Annual Report **2016**

NOW
National Organisation
Hydrogen and Fuel Cell Technology

NOW – Annual Report **2016**

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Foreword by Federal Minister Alexander Dobrindt MdB

We are currently living through the greatest mobility revolution since the invention of the car. Automated driving is already on the starting blocks. Transport is becoming interconnected. The triumph of alternative drives has begun. Mobility will change more over the next five to ten years than in the previous decades.

No one wants to miss this revolution. All major countries want to be first. What we are now experiencing is new international mobility competition. Hydrogen and fuel cells are at the forefront as key future energy sources. In every innovation centre – from Silicon Valley to Asia – people are working tirelessly to secure the lead.

Our approach must be to position ourselves at the top of the hydrogen and fuel cells market, and ensure that we emerge the winners in this new competition. We have already achieved much along the way. To date we have provided 1.5 billion euros to fund the drive transformation and have created the National Organisation Hydrogen and Fuel Cell Technology (NOW), an important institution for the coordination of our activities.

Now the task at hand is to lend more momentum to the market ramp up of alternative drives. So, we in the federal government have put together a strong set of measures with three central points:

1. We are driving the development of a nationwide charging and refuelling infrastructure for electricity and hydrogen. For these new technologies to be successful, drivers need to be sure that their vehicles can be recharged or refuelled anywhere, anytime. That is why we are now constructing 400 electric fast-charging points along motorways and have begun a new funding programme totalling 300 million euros for the installation of another 15,000 charging points throughout Germany. Together with industry we are also creating a comprehensive network of 400 hydrogen refuelling stations by 2025, allocating 350 million euros to build the world's first national network for refuelling fuel cell vehicles with hydrogen.

2. We are creating record growth in funding for hydrogen mobility and continuing the success story of the first National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP). In 2017 alone, we are investing over 60 million euro, and are allocating around 90 million euro, for NIP II in 2018 and again in 2019. That means that in total we will invest around 250 million euros in hydrogen and fuel cells by 2019.

3. We are funding hydrogen innovations and getting them on the road. Our objective is to bring hydrogen and fuel cells to different fields of application. This includes hydrogen buses in urban transport, vehicles in logistical and commercial transport, as well as rail vehicles in local public transport. In addition we are supporting the construction of the automotive industry's own fuel cell production facilities in Germany in order to cover the entire value chain of hydrogen mobility going forward.

I am convinced that the future belongs to alternative drives. Germany is the driving force here and is ready to assume the role of innovation leader. NOW is an indispensable partner on this journey and will continue to decisively contribute to leading us to the competitive pinnacle of mobility 4.0.

Alexander Dobrindt MdB

Federal Minister of
Transport and Digital Infrastructure


Flensburg
Cuxhaven
Elmshorn
Preetz
Kiel
Rügen
Stralsund
Rostock
Norderstedt
Hamburg
Schwerin
Emden
Eberswalde
Bremen
Lübeck
Neubrandenburg
Wilhelmshaven
Wesel
Hannover
Magdeburg
Bochum
Essen
Düsseldorf
Osnabrück
Berlin
Jena
Cologne
Wuppertal
Potsdam
Cottbus
Gera
Aachen
Dortmund
Erfurt
Dresden
NOW
Görlitz
Eisenach
Leipzig
Bonn
Fulda
Weimar
Halle
Chemnitz
Frankfurt
Hof
Mainz
Schweinfurt
Bamberg
Karlsruhe
Würzburg
Roth
Bayreuth
Wiesbaden
Offenbach
Mannheim
Nürnberg
Trier
Heidelberg
Erlangen
Regensburg
Heilbronn
Passau
Stuttgart
Weiden
Cham
Offenburg
Albstadt
Ingolstadt
Freiburg
Ulm
Augsburg
Stockach
Kempten
Biz
Villingen
Munich
Wehr
Konstanz
Memmingen
Inzell
Lörrach
Alps

NOW

NOW GmbH National Organisation Hydrogen and Fuel Cell Technology is responsible for the coordination and management of the federal government's National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP) and the electric mobility funding guideline of the Federal Ministry of Transport and Digital Infrastructure (German abbrev. BMVI). Both programmes are designed to prepare the market for the technologies. Research, development and mainly demonstration activities are funded.

The primary task of NOW is to initiate projects, evaluate proposals and to bundle projects in such a way that synergy effects can be exploited. NOW also undertakes so-called cross-sectional tasks. These include topics such as production technologies, further education and training, international collaborations, communication at the interface of politics, industry and science as well as public relations, in order to increase overall awareness of the technologies and their perspectives.

Commissioned by the BMVI, NOW is also responsible for the further development of the Mobility and Fuel Strategy (German abbrev. MKS), the implementation of EU Directive 2014/94/EU on the deployment of alternative fuel infrastructure (CPT – Clean Power for Transport) as well as the implementation of the recharging infrastructure programme for mobility. Specifically NOW supports the development of an overall strategy for individual fuel options, examines the positions of the relevant actors and coordinates projects which have German participation including those in the framework of trans-European transport networks (TEN-T).


P
Local electric mobility

Local electric mobility

Through the Electromobility Model Regions programme, the Federal Ministry of Transport and Digital Infrastructure (BMVI) supports cross-sectoral cooperation of industry, science and the public sector in order to promote the entrenchment of electric mobility in everyday life.

Electric mobility funding extends to all main areas of activity. Therefore in addition to individual projects, superordinate topics are dealt with in scientific accompanying research. Here all aspects of electric mobility are considered, beginning with the user perspective, to the further development of the drive and vehicle technology issues of safety and infrastructure, integration of electric mobility in public and company fleets, right up to questions on spatial and urban development and regulatory law.

With the funding guideline on battery-electric mobility running until 2019, the Federal Ministry of Transport and Digital Infrastructure is specifically targeting its support towards municipal actors in the development of local electric mobility using all modes of transport. Building on the Electromobility Model Regions funding programme, the market ramp up of vehicles with electric drives as well as the necessary infrastructure will therefore be advanced in the strategic field of local mobility and logistics.

Federal Ministry of Transport and Digital Infrastructure

ELECTROMOBILITY MODEL REGIONS – SECTORS OF APPLICATION (AS AT DECEMBER 2016*)

SECTOR OF APPLICATION	BUDGET IN THOUSANDS OF €	FUNDING IN THOUSANDS OF €
ORGANISATIONAL STRUCTUES	8,850	5,136
INTERNATIONALISATION &	6,468	6,023
EU NETWORKING	27,738	11,714
PUBLIC TRANSPORT (RAIL)	82,545	40,841
DRIVE AND ENERGY SUPPLY VEHICLE		
AIRPORT APPLICATIONS	13,169	6,897
ACCOMPANYING RESEARCH & STUDIES	38,555	33,952
RECHARGING INFRASTRUCTURE	53,349	28,870
PUBLIC TRANSPORT (BUSES)	50,029	26,068
TRANSPORT NETWORKING/INTERMODALITY	41,468	25,690
COMMERCIAL TRANSPORT	107,910	58,131
PERSONAL TRANSPORT	99,185	56,684
VEHICLE & RECHARGING INFRASTRUCTURE	33,788	14,418
PROCUREMENT		
ELECTRIC MOBILITY CONCEPTS	4,658	3,347
TOTAL	567,712	317,771

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


H
NIP

NIP

To accelerate the development of hydrogen and fuel cell technologies to market maturity in various application areas, the federal government and states along with industry and science started the ten-year National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP) in 2006, allocating a budget of 1.4 billion euros. Half of this sum is provided by the federal government – the Federal Ministry of Transport and Digital Infrastructure (BMVI) and the Federal Ministry for Economic Affairs and Energy (BMWi) – and the other half by participating industry. The programme has successfully contributed to creating technology standards, reducing costs and improving the reliability of the technology.

In September 2016 the federal cabinet adopted the hydrogen and fuel cell technology government programme for the period of 2016 to 2026. This denoted the commencement of the second phase of the successful NIP programme (NIP II). The continuation of the interdepartmental NIP firstly secures continuity for research and development, and secondly provides support for market activation through the development of corresponding products. NIP is implemented through the relevant actions of the participating federal ministries. The Federal Ministry of Transport and Digital Infrastructure (BMVI) is initially allocating 250 million euros to the support of hydrogen and fuel cell technology until 2019. The Federal Ministry for Economic Affairs and Energy (BMWi) is continuing its funding of hydrogen and fuel cell technology in the area of applied research and development within the 6th Energy Research Programme with around 25 million euros annually. In addition the BMWi has set up a funding programme under the National Action Plan on Energy Efficiency (NAPE) for the purchase of fuel cell heating devices for private customers. NIP continues to be supported by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) as well as the Federal Ministry of Education and Research (BMBF).

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

Federal Ministry
of Transport and
Digital Infrastructure

The Federal Ministry of Transport and Digital Infrastructure in NIP

The federal government has been funding hydrogen and fuel cell technology in the National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP) for 10 years. The federal government and industry have invested a total of 1.4 billion euros in the period 2006-2016 in hydrogen and fuel cell projects for mobile and stationary applications. During this period, the BMVI allocated 500 million euros for this purpose.

Because of its huge success, the federal government has adopted the hydrogen and fuel cell technology government programme for the period of 2016 to 2026 and is continuing funding. The BMVI alone is providing almost 250 million euros of funding for this (2016 – 2019).

NIP – SECTORS OF APPLICATION (AS AT DECEMBER 2016 *)

SECTOR OF APPLICATION	BUDGET IN THOUSANDS OF €	FUNDING IN THOUSANDS OF €
TRANSPORT & INFRASTRUCTURE	565,215	268,839
HYDROGEN PROVISION	25,011	12,404
STATIONARY INDUSTRY	70,686	34,497
STATIONARY HOUSEHOLD	125,665	58,249
SPECIAL MARKETS	108,779	51,875
INTERDISCIPLINARY THEMES	23,786	12,038
TOTAL	919,142	437,901

* Figures refer to BMVI funding for projects from 2008 onwards.

Federal Ministry
for Economic Affairs
and Energy

The BMWi is funding application-oriented R&D projects under NIP

The Federal Ministry for Economic Affairs and Energy (BMWi) is funding applied research and technological development in all energy technologies (except bioenergy and nuclear energy research) under the 6th Energy Research Programme. The entire energy chain will be represented, from energy provision and conversion, to transport and distribution, including storage, right up to energy consumption in a variety of sectors. One of the BMWi's funding priorities is fuel cells and hydrogen technologies.

NIP — SECTORS OF APPLICATION (AS AT DECEMBER 2016 *)

SECTOR OF APPLICATION	BUDGET IN THOUSANDS OF €	FUNDING IN THOUSANDS OF €€
TRANSPORT & INFRASTRUCTURE	148,537	77,525
HYDROGEN PROVISION	24,367	16,318
STATIONARY INDUSTRY	34,088	17,276
STATIONARY HOUSEHOLD	55,534	29,746
SPECIAL MARKETS	27,984	16,320
INTERDISCIPLINARY THEMES	58,998	38,155
TOTAL	349,508	195,340

* The information refers to BMWi funds for projects since 2011.

International Cooperation 2016

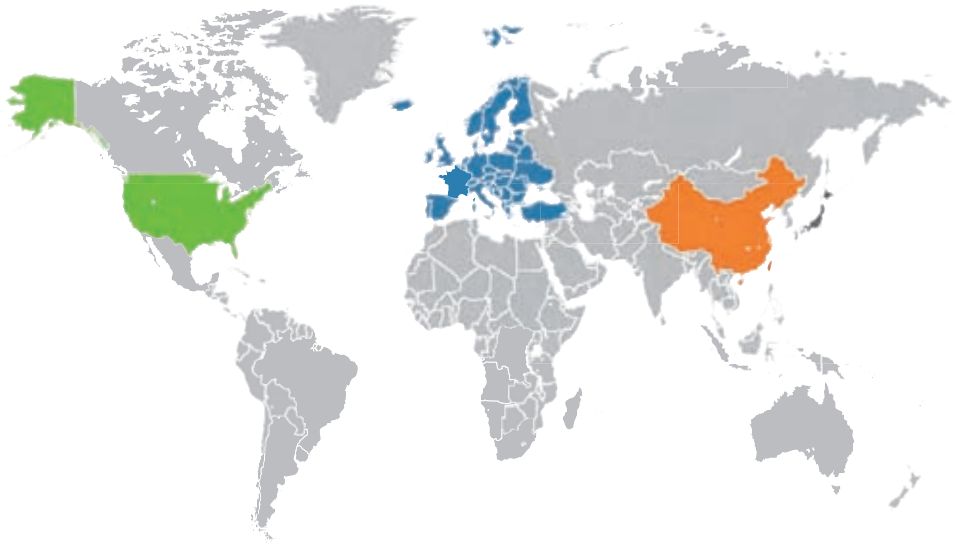
Germany will continue to play its part as an active proponent and driving force of a hydrogen economy on a global basis. The main partners in this effort include the US, Japan, the European Commission and and some EU member states with which NOW has nurtured closed cooperation over many years. China is also becoming more important in this regard. Furthermore NOW is active in international organisations such as the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) as well as the International Energy Agency (IEA).

Europe

The overall goal of the activities and partnerships on the European level is to establish Europe-wide suitable framework conditions for a hydrogen and fuel cell economy in the context of the energy transformation and climate protection. Therefore incorporating renewable energies into the entire energy system is the focus of activities. In 2016, such activities included in particular the implementation of the EU directive on the deployment of an alternative fuels infrastructure (AFID) as well as the adoption of the winter package.

In the implementation phase of the AFID, member states within the Government Support Group (GSG) had in-depth discussions in sub-working groups. NOW assumed the role of Secretariat and coordinated the working groups on behalf of the BMVI. In this context and also commissioned by BMVI, NOW developed Commissioned by the BMVI, in this context NOW also developed the National Strategic Framework to expand infrastructure for electricity, hydrogen, and to a lesser extent, gas, and coordinated this with neighbouring countries. The German strategic framework was adopted by the cabinet in the summer and then submitted to the European Commission within the deadline (18 November 2016).

On 30 November 2016,the European Commission (henceforth: Commission) presented a more than 4,000-page comprehensive package of various documents. Some are evaluations and assessments of the status quo. Others pertain to concrete proposals for modifying and adapting the existing legal framework for the period beyond 2020. The proposals in the so-called “winter package” are to help achieve European climate goals. They should also serve the goals of the energy union, i.e. guarantee a secure, affordable and climate-friendly energy supply. A fully-integrated internal market for energy is to be a central aspect. The Commission’s proposal also includes initial approaches to couple the sectors of power, heat and transport (storage technology, network subservience of



electric mobility) that are or could be relevant to battery, hydrogen and fuel cell technology. This affects not only the transport area, where green hydrogen (i.e. hydrogen from renewable energy, like wind energy) can be used as a fuel or as a raw material in the refinery to generate diesel. In fact changes in the heating sector are currently under consideration, where fuel cell cogeneration systems could lead to efficient supply of heat and electricity. NOW will continue to monitor the legislative process closely and advises the BMVI on transport matters.

China

Based on a joint declaration of cooperation in the electric mobility area as well as hydrogen and fuel cell technology between the BMVI and the Chinese Ministry of Science and Technology (MOST) in October 2014, the organisations commissioned by the respective ministries, China Automotive Technology & Research Center (CATARC) and NOW, signed the cooperation declaration in April 2016 in the presence of Minister Wan Gang (MOST) and Minister Alexander Dobrindt (BMVI).

Cooperation on the issues of bilateral cooperation will be formalised: battery-electric mobility, increasing scientific exchange and building up a partnership in the area of hydrogen and fuel cell technology, with a focus on the transport sector. To this end the virtual centre, Sino German Electro-Mobility Innovation and Support Center (SGEC), is to be developed, under which German-Chinese projects will be carried out in future. These will be open to all national partners and are structured according to specific subject areas.

In its most recent energy development plan until 2020, China has defined hydrogen and fuel cells as being one of the key technologies for achieving climate goals and wishes to catch up with other global regions in this area. With CATARC a Chinese representative participated for the first time as an observer in the International Workshop on Hydrogen Transportation and Infrastructure which took place in May (see below).

USA and Japan

Together with the US Department of Energy (DoE), the Japanese New Energy and Technology Development Organization (NEDO) and the Joint Research Centre (JRC) of the European Union, NOW organised the 4th International Workshop on Hydrogen Infrastructure and Transportation. At the workshop in May 2016 in Petten (Netherlands), over 60 technical experts took part from the US, Japan and Europe including Scandinavia and Germany, in order to discuss the current challenges in implementing international standards for hydrogen refuelling stations. In addition to China, South Korea also took part for the first time as an observer.

In the workshop the demand for laboratories for measuring hydrogen quality according to international standards was established as well as a harmonised certification of hydrogen refuelling stations, ideally with accepted test devices from car manufacturers. An international harmonisation of equipment and material standards for the systems would be welcome. This would have a positive effect on costs, on procurement and downtimes would be lessened through faster availability of spare parts.

Japan

Japan is continuing to develop into one of Germany's most important partners in order to further advance hydrogen and fuel cell technology in an international context. Besides to the continuous meetings with various Japanese stakeholders in the margins of the Fuel Cell Expo, NOW was also involved as expert support to the Federal Environmental Minister Hendricks at the G7 meeting of environmental ministers in Japan. In addition, a BMVI delegation trip to Tokyo under the leadership of Departmental Head Dr. Veit Steinle took place in February, which was accompanied by NOW. At a delegation trip in May the issue of power-to-gas was discussed in depth. Furthermore NOW accompanied Federal Transport Minister Dobrindt to a high-ranking meeting at the G7 transport ministers' conference in September. The subject of the meeting was the importance of hydrogen and fuel cell technology in a future transport system. Aside from government representatives, BMW and Toyota also participated.

In October the third Innovation for Cool Earth Forum (ICEF) took place in Tokyo. The ICEF served as a preparatory forum for the climate talks of the United Nations (UN). At this conference the issue of hydrogen and fuel cell technology was considered in the context of climate change. NOW was invited to make a presentation for the second time at this internationally-renowned conference.

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. German representation in the IPHE is provided by the BMVI, with NOW as the coordinating body. The Permanent Secretarial Office (PSO), which was established in 2015, is now fully operational and is proving its value. Besides half-yearly Steering Committee meetings, further formats are organised and regularly take place for the active exchange with various target groups. Among these is an Industry Forum in which current policy developments are discussed with partners from business. Within the scope of an educational event, the subject of hydrogen and fuel cell technology is discussed together with students from various disciplines.

More information can be found at: **www.iphe.net**

IEA

Hydrogen Implementing Agreement
NOW is a member of the Executive Committee of the International Energy Agency Hydrogen Implementing Agreement (IEA HIA) and co-designs the content orientation of the IEA HIA. The IEA HIA brings scientists together from all over the world who discuss joint research projects on current hydrogen and fuel cell topics. The platform offers a good basis for acquiring an overview of current global research activities as well as establishing and maintaining valuable connections to the IEA and other countries.

An overview of the current task package ("Tasks") can be found under the following link:
http://ieahia.org

Events 2016

25 – 26.01. | Kick-off Campaign "Energy for Ever" | BMVI, Berlin
01.02. | Car Symposium | Bochum
10.02. | Symposium Fuel Cell Technology in Rail Transport State Representative Office | Lower Saxony, Berlin
08 – 09.03. | "Elektromobilität vor Ort" conference on local electric mobility | Aachen
10.03. | Supplier Marketplace | Berlin
12.04. | H_2 Mobility Congress | Berlin
25 – 29.4. | Hannover Messe Hydrogen Fuel Cells Batteries | Hanover
27 – 28.05. | Roadshow (e-mobility day at Autoservice Demmler) | Wilkau-Haßlau, Saxony
29.05. | GreenTecAwards | Munich
29.05. | Roadshow ("Fahr zur Aar") | Aarbergern, Heidenrod and Hohenstein, Hesse
04.06. | Roadshow (Bicycle Day) | Braunschweig, Lower Saxony
07/08.06. | Week of the Environment | Schloss Bellevue, Berlin
10.06. | Roadshow (Wave Trophy) | Bremerhaven
11.06. | Roadshow (Electric Mobility Day of Action) | Lüdenscheid
13.06. | Innovative Drives Bus: "Where are we heading?" | Bochum
13.06. | Concluding Event EFBEL | Berlin
13.06. – 16.06. | World Hydrogen Energy Conference 2016 (WHEC) | Zaragoza, Spain
14.06. | Press meeting on the federal government's electric vehicle rebate scheme, test drives at RUHRAUTOe | University of Duisburg-Essen, Essen
15.06. | Opening H_2 Mobility | TS Wuppertal Wuppertal
15.06. | Concluding Conference SaxMobility II | Dresden
21.06. | 6th Dialogue of the Associations | Berlin
23.06. | e4Ships Status Presentation | Berlin
26.06. | Roadshow (6th Business Fair Wedemark) | Wedemark/Mellendorf (close to Celle)
29.06. | Roadshow (6th Day of Electric Mobility at the Technical University of Ingolstadt | Ingolstadt
30.06. | Presentation of Results HyTrustPlus, AP 5 | Steinfurt
30.06. | Presentation of Results E-Carflex Business | Dusseldorf
01.07. | Presentation of the "Hydrogen Rail Infrastructure" study | Berlin
05 – 06.07. | German Hydrogen Congress | State Representative Office of NRW, Berlin
06.07. | Anniversary Event 20 Years DWV | Berlin
14.07. | Roadshow (2nd Symposium Electric Mobility) | Trier
15.07. | Opening H_2 refuelling station at ZSW | Ulm
19.07. | Roadshow (5th Day of Electric Mobility) | Schwerin
19 – 21.07. | 15th Electrochemical Talks (UECT) | Ulm

14.12. Minister Alexander Dobrindt opens the NIP results conference "Clean Mobility with Hydrogen and Fuel Cells".

20.09. Henri Poupart-Lafarge, Alstom Chairman and CEO unveils the Coradia iLint fuel cell rail car at InnoTrans in Berlin in the presence of Minister Alexander Dobrindt.

12.04. At the H_2 Mobility Congress being held at the BMVI, industry representatives clearly explain their conviction towards hydrogen and fuel cell technology in the presence of Minister Alexander Dobrindt, BMVI and Wan Gang, MOST.

25.01. Norbert Barthle, Parliamentary State Secretary at the Federal Ministry of Transport and Digital Infrastructure and actor Hannes Jaennicke present the "Energie für immer" (Energy for Ever) campaign. "

15.11. Norbert Barthle, Parliamentary State Secretary at the Federal Ministry of Transport and Digital Infrastructure, opens the annual "Mobility and Fuel Strategy" (MKS – Mobilitäts- und Kraftstoffstrategie) conference.

14.12. Minister Alexander Dobrindt in discussion with the members of parliament Steffen Bilger (CDU), Stephan Kühn (Bündnis90/Die Grünen) and Martin Burkert (SPD) at the NIP results conference.

10.05. Notifications of electric mobility funding approval are handed over at the BMVI. Federal Minister Alexander Dobrindt, MdB, welcomes the representatives of the funded projects.

12.04. NOW Managing Director Klaus Bonhoff and Dr. Wu Zhixin, Vice President CATARC sign the Memorandum of Understanding for closer cooperation in the areas of H_2FC and electric mobility in the presence of the ministers.

11.4. Norbert Barthle, Parliamentary State Secretary at the Federal Ministry of Transport and Digital Infrastructure presents the CEP fuel cell vehicles to Minister Wan Gang of MOST.

01.07. Rainer Bomba, State Secretary at the Federal Ministry of Transport and Digital Infrastructure underscores the roll of rail transport during the presentation of the Hydrogen Rail Infrastructure study.

25.08. | Roadshow (Concluding event of the "Electric Mobility Central Germany" research project) | Halle an der Saale

27.08 – 28.08. | Open Day | BMVI Berlin

02.09. | Groundbreaking ceremony for storage transformer and H_2 refuelling station | Rostock

03.09. | Roadshow (Climate City Day) | Bremerhaven

07.09. | e4ships Results Event | Hamburg

11.09. | Roadshow (M-net Kinzigtal total) | Kinzigtal

11.09. | Roadshow (Day of Energy) | Geisenheim

15.09. | Concluding Event FREE (MR EM) | Kassel

17 – 18.09. | Roadshow | (Dorfen Car Show) | Dorfen

18.09. | Roadshow (7th Potsdam Environmental Festival) | Potsdam

18.09. | Roadshow (Family Energy Day) | Hambuch near Kaiseresch

20.09. | InnoTrans Alstom Unveiling of Alstom Fuel Cell Railcar + Handover of UIA Project BEMU Bombardier bx Minister Dobrindt | Berlin

22.09. | EMOTIF Specialist Conference "Electric Mobility in Rural Regions" | Erfurt

23.09. | Opening H_2 Refuelling Station 27 – 28.09. International Conference E-Mobility: Challenges for Technology and Urban Infrastructure Development, Hamburg with presentation of the research results from SINGER | Hamburg

28.09. | Commissioning of the first recharging column of the HansE project | Schenefeld

29.09. | Steering Committee on the German-Chinese cooperation BMVI-MOST | Berlin

01 – 02.10. | Roadshow (Hamburg Climate Week) | Hamburg

07.10. | Roadshow (Workshop "Municipal Locational Advantage Electric Mobility") | Karlsruhe

08.10. | Roadshow (Day of the Municipal Economy) Darmstadt

08.10. | Roadshow (Day of the Regions) | Hettstedt, Saxony-Anhalt

10 – 12.10. | World of Energy Solutions (WES) | Stuttgart

11 – 13.10. | Roadshow (Alpine Conference and Alpine Week 2016) | Achental/Chiemgau

14.10. | Roadshow (Day of Electric Mobility) | Ulm

17.10. | Bus inauguration Sylter Verkehrsgesellschaft | Sylt

24 – 25.10. | Concluding event of the emove project (Electromobility Model Regions) and the EU-funded projects Civitas Dynamo (Aachen) and Civitas 2Move2 (Stuttgart) | Aachen

25 – 26.10. | eMobility Summit (Tagesspiegel) | Berlin

26.10. | Subject area network meeting with EM accompanying research institutes | Berlin

26.10. | Press talk on the funding support for the procurement of four electric passenger vehicles | Krefeld

02.11. | Awards Ceremony "Land of Ideas" for "EcoTrain" project | Annaberg-Buchholz

03.11. | International workshop on intralogistics | Berlin

09.11. | Roadshow (Workshop "Municipal Locational Advantage Electric Mobility") | Villingen-Schwenningen

10.11. | Opening Air Liquide H_2 Refuelling Station | Offenbach

15.11. | Roadshow (Workshop "Municipal Locational Advantage Electric Mobility") | Fellbach

22.11. | Roadshow (Workshop "Municipal Locational Advantage Electric Mobility") | Biberach/Riß

30.11. | Zero-Emission Bus Conference IFCBW 2016 | London

02.12. | Press talk electric trucks Max Müller Spedition | Opfenbach

03.12. | Opening of fast-charging station during "Open Day" of the Vierländer Volksbank eG | Wiesbaden

05.12. | HRS opening Münster-Amelsbüren (Westfalen AG) | Münster-Amelsbüren

06.12. | Electric mobility in municipalities (Allianz Elektromobilität) | Wiesbaden

07.12. | H_2 refuelling station opening Geisingen | Geisingen

12.12. | Press conference on 5 electric vehicles and 4 recharging columns for the city of Dülmen and the community of Senden | Dülmen

14 – 15.12. | "Clean mobility with hydrogen and fuel cells" (NIP conference) | BMVI

Federal Ministry
for Economic Affairs
and Energy

The following BMWi NIP projects were approved In 2016:

PROJECT	COMMENCEMENT	CONCLUSION
GreenH2		
HyINTEGER	1 January 2016	31 December 2019
KontiFlex		
KontiFlex	1 January 2016	31 December 2017
PtTM-HGS		
PtTM-HGS	1 April 2016	31 March 2019
PtTM-HGS		
PtTM-HGS	1 April 2016	31 March 2019
PtTM-HGS		
PtTM-HGS	1 April 2016	31 March 2019
SILA-PEM		
SILA-PEM	1 September 2016	31 August 2019
SILA-PEM		
SILA-PEM	1 September 2016	31 August 2019
KerSOLife100		
KerSOLife100	1 September 2016	31 August 2019
KerSOLife		
KerSOLife	1 September 2016	31 August 2019
KerSOLife		
KerSOLife	1 September 2016	31 August 2019
GESAMT		

PARTNER	FUNDING RATIO [%]	FUNDING BUDGET [€]
		373,393
Johannes Gutenberg-Universität Mainz	100	213,130
		211,085
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.	85	369,390
		455,060
Max-Planck-Institut für Kohlenforschung	100	434,687
		368,721
Zentrum für Brennstoffzellen-Technik GmbH	100	478,916
		612,232
Umicore AG & Co. KG	50	638,218
		1,253,842
Eberhard Karls Universität Tübingen	100	162,178
		447,071
Gummiwerk KRAIBURG GmbH & Co. KG	50	274,927
		3,191,430
Karlsruher Institut für Technologie (KIT)	100	1,009,520
		1,198,017
Hochschule Aalen – Hochschule für Technik und Wirtschaft	100	566,679
		459,331
RJL Micro und Analytic Bernhard E. Heneka GmbH Gesellschaft für angewandte Elektronenmikroskopie und Analytik	60	421,918
		13,139,745

I. NIP — TRANSPORT AND INFRASTRUCTURE

THE PROJECTS ON THE FOLLOWING PAGES ARE LABELLED WITH I/01 – I/24.

NEWLY APPROVED PROJECTS

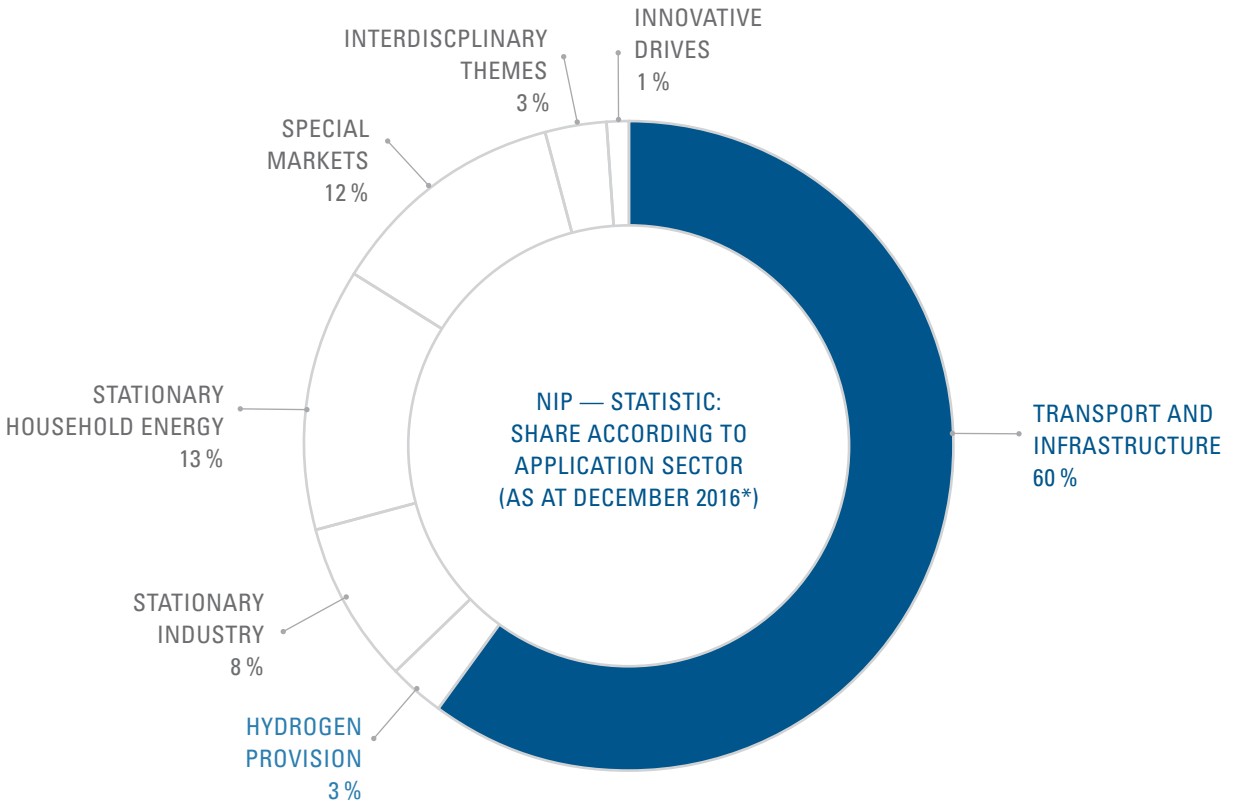
COMPLETED PROJECTS

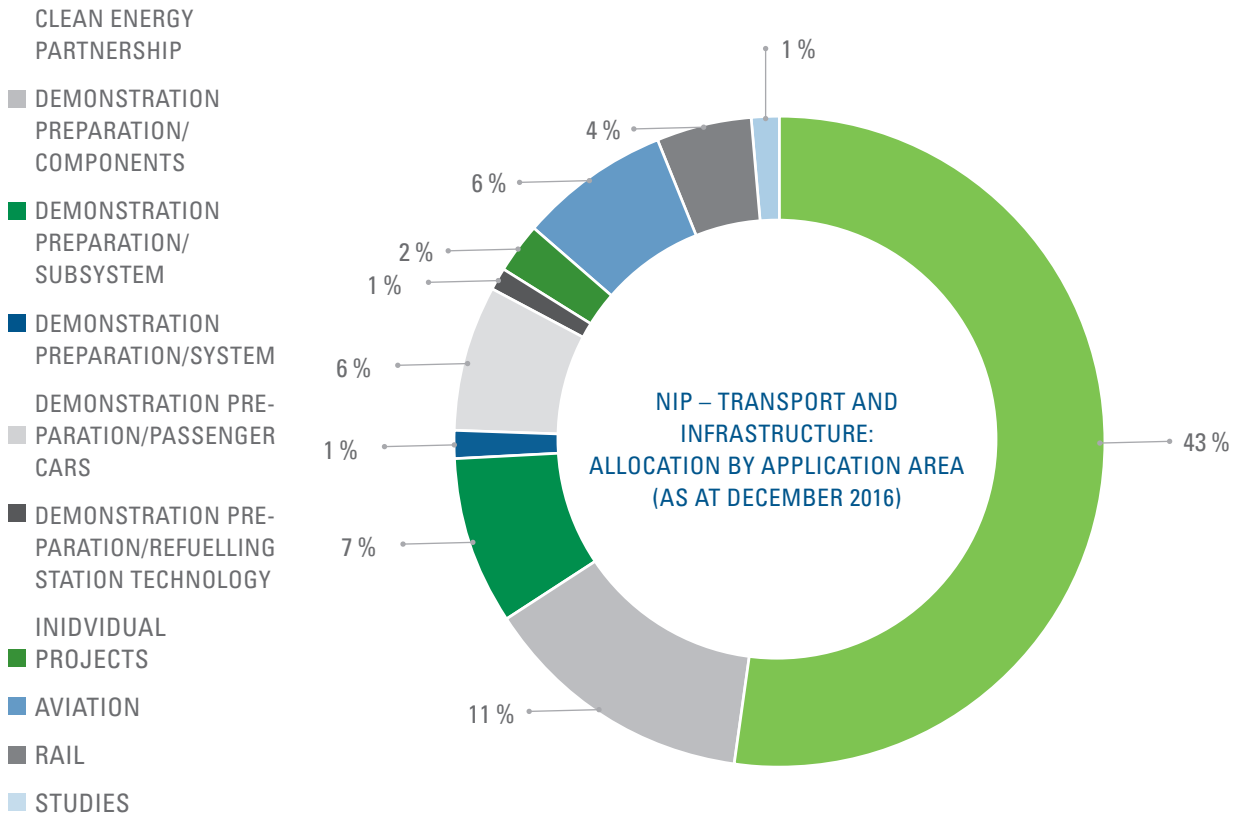
INTERDISCIPLINARY THEMES

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 as part of 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 fuel cell system production processes 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 application, such as for aircraft or 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 national supply network of hydrogen refuelling stations.


NIP — STATISTIC:
SHARE ACCORDING TO
APPLICATION SECTOR
(AS AT DECEMBER 2016*)
TRANSPORT AND INFRASTRUCTURE 60 %
HYDROGEN PROVISION 3 %
STATIONARY INDUSTRY 8 %
STATIONARY HOUSEHOLD ENERGY 13 %
SPECIAL MARKETS 12 %
INTERDISCPLINARY THEMES 3 %
INNOVATIVE DRIVES 1 %


NIP – TRANSPORT AND
INFRASTRUCTURE:
ALLOCATION BY APPLICATION AREA
(AS AT DECEMBER 2016)
43 %
11 %
7 %
1 %
6 %
1 %
2 %
6 %
4 %
1 %
CLEAN ENERGY PARTNERSHIP
DEMONSTRATION PREPARATION/ COMPONENTS
DEMONSTRATION PREPARATION/ SUBSYSTEM
DEMONSTRATION PREPARATION/SYSTEM
DEMONSTRATION PRE-PARATION/PASSENGER CARS
DEMONSTRATION PRE-PARATION/REFUELLING STATION TECHNOLOGY
INIDVIDUAL PROJECTS
AVIATION
RAIL
STUDIES

Study examines economic, legal and technical prerequisites for the deployment of fuel cell railcars

Hydrogen rail infrastructure

Around 50% of German rail networks are not electrified. Overhead wire construction is cost intensive, not profitable on little-used sections,, and in scenic areas often not wanted. Nevertheless, operators and the public have a great interest in ridding such rail network sections of emissions, traditionally serviced by diesel vehicles. Using electric trains with hydrogen-operated fuel cells presents an interesting and promising alternative in these cases.

As part of an accompanying research study, consultancy firm EY examined the deployment of fuel cell rail cars in Germany between October 2015 and May 2016, in cooperation with Ludwig-Bölkow-Systemtechnik, TÜV SÜD Rail, SIGNON Deutschland, Becker Büttner Held, as well as the IFOK. The aim was to clarify the framework conditions in terms of the economic, legal and technical prerequisites for the expansion of hydrogen infrastructure for the refuelling of fuel cell rail cars. The study was commissioned by the Federal Ministry of Transport and Digital Infrastructure (BMVI – Bundesministerium für Verkehr und Digitale Infrastruktur) and coordinated by the National Organisation for Hydrogen and Fuel Cell Technology (NOW) within the scope of the National Innovation Programme Hydrogen (NIP). The data on which this study is based was compiled in stakeholder group interviews, expert interviews, own expert estimates and surveys. The analysis of costs data in particular and profitability is based on expert estimates, which in respective individual cases will need to be validated with suppliers' concrete price quotes. As a first step the study examines the operational requirements arising from serviceable rail operation.

An important finding is that there will be no operational restrictions regarding vehicle scheduling for regional routes in Germany, as the range of the trains or rotations per day is sufficient.

Aside from zero emissions, the conversion of braking energy to kinetic energy is another advantage: the combined fuel cell-battery drive can exploit its potential particularly well on routes with many stops and changing altitude profiles.

Parallel to the operational requirements, both the requirements of hydrogen provision as well as the availability of hydrogen (hydrogen sources) were described in the study. These include the identification of hydrogen sources near eligible non-electrified routes

Hydrogen rail infrastructure study

Prepared by:
Ernst & Young GmbH Wirtschaftsprüfungsgesellschaft in cooperation with Ludwig-Bölkow-Systemtechnik GmbH, TÜV SÜD Rail GmbH, SIGNON Deutschland GmbH, Becker Büttner Held, IFOK GmbH

Term:
October 2015 to April 2016

Commissioned by: Federal Ministry of Transport and Digital Infrastructure

Coordinated by:
NOW GmbH – National Organisation Hydrogen and Fuel Cell Technology

in Germany as well as supply logistics. Initially, the transport of hydrogen via road in tankers or through a pipeline (in existing pipe systems) will be recommended. Over the medium and long term, rail transport with tank cars is considered suitable. The focus is also on tank containers both for road and rail transport.

Data was collected with the involvement of the four states of Lower Saxony, Baden-Württemberg, North Rhine-Westphalia and Hesse. Each plans the deployment of fuel cell rail cars for local rail transport in the medium to long-term. In the "BetHy" project of manufacturer Alstom, which was also supported by the Federal Ministry within the scope of the NIP, a new fuel cell-based rail car generation was developed. Two pilot vehicles from this project are to be deployed in Bremervörde, Lower Saxony, by the end of 2017.

The legal framework conditions, particularly with regard to regulatory approval as well as energy and public procurement law, represents a further area of focus.

To date it has not been clarified whether a clear legal framework exists. Having analysed the legal framework conditions however, this study asserts that under the current legal framework, the licensing of hydrogen facilities for hydrogen generation, transport and refuelling is already possible in accordance with the relevant licensing processes. In an award procedure a combined tender for all services from procurement to refuelling of the trains is feasible at least in the introductory phase of the technology.

Furthermore, on the basis of the information gathered, the study discusses which financing and operator structures can be achieved with respect to the goal of identifying operator concepts suitable for implementation. An important finding is that the additional service module "hydrogen provision" brings risks with it, which hitherto could not be optimally represented in the usual operator structures. One possible way of reasonably spreading the risk is the financing of the vehicle pool and making it available through the regional authorities to the rail transport companies. In this way politics and administration can directly influence the implementation of their sustainability strategies. Moreover, as part of acceptance management work conducted within the scope of the study, an introduction campaign with various effective PR activities was developed.

Finally the results of the study show that deploying fuel cell trains is economically feasible in principle. However the right framework conditions in the introduction phase must be created.

The study was presented to the public on 01.07.2016 at the Federal Ministry of Transport and Digital Infrastructure in Berlin.

EY Mobility Innovation Group

With new challenges and opportunities, the mobility sector is growing into a technology-driven and simultaneously cross-sector business environment with diverse players. We respond to these developments with an interdisciplinary team: specialists for telematics, digitisation, cyber security, logistics planning, town planning, alternative drives and infrastructure are complemented by strategy and management consultants. In this way, we offer our customers perfectly tailored, needs-based support for every project.

Website:
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rainer.scholz@de.ey.com

I/01 DEVELOPMENT OF A HYDROGEN RCS ROADMAP

The goals defined by the federal government for reducing greenhouse gas emissions, lowering energy demand and increasing the use of renewable energies in the energy and transport sector can only be achieved by employing electric mobility intensively, and this includes the extensive use of fuel cell vehicles. Emission-free fuel cell vehicles can be driven over long distances with renewably-produced hydrogen and fully refuelled in a matter of minutes. In addition hydrogen produced from electricity can store large quantities of energy over a long period of time and thus can complement the energy changeover with a major stabilising element.

To use hydrogen and fuel cell technologies in the existing energy and transport system, we need appropriate rules, norms and processes. Their establishment and harmonisation on national, European and international levels is complex and needs concerted action. Essential hydrogen regulations, codes and standards (RCS) are being developed on an increasingly international basis. In order to ensure representation of Germany's interests, active participation in and contribution to committee work of the EU, UNECE, ISO, IEC, CEN, and CENELEC is required.

Primarily in the key areas of road transport, including fuelling infrastructure and stationary applications, urgent action is required for agreeing upon and further developing the AFID (Alternative Fuels Infrastructure Directive – here hydrogen), GTR 13/UNECE R134 (Type approval of hydrogen road vehicles) and the ADR (Transport of dangerous goods by road).

Because of the approach taken by the European Commission of developing rules and regulations via the *New Legislative Framework*, the relevant players must synchronise and harmonise working out these standards and regulations. EU member states' governments also have to increasingly arrange between them what, for instance, takes place in the *Government Support Group*.

It is certainly the case that regulations, codes and standards (RCS) are complex and must be continually monitored closely by the hydrogen/fuel cell actors in Germany in order to bring products to the market. Currently there is a huge number of issues in the rules and standards area (RCS) which need urgent attention.

PARTNER:
Ludwig-Bölkow-Systemtechnik GmbH

PROJECT BUDGET/€:
451,133

PROJECT FUNDING/€:
451,133

COMMENCEMENT:
1 March 2016

CONCLUSION:
31 December 2016

I/02 FUEL CELL MODULE 5 KW CLASS (FCM 5)

In the FCM 5 project, a manufacturable PEM fuel cell module with processes suitable for mass production was developed. Aside from the NM5 stack based on metal bipolar plates in a power class of up to max. 20 kW, in addition an end plate media module assembly based on synthetic injection-moulded components was developed directly at the stack for the integration of system functions.

The project was able to demonstrate that the stacks could be made available in a nominal capacity between 3 kW_{el} (18 cells, atmospheric operation) and 40 kW_{el} (200 cells, pressure operation 2.5 bar_a). Meanwhile it has been proven that the NM5 stack with 260 cells and 60 kW can be optimally used.

NM5 key performance indicators:
Power density (pressure operation 2,5 bar_a):
- 7.5 kW/l (active areas)
- 6.6 kW/l (membrane areas used)
- 4.1 kW/l (cell stacks without end plates)
- Power density (low pressure operation):
- 4.7 kW/l (active areas) scaled accordingly.

Life cycle analyses in representative load cycles were carried out, which cover a typical operation window at atmospheric operation, except for explicit start/stop tests. The operating life was approx. 6,500 hours by the end of the project and was extended to more than 8,100 hours with degradation rates of under 6 µV per hour and cell, which corresponds to a power loss of significantly less than 10 per cent in 8,000 hours.

A new cell configuration which was tested in NM 5 individual cells, achieves a power density of 8.4 kW/l (pressure operation, see above), 7,8 kW/l and 4,8 kW/l respectively. Thus a stack with 400 cells has a power density of 3.6 kW/l.

In this new configuration, the NM5 stack format in particular fulfils the FCH JU (MAWP) performance goals of 1 W/cm² at a current density of 1.5 A/cm² in non-humidified operation.

The prestressing units were constructed on a synthetic/metal hybrid assembly basis and were qualified by means of experimental tests and FEM, where particularly the anticipated mechanical features had to be taken into account at advanced service life.

Within the media module, which is directly built onto on the end plate, are active and passive components like pressure and temperature sensors, valves, bypass tubes and droplet separators. The development of the function unit includes the fluid-technical construction of the subsystems with droplet separators as well as the provision of suitable sensors, which were developed in close cooperation with suppliers.

PARTNER:
ElringKlinger AG

PROJECT BUDGET/€:
7,735,102

PROJECT FUNDING/€:
3,712,849

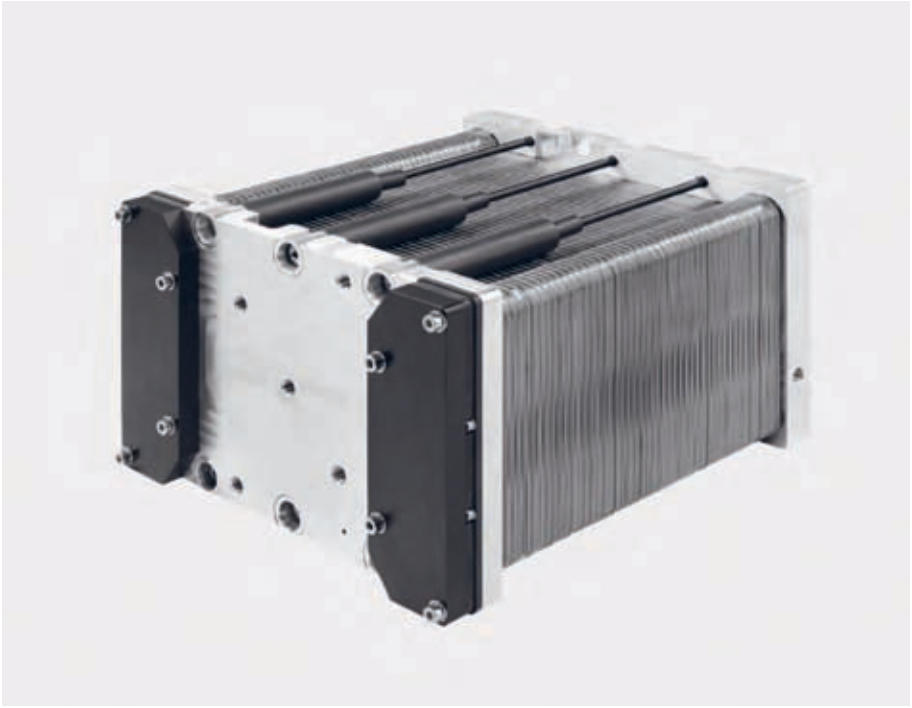
COMMENCEMENT:
1 September 2011

CONCLUSION:
30 June 2016

Synthetic end plates and a current collector assembly were also developed with a view to the cold start ability of the stack. In particular this ensured that the heat transfer between end plates and margin cells was very low. It was proven that a passive cold start as low as – 20°C is possible, without any heating of the stack components.

Stack and tension systems are designed for vibration and impact loads common in industrial applications. According to the provisions of the DIN EN 60068 *Environmental influences Part 2 – 27 and Part 2 – 64 standard*, the stack was subjected to a shock test at 25g and a vibration test with a noise spectrum of between 10 Hz and 1 kHz, with no function restrictions identified.

With the development of the NM5 stack format and the FCM 5 module, products will be made available that serve a broad field of application in industrial applications. The products can be used to great advantage in a capacity range from industrial trucks to light commercial vehicles.



The fuel cell stack serves a broad spectrum of applications in the area of industrial applications.

I/03 ANTARES H3

The Antares H3 project's goal involved the development of a research aircraft with fuel cells. The aircraft is based on the world's first electric plane in series production, the Antares 20E, and continues to build on the experience of the world's first fuel cell-based plane capable of taking off independently, the Antares H2.

Antares H3 is a single-seater plane with a wingspan of 23m, maximum take-off weight of 1,650kg including a 200kg payload and maximum flight duration of 40 hours. The Antares E2 is capable of conducting civil tasks in the area of "remote sensing" either manned or unmanned. The system is especially well suited for undertaking maritime tasks such as fisheries monitoring and environmental protection as well as for search and rescue missions.

Four external pods are placed under the aircraft's wings. These contain the fuel cells, reformer fuel and portions of the payload. The fuel cell system selected was a HT PEM fuel cell with methanol reformer. The reformer works with a methanol-water mix. The water is to be extracted from the exhaust air and fed back to the reformer fuel again. Six highly efficient electric motors were installed above the wings.

Compared with modern combustion engines, the fuel cell mass is high. Yet the longer the flight duration is, the more the mass of reformer fuel carried gains in significance. The highly efficient power yield – as is achieved in the fuel cell system used – not only balances the high fuel cell mass, during longer flights it also provides advantages over combustion engines. The Antares H3 project builds on this principal.

Furthermore, energy requirements while in flight remain very low due to the aircraft's exceptional aerodynamics. Because of the compact design and low mass of the highly efficient electric propulsion motors, the principle of distributed drives could be selected, which permits extremely high propeller and installation efficiency.

The Antares H3 project demonstrates that fuel cell aircraft is already suitable for applications requiring long flight times, with the implementation of existing technology. With support from the NIP, both pure fuel cell technologies as well as aircraft-specific technologies had to be developed significantly further. Antares H3 is approaching completion and its maiden flight is scheduled for the third quarter of 2017.

PARTNER:
Lange Research Aircraft GmbH

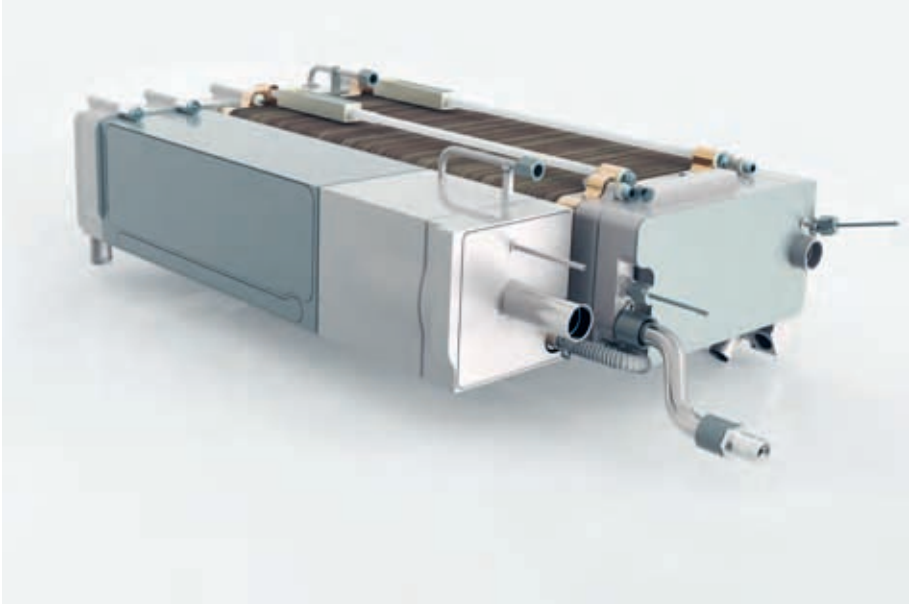
PROJECT BUDGET/€:
5,005,118

PROJECT FUNDING/€:
2,402,456

COMMENCEMENT:
1 March 2010

CONCLUSION:
31 December 2016

The Antares H3 in simulated flight.



The fuel cell system developed for Antares H3 comprising stack and reformer.

» The highly efficient power yield – as is achieved in the fuel cell system used – not only balances the high fuel cell mass, during longer flights it also provides advantages over combustion engines. The Antares H3 project builds on this principal. «

I/04 CRYOCODE: CRYOGENIC PRESSURE TANK SYSTEM AND REFUELLING – VALIDATION TO STANDARDISATION RECOMMENDATION

The current status of the technology in hydrogen vehicle storage is the capacity to store 700 bar of compressed hydrogen at ambient temperature (CGH_2). Through the refuelling and storage of cryogenic gaseous hydrogen in a cryogenic pressurised storage unit at up to 350 bar (CcH_2), the energy density of a 700 bar storage unit can be raised by more than 50%.

Within the scope of the publically funded "CryoCode" project, BMW AG together with its project partners tested and validated cryogenic pressure tanks for automotive deployment for the storage of hydrogen on board. Aim of the project was to prepare standardisation and type approval of hydrogen cryogenic pressure storage technology through extensive validation tests. In the process, the required functions, operational safety and system performance of the tank system and of refuelling were established.

Core content of the project was:

- The creation of the pool of data necessary for the preparation of cryogenic pressure tank and refuelling standardisation
- The acquisition of important insights on the lifetime and failure behaviour of cryogenic pressure tanks and systems
- The definition of suitable safeguarding programmes for tank systems – coupling and refuelling processes for a small vehicle series and refilling stations with cryogenic pressure technology

The results of this project are experimental data and insights on optimised testing procedures, allowing an outlook towards an optimised pressure vessel design and for measures leading to enhancing production quality as well as continuing to move towards the certification and standardisation of cryogenic pressure technology as a means of energy storage.

In order to achieve the NIP goal of marketable hydrogen technology, validation and standardisation processes are particularly required. The CryoCode project has made a significant step forward in this regard in that it will in future enable manufacturer-independent series production as well as the ability of suppliers to provide cryogenic pressure tanks for fuel cell vehicles. This can bring about a continued proliferation of cryogenic pressure tank technology including more competition and thereby decisively help to prepare the path towards the industrialisation process of cryogenic pressure technology in vehicles. In addition, technological competencies could be developed through the experiences gained in the course of the project. These competencies then not only accelerate the development of cryogenic pressure storage towards a market-ready technology, but due to the build-up of expertise also lead to a general growth in technology in other areas.

PARTNERS:
a) Bayerische Motoren Werke AG
b) Linde AG
c) Bundesanstalt für Materialforschung und -prüfung (BAM),
d) ET GmbH Gesellschaft für innovative Energie und Wasserstoff Technologie

PROJECT BUDGET/€:
a) 6,853,743
b) 201,670
c) 147,503
d) 88,376

PROJECT FUNDING/€:
a) 3,289,796
b) 96,802
c) 70,801
d) 42,420

COMMENCEMENT:
1 January 2013

CONCLUSION:
30 September 2016

I/05 FUEL CELL-RUN HYBRID RAIL CAR BETHY

The project aimed to research and develop hybrid fuel cell drive systems for rail applications. Two hydrogen-run rail cars, including the necessary provision of hydrogen, were to be researched, developed and built.

As part of the BetHY NIP project, which ran from September 2013 until October 2016, Alstom and the Institute of Vehicle Concepts (FK) of the German Aerospace Center (DLR) conducted comprehensive work towards the concept and development of a drive system based on hydrogen fuel cell technology for the CORADIA LINT rail car platform. Compared with other tests looking into this technology, fuel cell aggregates with vastly higher power densities and thereby with a more compact installation space were for the first time conceived, tested under realistic conditions and then installed in rail cars for the transport of passengers. The use of fuel cell-run rail vehicles had previously been limited to prototypes and some few special vehicles for underground applications. As no comparable vehicle (a rail car for regional transport) had to date been equipped with a fuel cell drive, this project provided the opportunity to prove the suitability for deployment of this low emission and efficient technology while also expanding Germany's technology leadership. With implementation in a, for fuel cell applications, new vehicle class, the project represented a pioneering project for rail vehicles in the passenger rail transport area and can serve as an innovative model project for future vehicle conversions.

As a result of the project, the necessary research and development work for the introduction of fuel cell-driven rail vehicles was advanced. Insights on the development of future series vehicles and thereby for the substitution of diesel drives could be obtained and corresponding experience gained. Following a targeted selection of components for fuel cell systems, battery systems and the remaining drive components (e.g. power converters, traction motors), the drive systems were examined on the test bench in order to obtain first indications for their suitability for deployment in the vehicle. Subsequent to the laboratory trials, two test vehicles – each with two drive units – were constructed. Through the construction and test operation of the hydrogen demonstration vehicles, test bench and later field data could be collected and analysed, which can flow into future series development. Accompanying standardisation and committee work was being conducted to create the prerequisites for the approval of the vehicles by the relevant authority, the Federal Railway Office (EBA – Eisenbahnbundesamt).

PARTNER:
ALSTOM Transport Deutschland GmbH

PROJECT BUDGET/€:
19,972,025

PROJECT FUNDING/€:
7,988,810

COMMENCEMENT:
1 September 2013

CONCLUSION:
31 October 2016

I/06 MASS PRODUCTION OF MEMBRANE ELECTRODE ASSEMBLIES, TECHNOLOGIES FOR (MASS) MARKET LAUNCH (MAS-TECH)

The road from market launch to the establishment of a mass market for PEM fuel cell systems is becoming progressively more dominated by the question of cost.
A major factor for successful market penetration of fuel cell systems is therefore the establishment of cost-effective and stable production processes.

The principal goal of the MAS-TECH project was to supplement the existing technology platform at Greenerity with additional cost-cutting elements, thus lowering overall manufacturing costs.

The process chain was equipped with selected automated inline control systems. This was developed and implemented within the scope of the project. This enabled scrap rates to be further reduced and thus costs to be minimised.

A further cost reduction was achieved through both the elimination of and above-average improvement of process steps, as well as the testing and introduction of better automated quality control systems. Of note here is the development of a process for the direct coating of polymer electrolyte membranes.

Finally the level of automation was increased further through the development of an automated roll-to-roll assembly process, thus demonstrating another boost to efficiency.

At the end of the project a cost-optimised technology platform for the establishment of an internationally competitive and complete MEA production had been created and the concept of Germany as an industrial location was reinforced.

» The principal goal of the MAS-TECH project was to supplement the existing technology platform at Greenerity with additional cost-cutting elements, thus lowering overall manufacturing costs. «

PARTNER:
Greenerity GmbH

PROJECT BUDGET/€:
3,708,288

PROJECT FUNDING/€:
1,557,481

COMMENCEMENT:
1 July 2014

CONCLUSION:
30 October 2016

I/07 ALTHYPTANK – EXAMINATION OF AN ALTERNATIVE PROCEDURE FOR THE MANUFACTURE OF HYDROGEN PRESSURE TANKS

New production process enables the manufacture of Type 4 hydrogen pressure tanks with minimum material usage

Hydrogen is a promising form of energy and will make its way into the vehicles of the future. Due to the high operating pressure, special tank systems that are capable of meeting the high safety requirements are necessary to allow hydrogen to be used as a fuel in cars. The hydrogen pressure tank will in future therefore represent a significant portion of the costs of the overall powertrain system of fuel cell-based vehicles.

Until now, tanks for the storage of hydrogen were manufactured using a so-called wet-winding process. This process, however, brought with it disadvantages in terms of material usage. As part of this project, polymer specialist REHAU succeeded in demonstrating the fundamental suitability of an innovative, higher performance approach for the production of hydrogen pressure tanks.

This new approach, which is based on braiding technology, results in less fibres being required in the manufacturing process. Besides the enhanced economic viability, a further benefit is the subsequent reduction of weight in the vehicle. Furthermore, due to the braiding process employed by the approach, automated large-scale production lines can be realised, with which the pressure tanks can be manufactured in constant high quality levels and with minimum material usage.

To test the method, which was developed in-house, REHAU used its lightweight construction technology centre (Leichtbautechnikum) in Viechtach, Bavaria. The entire process chain for experimental production of pressure tanks was depicted there. In this way, it was possible to experimentally examine the parameters influencing the process technology. Finally, the manufactured demonstration components were also tested in accordance with the relevant EC guidelines.

The theoretical component incorporated a characterisation of the material properties of the tank reinforcement. This information formed the basis for the comprehensive numerical simulation of the component design. In this way, the obtained results could then be tested for their plausibility and further process-related measures initiated in a targeted manner.

The results of the conducted examinations confirm the fundamental suitability of the procedure for the production of hydrogen pressure tanks with a working pressure of 700 bar. The most important tests of the relevant EC guidelines were completed successfully. The comparison with corresponding performance data from wet-wound tanks confirms the predicted reduction of material usage. Various further issues such as the durability of the overall process are to be examined in the future.

PARTNER:
REHAU AG + Co

PROJECT BUDGET/€:
2,128,308

PROJECT FUNDING/€:
1,021,587

COMMENCEMENT:
1 October 2014

CONCLUSION:
30 November 2016

I/08 TECHNICAL MODULE FORD FCEV

Ford has been an active partner of the CEP lighthouse project since its inception, which was established within the Transport area of the NIP. Proof of the technology's general suitability for everyday deployment had already been confirmed during the fleet trials in CEP Phases I and II. In Phase III, the focus was on the economic viability of hydrogen as a fuel source.

In addition to the continual involvement of Ford in the overarching activities of the entire consortium in the superordinate module, four technical work packages were defined for the period 2012 to 2016. They tied in with the work commenced in CEP Phases I and II, with the goal of improving the costs and service life of fuel cell technology.

- Cost-benefit analysis of 350 and 700 bar tank systems
- Improved recording of data in test vehicles to investigate correlations between operating conditions and service life
- Model-based examinations of various fuel cell powertrain topologies in regard to their energy efficiency
- Establishment of a trial vehicle for the testing of system technology in combination with the electrified powertrain

Concrete achievements, results

- With roughly the same tank size and refueling time, the 700 bar tank system used in the test vehicle provided a gain of 25% and thereby around 100km range. The simulation results showed significant cost benefits for 700 bar type 4 technology over 700 bar type 3 technology.
- The implemented data collection draws up the planed, predefined diagrams from real, unfiltered and raw vehicle data. The principle suitability of all measuring points could be confirmed.
- When using the same fuel cell system configuration, significant efficiency improvements and thereby a greater range could be partly proven by changes to the type of interconnection with the remaining HV system of the vehicle.
- The trial vehicle is built and is being used for the testing of model-based-developed operating strategies.

PARTNER:
Ford Werke GmbH

PROJECT BUDGET/€:
3,340,084

PROJECT FUNDING/€:
1,603,240

COMMENCEMENT:
1 April 2012

CONCLUSION:
30 September 2016

Difficulties, learning effects

- Vehicle operation and refuelling with all tank systems was without problems. The 100km greater range comes at the price of greater system costs due to higher carbon fibre requirements of the 700 bar tank compared with the 350 bar tank.
- During the testing period of three years, the reversible performance losses significantly outweighed the permanent types. They are indistinguishable on a macroscopic level.
- The model-based-developed optimised operating strategy must continue to be optimised and adjusted in real vehicle operations. This is the subject of the continuing work in WP4.
- The integration of all subsystems required for the powertrain in a series production vehicle such as the Mondeo continues to be a challenge.

Ford Mondeo with fuel cell-based drive system.

Driver safety training with the Mercedes-Benz B-Class F-CELL

I/09 CEP PROJECT MODULE: DEMONSTRATION MERCEDES-BENZ B-CLASS

As part of the project, 40 Mercedes-Benz B-Class F-CELL vehicles were put in the hands of customers in Berlin. The goal was to prove the suitability for everyday use and marketability of the technology. A service garage was established in Berlin and the respective staff was qualified accordingly. Through the development of a forward-looking operator model, numerous insights in regard to the target customer could be attained. Collectively, the customers travelled a total of almost one million kilometres over the project's duration. This provided for a better understanding of customer behaviour and market realities, and also delivered information on the failure rate of specific components. Error patterns could be identified during the refuelling of the vehicles.

The National Innovation Programme Hydrogen and Fuel Cell Technology (NIP) has interconnected the necessary research and development work in the transport area with market-preparatory demonstration projects. On the basis of existing activities in Germany, the hydrogen infrastructure was expanded further in the clusters and simulated, through large demonstration fleets such as those in Berlin. With such consolidated activities, Germany has established itself as a "first mover" in the global competition towards the market introduction of hydrogen and fuel cell technologies.

PARTNER:
Daimler AG

PROJECT BUDGET/€:
17,295,950

PROJECT FUNDING/€:
8,000,934

COMMENCEMENT:
1 May 2009

CONCLUSION:
30 June 2016

I/10 HAFENCITY HAMBURG HYDROGEN REFUELLING STATION

Through the funding project: HafenCity hydrogen station in Hamburg, Vattenfall is making a meaningful contribution towards integrating renewable energies in the mobility system, where hydrogen is generated from green electricity and used as a fuel in electric vehicles with fuel cells. Ideally electricity is used in the period when there is an overload in the grid and turning off wind turbines despite prevailing winds is prevented. The refuelling station can be described as a lighthouse project, as many aspects were prioritised above profitability. Not only its unique location and elaborate architecture that blends into the image of the new HafenCity city quarter but also its high refuelling capacity were designed to blaze the trail for using hydrogen technology.

The facility consists essentially of electrolysis equipment to split water, equipment to compress and store hydrogen as well as refuelling equipment (fuel dispensers) for passenger cars and buses. Throughout the project many results could be gathered, the most important of which are customer-related availability, sales volumes for bus and passenger cars as well as different approaches to energy consumption. These also serve to inform or confirm efficiency-increasing measures. There is potential for improvement not only in terms of the efficiency and maintenance costs of the components, but also regarding the electricity costs under the regulatory framework conditions. Technically speaking, the facility impressed overall and shows that hydrogen mobility is highly feasible in the future. Another important objective also set was to engage the public. This was successfully met – there were many thousand visitors from all over the world and large road traffic numbers directly to the facility.

PARTNER:
Vattenfall Europe Innovation GmbH

PROJECT BUDGET/€:
12,624,366

PROJECT FUNDING/€:
6,059,696

COMMENCEMENT:
1 June 2009

CONCLUSION:
31 Oktober 2016

Vattenfall hydrogen refuelling station at HafenCity, Hamburg.

» Not only its unique location and elaborate architecture that blends into the image of the new HafenCity city quarter but also its high refuelling capacity were designed to blaze the trail for using hydrogen technology. «

Battery bus from Solaris with fuel cell as range extender at the HafenCity refuelling station.


fenCity
Clean Energy Partnership
CEP
VATTENFALL

I/11 NABUZ – SUSTAINABLE BUS SYSTEM OF THE FUTURE (NACHHALTIGE BUSSYSTEME DER ZUKUNFT); SUBPROJECT: TEST OF FUEL CELL BUSES

From April 2011 to October 2016, the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP) of the BMVI supported the test operation of fuel cell buses by HOCHBAHN in regular scheduled services.

With the deployment of four fuel cell buses from the company EvoBus (12 metres) as well as two battery buses with fuel cells as range extenders from Solaris (18 metres), the goal of advancing the practical maturity of the hydrogen-run fuel cell buses in local public transport was pursued along with the goal of reducing carbon emissions and other airborne pollutants.

Focus of the project was the technical and operational demonstration as well as the optimisation of components and systems used by the fuel cell buses deployed. In close cooperation between bus operator HOCHBAHN, and EvoBus and Solaris as suppliers and service partners, the six buses recorded a total combined mileage of more than half a million kilometres in Hamburg's public transport network. In comparison with conventional Euro 6 diesel buses, this also allowed for the saving of approximately 530t of carbon emissions.

At the conclusion of the project, the EvoBus vehicles had been in regular service at HOCHBAHN for around five years. The Solaris vehicles were in operation by HOCHBAHN for about two years by the end of the project. The technological maturity of the EvoBus fuel cell buses can be indicated with a Technology Readiness Level (TRL) of 7. The battery buses with fuel cells as range extender correspond with a TRL of 5-6. These latter vehicles are the first of their type in the world.

With hydrogen consumption of around 8kg per 100km for the 12 metre bus types (EvoBus), a significant reduction in consumption compared with the predecessor generation could be achieved within the scope of the project. Hydrogen consumption for 12 metre buses in the past project was at approximately 22kg per 100km. The consumption for the articulated-type buses (18 metres) was around 14kg per 100km.

For the day-to-day deployment in regular scheduled services of the vehicles, drivers and maintenance personnel received regular training covering the various aspects of the buses' innovative drive technology. The project was accompanied by communication measures targeted to specified audiences to thereby further enhance the acceptance of the fuel cell buses – not only among HOCHBAHN staff but also among passengers, political decision makers as well as the general public.

Overall, the fuel cell buses from EvoBus that were tested within this project as well as the battery buses with fuel cell range extenders from Solaris, proved to be largely suitable for scheduled service operations and as such led to the successful completion of the project. Potential for development is particularly still possible in the availability of the buses, the after-sales support and the provision of innovative components by more suppliers.

PARTNERS:
a) Hamburger HOCHBAHN Aktiengesellschaft
b) Daimler AG
c) EvoBus GmbH

PROJECT BUDGET/€:
a) 14,200,363
b) 661,814
c) 2,148,006

PROJECT FUNDING/€:
a) 6,816,174
b) 317,671
c) 1,031,043

COMMENCEMENT:
1 April 2011

CONCLUSION:
31 October 2016

I/12 H_2MOBILITY STUTTGART: ESTABLISHING A HYDROGEN REFUELLING STATION INFRASTRUCTURE

PARTNER:
Netze BW GmbH

PROJECT BUDGET/€:
4,146,000

PROJECT FUNDING/€:
1,990,080

COMMENCEMENT:
1 February 2011

CONCLUSION:
31 December 2016

Fossil fuels are finite and it is necessary to ensure the sustainable integration of renewable energies in all sectors. Hydrogen mobility provides exactly the prerequisites to ensure this: renewable energies, storage medium, and efficient use as a carbon-free fuel.

To test the hydrogen technology, the operation of two refuelling stations in Karlsruhe and Stuttgart was examined over a five-year period. As a storage medium for renewable energy and as a fuel for fuel cell vehicles, hydrogen has the capability to interconnect the transport and energy sectors in the future and thereby promote the energy transition. With the hydrogen refuelling stations pilot project, we commenced examining this coupling of sectors at a very early stage.

The hydrogen plants in Stuttgart and Karlsruhe enabled us to examine the boundary conditions for reliable operation and economic deployment in practical application. In Stuttgart this involved the establishment of a hydrogen refuelling station with integrated electrolysis. We examined the demand-driven application of hydrogen production in intelligent network operations (Smart Grid). In the future, besides their task of refuelling hydrogen vehicles, hydrogen refuelling stations can also take on a useful and lucrative "second job" to help relieve the electricity networks. The Karlsruhe-based refuelling station was already constructed and supplied via a trailer. We equipped both stations for user-friendly operation in accordance with the CEP (Clean Energy Partnership) standard. This includes, for example, a central data collection system, a fuel terminal and integration in an online availability system.

We gained valuable experience for the successful implementation of hydrogen in the electricity network and transportation:

The technology is available. Approvable plants can be constructed and operated under the existing legal framework conditions.

On-site production via electrolysis works. The Stuttgart station produced the requisite green hydrogen independently. Only during faults did delivered hydrogen need to be used.

In an additional project supported with funding from the state of Baden-Württemberg, the Stuttgart refuelling station was expanded with an additional fuel pump suitable for buses.

For an improvement of the overall system, it became evident that a high volume of hydrogen plays a key role for operation and economic feasibility. The supply of bus fleets is one option in this regard. High costs for the on-site production of hydrogen are the result of levies that are raised for the grid electricity. In this respect, locations that do not require the public electricity network could be a solution. This may, for example, be the situation with directly connected wind farms.


Linde
EnBW
Wasserstoff
Tankstelle
JPSU
MAX. WT. 27,000 KG 59,535 LB
TARE WT. 7,000 KG 15,435 LB
PAYLOAD 20,000 KG 44,100 LB
CU. CAP. 71.61 CU.M. 2,529 CU.FT.
H-STAT

At the Stuttgart station, demand-controlled hydrogen production via electrolysis in intelligent network operations (Smart Grid) was examined.

I/13 CEP FLEET MODULE – FCHV-ADV FUEL CELL VEHICLES

Aim of the project was to expand the deployment of fuel cell vehicles. The deployment of up to five vehicles provided valuable insights on the everyday use of the technology in the hands of customers as well as the interplay with infrastructure. In addition, with a view to future market introduction, Toyota also pursued the goal of expanding hydrogen service capacities in Germany in order to be in a position to provide customers with comprehensive services for fuel cell vehicles.

The fleet operations supported the funding policy goals of the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP), which in accordance with the associated National Development Plan, comprised, on the one hand, the validation of systems and methods developed through R&D activities for the deployment of hydrogen as a fuel, and on the other, the market preparation of hydrogen-run vehicles:

- The inaugural fleet operations of vehicles in the hands of customers delivered valuable insights in regard to the suitability and acceptance of the vehicles for the tested application purposes.
- The cooperation with the OEMs and infrastructure companies active in the CEP led to the further technical developments and optimisation of interfaces relevant for refuelling and supported the process of standardisation.
- The testing of the necessary services associated with the fleet operations supported the identification of capital and personnel expenditures along with the organisational and infrastructural framework conditions for customer-oriented vehicle support. It also enabled valuable information to be obtained, especially in view of market preparation.

Furthermore, with the establishment of a hydrogen service station, Toyota contributed to value creation in Germany.

» Cooperation within the CEP led to further technical developments and supported the process of standardisation. «

PARTNER:
Toyota Motor Europe N/V S/A

PROJECT BUDGET/€:
4,146,000

PROJECT FUNDING/€:
1,990,080

COMMENCEMENT:
1 September 2011

CONCLUSION:
30 June 2016

Experiencing progress – SSB hydrogen fuel cell hybrid bus in regular daily service since 2014.

I/14 S-PRESSO – PRACTICAL TEST OF HYDROGEN-OPERATED BUSINESS IN STUTTGART AND SURROUNDING AREA

The stated objective of SSB AG is to structure local public transport in Stuttgart in a sustainable way. Therefore the plan of the S-presso project funded under NIP is to advance the further development of fuel cell hybrid technology for local buses through technical, but also operational optimisations, e.g. the testing of new innovative operational concepts.

Four 12-metre long hydrogen fuel cell hybrid buses by Mercedes Benz were newly acquired for the project and tested in regular service on the no. 79 line in Stuttgart and the no. 67 line in Fellbach. Their use in Fellbach is a new phenomenon in terms of the operating concept. There the bus will be run by the private bus operator Schlienz in regional transport, while the SSB provides the buses. Two fuelling stations will refuel the buses: the public OMV hydrogen refuelling station at the airport and the EnBW refuelling station close to an SSB depot which is specifically equipped for bus refuelling. In order to be able to successfully integrate new technologies into the fleets, the SSB takes a holistic system approach: apart from the procurement and testing of the buses, the requirements for an appropriate depot and the required personnel qualification were examined. The ecological and economic effects of the deployment of hydrogen fuel cell hybrid buses were evaluated by means of a life cycle analysis. The entire assessment was concluded with an examination of the level of acceptance of the new technology. Since the beginning of vehicle operation, a distance of over 225,000km was covered at an average consumption of 8.3 kg hydrogen per 100km. The uptime of buses was in line with the expectations of this young technology. At the start of vehicle operation, first a depot was fully trained: 220 bus drivers, additional traffic supervisors and a central service. In the next stages of the project, all newly-employed bus drivers were further trained, so that in total 460 drivers were trained. 62 workshop staff were qualified for maintenance work

PARTNER:
SSB AG

PROJECT BUDGET/€:
9,618,642

PROJECT FUNDING/€:
4,616,948

COMMENCEMENT:
1 June 2012

CONCLUSION:
30 September 2016

on the buses and 2 SSB depots modified according to hydrogen and high voltage safety requirements.

Daily operation has provided countless insights into improving suitability for practical application. It is important to continue to improve fuelling infrastructure in maintaining hydrogen purity, the carrying out of maintenance and checking activities in continuous operation (e.g. in pressure tank checking) and proper operation at low and high temperatures. At the height of summer, temperature compensation allows the available tank volume to be fully exploited. Additional improvements could be achieved through enabling the exchange of fuel filters in filled tanks and through the decommissioning of individual container tanks in order to continue to drive with reduced storage volume. While the environmental impact is greatly reduced using hydrogen from renewable sources (zero harmful emissions in operation, 80% less greenhouse gases over the entire life cycle), in terms of economic efficiency, further far-reaching efforts are required to reduce additional costs compared to conventional technologies.

There is a high level of acceptance of the technology. Aside from increased awareness of the necessity for technological transformation, drivers judge positively the product features such as improved driving comfort through the reduction of vibrations and noise. A PR highlight was the presentation of a bus at the COP21 UN climate conference in Paris. The insights and experiences gained contributes to increasing the practical usability of fuel cell technology, helps achieve market readiness and can be directly fed into the work of the CEP. In this way not only the SSB, but also other bus operators are facilitated in offering the most resource-efficient, environmentally-friendly and economic local public transport possible.

I/15 DEVELOPMENT AND ESTABLISHMENT OF TEN HYDROGEN REFUELLING STATIONS FOR NATIONWIDE NETWORK OPERATIONS

PARTNER:
Linde AG

PROJECT BUDGET/€:
10,323,073

PROJECT FUNDING/€:
4,953,635

COMMENCEMENT:
1 May 2012

CONCLUSION:
31 December 2016

Linde boasts many years of experience in all areas along the entire hydrogen value-added chain and has already developed and equipped more than 150 hydrogen refuelling stations throughout the world. The company considers itself to be a pioneer in the establishment of hydrogen infrastructure and continues to drive this goal forward. As part of the 50 refuelling stations programme of the BMVI, Linde and its partners are responsible for 10 stations. The programme will see that a total of 50 public hydrogen filling stations will be in operation within the first half of 2017, each with a capacity of more than 40 vehicles per day. This builds a bridge between the existing projects of the Clean Energy Partnership and the widespread infrastructure rollout via the now operative industry joint venture H2Mobility.

A network philosophy stands explicitly in the focus of this project. Through the strengthening of existing lighthouse regions and ensuring that corridors connecting the regions are adequately equipped, boundless hydrogen mobility between Germany's metropolitan regions is to thereby become a reality. In addition, research and development activities are to be directly connected with demonstration projects – allowing insights and experiences to flow in both directions and subsequently help identify more improvement potentials. For example, at the end of 2016, a hydrogen refuelling station was established at Munich Airport equipped with the latest generation cryo pump, which due to first insights having been made in this project, was developed in a further separate NIP project. This enabled, for example, the necessary electrical load and space requirements of the plant to be significantly reduced. In addition, the project saw the installation of first plants with ionic compressors produced from the small series production commencing 2014.

Besides the establishment of the 10 hydrogen refuelling stations, further development and improvement activities were conducted in the following areas:

1. **Service & maintenance** – The necessary maintenance activities and intervals were examined in detail, and training sessions for internal and external service activities were developed and conducted.

2. **Remote operation control** – Following the intensive evaluation of various integration possibilities in existing monitoring systems, this package involved the development of a comprehensive remote monitoring system (interfaces, parameters, process chains, activity/report matrix).

3. Supply interface/storage tank – After defining standard specifications together with potential suppliers, innovative 200 bar hydrogen storage tanks for installation at hydrogen refuelling stations were found, and a supply interface between this 200 bar storage tank and newer 500 bar hydrogen trailer technology was developed.

4. Spare parts management – Various storage options for spare parts were evaluated along with the implementation of an initial small storage facility with a specifically developed concept for replacement and consumable parts.

Aim of the project is to integrate the technology at existing refuelling station sites of various partners from the mineral oil industry. On the one hand, this shall serve to increase the infrastructural accessibility and visibility, an on the other, make a decisive contribution towards promoting the acceptance of hydrogen as a fuel among both operating partners and the public.

Opening of the TOTAL multi-energy refuelling station, Jafféstrasse.

I/16 HY8 – ESTABLISHMENT AND OPERATION OF 8 HYDROGEN REFUELLING STATIONS

The focus of this project – which TOTAL Deutschland GmbH commenced within the scope of the Clean Energy Partnership (CEP) as its contribution towards fulfilling the 50 refuelling stations programme that was initiated in 2012 by the federal government and industry – was the expansion of hydrogen refuelling infrastructure, which was closely coordinated with other refuelling station operators.

The aim of the project was to integrate a total of eight hydrogen refuelling points in existing or new stations, put these into service and operate them until the conclusion of the project timeframe. Legal authorisation of approvals proved to be problematic for many of the original locations, leading to the necessity during the project timeframe to identify new sites for the intended new refuelling pumps in order to overcome these regulatory hurdles. The realisation was thereby delayed in individual cases, and ultimately only seven sites could be completely brought to full implementation within the course of the project.

The following sites were established within the scope of the project:

- A multi-energy station with 700 bar hydrogen pump for passenger vehicles was established at Heerstrasse/cnr. Jafféstrasse in Berlin.
- Also suitable for 700 bar passenger vehicle refuelling was Germany's first H_2 refuelling station located on a motorway, which went into service at the Geiselwind station on the A3 motorway.
- A H_2 station was established at Ohmstrasse in Fellbach, which was particularly important for the supply in the metropolitan region of Stuttgart.
- A hydrogen refuelling station in Ulm was set up in the immediate vicinity of the Center for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW – Zentrum für Sonnenenergie- und Wasserstoff-Forschung) on Helmholtzstrasse. In close collaboration with the ZSW, this station was developed into a research refuelling station, which is to provide valuable insights especially in regard to the renewable production of hydrogen.
- A site was established in Karlsruhe at Erlachsweg.
- In Neuruppin, TOTAL provides vital infrastructure at the A24 motorway for the important corridor between Berlin and Hamburg.
- A further site is currently under construction at Cologne Bonn Airport.

All sites are ready for 700 bar passenger vehicle refuelling. The technology for all locations was provided and installed by Linde AG while TOTAL conducted all work that was necessary within the scope of this project to integrate, put into service and operate the system technology at the respective locations. The incorporated technology was financed by Daimler AG as part of a jointly initiated investment fund with Linde, for the establishment of 20 hydrogen refuelling locations, which – just as this project – is a part of the NIP's 50 refuelling stations programme.

PARTNER:
Total Deutschland GmbH

PROJECT BUDGET/€:
4,547,508

PROJECT FUNDING/€:
2,182,803

COMMENCEMENT:
1 September 2013

CONCLUSION:
31 December 2016

I/17 HRS DETMOLDSTRASSE: DEVELOPMENT & OPERATION OF A H_2 REFUELLING STATION WITH 300 BAR CRYO COMPRESSION TECHNOLOGY (CCH_2) & 700 BAR TECHNOLOGY (CGH_2)

PARTNER:
TOTAL Deutschland GmbH

PROJECT BUDGET/€:
2,774,610

PROJECT FUNDING/€:
1,331,813

COMMENCEMENT:
1 October 2013

CONCLUSION:
31 December 2016

In 2006, TOTAL had already erected a hydrogen refuelling station at its facility in Detmoldstrasse, Munich, which at the outset provided liquid hydrogen (H_2) to BMW's test fleet.

After BMW decided not to develop LH_2 technology any further and had begun preparations for testing the new cryo compression fuelling technology (CcH_2), TOTAL converted the existing hydrogen refuelling station within the framework of this project. From July 2015 TOTAL Deutschland GmbH continued in its role as operator of the research operation at the location. It was now possible to refuel with hydrogen as compressed gaseous hydrogen (CGH_2) at 700 bar and for the first time globally, also with cryogenic compressed hydrogen (CcH_2) at 300 bar using Linde's innovative cryo high-pressure pump technology. The delivery and storage of the hydrogen on site continued to be done in liquid hydrogen form (LH_2).

While the building of the facility was commissioned and coordinated by TOTAL, Linde AG was tasked with the delivery and installation of the entire facility's engineering. Cryogenic compression refuelling technology was developed under BMW's leadership. Planning and building of the station therefore was closely aligned to BMW's development activities. In July 2015 BMW presented the new vehicle generation and took over the first vehicle prototypes with cryo compression tanks in testing and demonstration operations. Since then refuelling of the vehicles takes place exclusively at the project location.

Aside from the practical testing of cryo compression technology and the optimisation of the refuelling process, in close cooperation with BMW, the examination of the energetic advantages of cryo compression technology was the central focus of scientific considerations.

Also the integration of hydrogen fuel in the operational processes of a conventional refuelling station was to be comprehensively researched, tested and optimised.

In 2016 the refuelling station became an important contact point for the 50 fuel cell vehicles brought onto the road as part of the car-sharing programme, BeeZero. As a result of this development, good capacity utilisation figures were achieved.

All experiences and results obtained were presented and discussed in the relevant committees of the CEP accompanying the project and in the accompanying research.

I/18 DEVELOPMENT AND ESTABLISHMENT OF TEN HYDROGEN REFUELLING STATIONS AS A FIRST STEP TOWARDS A COMPREHENSIVE NATIONWIDE HYDROGEN INFRASTRUCTURE

As one of the world's most successful automotive companies, Daimler AG is resolutely investing in the development of alternative drives – from hybrid vehicles to pure electric vehicles with battery or fuel cell – to enable emission-free mobility in the long term.

Fuel cell technology is an integral part of the Daimler AG drive strategy. But the market success of electric vehicles is intrinsically linked with the existence of a needs-oriented infrastructure. In order to give the expansion of hydrogen infrastructure an additional impulse, Daimler AG and the Linde Group agreed on a joint initiative in which each company will construct a further ten hydrogen refuelling stations in Germany. With these 20 additional refuelling stations, the companies are supporting the supply of completely renewably produced hydrogen for the continuously growing number of fuel cell vehicles on the roads.

The initiative builds a bridge to the existing Clean Energy Partnership (CEP) and H_2 Mobility Joint Venture infrastructure projects. At the same time, the initiative is also part of the BMVI's 50 refuelling stations programme. The focus of the research and development work lies chiefly in areas dealing with the supply to fleets as well as on the expansion of the refuelling station network in Germany.

PARTNER:
Daimler AG

PROJECT BUDGET/€:
14,460,710

PROJECT FUNDING/€:
6,941,141

COMMENCEMENT:
1 October 2012

CONCLUSION:
31 December 2016

Mercedes-Benz B-Class F-CELL at the Fellbach H_2 refuelling station.

I/19 ESTABLISHMENT OF A FULLY INTEGRATED PUBLIC HYDROGEN REFUELLING STATION IN SCHNACKENBURGALLEE, HAMBURG

The project was part of the activities of the NIP's transport programme area and is connected content-wise with the Clean Energy Partnership (CEP), the 50 refuelling stations programme and the H_2 Mobilitity initiative. Aim of the project was the integration of a new 700 bar hydrogen refuelling station in the existing Shell station in Schnackenburgallee, Hamburg; the production of hydrogen via on-site electrolysis; and integration in the energy balancing market.

The operational phase of the hydrogen refuelling station was successful overall, yet it was distinguished by a low demand for the hydrogen due to the unexpectedly low volume of vehicles in the Hamburg region. The anticipated experience to be gained for optimising the economic feasibility of hydrogen refuelling stations could therefore not be achieved to the originally planned extent.

Important insights could nevertheless be gained in regard to the implementation of the technology for on-site electrolysis and the hydrogen refuelling station. For example, while the integration of the on-site electrolyser in the energy balancing market could be achieved without problems on a technical and organisational level, the low demand led to a constant overproduction of hydrogen. An analysis of the interplay of the balancing market-integrated on-site electrolysis and the sale of hydrogen at the refuelling station illustrates that the economic viability of this stand-alone production and sales model is currently not given, even in the case of substantially more favourable framework conditions. The challenge in this regard is that the prices obtainable on the balancing energy market cannot offset the additional costs that exist through electrolysis due to the need for larger storage media or for the implementation of filling systems for the transportation of the surplus hydrogen.

In addition, the filling coupling jointly developed with the company Walther was deployed and successfully demonstrated in everyday use at the Schnackenburgallee location for the very first time. Through comparison with the generally implemented coupling from the manufacturer WEH, important insights regarding user friendliness and the optimisation of the interface between the refuelling station and the person refuelling, could be gained.

In view of optimised availability of the refuelling station in the future, success could be recorded through the increasingly automated operation of the refuelling station. While the resulting service and maintenance activities brought about higher personnel costs than anticipated, the reliable automation of refuelling operations culminated in a significant reduction in the number of aborted refuelling procedures in comparison to other hydrogen refuelling stations.

All experiences and results acquired in this project were presented and discussed in the relevant CEP committees as well as in the accompanying research.

PARTNER:
Shell Deutschland Oil GmbH

PROJECT BUDGET/€:
3,060,483

PROJECT FUNDING/€:
1,469,032

COMMENCEMENT:
15 October 2013

CONCLUSION:
30 June 2016

I /20 HY-UWE – CONVERSION AND FURTHER OPERATION OF THE HRS AT HOLZMARKTSTRASSE, BERLIN

In 2009 TOTAL had already built a hydrogen refuelling station at the Holzmarktstrasse, Berlin refuelling station location. In the first project phase a facility was deployed including electrolytic on-site production, which was mainly built by CEP partner Statoil. The facility did not however, live up to expectations in terms of operational reliability.

In the interest of supply reliability for Berlin's city centre, the original system technology was extensively replaced with one of Linde's hydrogen refuelling stations, within t he project.

During the conversion phase the facility was modified such that from May 2015 gaseous compressed hydrogen (CGH_2) at 700 bar could once again be filled at a dispensing pump. As there were no longer any LH_2-fuelled vehicles deployed at the start of operations, operation of the LH_2 dispensing pump was ceased. Some equipment like the existing LH_2 tank continued to be used for on-site storage. This equipment was supplemented by new components (cryo pumps, hydraulic containers, dispensing pumps). Accordingly hydrogen is delivered in liquid form. The object of the funding project was thus the modification or new construction of hydrogen equipment and the subsequent operation of the hydrogen refuelling station.

Over the course of the operating phase it was to be investigated in particular whether the projected energetic advantages of LH_2 delivery and the use of a cryo pump can be realised in practice. Comparative investigations were carried out with other TOTAL locations. The accompanying research programme on the 50 refuelling station programme of the federal government was provided with comprehensive operational data.

Considerably better results on operational reliability and performance were attained with the equipment than was the case with the preceding generation of equipment. Availability of up to 100% in the monthly average proved feasible. Through optimisation measures accompanying the project, e.g. at the pre-cooling cycle, improvements continued to be achieved. Additional stress tests were largely successfully completed. These were carried out on location in May/ June 2016 with the goal of investigating the behaviour of the operational parameters at higher refuelling station utilisation levels.

The integration of hydrogen as a fuel in the operational procedures of conventional refuelling stations was researched thoroughly, tested and optimised.

All experience and results obtained were presented and discussed in the relevant committees of the CEP and the accompanying research.

PARTNER:
TOTAL Deutschland GmbH

PROJECT BUDGET/€:
462,832

PROJECT FUNDING/€:
222,159

COMMENCEMENT:
15 October 2013

CONCLUSION:
31 December 2016

I/21 ELECTROLYSIS CONTAINER FOR HYDROGEN REFUELLING STATION (CEP)

PARTNER:
Siemens AG

PROJECT BUDGET/€:
782,056

PROJECT FUNDING/€:
375,387

COMMENCEMENT:
1 August 2014

CONCLUSION:
30 June 2016

The research project aimed to equip a hydrogen refuelling station with an innovative PEM hydrogen electrolysis system for the first time and test it in operation over a one to two-year period. The planned budget for the "CEP Refuelling Station Air Liquide" project was supported with funding from the BMVI.

At the time of application, the project was to be conducted in two phases:
- Test phase of approx. four months on industrial grounds
- Operational phase of approx. 14 months at a refuelling station site

The first project phase, which included the assembly and start-up of the PEM electrolysis system at the industrial grounds of Air Liquide in Krefeld, was implemented successfully. The electrolysis plant has been in regular operation since 2015, without any relevant disruptions. Only the operating timeframe is lower than planned and desired by both project partners, due to the conditions prevalent at the testing grounds.

The second project phase – operation at a refuelling station site – did not take place, as Air Liquide could make no suitable refuelling station site available at the scheduled time. As such, the duration of the first project phase has grown accordingly. Air Liquide is currently planning on erecting and operating the Siemens electrolysis plant at a separate site to a hydrogen refuelling station. The green hydrogen produced will then be financially assigned to the respective refuelling station.

Despite the changes to the original plan, valuable insights and experiences could be gained through this project: a DeOxoDryer was connected to an electrolyser and integrated in the electrolyser controller. A DeOxoDryer drys steam-saturated hydrogen and removes the complementary gas of oxygen, which for technological reasons is found in small quantities in the hydrogen gas.

Following a test phase, the performance of the plant was established and verified. Fortunately, the desired relatively high level of gas purity of 5ppm oxygen and 5ppm moisture in the hydrogen at the DeOxoDryer exit could be achieved. In addition, due to the many test series undertaken in varying operation conditions, the electrolysis plant itself as well as the interplay between the two technologies (electrolysis and DeOxoDryer) could both be optimised. The focus of gained knowledge was on the dynamic plant behaviour, e.g. during the changeover from stand-by phases to load and regeneration phases as well as in regard to the sensors for measuring gas quality. The abovementioned insights on dynamic operation and on hydrogen quality as well as the positive experiences made within the scope of service calls have thereby shown that the Siemens electrolysis technology can also be applied in a hydrogen mobility context.

I/22 RESEARCH OPERATIONS OF HYDROGEN REFUELLING STATION SACHSENDAMM

The verification of failure-free refuelling systems with 100 % availability is a prerequisite for the sustainable operation of refuelling stations. The aim of the "Research operations of hydrogen refuelling station Sachsendamm" project is thereby the examination of the Sachsendamm refuelling station in regard to the durability and resistance to ageing of system components used under capacity and in comparison with conventional pressurised gas technology.

A focus is placed on safeguarding operational availability and particularly on testing the technological concept in terms of the entire plant's vulnerability during periods of working under capacity as is anticipated over the coming years. The technology concept used involves the delivery of liquid hydrogen (LH_2) and conversion via a 900 bar cryogenic pump. In this way, compressors needn't be implemented, which often comprise a particular area of vulnerability in other concepts and decisively contribute to long, market-incompatible outages.

Within the scope of the project, a large-scale validation of the concept – supported by the comprehensive collection and evaluation of data – is being conducted, especially in regard to: operating and service costs; plant efficiency; as well as the operational reliability of the components and their serviceability. In addition, further improvements to the technology, based on the experiences made in the preceding project (optimised hydraulic concept) are being tested. The principal innovative subcomponents of the system include: the cryogenic pump; the on-site temperature management using cryogenic LH_2 for precooling the hydrogen to be dispensed; and the underground installation of the system technology in order to reduce the system's space requirements. Furthermore, due to the age of the plant, an inspection by TÜV Rheinland is necessary. As tests must be conducted without disruption, Shell will develop its own testing process in collaboration with TÜV Rheinland.

» The aim is thereby the examination in regard to the durability and resistance to ageing of system components used under capacity. «

PARTNER:
Shell Deutschland Oil GmbH

PROJEKTBUDGET/€
433,784

PROJECT FUNDING/€:
143,149

COMMENCEMENT:
1 June 2016

CONCLUSION:
31 December 2016

I/23 SHELL5HY – INTEGRATION OF FIVE HRS IN EXISTING MINERAL OIL REFUELLING STATIONS

Considering the still very low supply density of publically accessible hydrogen refuelling stations for passenger vehicles and the low availability of hydrogen refuelling stations when compared with conventional stations, the establishment of new, public refuelling stations with 700 bar technology is of material importance if the market introduction of hydrogen vehicles is to be successful. To enable this, the H_2 refuelling station technology and the integration of the hydrogen fuel in the operational processes of conventional stations must be tested, developed further and standardised.

Yet to develop innovative drive concepts and research the possibilities for technical and economic optimisation, further verifiable experiential and comparative operating data is required from a larger number of similar refuelling stations at numerous locations and under varying framework conditions. Within the scope of this project and in cooperation with Daimler AG and Linde AG, Shell is integrating five Linde IC 90-type hydrogen refuelling stations (HRS) in existing mineral oil refuelling stations in Bremen, Hamburg, Pforzheim, Sindelfingen and Wiesbaden. Shell is responsible for the integration concept of the HRS in the respective stations, coordinates the implementation and is also the operator of the facilities.

The main objective of the research project is the accompanying research during the development, implementation and optimisation of various HRS installation concepts, in order to significantly enhance the degree of standardisation and process optimisation for the establishment of future HRS and simultaneously lay the foundation for future research operations at the facilities. Moreover, the research project also serves to help in the development of operating concepts for the integration of hydrogen as a fuel in the Shell portfolio of products.

» Shell is responsible for the integration concept of the HRS in the respective stations, coordinates the implementation and is also the operator of the facilities. «

PARTNER:
Shell Deutschland Oil GmbH

PROJECT BUDGET/€:
2,242,662

PROJECT FUNDING/€:
1,076,477

COMMENCEMENT:
1 June 2016

CONCLUSION:
31 December 2016

I/24 DEVELOPMENT OF HUMIDIFIER AND FILTER PROTOTYPES FOR THE OPTIMAL SUPPLY OF INTAKE AIR FOR PEM FUEL CELLS

The "Development of humidifier and filter prototypes for the optimal supply of intake air for PEM fuel cells" project (proAir) involved the provision of inexpensive and certifiable components for fuel cell systems. Supplying polymer electrolyte membrane fuel cells (PEM FC) with optimally humidified air without contaminants has a significant influence on the efficiency, reliability and service life of PEM FC.

Aim of the project was the development of filters and humidifiers for the preparation of intake air for PEM FC with the characteristics outlined below.

By implementing new production concepts, various filter and humidifier components were developed that:

- allow for cost reductions and design flexibility in the tools, enabling the components to be adjusted to specified assembly spaces and connections more inexpensively, and
- through the optimisation of airflow, boast minimal loss of pressure and optimal performance.

In addition, the filters were developed in such a manner to provide protection against damaging salt aerosols and ammonia, and also allow for service-friendly and leak-proof maintenance when installed in a housing unit.

proAir is a joint Freudenberg and mm plastic GmbH project.

Freudenberg developed the concepts and provided the guidelines necessary for the development of the tools. mm plastic developed the tools and the processes for the manufacture of the housing, and produced parts for the fabrication of test samples and prototypes.

The prototypes were designed in cooperation with associated end users and then tested and evaluated for suitability in laboratory and field tests. Through the close cooperation with end users during the close-to-series development of the components, the foundations for accelerated deployment of the developed components in marketable products had already been laid.

Following the completion of the project, a basic portfolio of products exists, forming the basis for the qualification of the products for series deployment.

PARTNERS:
a) Freudenberg Filtration Technologies SE & Co. KG
b) mm plastic gmbh

PROJECTBUDGET/€
a) 1,576,476
b) 593,269

PROJECT FUNDING/€:
a) 756,708
b) 284,769

COMMENCEMENT:
1 August 2012

CONCLUSION:
30 June 2016

II. NIP — HYDROGEN PROVISION

THE PROJECTS ON THE FOLLOWING PAGES ARE LABELLED WITH II/01.

NEWLY APPROVED PROJECTS

COMPLETED PROJECTS

INTERDISCIPLINARY THEMES

NIP — HYDROGEN PROVISION

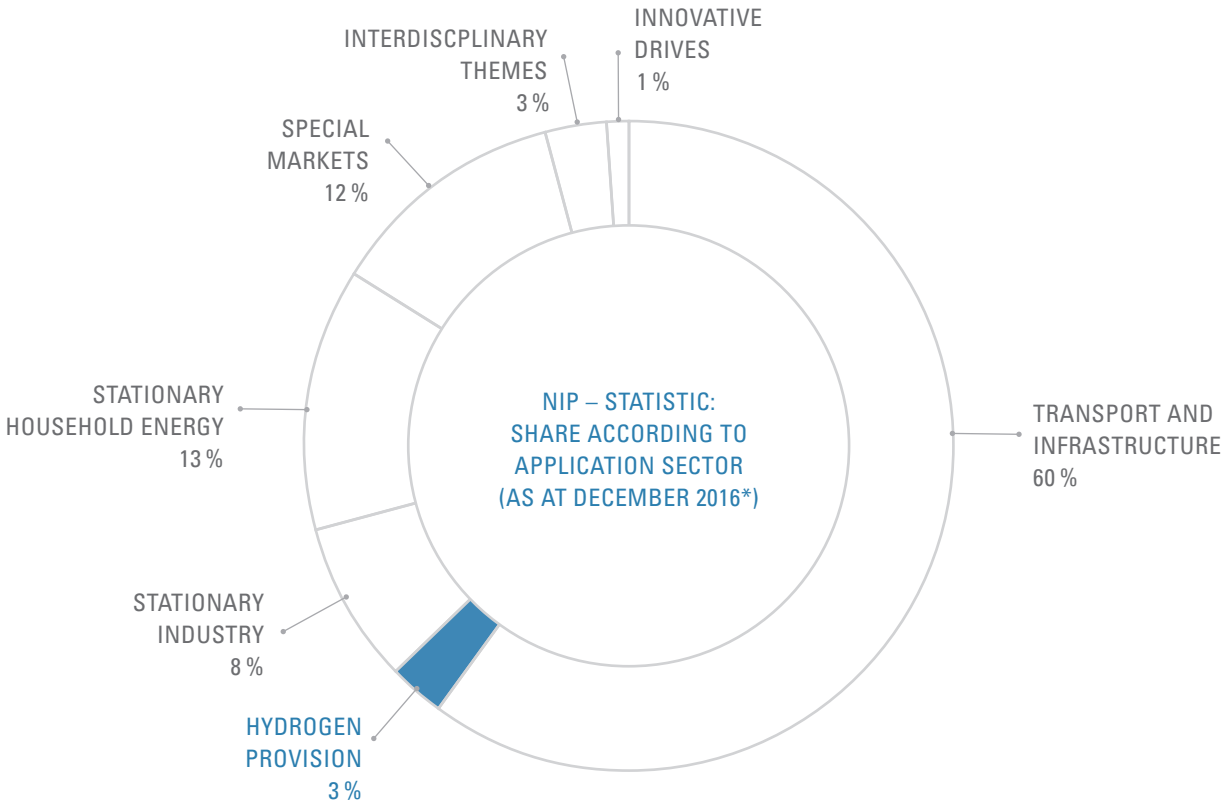
Demonstration projects and studies on the production, storage and distribution of hydrogen are conducted within the Hydrogen Provision programme area in the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP). In line with the goals of the federal government's energy concept, the hydrogen 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 energy from fluctuating renewable sources. 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.

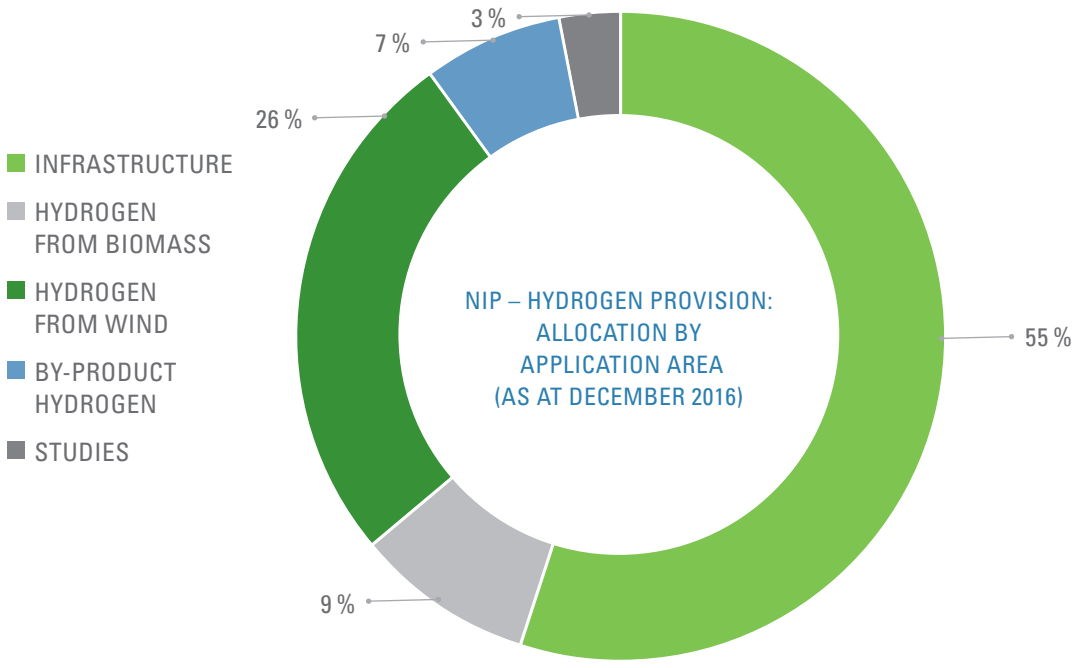
The use of regenerative hydrogen can make a significant contribution to the goals of the so-called energy transition. Not only does it accelerate the switch from fossil-based fuels to renewable sources of energy in the transportation and energy sector – as set out in the energy concept – it also creates energy storage capacities, which are urgently required for the energy transition 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. The potentials of hydrogen and fuel cell technologies to reach the goals set out for the energy transition 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 transition.


INNOVATIVE DRIVES 1 %
INTERDISCPLINARY THEMES 3 %
SPECIAL MARKETS 12 %
STATIONARY HOUSEHOLD ENERGY 13 %
STATIONARY INDUSTRY 8 %
HYDROGEN PROVISION 3 %
TRANSPORT AND INFRASTRUCTURE 60 %
NIP – STATISTIC: SHARE ACCORDING TO APPLICATION SECTOR (AS AT DECEMBER 2016*)


INFRASTRUCTURE
HYDROGEN FROM BIOMASS
HYDROGEN FROM WIND
BY-PRODUCT HYDROGEN
STUDIES
3 %
7 %
26 %
55 %
9 %
NIP – HYDROGEN PROVISION: ALLOCATION BY APPLICATION AREA (AS AT DECEMBER 2016)

II/01 COMPACT 1 MW PEM WATER ELECTROLYSIS SYSTEM – REGENERATIVE HYDROGEN FOR MOBILITY AND ENERGY STORAGE

Relevance for the NIP/project goals:
Aim of the project was to develop a PEM water electrolyser in the 1MW performance range for the first time, to manufacture it as a pilot unit and to then test its operation under real conditions via a relevant application. The developed PEM electrolysis system is to make the benefits of PEM technology (e.g. dynamic operating behaviour, high power density) available in a new performance class and to also enable cost advantages through the upscaling of the unit sizes. The development of the PEM electrolyser was to thereby meet the demands for deployment in the mobility sector (generation of green hydrogen as a fuel) as well as the highly flexible integration of renewable sources of energy in the energy and heating sectors.

Approach, methodology/technology, schedule:
The pilot unit, based in Reitbrook, was developed, manufactured and tested under real conditions by the partners involved.

Hydrogenics was responsible for the construction of the PEM electrolysis unit. Greenerity was accountable for the development and supply of the membrane electrode assemblies, Uniper for the establishment of the requisite ancillary systems and for operation. The scientific partners DLR (German aeronautics and space research centre) and Fraunhofer ISE supported the project via laboratory examinations of membrane electrode assemblies and short stacks along with diverse other scientific examinations for the improvement of the next electrolysis system generation. Both institutes also designed comprehensive measurement programmes, conducted these on the pilot unit and evaluated the results.

Following the commencement of the project in November 2012, the PEM electrolysis was developed to the point of market maturity and the actual stack design conceived by Greenerity (membrane technology) and Hydrogenics (stack and unit).

Construction of the pilot unit took place in 2014. At the same time, the approvals processes were conducted and operational plans created. The official commencement of pilot unit operations took place on 15 October 2015. The unit was tested under real conditions and optimised in a number of areas until the end of the project in September 2016.

Specific achievements, results:
Significant increases to efficiency compared with existing units could be proven. Overall, the pilot plant produced more than 100,000Nm^3, which was fed into the natural gas network.

The following table compares the final specifications achieved by the unit with the original project goals from the application. The set goals were entirely achieved.

PARTNERS:
a) Uniper Energy Storage GmbH
b) Hydrogenics GmbH
c) Greenerity GmbH
d) Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLR)
e) Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V.

PROJECT BUDGET/€:
a) 4,386,005
b) 3,812,244
c) 2,353,668
d) 951,731
e) 2,285,830

FUNDING BUDGET/€:
a) 2,105,282
b) 1,829,877
c) 1,129,761
d) 456,831
e) 1,097,198

COMMENCEMENT:
1 November 2012

CONCLUSION:
31 October 2016

Comparison of the original project goals with the real values achieved by the pilot unit

PARAMETER	SPECIFICATION VALUES AT APPLICATION	SPECIFICATION VALUES IN OPERATION
Stack volume	0.25 m^3	0.38 m^3
Hydrogen production rate at nominal load	Not specified	229 Nm^3/h
Electrical output at nominal load	1 MW	1 MW
Hydrogen production rate at overload	Not specified	290 Nm^3/h
Electrical output at overload	1.5 MW	1.5 MW
Design pressure (DP)	Not specified	40 barg
Max. operating pressure (MOP)	10 – 30 barg	30 barg
Operating temperature	50 – 80 °C	50 – 80 °C
Hydrogen purity	> 99.99 %	> 99.99 %
Energy consumption	3.8 – 4.86 kWh/Nm^3	4.0 – 5.2 kWh/Nm^3

Besides the industry partners Uniper, Greenerity and Hydrogenics, the two research partners Fraunhofer ISE and DLR also accompanied the project and examined, among other things, the pilot unit's ageing behaviour.

Problems, learning effects:

Enabling a compact form and efficient operation, PEM technology can significantly reduce the costs of producing hydrogen. The classification of P2G units as final consumers and the subsequently associated real price of electricity, however, currently prohibit economically feasible commercial operations. The cost effective realisation of economic benefits of the P2G unit must therefore be supported by an adjustment to the legal framework.

The operational pilot unit, based in Reitbrook.

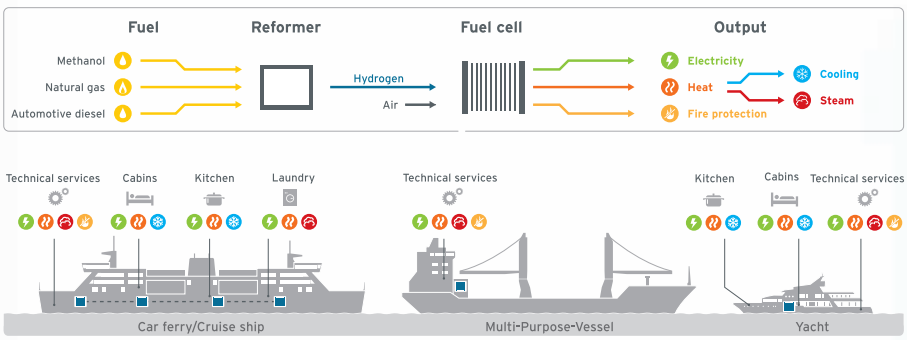
III. NIP — STATIONARY ENERGY SUPPLY

THE PROJECTS ON THE FOLLOWING PAGES ARE LABELLED WITH III/01.

NEWLY APPROVED PROJECTS

COMPLETED PROJECTS

INTERDISCIPLINARY THEMES



Improved air quality
by reducing pollutants such as nitrous oxides (NO_x) and sulphur dioxides (SO_2)

+

Reduction of CO_2 emissions
by 25 to 30%, as a contribution to climate protection and in response to stricter emission regulations

+

Economic viability
by being independent from finite fossil resources

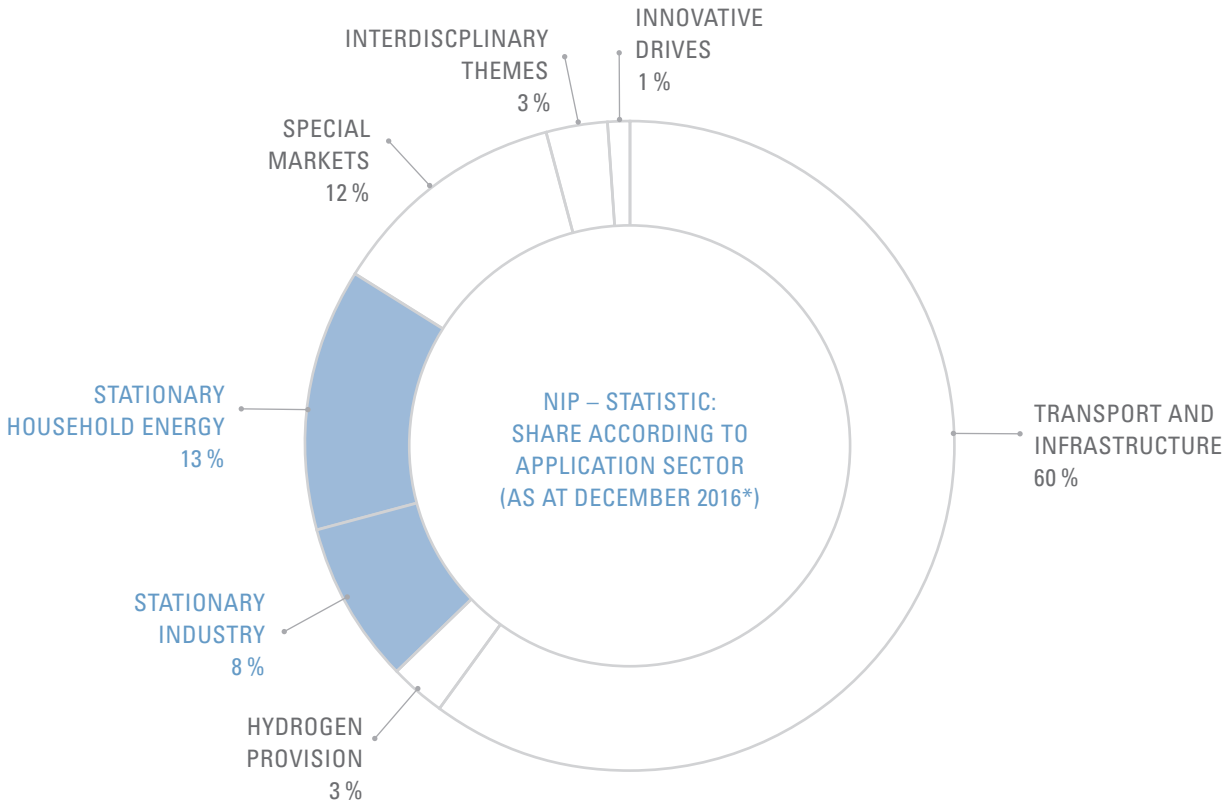
NIP — STATIONARY ENERGY SUPPLY

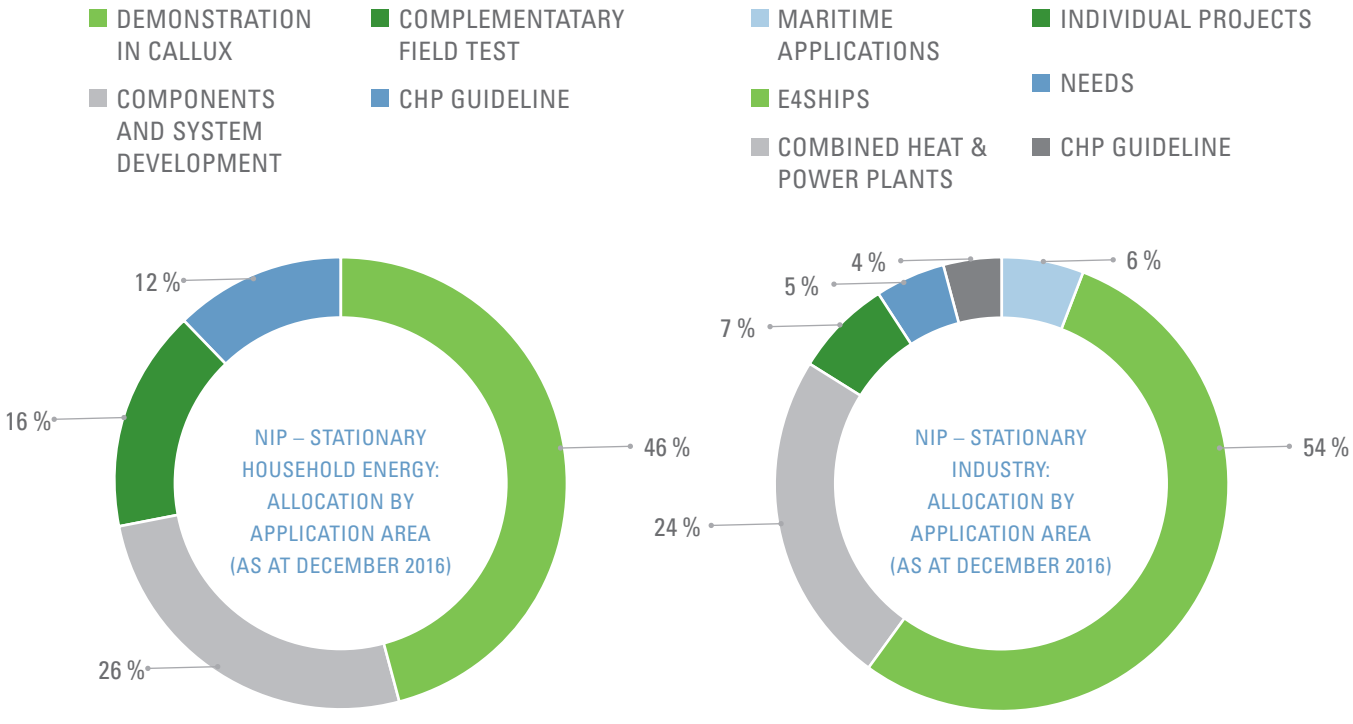
The Stationary Energy Supply programme area includes systems with an electrical output range spanning from several hundred watts up to five kilowatts in the area of household energy, and from double-digit kilowatts to several megawatts for industrial applications. The simultaneous generation of heat 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 the area of household energy supply work on the principle of combined heat and power, and operate using natural gas from existing supply networks. In the medium term, renewable energies that are fed into the natural gas network will also be used. Fuel cell systems for household energy thus have the advantage of being directly usable without requiring investment in 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, MCFC PAFC or HT/LT PEM technologies are implemented.

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.


INNOVATIVE DRIVES 1 %
INTERDISCPLINARY THEMES 3 %
SPECIAL MARKETS 12 %
STATIONARY HOUSEHOLD ENERGY 13 %
STATIONARY INDUSTRY 8 %
HYDROGEN PROVISION 3 %
TRANSPORT AND INFRASTRUCTURE 60 %
NIP – STATISTIC: SHARE ACCORDING TO APPLICATION SECTOR (AS AT DECEMBER 2016*)


DEMONSTRATION IN CALLUX
COMPLEMENTATARY FIELD TEST
COMPONENTS AND SYSTEM DEVELOPMENT
CHP GUIDELINE
12 %
16 %
46 %
26 %
NIP – STATIONARY HOUSEHOLD ENERGY: ALLOCATION BY APPLICATION AREA (AS AT DECEMBER 2016)
MARITIME APPLICATIONS
INDIVIDUAL PROJECTS
E4SHIPS
NEEDS
COMBINED HEAT & POWER PLANTS
CHP GUIDELINE
4 %
6 %
5 %
7 %
54 %
24 %
NIP – STATIONARY INDUSTRY: ALLOCATION BY APPLICATION AREA (AS AT DECEMBER 2016)

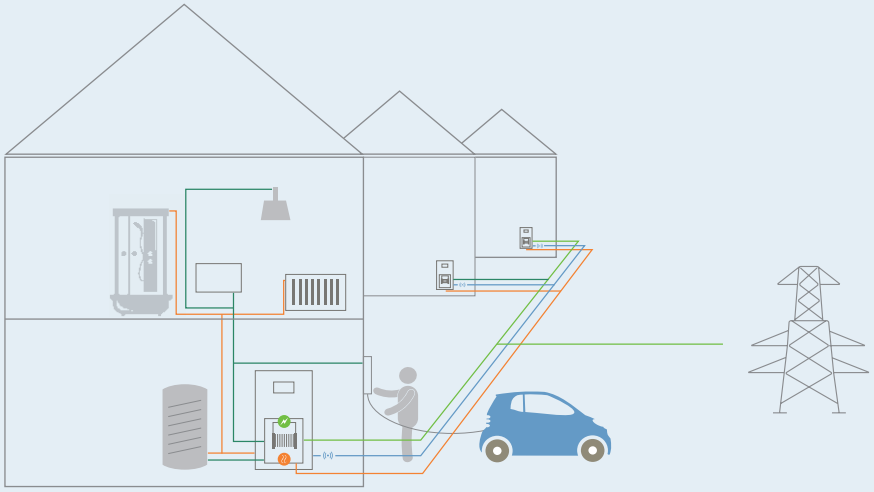
BMVI's fuel cell CHP directive

Subsidised systems produce efficient heat and power

Because of their high level of energy efficiency, fuel cell-based combined heat and power systems not only protect the environment – they also are an important factor in successfully implementing the energy transition. To support the market ramp-up of the systems, in the autumn of 2016 the Federal Ministry of Transport and Digital Infrastructure (BMVI) approved seven funding applications for the procurement of a total of 1,292 fuel cell-based CHP systems to be used in both the industrial and home energy areas. This was done under the funding directive "Fuel cells for highly efficient combined heat and power systems" (Fuel cell CHP directive).

Totalling approximately 6.8 million euro, the funding is designed to support the testing of potential business models and the construction of larger energy supply facilities for industrial application. Multipliers will thus gain the opportunity to get to know and test fuel cell technology in the context of commercial applications.

Two large combined heat and power systems with a power range of between 100 and 400 kilowatts will ensure energy supply for larger properties and industrial facilities. Specifically the subsidised systems will be used in a hotel and in a deep-freeze warehouse.

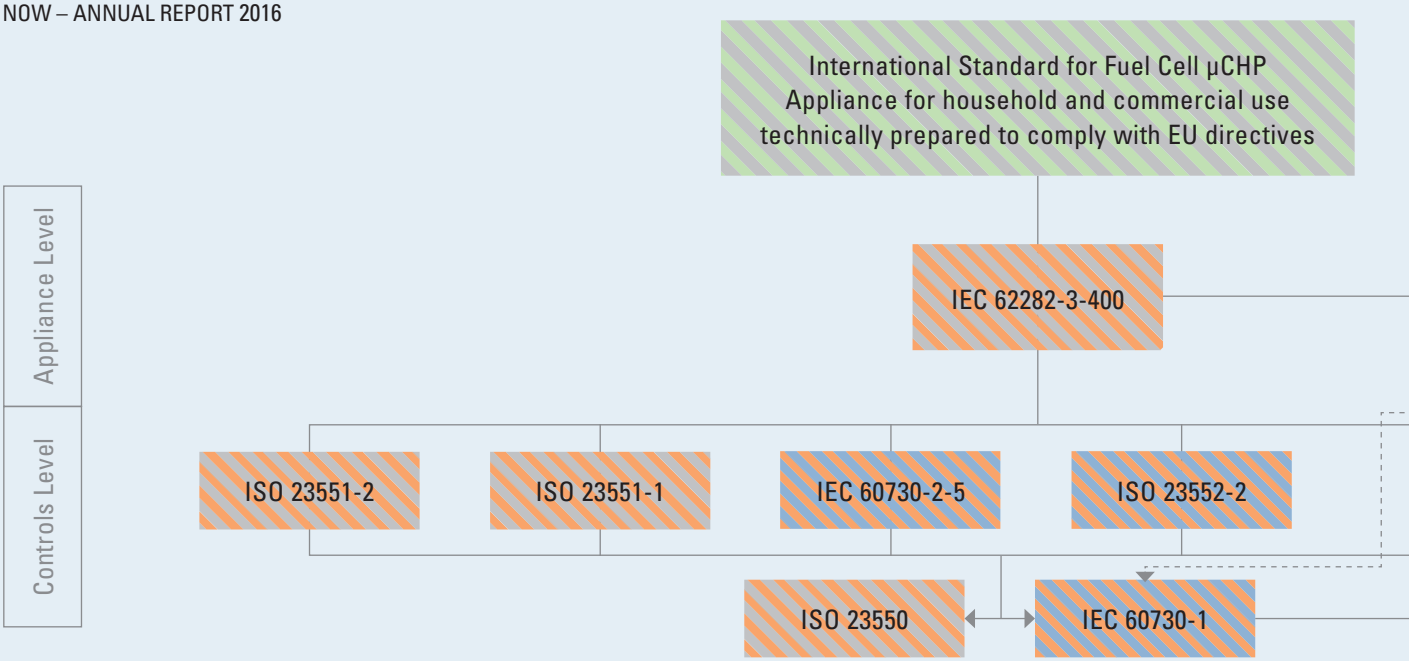


The procurement of 1,290 systems for home energy supply through distribution and trading companies will also be supported by the funding programme. The companies supported are afforded the opportunity to develop and start business models in contracting, leasing or in the rental area. At present, still high appliance manufacturing costs form the backdrop to the incentive programme. Through higher production numbers during market activation, procurement costs could be lowered for users in the long term.
A basic prerequisite for approving a funding application included the purchase of at least five fuel cell-based heating systems for further sale in the business model being tested.

The applications for commercial systems with over 20 kilowatt electrical output (kWel) could be made by the users themselves. In the area of home energy, the funding directive now implemented marks the transition from the Callux practical test, the focus of which was market preparation and optimisation of the appliances, to the energy efficiency incentive programme of the Federal Ministry for Economic Affairs and Energy (BMWi), which began in August 2016.

As part of the programme, the Kfw subsidy 433 "Energy efficient construction and renovation – fuel cell grant" supports the installation of fuel cell heating appliances with investment grants in single and two-family homes and owner-occupied apartments in homeowner associations.

In Japan in the home energy area there are currently more than 180,000 fuel cell heating appliances in operation.



International standardisation IEC TC 105 for stationary fuel cell heating appliances

The launch of the CALLUX funding programme in 2008 saw participating partners, while developing fuel cell heating appliances, also considering the issue of devising safety standards on European and international levels. Until 2010 the highly successful CALLUX project had played a leading role within Europe. This resulted in an ever-increasing demand for internationally reliable standards and norms, particularly in Japan, as more and more systems came on to the market through the Ene.Farm programme. Because of this funding programme, Japan was able to enjoy a substantial lead of several years in terms of marketing and development. This is also reflected in its considerably higher sales figures. This lead was built up over years. By contrast Germany has the edge over USA and Canada, where market figures are lower and the scope of field tests narrower than in Germany.

With a view to fulfilling European directives, e.g. GAD (2009/142/EG) and LVD (2014/35/EU) and following gas appliance standard EN 483, the European standardisation bodies CEN/CENELEC (European Committee for Electrotechnical Standardisation) developed the fuel cell heating appliance standard EN 50465:2008 as a purely European standard during the period 2002-2008. Almost parallel to the European standardisation project, the *IEC 62282-3-x stationary fuel cell power systems series* of standards was developed through the International Electrotechnical Commission, dominated by the US and Japan. A few attempts at direct cooperation between the relevant technical committee in the IEC (IEC TC 105) and the corresponding working group at the CEN/CENELEC (JWG FCGA – Joint Working Group on Fuel Cell Gas Appliances) have been unsuccessful because the initial focus as well as the safety-related content of the two bodies differed significantly from one another.

For the German fuel cell heating appliance industry, the situation in 2010 regarding the European and international market was unsatisfactory. Because it complied with EU directives, product standard EN 50465 was ideal for Europe, but was inconsistent with international standard IEC 62282-3-1:2008, e.g. with regard to requirements for gas safety (gas leakage). Consequently the very positive market development in Japan could only be implemented to a limited extent in cost-effective supply chains because the


IEC 62282-3-400

Edition 1.0 2016-11

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Fuel cell technologies –
Part 3-400: Stationary fuel cell power systems – Small stationary fuel cell power system with combined heat and power output

Technologies des piles à combustible –
Partie 3-400: Systèmes à piles à combustible stationnaires – Petits systèmes à piles à combustible stationnaires avec chaleur et puissance en sortie combinées

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

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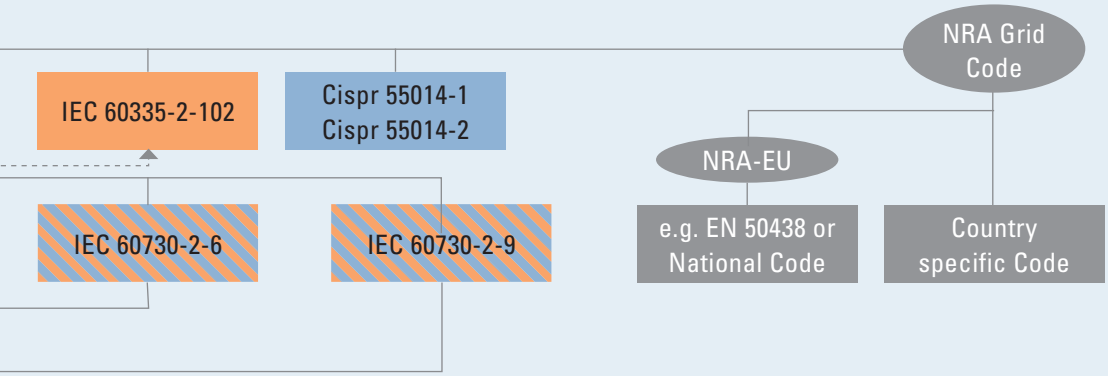


products were developed on different normative frameworks. There was no compliance with the European standard or the European directives.

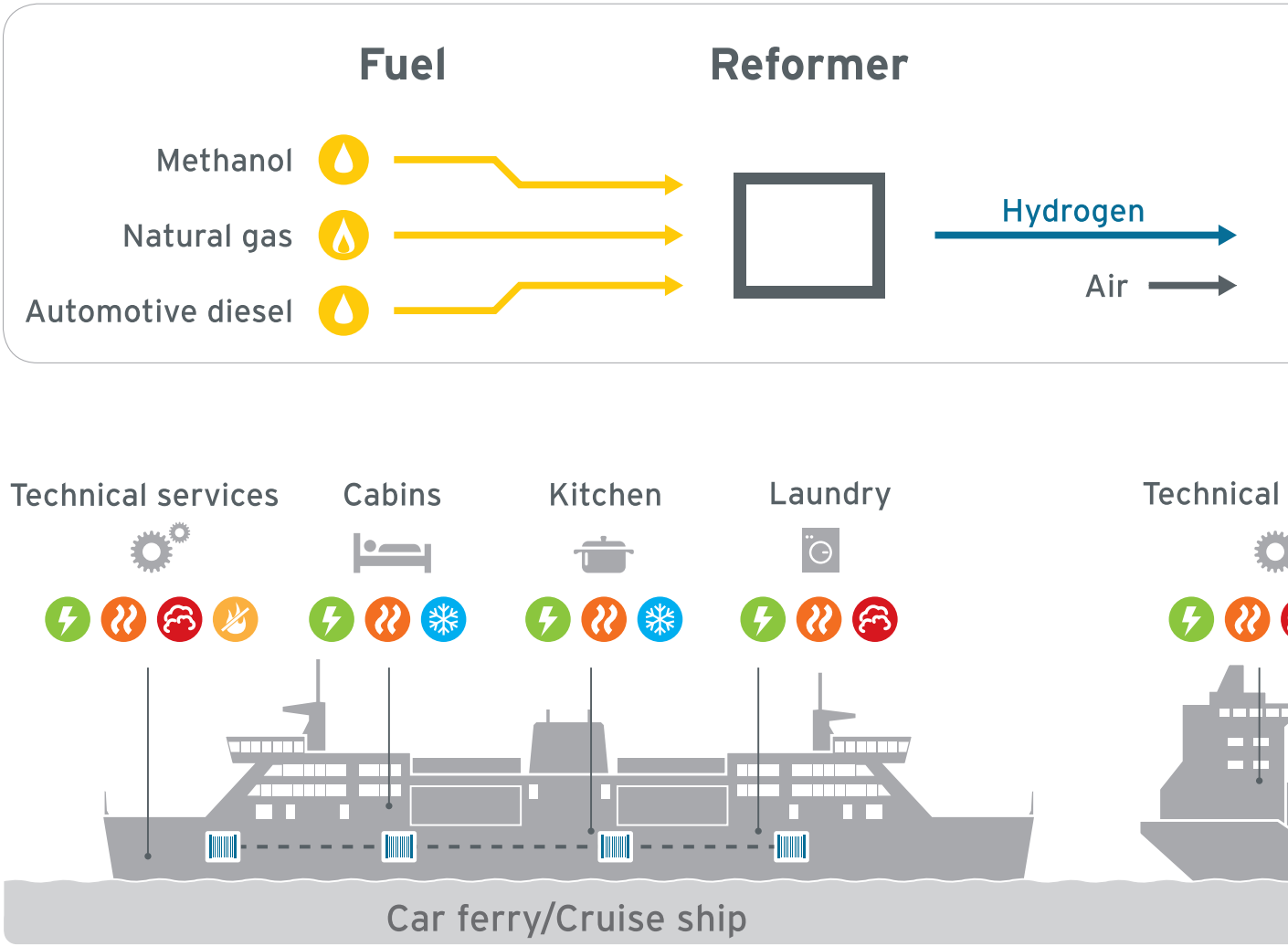
In order to incorporate EN 50465 in the IEC TC 105 set of standards, in 2010 a study was carried out under the NIP. Here a strategy was developed on how Germany should participate in international standardisation within IEC TC 105 Fuel Cell Technology in order to significantly increase its influence which at present, hardly exists. Part of this strategic development was to participate in the IEC TC 105 standardisation sessions and their working groups in the "Stationary Fuel Cell" and "Modules" areas, in order to be able to actively propose amendments.

By the end of 2016, thanks to continuous support from NOW and industry partners BAXI INNOTECH, Bosch Thermotechnik, ELCORE, Hexis, SOLIDpower, Vaillant and Viessmann, the internationalisation of European standard EN 50465 was achieved.

On 14 October 2016 at a positive vote of the IEC and CEN/CENELEC, EN 50465 was integrated into IEC 62282-3-400 *Fuel cell technologies – Part 3-400: Stationary fuel cell power systems – Small stationary fuel cell power system with combined heat and power output.* In November 2016 it was published as IEC 62282-3-400:2016 Ed.10.

Undoubtedly this project bolsters the successful market launch of fuel cell heating appliances. The standard will lay the regulatory foundations for international distribution of German appliances. At the same time options for reducing additional costs through the use of international supply chains can be exploited.

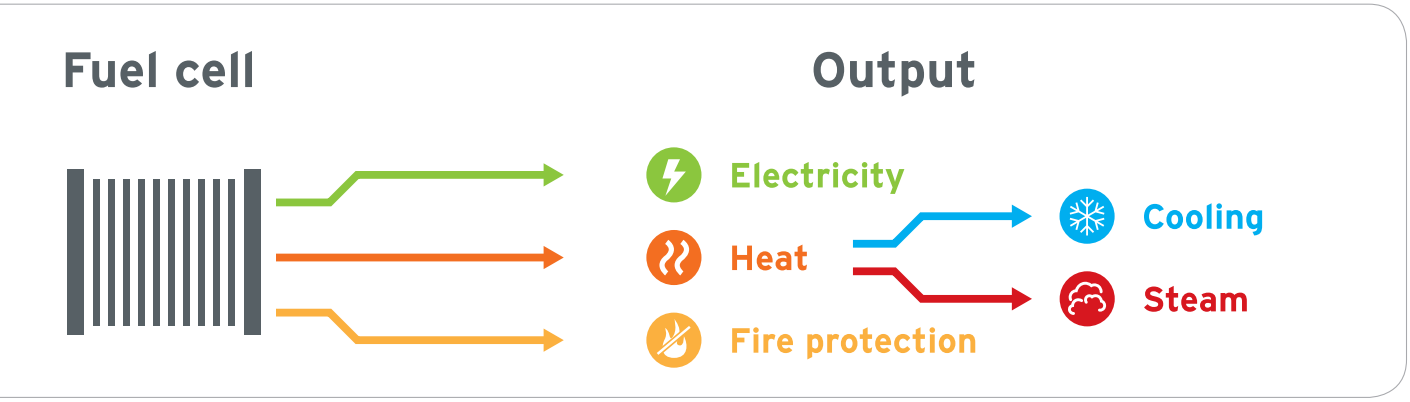
Diagram of fuel cell fields of application in the project e4ships

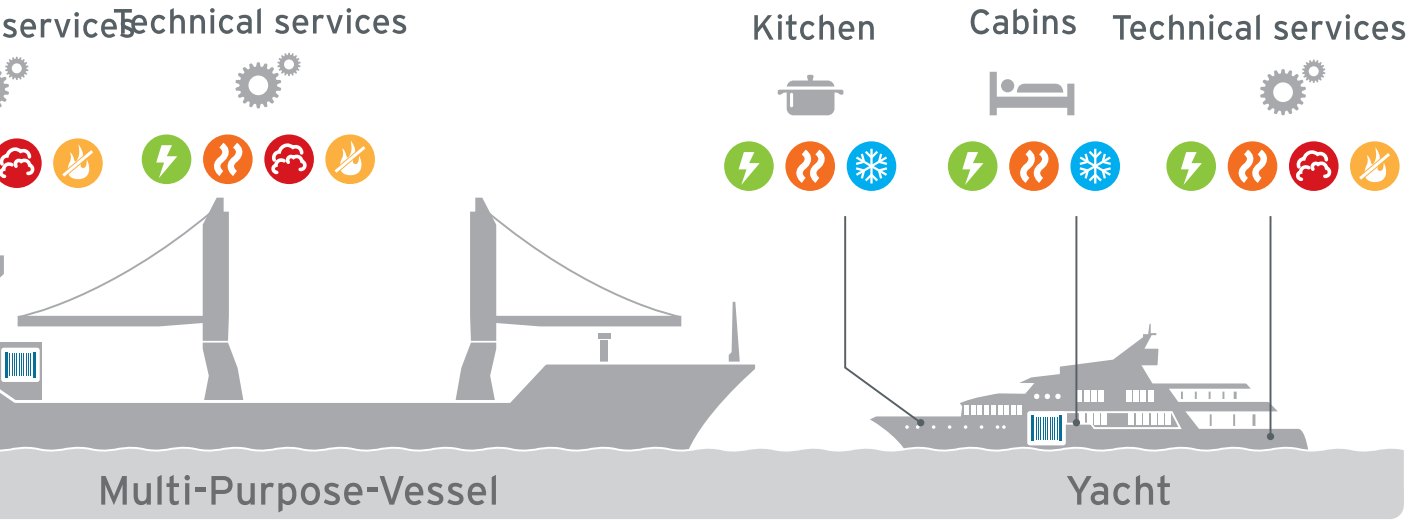


Improved air quality

by reducing pollutants such as nitrous oxides (NO_x) and sulphur dioxides (SO_2)

+





Reduction of CO_2 emissions
by 25 to 30%, as a contribution to climate protection and in response to stricter emission regulations

+

Economic viability
by being independent from finite fossil resources

III/01 LIGHTHOUSE PROJECT E4SHIPS – FUEL CELLS IN MARITIME DEPLOYMENT

In shipping the requirements for adhering to EU environmental law are increasing rapidly. The aim of the e4ships lighthouse project is to considerably reduce harmful emissions through the use of climate-friendly fuel cells on ships, because this provides an environmentally-friendly alternative to conventional aggregates on board ships.

The e4ships project successfully demonstrated new technical solutions for reducing emissions by using fuel cells on ships. The systems tested are not initially designed to replace the propulsion engines, but rather the units supplying the auxiliary users with electricity and heat, or cooling. Due to the use of the fuel cell for power, heat and cooling, they are highly efficient. Compared to conventional combustion engines that run on marine diesel or heavy oil, significantly reduced noise and exhaust emissions have been demonstrated. The decentralised and modular approach not only provides a flexible and safe structure on board, but also simultaneously a redundant energy supply and thus enhanced security (Safe Return to Port). Through the project work, joint requirements in the establishment of national, European and international rules, norms and standards in the relevant specialised bodies like for example the International Maritime Organisation (IMO) were introduced in order to facilitate the use of alternative fuels and fuel cells in international shipping in the future. To this end an intensive exchange between the coordinators of IMO member states, i.e. in Germany the Federal Ministry of Transport and Digital Infrastructure, is required. In the framework of regular project meetings a platform for professional exchange between project partners was created, and through joint communication, a high level of awareness of the lighthouse project was guaranteed in both political and public arenas.

Toplaterne is a superordinate module in the e4ships joint project in which all superordinate insights are compiled, for example on the fuel cells deployed. The systems tested in the demonstration projects of the lighthouse (Pa-X-ell and SchIBZ) are still prototypes that will have to be further tested and optimised in real operation. Possible fuels include methanol, natural gas (CNG, LNG), diesel or hydrogen. Aside from their use on different types of ship, deriving uniform technical standards for all system models and power classes poses significant technical challenges. Furthermore more powerful systems are planned for the future. The results already obtained form the basis for continuing further development in maritime fields of application. Under the leadership of Meyer Werft

PARTNERS:
a) hySOLUTIONS GmbH
b) AIDA Cruises – German Branch of Costa Crociere S.p.A.
c) DNV Germany GmbH
d) Fr. Lürssen Werft GmbH & Co. KG
e) Flensburger Schiffbau-Gesellschaft m.b.H.& Co. KG
f) DNV GL SE
g) Elsflether Zentrum für maritime Forschung GmbH
h) MEYER WERFT GmbH & Co. KG
i) ThyssenKrupp Marine Systems GmbH
j) Verband für Schiffbau und Meerestechnik e.V.
k) Zentrum für Brennstoffzellen-Technik GmbH

PROJECT BUDGET/€:
a) 194,886
b) 67,954
c) 102,549
d) 84,867
e) 69,672
f) 246,925
g) 18,113
h) 85,789
i) 140,451
j) 103,189
k)118,276

FUNDING BUDGET/€:
a) 93,545
b) 32,618
c) 49,224
d) 40,736
e) 33,443
f) 118,523
g) 8,694
h) 41,180
i) 67,416
j) 49,531
k) 56,773

COMMENCEMENT:
1 October 2009

CONCLUSION:
31 December 2016

together with their project partners, the *Pa-X-ell* demonstration project focusses on developing fuel cell systems with liquid-cooled high temperature PEM fuel cells which are tested on a passenger ship. The fuel cell system is based on standardised modules for generating electricity, heat and cooling which can be scaled to any power capacity. The system is operated by an internal reformer using a mixture of methanol and water. The long-term goal of the project partners is to deploy fuel cells in decentralised networks on board passenger ships. The decentralised structure increases safety as every single fire zone can be fitted with fuel cells. Apart from the positive safety aspect of supplying energy to the hotel area, energy currents are reduced and thus the efficiency of the overall system is increased. One fuel cell system prefabricated onshore was installed and tested in the first fuel cell maritime test on the MS Mariella ferry between Stockholm and Helsinki. The next step will require further intensive development in the manufacture of fuel cell modules, increasing the energy density and the intensive development of the decentralised and hybrid energy system for seafaring ships.

Under the leadership of thyssenkrupp Marine Systems, in the *SchIBZ* project different companies and institutions are working towards replacing motor-driven generators with environmentally-friendly fuel cell systems in the long-term. Through interdisciplinary cooperation, a hybrid power generator based on solid oxide fuel cells (SOFCs) and lithium-ion batteries that is suitable for deployment on the high seas will be developed, manufactured and tested for ensuring the on board supply of energy. The unit as well the number of the modules per ship are scalable – in this way output could be built up gradually to the megawatt capacity. Low-sulphur diesel serves as fuel for the system because it is available worldwide, has a high volumetric energy density and in addition to greatly reduced carbon dioxide emissions when used in the fuel cell, does not generate any further harmful pollutants. For all onshore system-related sub-processes assessed, a demonstrator was built onshore first, tested and then set up on MS Forester for operation at sea. On the basis of these results the system will be further developed for integration into the on board network, as well as in terms of power density.

IV. NIP — SPECIAL MARKETS

THE PROJECTS ON THE FOLLOWING PAGES ARE LABELLED WITH IV / 01 – IV / 6.

NEWLY APPROVED PROJECTS

COMPLETED PROJECTS

INTERDISCIPLINARY THEMES

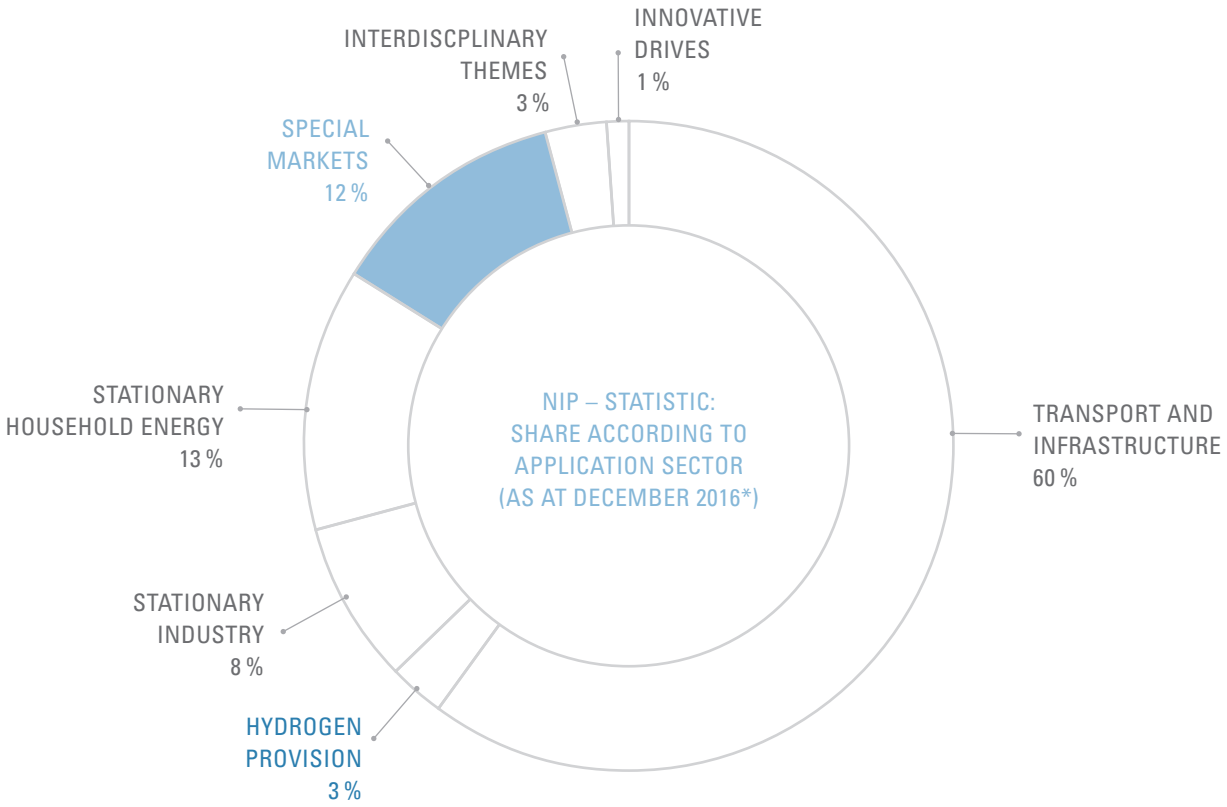
NIP — SPECIAL MARKETS

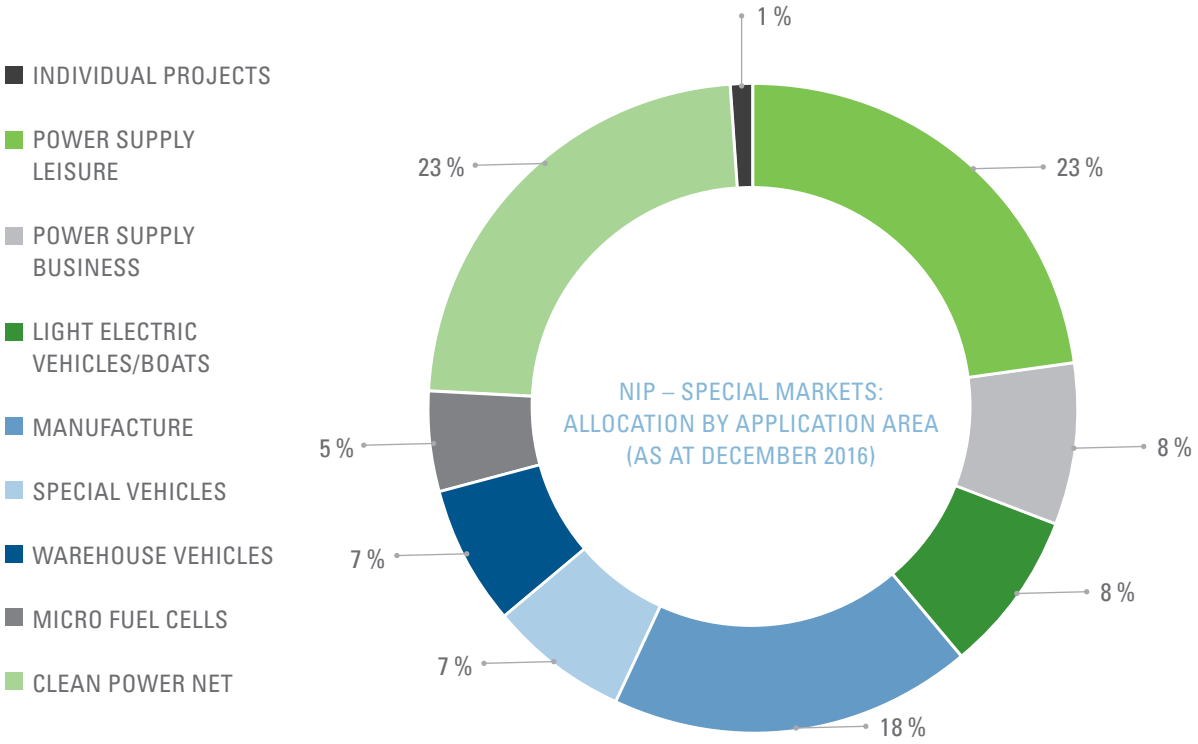
The Special Markets programme area of the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP) incorporates a broad spectrum of applications. Likewise, the scope of power ranges deployed in the Special Markets is large, as are the diverse types of implemented fuels and fuel cell technologies.

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).

Special Markets incorporates the following areas of application:

- Power supply for business (emergency power supply, UPS, off-grid power supply, autonomous/hybrid power supply, emergency power systems, e.g. in the areas of telecommunications, IT and traffic control systems)
- Power supply for leisure (on-board power supply (auxiliary power units), caravans, camping, mountain cabins, boats)
- Warehouse vehicles (forklifts, haulers, tuggers, cargo tractors, conveyor belt cars, baggage tractors at airports, other industrial trucks)
- Special vehicles (service vehicles, municipal/street cleaning vehicles, refuse collection vehicles, small trucks with fuel cell range extenders)
- Electric light vehicles/boats (bicycles, cargo bikes, golf buggies, light boat (drives), fuel cell scooters, wheelchairs)
- Micro fuel cells (industrial sensors, small device supply)


INNOVATIVE DRIVES
1 %
INTERDISCPLINARY THEMES
3 %
SPECIAL MARKETS
12 %
STATIONARY HOUSEHOLD ENERGY
13 %
STATIONARY INDUSTRY
8 %
HYDROGEN PROVISION
3 %
TRANSPORT AND INFRASTRUCTURE
60 %
NIP – STATISTIC:
SHARE ACCORDING TO
APPLICATION SECTOR
(AS AT DECEMBER 2016*)


INDIVIDUAL PROJECTS
POWER SUPPLY LEISURE
POWER SUPPLY BUSINESS
LIGHT ELECTRIC VEHICLES/BOATS
MANUFACTURE
SPECIAL VEHICLES
WAREHOUSE VEHICLES
MICRO FUEL CELLS
CLEAN POWER NET
1 %
23 %
23 %
8 %
8 %
18 %
7 %
7 %
5 %
NIP – SPECIAL MARKETS:
ALLOCATION BY APPLICATION AREA
(AS AT DECEMBER 2016)

NOW as both interface and catalyst

Positioned at the crossroads where the public sector, business and science meet, with the Clean Power Net (CPN) NOW GmbH has been able to promote the subject of fuel cells further and to provide a stronger focus in the area of intralogistics with the development of the Clean Intralogistics Net (CIN). The success is multifaceted and underpinned by several factors.

Among these is the fact that in 2016, the subjects of climate change, energy security and the scarcity of resources have put hydrogen and fuel cell technology onto the political and economic agenda more than ever before.

No matter if in logistics, intralogistics or critical infrastructure: never were the opportunities for commercial market introduction greater. In the CIN there are connections to the German Mechanical Engineering Industry Association (VDMA – Verband Deutscher Maschinen- und Anlagenbau) Materials Handling and Intralogistics, Industrial Trucks section, in which 36 industrial truck manufacturers are currently organised. Furthermore, renowned users in Europe are beginning to deploy fuel cell systems in logistics, including BMW, Daimler, IKEA, Colruyt, FM Logistics and Prelocentre. The logistics industry sector is already realising many national and international projects with fuel cell-based tractors and forklifts.

As usual, NOW not only works as the coordinator in that it analyses and evaluated fuel cell projects: over the past years, NOW GmbH has additionally become recognised as a neutral moderator in the discussions between partners and public bodies.

An important step taken in 2016 was the establishment of a common network, the CIN, incorporating industry, users and manufacturers. The network aims to promote fuel cell technology in the area of intralogistics. The CIN, coordinated by NOW GmbH, has set itself the objective to create and exploit synergy potentials. Further goals include greater interdisciplinary collaboration and the realisation of economies of scale for procurement and manufacture. Increased awareness in international professional circles is imperative for this. Marketing and PR measures should also help in this regard as well as greater market analyses and observations.

An example the CIN not least intends to follow is the success of the CPN, which with e4ships, Clean Energy Partnership (CEP) and Callux has long since counted among the lighthouse projects of the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP).

Already in the first-half of 2017, the CIN – as the NIP lighthouse projects – is to become established as an innovation cluster. An application for funding will therefore be submitted to the NIP2 for this purpose (for an initial period of three years).

IV/01 GENSTORE

GenStore stands for "Generation" and "Storage". The system developed within the scope of this project combines decentralised (off-grid) hydrogen production via electrolysis with the decentralised production of power via fuel cells in a modularly constructed physical unit. The previously existing restrictions of hydrogen logistics do not apply to GenStore fuel cell systems. As such, this funding project thereby promotes the acceleration and diffusion of hydrogen and fuel cell technologies far beyond their current boundaries while retaining the inherent benefits of the system – 100% emission free, CO_2-free, quiet and vibration-free, low maintenance, decentralised and modular.

Aim of the GenStore funding project was the development of the first generation of a combined fuel cell and electrolysis system that has the potential to accelerate the expansion of communication in the off-grid sector while using renewable sources of energy and replace the use of diesel generators as emergency power supply units.

Based on information obtained from various market research analyses, including studies from GSMA and in-house assessments, the serviceable addressable market (SAM) potential is estimated to be around 50,000 units annually.

Due to the existing market access of Heliocentris in the telecommunications sector, a detailed profile of demands for a modular, fully-integrated fuel cell and electrolysis system that can cover the majority of general requirements for off-grid and emergency power systems, could be defined. To achieve the first generation goals of GenStore systems, existing subsystems – fuel cell, electrolysis and energy management – were optimised and combined in one housing unit. Besides functionality, safety and modularity, cost reduction potentials were a primary aspect taken into account for system design considerations. The anion exchange membrane (AEM) electrolyser technology implemented combines the benefits of PEM and alkaline electrolysers: high dynamics for the combination with renewable sources of energy, low system complexity, precious metal-free catalyst along with low deionised water quality demands.

As part of the GenStore funding project, fuel cell and electrolyser systems with a performance range of up to 5kWp and hydrogen production rates of up to 500l/h were developed, tested and put into operation at reference customers. The first externally installed GenStore system was put into operation by MTN in South Africa. MTN is Africa's largest mobile communications operator and in South Africa must deal with regular power outages that sometimes can last for longer periods of time. Alternative technologies such as diesel-based generators or large battery banks are often not available when required due to theft. Furthermore, the GenStore systems provide a significantly better ecological footprint than conventional battery or diesel systems. Both of these aspects were key criteria for MTN to be the first to test a GenStore system.

PARTNER:
Heliocentris Industry GmbH

PROJECT BUDGET/€:
3,075,942

FUNDING BUDGET/€:
1,476,452

COMMENCEMENT:
1 November 2013

CONCLUSION:
30 September 2016

IV/02 BODENSEE PROJECT – DEVELOPMENT, TESTING AND IMPLEMENTATION OF A MODULAR FUEL CELL SYSTEM

As part of the NIP, *SWU Stadtwerke Ulm/Neu-Ulm GmbH* pursued the development, testing and implementation of modular fuel cell systems.

The stack module used as a basis for the modular fuel cell system boasted approx. 1.5kW_{el} output and was a low-temperature PEM fuel cell type with metallic bipolar plates from the company Reinz/DANA. With the possibility of running up to four of the so-called power generation modules in parallel, total output of around 4 to 5 kW can be achieved. The fuel cell system is completed with the components for stack cooling, such as the water/air heat exchanger and a separate cooling module to regulate the cooling circuits. The entire system, including all modules, is controlled via specially developed control devices. Ensuring the subject of safety was not left wanting, a risk assessment was conducted in coordination with TÜV Süd during the development phase and all results taken into account during the subsequent project realisation.

Both mobile platforms as well as stationary application are potential areas of deployment for the modular fuel cell system. A concrete application of the modular fuel cell system at SWU was the development and manufacture of an *uninterruptible power supply (UPS)*, which was equipped with two power generation modules. In the future, the UPS unit will be made available for use as a demonstration aid for the subject of uninterruptible power supply using fuel cells at the Ulm University of Applied Sciences for teaching purposes. An inverter (~230 V) with a constant output of 2.5 kW is integrated in the UPS unit.

In a further application for the deployment of modular fuel cell systems, SWU purchased an electric boat with pre-installed fuel cell technology with the intention of enabling commercial passenger transportation on the Danube in Ulm/Neu-Ulm. For this purpose, it was now necessary to develop the necessary safety measures and registrability with the local authorities as well as with *Germanischer Lloyd*. During this process it emerged, however, that the prospect of achieving subsequent commercial shipping operations were only possible if the purchased technology was modified to a substantial extent and with significant effort. The work necessary to accomplish this was conducted over a course of approx. 18 months to around 90 % completion but then discontinued. Due to requirements relating to safety measures and thereby also the associated operation of the fuel cell boat, a subsequent cost-covering deployment of the vessel could no longer be anticipated.

In principle, SWU traversed all phases of the product development of fuel cell systems throughout the project timeframe, and also got to know the special challenges involved in the deployment of this technology. Due to changed framework conditions, including those in the energy sector, SWU is no longer able to be actively involved with fuel cell technology in this form.

PARTNER:
SWU Stadtwerke Ulm/ Neu-Ulm GmbH

PROJECT BUDGET/€:
1,488,745

FUNDING BUDGET/€:
714,598

COMMENCEMENT:
1 September 2010

CONCLUSION:
31 October 2016

With the help of renewable energy sources, fuel cell-based power supply systems can be operated independently of the electricity grid.

IV/03 RENEWABLE ENERGY IN MOBILE COMMUNICATIONS – SUPPLY OF ENERGY FOR MOBILE PHONE BASE STATIONS WITH FUEL CELL TECHNOLOGY, WIND AND SOLAR ENERGY

Aim of the demonstration project was to ensure the supply of power for an off-grid mobile phone base station in the E-Plus mobile phone network, located far from the nearest connection to the public power supply grid. The supply of power was to be provided with the help of renewable sources of energy and new modular fuel cell technology including an intelligent power management system and operated independently of the electricity grid.

As part of the project, fuel cell systems – partly in combination with electrolysis systems – were installed and tested for the operation of base stations (BTS: base tranceiver stations) in a mobile phone network. The supply of power was independent of the public electricity network and renewable, embedded in a complete system comprising fuel cell technology as well as wind power and photovoltaic systems.

The project demonstrates the implementation of renewable energy sources (small wind power and solar systems) combined with fuel cell systems (approx. 10kW) as hybrid decentralised (off-grid) energy generation systems with close-to-grid availability levels and no local emissions whatsoever. Three demonstration plants were established and operated in remote off-grid locations within the E-Plus mobile phone network.

New applications such as broadband internet access (UMTS, LTE, growing volumes of data) as well as digital terrestrial television (DVB-H/so-called "ubiquitous TV") are growth markets in the mobile phone sector. Each year, a total of around 5,000 to 6,000 new base stations are established by all network operators for mobile communications in Germany. Especially in rural areas, the infrastructure necessary to provide a comprehensive network for mobile broadband internet is not sufficiently available. With the establishment of new mobile phone base stations, the problem of providing these with a constant supply of energy is an issue being encountered ever more frequently.

» The project demonstrates the implementation of renewable energy sources combined with fuel cell systems as hybrid decentralised (off-grid) energy generation systems. «

PARTNER:
E-Plus Mobilfunk GmbH & Co. KG

PROJECT BUDGET/€:
1,536,999

FUNDING BUDGET/€:
701,640

COMMENCEMENT:
1 July 2010

CONCLUSION:
30 June 2016

IV/04 EQUIPPING OF EMERGENCY SERVICES (BOS) DIGITAL RADIO NETWORK IN BAVARIA WITH FUEL CELL EMERGENCY POWER SYSTEMS WITH HIGHER REQUIREMENTS

In the course of the development of the emergency services digital radio network in Bavaria, around 900 station locations were established. Fuel cell emergency power systems (FCEPS) were incorporated to back up the supply of power at 44 of these base stations with higher requirements, such as in pre-alpine or alpine regions of the state.

The FCEPS guarantee the emergency supply of power to these digital radio stations for a minimum period of 72 hours. The higher requirements have, among other things, an influence on the energy requirements of the base station locations as well as the operation and maintenance of the fuel cell systems and the hydrogen logistics.

Within the scope of this project, the FCEPS operations were extensively tested for their practical feasibility, along with the associated service and logistics concepts. Aim of these examinations was to test and confirm the suitability and maturity of the technology for this area of deployment. Further goals included the verification of lowest operating costs, highest reliability during power outages as well as the optimisation of stand-by consumption. The project was divided into work packages and implemented with technical support. The call to tender was conducted in two lots with contract award limitation resulting in two general contractors being awarded the contract with different system suppliers. Construction could therefore commence in parallel and was successfully completed at all locations before the start of winter, as scheduled.

A comprehensive testing programme included test routines with simulation loads and constant operation. Several simulated power failures also lasted longer than 120 hours. Testing of short-term power outages and widely varying load distributions were also part of this testing programme. In total, more than 1,800 operating hours were completed by the FCEPS, in part at extreme temperatures of up to 45 °C with direct and continuous exposure to the sun.

Furthermore, during the course of the project there were three power failures confirmed by the energy supply company in which the FCEPS bridged the outage period without any problem. In two instances, the FCEPS took over the supply demands of the base stations due to scheduled work on the power network – here too did the system take over without a hitch.

It can be concluded that both general contractors and their suppliers fulfilled the demands and that the technical goals of the project were entirely achieved. Due to the large load range between 300W and up to 8,000 W, the hysteresis behaviour required several adjustments during the switching of the fuel cell on and off for battering charging, to avoid pendulum operation. The differences in power consumption for the supply of selected FCEPS base station sites could also be clearly ascertained and the assumptions confirmed. Also noteworthy is that the surveyed public interest bodies consistently responded positively on the establishment of the FCEPS and all approvals (nature and water protection zones) were received promptly and without problem.

PARTNER:
Bayerisches Staatsministerium des Innern, für Bau und Verkehr

PROJECT BUDGET/€:
5,373,950

FUNDING BUDGET/€:
2,579,496

COMMENCEMENT:
1 May 2015

CONCLUSION:
31 December 2016

Digital radio base station locations with fuel cell emergency power systems in Bavaria.

IV/05 TESTING OF POWER SUPPLY AND NETWORK BACKUP SYSTEMS BASED ON PEM FUEL CELLS FOR THE BADEN-WÜRTTEMBERG BOS BASE STATIONS

PARTNER:
Vermögen und Bau Baden-Württemberg

PROJECT BUDGET/€:
2,779,169

FUNDING BUDGET/€:
1,334,001

COMMENCEMENT:
1 July 2013

CONCLUSION:
30 June 2016

Around 700 radio transmitter sites were established in Baden-Württemberg for the introduction of the digital radio network in Germany for the emergency services (BOS – Behörden und Organisationen mit Sicherheitsaufgaben). Particularly high demands exist for this so-called critical infrastructure in regard to availability and reliability. For this reason the state of Baden-Württemberg resolved to provide 35 of these base stations located in important – and in winter sometimes difficult to reach – sites with the installation of stationary fuel cell-based emergency power supply systems.

The type of fuel cell being deployed is the polymer electrolyte membrane (PEM) type. The power demands at the digital radio stations is in the range between 2.0 and 2.5 kW. The energy supply is provided through compressed hydrogen in pressurised gas cylinders. In the case of a power failure, the digital radio base stations can thereby be supplied with power for up to 100 hours of operation. With the deployment of pressurised gas cylinders, additional hydrogen can thereby be delivered quickly and relatively simply. At each location there are two cylinder strands (incorporating two and twelve gas cylinders respectively). The two-cylinder strand is used for the regular conditioning of the system, and the twelve-cylinder strand for the emergency supply of power. The cylinders are each filled with 50 litres of hydrogen compressed at 300 bar.

The project aims to help promote the implementation and operation of fuel cell systems in so-called critical infrastructure. At the same time, valid and reliable data on the deployed systems is to be accumulated via field tests to support the system manufacturers in the continued development of the systems.

The project commenced in July 2013 with the preparation and undertaking of a tendering procedure for the provision of the fuel cell systems and hydrogen cylinders. The most economical provider was awarded the contract in each case. The establishment of the systems was conducted between November 2014 and July 2015, and operation commenced immediately thereafter. The systems are monitored via a central server, which was implemented in the final quarter of 2015. This enables fault and status messages along with operating data to be gathered and documented.

After a year in operation, it can be concluded that the fuel cell systems provide a stable and reliable service. The conditioning of the fuel cell, which is automatically conducted every 30 days, takes no more than around 30 minutes, on average. The two gas cylinders that are designated for this purpose should thereby last for around eight years.

Incidences of faults essentially had nothing to do with the fundamental principle of energy generation. Rather, the incidences affected peripheral components for control and monitoring along with the gas supply. In regard to the fuel cell controller and the energy manager, restarts or software updates were required several times at the beginning of the project. In respect to the gas supply, faults included a leak, a mix-up between to the two gas supply strands, as well as a faulty gas switchover station, each at one location.

To date, these identified faults and disruptions have not resulted in operations becoming impeded.

Due to a "genuine" power failure for a period of 36 hours, system behaviour could be analysed at one location and the exchange of gas cylinders could also be tested. During this time it was shown that: there were no problems regarding the fuel cell system taking over the load; the switchover between both gas cylinder strands when the set switchover threshold was reached was clean; and a clear alert was given when the cylinder pressure reached the warning level threshold set. The necessary cylinder exchange was completed within the required timeframe. Several short power outages (between approximately one and ten hours) were also covered by the system without a hitch.

In day-to-day operation of the fuel cell systems, dealing with the measurement unit of "pressure" for checking the fill levels of the gas cylinders is currently still unfamiliar. Due to the physical relationship with the temperature and the fill level-dependent compressibility factor of the gas, it is easy to misinterpret the real fill levels. In one instance this resulted in a leak being suspected, which could then not be confirmed under closer scrutiny. In this important aspect for operation, further avenues for analysis are necessary.

35 of 700 mobile communications base stations in Baden-Württemberg were equipped with fuel cell systems.

IV/06 DEMONSTRATION OPERATION OF FUEL CELL INDUSTRIAL VEHICLES AT THE DAIMLER PLANT IN DÜSSELDORF

The project serves to test and to evaluate both the technical and especially the economic merits of two fuel cell-drive industrial vehicles (forklifts) under real conditions deployed for internal logistics operations. The two forklifts were part of a 24-month practical test in the production logistics area of the Daimler plant in Düsseldorf.

Through user surveys conducted on the test operations, it was possible to dismantle any fears regarding hydrogen technology and build acceptance towards it among staff and the public alike.

The project was accompanied by targeted public relations measures to highlight the possible areas of application of hydrogen technology and to enhance its acceptance. In addition, initial further technical development and optimisation in the area of drivetrain and refuelling systems were undertaken in regard to low maintenance efforts, high availability and short refuelling times.

The project joins a series of activities to promote the market introduction of hydrogen as a fuel. The goal is to decisively contribute to the exploitation of hydrogen as a fuel for in-house logistics through pre-industrial research and development, and to conduct comprehensive tests on its suitability for everyday use and its system capabilities. In this context, the main focus is on the demonstration of industrial vehicles and associated infrastructure for refuelling and the maintenance of corresponding vehicles.

This project has a pilot character within the Daimler Group. It enables practical experience to be gained for the deployment of prospectively larger fleets of fuel cell-powered industrial vehicles in production facilities in the future. Particularly the efficiency increase through the replacement of battery-electric drives with hydrogen drives and the associated potential to optimise internal processes is a key area of focus of the investigations accompanying the project. In the long term, the insights gained are to contribute to converting the entire internal logistics fleet at the Düsseldorf plant as well as others, entirely to innovative hydrogen fuel cell drives.

PARTNER:
Daimler AG

PROJECT BUDGET/€:
724,180

FUNDING BUDGET/€:
347,606

COMMENCEMENT:
1 June 2012

CONCLUSION:
31 December 2016

V. BMVI — ELECTROMOBILITY MODEL REGIONS

THE PROJECTS ON THE FOLLOWING PAGES ARE LABELLED WITH V/01 – V/19.

NEWLY APPROVED PROJECTS

COMPLETED PROJECTS

INTERDISCIPLINARY THEMES

ELECTRIC MOBILITY AS AN ELEMENT OF THE ENERGY TRANSITION

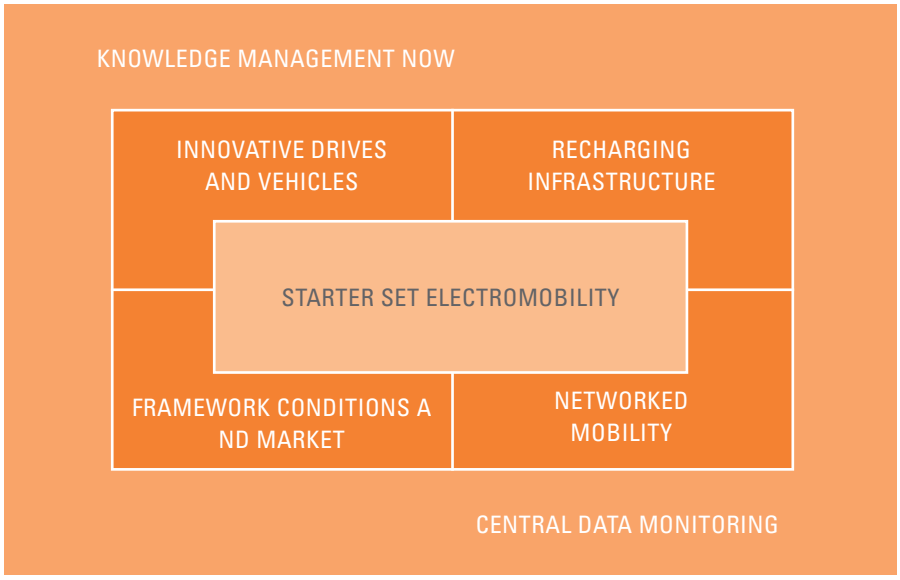
Funding priority electric mobility

The federal government supports research and development into alternative drive concepts and 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 electric mobility. Through the electrification of the transport sector, future mobility is to become more climate and environmentally friendly and less reliant on fossil resources. The expansion of electric mobility 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 electric mobility 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 were established. The work of the BMVI Model Regions aimed to prepare the market by testing the technology under everyday conditions. Experiences made and results achieved were dealt with as key issues within the scope of the accompanying overarching scientific research. The goal here was to ensure that all involved companies and organisations could jointly learn from the experiences made and to also prime new players to be in a position to enter into the area of electric mobility.

As market ramp-up commenced and a new funding guideline adapted to the prevailing market requirements was published, more focus was placed on accompanying research issues in 2015. With the clear goal of supporting market introduction, four central subject areas were identified, which represent the pillars of the accompanying research to the programme area.



Focus of the accompanying research in 2015

Communication is bundled within the Starter Set Electromobility or handed over directly to the relevant stakeholders in the subject areas or to the municipal players. The subject areas "Framework Conditions and Market" and "Networked Mobility" took up their work in July 2016 and will deliver first results in 2017.

Implementing organisational structure

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

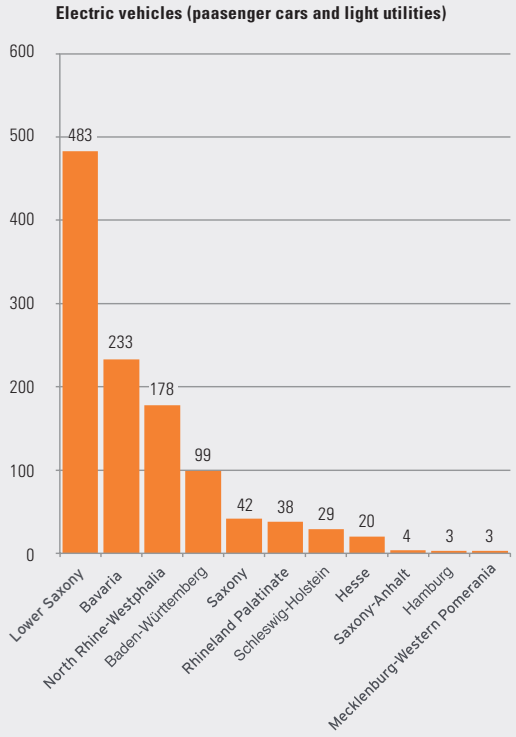
The BMVI ensures the contents are aligned in a political context and together with the federal government is responsible for determining the focus of content in the area of electric mobility. Projektträger Jülich (PtJ) is responsible for project administration and supports the programme with legal advice 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.

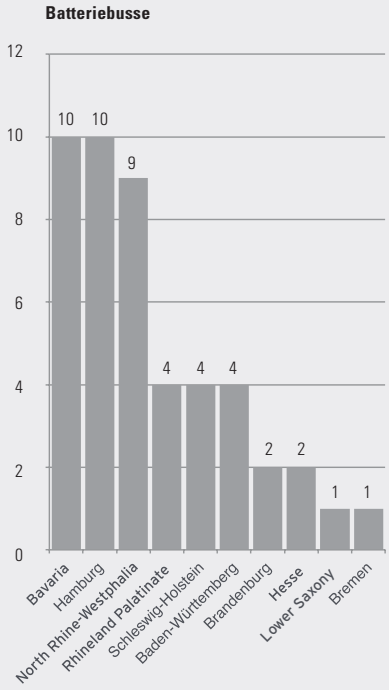
Cross-regional exchange is conducted in the the BMVI Strategy Group. It provides the platform in which representatives from the Model Region project headquarters, players from the accompanying research as well as BMVI, NOW and PtJ can discuss all aspects of programme activities. The Electromobility Showcases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

Support for electric mobility in the Model Regions

A new funding guideline for electric mobility was published on 9 June 2015. This is the basis for the continuation of the BMVI electric mobility funding programme. With the funding guideline, the BMVI supports the procurement of electric vehicles, particularly in municipal fleets, with the goal of increasing the numbers of such vehicles in this sector. Parallel to this, the coordinated establishment of a demand-oriented and strategically positioned recharging infrastructure is being supported along with the linking of vehicles to the electricity network, combined with the expansion of renewable energy. Furthermore, municipalities may now submit electric mobility concepts (so-called environmental studies) in order to integrate the subject of electric mobility more strongly in the municipal sphere. Besides these two new funding possibilities for the procurement of electric vehicles and the submission of municipal electric mobility concepts, the third funding instrument continues to allow applications for R&D (research and development) projects. Due to this enhancement of the programme and subsequent additional funding possibilities, the market introduction of electric mobility can now be optimally supported.

Based on the funding guideline, calls for submissions for all three funding areas are made each year. It is hereby possible to undertake annual adjustments and fine-tuning in the programme to take changing market demands into account. The current status in the respective areas is illustrated below.





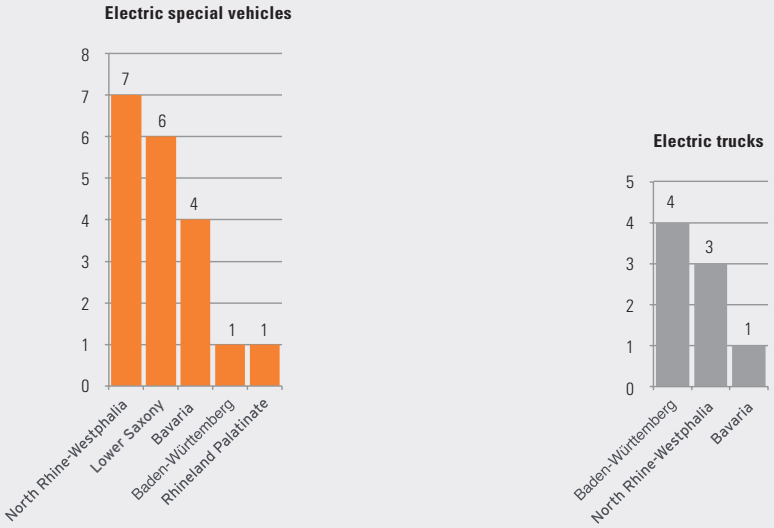
Procurement projects support establishment of market

With the various projects approved within the framework of the Electric Mobility Funding Guideline of the BMVI, the establishment of an electric mobility market is being supported. An area of special focus is on the procurement of electric vehicles (passenger cars, commercial vehicles and electric buses) in commercial fleets along with the establishment and expansion of the necessary corresponding recharging infrastructure at public and private sites.

The deployment of electric vehicles by operators of private and municipal fleets is worthwhile in several respects. Through the successive integration of electric vehicles into the fleets, pollutant emissions (CO_2, NO_x, noise) can be sustainably reduced. As the daily deployment profile is already prescribed in many instances, electric vehicles can be assigned in those situations where distances are predictable and/or opportunity charging possibilities exist en route.

Not only was the deployment of electric passenger cars demonstrated within the scope of the funding programme, so too was the use of electric commercial vehicles. Moreover, as part of individual funding projects, some public sector employees have the opportunity to use the municipal fleet privately as part of carsharing models. This enables staff to experience electric vehicles in both a business and private context, while also improving their emissions footprint. Furthermore, this also reduces the overall costs as the vehicles are used more often.

Municipal transport companies providing local and regional public transport services using buses are supported to procure battery-electric buses and to test these in scheduled services.



Procurements arising from the electric mobility funding guidelines 1st and 2nd calls for proposals

Within the scope of the procurements, at total of 106 applications were approved in 2 calls for proposals.

With a total funding volume of 14,734,766 euros, 1,206 vehicles could therefore be brought to the roads or are currently in the procurement process.

Furthermore, the establishment of 749 charging points was approved.

The regional energy providers, network operators and public utility companies involved in many of the projects indicate, that with the establishment of the recharging infrastructure, they largely wish to use renewable energy and also intend to examine the effect recharging procedures have on the regional electricity network.

From July 2015 to January 2017, the BMVI made three separate calls for funding submissions for the procurement of electric vehicles and the associated recharging infrastructure. In the first two funding calls (July/August 2015 and March to May 2016), 106 applications were approved. The BMVI thereby enabled the procurement of 1,206 electric vehicles throughout Germany as well as 749 charging points, providing a total funding volume of more than 14.7 million euros.

Among the 1,206 approved vehicles were, eight electric trucks, 47 battery buses and 19 electric special vehicles. Passenger vehicles, however, represented the area of application with the overwhelming majority of supported procurements totalling 1,132.

Of the 749 approved recharging points, the “AC 22kW” type was the most common version with 651 approvals, followed by DC recharging columns (59) and bus/truck infrastructure (39).

Results of the first two calls for proposals for the electric mobility funding guideline

Within the scope of the electric mobility funding guideline of 9 June 2015, 46 electric mobility concepts from the first two calls for proposals are being funded by the BMVI.

The vast majority of local authorities, companies and associations that are funded are located in urban regions (76 %). Only 7 % are found in regions with population concentrations and only around one sixth (17 %) of all funded electric mobility concepts are in rural regions.

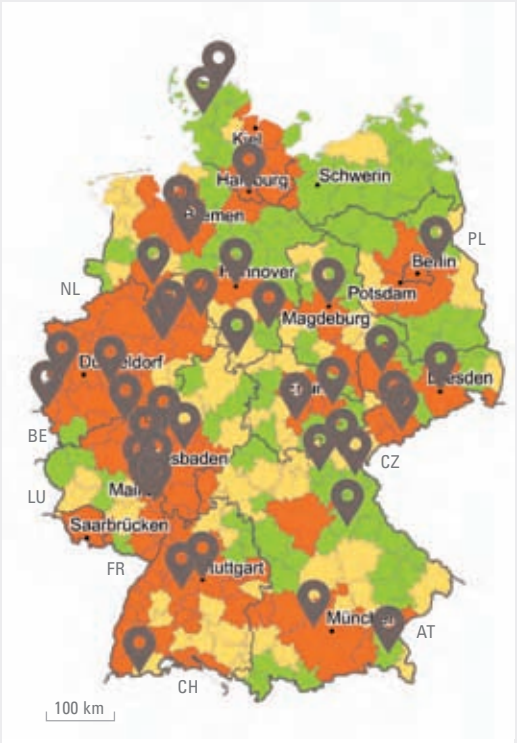
The strategic incorporation of electric mobility concepts is very important for their implementation. By interlinking them with existing concepts – e.g. in the areas of climate protection, transport, urban development – chances of successful implementation can be substantially increased.

In terms of themes, a broad field is already opening up. The electrification of car fleets is a goal in approximately three quarters of all electric mobility concepts funded. Of these 20 concepts aim to electrify municipal car fleets; in 14 concepts the conceptual framework conditions for the electrification of commercial car fleets is to be developed. It is clear that more than half of the concepts (26) identify and factor in the establishment of a demand-oriented charging infrastructure as the first prerequisite. In almost every fourth concept (11), the goal is to set up eCarsharing, in some cases in conjunction with pedelec-sharing. The connection of e-mobile services to local public transport, thus the creation of intermodal transport chains is the focus of 10 concepts.

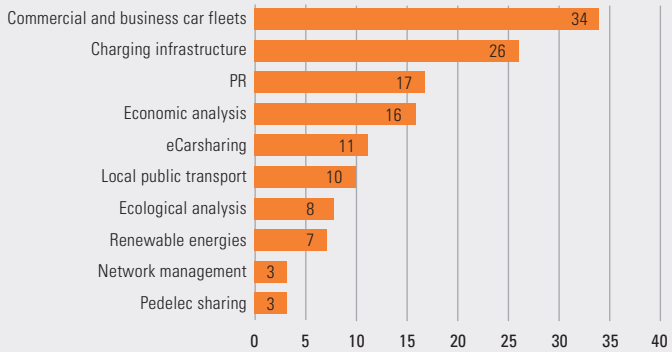
Aside from establishing e-mobile services, most concepts include interdisciplinary tasks. Above all here economic analyses (16) are pursued. 13 concepts want to explicitly concentrate on activation or public relations work. Ecological analyses (8) and the potential of renewable energies (7) are also included.

The actors most targeted in the concepts are municipal administrations (17), companies (16) and citizens (15). 12 of the concepts are formulated in an 'open-user' way and include a differentiated user analysis in the course of the concept development. Of more minor importance are the user groups of tourists and commuters (5 each) as well as cooperatives and local public transport providers (2 each). In addition there is a concept each on housing, delivery services, taxi drivers and early adopters.

Although thematic variety of the concepts is to be welcomed, it suggests that currently some themes will not be dealt with in a way that matches their potential. It should be noted that for example, the issue of integrating electric mobility into the electrical grid is not the focus of applicants. The electrification of commercial car fleets is also underrepresented here, however municipal authorities could assume a critical mediating role. After all, there is clearly much greater potential for market ramp up in the commercial area than there is in municipal fleets. Municipal authorities could also assume a similar role in consultation with the housing industry, which often has not recognised the potential of electric mobility. There are very few objectives in this area in the concepts funded. If e-mobile products and services are to be created, it should be urgently considered how they can be consolidated and stabilised (e.g. through business models). This goal is hardly reflected in the concept proposals to date. The reason that few public utilities and local public transport providers feature among the applicants is that they are already involved in numerous procurement projects which support the market ramp up.



Thematic overview of electric mobility concepts



Type of settlement structures in urban and rural regions 2014

Database:
Ongoing spatial observation of the BBSR

Geometric basis:
Municipalities (generalised)

© GeoBasis-DE/BKG
Editor: P. Kuhlmann
31.12.2014

Funding priority research and development (R&D)

In addition to the procurement of electric vehicles and their associated charging infrastructure and the funding of electric mobility concepts, a third funding instrument is established through the electric mobility funding guideline of June 2015. Aside from direct support of the market ramp up, R&D (research and development) projects can still be funded.

Following the funding guideline's entry into force, two funding calls were initiated in the R&D area. The first call was published together with the funding guideline in June 2015. Project ideas according to the priorities of the funding guideline could be submitted here. These priorities were found in the following areas:

- Projects on testing electric mobility use and operating concepts in the relevant vehicle segments,
- Application-oriented projects on batteries and battery components with a focus on vehicle integration,
- Projects on development and testing of innovative charging technologies,
- Projects on development of integrated approaches for linking infrastructure and the vehicle,
- Projects on technical implementation of system solutions and services in the wider context of electric mobility,
- Projects on the strengthening of electrification in the areas of public transport, goods and special transport,
- Maritime or other transport policy-relevant applications.

Following the submission and evaluation of the project outlines for the first call, 18.4 million euro in funding was invested in R&D projects. The priority of the projects was mainly local public transport with four projects. Three of the projects have a focus on electric buses and one project on public rail transport. The other projects cover commercial vehicle and passenger car areas. In the passenger car area, in addition to the vehicle aspect, the infrastructural side was also considered closely.

In the second call for R&D projects in September 2016 the following thematic priorities were outlined:

- Local public transport with a focus on battery buses including charging technology, Goods and commercial transport as well as city logistics,
- Integration of renewable energies in the transport sector as well as the networking of charging infrastructure and electric vehicles,
- Shipping as well as special transport, e.g. at airports, harbours and logistical centres.

Until the submission deadline on 29 October 2016, 66 project outlines were submitted on all four priority areas.

Recharging infrastructure using renewable energy in the public domain.


ridesharing

Subject area; Framework conditions and market

The success of electric mobility is highly dependent on external factors. The accompanying reseach in the subject area Framework Conditions and Market examines these various factors. These include mobility behaviour as well as the mobility requirements of potential private, public or commercial customers. The question of how electric mobility can address exactly these needs will be pursued. Changing life circumstances and social trends (such as using/sharing rather than owning) play an important role in the examination.

The accompanying research will also examine which fleet applications are particularly suitable for electric vehicles and thereby assume a consultative role. In addition, recommendations for action are to be developed regarding the legal and political courses that need to be taken in order to help electric mobility achieve its breakthrough. The developments of electric mobility in Germany will be comprehensively analysed and assessed for this purpose, and compared with selected international markets.

Target groups for the results
Companies (especially SMEs), policymakers, municipalities, private individuals

Contacts:
Dominique Sévin, NOW GmbH
Dr. Márcia Giacomini, TÜV Rheinland Consulting GmbH
Dr. Jadranka Dokic, iit

Consortium:

TÜVRheinland® Genau. Richtig.
INSTITUT FÜR INNOVATION UND TECHNIK
KIT Karlsruher Institut für Technologie

Subject area: Networked mobility

Orientation and content

The focus of the accompanying study "Networked mobility" is the interfaces of different applications of electric mobility and different transport modes as well as between electric mobility and the energy industry. A special priority is the establishment and development of competencies on the municipal level regarding holistic mobility strategies and their associated actions. This is particularly relevant to the issues of funding inter- and multi-mobility, assessment of multiple-leg journeys including in commercial transport and in the logistics area, development of regional and municipal strategies as well as interlinking energy and transport sectors on a local or municipal level. This links in to the overall energy and climate goals of the federal government. The overarching aim is to support the market ramp up of local electric mobility.

The **main questions** of the accompanying research are:

a) What are the priorities of current and future mobility strategies in the context of energy and climate goals of the federal government?
b) How effective are measures already identified in integrating electric mobility as a component of future mobility strategies?
c) What contribution can local generation, provision and storage of renewable energy make to the transport sector with the core goal of reducing end energy consumption and greenhouse gas emissions?
d) How can recommendations of the federal government be integrated and implemented in municipal planning?

The analysis and evaluation of municipal mobility strategies and concepts are expected to answer these questions and to achieve these goals. This is done by analysing available documents, having discussions with the relevant actors as well as a survey of municipalities (autumn 2018), in addition to gathering best practice examples and discussions in expert panels. Another pillar of the accompanying research are **subject area meetings** and workshops as well as the support of expert conferences and roadshows.

All results will be published on the platform of the Electromobility Starter Set, and also published in brochure form. Interim results will be regularly compiled in fact sheets and published.

The first subject area meeting took place in Berlin on 8 December 2016. Guest lectures along with thematic workshops acted as a point of entry to the subjects of the accompanying research and also assisted in further refining the research questions.

Results brochures planned

- Mobility strategies, measures and recommendations for action for municipalities to support the market ramp up of electric mobility, 11/2018
  Target group: municipal actors
- Results of the city survey , 05/2018
  Target group: Policy-makers and the scientific sphere
- Measures on municipal level to link the transport and energy systems, 04/2019
  Target group: municipal actors

Target groups of the results

Municipalities, administrative districts, local authorities, municipal and state companies

Contacts:

Silke Wilhelm, NOW GmbH
Dr. Elisabeth Dütschke, Fraunhofer ISI
Prof. Dr. Wolfgang Rid, ISME

Consortium:

Fraunhofer Institute for Systems and Innovation Research ISI, Karlsruhe
Institut Stadt I Mobilität I Energie (ISME), Stuttgart
EE energy engineers, Gelsenkirchen
Noerr LLP, Munich


Berlin
M16 U Britz-

V/01 HEAT2GO – MODULAR HEAT STORAGE HEATERS FOR FULLY ELECTRIC CITY BUSES

Over the coming years, one the biggest socio-political challenges facing urban passenger transport services is having to operate without environmentally damaging emissions. While electric vehicles are already being developed for this purpose, they do not integrate a satisfactory solution for emission free and energy efficient heating.

The HEAT2GO project thereby aims to develop a fast-charging, modular heat storage heater using phase change materials (PCM) for full-electric city buses. The goal is to not only enable the electric charging of the battery at the terminating stop, but also of the heat storage within just a few minutes (principle of opportunity charging). The heat energy stored in this way reaches the passenger compartment in a controlled manner without requiring any additional support from the battery. At the same time, recuperation energy is used directly for the task of heating, if required, to thereby further enhance overall efficiency.

The developed solutions will be installed in a full-electric, fast-charge compliant, and authorised public bus of Fraunhofer IVI in order to both validate its functionality in a climate chamber and to demonstrate this on the road. The fast-charging infrastructure is also available to the consortium, consisting of Aurora Konrad G. Schulz GmbH & Co. KG, Konvekta Thermo Systems AG the Fraunhofer Institute for Transportation and Infrastructure Systems IVI.

PARTNERS:
a) Fraunhofer-Gesellschaft zur Förderung der ange wandten Forschung e. V. (Institut für Verkehrs- und Infrastruktursysteme IVI)
b) AURORA Konrad G. Schulz GmbH & Co. KG
c) Konvekta Thermo Systems KG

PROJECT BUDGET/€:
a) 671,649
b) 214,803
c) 379,272

FUNDING BUDGET/€:
a) 604,484
b) 438,374
c) 189,636

VEHICLES:
12m electric bus

INFRASTRUCTURE:
250kW fast charging station

COMMENCEMENT:
1 October 2016

CONCLUSION:
30 September 2019

12m electric bus at fast-charging station

V / 02 ENERGY AND COST-EFFECTIVE ELECTRIFICATION OF LOCAL PUBLIC TRANSPORT FLEETS – EKE ÖPNV

With the help of this project, local public transport bus operators are to be given the opportunity to test, compare and evaluate various electrification concepts (vehicle & infrastructure), in terms of their suitability from a transport and energy perspective, using a software tool. This tool is to use parameters such as the route profile, driving profile, turnaround times, etc., in order to provide a scientifically-based recommendation regarding which electrification concept type is best for individual public transport bus routes given the specific conditions of these routes. Optionally, alternative solutions are to be provided through the changing of parameters.

» With the help of this project, local public transport bus operators are to be given the opportunity to test, compare and evaluate various electrification concepts (vehicle & infrastructure), in terms of their suitability from a transport and energy perspective, using a software tool. «

PARTNERS:
a) Technische Universität Dresden
b) Dresdner Verkehrsbetriebe AG

PROJECT BUDGET/€:
a) 739,429
b) 265,038

FUNDING BUDGET/€:
a) 739,429
b) 132,519

VEHICLES:
Solaris Urbino 12 Electric; Mercedes-Benz Citaro G Blue Tec-Hybrid

INFRASTRUCTURE:
Pantograf fast-charging station with contact traction power network

COMMENCEMENT:
1 December 2016

CONCLUSION:
30 November 2019

V / 03 BEMU – BATTERY ELECTRIC MULTIPLE UNIT TRAINS FOR NON- OR PARTLY-ELECTRIFIED REGIONAL RAIL TRANSPORT ROUTES

Bombardier Transportation is developing and building a TALENT 3 train equipped with BOMBARDIER PRIMOVE batteries for use on non- or partly-electrified routes. Bombardier will implement this development project together with project partner TU Berlin as well as a local public transport operator and associated authorities.

The project will be accompanied by the scientific study of infrastructural and operational boundary conditions of the battery operation and the formulation of a guide for policy-makers, operators and authorities on battery operation and battery electric multiple unit (BEMU). The uptake of battery electric multiple unit trains in future transport and vehicle tenders is to be taken into account using the guide.

In addition to the development, licensing and deployment of the battery electric multiple unittrain in passenger service, the aim of the project is to demonstrate the overall economic efficiency of the battery operation in standard gauge railways. The TALENT 3 battery electric multiple unit train is to provide an environmentally-friendly alternative to diesel trains on non-electrified routes. The significant decrease in harmful and noise emissions will make regional rail transport cleaner and more appealing. Operators and passengers both benefit from the fact that a time-consuming switch from electric to diesel trains is no longer necessary in order to bridge non-electrified route sections.

» In addition to the development, licensing and deployment of the battery electric multiple unit train in passenger service, the aim of the project is to demonstrate the overall economic efficiency of the battery operation in

PARTNERS:
a) Bombardier Transportation GmbH
b) Technische Universität Berlin

PROJECT BUDGET/€:
a) 8,320,373
b) 399,131

FUNDING BUDGET/€:
a) 3,681,765
b) 399,131

VEHICLES:
A 3-part TALENT 3 battery electric multiple unit train for use on non- or partly-electrified railway lines

INFRASTRUCTURE:
No additional infrastructural measures are necessary, as existing overhead rail lines will be used for recharging the traction batteries. Over 50% of the German railway network is electrified, which means that an overhead line route connects to almost every non-electrified route, or almost every route is partially electrified with overhead lines.

COMMENCEMENT:
1 September 2016

CONCLUSION:
30 June 2020

Presentation of the funding notification to the partners of the SEEN-KV joint project by Parliamentary State Secretary Norbert Barthle on 16 January 2017 in the Federal Ministry of Transport and Digital Infrastructure (BMVI) in Berlin.

V / 04 PRE-INVESTMENT SIMULATION OF THE USE OF ELECTRIC UTILITY VEHICLES IN COMBINED TRANSPORT – SEEN-KV

The aims of the joint SEEN-KV (*Simulation des Einsatzes von elektrischen Nutzfahrzeugen im Kombinierten Verkehr*) project are the research and development as well as hands-on experience of a decision-making support tool for using heavy-duty electric utility vehicles for the so-called 'last mile' of combined transport. Primarily the hitherto problematic use of purely electric utility vehicle fleets in the dynamic environment of combined transport freight terminals is to be examined and facilitated. Combined transport is the transport of standard loading units (containers, swap bodies, semi-trailers) using several transport modes. The changeover between the transport modes takes place in combined transport terminals, e.g. in inland ports and freight centres. Over the two-year project the operating conditions of electric vehicles around combined transport terminals in Saxony will be analysed. The practice partners are Sächsischen Binnenhäfen Oberelbe GmbH and Emons-Rail-Cargo GmbH. The group coordinator is LUB Consulting GmbH. The Technical University of Applied Sciences in Wildau is responsible for the simulation. Associated partners are GVZ-Entwicklungsgesellschaft Dresden mbH and Deutsche GVZ-Gesellschaft mbH.

The SEEN-KV project allows users to conduct simulations using electric trucks for their application area and thus facilitate them in making a reliable decision in the procurement of suitable vehicles. Another goal is the research of requirements of charging infrastructure in freight transport cluster points. With GVZ Dresden, the three inland ports of Dresden, Riesa and Torgau and the combined transport terminal Schkeuditz, five research locations are at the project's disposal.

PARTNERS:
a) LUB Consulting GmbH
b) Technische Hochschule Wildau (FH)
c) Emons-Rail-Cargo GmbH
d) Sächsische Binnenhäfen Oberelbe GmbH

PROJECT BUDGET/€:
a) 136,681
b) 141,963
c) 95,255
d) 79,388

FUNDING BUDGET/€:
a) 82,008
b) 141,963
c) 38,102
d) 31,755

COMMENCEMENT:
1. October 2016

CONCLUSION:
30 September 2018

V / 05 ELECTRIC MOBILITY VIA INDUCTIVE CHARGING WITH 200KW IN LOCAL PUBLIC TRANSPORT IN THE CITY OF BRAUNSCHWEIG

EMIL – electric mobility via inductive charging technology (Elektromobilität mittels induktiver Ladetechnik) is the name of a research project of Braunschweiger Verkehrs-GmbH (project management, scheduled public transport operations), together with Bombardier (recharging technology), BSIENERGY (energy supply) and the Technical University of Braunschweig (development and project support) for the implementation of electric mobility in regular scheduled public transport services in Braunschweig. In March 2014, Germany's first inductively charged electric bus, charged with 200kW, went into regular passenger service. Operations on the circular M19 route were expanded in December 2014 with four 18m electric articulated buses. By the end of 2016, the electric buses in Braunschweig had travelled around 230,000km on the 45-minute route and had completed more than 22,000 contact-free charging cycles in year-round operations.

Based on technology that has its foundations at the Technical University of Braunschweig and further developed by Bombardier for contact-free energy transmission via induction plates under the road's surface, the PRIMOVE system liberates electric mobility from the restrictions of cables, plugs and long recharging times. Via charging stations installed under the road and a receiving pad installed under the vehicle, the electric buses can be recharged while in operation at selected stops – without any adjustment to the existing timetable. Essential for this is the fast 200kW power transfer capability, leading to a neutral number of vehicles in respect to diesel buses.

18m emil Tramino electric bus in scheduled public transport service operations in Braunschweig.

PARTNERS:
a) Braunschweiger Verkehrs-GmbH
b) Bombardier Primove GmbH
c) BSIENERGY Braunschweiger Versorgungs-AG & Co. KG
d) Technische Universität Carolo-Wilhelmina zu Braunschweig

PROJECT BUDGET/€:
a) 3,569,885
b) 1,235,100
c) 255,627
d) 506,114

FUNDING BUDGET/€:
a) 1,784,942
b) 617,550
c) 127,813
d) 506,114

VEHICLES:
Fully electric buses from manufacturer Solaris with PRIMOVE onboard components (induction charging system and batteries)

INFRASTRUCTURE:
Bus route M19, 12km route length, Braunschweig inner city

COMMENCEMENT:
1 June 2012

CONCLUSION:
30 September 2016

Decentralised charging at HOCHBAHN.

V / 06 BEEDEL – EVALUATION OF THE IMPLEMENTATION OF ELECTRIC BUSES WITH DECENTRALISED RECHARGING INFRASTRUCTURE IN URBAN REGIONS USING THE EXAMPLE OF HOCHBAHN

The BEEDeL project (Bewertung des Einsatzes von Elektrobussen mit Dezentraler Ladeinfrastruktur) aims to ascertain and evaluate the deployment potential as well as to design implementation scenarios for electric buses within a decentralised recharging infrastructure in Hamburg.

Following the comprehensive collection of data from more than 300,000km travelled in the entire Hamburger Hochbahn AG network, selected driving profiles were evaluated via simulation for their demands on the necessary infrastructure, while also taking typical variations into account. Analysed was to what extent the flexible deployment of the electric buses was possible as well as the question of at which points in the network is recharging infrastructure required to ensure reliable operation. The influence on today's deployment and timetable schedules was tested and the anticipated dimensioning of recharging points ascertained.

Two partial routes were evaluated and it was shown that a large portion of bus routes could be sufficiently served electrically without any adjustment to scheduling being necessary. The need to establish corresponding charging points on public streetscapes as well as finding the necessary space and the provision of the required electricity must, however, also be taken into account. Operational adjustments that could lead to additional expenses and reduced productivity could be largely foregone.

Parallel to this work, examinations on the ageing of various batteries as deployed in electric buses were conducted, to assess their fatigue strength and to provide a recommendation for their use.

PARTNERS:
a) Hamburger Hochbahn AG
b) Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V.
c) Hochschule für Angewandte Wissenschaften Hamburg

PROJECT BUDGET/€:
a) 155,740
b) 247,128
c) 36,816

FUNDING BUDGET/€:
a) 77,870
b) 222,415
c) 136,816

COMMENCEMENT:
1 October 2014

CONCLUSION:
31 December 2016

V / 07 CROSS-COMPANY AND SECTOR TESTING OF ELECTRIC MOBILITY IN OPERATIONAL PRACTICE

Until now, the deployment of electric mobility was only scientifically supported in individual fleet trials. A cross-company test for everyday operation by companies of different sectors and sizes has, however, not yet been conducted. Therefore, the 90 members of "UI EIMo" *(Unternehmensinitiative Elektromobilität: Unternehmens- und branchenübergreifende Erprobung von Elektromobilität in der betrieblichen Praxis)* came together to test electric vehicles used in business operations and/or as a company car for private use in business practice in order to test their suitability for normal everyday operation.

A special feature of the project is the cross-company approach, in which participants commit themselves to opening their charging infrastructure to all member companies of the initiative in order to provide a comprehensive infrastructure.

Furthermore, the companies declare themselves prepared to make their respective company-owned electric vehicle fleet also available to those within "UI EIMo". Also included in the project is the testing of service and maintenance facilities outside of the regular brand garages and dealers. The company initiative is scientifically supported by the DFK.

Only vehicles and recharging infrastructure of the latest standard of technical development commercially available are being deployed. Moreover, uniform standards will be implemented at the charging stations enabling each user to be identified and the recharging costs to be correctly allocated accordingly.

Current activities, results, effects (concrete and verifiable)
UI EIMo primarily serves to test electric mobility in day-to-day operation. The high number of participants has resulted in numerous drivers being brought into contact with electric mobility.

As anticipated, electric mobility was accepted in various ways. A small number of companies signalled early on that they couldn't sensibly deploy the vehicles. Others were more open and used the deployed vehicles very intensively. Interesting is an individual case where the vehicle parameters were criticised from the very beginning, yet the user then still took over vehicle at the end of the term because he adjusted his usage in line with the existing parameters.

A concrete goal of UI EIMo was the establishment of a very dense network of recharging station in Bremen and the surrounding region. This goal could by completely fulfilled. Even if the range of vehicles is meanwhile sufficient for most inner city and regional transport requirements, this network of recharging stations provides added security and will largely remain in operation. A particular success: since their installation, two recharging stations from the network operator Avacon have resided in the top places of the nationwide ranking list of the most popular charging stations in Germany.

PARTNERS:
a) Nehlsen Aktiengesellschaft
b) HWT Hansen Wärme- und Tanktechnik GmbH & Co. KG
c) Emigholz Gesellschaft mit beschränkter Haftung
d) Move About GmbH
e) Deutsches Forschungszentrum für Künstliche Intelligenz GmbH

PROJECT BUDGET/€:
a) 7,149,236
b) 58,825
c) 172,550
d) 844,164
e) 713,222

FUNDING BUDGET/€:
a) 3,574,618
b) 29,412
c) 86,275
d) 506,498
e) 641,900

VEHICLES:
147 vehicles
- BMW: 19 i3, of which 6 without REX
- Daimler: 55, of which 53 Smart fortwo ed and 2 Vito E-Cell
- Renault: 50, of which 24 ZOE, 16 Kangoo Z.E., 9 Twizy, 1 Fluence Z.E.
- 4 Ampera
- H_2O Automobile: 3 Elano 1.Go
- Mitsubishi: 2 i-MiEV
- Nissan: 11 Leaf
- Peugeot: 3 iOn

INFRASTRUCTURE:
292 recharging points:
- 115 AC charging points with charging capacity of up to 3.7kW
- 2 AC charging points with charging capacity of up to 7.4kW
- 170 AC charging points with charging capacity of up to 22kW
- 5 DC charging points with charging capacity of up to 50kW

COMMENCEMENT:
1 October 2012

CONCLUSION:
30 June 2016

V / 08 FREE – LEISURE AND EVENT TRANSPORT WITH INTERMODAL BOOKABLE ELECTRIC VEHICLES

The "FREE" project *(Freizeit- und Eventverkehre mit intermodal buchbaren Elektrofahrzeugen)*, which commenced in 2012, has made a significant contribution to establishing the subject of electric mobility in northern Hesse and towards the testing of various applications for their suitability for everyday use. Goal was the provision of sustainable transport services from a single source. The integration of electric vehicles and pedelecs in the public transport offer, in conjunction with hosts and institutions, is to provide visitors to the region of northern Hesse the opportunity to arrive without their own vehicle but to nevertheless remain mobile in every area.

The electric carsharing fleet comprises 13 electric passenger vehicles, which can be recharged at over 200 charging points throughout northern Hesse. Another 44 charging points expanded this recharging infrastructure within the scope of FREE. With the cooperation of the local participating energy providers EAM and Städtische Werke AG with the municipal utilities company Stadtwerke Union Nordhessen, a common RFID card was developed for barrier-free access to the north Hessian recharging infrastructure. Furthermore, there are also 70 pedelecs available at 14 rental stations – and the number is growing. Besides the carsharing users and the thereby associated electric mobility offer for tourists, the expansion of recharging infrastructure within the scope of the FREE project represents an important foundation for the breakthrough of electric mobility.

» The Goal was the provision of sustainable transport services from a single source. «

PARTNERS:
a) Kasseler Verkehrs-Gesellschaft AG
b) EnergieNetz Mitte GmbH
c) Universität Kassel
d) Heinrich Müller – Touristikdienstleistungen mit dem E-Bike
e) Regionalmanagement Nordhessen GmbH

PROJECT BUDGET/€:
a) 1,946,594
b) 479,291
c) 770,618
d) 167,390
e) 1,033,344

FUNDING BUDGET/€:
a) 973,296
b) 239,645
c) 770,618
d) 133,912
e) 671,673

VEHICLES:
13 carsharing electric passenger vehicles:
- 6 Renault Zoe
- 6 Smart Electric Drive
- 1 eGolf

Company vehicles of the KVG:
- 1 Renault Kangoo Z.E.

Public transport vehicle:
- 1 SOR E-Bus(in scheduled service of the KVG 04/2013–03/2015)

70 pedelecs at 14 rental stations in northern Hesse

INFRASTRUCTURE:
44 new charging points in the project, thus more than 200 in total in northern Hesse

COMMENCEMENT:
1 September 2012

CONCLUSION:
30 September 2016

The "E-Bike-Netz Nordhessen" (Northern Hesse electric bicycle network) boasts 14 rental stations and more than 70 pedelecs throughout northern Hesse.

Northern Hesse currently has more than 200 recharging points.

As a result of the cooperation with electric carsharing provider E-Wald, the preconditions were created for the provision of integrated electric mobility in all regions of northern Hesse.

A total of 13 electric passenger vehicles were procured for carsharing.

V / 09 TEBALE – TECHNICAL ACCOMPANYING RESEARCH "ELECTRIC MOBILITY ALLIANCE"

The introduction of electric mobility in Germany is being developed intensively in various Model Regions and Showcase projects. Several projects from the Rhine-Main Model Region have connected themselves under the umbrella of the "Electric Mobility Alliance" (*"Allianz Elektromobilität"*) in order to establish a platform for the exchange of experiences towards the introduction of electric mobile applications as well as for the coordination of technical innovations.

The TeBALE *("Technische Begleitforschung Allianz Elektromobilität")* project accompanied the demonstration projects of the alliance. Solutions were developed for the collection of operational data from the electric vehicles being used as well as for the further processing of the data. This applies equally to special vehicles that are deployed at airports. Furthermore, the equipment technology of single special vehicles was examined and improvement potentials identified.

Energy efficiency and operational recharging systems are important for the development of electric mobility. To this end, a procedure for the system test of the recharging device and electric vehicle was developed in which driving and charging tests are dealt with integrally to thereby take interrelationships into account. The procedure was tested and further developed over the course of two test campaigns. Detailed recharging characteristics, information on energy efficiency and results from test drives on a roller test stand, are now available for diverse vehicle and charging device types.

A measuring system was developed for future examinations of cable-free recharging systems with which the electromagnetic radiation emitted during operation can be examined.

» Energy efficiency and operational recharging systems are important for the development of electric mobility. «

PARTNERS:
a) Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V.
b) Fraunhofer-Institut für Windenergie und Energiesystemtechnik

PROJECT BUDGET/€:
929,362

FUNDING BUDGET/€:
836,426

VEHICLES:
No procurement within the scope of the project

INFRASTRUCTURE:
No procurement within the scope of the project

COMMENCEMENT:
1 November 2012

CONCLUSION:
29 February 2016

Presentation of the 40 eMiO vehicles at Offenbach's Büsing Palais

V/10 EMIO – ELECTRIC MOBILITY IN OFFENBACH

"eMiO – Electric Mobility in Offenbach" is a project being conducted within the scope of the Electromobility Model Region Rhine-Main and is supported through the trans-regional coordination undertaken by the National Organisation Hydrogen and Fuel Cell Technology (NOW GmbH) and with funding from the Federal Ministry of Transport and Digital Infrastructure (BMVI). The eMiO project succeeded in generating interest and admiration for electric mobility among companies in Offenbach and brought 40 electric vehicles to the city's roads. A comprehensive package deal covering numerous aspects including vehicle procurement, maintenance, insurance and more, alleviated entry to electric mobility for the "eMiO pioneers". But almost certainly the most important factor for success was the individual consultation that was provided: whether regarding the configuration and operation of the vehicles, installation of recharging infrastructure or questions on the ideal deployment of the vehicles in day-to-day operation – users obtained far-reaching advice within the scope of the eMiO project. Through the comprehensive collection of data for the accompanying socio-scientific and technological research, valuable insights regarding the suitability for deployment of the vehicles could also be gained. As a result of the eMiO project, the subject of electric mobility has not only become more visible in the city of Offenbach, it has also gained much wider acceptance.

PARTNERS:
Stadtwerke Offenbach Holding GmbH

PROJECT BUDGET/€:
1,626,446

FUNDING BUDGET/€:
711,407

VEHICLES:
40 electric vehicles from small cars to vans

INFRASTRUCTURE:
- Publically accessible DC and AC recharging infrastructure at three locations
- Private recharging infrastructure at the respective companies

COMMENCEMENT:
1 October 2012

CONCLUSION:
31 December 2016

V/11 LEBENIMWESTEN – IMPLEMENTING SUSTAINABLE ELECTRIC MOBILITY IN URBAN FRINGE HOUSING AREAS

The focus of the "LebenImWesten" project was on the integration of sharing offers within sustainable urban planning concepts. With the funded vehicles (as well as 12 "Bakfiets" electric cargo bikes), the KEG, or rather the executive project management team comprising BSMF mbH and Planpool.EU, mainly supplemented its sustainable residential buildings (energy-plus standard and similar) and in a step-by-step process equipped all of its existing buildings with recharging infrastructure. Moreover, diverse project partners from the housing and social sectors as well as from the local economy could be won over. With the electric vehicles, these partners, in turn, supplemented their rental properties or own businesses and equipped them with recharging infrastructure – which according to the stipulations of the project management team needed to be fed with green power.

A sharing system with 15 public rental stations was established within the scope of this project. In addition, diverse planning instruments for the integration of electric mobility in urban planning along with business models and products in the form of diverse services (serviced e-parking, pick-up & delivery services, etc,) were developed and tested.

Towards the end of the project a suitable operator structure was established in the form of the "EMO-FFM eG E-Mobilitätsgenossenschaft Frankfurt am Main". Its role is to continue managing operations in the long term and successively expand the portfolio. Here too, the focus remains on the offers of electric mobility (sustainable mobility chains as a product) that are accessible to all citizens along with customised mobility concepts for the housing sector and property developers.

PARTNER:
KEG Konversions-Grundstücks-entwicklungsgesellschaft mbH

PROJECT BUDGET/€:
937,728

FUNDING BUDGET/€:
468,864

VEHICLES:
22 (16 passenger cars, 2 vans, 4 quads "Twizy")

INFRASTRUCTURE:
2 rental headquarters, 1 solar parking station, 12 rental stations, 54 charging points

COMMENCEMENT:
1 February 2013

CONCLUSION:
31 October 2016

Urban city runabouts Renault Twizy and Smart Electric Drive

V/12 EFBEL VRR – EXTENDED ACCOMPANYING RESEARCH FOR THE USE OF ENERGY EFFICIENT SCHEDULED SERVICE BUSES IN THE RHINE-RUHR TRANSPORT ASSOCIATION

Following the completion of tests in the EFBEL VRR *(erweiterte Forschungsbegleitung für den Einsatz von energieeffizienten Linienbussen im Verkehrsverbund Rhein-Ruhr)* project, the following key statements can be made: city buses with hybrid drives show a great potential for reducing energy consumption, harmful gaseous emissions as well as noise emissions. Large differences could be recorded in the characteristics of the vehicles analysed to date. Depending on the vehicle model, drivetrain concept, route characteristics, outside temperature and driver, fuel savings of between 6 % and 29 % could be recorded compared to conventional diesel vehicles. The availability of the hybrid vehicles rose continuously throughout the duration of the project. The average availability across all vehicles was 78% of planned operational hours. Under ideal conditions, the noise emissions of hybrid buses leaving a stop in pure electric mode are reduced by up to 61 % compared with diesel buses.

Besides the quantitative results of the testing campaigns, a new and comprehensive research methodology for the evaluation of city buses with conventional and alternative drives was developed and established. By continuing to use this methodology, future vehicle concepts can be soundly evaluated and compared with vehicle models already tested. The results of the examination have been incorporated in the nationwide accompanying research as part of the Innovative Drives Bus working group as well as in further publically funded projects and test programmes.

» Besides the quantitative results of the testing campaigns, a new and comprehensive research methodology for the evaluation of city buses with conventional and alternative drives was developed and established. «

PARTNERS:
a) Rheinisch-Westfälische Technische Hochschule (RWTH) Aachen
b) Verkehrsverbund Rhein-Ruhr AöR

PROJECT BUDGET/€:
a) 2,175,296
b) 124,820

FUNDING BUDGET/€:
a) 2,175,296
b) 62,409

VEHICLES:
15 vehicles were procured, all of which are in operation
(as at: Q4 2016)
- 4 EvoBus Citaro G Hybrid
- 2 Hess Swisshybrid
- 2 MAN Lion's City Hybrid
- 5 Solaris/Voith Urbino 18 Hybrid
- 2 Volvo 7700 Hybrid

INFRASTRUCTURE:
No recharging infrastructure was developed/procured.

COMMENCEMENT:
1 January 2013

CONCLUSION:
30 June 2016

V/13 E-CARFLEX BUSINESS

Project partners the City of Düsseldorf, Drive-CarSharing and Stadtwerke Düsseldorf, provided a total of 31 newly procured electric passenger cars for a vehicle pool. In a first phase, the electric vehicles from the City of Düsseldorf and Stadtwerke Düsseldorf were exclusively implemened for company use so that a basic level of utilisation could be ensured in this way. In the second phase, the vehicles from the City of Düsseldorf were also made available to employees on weekends and after hours – and in a third phase also rented out to third parties. For this purpose, the City of Düsseldorf's company public transport ticket was activated for use with the E-Carflex pool, in cooperation with the local public transport company Rheinbahn AG. Customers of the German Railways' Flinkster carsharing service could also rent the vehicles.

The project provided valuable insights into which framework conditions prevent an increase in demand and under what prerequisites at the individual fleet operators is a higher utilisation rate of the vehicles to be expected.

Through this project, Stadtwerke Düsseldorf further expanded the recharging infrastructure in Düsseldorf. By the end of the E-Carflex Business project, 70 publically accessible recharging columns had been installed in the Düsseldorf city region.

The accompanying scientific research was conducted by the Wuppertal Institute.

» The project provided valuable insights into which framework conditions prevent an increase in demand and under what prerequisites at the individual fleet operators is a higher utilisation rate of the vehicles to be expected. «

PARTNERS:
a) Landeshauptstadt Düsseldorf
b) Drive-CarSharing GmbH
c) Stadtwerke Düsseldorf AG
d) Wuppertal Institut für Klima, Umwelt, Energie gGmbH

PROJECT BUDGET/€:
a) 694,770
b) 741,839
c) 1,727,684
d) 476,486

FUNDING BUDGET/€:
a) 474,462
b) 519,287
c) 863,842
d) 428,837

VEHICLES:
31 vehicles

INFRASTRUCTURE:
30 recharging columns, 10 wallboxes

COMMENCEMENT:
1 October 2012

CONCLUSION:
30 December 2016

Carsharing – electric car rental station with recharging infrastructure.

V/14 EMOVE – ELECTRIC MOBILITY ASSOCIATION AACHEN

The emove *("elektromobiler Mobilitätsverbund Aachen")* project examined the integration of electric mobility in urban transport planning. In the "Municipal Planning" (Kommunale Planung) work package, planning documents of large German cities were examined regarding the level to which they take electric mobility into consideration, including zoning plans and transport development plans. Based on the findings, a tool to support the future integration in urban planning was developed. Furthermore, the Aachen transport development plan process was accompanied and user needs observed in the course of electric mobility neighbourhood development. In the "Mobility Association" *(Mobilitätsverbund)* work package, a job ticket option was developed that incorporates electric vehicles, which was preceded by comprehensive surveys of employees and employers.

As part of the implementation, 15 electric vehicles were acquired in Aachen, including models at the city council and the fire department, and have since been in deployment. Five further electric vehicles are also available in a carsharing service tied to fixed pick-up and drop-off locations in Aachen. In addition, both Aachen and Herzogenrath each saw the installation of two "mobile stations" with a recharging column for one electric carsharing vehicle. A combustion engine carsharing vehicle is also available at the stations for use on longer trips. To draw attention to the stations, a design concept featuring steles was developed and installed in order to catch the eye. Furthermore, a new pedelec rental station is to extend the existing station at Aachen Westbahnhof.

PARTNERS:
a) Rheinisch-Westfälische Technische Hochschule Aachen
b) Stadt Aachen
c) Aachener Verkehrsverbund GmbH
d) Stadtwerke Aachen Aktiengesellschaft
e) STADTTEILAUTO Car Sharing GmbH
f) EcoLibro GmbH
g) Fachhochschule Aachen
h) Probst & Consorten Marketing-Beratung

PROJECT BUDGET/€:
a) 141,764
b) 882,492
c) 80,622
d) 154,060
e) 253,296
f) 135,772
g) 150,295
h) 111,017

FUNDING BUDGET/€:
a) 141,764
b) 661,869
c) 40,311
d) 77,030
e) 162,768
f) 95,041
g) 150,295
h) 55,508

VEHICLES:
22 vehicles

INFRASTRUCTURE:
4 recharging columns (each with two charging points) up to 22kW

COMMENCEMENT:
1 December 2012

CONCLUSION:
30 June 2016

V/15 SAXMOBILITY II – MOBILE TERMINALS AS ACCESS AND SETTLEMENT SYSTEMS FOR RECHARGING INFRASTRUCTURE AND LINKING WITH LOCAL PUBLIC TRANSPORT

The project partners tested an access and settlement system *(ZAS – Zugangs- und Abrechnungssystem)* called "StromTicket" (PowerTicket) in connection with local public transport, for the spontaneous use of the infrastructure for the recharging of electric vehicles.

Considering the large number of local public transport customers, a combined access and settlement system for both public transport services and recharging appeared promising. The idea is to deliver mobility services from a single source: recharging services, recharging column reservations and settlement of the fees. It boosts environmentally friendly mobility options and whets the appetite for wishing to utilise electric mobility.

The time-based accounting of recharging procedures with the "StromTicket" has been integrated in the "HandyTicketDeutschland" association system since 2013 and has been available for use to all customers of transport companies in the association since 2016. In the Leipzig region, the "StromTicket" was embedded parallel in the "easy.GO" local public transport offer during the installation of 25 new types of mobility stations. The SaxMobility II project additionally initiated that customers could use the complete range of services at a single location: recharging at the stations; transfer, information and ticketing services; carsharing (including electric carsharing) and bicycle rental. Due to its innovative nature, numerous enquiries regarding its application were received from third parties.

Furthermore, at the HTW Dresden campus, the so-called Car and More Sharing (CAMS 2.0) system for the autarkic processing of electric vehicle rental services was introduced. Students and staff can now experience electric mobility first hand – on both four and two wheels.

Getting connected: the StromTicket

PARTNERS:
a) KEMA – IEV Ingenieurunternehmen für Energieversorgung GmbH (DNV GL-Energy)
b) Stadtwerke Leipzig GmbH
c) ENSO NETZ GmbH
d) Hochschule für Technik und Wirtschaft Dresden (HTW)
e) Forschungs- und Transferzentrum Leipzig e. V. (FTZ)
f) DREWAG – Stadtwerke Dresden GmbH
g) Leipziger Verkehrsbetriebe (LVB) Gesellschaft mit beschränkter Haftung

PROJECT BUDGET/€:
a) 145,527
b) 1,404,638
c) 493,319
d) 1,211,069
f) 1,248,651
g) 656,697

FUNDING BUDGET/€:
a) 72,764
b) 702,319
c) 246,660
d) 1,211,069
e) 66,759
f) 624,325
g) 328,348

COMMENCEMENT:
1 October 2011

CONCLUSION:
30 June 2016

V/16 EMIS – ELECTRIC MOBILITY IN STAUFERLAND – INTEGRATED IN URBAN DEVELOPMENT AND CLIMATE PROTECTION

The Staufer towns of Göppingen and Schwäbisch Gmünd undertook the "EMiS" *(Elektromobilität im Stauferland – integriert in Stadtentwicklung und Klimaschutz)* together with a further six partners and the Institute of Urban Development of the University of Stuttgart. Aim of the project was to evaluate the contribution electric mobility can provide for urban development and climate protection goals, and to integrate these into the same.

The climate protection contribution along with the cost effectiveness of electric vehicles was examined in a private, commercial (two hybrid waste collectors) and public context in the two cities. Overall, the use of electric vehicles was assessed as being positive. An electric carsharing service was tested, which was located in the StadtGarten residential district of Göppingen.

A major part of the project involved the demand-oriented establishment of publically accessible recharging infrastructure. The geographical distribution of the public infrastructure was determined by conducting a stakeholder analysis and by also taking the district typology into account. This then comprised the foundation for installing recharging columns that were supplied exclusively with power from renewable sources.

The results of the project were fed back into a "Toolbox for electric mobility in mid-sized cities", which provides detailed information on the steps and conditions under which a municipality can develop into an "e-mobile city."

A total of seven electric vehicles were deployed in day-to-day operation in Göppingen and Schwäbisch Gmünd.

PARTNERS:
a) Stadt Göppingen
b) Stadt Schwäbisch Gmünd
c) Stadtwerke Schwäbisch Gmünd GmbH
d) Wohnbau GmbH Göppingen
e) Energieversorgung Filstal GmbH & Co. KG
f) Heldele GmbH
g) ETG Entsorgung + Transport GmbH
h) Gesellschaft im Ostalbkreis für Abfallbewirtschaftung mbh (GOA)
i) Universität Stuttgart (Städtebau-Institut)

PROJECT BUDGET/€:
a) 151,404
b) 96,548
c) 357,646
d) 21,571
e) 47,500
f) 1,266,880
g) 300,615
h) 399,834
i) 779,633

FUNDING BUDGET/€:
a) 109,616
b) 69,128
c) 178,823
d) 10,785
e) 23,896
f) 633,440
g) 150,307
h) 199,917
i) 779,633

VEHICLES:
7 electric vehicles,
2 hybrid waste collectors

INFRASTRUCTURE:
31 recharging stations
with 43 charging points

COMMENCEMENT:
1 September 2012

CONCLUSION:
31 August 2016

V/17 BODENSEEMOBIL – INNOVATIVE MOBILITY IN THE SOUTH

An innovative mobility service was initiated in the Lake Constance region under the name of "emma – e-mobil mit anschluss". The idea at the core of the project was the three-way networking of electric vehicles: in the public transport system, in the energy system, and with one another via state-of-the-art information and communication technology. The goal was to improve transport conditions in the region through its enhancement with electric vehicles.

Comprised of 23 local communities, the Lake Constance district offered an ideal backdrop for the project with various target groups, tourist highlights as well as urban densification zones that disperse into rural areas.

In order to achieve the project goals, various scenarios for the integration of electric vehicles in the local public transport systems were drafted, the necessary recharging infrastructure established and an integrated mobility app developed.

In three pilot communities, electric vehicles were deployed to supplement existing bus routes, driven by bus drivers of the local operators or by volunteer drivers of a citizen bus association, which was initiated specifically for this purpose. The electric vehicles operated on a needs-oriented basis, in other words only after an advance booking and thereby filled both the spatial and time gaps in the existing public transport timetable. Furthermore, with CampusMobil and Community-Carsharing, working alternatives to the classic carsharing systems were specially developed for rural areas, and continued to operate following the conclusion of the project.

CampusMobil – one-way electric mobility carsharing in a student environment.

PARTNERS:
a) DB FuhrparkService GmbH
b) T-Systems International GmbH
c) Technische Universität Berlin
d) Innovationszentrum für Mobilität und gesellschaftlichen Wandel (InnoZ) GmbH
e) Duale Hochschule Baden-Württemberg
f) Landkreis Bodenseekreis
g) Stadt Friedrichshafen
h) Stadtwerk am See GmbH & Co. KG
i) HaCon Ingenieurgesellschaft mbH

PROJECT BUDGET/€:
a) 687,466
b) 397,007
c) 188,645
d) 361,833
e) 469,366
f) 922,080
g) 922,557
h) 578,009
i) 588,174

FUNDING BUDGET/€:
a) 343,733
b) 166,743
c) 169,780
d) 180,917
e) 422,429
f) 647,208
g) 738,045
h) 289,005
i) 294,087

VEHICLES:
A total of 19 vehicles were put into operation during the project's duration: 8 Citroën C-Zero, 4 Peugeot iOn, 4 Nissan Leaf, 2 Nissan eNV 200, 1 Renault Kangoo Z.E.

INFRASTRUCTURE:
34 recharging columns AC, each with 2 recharging point with max. 22kW
3 mobile fast-chargers DC, each with 1 recharging point

COMMENCEMENT:
1 November 2012

CONCLUSION:
31 Dezember 2016

V/18 EMOTIF – ELECTROMOBILE THURINGIA IN THE REGION

Aim of the "EMOTIF – Elektromobiles Thüringen in der Fläche" research project was the establishment of an electric mobility carsharing service in the state of Thuringia. A total of four carsharing stations – each with two electric vehicles – were established at the train stations in the cities of Eisenach, Erfurt, Weimar and Jena and integrated in the Flinkster carsharing service of DB Rent GmbH. Furthermore, a total of eight recharging stations at tourist highlights in the surrounding region were put into operation. This primarily brought about that destinations in rural regions, which were difficult or impossible to reach with public transport, were now accessible. This enabled customers –and especially rail commuters – to enjoy a completely electromobile journey chain. With the availability of the new electric fleet, destinations in rural areas could now not only be reached faster and more reliably but also in an environmentally friendlier manner. As part of the accompanying research of the project, for which the Institute of Transport and Spatial Planning of the Erfurt University of Applied Science was responsible, various methodological approaches could be tested. Besides the technical and organisational functional capacity, a further focus was also placed on the accompanying socio-scientific research and thereby the study of the user. This involved: conducting a survey of hotel guests for the purpose of a potentials analysis; carrying out a qualitative user survey on motives and experiences with the electric vehicles; and undertaking qualitative interviews with the operators of the recharging infrastructure, the carsharing systems and tourism service providers. Overall, despite high levels of technical availability and reliability, considerable barriers for use appeared to remain, resulting in the system being predominantly used by ecologically or technologically-oriented early adopters.

» With the availability of the new electric fleet, destinations in rural areas could now not only be reached faster and more reliably but also in an environmentally friendlier manner. «

PARTNERS:
a) Fachhochschule Erfurt University of Applied Sciences
b) Erfurt Tourismus und Marketing GmbH
c) DB Rent GmbH
d) Eisenacher Versorgungs-Betriebe GmbH
e) Stadtwerke Energie Jena-Pößneck GmbH
f) Stadtwerke Weimar Stadtversorgungs-GmbH

PROJECT BUDGET/€:
a) 368,449
b) 122,640
c) 474,197
d) 76,292
e) 98,117
f) 90,000

FUNDING BUDGET/€:
a) 368,449
b) 61,320
c) 237,098
d) 38,146
e) 49,058
f) 45,000

VEHICLES:
8 Citroën C-Zero

INFRASTRUCTURE:
4 carsharing stations with corresponding recharging infrastructure as well as 7 recharging columns/wallboxes in the surrounding region

COMMENCEMENT:
1 October 2012

CONCLUSION:
31 August 2016

V/19 ELECTRIC MOBILITY CENTRAL GERMANY – GREEN MOBILITY CHAIN

The Idea

The "Green mobility chain" *(Grüne Mobilitätskette)* project, which aims to bring people door-to-door, arose out of an overarching examination of the areas of electric mobility, housing and urban development.

Project elements

In the future, the existing public transport timetable information systems should be extended to also be usable for trips in which electric bike or carsharing is combined with public transport. The project examined how these timetable information systems can be developed further in order to fulfil these demands. The partners to the project vigorously looked into the potentials such a combination of (e-) carsharing and local public transport could provide.

It was investigated which new business areas electric mobility would open up if public utility companies – that have long since sold mobility as transport operators and energy and energy suppliers – would combine both of these business areas.

Finally, it was also examined how electric mobility can be integrated into housing development. The key issue here was which technical and organisational challenges would developers wishing to integrate electric mobility in multi-floor construction projects be prepared to meet. Also important in this respect was the question of whether the integration of electric carsharing would have an impact on the number of car parking spaces required.

» The question of how electric mobility can be integrated into housing was also examined. «

PARTNERS:
a) Nahverkehrsservice Sachsen-Anhalt GmbH
b) Verkehrsgemeinschaft Mittelthüringen GmbH (VMT)
c) Stadtwerke Halle GmbH
d) HaCon Ingenieurgesellschaft mbH
e) TAF mobile GmbH
f) Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V. (IMWS)
g) ibh-bauwerke (Hans-Georg Herb)
h) Technische Universität Ilmenau (Thüringer Innovationszentrum Mobilität)

PROJECT BUDGET/€:
a) 870,416
b) 306,392
c) 706,753
d) 844,480
e) 363,939
f) 280,349
g) 205,975
h) 420,112

FUNDING BUDGET/€:
a) 435,208
b) 153,196
c) 353,376
d) 422,240
e) 181,969
f) 252,314
g) 102,987
h) 420,112

VEHICLES:
19

INFRASTRUCTURE:
24 recharging columns/wallboxes

COMMENCEMENT:
1 October 2013

CONCLUSION:
30 September 2016

Newly constructed residential building in Erfurt with integrated recharging infrastructure in the underground parking lot.

Funding by:

Federal Ministry
of Transport and
Digital Infrastructure

following a resolution by
the German Bundestag

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