Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

Towards sustainable energy systems – Current developments in Germany

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Clean Power for Transport Directive General

Targets of the directive:

- Solve the “Chicken-and-Egg-Problem” = Energy/Fuel– Powertrain – Infrastructure, Safety for investment into alternative power trains due to availability of infrastructure.
- Establishment of an EU market for alternative fuels and power trains.
- Enforcements of the the EU‘s innovation and competitiveness

CPT-directive covers specific infrastructure requirements for the following fuel options:

- Power for BEV’s as well as charging opportunities for ships in habors.
- Hydrogen
- Methane (CNG and LNG: for street traffic and maritime applications)

Key elements of the CPT-directive:

- Member states(MS) have to develop national implementation plans (NIP); no specific guidelines for infrastructure by the directive: MS have to decide within their NIP about a „appropriate number“ for „Charging/H2/LNG&CNG“-infrastructures
- Establishment of binding technical standards and specifications for the interconnection between „Fuel / Vehicle / Infrastructure“. Motivation/Target: Interoperability und anti-discriminatory availability of infrastructure.

Clean Power for Transport Directive
Impact for the Hydrogen Technology

- Integration of the directive into national laws: 24 month after empowerment (expected: mid of 2014)

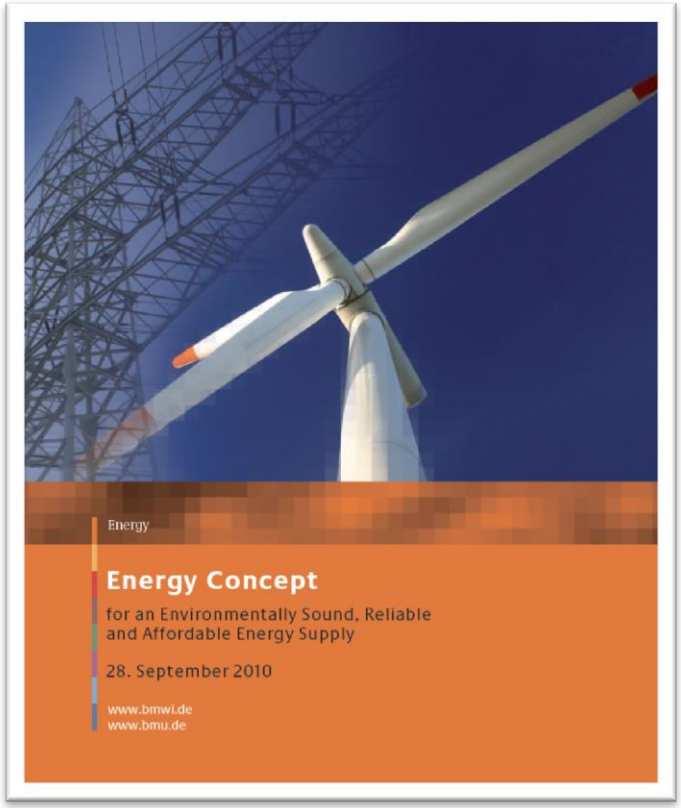
- H2-Infrastructure: 31.12.2025 (just for MS which will use the H2 option)

- Relevant Standards:
  - The **hydrogen purity** dispensed by hydrogen refuelling points shall comply with the technical specifications included in the **ISO 14687-2** standard.
  - Hydrogen refuelling points shall employ **fuelling algorithms** and equipment complying with the **ISO/TS 20100** Gaseous Hydrogen Fuelling specification.
  - **Connectors for motor vehicles** for the refuelling of gaseous hydrogen shall comply with the **ISO 17268** gaseous hydrogen motor vehicle refuelling connection devices standard.

- Transition period for all fuel options: 36 month after empowerment of the directive all new or renewed fuel infrastructure has to follwed the mentioned standards.

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.



Political Framework for the Transport Sector

- Share of transport in final energy consumption nearly 30%
- Tripling of energy consumption in transport since 1960, even five-fold increase in road traffic

- 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)

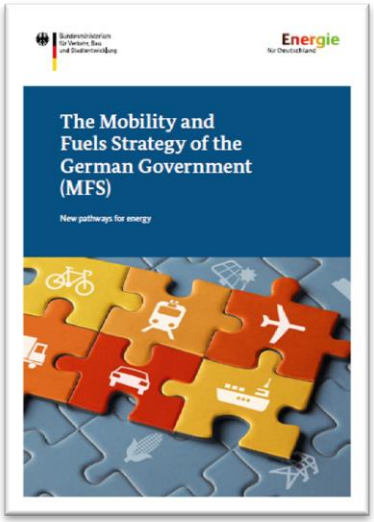
➔The Mobility and Fuels Strategy of the German Government[2] outlines the way how to achieve these objectives.

➔**Electrification of the drive train (BEV's and FCEV's) is an key issue to reach the targets!**

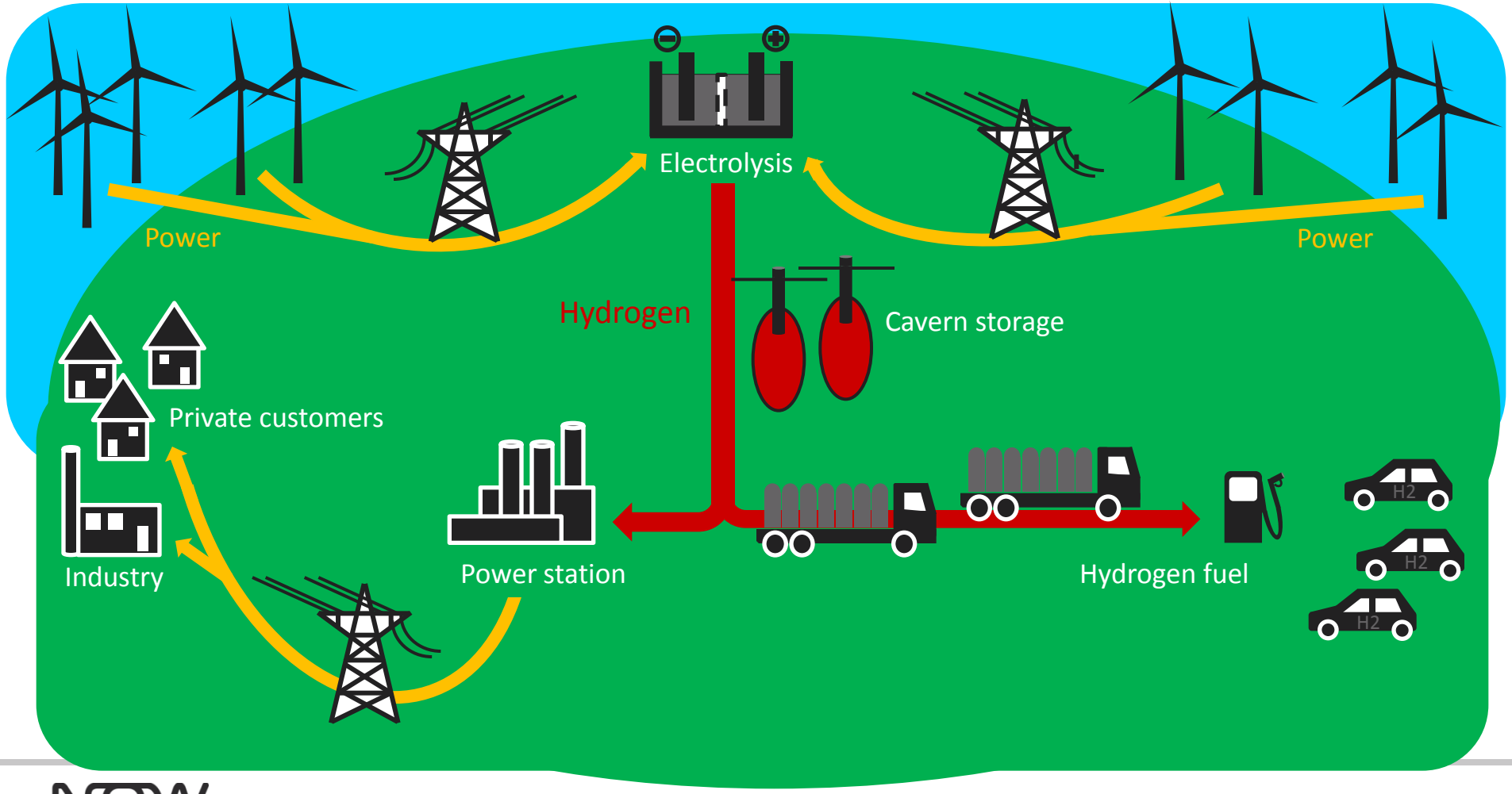
➔**Targets only achievable with renewable power to gasous fuels.**

➔**Further increase of RE mandatory to achieve the targets.**

➔**Large scale storage for Hydrogen is inevitable.**



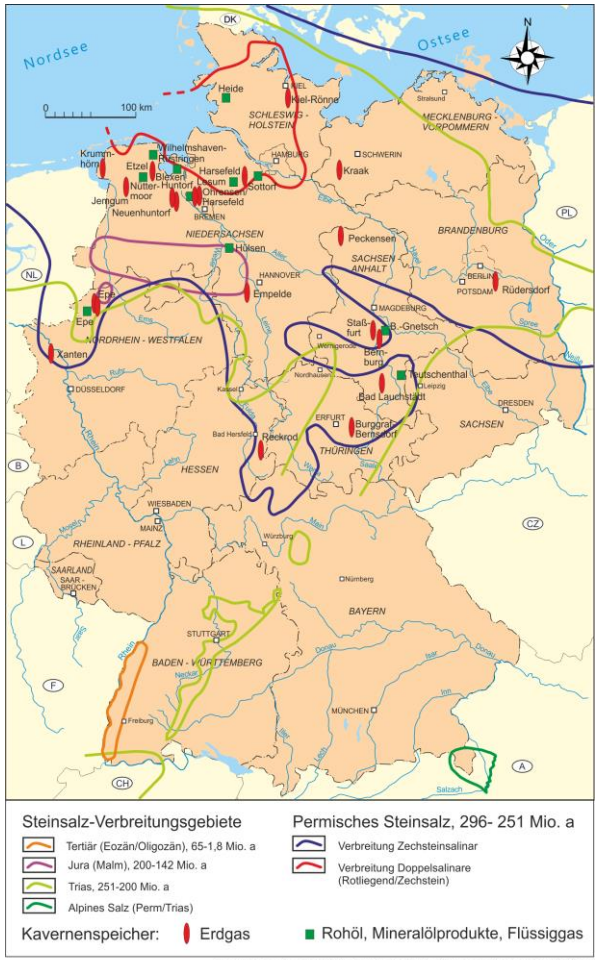
Utilise Surplus Wind Energy via Hydrogen in the Northern Part of Germany



Availability of salt caverns in Germany

- Geological opportunities for salt caverns only in the northern part of Germany.
- Highest share of wind energy in the northern part of Germany
- Lack of grid connection between north and south.

➔ Storing the excess wind energy in the northern part is crucial.



Results of the Scenario 2 in the North/East-Part

Fall	"weniger Kraftstoff"	"Standard Nordost"	Investition GuD 600 €/kW statt 800 €/kW	GT statt GuD, Investition 504 €/kW	Investition Elektrolyse 700 €/kW statt 900 €/kW	Investition Elektrolyse 500 €/kW statt 900 €/kW	preis-gesteuert
Stunden Elektrolyse	3.052	3.052	3.052	3.052	3.052	3.052	5.600
Menge / Jahr	32.044	32.044	32.044	32.044	32.044	32.044	59.100
Anteil Rückverstr.	38%	7%	7%	7%	7%	7%	39%
	notwendiger spezifischer Erlös €/kg H_2-Kraftstoff						
Spotmarkt (0 €/MWh)	3,71	2,92	2,74	2,56	2,50	2,08	1,55
40 €/MWh	6,80	5,00	4,82	4,49	4,58	4,16	
80 €/MWh	9,90	7,08	6,90	6,43	6,66	6,24	

Analysis PtG in Germany

Outcomes:

- Geological and technically large scale salt cavern storage is possible in Germany.
- There are business case for a profitable operation of the hydrogen storage plant if not only excess energy is used for the electrolyzer.
- Selling hydrogen as a fuel for transport is in the most cases the most profitable way to go.

Challenges:

→Reducing cost of the electrolyzer

→Creating a positive regulatory environment (e.g. exemption of grid fee for electolyzer power, RE-contribution, energy tax, H2 injection into the NG grid)

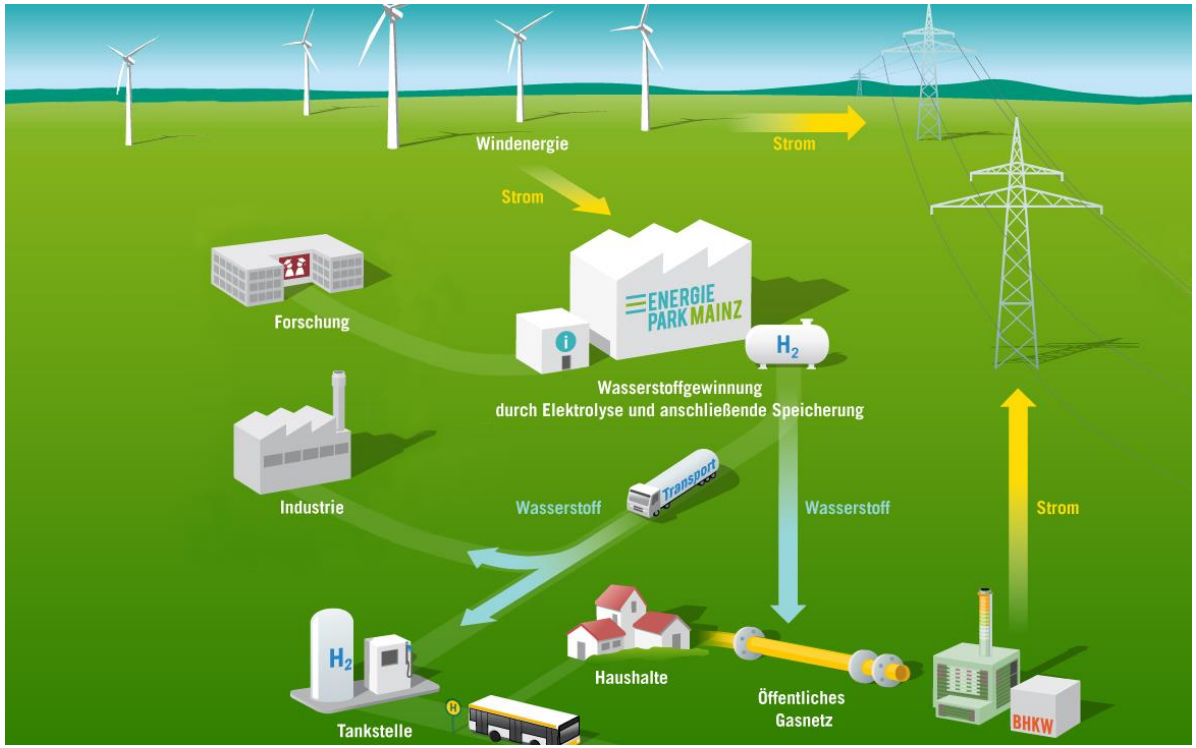
→First small demonstration projects have to be started soon.

→Defining a clear PtG-roadmap for Germany

→Increase the share of RE in order to achieve the climate targets for transport.

Wind-Hydrogen in the Energy Park Mainz

- Public service Mainz, Siemens, Linde, University Rhine-Main
- 2 MW PEM-Electrolyzer
- Ionic compressor
- Multiple pathways to use hydrogen
- Start of operation in 2015



42,90 Mio.€ for Wind-Hydrogen Projects

50 HRS for Germany

- **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)
- **coordination by NOW GmbH in the frame of the Clean Energy Partnership (CEP)**

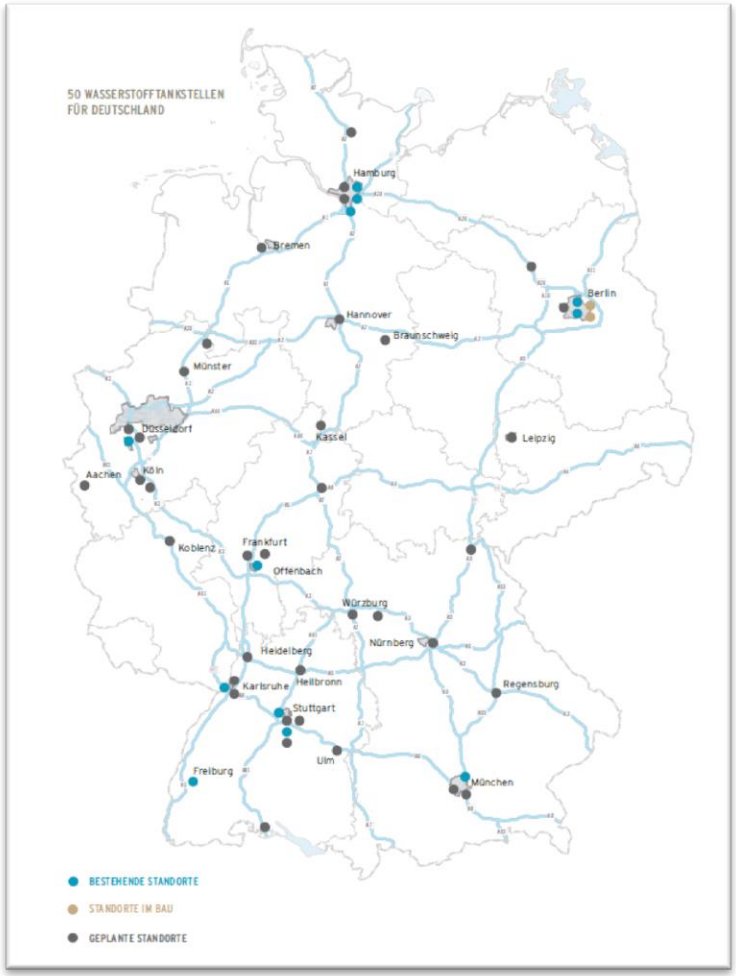
Federal Ministry of Transport, Building and Urban Development

Clean Energy Partnership CEP

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

Current Status:

- Location planning of the 50 HRS has been finalized.
- Currently there are application for funding for 23 HRS, the remaining 12 HRS are in the planning phase.
- The majority of the HRS will be operated by H2-Mobility after the funded project time frame has ended.
- About ~110 FCEV's are currently on the road.



Federal States in Germany – Policy and Market Preparation

Motivation: Climate protection and economic development
Implementation: Own state strategies und funding

- **Baden-Württemberg:**
  - Program for H2 infrastructure set-up (€4 m)
  - Market program micro CHP with FC (€1 m)
  - Organisation: e-mobil BW

e-mobil BW
Landesagentur für Elektromobilität und Brennstoffzellentechnologie Baden-Württemberg GmbH

- **Hamburg:**
  - FC buses at „HOCHBAHN“, monitoring FC cars
  - Extention of HRS “HafenCity” to marine applications
  - Funding of €13 m until 2016
  - Organisation: hySOLUTIONS

hy SOLUTIONS
Innovative Antriebe für Hamburg

- **Hessen:**
  - Energy program with funding for H2 and FC
  - Power to gas, FC special applications, H2 infrastructure
  - Market program micro CHP with FC
  - Organisation: H2BZ-Initiative Hessen

Federal States in Germany – Policy and Market Preparation

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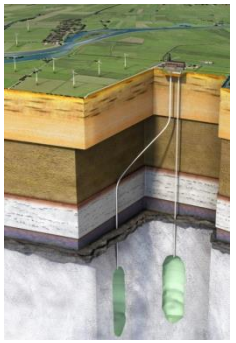
- **Lower Saxony:**
  - Study on wind-hydrogen in the Northern region (with Hamburg and Schleswig-Holstein)
  - Electrolysis and H2 storage in salt caverns
  - Organisation: State Initiative on Energy Storage and Systems

LANDESINITIATIVE NIEDERSACHSEN ENERGIESPEICHER UND -SYSTEME



- **North Rhine-Westphalia (NRW):**
  - RD&D program (NRW Hydrogen HyWay) on H2 production, infrastructure, FCEVs
  - Market program micro CHP with FC
  - Funding of €30m until 2016
  - Organisation: Fuel Cell and Hydrogen Network NRW

+H2 Fuel Cell and Hydrogen Network NRW

Annual project funding of all federal states:
> €30 m

Power to gas – H2 from renewable power

Example: Wind power electrolysis in H2 Application Center Herten (NRW)

Location: Herten (Ruhr area)

Budget: €3 m / funding €2.7 m

Duration: 2009 - 2025

Idea: Net autonomous power supply of technology centre with wind energy via electrolyser, battery and fuel cell

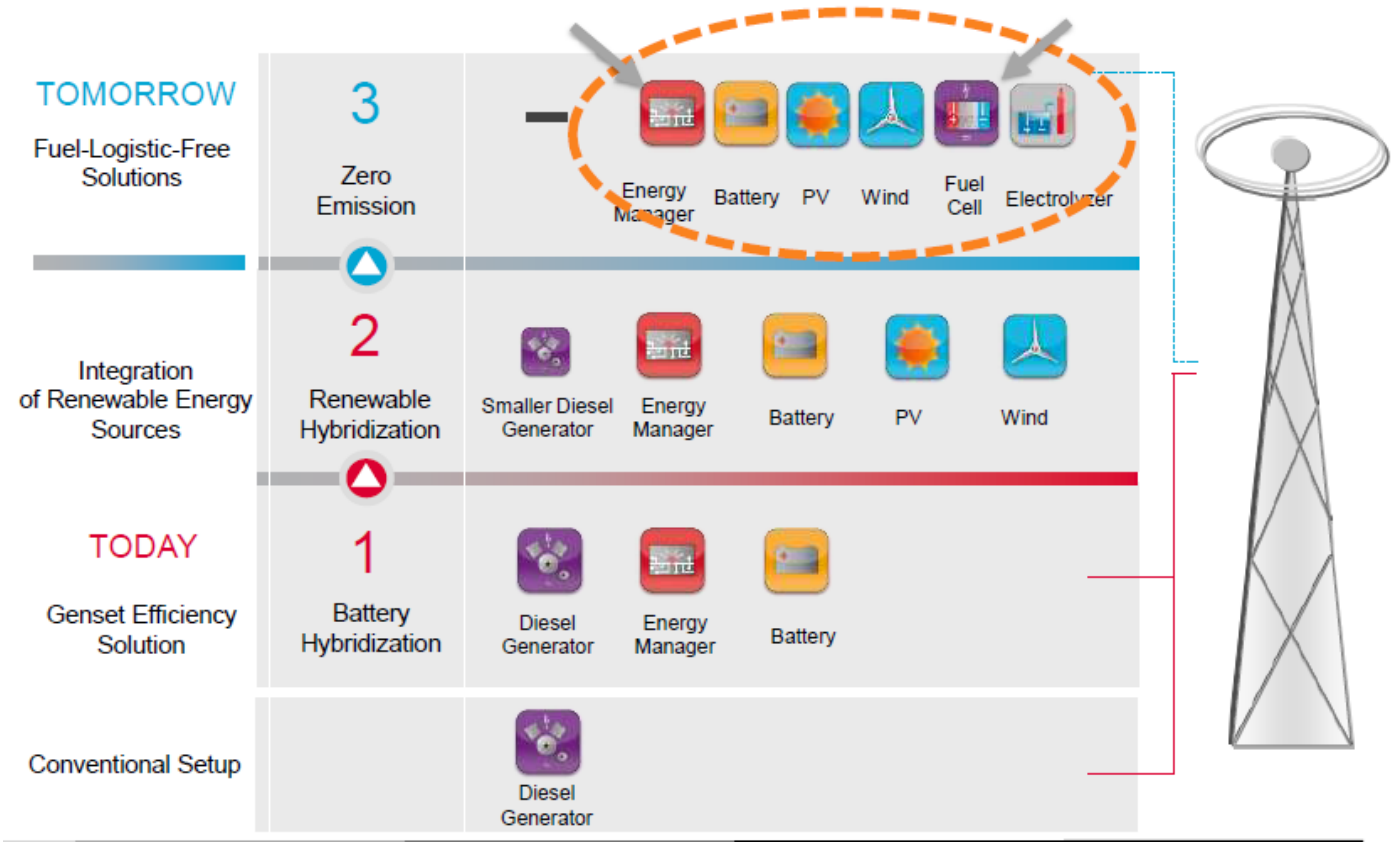
Partners: City of Herten, University of Applied Science Gelsenkirchen, Evonik, Hydrogenics, Linde, Gustav Klein, Saft, Vako

Status: Operation started in 2013

Next: Gainig of experiences, optimisation of system, adding of components

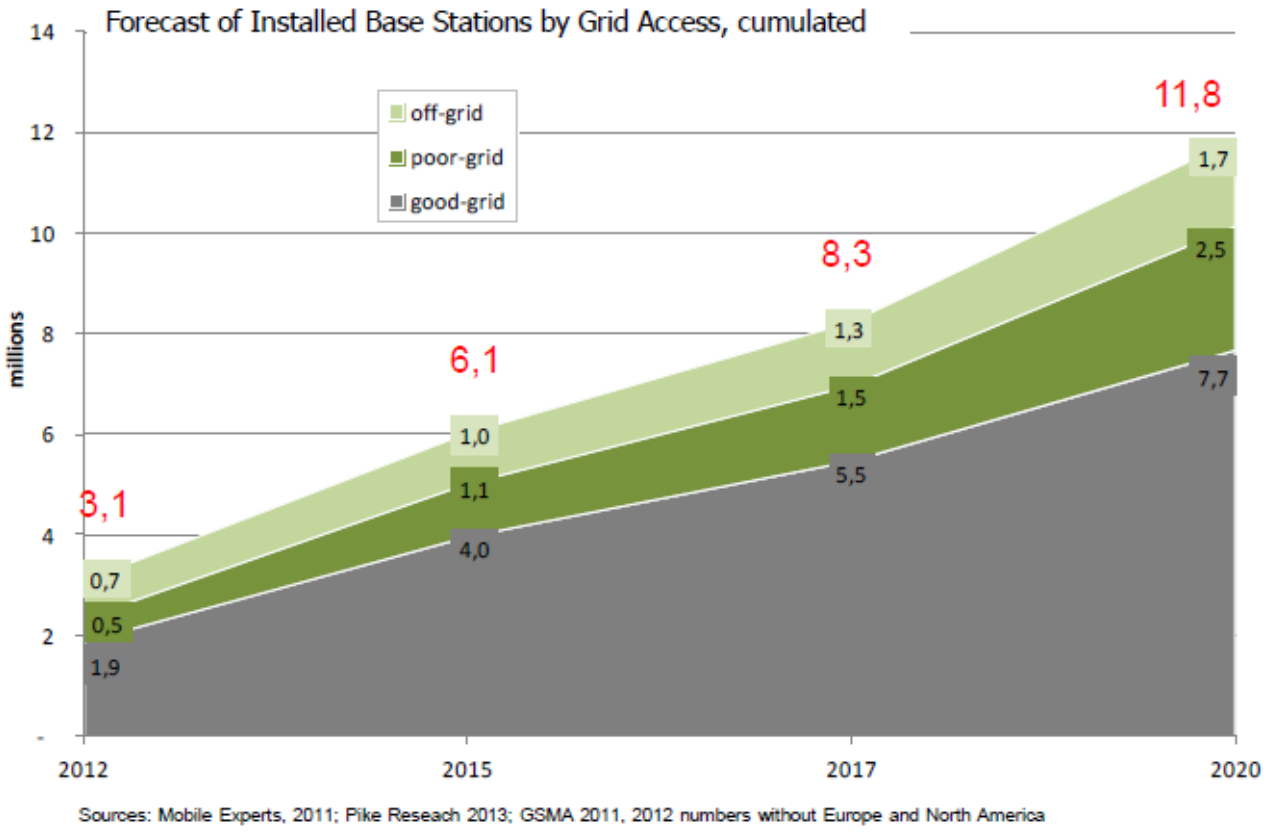
Quellen: h2-netzwerk-ruhr

Fuel Cells in the back-up power market



Market development for back-up power systems

Telecom Case: A multi billion global market asking for energy efficiency and site uptime



Sources: Mobile Experts, 2011; Pike Reseach 2013; GSMA 2011, 2012 numbers without Europe and North America

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Thank you very much!

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