GERMANY

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ENERGY FRAMEWORK AND RELEVANT POLICIES

The German Federal Government set ambitious targets for energy and climate policy with the introduction of the Energy Concept in September 2010. Therefore, the energy supply system in Germany will undergo a fundamental transformation. At the same time, a secure and affordable supply of energy will also be imperative in the future if Germany is to remain in a competitive business position. The Federal Government laid the foundations for this new energy era in the summer of 2011 with the adoption of a comprehensive legislative package known as the "Energy Package" (six laws and one ordinance). The master plan for the development of the German Energy System towards 2050 contains concrete goals for different energy related sectors:

- Phase out of Nuclear Energy by end of 2022
- 40% Reduction of CO_2 emissions by 2020, 55% by 2030 and 80% by 2050 (reference year for emissions: 1990)
- 50% Reduction in primary energy consumption by 2050
- Minimum 30% share of renewable energy relative to primary energy carrier by 2030
- 10% reduction of electricity consumption (gross) by 2020 and 25% until 2050
- 50% share of renewable energy for electricity generation by 2030 and 80% by 2050
- 20% reduction of heat demand for space heating by 2020
- 10% share of renewable energy for transportation fuels by 2020; 1 mill. EV by 2020 and 6 mill. EV by 2030 (This can be Battery Electric Vehicle (BEV), Plug-In Hybrid Electric Vehicle (PHEV) and Fuel Cell Electric Vehicle (FCEV))

To achieve these goals, the federal government will intensify energy research to identify new technologies which maintain a reliable energy supply at affordable prices in the future. On the basis of the sixth Energy Research Program, R,D&D projects are developing technologies for the energy supply of tomorrow. The development of new storage technologies is a central thrust of energy research and hydrogen is an important part of that research strategy.

HYDROGEN RELATED ENERGY POLICY STRATEGIES

The German Research, Development and Demonstration of Hydrogen Activities are mainly combined in the "National Hydrogen and Fuel Cell Technology Innovation Programme (NIP)." The activities are added by industrial R&D activities, programmes of Federal States and European research cooperation.

VITAL STATISTICS

EU member state

Population

82.0 Million[1]

Territory

357,112 km² [1]

Capital

Berlin

The total budget within NIP in the period from 2006 to 2016 is €1.4 billion, coming in equal parts from NIP and the participating industries. Governmental sponsors of NIP are the Federal Ministry of Transport, Building and Urban Affairs, the Federal Ministry of Economics and Technology, the Federal Ministry of Education and Research and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

Research, development and demonstration projects within NIP are concentrated on the following R,D&D topics: transportation; production; stationary and residential household applications; special markets; and cross-cutting issues. The financial details and goals of the individual topics are described in the Nationale Organisation Wasserstoff-und Brennstoffzellentechnologie (NOW) 2012 Annual Report. [1]

The first phase of NIP ends in 2016. By end of summer 2013 there was a proposal prepared by the representatives of industry and science in the advisory board of NOW GmbH for the future scope of work in the second phase 2014–2023. The defined goals for 2025 are [2]:

- 500 Filling Stations
- 500,000 FCEVs
- 2000 buses for public transport
- Hydrogen production from renewable energies: flexibility and storage option
- Integration throughout the entire energy system: combining electricity, gas and transport sector
- 1500 MW installed electrolysis capacity
- Power to Gas and hydrogen storage
- 500,000 Micro CHP FC units

The financial requirements for the NIP will be about €3.9 billion, whereas the planned industry contribution will be €2.3 billion.

HYDROGEN RESEARCH, DEVELOPMENT, DEMONSTRATION AND DEPLOYMENT ACTIVITIES

Transportation

The Clean Energy Partnership (CEP) is the lighthouse project within the current NIP. One of the main goals of the CEP is to develop, build and operate a safe hydrogen refuelling infrastructure with 50 filling stations for 5000 fuel cell electric vehicles (FCEV) by 2015[3]. Therefore, several filling stations were opened for operation by 2012. Figure 1 shows an extract of new filling stations installed in 2012 and some technical data.

	Berlin - Heidestraße	Hamburg - Barmfelder Chaussee	Hamburg - Cuxhavener Straße	Düsseldorf - Höherweg
				
H_2 production	Centralized wind electrolysis and BtH	Byproduct	Centralized wind electrolysis	Byproduct
H_2-transportation	GH_2-trucks	GH_2-trucks	GH_2-trucks	GH_2-trucks
Pressure	700 bar (filling)	700-1000 bar (at storage)	700 bar (filling)	200 bar (storage) 350 and 700 bar (filling)
Filling time	3 minutes	3 minutes	3 minutes	3-5 minutes
Filling capacity	200 kg/d	40 kg/d	30-35 cars/d	212 kg/d
Highlights	Advanced cooling system, Ion-compressor	Meets SAE J2601	Upgraded with "H2small"	1st of at least 7 filling stations in NRW
Partners	Total, Linde, Enertrag	Shell, Air Products, Daimler AG	Total, Linde, Enertrag	Air Liquide, Opel, 3M, e-plus, EnergieAgentur. NRW

Figure 1 New Filling Stations in Germany in 2012

TÜV Süd & Ludwig Bölkow Systemtechnik, 2012, CEP, 2013[4]

TOTAL, Enertrag and Linde are currently planning another "multi-energy filling station" at Berlin-Brandenburg-International Airport within the CEP.

The industry partners involved in CEP in 2012 are GM/Opel, Berliner Verkehrsbetriebe, BMW, Daimler, EnBW, Enertrag, Ford, Hamburger Hochbahn, Linde, Shell, Siemens, Statoil, TOTAL, Toyota, Vattenfall and Volkswagen.

In addition to the CEP Fraunhofer ISE in Freiburg (South of Germany) built a filling station that is currently operational. There the hydrogen is produced by a pressurized PEM-electrolyser operating with wind and solar power. The capacity of the electrolyser is 13 kg/d and the produced hydrogen meets a purity of 5.5 (99.9995%). The hydrogen is compressed in two temporary stages up to a pressure of 700 bar.[5] The filling station (Figure 2 Filling station at Fraunhofer ISE in Freiburg) is funded outside of CEP by the Federal State of Baden-Württemberg.

Figure 2 Filling station at Fraunhofer ISE in Freiburg

[ISE, 2012]

In 2012, the HyCologne Initiative celebrates one year of operation by Phileas buses. The buses consume 15 kg H_2 per 100 km and have a storage capacity of 40 kg. Within the project, the installation and operation of a safe H_2 infrastructure is another important aspect. As well, this study gathers operating experience and information for standardisation of infrastructure.

Hydrogen Production

Hydrogen production from renewables is the main focus of the Hydrogen Production part of NIP. The coupling of renewable energy with electrolysers is the main funding topic within NIP. In 2012, NOW published a report on the technical status of electrolysers and their ability to use fluctuating energies for hydrogen production. Another study evaluates processes and technologies for producing hydrogen from biomass. The study uses technical, economic and ecological criteria for concept evaluation and delivers recommendations for German hydrogen strategy.

Stationary and Residential Applications

In the lighthouse project Callux, more than 200 fuel cell heating appliances were in operation in 2012. Baxi-Innotech, Hexis and Vaillant installed the micro CHP units mainly in one and two-family houses. More than 1 million operating hours have been reached in 2012. A highlight within the Callux project is the first installation of a wall-mounted FC operating in Karlsdorf. This fuel cell has an electric power of 1 kW and a heating power of 2 kW. However, for fuel cell heating applications the market launch is expected at the end of the Callux project in 2016.

A molten carbonate fuel cell (MCFC) was installed at the new building of the Federal Ministry of Education and Research (BMBF). Its operation started in December 2014 [IKTS, 2014][6]. The goals for the electric efficiency is between 40% and 60% overall efficiency, including heat generation.

Another stationary fuel cell was installed at a Mercedes-Benz dealership in Hamburg. The Phosphoric Acid Fuel Cell (PAFC) has an electric capacity of 100 kW and a thermal capacity of 120 kW. Activities focused on building insulation and the use of the fuel cell will reduce CO_2 emissions by 60%. The payback period of the €1 million investment on the fuel cell will be six to seven years.

Special Markets

In the Special Markets program, essential goals include market preparation and launch, the demonstration of practical suitability and transition to series production. Projects in the Special Markets area are divided into application segments remote systems, USV, independent/hybrid power supply, electricity supply for camping applications, industrial and special transport vehicles and micro fuel cells. Strategies used to reach these goals include optimisation of components and systems, integration developments and refuelling infrastructure as well as approval issues. [1, Op. Cit.]

As a cross-cutting activity, the strategic alliance Clean Power Net was established with approximately 70 Germany companies from the information and communication sector. The goal of this network is to accelerate the commercialization of fuel cells in ICT and process automation applications.

Industry Activity

In 2009, leading industrial companies initiated the so-called "H2Mobility" group. The goal of the industry group is the establishment of a nationwide network of hydrogen fuelling stations in Germany. In 2013, the H2Mobility activity (supported by Air Liquide, Daimler, Linde, NOW, OMV, Shell and Total) agreed on a concrete action plan for the construction of a hydrogen refuelling network in Germany. The goal of the action plan is to expand the current network (15 filling stations) of public hydrogen infrastructure to approximately 400 H_2 filling stations in 2023. The hydrogen supply by then will be suitable for everyday use in urban areas and rural areas. The average distance to reach a hydrogen filling station should be at least 90 km. An intermediate step to this long-term goal will be the build-up of 100 hydrogen stations over next 4 years. An overall investment of around €350 million planned, combined with this build-up of refilling stations will be the precondition for the market success of Fuel Cell Electric Vehicles. The launch of Fuel Cell Electric Vehicles in German by first manufacturers is scheduled for 2015.[7]

END NOTES

1] NOW (2012) Annual Report 2011. http//www.now-gmbh.de, 2012-06-20.

2] NOW (2013b) Hydrogen and fuel cell technologies – key pillars of the energy transition 2.0 *Further development of the National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP)* www.now-gmbh.de/fileadmin/user_upload/Download/hydrogen_and_fuel_cell_technologies_-_key_pillars_of_the_energy_transition_2_0.pdf

3] CEP (2013) Clean Energy Partnership www.cleanenergypartnership.de, 2013-05-05.

4] TÜV SÜD & LUDWIG BÖLKOW SYSTEMTECHNIK (2012) *Hydrogen Stations Worldwide* http//www.netinform.net/h2/H2Stations, 05.04.2013.

5] ISE (2012) Mit Sonne und Wasser Auto fahren - Fraunhofer ISE weiht solare Wasserstoff-Tankstelle ein. *Press release 2012-03-02.* www.ise.fraunhofer.de.

6] IKTS (2014) 250 kW Brennstoffzellenkraftwerk liefert Energie fuer Bundesministerium

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7] NOW (2013a) *H2 Mobility Initiative* http//www.now-gmbh.de/en/aktuelles-presse/2013/h2-mobility-initiative.html. 2013-09-30: 2013.

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