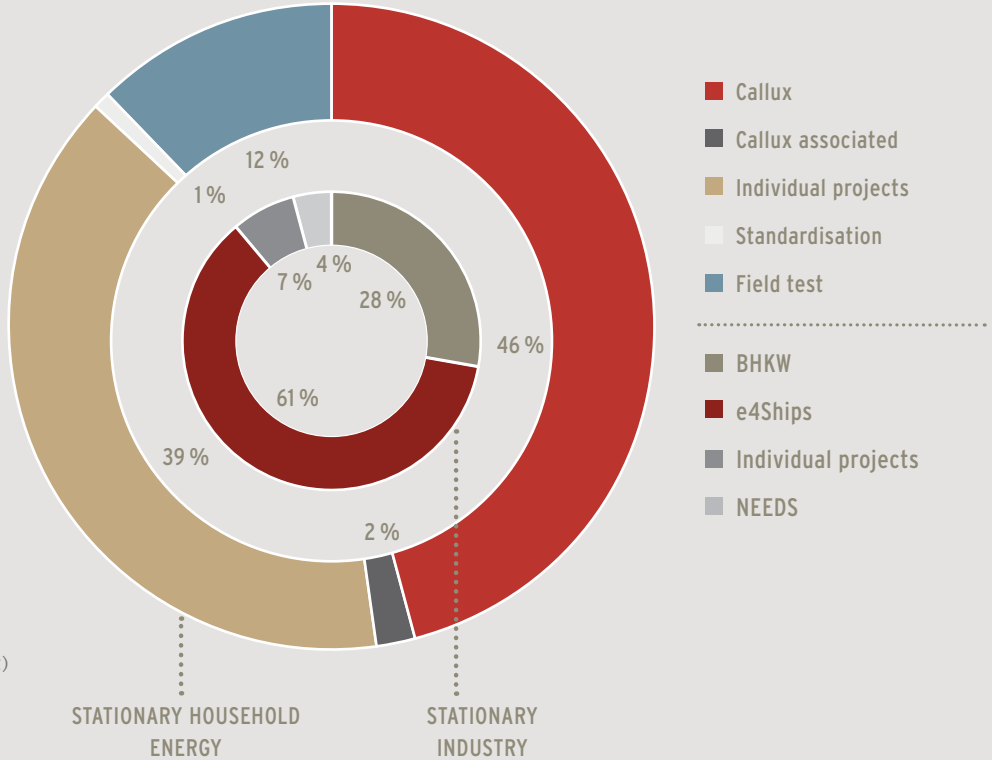
For fuel cell facilities in the industrial and shipping areas, SOFC technology is mainly used. However, high-temperature PEMFC technology is also becoming an important issue.

In total there are several hundred fuel cell combined heat and power plants with a power capacity of 100 kilowatts and above in use worldwide.

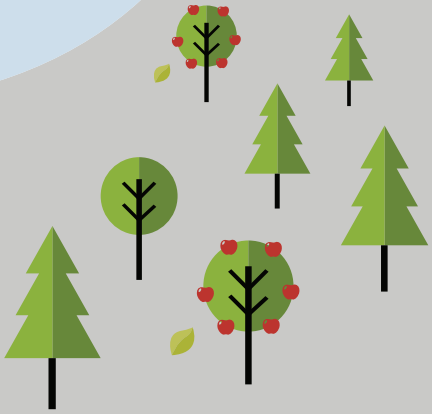
NIP – STATISTIC: SHARE ACCORDING TO APPLICATION SECTOR
(AS AT DECEMBER 2014 *)



NIP – STATIONARY APPLICATIONS: ALLOCATION BY APPLICATION AREA
(AS AT DECEMBER 2014)



* The diagram incorporates projects at planning stage at NOW, being processed by PtJ, LOI (Letter of Intent) as well as those approved.



callux (nip)
Fuel cell field tests for the home

CALLUX BLAZING THE TRAIL TO THE MARKET
FUEL CELL HEATING SYSTEMS PROVE THEMSELVES IN DAY-TO-DAY OPERATION

With close to 450 installed fuel cell heating systems, the Callux project has amassed more experience in the operation of these innovative systems than any other in Europe. Overall, the results are positive: market introduction has commenced – and as planned, a large range of fuel cell heating systems will be available by 2016 for purchasers.

THE UNSPECTACULAR DAILY LIFE OF A HEATING SYSTEM

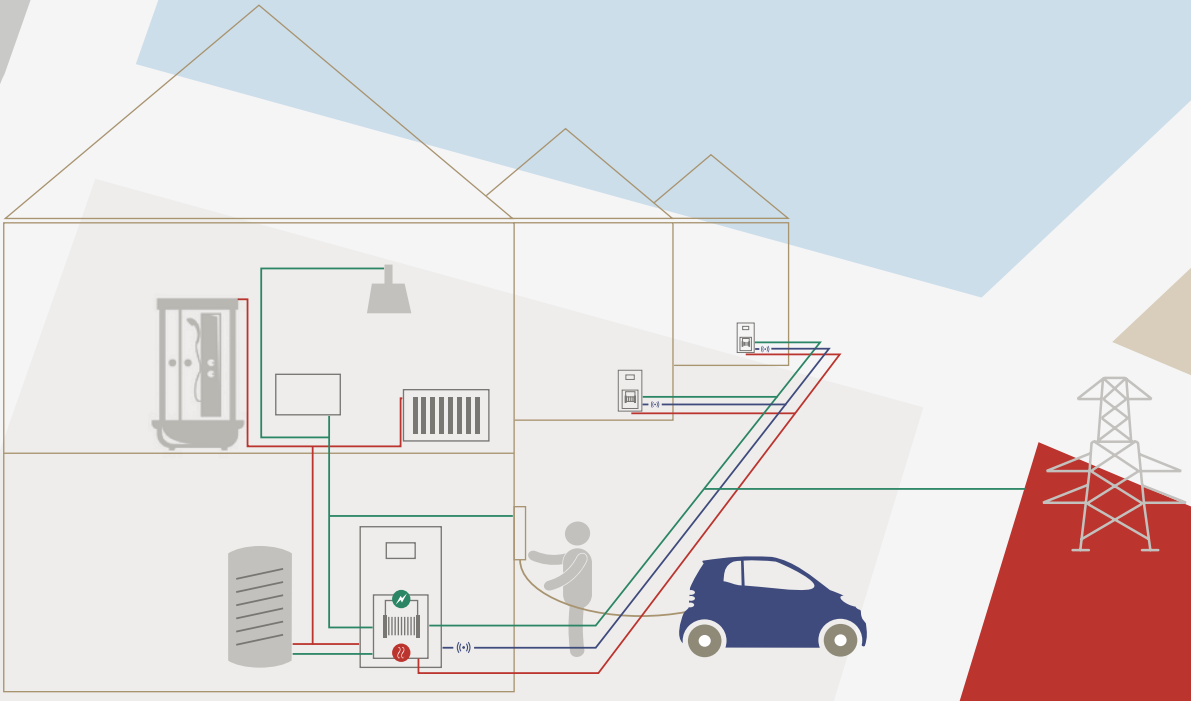
Customers that have experienced a fuel cell heating system in their home find it easy to sum up the level of reliability in the advanced combined heat and power (CHP) plants: "They do what they're supposed to do: the rooms are warm and we have power." A difference to conventional heating systems is hardly perceptible in practice. Fuel cell-based plants are quieter than motor-operated CHP plants and the amount of power produced can be read on the electricity meter – both the power fed into the grid as well as the power used in the home. Other than that, everything is as it always is.

EVERYTHING IS FINE FROM THE CUSTOMER PERSPECTIVE, EXCEPT THE FUNDING

It is therefore unsurprising that satisfaction is high among fuel cell heater customers. Nuremburg-based market research institute GfK noted a very high level of acceptance among test candidates. They value the combined generation of heat and power, the high level of efficiency and low CO_2 emissions. Consumers criticise, however, that due to the low production quantities early in the product lifecycle, the initial cost of the units is still higher than that of other efficiency systems. Even after Callux, it is therefore crucial that further funding support for the initially marketed products is provided. Larger volumes in the market will then lead to the required reductions in cost.

PRIMING THE SPECIALIST TRADE

The point of contact for a new heater is usually a local trade specialist. In most cases the individual local circumstances, such as an existing gas connection, will lead to another natural gas heater being purchased. Among the systems, however, fuel cell types deliver the advantage of producing heat and power more efficiently than other natural gas systems. Technically, there are several prerequisites that must be fulfilled, which do not apply to conventional heating systems. The power generation function requires electrical work to be conducted, including the installation of a further electricity meter. To ensure that trade specialists become acquainted with the special demands of this new technology quickly and so that they can provide informed advice to customers, Callux and the heating systems manufacturers are providing special training and information. Callux has developed a fuel cell heating device information program along with various presentations that are implemented in vocational training establishments. With a great level of enthusiasm and commitment, Callux is also approaching vocational schools and continuing education institutes to expand the base of knowledge on the production of heat and power via fuel cells.



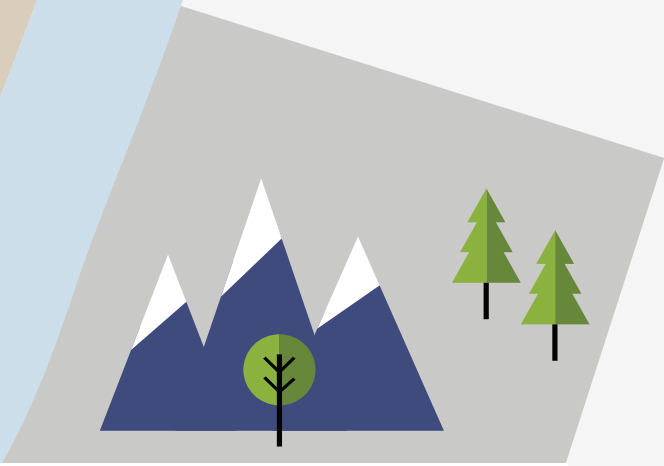
A VIRTUAL POWER PLANT THAT IS FOUND IN MANY BASEMENTS

This technology is well primed for the future. With the Callux-Box – which was developed within the scope of the project – plants not only can be controlled remotely and data collected for monitoring, their operation as virtual power plants is also made possible. Especially on the backdrop of the energy turnaround and fluctuating energy yields from renewable energy production can additional electricity capacities be accessed and fed into the grid to stabilise the networks. Considering the large number of natural gas-based heaters used in homes today, an increasing deployment of fuel cell heaters can represent a significant pillar for the energy turnaround. The preconditions for this to become reality are good.

HUGE POTENTIAL FOR FUEL CELL HEATER

With a view to the heating landscape in Germany, fuel cell heaters are particularly suited for modernising heaters in the home. Almost every second household uses natural gas for heating. This means that in principle, the basic prerequisites for installation are fulfilled in just about half of German households. Of all existing natural gas units, 5.5 million were installed prior to 1998. A corresponding demand for modernisation will exist over the coming years. Given these underlying conditions, the fuel cell has exceptional opportunities – provided that funding support is available to help facilitate the market introduction of this still expensive, new efficient technology.

More information on Callux can be found at:
www.callux.net



e4ships (nip)
Brennstoffzellen im maritimen Einsatz
Ein Projekt im Nationalen Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie

E4SHIPS
FUEL CELLS IN MARITIME APPLICATIONS

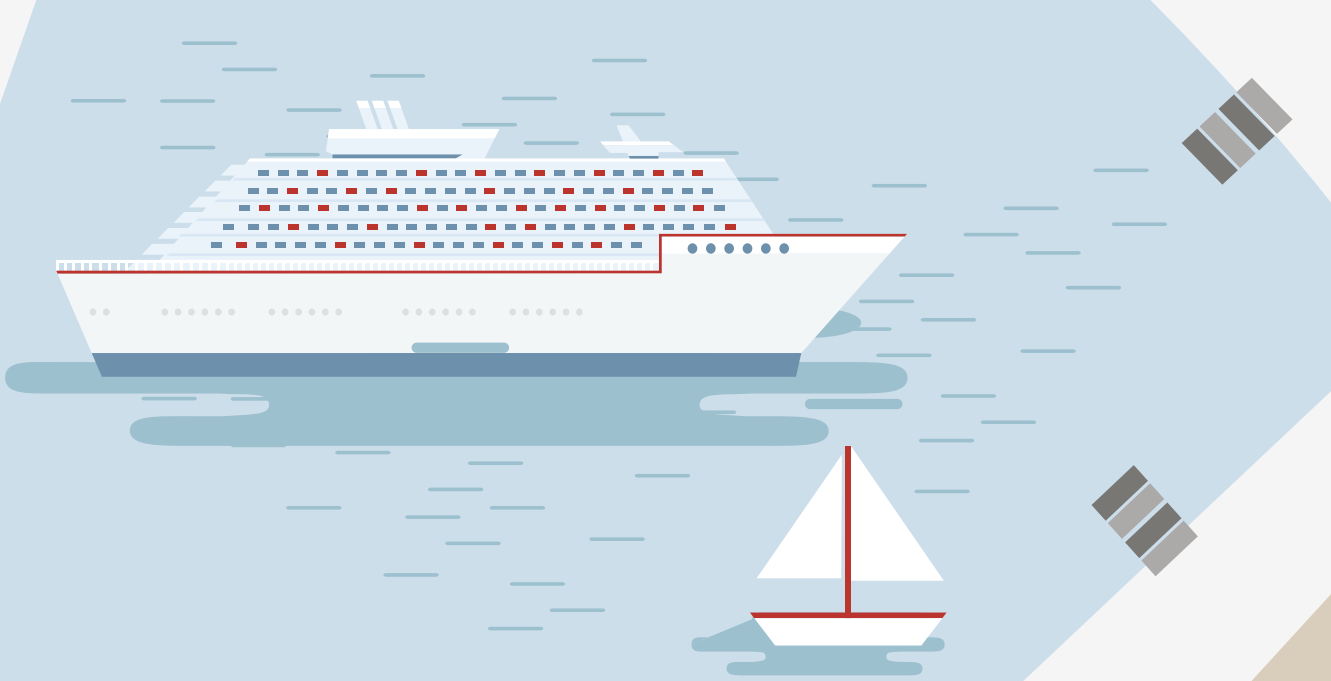
Alone the energy requirements for power and heating on seafaring vessels such as cruise liners and ferries can quickly reach that of a small city. The resulting pollutant emissions have a significant impact on air quality in port cities and coastal regions. Nevertheless, strict environmental regulations and the reduced emissions limits of the International Maritime Organisation (IMO) exist in various regions such as the Emission Control Areas (ECA) in the North and Baltic Seas or the coastlines of North America.

Fuel cells can make a significant contribution as a part of the solution to ensure the future sustainability of the maritime sector. Its advantages stem from a higher level of efficiency due to the coupling of electrical and thermal energy, especially for in-port operation. If required, thermal energy can also be used for cooling. In this way, pollutant emissions are radically cut. Using installations featuring a decentralised arrangement, redundancies are significantly increased and thereby also the reliability of the on board power supply (Safe Return to Port).

Aim of the e4ships lighthouse project is the targeted development of fuel cell systems for maritime deployment and tests on board of seafaring vessels. High temperature fuel cells (SOFC and HT-PEM) are used for this purpose. Fuels employed may include methanol, natural gas (CNG, LNG) or diesel. With the selection of these energy carriers, the goal of significantly reducing pollutant emission is further supported. Within the framework of this project, suggestions and initiatives are being developed to assist in the creation of international guidelines for marine fuels, which are currently being drafted at the IMO. Besides the systematic implementation on various vessel types and integration in the energy supply systems, the major technical challenges include deriving the technical standards for system types and performance classes for the shipping industry. Moreover, the path must be prepared towards higher performance systems in the future. Two demonstration projects for fuel cell applications on board ships are being conducted within the e4ships lighthouse project.

The *Pa-X-ell* project involves the testing of high-temperature PEM fuel cells in a passenger ship and is led by the Meyer Werft shipyard in association with further project partners. The system is based on standardised modules that can be scaled up to any performance range by interconnecting them. A 30 kW module was constructed as a standardised 19-inch double rack system within the project for the production of power, heating and cooling. This model was installed in a demonstration container together with a 20 kW absorption chiller, depicting the overall system in smaller performance classes. The container was displayed at the State Horticultural Show in Papenburg, Germany, from July to October 2014 and since then is being used at Meyer Werft for the production of power and heat in an office building. The projected fuel cell service life of 10,000 hours for the first testing period has already been exceeded. Further fuel cell modules with a total of 60 kW are being produced. Following four to six months of operation on land, the modules will be installed on board of passenger ships from summer 2016 and run parallel to the conventional energy supply. The system will initially be run on methanol via internal reforming. A natural gas reformer will be developed in a further step, which can later be deployed on gas-run ships to supply the fuel cell plant.

The *SchIBZ* project is being conducted by a consortium led by ThyssenKrupp Marine Systems. At the core of activities is the development of an integrated fuel cell system with a performance level of 500 kW for seafaring ships. The system is to comprise the main energy source for the supply of power on all types of ocean-going vessels. Within the project, it has been possible to develop a reformer that is capable of catalytically processing conventional diesel. This allows the diesel reformat gas to then be used as a fuel to operate the SOFC module. In addition, a 10 kW module was tested in a laboratory for more than 1,000 hours using the produced diesel reformat gas – thereby reproducing actual operation of the system on a ship. An SOFC module was also developed that currently provides 25 kW per-



formance, which will increase to 40 kW in a subsequent generation. This was also operated for more than 1,000 hours using the diesel reformat gas and returned very good performance and aging values. Following the completion of the current tests of reformer and fuel cell module, further 25 kW modules will be produced. Four modules will boast a combined performance of 100 kW and will be installed early 2016 as a demonstration unit on board of the "MS Forester" cargo ship of the Rörd Braren shipping company, where it will provide the majority of the required on board power for at least six months. The potential thermal use of the exhaust air is also being currently investigated.

Supplementing the test projects, the partners have joined together in an overarching subproject that considers questions regarding various issues including: the effects on climate protection; cost effectiveness; safety standards; and market introduction strategies – especially where this applies to non-typical fuels. The specific objectives are:

↗ Comparison and evaluation of existing ship energy supply systems with the hydrogen and fuel cell systems implemented, taking the aspects of ecological sustainability and energy efficiency into account

↗ Establishment of the required investment and operating costs of fuel cell systems and derivation of future potentials for optimisation as well as examining the economic impact of changes to various parameters

↗ Examinations of technical usage and expansion strategies in regard to typical space, weight and performance demands

The activities also include involvement in making contributions towards the drafting of international regulations and standards for the certification and installation of fuel cells as well as the use of low emission fuels such as LNG or methanol on ships and the provision of such fuels in ports. A main focus here is the coordination with the International Maritime Organisation (IMO).

A continuation of the activities beyond the scheduled project completion date of 30 June 2016 is of great importance in terms of the technological development potentials of fuel cell systems in the maritime sector and corresponding tests. A major aspect in this regard is market preparation to enable the commercial deployment of fuel cells on board of ships in the medium term and thereby also fulfil future regulations for air quality in ports.

More information on e4ships can be found at:
www.e4ships.de

III / 01

» LEONARDO – DEVELOPMENT OF A FUEL CELL HEATING SYSTEM BASED ON SOFC TECHNOLOGY «

Under the project name Leonardo, Viessmann Werke is developing a fuel cell heating system together with HEXIS, which will ultimately expand the range of fuel cell-based micro CHP (combined heat and power) systems available on the market. An overarching goal is to decrease the required financial investment and operating costs of series production in comparison to that of currently available fuel cell-based micro CHP systems. Viessmann's extensive systems engineering know-how, particularly from its Vitovalor 300-P fuel cell heater, will be instrumental in achieving this goal.

Core of the new fuel cell unit is the high-temperature fuel cell technology (SOFC) of the HEXIS Galileo 1000 N fuel cell heater. The first half of the project will see the development of a new version for field tests, while maintaining the stack architecture. Production costs will be significantly lower than those of today. The new version will then undergo practical tests in around ten systems.

In the project's second half, the unit will be developed to series maturity. Accompanying the project, the new fuel cell heating system will also be prepared for series production.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Viessmann Werke Allendorf GmbH	7,631,971	3,663,346

COMMENCEMENT: 01 August 2013
CONCLUSION: 31 December 2015

» An overarching goal is to decrease the required financial investment and operating costs of series production in comparison to that of currently available fuel cell-based micro CHP systems. «

» The Elcore 2400 can be installed in any house with a gas connection and can also be easily and inexpensively retrofitted with existing heating systems at any time. «

III / 02

» MARKET VALIDATION – DEVELOPMENT OF ELCORE 2400 HOUSEHOLD ENERGY PLANTS «

The Elcore 2400 is the most efficient and compact combined heat and power system for households and is based on high temperature polymer electrolyte fuel cell technology (HT-PEM). It can cover the base energy supply requirements of up to 70 % for electricity and 100 % for hot water. It therefore allows energy cost savings of around 1,300 euros a year in a single-family house and significantly reduces exposure to electricity price increases due to the high level of private consumption.

The Elcore 2400 can be installed in any house with a gas connection and can also be easily and inexpensively retrofitted with existing heating systems at any time. Within this project, the Elcore 2400 was developed to production maturity according to schedule and has since successfully passed the CE certification process. With an overall operating efficiency rating of 104 %, it is by far the most efficient combined heat and power system unit available – which pays off for end consumers in terms of energy cost savings.

This high level of efficiency was primarily achieved through a substantial increase in HT-PEM stack performance and significant simplification of the system architecture. Parasitical users could also be significantly reduced and the internal inverter has a substantially enhanced level of efficiency. In addition, the entire unit was steadfastly developed in the direction of reducing production costs and simplifying serviceability.

400 Elcore 2400 units will be built in the further course of the project and implemented in a comprehensive market validation programme.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Elcore GmbH	7,954,028	3,817,933

COMMENCEMENT: 01 September 2013
CONCLUSION: 31 July 2016

III / 03

» ELCORE 2400 HOME ENERGY SYSTEM FIELD TEST «

Buildings are responsible for 40 % of CO_2 emissions in Germany and are the primary fossil energy consumer. With Germany committed to ambitious climate protection goals, cuts in this area – which will consist of numerous measures – are urgently required.

The potential is particularly large in the area of efficient household energy – especially with the deployment of combined heat and power (CHP) plants in the home. CHP plants alone can result in the large reductions in household CO_2 emissions with decreases of up to 50%. Further measures such as insulation, more efficient heating technology and other more efficient household devices can result in additional savings.

The majority of buildings in Germany are detached single-family homes. Their share of CO_2 emissions is considerable. But it is exactly this category of building that until now has only played a negligible role in terms of CHP generation. Just a few years ago there was no commercially available CHP solution available for such households despite there being significant interest among end users.

During the course of the project, it could be established that the Elcore 2400 fulfilled all expected aspects completely. A total of 50 devices were installed in houses throughout the project and were intensively tested. Within the scope of these tests it was confirmed that the devices boast a high level of availability and that their installation was straightforward and trouble-free even with many different heating system types and in buildings of various sizes. The attainment of expected savings for power and heating could be demonstrated in all cases.

The respective field test partners were extremely satisfied with the performance of the units. Feedback on services associated with installation was also regularly positive.

Within the scope of the installations it became clear that some service technicians still reacted with some uncertainty when confronted with the new fuel cell technology. For this reason, Elcore also developed an installation package for service technicians, comprising a 500 litre water tank, a fresh water station for the heating of drinking water, an expansion reservoir along with ready-made piping. This installation package has since been used in several installations and has led to positive responses from service technicians and reduced installation times.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Elcore GmbH	1,745,943	838,053

COMMENCEMENT: 01 September 2012
CONCLUSION: 31 December 2014

SPECIFICATIONS

ANNUAL ENERGY PRODUCTION:	2,400 kWh[1]
TOTAL EFFICIENCY:	98 %
ELECTRICAL OUTPUT:	300 W
THERMAL OUTPUT:	600 W
FUEL:	Natural gas
ELECTRICAL CONNECTION:	230 V / 50 Hz
NOISE EMISSIONS:	max. 49 dBA
FLOW TEMPERATURE:	max. 90°C
DIMENSIONS (H X B X D):	90 x 50 x 50 cm
WEIGHT:	85 kg

[1] Typical single-family household

» CHP plants alone can result in large reductions in household CO_2 emissions with decreases of up to 50 %. «

III / 04

» DESULPHURISATION SOLUTION FOR FUEL CELL HEATING SYSTEMS «

Fuel cell heating systems (FCHS) are being developed in an effort to contribute to the reduction of CO_2 through increased energy efficiency and conservation. The operation of a FCHS requires natural gas that is virtually free of sulphur. For this reason, the aim of the project was the development of a desulphurisation solution that was to become an industry-wide solution for the economical and service-life conform operation of FCHSs. A working programme was created for this purpose, which was split into nine work packages, developed further and transposed into a project structure. The work packages (WP) were subdivided as follows according to the project plan:

WP-1: Specification of requirements/demands of the system manufacturers
WP-2: Creation of a sulphur map
WP-4: Development of materials
WP-5: Characterisation of materials
WP-6: Design of the industry solution
WP-7: Certification
WP-8: Feasibility study
WP-9: Recycling and logistics

According to the project plan, an initial project timeframe of three years was set aside. Due to additional tasks, long trial periods and longer term testing of the development, a cost-neutral two-year extension to the project was necessary. In order to develop a desulphurisation unit, the following specifications were initially established:

1. Definition of the sulphur content threshold for FCHSs at 0.1 Mol-ppm

2. Adsorptive, two-step desulphurisation concept

↗ Desulf-1: Removal of mercaptans, COS and H_2S

↗ Desulf-2: Removal of THT, disulphides, DMS, etc.

The key results arising from the project include:

↗ Development of an industry-wide specification sheet for FCHSs

↗ Development of a representative odourisation map for Germany (coverage: 26 % of the gas market)

↗ Material characterisation of 12 different BASF materials

↗ Development of two materials in accordance with the specification sheet

↗ Assessment of desulphurisation technologies, selection and design of a desulphurisation cartridge via simulations

↗ Production of approx. 45 desulphurisation cartridges by industry partners

↗ Field testing of the desulphurisation cartridges at FCHS manufacturers and ZBT; achieved 75 % of goal value by the end of the project – testing will continue

↗ Programming of an Excel®-based cost estimate tool

↗ Development of a closed-loop concept for recycling and logistics

↗ Confirmed test specifications for CE certification of a desulphurisation cartridge

↗ The desulphurisation unit corresponds with the specification sheet demands

PARTNERS:	PROJECT BUDGET/€	PROJECT FUNDING/€
Zentrum für Brennstoffzellen-Technik ZBT GmbH	1,048,079	503,078
Hexis GmbH	125,614	60,295
EBZ Entwicklungs- und Vertriebsgesellschaft Brennstoffzelle	123,993	59,516
BASF SE	561,344	269,445
DBI Gas- und Umwelttechnik GmbH	414,776	199,093
Donaldson Filtration Deutschland GmbH	129,639	62,227
BAXI INNOTECH GmbH	133,407	64,035
DVGW Deutscher Verein des Gas- und Wasserfaches e. V.	384,614	184,614
Filter Profitlich Maschinenbau GmbH	234,528	112,573
Vaillant GmbH	99,512	47,766

COMMENCEMENT: 01 September 2009
CONCLUSION: 30 August 2014

» The aim of the project was the development of a desulphurisation solution that was to become an industry-wide solution for the economical and service-life conform operation of FCHSs. «

NIP – SPECIAL MARKETS

THE PROJECTS ARE LISTED IV / 01 – IV / 07 THE FOLLOWING PAGES,
COMPLETED PROJECTS ARE MARKED WITH 🏁 .

NIP – SPECIAL MARKETS

The Special Markets programme area of the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP) incorporates a broad spectrum of applications. Likewise, the scope of power ranges deployed in the special markets is large, as are the diverse types of implemented fuels and fuel cell technologies.

The Special Markets also utilise many of the components that are also deployed in fuel cells for vehicles and stationary applications. The power range of applications in the Special Markets extends from several 100 watts for on-board power supplies, up to several ten kilowatts for uninterruptible power supplies and for special vehicle applications. Hydrogen, methanol, ethanol, bioethanol and LPG (propane, butane) in conjunction with a reformer, are employed as fuels. Various systems are in use for the supply of hydrogen, including gas cylinders and cartridges with metal hydrides or hydrogen generators based on chemical hydrides. In addition, the development of small hydrogen refuelling stations is also envisaged. For methanol-based systems, an existing infrastructure with distribution logistics is already in place. In terms of fuel cell technologies, the spectrum covers polymer electrolyte membrane fuel cells (PEMFC), high temperature polymer electrolyte membrane fuel cells (HT-PEM), direct methanol fuel cells (DMFC) and solid oxide fuel cells (SOFC).

The Special Markets incorporate fields of application that include:

↗ Power supply for business (emergency power supply, UPS, off-grid power supply, autonomous/hybrid power supply, emergency power systems)

↗ Power supply for leisure (on-board power supply and drives),

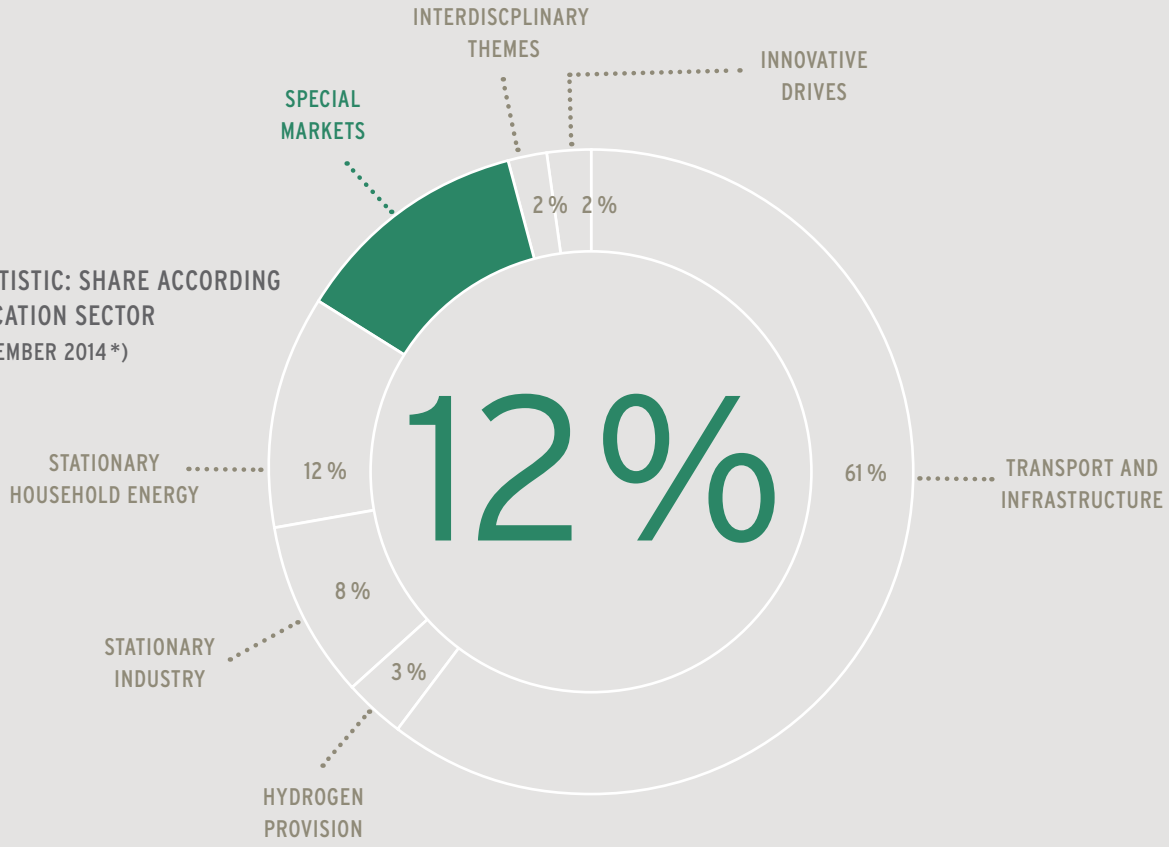
↗ Warehouse vehicles (forklifts, haulers, tuggers, baggage tractors at airports)

↗ Special vehicles (refuse collection vehicles, small trucks with fuel cell range extenders)

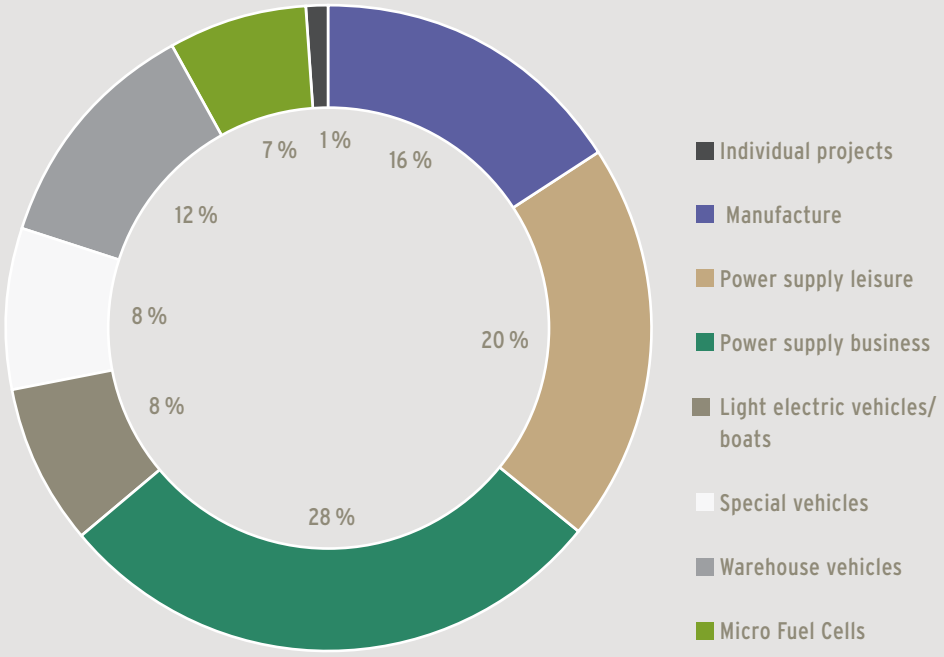
↗ Electric light vehicles/boats

↗ Micro fuel cells (industrial sensors, small device supply)

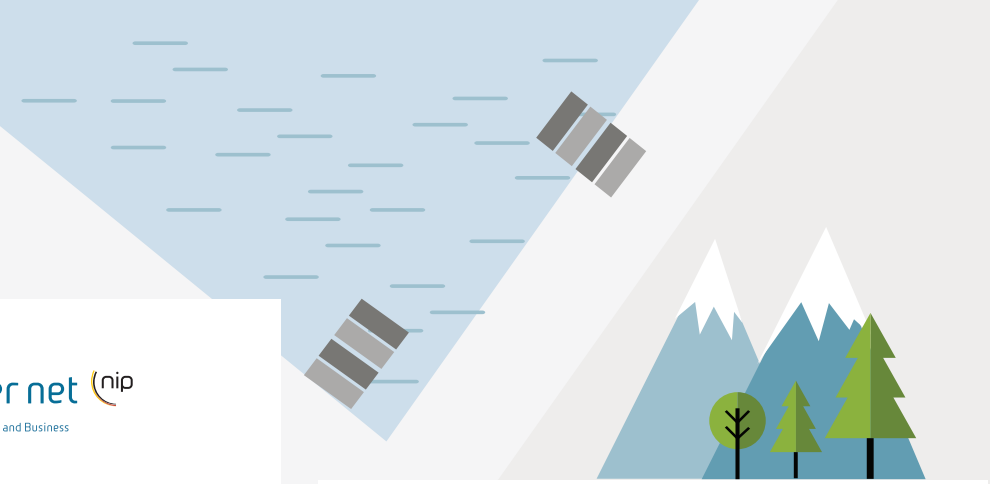
NIP – STATISTIC: SHARE ACCORDING TO APPLICATION SECTOR
(AS AT DECEMBER 2014 *)



NIP – SPECIAL MARKETS: ALLOCATION BY APPLICATION AREA
(AS AT DECEMBER 2014)



* The diagram incorporates projects at planning stage at NOW, being processed by PtJ, LOI (Letter of Intent) as well as those approved.



clean power net (nip)
Fuel Cells in Industry and Business

1.5 YEARS CLEAN POWER NET: A LIGHTHOUSE PROJECT OF THE NATIONAL INNOVATION PROGRAMME HYDROGEN AND FUEL CELL TECHNOLOGY (NIP)

EMERGENCY POWER SUPPLY WITH FUEL CELLS

The vulnerability of modern society can clearly be shown through the effects of power failures. Computers, base stations for mobile phone networks, industrial robots, production facilities, traffic management signalling systems, intensive care wards and the like – nothing runs without power. As such, a secure power supply is more important than ever as we are reliant on a failsafe supply of power.

At the same time we must fulfil important climate policy goals that are associated with the energy turnaround and produce power as close to carbon neutral as possible. Fuel cells can make a significant contribution in this regard. Clean Power Net (CPN) is a lighthouse project that has now existed for one-and-a-half years within the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP) and has brought together 24 representatives actively engaged in the fuel cell sector. This association of companies and research institutes is paving the way for the fast and cost-effective implementation of fuel cell technology.

Joint CPN activities in 2014 focused on the development of a concept for a user-oriented hydrogen infrastructure and logistics in the Hydrogen Working Group. This group also commenced engaging in extensive exchanges with other fuel cell parties at airports such as the Clean Energy Partnership and the Working Group for Hydrogen, Fuel Cells and Electromobility.

With a view to the international market, an export workshop entitled "Autonomous energy supply with fuel cells – The export potential of applications made in Germany" took place in May 2014. Among the speakers taking the podium were experts from Euler Hermes Deutschland AG, Germany Trade & Invest (GTAI), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and the European Investment Bank EIB. The event concluded that especially in the case of so-called emerging markets, the supply of power is particularly unstable or regions are even off-grid. Furthermore, the growth in the mobile communications market is massive and promises correspondingly high opportunities for sales of fuel cell solutions.

The focus of CPN activities is initially directed towards the telecommunications market segment. It is upon this backdrop that the CPN also presented the subject of fuel cell technology to the European Telecommunications Network Operators' Association (ETNO) in Copenhagen. In addition, a global reference project valued at more than six million euros commenced in February 2014 for the reliable supply of power for the digital communications of public authorities and organisations including emergency services (BOS) in the state of Brandenburg. The Ministry for Transport and Digital Infrastructure (BMVI) is providing 3.2 million euros of funding via the National Innovation Programme Hydrogen and Fuel Cell Technology for this initiative.

As part of the accompanying research of the lighthouse project, a so-called design tool for hydrogen-based fuel cell applications is being developed, which will be available to benefit all CPN partners.

In both the home market Germany and across the whole of Europe, it must be shown what German industry is capable of. This is particularly important when faced with the strong competition coming from the USA, and moreover, corresponding references will also assist in undertaking projects in the emerging markets and acquiring new contracts. The export opportunities for German fuel cell providers are vast.

Nevertheless, obstacles and disadvantages still exist compared with conventional technologies and these must be minimised for market preparation and the introduction of fuel cells for industrial and business applications. As an open, national and cross-sector industry association, CPN thereby aims to ensure a more efficient and intelligent, climate-friendly supply of energy for industrial users and thereby simultaneously strengthen the German supplier industry.

More Information on Clean Power Net can be found at
www.cleanpowernet.de

IV / 01

» GENSTORE «

Aim of the project is the development and testing of a modular fuel cell energy supply system featuring an integrated hydrogen production facility. The hydrogen is to be produced via electrolysis using energy from a discontinuous source (e.g. photovoltaic or irregular electricity network) and to be reconverted to electrical energy on demand. This will facilitate a secure and continuous supply of energy for decentralised/off-grid users without fuel logistics. Areas of deployment will include mobile telecommunications and other applications in information and communication technology (ICT).

The following subjects will be dealt with as part of the project:

- ↗ Evaluation of various hydrogen storage technologies
- ↗ Development of an electrolysis module in accordance with the selected storage technology
- ↗ Mechanical and thermal integration of all components
- ↗ Electrical integration and power management
- ↗ Operational management of the plant
- ↗ Demonstration set-ups and field tests

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Heliocentris Industry GmbH	3,075,942	1,476,452

COMMENCEMENT: 01 November 2013
CONCLUSION: 31 August 2016

» Areas of deployment will include mobile telecommunications and other applications in information and communication technology (ICT). «

» The implementation and operation of fuel cell systems in the area of critical infrastructure is to be promoted within this project. «

IV / 02

» TESTING OF FUEL CELL-BASED ELECTRICITY SUPPLY AND NETWORK SECURITY PLANTS FOR THE EMERGENCY AND RESCUE SERVICES (BOS) DIGITAL RADIO NETWORK IN BADEN-WURTTEMBERG «

For the introduction in of the digital radio network in Germany for the emergency and rescue services (BOS – Behörden und Organisationen mit Sicherheitsaufgaben), around 700 sites were constructed in Baden-Wurttemberg. Especially high specifications exist for this so-called critical infrastructure in terms of availability and reliability. The state of Baden-Wurttemberg therefore has resolved to install stationary emergency power supplies using fuel cell systems at 35 important, yet in winter partially difficult to access, sites.

Polymer electrolyte fuel cells will be used. The required performance in the locations in question is in the 2.0 to 2.5 kW range. Hydrogen will be supplied in the form of pressurised gas cylinders. This will allow a sufficient emergency power supply at the digital radio network sites of up to 100 hours in the case of power failures. Through the use of pressurised gas cylinders, hydrogen can be quickly and easily replaced, if required.

The implementation and operation of fuel cell systems in the area of critical infrastructure is to be promoted within this project. At the same time, valid and reliable data on the deployed systems is to be recorded through field tests in order to support system manufacturers in their ongoing efforts to adjust and develop the systems further.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Vermögen und Bau Baden-Württemberg	2,621,597	1,258,366

COMMENCEMENT: 01 July 2013
CONCLUSION: 30 June 2016

IV / 03

» FUEL CELL RANGE EXTENDER FOR UTILITY VEHICLES – REX «

The fuel cell range extender system for battery-electric utility vehicles was developed by Proton Motor Fuel Cell GmbH as a conceptual modular solution based on its own stack and system technology. The modular approach guarantees it can be implemented across various platforms and thereby ensures that fuel cell technology becomes accessible to a larger range of applications. Cooperation with German contract developers and suppliers means the technological know-how and value-added chains remain in Germany. As one of just a handful of fuel cell manufacturers in the higher performance category, Proton Motor is striving for technological leadership in Europe with this development. Based on existing technology, a step-by-step adjustment to automotive requirements was conducted including mechanical stability, electromagnetic compatibility and starting ability in frosty conditions. To demonstrate usability from the very beginning, an existing 7.5 t battery-electric utility vehicle was selected. The project commenced in April 2010 with the creation and testing of a functional model. The development and testing of a test vehicle took place from January 2011. It was upon this basis that a second, improved prototype was built and tested in 2012. From 2013, this vehicle was then used by various operators for testing its suitability for everyday use under real conditions.

Due to its modular design and the development of standardised interfaces, a universally adaptable fuel cell system could be developed. The involvement of the SGS-TÜV testing organisation from the very beginning enabled us to obtain approval for use on European roads in accordance with guideline 79/2009/EC. An important prerequisite for this was the intelligent safety system, which was also developed by Proton Motor. To document the potential economic success of this technology, a comprehensive TCO (Total Cost of Ownership) analysis was prepared together with the Technical University of Munich.

Difficulties arose due to a limited and sometimes lacking availability of suitable components. Some of these components needed to first be developed according to specifications, e.g. the DC/DC converter for the voltage ranges required in the automotive area. As hydrogen and fuel cell technology is still largely unknown at the respective authorities, significant bureaucratic hurdles needed to be overcome in the approvals process. The biggest challenge in the search for operators willing to test the vehicles in everyday use was, however, the largely non-existent hydrogen infrastructure.

The fuel cell range extender is an ideal solution to supplement electromobility as it preserves emission-free mobility while simultaneously expanding the potential application spectrum to include those instances where normal battery capacity alone would be insufficient.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Proton Motor Fuel Cell GmbH	3,246,057	1,558,107

COMMENCEMENT: 01 April 2010
CONCLUSION: 31 December 2014

Vehicle chassis with integrated range extender system

IV / 04

» VEGA 2000 – ON BOARD POWER SUPPLY FOR LEISURE VEHICLES «

Truma Gerätetechnik GmbH & Co. KG of Putzbrunn, Germany, developed a fuel cell reformer system for the off-grid supply of on board power for leisure vehicles. Named VeGA, the APU (auxiliary power unit) system features maximum output performance of 250 Wel and operates with widely available liquid gas as its energy source. Areas of focus of the demonstration project, which aimed to produce 2,000 such fuel cell systems, included:

↗ Conduct field trials of fuel cell systems

↗ Realisation of corresponding production volumes

↗ Development and establishment of the necessary production processes at Truma and associated suppliers

↗ Achieving initial, important cost reduction potentials through the attainment of significant production quantities

The units were provided to customers in the leisure vehicle (caravans) market – and thereby directly and sustainably contributed to boosting the image and acceptance of fuel cell technology, in accordance with the aims of the National Innovation Programme Hydrogen and Fuel Cell Technology.

The project provided Truma and associated suppliers the opportunity to enter this market as well as allowing for the qualification and validation of their own internal developmental processes. Furthermore, the project also served as an important reference and drew attention to the involved supplier companies and their activities as market pioneers.

Realisation of the demonstration project comprised of three main parts: measures for production development and preparation at Truma and associated suppliers; testing of the APU systems by end consumers; and accompanying market introduction measures such as the training of dealers, vehicle manufacturers and customers – along with public relations activities.

The project timeframe was originally estimated at three years. Due to delays in the delivery of the membrane electrode units, however, an extension to this timeframe was necessary. Ultimately, a process suitable for the series production of a fuel cell reformer system could be successfully established. It encompassed the development of suitable production and quality assurance processes along with the establishment of corresponding production capacities. Also specified was the development and procurement of component-specific tools, testing equipment and production materials at Truma and the various suppliers. This enabled the step from one-off to series production to be set in motion, together with the supplier firms.

While the total number of produced units did not hit the 2,000 mark within the scope of the project as originally planned, comprehensive testing phases could nevertheless be conducted leading to extremely valuable insights being gained in terms of process stability, practical operation of the system and the requirements for support including consultation and service.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Truma Gerätetechnik GmbH & Co. KG	4,327,001	1,947,149

COMMENCEMENT: 01 February 2010
CONCLUSION: 30 June 2014

IV / 05

» PLAKONEXA «

Based on the Heliocentris Nexa® 1200 fuel cell module, the project aimed to develop various demonstrators for industrial applications and to test these together with the application partners. In this process, it was also to be assessed for which areas of application the Nexa® 1200 is principally suited to and what improvements are required for industrial commercialisation.

IMPLEMENTED DEMONSTRATORS (SELECTION):

APPLICATION	PARTNER	TEST PERIOD	SPECIAL CHALLENGES
1 kW UPS	Chemical company	6 months	Test on two different load systems: emergency lighting and a small data centre
1 kW UPS	Regional radio station operator	5 months	Container installation
8 kW emergency power system for IT	Municipality	12 months	Parallel connection of 8 fuel cell modules, building-integrated with internal H_2 provision
1 kW Range Extender for existing UPS	Medium-sized manufacturer	6 months	Incorporation in the existing UPS
1 kW back-up system for mobile communications system	P21, Munich	5 months	Electrical integration and incorporation in an energy management system
0.5 kW primary power supply for broadband distribution	Internet provider, Brandenburg	6 months	Continuous operation at < 50 % nominal load, winter operation, hydrogen logistics

Nexa® 1200 could impress in all applications tested. Due to its simple architecture and straightforward implementation, it is particularly suited for UPS (uninterruptible power supply) and back-up applications.

Nevertheless, besides a substantial reduction in production costs, optimisation at least in the following areas is required for commercial introduction:

- ↗ Approval for operation with 3.0 hydrogen
- ↗ Increase of the permissible operating temperature
- ↗ Reduce start-up time
- ↗ Increase starting time availability

The system failures that were experienced were attributable either to problems with peripheral components (e.g. as a result of excess temperature, leakages) or integration issues (air quality, electrical integration). In further project planning, special attention must therefore be given to the implementation of more mature and qualified peripheral components.

A significant hurdle for the fast and cost effective implementation of the demonstrators has proven to be the effort required to produce the necessary hydrogen, in particular the fulfilment of compliance requirements and the cylinder logistics. In this regard, it quickly became clear that far more is required for commercialisation to be successful than simply a technically mature fuel cell system.

Through the acquisition of the insolvent company P21 GmbH from Munich in 2011, the strategic direction of Heliocentris has changed markedly: since then, the market focus has moved to energy systems for mobile communications and other ICT applications, especially in regions with weak or non-existent electricity networks. The hereby-associated shift in the value-added approach meant that a stronger focus was placed on the development of hybrid energy systems and energy management. This led to aborting further development on the in-house Nexa® fuel cell platform in favour of entering into a strategic partnership with FutureE Fuel Cell Solutions GmbH. Since the middle of 2013, their Jupiter fuel cell platform is being successfully implemented in Heliocentris solutions.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Heliocentris Energiesysteme GmbH	1,589,181	762,807

COMMENCEMENT: 01 May 2010
CONCLUSION: 30 September 2014

» Nexa® 1200 could impress in all applications tested. «

IV / 06

» ALL ELECTRIC YACHT «

The project is part of the Special Market programme area of the National Innovation Programme Hydrogen and Fuel Cell Technology. Its aim is to develop a fuel cell drive for boats and light vehicles in order to enhance the image and promote acceptance of hydrogen and fuel cell technology. This demonstration project was conducted in a well-visited tourism region in Germany (Müritz) and could make a positive contribution in this regard.

Goal of the project comprised the complete electrification of three "Voyager for 2" houseboat models from Woterfitz Wasserfreizeit Holtkamp + Partner OHG, based in Rechlin an der Müritz. Three different constellations of PV module, fuel cell, lithium-ion battery and electric drive were developed and integrated in the houseboats. In contrast, the pressurised hydrogen cylinders to be deployed along with all associated valves and pipelines retained the same dimensions and characteristics in all three houseboats. The set up of each of the three houseboats was as follows:

↗ Voyager for 2 (1): 2 kW electric drive, 0.5 kW fuel cell, 600 Ah Lithium-Ion battery

↗ Voyager for 2 (2): 2 x 2 kW electric drive, 1 kW fuel cell, 500 Ah Lithium-Ion battery

↗ Voyager for 2 (3): 2 x 1 kW electric drive, 2 kW fuel cell, 500 Ah Lithium-Ion battery

The scientific/technical aims of the project could be fully accomplished. Valuable technical information on the developed houseboat types and the components used could be gained. The constructive collaboration and integration of various developmental partners and organisations could be intensified. Moreover, some of the data on the use of fully-electric houseboats that could be gathered was not available in such a format previously. A transfer of the experiences made to other areas of hydrogen and fuel cell technology as well as electromobility is possible, in a general sense. The demonstration project assisted the project leaders and staff involved to gain considerable fundamental know-how in terms of the integration or substitution of alternative green energy producers and consumers within a conventional area of application. In particular, experience in regard to the use of pressurised hydrogen and safety could be gained. All results could be achieved in line with the agreed budget. Nevertheless, the project needed to be extended by half a year due to delayed deliveries of components. The difficulties experienced in the project were attributable to the lack of a suitable hydrogen infrastructure in the Müritz region.

PARTNERS:	PROJECT BUDGET/€	PROJECT FUNDING/€
Woterfitz Wasserfreizeit Holtkamp & Partner OHG	568,646	272,950
Hochdruck-Reduziertechnik GmbH	442,524	212,412
FutureE Fuel Cell Solutions GmbH	528,944	253,893

COMMENCEMENT: 01 August 2011
CONCLUSION: 30 September 2014

» The development of fuel cell drives for boats and light vehicles enhances the image and promotes acceptance of hydrogen and fuel cell technology. «


HAFENDALEDIE
RZ-410i V

IV / 07

» PRACTICAL TESTING OF FUEL CELL-BASED POWER SUPPLY AND NETWORK SECURITY SYSTEMS AT EMERGENCY AND RESCUE SERVICES (BOS) DIGITAL RADIO BASE STATIONS «

As part of the expansion of the digital radio network for the emergency and rescue services (BOS – Behörden und Organisationen mit Sicherheitsaufgaben), four base stations in Lower Saxony were equipped with fuel cells. In the case of power failures they are capable of providing at least 72 hours of emergency power, thereby ensuring the functionality of the radio technology over this time period. The selection of the sites took into account the accessibility of the location under conditions such as flooding.

In association with the Leibniz University of Hanover, the requirements were specified and the cost-effectiveness compared to conventional emergency power systems was assessed. The most cost-effective supplier was awarded the contract.

Construction took place between 2012 and 2014 as part of the step-by-step establishment of the BOS digital radio network. The operability of the fuel cells cannot be conclusively assessed at this stage.

A particular challenge for ongoing operations is the delivery of replacement hydrogen cylinders. In this regard, the following question will continue to be posed at regular intervals in the future: At what remaining fuel level does the bundle of cylinders need to be replaced?

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Zentrale Polizeidirektion Niedersachsen	365,912	175,638

COMMENCEMENT: 01 July 2010
CONCLUSION: 30 June 2014

» In the case of power failures they are capable of providing at least 72 hours of emergency power, thereby ensuring the functionality of the radio technology over this time period. «

BOS (emergency services) base station fuel cell system

BMVI – ELECTROMOBILITY MODEL REGIONS

THE PROJECTS ARE LISTED V / 01 – V / 10 ON THE FOLLOWING PAGES,
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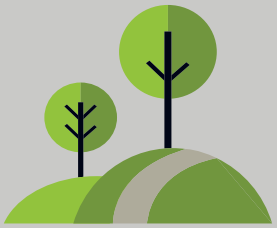


ELECTROMOBILITY AS A PART OF THE ENERGY TURNAROUND

FUNDING PRIORITY ELECTROMOBILITY

The federal government supports research and development into alternative drive concepts as is open to all technology types and transport modes. Supported are plug-in hybrid, battery and fuel cell drive-based models, for road, rail, ship or air transport. With the National Development Plan Electromobility, the federal government set itself the goal to develop Germany into a lead market and leading supplier in the area of electromobility. Through the electrification of the transport sector, future mobility is to become more climate and environmentally friendly and less reliant on fossil fuels. The expansion of electromobility is therefore an essential supporting pillar for the realisation of the government's mobility and fuel strategy (MKS – Mobilitäts- und Kraftstoffstrategie).

ELECTROMOBILITY MODEL REGIONS

The Electromobility Model Regions were established in 2009 by the Federal Ministry of Transport and Digital Infrastructure (BMVI – Bundesministerium für Verkehr und digitale Infrastruktur) formerly the Federal Ministry of Transport, Building and Urban Development (BMVBS – Bundesministerium für Verkehr, Bau und Stadtentwicklung), using funds stemming from the second economic stimulus package (Konjunkturpaket II). The strategic approach of the Model Regions is divided into two main areas: the demonstration and examination of the suitability of electromobility under everyday conditions in the regional projects as well as overarching accompanying scientific research. Through the cooperation between partners from industry, research and the public sector, local networks are being established. The work of the BMVI Model Regions aims to prepare the market by testing the technology under everyday conditions. Experiences made and results achieved are dealt with as key issues within the scope of the accompanying overarching scientific research. The goal here is to ensure that all involved companies and organisations can jointly learn from the experiences made and to also prime new players to be in a position to enter into the area of electromobility. The focus of the accompanying research is on the subject areas infrastructure, innovative drives & vehicles, fleet management, safety, user perspectives, regulatory framework as well as spatial/urban and transport planning.

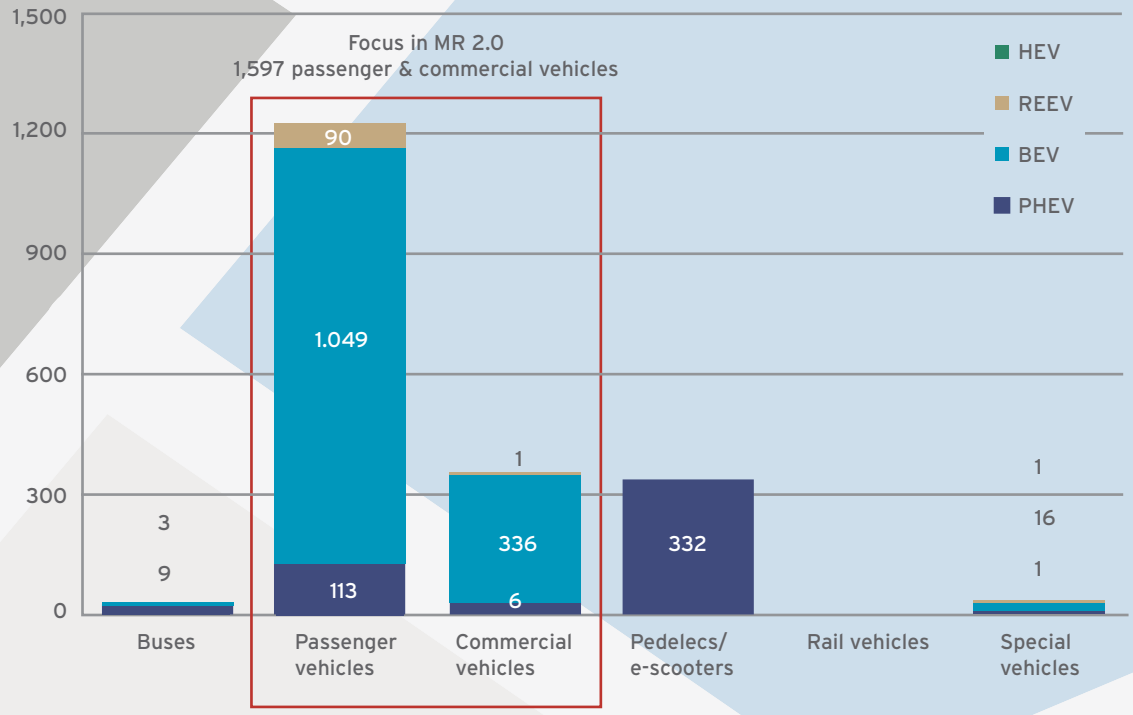
IMPLEMENTING ORGANISATIONAL STRUCTURE

The BMVI Electromobility Model Regions are implemented and coordinated by NOW. Its key duties involve the definition and selection of programmatic areas of focus in conjunction with the BMVI, the coordination of the accompanying scientific research along with the management of individual projects.

The BMVI ensures the contents are aligned in a political context and together with the federal government is responsible for determining the focus of content in the area of electromobility.

Projektträger Jülich (PtJ) is responsible for project administration and supports the programme with legal advice on public funding. Regional coordination is conducted by the project headquarters (PLS – Projektleitstellen), comprised of regionally based players from the areas of business development, public utilities, energy agencies and from other public-private partnerships. They also ensure exchange takes place between project partners and thereby promote local and regional participation in the programme.

Cross-regional exchange is conducted in the Strategy Group. It provides the platform in which representatives from the Model Region project headquarters, players from the accompanying research as well as BMVI, NOW and PtJ can discuss all aspects of programme activities. The Electromobility Showcases (Berlin/Potsdam, Stuttgart, Bavaria/Saxony) as will as the accompanying research and impact studies of Showcases are also involved in the Strategy Group.



SUPPORT OF ELECTROMOBILITY IN THE MODEL REGIONS

A diverse project landscape characterises the activities in the Model Regions. Over the past years, many areas of focus were set, providing a broad framework for future projects to be pursued. Some examples include:

↗ Integration of electromobility in the regional local public transport network

↗ Focus on commercial transport and urban courier services

↗ Intermodality and linked e-carsharing services (mobility chain)

↗ Interlinking the place of living with electromobility via neighbourhood-based projects

↗ Hybridisation in regional rail transportation

↗ Special vehicle applications at airports and for municipal deployment

↗ Fleet applications in municipal and commercial areas

On the basis of the funding guidelines of June 2011, around 80 project alliances with more than 250 partners and a total funding volume of approx. 140 million euros were implemented. The specific figures from the projects in regard to the progress of infrastructure and number of deployed vehicles are collected each quarter. At the end of 2014, around 78 percent of vehicles and 82 percent of recharging stations that were planned in the projects were in operation. As such, about 2,000 vehicles are in use and 1,200 recharging points were established through the projects and are now in operation.

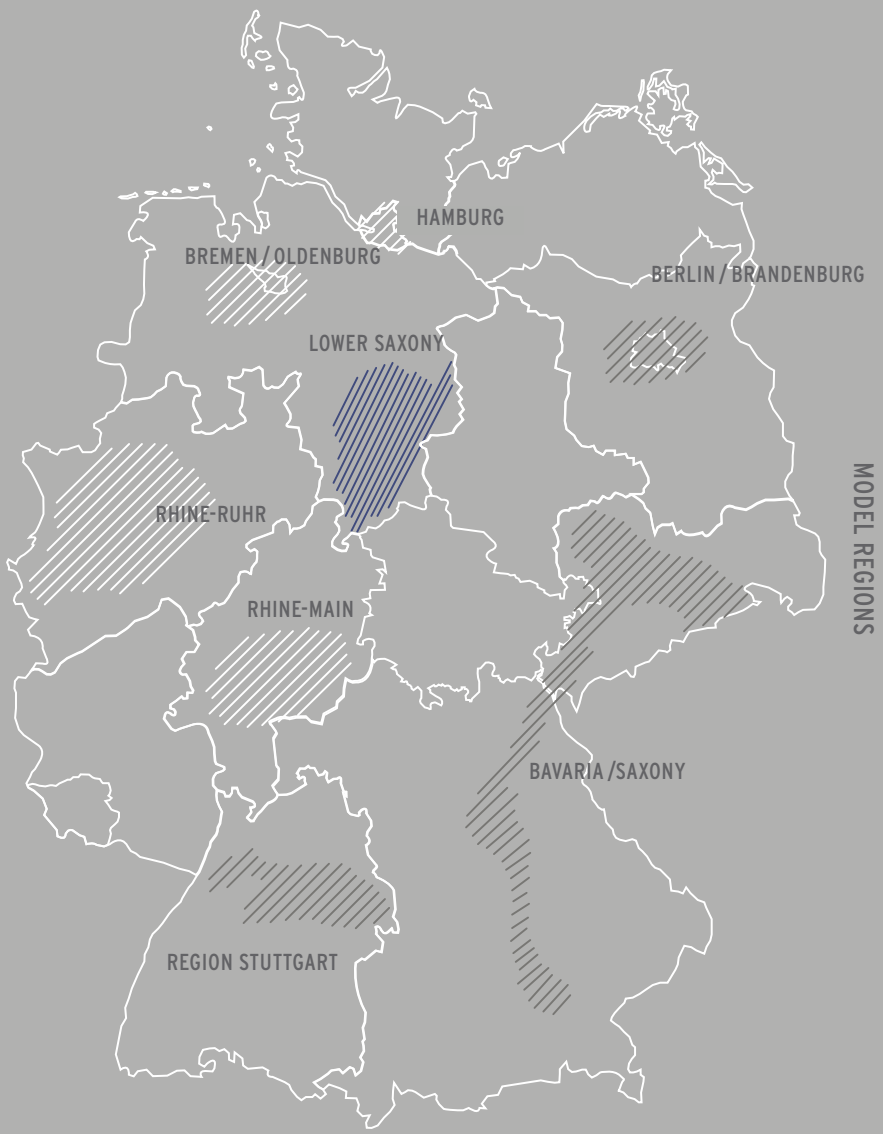
A data monitoring system is used by NOW as a central tool to coordinate the collection of the comprehensive data on current vehicle and infrastructure figures from the ongoing projects in the Model Regions. The diagram on the following page depicts the situation at the end of 2014 in the area of vehicles. In accordance with the aims of the federal government, at more than an 80 percent share of the overall fleet, the focus of application is on passenger and commercial vehicles.

In 2009 and 2010, German car manufacturers had no commercially available electric vehicles in their product range that could cover the demand for vehicles in the Model Regions and associated projects. As such, it was often required to make use of foreign products or undertake special modifications. Spurred on by the support programmes, German manufacturers are now supplying suitable vehicles – a total of 17 models from German manufacturers were available at the end of 2014.

JOINT STRATEGY GROUP

ACCOMPANYING RESEARCH

- USER PERSPECTIVES
- FLEET MANAGEMENT
- INNOVATIVE DRIVES & VEHICLES
- SAFETY
- INFRASTRUCTURE
- SPATIAL/URBAN & TRANSPORT PLANNING
- REGULATORY FRAME-WORK



MODEL REGIONS

CENTRAL DATA MONITORING

- MODEL REGIONS
- SHOWCASES/PREVIOUS MODEL REGIONS
- SHOWCASES

SUBJECT AREAS OF THE SUPPLEMENTARY SCIENTIFIC RESEARCH

SAFETY (FOCUS ON BATTERY SAFETY)

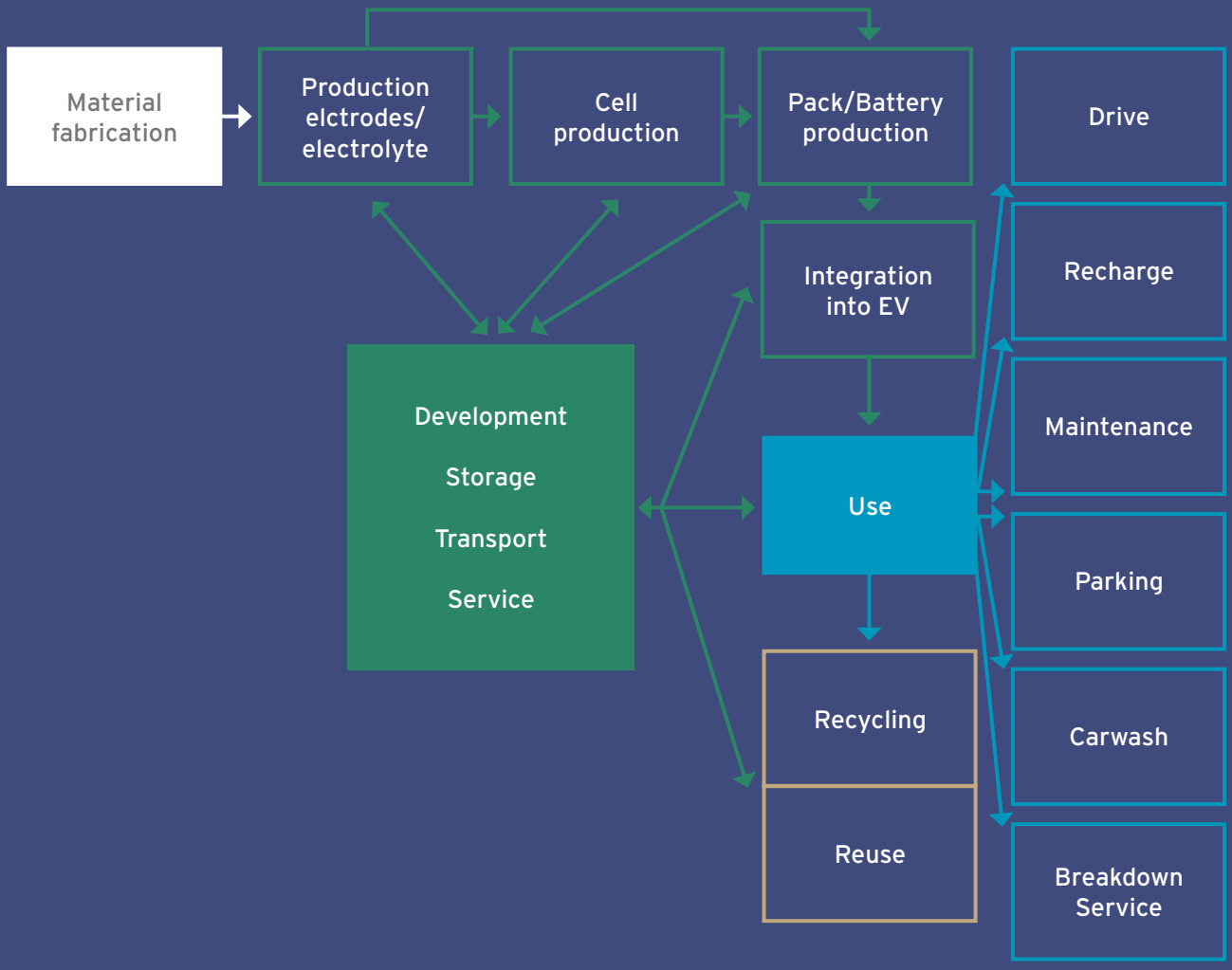
Coordination of the subject area:
↗ Silke Wilhelm, NOW
↗ Dr. Christian Schlosser, BMVI
↗ Zentrum für Sonnenenergie- und Wasserstoff-forschung (ZSW) (ZSW – Centre for Solar Energy and Hydrogen Research)
↗ Additional specialists from the areas of vehicle and battery safety

Participants:
Coordinating entities (NOW and BMVI), scientific supervision by the Centre for Solar Energy and Hydrogen Research (ZSW) in cooperation with experts from the fields of vehicle and battery safety as well as exchange with the Kompetenznetzwerk Lithium-Ionen-Batterien e.V. (KLiB – lithium-ion battery competency network) and its members from the fields of research and development, battery materials and components, cell and battery manufacture, and OEMs

Core focus/Issues:
Compliance with safety standards is a key requirement for the acceptance and market introduction of electric vehicles. The subject area thus addresses safety-related aspects and issues surrounding the electric vehicle. These comprise, among others, the subjects of battery safety, risk and safety evaluation for vehicles and infrastructure as well as the influence of electric vehicles on traffic safety, e.g. as a result of the reduction of vehicle noises at lower speeds.

Under funding from the Model Regions from 2009 to 2011, extensive safety documentation was compiled on the electric vehicles used in the Model Regions. In addition, the failure and breakdown of vehicles and components was monitored. Work in the subject area is currently continuing based on these preliminary findings and activities. This involves further examinations on the safety of traction batteries that are being conducted throughout the entire battery lifecycle. These are embedded in the BatSich (battery safety) study of the ZSW, together with partners KLiB (Kompetenznetzwerk Li-Ionen-Batterie), Fraunhofer FHG ISI and ICT, Clairant, Adam Opel AG, envites, EnergieAgentur.NRW and FC-BAT. Study content includes the assessment of risks throughout the lifecycle and the development of risk reduction proposals.

This lifecyle examination integrates the areas of availability of raw materials, the design and concept phase, production, storage and transport, up to the use and reuse of batteries with relevant recycling on both the cell and battery levels. Part of the usage phase also incorporates the deployment of batteries in vehicles and the assessment of safety aspects according to various deployment areas. For this reason, the activities relating to vehicle safety will be continued by a working group as a work package, within the scope of the study.



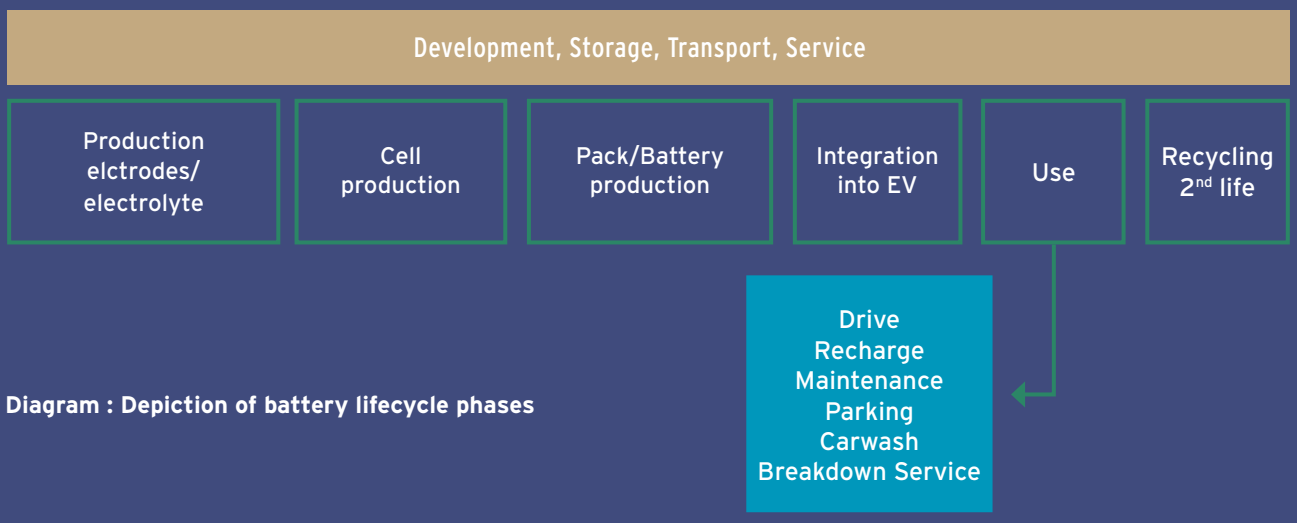


Diagram : Depiction of battery lifecycle phases

The aim of the work within the subject area is to gauge existing knowledge, assess this and also identify and evaluate any gaps. Further insights are to be gained from this process and recommendations for action by relevant players and institutions (government, research and business) developed. The results will be made available in a comprehensive final report at the end of 2015. All work and the results of the subject area are to serve all interest groups as a forum for dialogue to ensure the safety of batteries and electric vehicles.

FLEET MANAGEMENT

Coordination of the subject area:
↗ Dominique Sévin, NOW/Frank Blinde, NOW
↗ Dr. Christian Schlosser, BMVI/Sabine Domke, BMVI
↗ Wolfgang Rid, Fachhochschule Erfurt & Städtebau-Institut der Universität Stuttgart (Institute of Urban Design)/Michael Grausam, Städtebau-Institut der Universität Stuttgart (Institute of Urban Design)

Participants:
The subject area network comprises more than 200 representatives from science, business and public authorities, of which more than 50 participated at the subject area meetings and workshops.

Core focus/issues:
The Fleet Management subject area deals with issues concerning the electrification of municipal and commercial fleets. A focus is placed on answering the following questions:

↗ Which advantages and disadvantages do electric vehicles have for fleet operators?

↗ What factors are decisive for the successful integration of electric vehicles into fleets? What needs to be taken into consideration for the integration of electric vehicles into fleets?

↗ What are the prerequisites for the economically viable operation of electric vehicles in fleets?

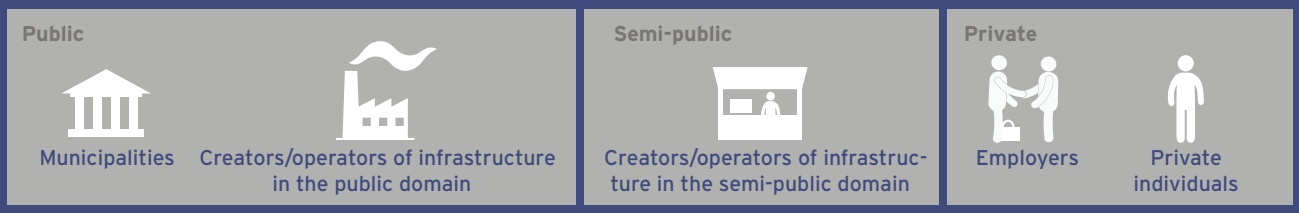
↗ What experiences and results were gathered from projects of the Electromobility Model Regions?

Subjects/Projects/Content 2014:
The results of a survey that asked project headquarters, accompanying research institutes, companies and municipalities about their knowledge requirements is the basis of the subject area focus. The thematic priorities of the accompanying research were derived from the results of a preliminary survey.

Two subject area meetings provided scope to exchange experiences and to build networks with other players from research and practice. Furthermore, in two workshops participants discussed in detail the factors required to make the implementation of electromobility in fleets a success and also developed recommendations for action for the integration of electric vehicles in municipal and commercial fleets. A broadly based survey of fleet operators with experience in the area of electromobility allowed insights to be gained on the core issues of electromobility in fleets (costs, operator models, recharging infrastructure, etc.). This was supplemented by nine in-depth interviews of fleet operators that examined the challenges faced as well as the approaches used during the introduction of electric vehicles in various fleets (municipal and commercial).

The results of the accompanying research to the Fleet Management subject area will be prepared in a practical "Electromobility in Fleets" handbook for action. The guideline is aimed at fleet operators and their managers to assist in answering important questions on the integration of electric vehicles in municipal and commercial fleets.

PROCESS VISUALISATION RECHARGING INFRASTRUCTURE



Process visualisation for recharging infrastructure in the Electromobility Starterset.

INFRASTRUCTURE

Coordination of the subject area:
↗ Johannes Pallasch, NOW
↗ Dr. Christian Schlosser, BMVI
↗ Dr.-Ing. Gerald Rausch/Markus Müller Fraunhofer-Institut für Fertigungstechnik und Angewandte Materialforschung (IFAM)

Participants:
Representatives from public utility companies, associations, research institutes, municipalities, recharging technology manufacturers, recharging station operators, energy supplier firms

Core focus/issues:
Goal is the establishment of a national recharging infrastructure. Recommendations for action are to be provided for municipalities, energy supply firms and public utility companies. Questions still exist in terms of the following:

↗ Technical implementation

↗ Economic opportunities

↗ Legal requirements

↗ Location and necessary density of recharging points

Subjects/Projects/Issues 2014:
The Electromobility Starterset online platform was developed in the 2014 project year. This web-based information platform is intended for decision makers from municipalities and elsewhere to obtain fast and relevant information on the local establishment of recharging stations. The visualisation of processes within the online platform simplifies usage through its intuitive design, as depicted above. Users must first select the sphere in which the recharging station is to be established. This ensures that the information provided is then limited to content relevant to their particular situation.

The process visualisation is intended as a tool to depict the planning, approval, developmental and operational processes of recharging infrastructure for electric vehicles.

The "Öffentliche Ladeinfrastruktur für Städte, Kommunen und Versorger" (Public Recharging Infrastructure for Cities, Municipalities and Suppliers) publication was compiled in February 2014 and serves as a basis of information on the current status of recharging technology for electromobility. It aims to facilitate and support the expansion of an interoperable and demand-oriented recharging infrastructure for electric vehicles. On 4 and 5 February 2014, the "Elektromobilität vor Ort – Fachkonferenz für kommunale Vertreter" (On-site Electromobility) specialist conference for municipal representatives took place in Bremen. More than 200 representatives from municipalities, municipal firms, business development agencies and state ministries attended the two-day kick-off event of this new series of conferences set to be held at regular intervals. Within the framework of three forums with specialist lectures and discussion sessions, the topics of recharging infrastructure, regulatory framework and transportation planning were addressed. A comprehensive supplementary programme including roadshow, vehicle display and excursion also accompanied the event.

In October 2014, the "Prozessschritte zur normgerechten Errichtung von Ladesäulen/Wallboxen" (Process steps for the standardised installation of recharging columns/wallboxes) overview was published in a flyer. This recommendation for action provides a point of reference that can be consulted prior to installation to ensure standardisation of recharging points and operation and to also guarantee safe operation in the long term.

REGULATORY FRAMEWORK/URBAN DEVELOPMENT AND TRANSPORT PLANNING

Coordination of the Regulatory Framework subject area:
↗ Dominique Sévin, NOW
↗ Eva Schmitz-Michels, BMVI
↗ Stefanie Hanke, Deutsches Institut für Urbanistik

Coordination of the Urban Development and Transport Planning subject area:
↗ Silke Wilhelm, NOW
↗ Dr. Christian Schlosser, BMVI
↗ Anne Klein-Hitpaß, Deutsches Institut für Urbanistik

Participants:
Municipal representatives from the Electromobility Model Regions across different areas of responsibility as well as other stakeholders from science and industry

Core focus/Issues:
The important role that municipalities play for the integration and expansion of electromobility is now recognised by all players. The involvement of cities and municipalities is vital, for example, when it comes to the day-to-day availability of electric vehicles, the implementation of (electric) mobility concepts and also for the approval of recharging locations. In the Urban Development and Transport Planning subject area, accompanying scientific research does justice to this central role.

A focus of attention in 2014 was on the question of how electromobility can be integrated as an element of a system for sustainable urban and transport planning: which strategies can municipalities pursue for the integration of electromobility; and which planning instruments are available to implement the measures. Many of the communal tasks dealing with electromobility can only be tackled within the scope of existing strategic and operational instruments. Both planning and legal expertise is required in this regard. Due to this contextual linkage, the subject areas of Regulatory Framework and Urban Development and Transport Planning worked closely together in 2014.

Various working groups and exchanges of information were a key focus of this cooperation:

↗ The **"Municipal Strategies/Governance"** working group, which investigated issues including the structures that are required within municipalities to successfully implement electromobility.

↗ To complement this, invitations to **"municipal exchanges of experiences"** were also made, which similarly focused on internal municipal structures, processes and organisation.

↗ The **"Planning instruments"** working group dealt with the issue of the integration of electromobility in strategic, operative and planning instruments.

The working group results have led to the preparation of a joint publication by both subject areas: "Elektromobilität in der kommunalen Umsetzung: Strategien und planerische Instrumente" (The Municipal Implementation of Electromobility: Strategies and Planning Instruments), which was released in Offenbach in January 2015.

Urban Development and Transport Planning subject area

In addition to the activities above, the work of the **"E-Commercial Transport"** working group, which began in 2013, continued. Besides the networking of participants, the opportunities for municipalities and their scope for action were discussed in theme-based workshops. The results were made available to municipalities in the publication entitled "Elektromobilität im städtischen Wirtschaftsverkehr. Chancen und Handlungsräume in den Kommunen" (Electromobility in inner-city commercial transport. Opportunities and scope for action by municipalities). The brochure focuses on presenting the potentials of electromobility to deliver sustainable inner-city mobility in the area of commercial transportation, and besides providing information on areas of emphasis and specific measures, it also suggests strategies for action that municipalities may adopt.

In order to obtain a genuine picture of the activities connected with electromobility that cities have undertaken, a national survey of cities was conducted in Germany. The results of this **"Difu-Städteumfrage"** were released in early 2015 and paint a picture of the current "mood" in municipalities in regard to the subject of electromobility.

Regulatory Framework subject area

Besides the activities undertaken in cooperation with the subject area of Urban Development and Transport Planning as described above, a focus of the Regulatory Framework subject area was the Electromobility Act (EMoG – Entwurf eines Gesetzes zur Bevorrechtigung der Verwendung elektrisch betriebener Fahrzeuge), which comes into force in the spring of 2015. Its task is to provide legal clarity and provide a range of opportunities for municipalities to permit certain advantages to be allowed for electric vehicles. The subject area conducted important systematic preliminary work for the draft legislation along with presentations on the legislative content. In addition, pre-structuring and preliminary evaluations of state and association hearings were also conducted. Another component of the subject area, which will continue to play a role in its future, was the exchange and collection of subject matter for further legislation. Furthermore, collaboration in the subject area of Infrastructure also took place in specific instances.

USER PERSPECTIVES

Coordination of the subject area:
↗ Dominique Sévin, NOW
↗ Dr. Christian Schlosser, BMVI
↗ Dr. Elisabeth Dütschke/Joachim Globisch, Fraunhofer-Institut für System- und Innovationsforschung (ISI)

Participants:
University-based sciences, public and private institutions, the energy and automotive industries, energy agencies and consultancies

Core focus/Issues:
Identification of electromobility target groups as well as the factors influencing user acceptance

Subject/Projects/Contents 2014:
Electromobility only has a future if it finds users and beneficiaries in sufficient number. In this respect the analysis of the needs and expectations of early users of electric vehicles is essential in order to, on the one hand, create appropriate vehicles and services, and on the other, to identify promising target groups that can be catered to during the process of getting the market up and running. In addition, policy recommendations can thus be derived for the promotion of electromobility.

The aim of the work in the User Perspectives subject area is to interlink the individual programme projects with a view to these questions and to position the results obtained in an overview of user acceptance of electromobility. This happens on the one hand by bringing together experts from the projects in thematic workshops, and on the other by a common and standardised survey of all users in every project. To date, more than 1,500 users from Model Region projects have been surveyed. The research will be supplemented by further studies by Fraunhofer ISI. The main focus will be on the different user scenarios of electromobility, i.e. private users, commercial use as well as electric vehicles as part of an integrated transport system. The question of necessary infrastructure from the user point of view will also be analysed.

In 2014, experts from the subject area took part in a workshop on integrated electromobility solutions (deployment of shared electric vehicles in combination with public transport services). Within the workshop, target groups of shared electric vehicles and integrated solutions were characterised and compared with private purchasers of electric vehicles. It was shown that both groups are very similar from a socio-demographic perspective – but that differences were evident in the place of residence (carsharing users more likely to live in large cities; private electric vehicle purchasers found more often in the periphery of cities). In addition, further possible electric vehicle target and user groups were identified in collective user scenarios.

In a subject area meeting held in November 2014, an interim summary of results from ongoing projects was made. Announcements on the results and remaining challenges will be published in the form of a separate position statement.

A brochure was produced together with the working group participants for the area of commercial use, building on the cross-project user survey and results from the projects. Key insights included that fleet managers see electric vehicles as still not being cost effective. The main focus of the currently used electric vehicles is primarily, however, the collection of experiences and less so cost effectiveness. While fleet managers perceive the limited range of electric vehicles as a disadvantage, the availability of conventional replacement vehicles for long distances means that range is rarely a genuine problem in commercial fleets. Safety and reliability are moreover very important from the fleet manager perspective – and there are hardly any problems anymore in this respect with the currently deployed vehicles. The newness of the technology does not represent major problems for the vehicle drivers. Rather, the use of electric vehicles is associated with driving enjoyment by the drivers and also positions the company using the vehicles as being a pioneer. Nevertheless, drivers still consider the cost effectiveness and range of electric vehicles as being unsatisfactory.

INNOVATIVE DRIVES AND VEHICLES

Core focus/Issues:
Optimisation, continued technical development and balancing of vehicles, components and batteries in the "Innovative Drives Bus" and "Passenger and Commercial Vehicles" working groups (WG).

Innovative Drives Bus WG

Coordination and scientific support of the WG:
↗ Ministerial implementation by the BMVI/BMUB
↗ Coordination by Oliver Braune, NOW GmbH/ Heinrich Klingenberg, hySOLUTIONS
↗ Scientific support by Dr. Michael Faltenbacher, PE International

WG composition:
The working group performs its tasks in conjunction with the BMUB and BMVI. Besides the three funding ministries (BMUB, BMVI, BMWi), the working group has an interdisciplinary composition from the approx. 35 involved transportation companies, business representatives (manufacturers and suppliers), the Association of German Transport Companies (VDV – Verband der deutschen Verkehrsunternehmen) and representatives from transport associations. Furthermore, various organisations from the areas of research and consultation are also involved.

Subjects/Projects/Content 2014:
The WG focuses on evaluating:

↗ Optimisation measures for innovative drives already in deployment in local public transportation

↗ New technical developments in the area of diesel hybrid and plug-in hybrid buses

↗ Pure electric drives in which various different storage and recharging technologies are implemented

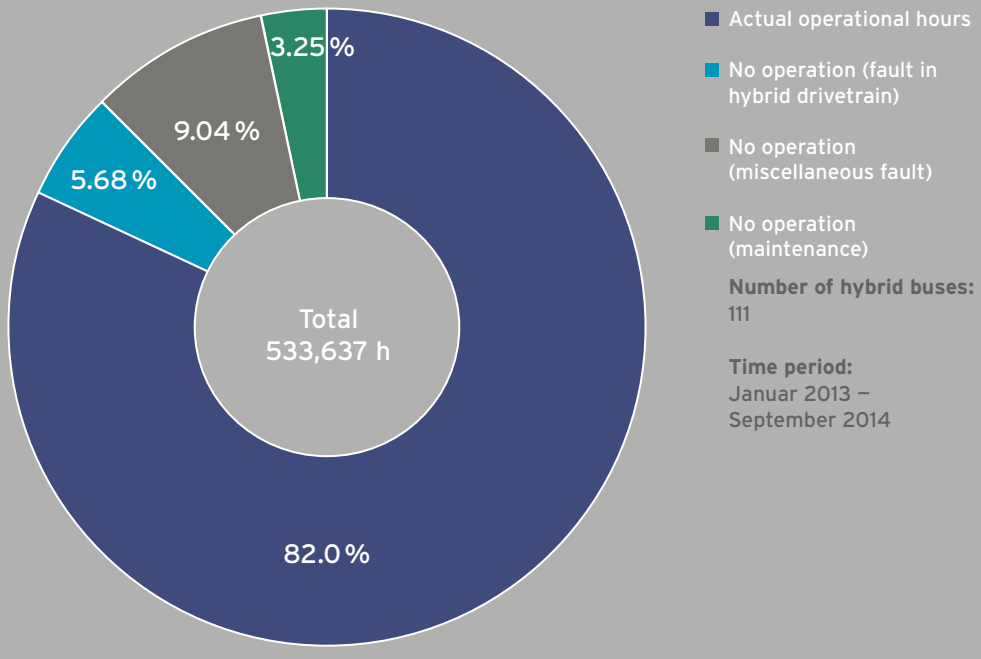
Besides the continuous long-term collection of data, further specific measurements such as fuel consumption, pollutant emissions and noise are also conducted. Both vehicles with innovative drives as well as reference vehicles with conventional diesel drivetrains are taken into account in this regard. The data is collected from around 180 buses operating in 28 projects. With the long-term data collection, daily operational data could be gathered over a total mileage of more than ten million kilometres since 2013. This ensures that there is a solid information base, especially in the area of hybrid and diesel buses – and the pool of data is still being further developed for battery buses. The findings made to date were published in a status report in 2014.

Suitability for practice and operational maturity
The average monthly distance covered by the diesel hybrid buses ranges between 2,200 and 7,900 kilometres, depending on the transport company. This is attributable to the varying operational contexts of the individual operators. As such, buses used for overland routes generally have a higher monthly mileage due to the higher average speeds that are driven. Scheduling of the vehicles also plays a role. It was observed that hybrid buses are currently scheduled to operate an average of six days per week, while diesel buses are usually operated six to seven days per week. Accordingly, the average mileage of conventional diesel buses (approx. 5,040km) was somewhat higher than that of the hybrid buses (approx. 4,400km).

Overall, an increase in mileage is evident when compared to the figures of the accompanying BMVI research in the 2010/11 period (from approx 3,300km per month in 2010/11 to now approx. 4,400km per month), attesting that advances have been made in the suitability of diesel hybrid buses for everyday use and their operational maturity. The availability of the diesel hybrid is up to 91%, depending on drive technology im-

plemented and vehicle class. The rigid parallel hybrid buses thereby can already attain the reference value of a conventional diesel bus. A positive trend could be identified across all diesel hybrid buses over the time period, with average rates of availability approaching 82 % of that what conventional diesel buses provide. In the majority of cases, reasons for unwanted downtime stem from the conventional vehicle componentry.

SUITABILITY FOR PRACTICE AND OPERATIONAL MATURITY
MILEAGE, OPERATING HOURS, AVAILABILITY

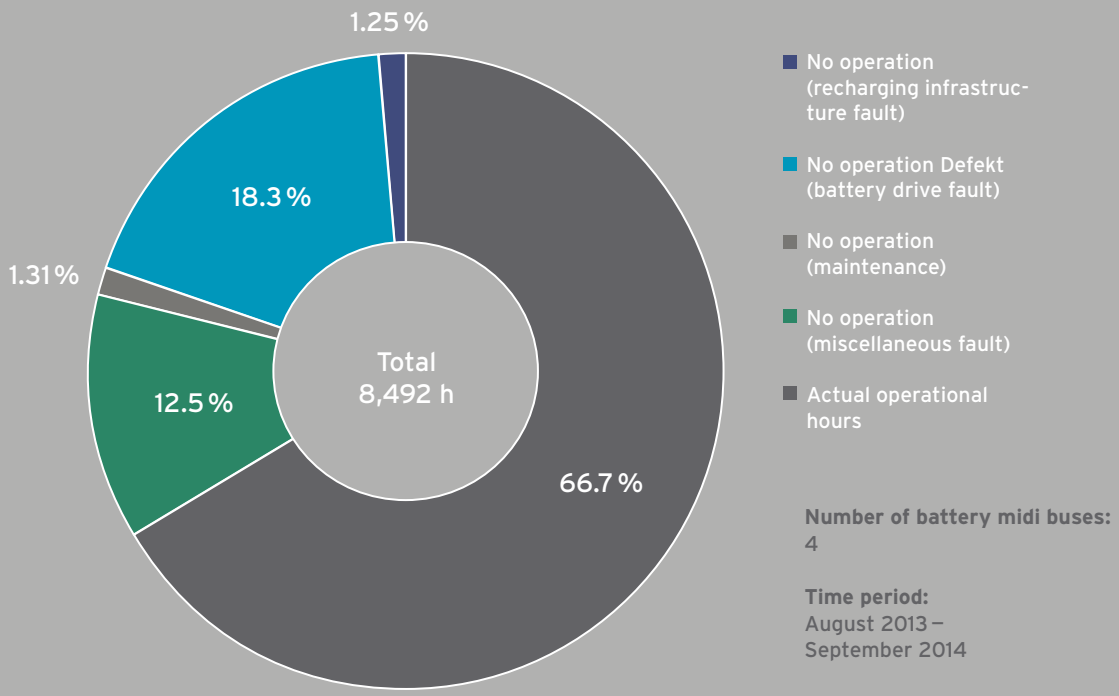


Hybrid buses

The average availability of the battery buses being examined is currently 67 %, which is partly due to one-off effects. Two of the four vehicles already provide approx. 80 % availability. These effects are typical during the introduction of innovative technologies. It is to be expected that for subsequent observations of new vehicles being deployed, an increase in availability will occur due to the positive learning curve.

SUITABILITY FOR PRACTICE AND OPERATIONAL MATURITY

MILEAGE, OPERATING HOURS, AVAILABILITY



Number of battery midi buses:
4

Time period:
August 2013 – September 2014

Battery buses

Energy efficiency

Fuel savings averaged 14 % in hybrid buses. Savings could be detected on all routes examined. Through the implementation of optimisation measures, a significant improvement could be recorded in comparison to the accompanying research results from 2010 to 2012. Heating of the passenger compartment in winter in battery buses results in higher energy consumption – to around that of the level of the drive. Depending on the prevailing temperatures outside, this level may even be higher.

Appropriate steps should therefore be taken to counter this effect, such as through the implementation of efficient supplementary heating and cooling systems.

Ecology and climate protection

Since the beginning of 2013, the diesel hybrid buses being observed could avoid a carbon equivalent of more than 1,000 tons or 364,000 litres of diesel. As the battery midi buses are currently deployed in very specific routing contexts, no directly comparable consumption data for diesel buses is available at this time.

With 95 % less NOx emissions, the hybrid buses exhibit a significant potential for reducing pollutant emissions. Battery buses operate without producing any local emissions: ultimately, however, a shift of emissions occurs from the place of bus use to the place of energy provision. As such, the pollutant emissions must be considered subject to the utilised method of energy production – either on the basis of renewable or non-renewable resources.

With their fully electric acceleration from a standing position, the diesel hybrid buses could record a reduction in noise levels of 65 % compared with their conventional diesel counterparts. Battery buses also provide an analogous potential for noise reduction.

ECOLOGY AND CLIMATE PROTECTION

Avoided greenhouse gases bus platform:
1,053t* (~ 364,000 litres of diesel or more than 910,000km by a rigid bus at 40l/100km consumption)

Number of buses:
123 (1–19 per operator)

Time period:
Jan 2013 – Sept 2014
LVB, Hochbahn, MVG,
SSB from Jan 2013
VRR from April 2013
Jasper, SBG from Sept 2013
HVG from Oct 2013
VHH, SBI from March 2014
AVG, BBW, üstra from April 2014
WVG from Aug 2014

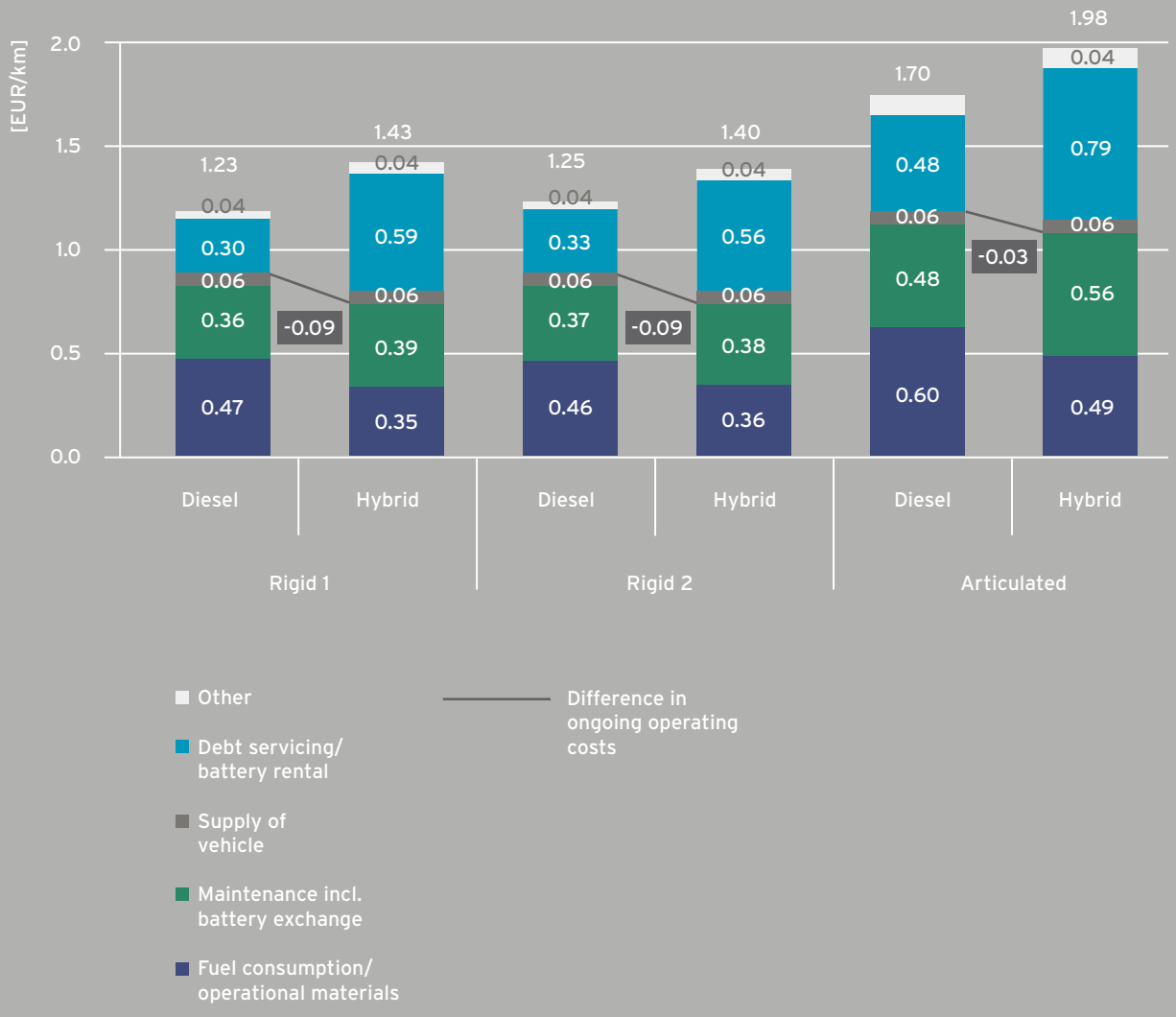
*Taking into account combustion emissions and energy provision

Avoided greenhouse gas emissions WG Bus

Economic efficiency

In order to evaluate economic efficiency, the costs of hybrid and conventional diesel reference buses in scheduled services are to be ascertained and then compared. At present, a determination of costs can only be approximated as the basis of experience with this still young technology is still being developed. Some buses are still being optimised and there is currently a maximum of four years operational experience in the case of hybrid buses. As such, at the present point in time there are also no meaningful examinations of the economic efficiency in regard to pure electric buses as these are still even closer to the beginning of their technological development curve.

Additional costs continue to be associated with hybrid buses. A reduction in costs of around five to ten cents per kilometre compared to those in the results of earlier accompanying research can be observed, however. Economically viable operation of hybrid buses, compared with conventional diesel buses, is possible if: i) the additional procurement costs and necessary battery rental costs reduce annually by 10 % and 5 %, respectively, and ii) the cost of diesel fuel increases at around 5 % per annum. It is further assumed that until 2020, fuel savings could be further increased slightly to 25 % and the additional hybrid-specific servicing costs do not exceed 10%.



Total costs hybrid and diesel reference buses in comparison

Passenger and Commercial Vehicles WG

WG coordination:
↗ Ministerial implementation by the BMVI
↗ Coordination by Oliver Braune, NOW
↗ wissenschaftliche Begleitung durch Roberta Graf, Scientific support by Roberta Graf, Fraunhofer-Institut für Bauphysik/Dr. Stefan Eckert, PE International

WG composition:
The working group is comprised of vehicle manufacturers, producers of drive systems and components, testing facilities and laboratories, representatives from tertiary institutions and the Fraunhofer Society as well as vehicle and fleet operators.

Subjects/Projects/Content 2014:
Focused on the areas of passenger and commercial vehicles, the working group is concerned with the following questions:

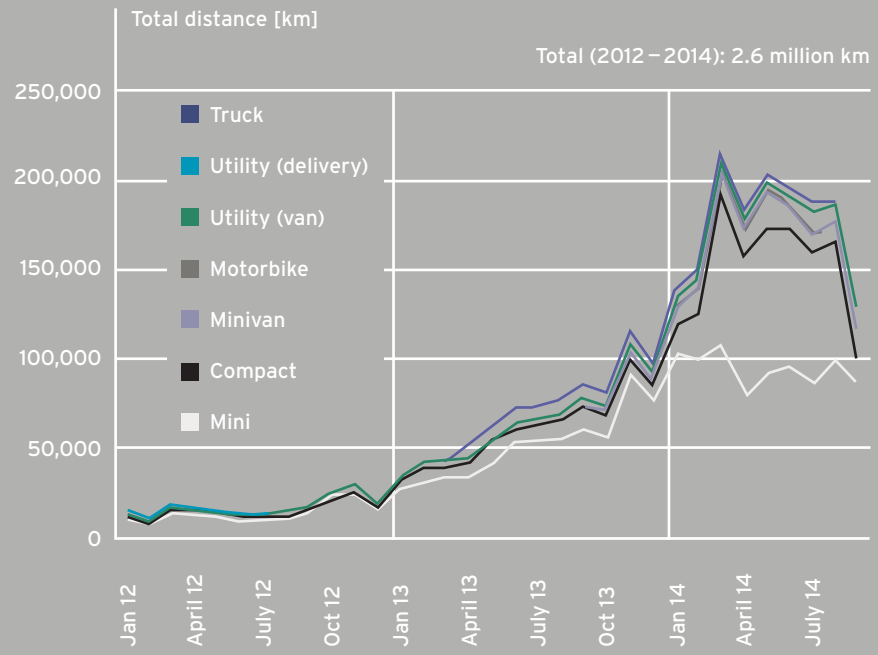
↗ Suitability in practice: How do electric and hybrid vehicles fulfil user demands in practice? Significant here is not only data on operational duration, driving distance and speed profiles, but also the recharging data including the time, duration and type of energy used for recharging.

↗ Performance: What are the relevant parameters with significant influence on vehicle energy consumption? Here, interrelationships with factors such as routing profiles, driving behaviour and outside temperatures are examined.

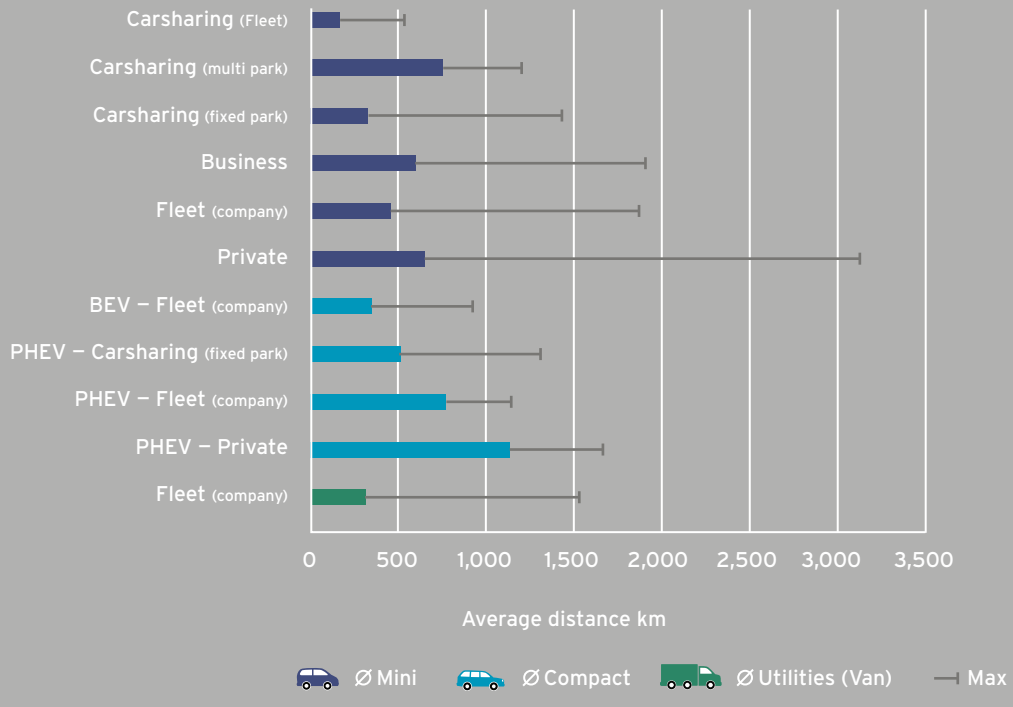
↗ Environmental impact: What effects do electric and hybrid vehicles have on the environment in comparison to conventional vehicles? Key criteria in regard to the environmental effects include the primary energy demands, CO_2 emissions as well as the vehicle's potential contribution to summer smog over the entire vehicle lifecycle. For the evaluation, the assessed impact on the environment of electric and hybrid vehicles will be compared with the impact of conventional reference vehicles.

The questions listed above will be analysed using data from currently around 500 vehicles from the Electromobility Model Regions. This corresponds with around 35% of relevant vehicles currently in deployment in the Electromobility Model Regions. To date, usage information from more than 295,000 trips with a total mileage of approx. 2.6 million kilometres could be collected in an anonymised format. Due to the make-up of the fleet of vehicles in the Model Regions, the results to date concentrate on the mini, compact and light utility classes of passenger vehicles. The examined deployment contexts incorporate various carsharing concepts, commercial deployment as company cars or within company fleets, municipal fleets as well as private use. All results were published in a status report in 2014.

Since the beginning of 2013, the mileage has continuously grown, especially due to the recording of further segments. The monthly mileage varies widely, depending on the deployment context.



Development of the monthly distance travelled (2012 to 2014, segmented)



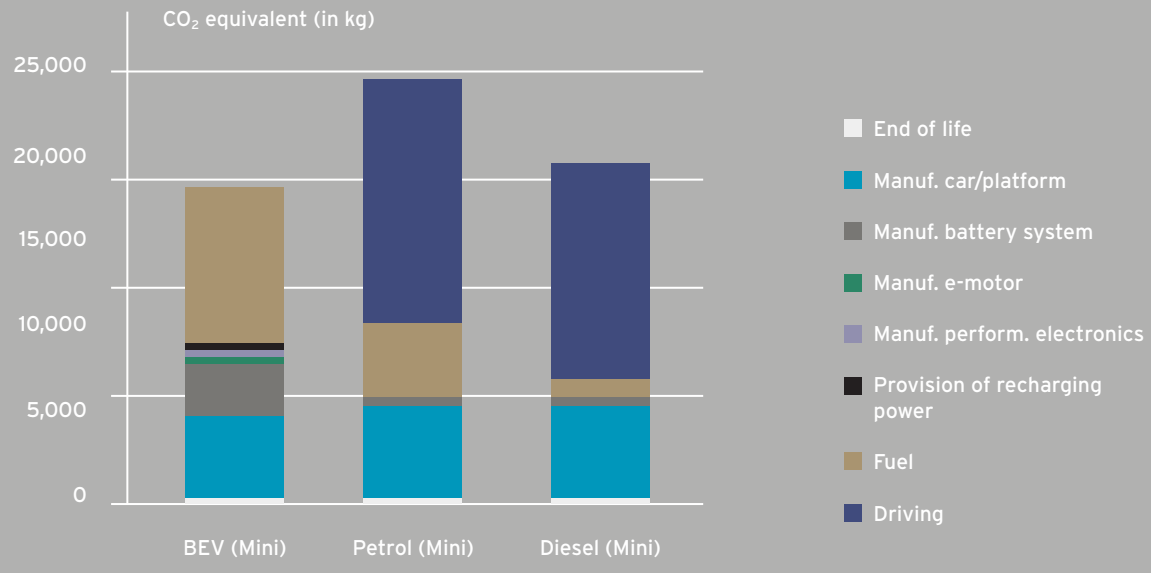
Average and maximum monthly distance travelled (segmented according to deployment context)

The current results of the long-term data analyses show that the vehicles fulfil the mobility requirements of many road users, including the demands for sufficient range. They therefore can be considered as having a very high level of suitability for day-to-day operation in practice. The battery capacity is often not fully discharged in daily use, leaving considerable scope for even longer distances to be covered. In terms of the technical requirements, the vehicles currently available on the market are therefore suited to even greater market penetration.

Based on the data gathered to date, the following energy consumption figures could be calculated for the segments mini, compact and utilities (vans). The driving energy consumption, which was established from real driving operations, is at 15.4kWh/100km for minis – only slightly above the statistical average consumption according to the figures of the New European Driving Cycle (NEDC) for this segment.

In terms of environmental impact, the results highlight the special significance that the manufacturing phase of battery-electric vehicles has. High-tech materials are used in the manufacture of batteries. Particularly the extraction and processing of these materials along with the production of the battery itself all have an environmental impact – which must be compensated for through a high vehicle mileage. An important prerequisite for the optimal ecological use of battery-electric vehicles is also the use of recharging power that boasts a large share from renewable sources, as is the case in the majority of the Model Region vehicle fleet.

COMPARISON REFERENCE VEHICLES, MINI SEGMENT (ELECTRIC, CONVENTIONAL)
GREENHOUSE GAS POTENTIAL WITH A TOTAL MILEAGE OF 150,000 KM



Comparison between BEV mini with ICE mini.

V / 01

» BEEDEL – EVALUATION OF THE IMPLEMENTATION OF ELECTRIC BUSES WITH DECENTRALISED RECHARGING INFRASTRUCTURE (BEWERTUNG DES EINSATZES VON ELEKTROBUSSEN MIT DEZENTRALER LADEINFRASTRUKTUR) IN URBAN REGIONS USING THE EXAMPLE OF HOCHBAHN «

The BEEDeL project aims to ascertain and evaluate the deployment potential as well as designing implementation scenarios for electric buses within a decentralised recharging infrastructure in Hamburg.

A focus is placed on examining and assessing operational issues and their economic and functional impact. The extent to which the flexible deployment of the electric vehicles is possible is to be analysed along with the question of what structure for partial electric bus routes would be advantageous. Other important aspects include timetable scheduling befitting battery-based operation as well as the space requirements for the recharging stations.

The goal is to achieve the highest possible degree of planning security for a growing fleet of electric buses with a decentralised recharging infrastructure installed within the HOCHBAHN network.

Hamburg's University of Applied Sciences (HAW) will draw conclusions on issues of technical feasibility coming from the recorded operational and driving data as well as through examinations of the charging and discharging behaviour of the battery cells. The impact on performance and productivity will be assessed using the results from simulation models from the Fraunhofer Institute IVI in Dresden.

The overall results are to be used for planning tasks at HOCHBAHN as well as by other bus transport companies. By doing so, higher levels of investment security for future developmental projects are to be attained and the attractiveness of the portfolio of services is to be continually enhanced.

PARTNERS:	PROJECT BUDGET/€	PROJECT FUNDING/€
Hamburger Hochbahn AG	207,000	103,500
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V.	247,128	222,415
Hochschule für Angewandte Wissenschaften Hamburg (HAW)	136,816	136,816

COMMENCEMENT: 01 October 2014
CONCLUSION: 30 September 2016

» The goal is to achieve the highest possible degree of planning security for a growing fleet of electric buses with a decentralised recharging infrastructure installed within the HOCHBAHN network. «

V / 02

» BEMOBILITY 2.0 «

BeMobility 2.0 is a project of the Electromobility Model Region Berlin/Potsdam under the lead of Deutsche Bahn AG. Its origins can be traced back to the first project of the Model Region for public short-term usage of electric rental vehicles (BeMobility 1.0, 2009 – 2011). It comprises a junction to the projects of the "Berlin-Brandenburg International Showcase for Electromobility". A chief focus is on the effective integration of e-carsharing in regard to public transportation, information and communication systems as well as urban energy networks and/or recharging infrastructure. Through the synergies existing between the various areas, user friendly, sustainable applications as well as reasonable business models for integrated electromobility are to be developed.

Based and building on existing cooperation partners and test users, the number of stations and information channels of BeMobility 1.0 could be developed further and user surveys continued. The availability of more diverse and improved electric vehicles meant that the quality of the overall service offering was enhanced. At the EUREF Campus in Berlin, the "Micro Smart Grid" (MSG) using locally produced solar and wind energy was established. Recharging infrastructure and energy management (network integration, storage, charge regulation) was tested in the MSG.

The key results include:

↗ Site optimisation and accompanying research for station-based e-carsharing within the framework of "Flinkster", the DB carsharing operation

↗ Additional, comparative inclusion of the station-independent (flexible) e-carsharing from Citroën, "Multicity"

↗ Simultaneous use and optimisation of a smartphone-based information app ("BeMobility Suite") through the separation of the "productive" and "research" app

↗ Establishment and expansion of the "Micro Smart Grid" with demonstration of load management incl. energy storage and data processing in a control room

↗ Introduction of a year-long test of the "BahnCard 25 mobil plus" for discounted use of long-distance German Railways services, carsharing (Flinkster/Multicity), bike rental (Call a Bike) as well as the optional inclusion of an annual ticket for local public transport in Berlin (zones A/B)

Overall, the results confirm that electromobility in public transport requires integration across several levels to be attractive for users and for it to be adequately implemented in the future. The networking requires legal and technical standards along with common sales platforms going beyond those of the service providers themselves. Due to the low preparedness of customers to pay higher prices, additional revenues or compensatory pricing is necessary – such as via tariff bundles (mobility cards) or grid yields (load/storage management). The detailed examination regarding which processes and business models will allow for reasonable operations will be continued in other projects.

PARTNERS:	PROJECT BUDGET/€	PROJECT FUNDING/€
DB FuhrparkService GmbH	2,971,622	1,485,811
Innovationszentrum für Mobilität und gesellschaftlichen Wandel (InnoZ) GmbH	1,461,657	730,829
Technische Universität Berlin	1,560,291	1,560,291
HaCon Ingenieurgesellschaft mbH	690,015	345,008
Robert Bosch Car Multimedia GmbH	450,762	225,381
Contipark Parkgaragen GmbH	70,223	35,112
Schneider Electric GmbH	664,053	332,027
CHOICE GmbH	228,806	114,403
Happold Ingenieurbüro GmbH	815,700	407,850
Daimler AG	221,850	110,925

VEHICLES: More than 75 electric/hybrid vehicles including:
↗ 50 C-Zero vehicles deployed in flexible e-carsharing
↗ over 25 vehicles in stationary e-carsharing and in e-fleets.
Models include: C-Zero, Toyota Prius, Opel Ampera, Fiat Karabag, Renault Kangoo, Stromos (German E-Cars)
INFRASTRUCTURE: Approx. 15 carsharing stations with recharging infrastructure (e-Flinkster), Platform electroMobility and Micro Smart Grid at the EUREF Campus located in the Schöneberg district of Berlin (including around 20 recharging points of various makes, large-scale battery, wind and solar plants)

COMMENCEMENT: 01 January 2012
CONCLUSION: 31 March 2014

Smartphone application "BeMobility Suite"

EUREF Campus at the gasometer in Berlin-Schöneberg

V / 03

» Suitability of electromobility for everyday use – Suitability and acceptance over long distances «

The demonstration project aimed to examine the suitability of electromobility over long distances under day-to-day operations. A main criticism of electric vehicles leading to a purchasing restraint of potential customers is their low range. To address this issue, various technical concepts including innovative recharging technologies were therefore tested in field trials as part of this project. Assessments were made in terms of energy efficiency and user acceptance. The main target groups were commuters needing to cover medium or long distances as well as service enterprises. With its high share of commuters and a heavily represented service sector, the Rhine-Ruhr Model Region provided excellent conditions for the fleet trial.

The project was based on a three pillar strategy to examine the topic of range under everyday conditions of use:

↗ The energy efficiency of the vehicles was analysed and improvement potentials were researched. The recovery of energy during braking (recuperation) represented a key area of focus.

↗ Comprehensive testing and examination of vehicles with range-extender drives was conducted in terms of their suitability for everyday implementation among users with above-average daily distances to cover.

↗ This was contrasted with tests and examinations of fast-charging vehicles. Accompanying this, the fast-charging infrastructure was expanded and the recharging stations examined in terms of their impact on the local energy supply networks.

The analysis of the various technologies was conducted taking technical and socioeconomic factors into account. 420 users – 70 more than originally planned – from a representative cross-section of the population with varying socioeconomic backgrounds and driving profiles, integrated electric vehicles in their daily routine. A fleet of 24 vehicles was procured for this purpose, equipped with precision measuring technologies for the recording of operating and driving data as well as energy flows. Most vehicles were procured by the end of 2012, enabling the field trials to commence in the first quarter of 2013 after the measuring equipment had been installed. The recorded vehicle operating data will provide important insights on the use of the vehicle. The information will be made available to the German automotive industry to help secure a leading position in this sector.

A total distance of more than 75,000 km was covered within the project. Examinations have shown that the fast-charging vehicles are perceived as an ideal replacement for a second vehicle. 85 % of testers of fast-charging vehicles conducted at least one fast charge. The range-extender vehicles, which are intended as a primary vehicle replacement, are regularly charged by users to maximise the amount of electric performance. Nevertheless, the complete battery capacity is regularly completely discharged so that the ratio of electric range coverage was at less than 50% – for both private and commercial users.

» With its high share of commuters and a heavily represented service sector, the Rhine-Ruhr Model Region provided excellent conditions for the fleet trial. «

PARTNERS:	PROJECT BUDGET/€	PROJECT FUNDING/€
Ruhr-Universität Bochum	541,794	541,794
Adam Opel AG	248,046	124,023
Delphi Deutschland GmbH	233,926	116,963
Franz Rüschkamp GmbH & Co. KG	138,172	69,086
GLS Gemeinschaftsbank eG	358,363	179,181
Stadtwerke Bochum Holding GmbH	53,972	26,986
USB Umweltservice Bochum GmbH	61,846	30,923

VEHICLES: 24 electric vehicles
INFRASTRUCTURE: 17 recharging points

COMMENCEMENT: 01 March 2012
CONCLUSION: 31 December 2014

Ampera i-MiEV

V / 04

» METROPOL-E «

For the first time, metropol-E developed and tested a recharging and fleet management system for the implementation of electric vehicles in a municipal fleet. Renewable energies were specifically used to enable mobility. The project consortium tested the operation of a fleet comprising ten electric vehicles and ten pedelecs in use by the city as well as two electric vehicles deployed by a company. During the project, a further 60 recharging points were added in the city area thereby expanding the recharging infrastructure in Dortmund to a total of around 150 RWE recharging points. Fast-charging stations were also installed and various user-friendly services relating to recharging were developed and tested.

Recognised by the federal government as a Lighthouse Project, the metropol-E electromobility test project has shown since the end of 2012 how local green energy can be used for recharging stations. Two solar power plants as well as two micro wind power plants were installed specifically for the municipal fleet and connected with very high capacity battery storage facilities at three locations in Dortmund. In this way, 67,000 kilowatt hours of wind and solar power have been used for recharging the electric vehicles to date. This occurs either directly at times when much green energy is available or from the battery storage when neither of the renewable energy plants is producing power. By the end of 2014, city council staff had travelled a total of 180,000 kilometres in the vehicles of the municipal fleet. The suitability of such vehicles for day-to-day deployment has thereby been successfully demonstrated. In comparison to modern diesel vehicles, savings of almost 30 tons of CO_2 emissions could thereby be made. This also means less noise and better air quality for this large city in the Ruhr region. It is an initiative that should set precedents: the city of Dortmund is preparing a concept for other municipalities that explains the things needing to be considered by city administrations from the guidelines for the procurement of the electric vehicles right through to planning for the establishment of recharging stations.

The project strongly relies on information and communication technologies. An energy management system controls the production of the energy, its storage in batteries and the intelligent recharging of the vehicles. A new booking tool also enables the municipal staff to choose the most efficient form of mobility for their needs. Depending on the total distance and location of a specific route, the booking software can combine the various mobility forms with electric car, bus and rail, on foot, bike or pedelec, or using a conventional passenger vehicle. Twelve electric cars, ten pedelecs and 60 new, networked recharging points comprise the foundation for the municipal electric vehicle fleet.

Two identical micro wind power turbines located on the Dortmund Stadthaus and the RWE building in Dortmund, each with a capacity of 6 kilowatt hours, have the potential to produce up to 7,500 kilowatt hours of wind energy each per year.

While the plant located on the Dortmund Stadthaus is connected to a 25 kilowatt hour battery storage system, the facility at RWE Effizienz is connected to storage measuring 200 kilowatt hours. A photovoltaic plant is additionally located at the RWE building, covering eight floors of the building façade, and boasts nominal power performance of 42 kWp. The depot of the city of Dortmund comprises the third location, featuring a 25 kilowatt hour green energy storage system and a smaller 8 kWp photovoltaic system.

The booking system for metropol-E vehicles is connected to an energy management system that also takes the recharging requirements into account. The recharging of the vehicles preferably takes place during scheduled downtimes when much green energy is available. At times when no vehicle is being recharged, rather than feeding the excess power into the electricity grid, as is commonly the case, the power is temporarily stored on site to ensure the electric vehicles can be recharged at any time.

The results available so far from individual partners show that: it is of significant importance for the city of Dortmund that the public, businesses, the research community and government are all involved in the technological urban development processes and that the available knowledge and experiences – along with critical thoughts – are all shared. Based on this proven process the subject of electromobility was integrated into the city's sustainability strategy – both in terms of the internal administrative processes of the metropol-E project and with the initiation of the external Electromobility Steering Committee. The project contents could be made more tangible and accessible for the broad general public through creative public relations activities such as photo competitions as well as so-called science and electromobility days. Not only could acceptance be raised by staff, it was also increased

among the community. It was precisely for these integrative activities that the city of Dortmund was awarded the German Sustainability Prize 2014 (Deutscher Nachhaltigkeitspreis). With its model characteristics, metropol-E will encourage other municipalities to reproduce this project.

RWE Effizienz GmbH is a leading operator of intelligent recharging infrastructure in Germany. 2,300 smart recharging points are connected with one another in Germany; in Dortmund there are currently around 150 active recharging points from RWE and other partners in this network. 60 of these recharging points were established specifically for the metropol-E project with three stations in Dortmund providing ultra-fast direct current recharging. RWE implemented the networking of the new recharging points within the national recharging network with a focus on the Ruhr region along the A40 motorway. The powerful RWE backend system guarantees reliable needs-based recharging of the municipal fleet. Construction and operation of the renewable energy plants with storage facilities and the development of the management software for the decentralised energy and recharging system in combination of the fleet was implemented by RWE.

PTV Planung Transport Verkehr AG continued the development of an idea put forward by the National Platform Electromobility (NPE) to develop a "residentially-oriented model for the sustainable establishment and promotion of electric recharging infrastructure" (SIMONE – "Siedlungsorientiertes Modell für nachhaltigen Aufbau und Förderung der e-Ladeinfrastruktur"). Universally applicable calculation formulas to establish the publically accessible recharging infrastructure demands and the locations differentiated according to types of areas are now available as a result.

The ie3 Institute of Dortmund Technical University promoted the creation of models for the differentiated examination of the managed and unmanaged recharging behaviour of electric vehicle fleets. The recharging of vehicles is regarded in combination with the integration of renewable energy and stationary batteries. The models will enable the target-oriented design of required system components. These include, for example, renewable energy plants and storage facilities.

Ewald Consulting provided a fleet management system for the administration and management of the electric vehicles for the project. At the same time, the implementation of interfaces for the transmission of relevant vehicle data to the system for the optimisation of recharging procedures took place.

PARTNERS:	PROJECT BUDGET/€	PROJECT FUNDING/€
RWE Effizienz GmbH	4,468,206	2,234,103
PTV Planung Transport Verkehr AG	679,520	339,760
Technische Universität Berlin	174,627	174,627
Technische Universität Dortmund	637,578	637,578
Stadt Dortmund	721,977	577,581
Ewald Consulting GmbH & Co. KG	547,400	328,440

VEHICLES: 10 electric vehicles plus 10 pedelecs and eScooters
INFRASTRUCTURE: 60 recharging points

COMMENCEMENT: 01 December 2011
CONCLUSION: 31 December 2014

Members of the project in the battery room at Flamingoweg, Dortmund

Dortmund's municipal fleet recharges with green energy

Dortmund's wind energy Stadthaus for electric vehicles

V / 05

» RUHRAUTOE: ELECTRIC VEHICLES AS A COMPONENT OF INTERMODAL MOBILITY «

RUHRAUTOe is the first e-carsharing project in Germany incorporating both local public transportation and a housing association in its project planning. The RUHRAUTOe consortium comprises the University of Duisburg-Essen, Drive-CarSharing GmbH, Vivawest Wohnen GmbH, Verkehrsverbund Rhein-Ruhr AöR and D+S Automotive GmbH. Also cooperating with the project are numerous municipalities in the Ruhr region, local energy suppliers, public and private initiatives and establishments as well as the private sector.

The project strongly pushes forward the funding policy objectives for the large-scale implementation and demonstration of electromobility, the establishment and development of new business models and the integration of electromobility in public transport.

Consequently, the primary goal of the project is to establish a sustainable demonstration and test platform of a multimodal mobility concept in the Ruhr region through an e-carsharing system that is tightly integrated with public transport. The project's research goals are broken down into further sub items. These goals include: to identify application areas for electromobility with high customer usage and drivers of acceptance; to develop an economically sustainable business model; to improve living conditions in peripheral urban areas; to gather subjective and objective data on typical driving habits; and to scientifically reveal the technical prerequisites.

RUHRAUTOe follows a traditional carsharing approach whereby the 20 PHEV and 40 BEV vehicles are available at 27 carefully selected and continually monitored public and private recharging stations in ten different cities in the Ruhr region. With nine different models, RUHRAUTOe currently boasts the most diverse e-carsharing fleet in Germany. To date, 1,600 private and public users have travelled a total distance of 325,000 kilometres and have thereby saved (in theory) 40 tons of (local) CO_2 emissions. Significant interfaces with local public transport were also identified and utilised for the project. Of particular note is that: the customer service centres of the local public transport authorities take care of the registration process; the VRR electronic tickets can be used as the access medium for the vehicles; and the RUHRAUTOe system was integrated in the electronic timetable information of the VRR.

In addition, numerous insights in regard to user acceptance, residential location-relevant aspects to mobility and potential business areas could be gathered, which form the foundation for a follow-up project. As such, the return of the vehicles is to be made more flexible, the private e-carsharing approach is to be implemented in residential areas and a one to six month "trial rental" period for companies is to be integrated in the business model as an integral component.

PARTNERS:	PROJECT BUDGET/€	PROJECT FUNDING/€
Verkehrsverbund Rhein-Ruhr AöR	249,650	124,825
Drive CarSharing GmbH	711,208	355,604
Universität Duisburg-Essen	561,600	561,600
D + S Automotive GmbH	85,565	42,782
Vivawest Wohnen GmbH	98,750	49,375

COMMENCEMENT: 01 September 2012
CONCLUSION: 31 October 2014

V / 06

» ELEKTROMOBILISIERT.DE «

The Elektromobilisiert.de project involved developing a service featuring corresponding software applications with the specific goal of supporting fleet operators to efficiently integrate electric vehicles in their fleets. The service encompasses: (i) a comprehensive analysis of existing fleets – especially in regard to existing cost saving and efficiency potentials, and (ii) the entire area regarding the integration of electric vehicles of all categories in existing fleets. A main focus of the project was to determine the most suitable degree of electrification in a fleet – taking both economic and ecological factors into account – which is to be assessed in terms of the individual mobility demands of each examined fleet. Furthermore, fleet operators should be given the possibility of testing electric vehicles in their own fleet for a limited period of time in order to avoid any potentially bad and costly investments from the outset.

Throughout the project, the fleets of nine partners were examined. The chosen methodology involved a five-step approach for the electrification of a fleet, which was continuously developed further and adjusted to the various demands of the fleets being examined.

In Step 1, the fleets were examined in terms of their function, use and exploited capacity. Driving data from conventional combustion engine-based vehicles – mainly in the form of analogue driving logs – was recorded, processed and evaluated. Building on the analysis of the existing mobility demands, Step 2 involved developing various electrification scenarios for the fleet, which besides the vehicles themselves also encompassed the fleet-side recharging infrastructure. The draft scenarios were then subjected to an economic and ecological evaluation. In Step 3, partners were trained in the use of the electric vehicles and the associated recharging infrastructure.

In order to validate the chosen electrification scenario, a phase of practical tests with electric vehicles was conducted in Step 4. Project partners were provided with various electric vehicles for a limited period during which their deployment and user/staff acceptance was monitored through accompanying research. This enabled the project partners to test the deployment of electric vehicles in their fleets without risk – without the need to actually procure the electric vehicles at this test stage.

As soon as the analysis and test phase was completed and the introduction of electric vehicles was assessed as being suitable – either cross-fleet or for certain areas – Step 5 then involved providing support in terms of procurement management for electric vehicles and the necessary recharging infrastructure.

The project results showed that from an ecological, economic and technical perspective it already makes sense to deploy electric vehicles in fleets today. All fleets examined in the project possessed the potential for electrifying at least part of the fleet.

Based on the individual analyses within the framework of the Elektromobilisiert.de project – and dependent on sufficiently high kilometres driven annually – it became clear that electric vehicles can contribute to overall cost savings in companies as the higher procurement costs are offset by the lower operating costs.

PARTNERS:	PROJECT BUDGET/€	PROJECT FUNDING/€
Fraunhofer-Institut für Arbeitswirtschaft und Organisation IAO	225,709	203,138
Universität Stuttgart	521,944	521,944
Langmatz GmbH	355,881	142,352

VEHICLES: 12 (Opel Ampera, Renault Twizy, Nissan Leaf, Renault Kangoo ZE)
INFRASTRUCTURE: Mobile recharging infrastructure from Langmatz GmbH for temporary project deployment in municipal and company fleets

COMMENCEMENT: 01 October 2011
CONCLUSION: 30 June 2014

V / 07

» E-MOBIL SAAR – ELECTROMOBILITY AS PUBLIC TRANSPORT: SAARLAND AS AN EXAMPLE «

The idea of a sustainable, networked mobility system with a focus on shared mobility has been taken up by the joint e-Mobil Saar research project and has begun to be developed in a first step.

As part of the project, 34 recharging stations with 68 recharging points could be successfully established across the whole of the state of Saarland at local public transport hubs. 20 e-carsharing vehicles situated at selected recharging stations can be used in a multi-modal manner via a so-called mobility card of the Saarland public transport authority (saarVV). Private electric vehicle drivers can recharge their vehicles barrier free with green power (Green Electricity Label Gold) at no cost at vacant recharging points – thereby providing an important initial impulse and incentive for an increased proliferation of private electric vehicles. The Saarfahrplan (Saar Timetable) app for Apple and Android smartphones was developed and introduced within the research project to enable easy routing and booking. With more than 60,000 downloads, the app is the ideal real-time mobility planner for public transport in Saarland with which e-carsharing vehicles can also be located and reserved.

A special milestone could also be achieved through the research project: in March 2013, with the e-Mobil Saar Mobility Card, saarVV became one of the first transport associations with a uniform local public transport card that could also be used as the key to access the e-carsharing vehicles. Together with the saarVV, Saarland (the smallest German state by area) can boast a state-wide integrated e-carsharing system together with a state-wide recharging infrastructure. Besides the development and demonstration of the e-Mobil Saar mobility system, insightful accompanying research was also conducted. This included an evaluation of user demands and an assessment of their experiences over the course of three phases of questionnaires. In addition, customer tests on the usability of the Saarfahrplan app were conducted. The surveys have shown that more flexible (e-) carsharing systems that are paired with better prices and easier registration processes can improve the acceptance of the mobility system. Furthermore, a higher degree of public awareness would help in this regard. The feedback received from customers for Saarfahrplan flowed directly into the continued development of the app. Overall, the app was widely accepted – a fact reflected by the high usage figures.

Besides acceptance criteria, technical aspects could also be promoted during the research project. In an e-Mobil Saar research project company vehicle, a self-developed onboard computer was deployed to record data from sensors and was also capable of reading vehicle data via the CAN bus (Controller Area Network) connection. On all trips with this vehicle, data could be collected in anonymised manner and retrieved – which continues to occur even after the conclusion of the project.

Business models were also developed and calculated within the research project. It was shown that the higher price of electric vehicles, the limited range and uncertainty on the service life of the battery remained as significant purchasing impediments – in stark contrast to the low maintenance costs. Ultimately economic aspects stand in contrast to ecological aspects, with a main focus being placed on the economic aspects.

A challenge for the research project was the state-wide expansion of the recharging infrastructure to a total of 34 recharging stations to establish the e-carsharing system – a task that proved to be difficult and burdensome especially considering the prescribed timing aspects. Due to varying interests of respective municipalities and public funding being coupled with specific tendering conditions, the establishment of the recharging infrastructure was delayed. The process was pragmatically conducted over two stages and tenders, enabling experiences and insights made from initial demonstrations from the first development phase to be taken advantage of in order to enhance the continued course of the project. Principally due to the foreseeable delay in the establishment of infrastructure, the research project was extended in a cost neutral manner for a year to ensure that the demonstration phase was successfully executed in conjunction with the accompanying socio-scientific research. A significant project conclusion was that a very substantial amount of time and effort must be invested in planning and consultation for the realisation of establishing a public recharging infrastructure using public funding.

The e-Mobil Saar project required quite some courage of all parties involved: in a state boasting the highest levels of vehicle density in a national context, with significant levels of private vehicle ownership and with a partly very urban structure but simultaneously also with a very rural landscape, the vision of mobility as the e-Mobil Saar project took up, was not easy to implement. This was reflected in the initially low utilisation figures of the e-Mobil Saar fleet. The project was an experiment to ascertain to what extent e-carsharing can work in a rural region and where the boundaries exist so that these can be overcome or removed in the future. Research partners are currently jointly developing ideas to be taken up in a follow-on project.

PARTNERS:	PROJECT BUDGET/€	PROJECT FUNDING/€
DB FuhrparkService GmbH	2,494,896	1,247,448
IZES gGmbH (Institut für ZukunftsEnergieSysteme)	892,082	802,874
VGS Verkehrsmanagement-Gesellschaft Saar mbH	497,752	248,876
Ministerium für Wirtschaft, Arbeit, Energie und Verkehr des Saarlandes (MWAEV)	791,022	791,022

VEHICLE: 20 e-carsharing vehicles
INFRASTRUCTURE: 34 recharging stations with 68 recharging points

COMMENCEMENT: 01 June 2011
CONCLUSION: 31 May 2014

Site at the main bus station/Kleiner Markt in Saarlouis

European Cooperation

In order to create the relevant long-term and sustainable conditions for electromobility development in Europe, the transnational funding initiative Electromobility+ was launched, with the participation of public funding programmes from eleven countries: France, Germany, the Netherlands, Austria, Finland, Norway, Sweden, Denmark, Poland, Belgium and Italy.

Through the opening up of these regional and national programmes for transnational cooperation, their research activities were networked in order to thus generate a European added value.

In addition to the total of 15 million euros from national funding, the EU is providing up to 7.3 million euros for the subsidised programmes in the framework of the ERA-NET Plus programme.

Funding areas include research projects on political and regulatory aspects of electromobility as well as technology-based and experimental research.

The project funding within Germany is undertaken by the Federal Ministry of Transport and Digital Infrastructure (Bundesministerium für Verkehr und digitale Infrastruktur – BMVI) and the Federal Ministry of Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie – BMWi). TÜV Rheinland is responsible for the overall coordination of the transnational Electromobility+ initiative.

V / 08

» EVERSAFE – EVERYDAY SAFETY OF ELECTRIC VEHICLES «

The overriding goal of the EVERSAFE project was to record the safety requirements of electric vehicles (EVs), taking into account new electro-specific designs, and to develop suggestions for adjustment. The research topics dynamic driving stability, battery safety and the behaviour of EVs during and after serious road accidents were worked on in two subprojects. In addition, a review of literature and two focus groups evaluating user assessments of EV safety were conducted. Various user concerns in terms of driving, recharging, road accidents and EV component aging were identified from both experienced and inexperienced user groups.

Subproject 1

Driver reactions to two EV system errors (wheel-hub motor error, failure of recuperation) and the thereby associated changes to driving dynamics were examined.

During trials in a driving simulator (110 km/h) and on a test track (30 km/h), almost all test persons noticed the wheel-hub motor error but this was only rated in the simulator as being more disturbing or hazardous than the baseline measurement. The majority of test persons compensated the error through an adjustment of steering angle and use of the accelerator to work against the lag caused by the error.

The results of the field study on the recuperation error showed that only half of all test persons registered this occurrence. While the error was assessed as being hazardous, almost all test persons could compensate for this error without increased stress perception.

Both system errors were compensated through suitable driving behaviour by the test persons so that the vehicle remained stable at all times. Recommendations for action for the safety requirements of EVs in the area of driving dynamics are therefore not needed at this point in time.

Subproject 2

Crash test compatibility (EVs crashing with conventional vehicles) and the behaviour of the high voltage energy storage systems in EVs during accidents were examined using various computer simulations and experimental trials on both a cell and an overall vehicle level.

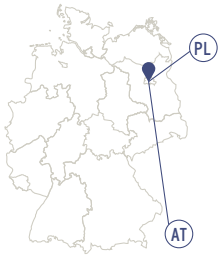
The tested battery cells demonstrated very good safety behaviour characteristics along with a high level of sturdiness during standard testing procedures. Deviations from these standards partly led to violent reactions. Nevertheless, no conclusions can be drawn directly from those results on the behaviour of the overall system. However, simulated collision tests with a generated EV model and overall vehicle tests allowed the conclusion to be drawn that the tested EVs exhibited safety levels that were (at least) comparable to conventional vehicles.

The test results were used to formulate suggestions for changes to laws and test procedures, as well as for continuing the development of existing procedural guidelines for fire departments in cases of serious road accidents involving EVs.

PARTNERS:	PROJECT BUDGET/€	PROJECT FUNDING/€
Bundesanstalt für Straßenwesen (BASt)	329,282	329,282
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V.	356,500	320,850
Technische Universität Chemnitz	237,682	237,682

EUROPEAN PARTNERS:
- ↗ VTI (Swedish National Road and Transport Research Institute)
- ↗ KTH (Royal Institute of Technology)
- ↗ VCC (Volvo Car Corporation)

COMMENCEMENT: 01 May 2012
CONCLUSION: 31 December 2014



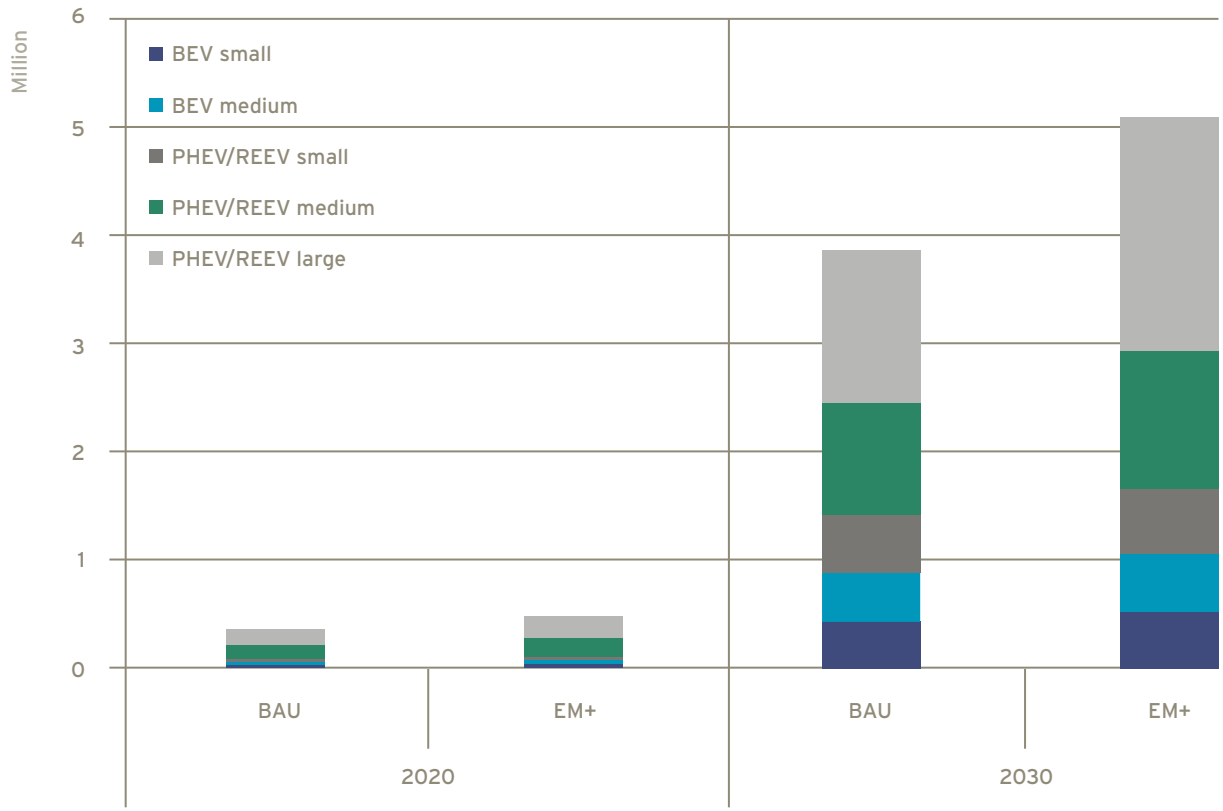
V / 09

» DEFINE – DEVELOPMENT OF AN EVALUATION FRAMEWORK FOR THE INTRODUCTION OF ELECTROMOBILITY «

How is the number of electric passenger vehicles developing in Germany? What impact does the use of electric vehicles have on the electricity supply system and the exploitation of power plant capacities in Germany? And what changes can be seen in the levels of CO_2 emissions when electric passenger vehicles are used?

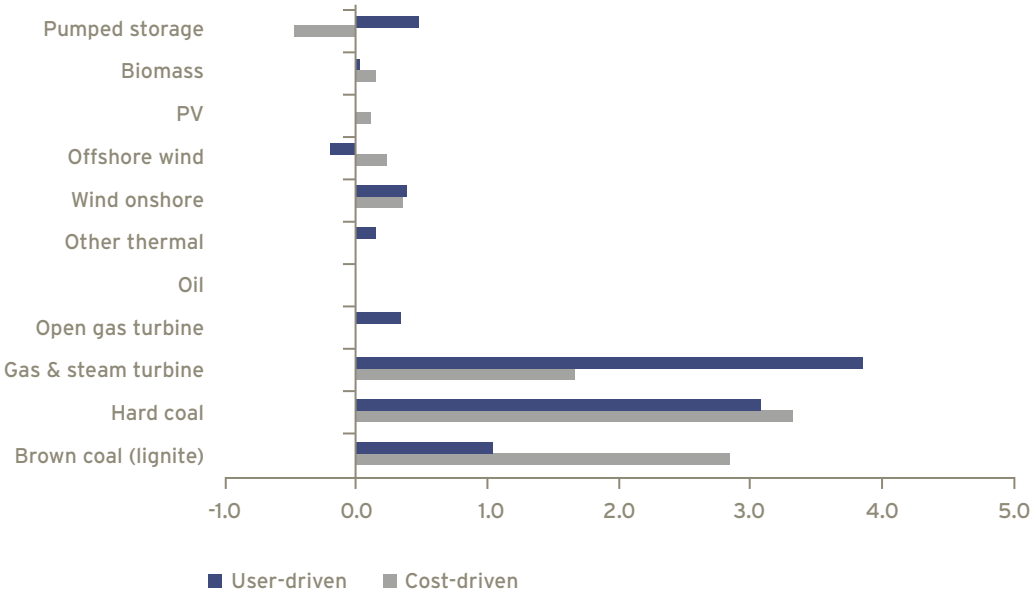
These were questions that the Oeko-Institut for Applied Ecology (Öko-Institut für angewandte Ökologie e. V.) and the German Institute for Economic Research (DIW Berlin – Deutsches Institut für Wirtschaftsforschung Berlin) devoted themselves to answering as a part of the project over two years. As part of the process, the market potentials of electromobility and the effect on electricity production in Germany were derived for a period spanning to 2030. Besides the development of two market scenarios for electric passenger vehicles, the effects that the higher electricity demand would have on the methods of power generation were evaluated and a carbon footprint assessment for electromobility in Germany was made.

Two scenarios for the market development of electric passenger vehicles were derived. The Business-As-Usual (BAU) scenario assesses the development on the basis of today's framework conditions and policies. Meanwhile, in the Electromobility+ (EM+) scenario, additional assumptions were made for deriving vehicle numbers based on various potential policy instruments such as increasing fuel taxes; introducing a so-called "feebate" system to promote the sale of low emission vehicles; and ambitious goals for regulating CO_2 emissions on a pan-European level. With the evaluation of representative empirical data, vehicle requirements were also taken into account that can be derived from today's driving habits and a purchasing decision was simulated using a conjoint analysis. The BAU scenario sees that there will be a total of 3.9 million electric passenger vehicles by 2030. With the additional promotional measures incorporated in the EM+ scenario, the number rises to 5.1 million (see diagram). Plug-in hybrid and range extender vehicles, which feature a combustions engine in addition to the electric drive, represent the majority of the vehicles.



Number of electric passenger vehicles in Germany 2020/2030

The impact the integration this vehicle fleet would have on the German power system was examined using a numerical dispatch model. Of particular use for input parameters was data from the German network development plan for conventional and renewable power generation capacities. Two extreme recharging strategies were differentiated: completely "user-driven" recharging where electric vehicles are fully recharged as quickly as possible as soon as they are connected to a recharging point; and "cost-driven" recharging where recharging takes place within limits set out in the vehicle profile in order to exploit periods of low electricity costs. The annual energy consumption of the modelled electric vehicle fleet is low when compared with overall power consumption, yet the hourly recharging performance can be very high. In the user-driven mode, vehicles are predominantly recharged during the day or in the evening, which can lead to a problematic increase in peak loads in the power system. The cost-driven mode, in contrast, sees most recharging taking place during the night. This, in turn, helps to exploit the capacities of coal and lignite power plants significantly better. In the user-driven mode, meanwhile, the additional power required predominantly originates from natural gas or coal-fired power stations (diagram below).



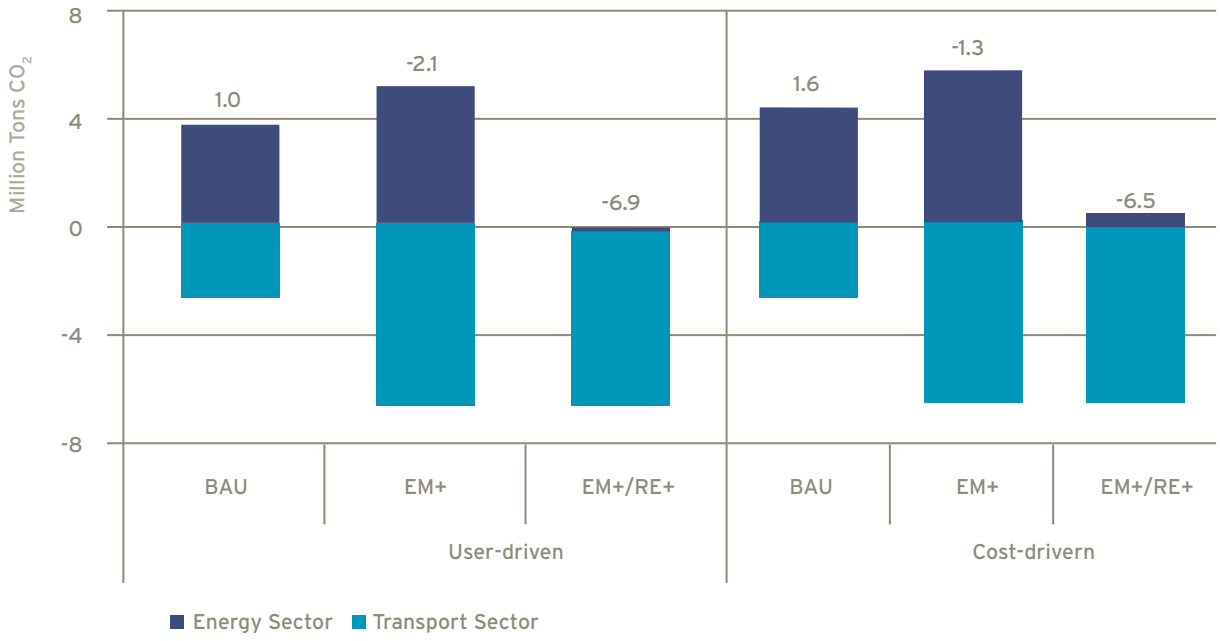
Changes to power plant usage in comparison to scenario without electromobility (in the year 2030, EM+ scenario)

The CO_2 emissions arising from the additionally generated power are significantly higher in most scenarios than the average CO_2 emissions of the overall power mix. The reason for this is that the slight improvement of the integration of renewable energy into the energy system through the use of electric vehicles is offset by an increase in coal-based power generation. The emissions are especially high in the case of cost-driven recharging as this opens up the enticing possibility of using the inexpensive yet high-emission coal-based electricity. Only if the introduction of electromobility is accompanied by a corresponding expansion of renewable energy capacities can a rise in the levels of emissions in the energy sector be avoided.

The use of electric drives that produce no direct CO_2 emissions themselves reduces emissions in the transport sector. Offsetting this, however, is that CO_2 emissions in the power sector will increase due to higher power demands. For this reason, the net carbon foot-

print, taking the impact of electromobility on the energy and transportation sectors into account, was established to assess how the CO_2 emissions change in comparison to a scenario without electromobility.

In the BAU scenario, the effect of the additional emissions in the energy sector is larger, entailing that the sum of emissions in both the energy and transport sectors is greater than without electromobility. Meanwhile, in the EM+ scenario, the net emissions reduce compared to the base scenario. This is the result, however, of the assumption of ambitious anticipated future CO_2 emissions standards for more efficient conventional vehicles in comparison to those in the base scenario. The potential to reduce CO_2 emissions can only be fully exploited when additional renewable energy production capacities are available, in comparison to those in the base scenario. As such, the introduction of electromobility must go hand-in-hand with an adjustment and expansion of renewable energy if electromobility is to have anything like an overall neutral carbon footprint. In order to ensure coal or lignite-fired power plants do not produce the additional power, we must increase the plans for expansion of renewable energy from the levels currently planned.



Net carbon footprint of the energy and transport sector for various scenarios (in millions of tons CO_2) in comparison to the base scenario without electric passenger

PARTNERS:	PROJECT BUDGET/€	PROJECT FUNDING/€
Deutsches Institut für Wirtschaftsforschung Berlin	204,635	204,635
Öko-Institut für angewandte Ökologie e. V.	139,344	125,410

EUROPEAN PARTNERS:
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- ↗ Technische Universität Wien, Österreich
- ↗ Umweltbundesamt, Österreich
- ↗ CASE – Center for Social and Economic Research, Polen

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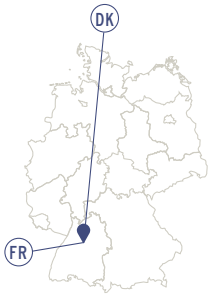


» EV-STEP: SUSTAINABLE TECHNICAL AND ECONOMIC PATHWAYS FOR ELECTRIFIED MOBILITY SYSTEMS IN EU28 BY 2030 «

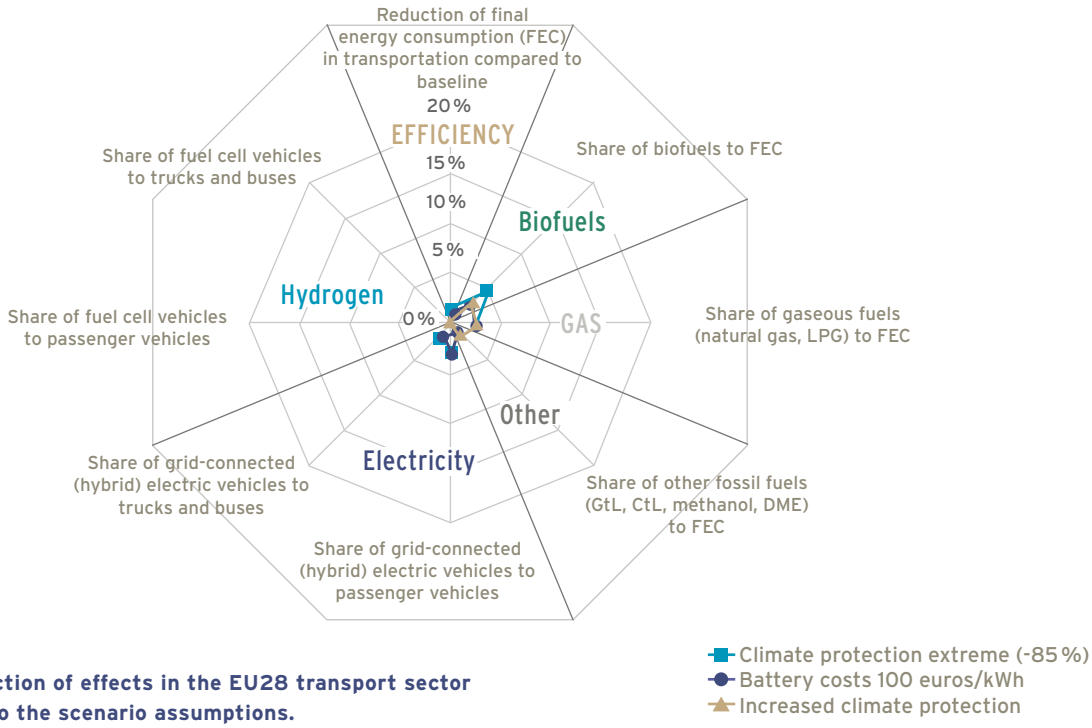
As part of the EV-STEP project, the long-term perspectives of various electric drive concepts and their impact in both a national and pan-European level were to be analysed. The evaluation of sustainable developmental options for the transport sector represents a complex issue. Electric vehicles can play an important role in this regard: they can reduce the dependency on fossil fuels, increase energy supply flexibility, boost energy efficiency in end-user sectors while also significantly reducing the emission of greenhouse gases and other pollutants in the transport sector.

Due to the wide-ranging linkages of electromobility within the energy system, special care must be exercised that any evaluation of the developmental opportunities of electric vehicles occurs within consistent terms of reference. For this purpose, the European energy system model TIMES PanEU was further developed and the role of electromobility was examined using a scenario analysis.

The scenario analyses conducted within the project show that alternative drives and fuels can play an important role, in the long term, within the transport sector of Germany and EU28, depending on prevailing energy and environmental policy framework conditions as well as the technological advancements that are attained. Important influencing factors in regard to their marketability have proven to be the strictness of climate protection targets expressed as the respective greenhouse gas reduction goals and the attainable decreases in costs in the area of battery technology.

However, in all scenarios examined, significant substitution effects between conventional and alternative fuels and drives can only be seen from 2030 at the earliest. In earlier years, and with greenhouse gas certificate prices at mostly less than €50/t CO_2eq, the avoidance of greenhouse gases in other areas of the energy sector is economically more viable – whereby in the case of alternative drive technologies and the production processes for alternative fuels, a substantial portion of the technical and economic developmental potential appears to have already been attained.

The diagram below shows a summary of the effects in the EU28 transport sector in 2030, subject to the scenario assumptions. Nevertheless, biofuels account for a share of 6 % by 2030 under distinctly ambitious greenhouse gas reduction targets (scenario "climate protection extreme").



Summarised depiction of effects in the EU28 transport sector in 2030 subject to the scenario assumptions.

Grid-connected electric vehicles such as BEVs and PHEVs play no significant role until 2030 in reaching energy and climate policy goals under all the scenarios assuming a free choice of technology. Even less significance is evident in the case of fuel cell-based electric vehicles in 2030, which until this point in time are not deployed in neither the areas of passenger vehicles, nor commercial vehicles or buses.

The significance of alternative fuels and drives will continue to increase in the transport sector until 2050. The chief reasons for this include continued advances in technology enabling a reduction of the additional costs in comparison to conventional drives, as well as continuously enhanced greenhouse gas reduction targets – which in part will push greenhouse gas certificate prices well over €300/t CO_2eq.

Irrespective of other framework conditions and with an ambitious climate protection target (greenhouse gas reduction of 75 % by 2050 compared with 1990 levels), biofuels will play a continued decisive role in the transport sector in 2050. Their share of the final energy consumption in the EU28 transport sector extends from just short of 30 % to more than 50 %. Road freight with heavy-duty vehicles represents a main area of deployment as well as aviation, as the availability of other alternatives to reduce greenhouse gas emissions in this area is limited.

Another sharp increase can be observed in the share of grid-connected electric vehicles such as BEVs and PHEVs in the overall vehicle numbers. Here, strict climate protection targets and the attainable reductions in costs of battery technology are particularly influential for the marketability of these drive concepts. But even with a less extreme greenhouse gas reduction target of 75 % in 2050 over 1990, and without any further energy policy and technical framework conditions that economically benefit grid-connected electric vehicles ("increased climate protection" scenario), these drive concepts reach a market share of 19 % in the case of passenger vehicles and 10% for commercial vehicles and buses.

» Strict climate protection targets and the attainable reductions in costs of battery technology are particularly influential for the marketability of these drive concepts. «

In contrast, even in 2050, fuel cell-based electric vehicles will not take on a dominating role in any of the scenarios examined. The reason for this low market relevance in comparison to battery-electric vehicles lies less so in the high initial investment for the vehicle, but rather in the high costs involved in producing hydrogen and the lower greenhouse gas reduction potentials. The latter is the result of, on the one hand, the higher specific energy consumption of the fuel cell-electric drive combination in comparison to a battery-electric motor, and on the other hand, due to the production of the hydrogen (predominantly electrolysis, coal gasification with CCS and as a by-product of industrial chlorine production).

Gaseous fuels such as LPG and natural gas also play no major role in 2050, irrespective of the framework conditions. The situation is similar with Fischer-Tropf fuels based on fossil energy sources (coal), which only comprise a 27 % share of final energy consumption with limited oil and gas availability.

In respect to the overall volume of energy consumption in the EU28 transport sector, a strong correlation can be observed in regard to the share of electric drive concepts to overall vehicle numbers. The more this share increases, the more strongly final energy consumption reduces compared to the baseline level.

Significant policy efforts are currently underway in Germany and other EU countries to promote electromobility on the roads, with the goal of reducing the costs of the technology and to accelerate market introduction. The results of the scenario analysis confirm that an accelerated reduction in prices, in particular in the area of battery technology, can significantly increase the market share of electric drive concepts such as BEVs and PHEVs in the long term. The promotion and support of research and development in this area, such as being done, for example, in Germany's Innovation Alliance Lithium-Ion Battery (LIB 2015) within the framework of the government's high-tech strategy, can be seen as making an important contribution in this regard.

The scenario analysis results, however, also simultaneously highlight that an economically viable expansion of grid-connected (hybrid) electric vehicles will not occur until 2030 at the earliest and that only in the years following, until 2050, will significant market shares compared to existing passenger and commercial vehicles be achievable.

PARTNER:	PROJECT BUDGET/€	PROJECT FUNDING/€
Universität Stuttgart	129,607	129,607

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↗ Technische Universität Dänemark – DTU Risø Campus, Dänemark
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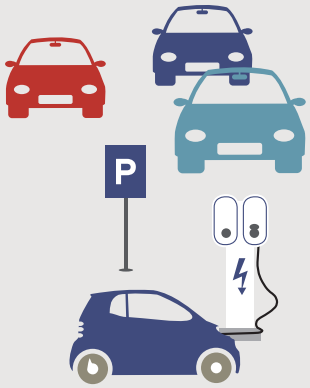

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