Federal Ministry
of Transport and
Digital Infrastructure

Towards sustainable energy systems – Overview of German HFC-Developments

Nilgün Parker, German Ministry of Transport and Digital Infrastructure

IPHE
International Partnership for Hydrogen and Fuel Cells in the Economy

UiO : Universitetet i Oslo

IPHE Educational Event in Oslo

H2igher Educational Rounds – H2ER

Political background for the transition to renewable energies

Three reasons why it is inevitable to change the energy system in Germany:

- **Climate protection:**
  Global responsibility for the next generation.

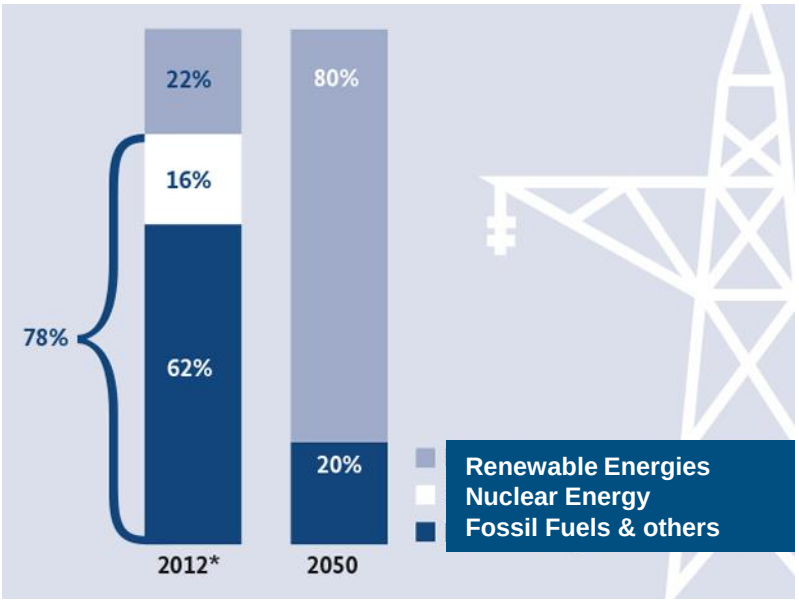
- **Energy security:**
  More independency from fossil fuels.

- **Securing the economy:**
  Creating new markets and jobs through innovations.

The broader picture

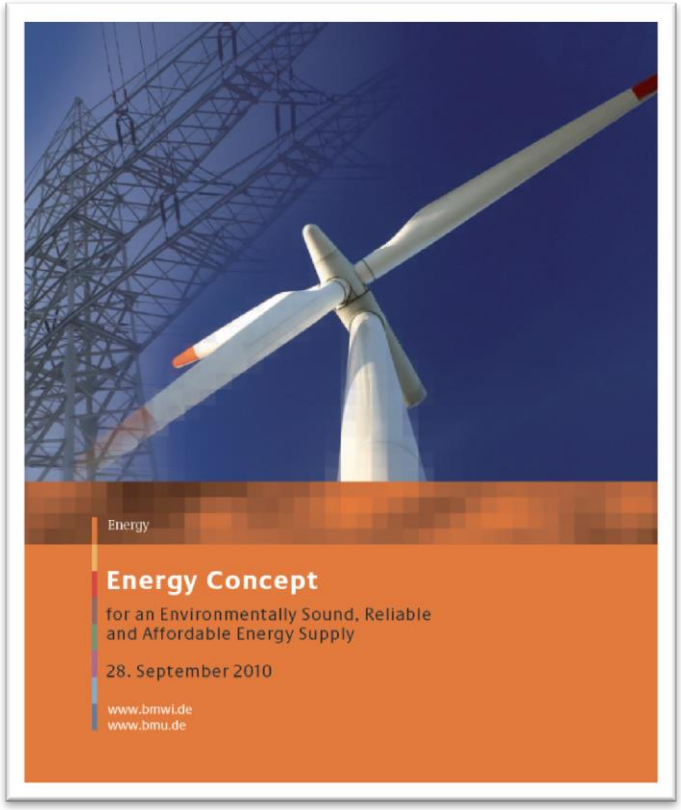
The German „Energiewende“

Transforming the Energy System



Political Climate and Energy Targets for Germany[1]

- **Reducing GHG across all sectors (1990 baseline):**
  40% by 2010 ➔ 80% by 2050
- **Share of renewable energies of the gross final energy consumption:**
  18% by 2020 ➔ 60% by 2050
- **The share of renewable energies for the electric power supply:**
  40-45% by 2025 ➔ 55-60% by 2035
- **Reducing primary energy consumption:**
  20% by 2020 ➔ 50% by 2050.
- **Increase of Energy productivity:**
  2.1% per year compared to final energy consumption.
- **Decrease of electricity consumption (baseline 2008):**
  10% by 2020 ➔ 25% by 2050
- **Compared to 2008, heat demand in buildings** is to be reduced by 20% by 2020, while primary energy demand is to fall by 80% by 2050.
- **Goals of the German Energy Concept (2010) for Transport:**
  about -10 % until 2020 of energy consumption
  about -40 % until 2050 of energy consumption (vs. 2005)



Challenges –
Energy Consumption and Energy Targets of Transport/Germany

- Share of transport in final energy consumption nearly 30%
- Tripling of energy consumption in transport since 1960, even five-fold increase in road traffic
- Development of final energy consumption 2005-2009:
  - Transport sector as a whole: + 3%
  - Car Traffic : - 7 %
  - Road Transport: + 3 %
  - Aviation: + 7 %

→ Goals of the German Energy Concept (2010) for Transport:
about - 10 % until 2020
about - 40 % until 2050 (vs. 2005)

→ **How can the goals be achieved to reduce the energy consumption of transport?**

Final Energy Consumption of the Transport Sector in Germany

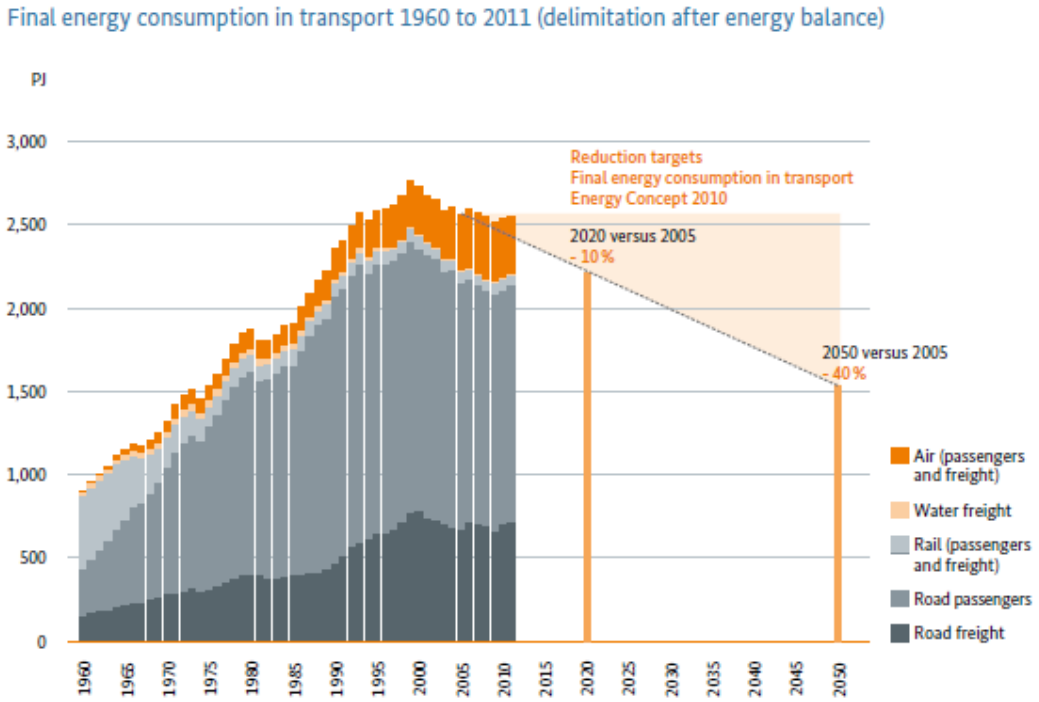
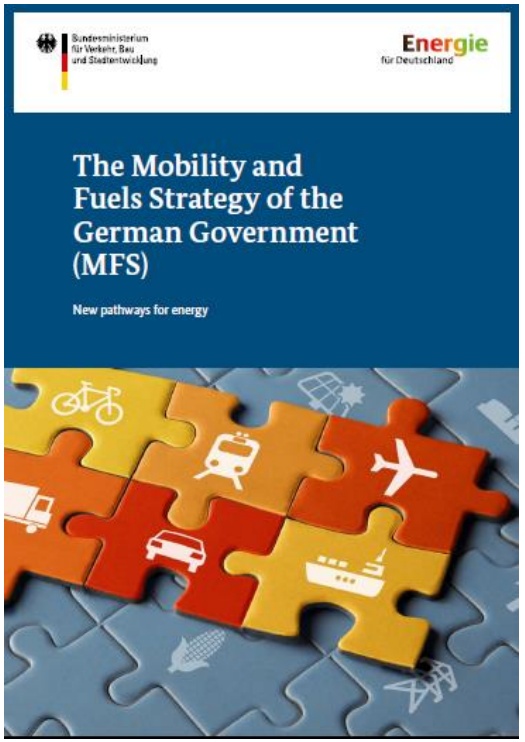


Figure 3: The diagram shows the energy consumption of the individual modes of transport, the current situation and the targets for 2020 and 2050. (Source: own diagram BMVBS / ifeu)

Quelle: Tremod

Political Framework for the Transport Sector

➔ **The Mobility and Fuels Strategy of the German Government[2] outlines the way how to achieve these objectives.**



➔ **Electrification of the drive train (BEV's and FCEV's) is an key issue to reach the targets!**
➔ **Targets only achievable with PtG-H2 and PtG-Methane.**
➔ **Further increase of RE then planned.**
➔ **Large scale storage for Hydrogen is inevitable.**

Clean Power for Transport (CPT) Directive
Europe`s way forward to alternative fuels
Core Elements

CPT-Directive contains specific infrastructure requirements for different “fuel options":

- electricity
- hydrogen
- Methane (LNG and CNG, for roads and waterways)

- No binding infrastructure requirements (“where” / “numbers”); Member States define infrastructure roll-out in *National Infrastructure Plans*
- Binding technical standards for all alternative fuels infrastructures – aim: EU-wide harmonization

National Implementation: Development of a national framework for the different fuel options (electricity, H2, CNG, LNG)

- Clarification of minimum requirements: minimal infrastructure requirements (standard equipment per fuel option)
- Explore operator models and set up by the state required canon of rules ("non-discriminatory access")
- Capital deployment (public funding ? / private capital)
- EU support to integrate, organize cooperation with neighboring MS
- Availability of EU-Funds (e.g.. Ten-T) for infrastructure deployment!?

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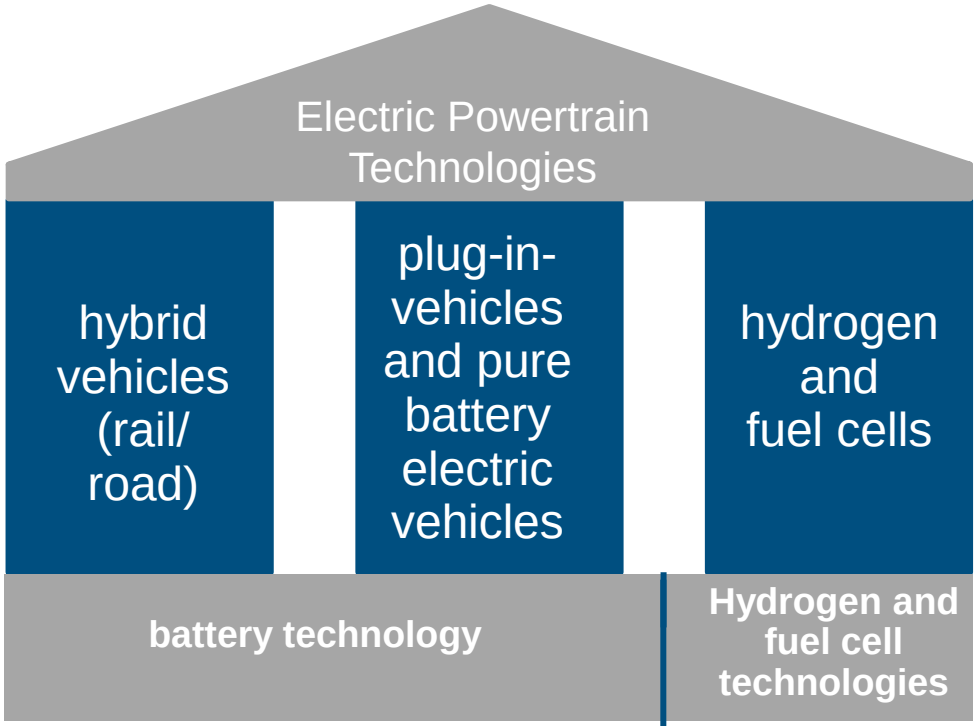
Fuel Cells and Hydrogen – Experiences in Germany

The NIP – National Innovation Program for Hydrogen and Fuel Cell Technologies

Market Preparation for Electric-Mobility

Three pillars of electrifying the powertrain



Modellregionen Elektromobilität

500 mio. € budget (2009-2015);
- Incl. 150 mio. € BMVBS (2009-2011)
- ~ 100 mio. € (2012-2015/16)

nip

1,4 bn. € budget (2007-2016)
- incl. 700 mio. € federal funding: BMVBS (500 mio. €) and BMWi (200 mio. €)

batteries

and

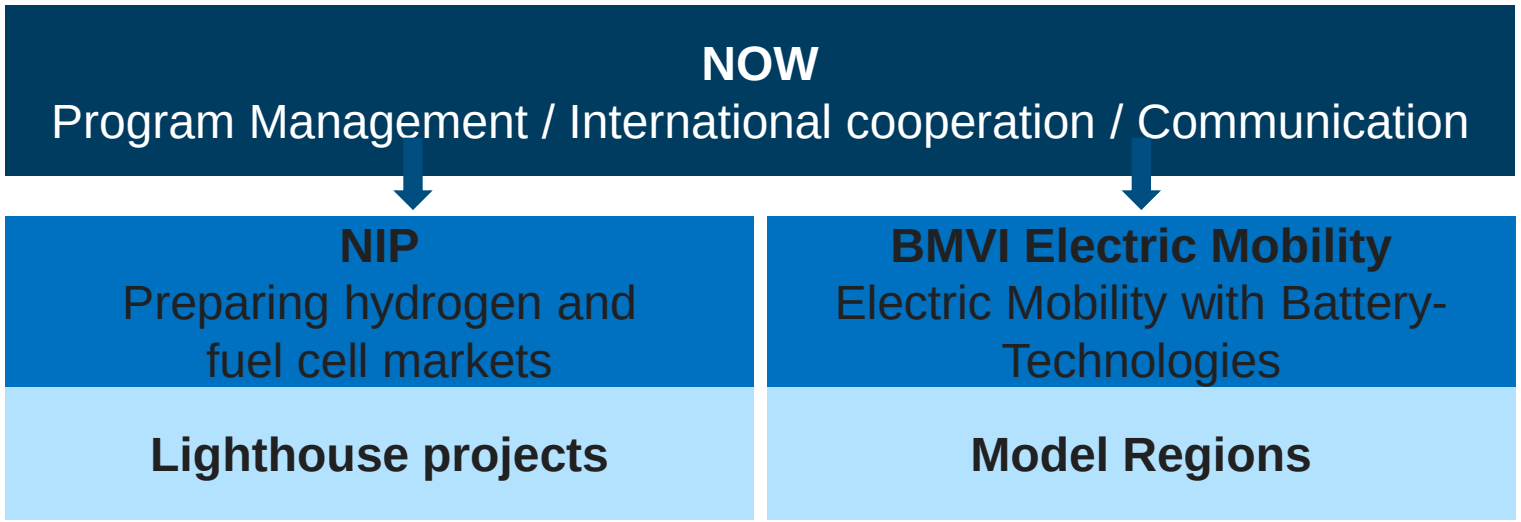
hydrogen / fuel cells

are

key technologies for a sustainable mobility

NOW GmbH
National Organization Hydrogen and Fuel Cell Technology

- Government-owned company (100 %) funded in 2008
- Co-financing by industry (project overheads)
- Supervisory board: BMVI (Chair), BMWi, BMBF, BMUB
- Advisory board: strategic controlling and development of programs



programs addressing market preparation

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National Innovation Program for Hydrogen and Fuel Cell Technology (NIP)
Preparing Hydrogen and Fuel Cell Markets

Transportation (54%*)

- H_2 production and infrastructure
- Expanding vehicle fleets and hydrogen infrastructure starting from key regions

Stationary Applications (36%*)

- Micro CHP for residential use
- Industrial gensets for CHP and trigeneration

Special Markets (10%*)

- IT, telecommunications
- Logistics, leisure and tourism markets

* distribution according to the National Development Plan

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NIP -
Integrated Approach for Market Preparation

Technology
- components
- subsystem
- systems + products

Application
- cost
- reliability
- lifetime

Markets
- customer acception
- safety
- approval processes

Bosch:
Hydrogen Gas
Injector HGI

CEP
Clean Energy Partnership
Ein Projekt im Nationalen Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie
nip

FCCT:
Gas Diffusion Layer
(GDL)

callux
Praxistest Brennstoffzelle fürs Eigenheim
Ein Projekt im Nationalen Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie
nip

Linde:
Ionic H2-Compressor

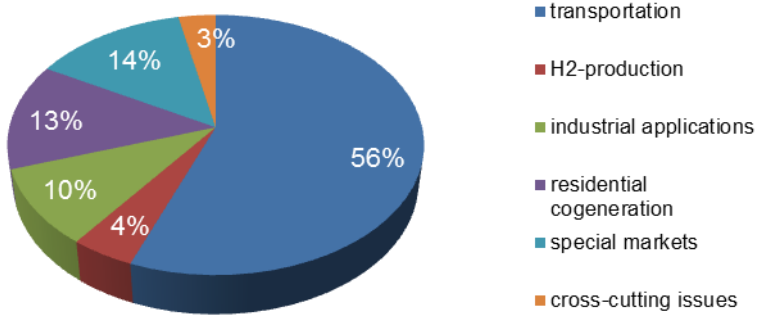
clean power net
Brennstoffzellen in Industrie und Business

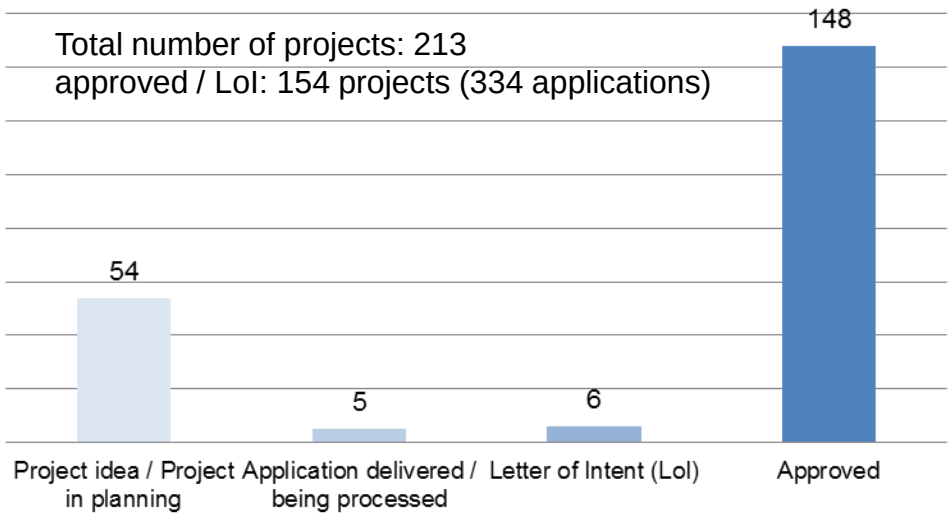
Federal Ministry of Transport and Digital Infrastructure

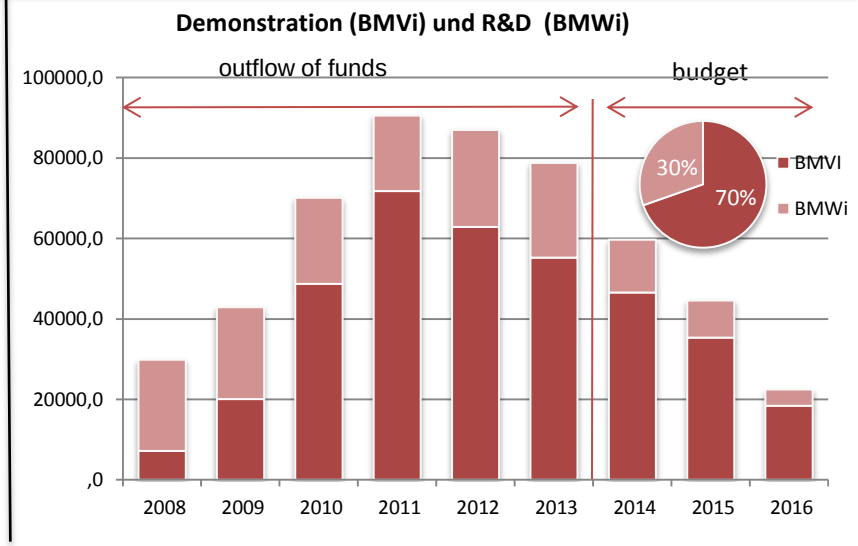
National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP)

BMVI-funding Status 12/2013

program area	Budget k€	funding k€	LoI & approved k€	In discussion €k
transportation	579.058	276.755	238.361	38.394
H2-production	44.002	21.795	14.792	7.003
industrial applications	91.302	47.667	29.904	17.764
residential cogeneration	140.171	65.557	55.063	10.494
special markets	137.767	67.219	51.700	15.518
cross-cutting issues	31.777	16.299	6.824	9.475
innovative drive systems	15.439	7.411	7.411	-
product line	**1.039.516**	**502.703**	**404.055**	**98.648**







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Fuel Cells and Hydrogen – Experiences in Germany

FC Fleets & Hydrogen Infrastructure

Federal Ministry of Transport and Digital Infrastructure

Clean Energy Partnership – Hydrogen Refueling Stations (HRS)

Ein Projekt im Nationalen Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie

Hamburg, Bramfelder Chaussee Shell

Hamburg, HafenCity Vattenfall/ Shell

Hamburg, Cuxhavener Str. Total *(location change ongoing)*

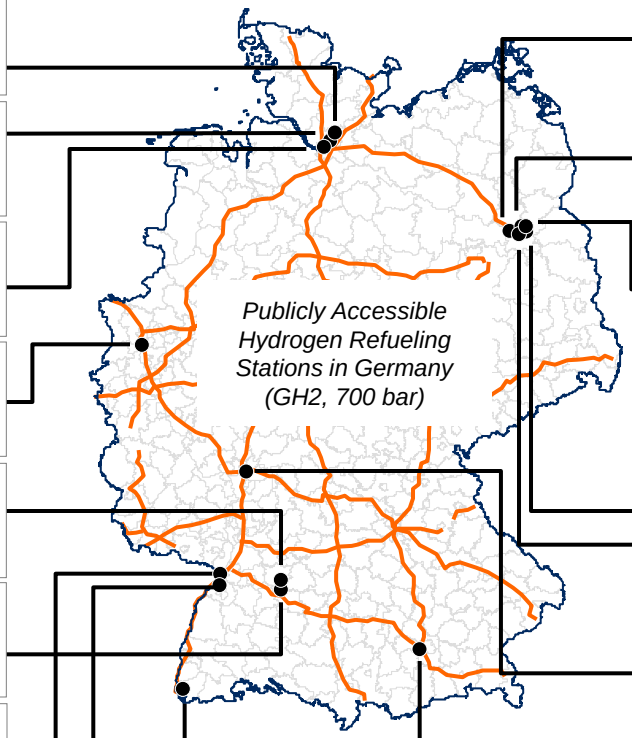
Düsseldorf, Air Liquide

Stuttgart, EnBW

Stuttgart, Airport OMV

Karlsruhe, EnBW

Karlsruhe, KIT *(only 350 bar; upgrade planned)*



Freiburg, FhG ISE

Berlin, Heidestraße Linde/Total

Berlin, Heerstraße Total *(location change ongoing)*

Berlin, BER Total *(under construction)*

Berlin, Holzmarktstraße Linde/Total (rebuild ongoing)

Berlin, Sachsendamm Shell

Frankfurt (Höchst), Infraserv/AGIP

Munich, Detmoldstraße Total *(only LH2, rebuild ongoing)*

Key achievements

- Safety of stations proven
- Refueling standards agreed
- Storage and compressor technology tested
- H_2 supply chain tested
- Bugs of station technology eliminated

Clean Energy Partnership
FCV – Fleet: Today

Fleet of Fuel Cell Vehicles and busses

90 Daimler B-series F-CELL
20 Opel Hydrogen4
8 Volkswagen Touran, Caddy, Tiguan HyMotion, Audi Q5-HFC
5 Toyota FCHV
2 Honda FCX Clarity
more car manufacturers are planning to join the CEP
10 EvoBus fuel cell busses in Hamburg, Stuttgart, Karlsruhe
4 Busses with Hydrogen-ICE in Berlin



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Germany to expand nationwide network of hydrogen filling stations from 15 to 50 by 2015

Clean Energy Partnership CEP

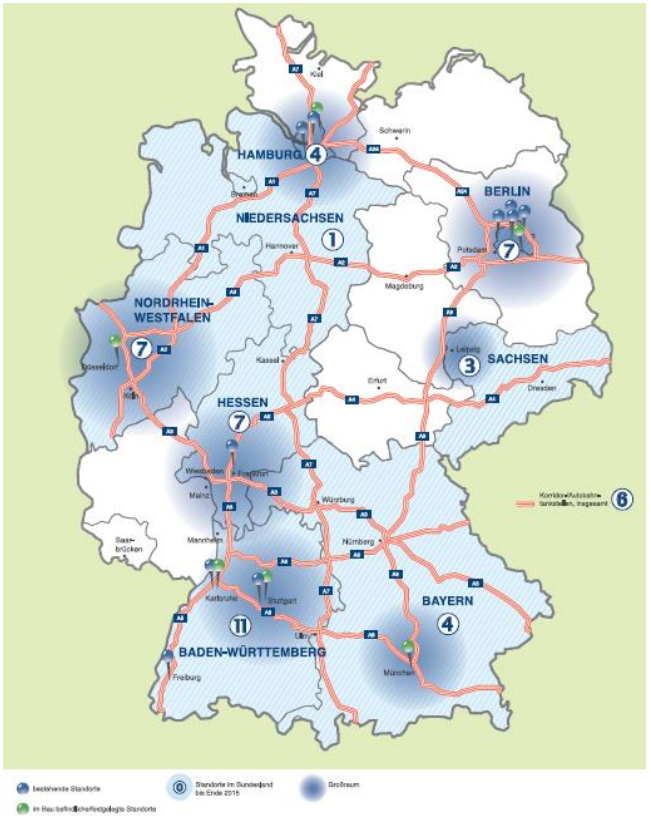
Ein Projekt im Nationalen Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie (nip)

- **joint Letter of Intent to expand the network of hydrogen filling stations in Germany**
  - signed by the German Ministry of Transport, Building and Urban Development (BMVBS) and several industrial companies
  - part of the National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP)
  - overall investment more than €40 million (US$51 million)
- **market-relevant testing of filling-station technology**
- **ensure a needs-driven supply for fuel cell vehicles**
- **coordination by NOW GmbH in the frame of the Clean Energy Partnership (CEP)**

June 20, 2012

„To facilitate market introduction [of fuel cell vehicles] we need a hydrogen station network covering and connecting the metropolitan regions.“

Dr. Peter Ramsauer
Federal Minister for Transport,
Building and Urban Development, 2012

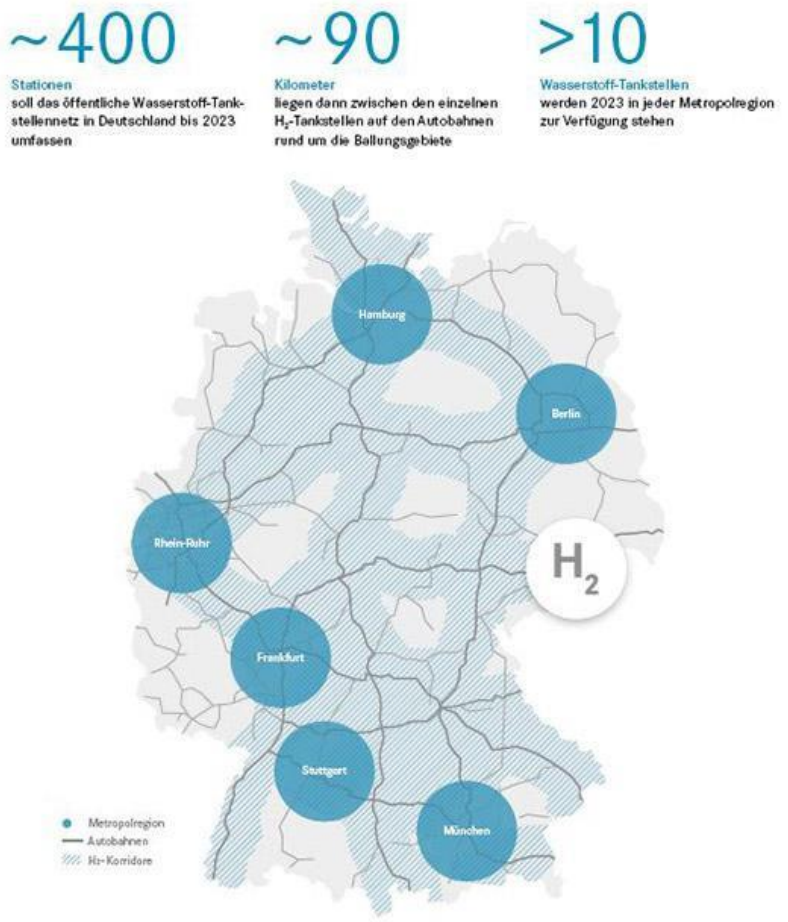


Next: H2-Mobility Action Plan until 2023

Air Liquide, Daimler, Linde, OMV, Shell and Total agree on an action plan for the construction of a hydrogen refueling network in Germany.

Targets:

- **400 HRS** until **2023** (100 HRS until 2017)
- **350 mio. €** investment.
- Max**. 90 km** distance between two HRS at the motorway
- **10 HRS** in each metropolitan area.



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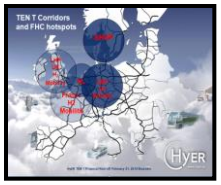
International Hydrogen Infrastructure Activities

UK H_2 Mobility
- Phase 1 accomplished

H2-Mobility France
- In preparation

Hydrogen Infrastructure for Transport (HIT)
(TEN-T) 3 HRS



Scandinavian Hydrogen Highway Partnership
- 45 HRS / 2015
- 500 cars / 2015

H_2 Mobility

CEP

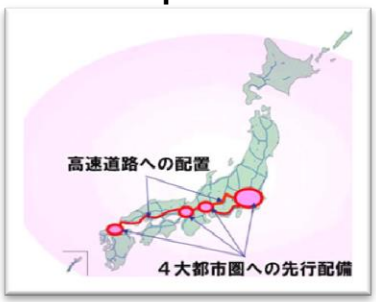
- 100 HRS (50 within the CEP) / 2017
- 5000 cars / 2015

H2 SWISS MOBILITY
- 10-15 HRS

USA (California)

- 68 HRS till 2015
- 5000 FCEVS till 2015

Japan



- 1000 HRS till 2025
- 1 Mio. FCEV‘s till 2025

South Korea

- 500 HRS till 2020
- 50.000 FCEV‘s till 2020

China

- 5 HRS till 2015
- 1.000 FCEV‘s till 2015

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Fuel Cells and Hydrogen – Experiences in Germany

Hydrogen and the German “Energiewende”

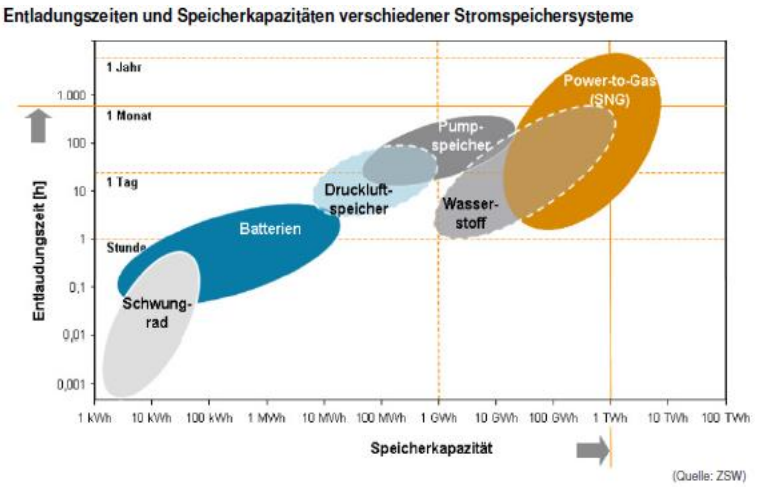
Hydrogen as storage medium for volatile energies

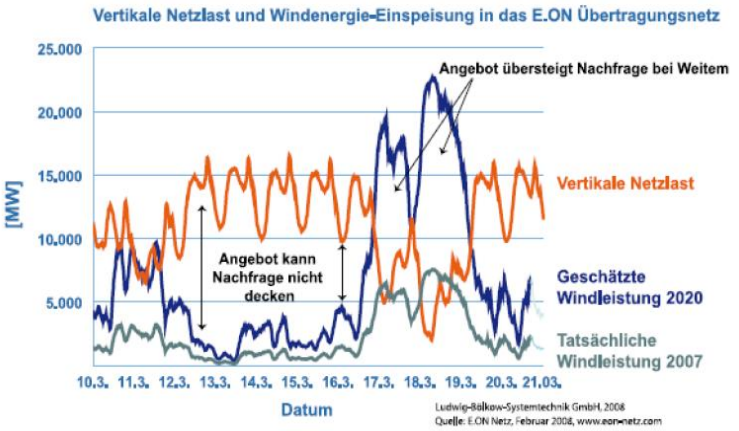
- **With the increasing share of renewable energies (80% by 2050) the need for energy storage increases as well.**

- **Excess energy from renewable energys:**
  - **2012 500 GWh**
  - **2030 14 TWh**
  - **2050 40-50 TWh**

- **Available storage capacity in Germany:**
  - Water pump storage: ca. 0,07 TWhel
  - E-Mobility: 45 Mio. cars ca. 0,45 TWhel

➔ **Hydrogen has to play a major role to store the excess energy of volatile energy sources.**





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Hydrogen Production and Usage

NOW Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

transportation fuel cell vehicles

fuel cell co-generation plants (residential/industrial)

hydrogen for industrial processes

large scale storage for renewable energies

feed-in into NG pipeline

INITIATIVE BRENNSTOFFZELLE

hydrogen fuelling stations

performing energy BÜNDNIS FÜR WINDWASSERSTOFF

power production

H2

electrolyser

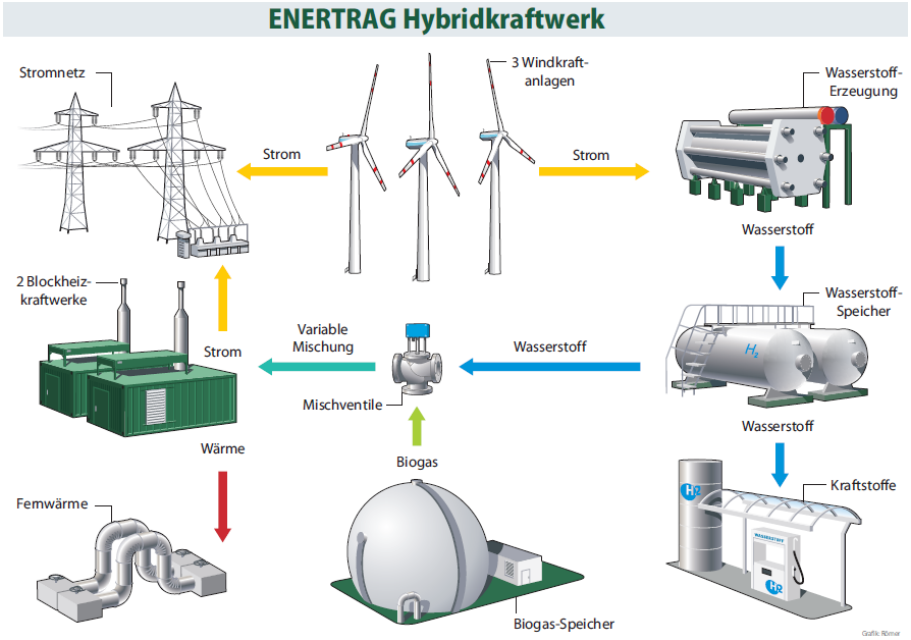
by-product (chemical industry)

hydrogen from NG- and biogas-reforming

wind- and PV-power

Hydrogen facilitates Integration of Renewable Energies into Transport and Stationary Sectors

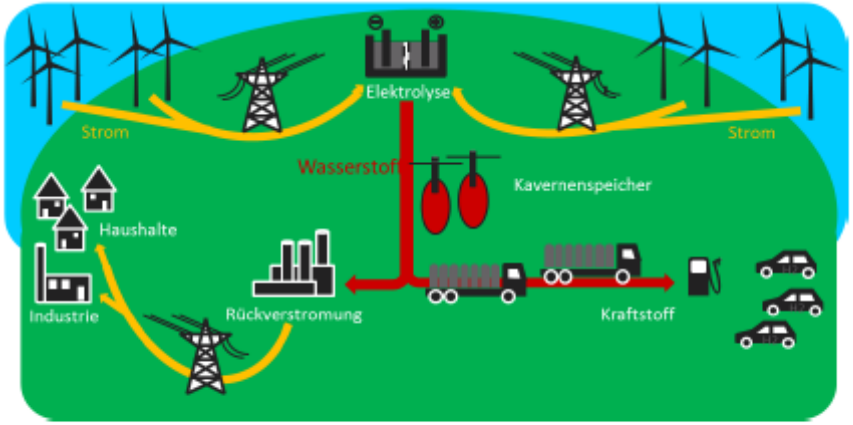
hydrogen as part of an integrated energy system ⇒ **renewable hydrogen as fuel**



Enertrag: Hybrid Power Plant

Total: Refueling Station at Heidestr., Berlin
First delievery of wind-hydrogen on April 18th, 2012

'Integration of Wind-Hydrogen-Systems in the Energy System' – Study Findings Presented 28th January 2013



Questions:

- Volume 'excess' wind power in Germany up to 2030?
- Technology and costs of wind-hydrogen-systems?
- Best options for H_2 transport and stationary use?

Answers:

- Large volumes of 'excess' wind power in Germany's coastal regions expected
- Wind-hydrogen-systems are technologically feasible; limited further R&D required
- Wind-H_2 can be sold as transport fuel with profit in several scenario cases
- Re-electrification of H_2 and sale to stationary sector only in few cases profitable
- Synergies between transport and stationary exist and improve overall profitability

Perspective: NIP 2016+

Transport sector:

- more than 500 public hydrogen fuelling stations nationally,
- over half a million fuel cell cars on the road and
- 2,000 fuel cell buses in line service operation within the public transport system

Hydrogen generation from renewable energies:

- 1,500 MW capacity electrolysers for the generation of hydrogen from renewable energies
- definition and implementation of successful business models for power to gas
- development of hydrogen storage mechanisms to store renewable electricity

Fuel cells for stationary energy supply:

- more than a half a million fuel cell heating appliances in operation
- more than 1,000 MW fuel cell CHP installations in operation
- more than 25,000 secure power supply installations in place

www.now-gmbh.de

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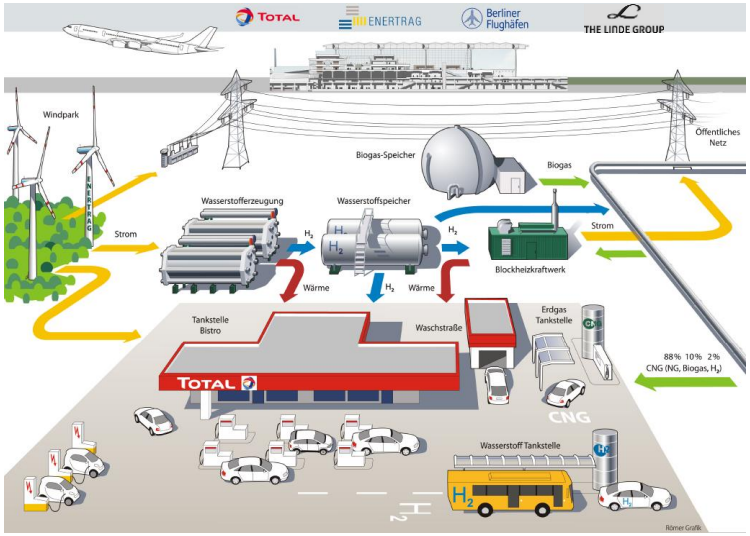
Towards Sustainable Energy Systems with Fuel Cells and Hydrogen

Key Messages

- Moving away from oil – „no-regrets-option“ for Europe!
- **Aim:** Transformation of the energy sector - including transportation! Closer alignment of the general ***energy and the transport systems*** needed.
- **Hydrogen as part of an integrated energy system**
- Implementation of a comprehensive, future oriented, sustainable fuel strategy (national & Europe) as “learning strategy” / step-by-step approach.
- “Energiewende”: push for “new” efficiency **technologies, competitiveness, growth and jobs.**
- **Electric vehicles (battery & fuel cell) will play crucial role**



International Airport Berlin BER
Multi-Energy Filling Station

- FC-Technology is ready! Hydrogen Infrastructure built-up is still a challenge
- **Next steps:** market activation of new transport technologies and their infrastructures
- “Clean Power For Transport” directive – **Europe**`s way forward to alternative fuels!
- **International Collaboration**:
  a global vision and approach is needed

International Partnership for Hydrogen and Fuel Cells in the Economy

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Thank you very much!

www.bmvi.de

www.now-gmbh.de

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Back up

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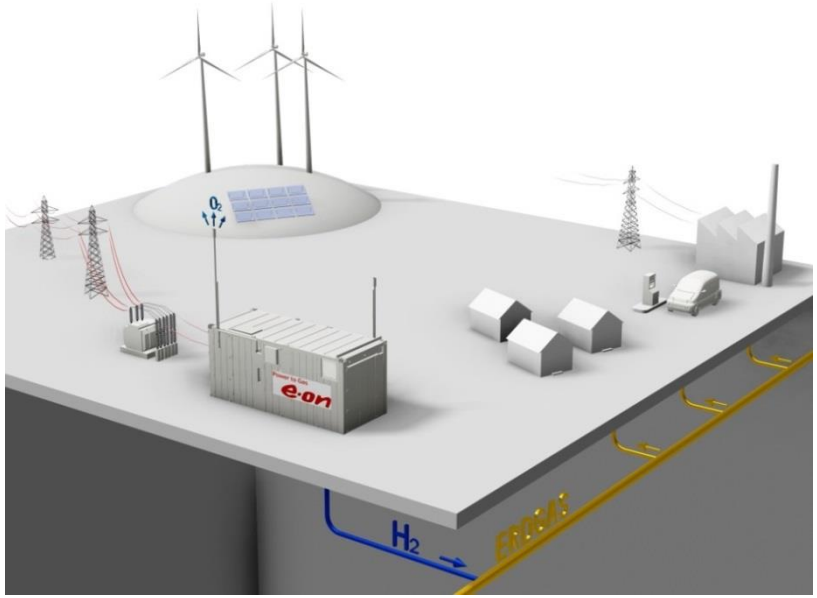
nip

Project „Power-to-Gas for Hamburg“



- 1MW PEM-electrolyzer
- injection of H_2 into natural gas grid

ground-breaking ceremony June 2013

e·on HYDROGENICS SHIFT POWER | ENERGIZE YOUR WORLD SolviCore Fuel Cell Technologies DLR Deutsches Zentrum für Luft- und Raumfahrt Fraunhofer ISE

Fuel Cell CHP Technology offers Multi-Purpose Solutions

Conversion of fossil power generation system

Grid expansion

Combined Heat & Power-Technology with highest electric efficiency

Predestined for flexible use and leveling out fluctuating renewable energies

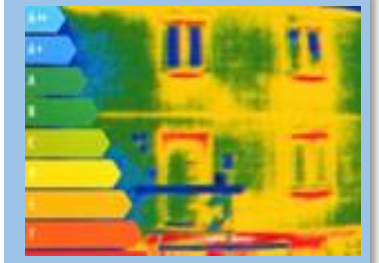
Opportunities for integration into virtual power networks

Operation with biogas or SNG

Ease pressure on and help stabilizing electricity grid through de-central operation

Much higher efficiency compared to non-coupled heat and power production

Expansion of REN



Increases in energy efficiency

Fuel cell CHP appliances offer ideal building blocks for future energy systems due to their efficiency, flexibility and de-central deployability

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NIP Lighthouse Projects
Callux & Clean Power Net

callux (nip)
Praxistest Brennstoffzelle fürs Eigenheim
Ein Projekt im Nationalen Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie

Germany's biggest field test for fuel cell combined heat and power systems for domestic use:

- Some 400 fuel cell CHP in the field

www.callux.net

clean power net
Brennstoffzellen in Industrie und Business

Projects for uninterrupted power supply financed by NIP:

- 10 projects
- some100 fuel cells in field test operation across Germany

www.cleanpowernet.de