Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

Towards sustainable energy systems – The role of large scale hydrogen storage in Germany

May 14th, 2014 | Sacramento

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NOW GmbH National Organization Hydrogen and Fuel Cell Technology

Political background for the transition to renewable energies

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

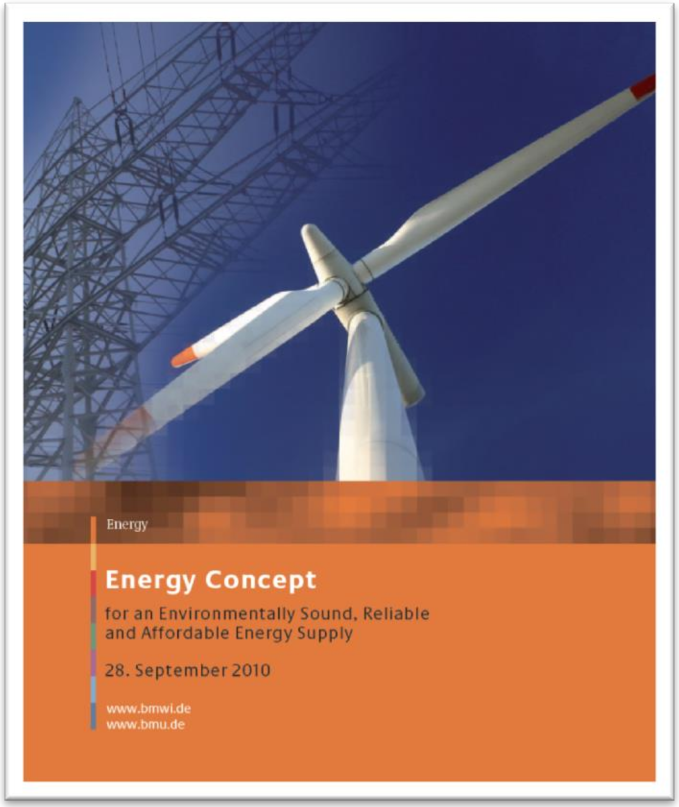
- **Climate protection:**
  Global responsibility for the next generation.

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

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

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 buildin**gs 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)

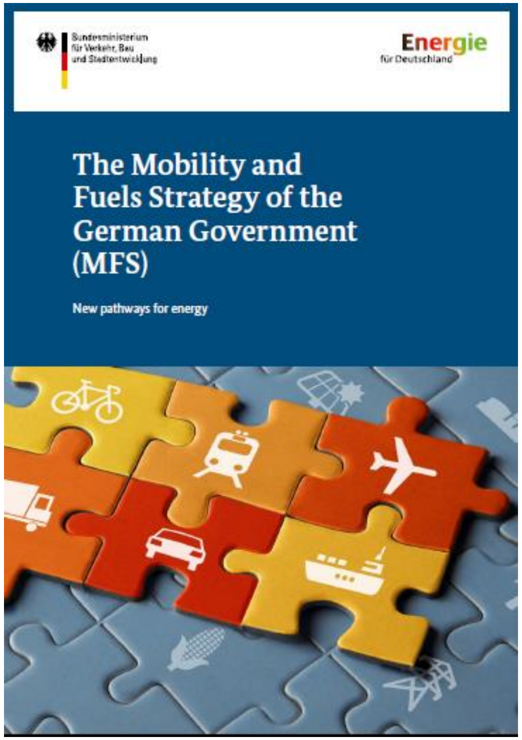
➔The Mobility and Fuels Strategy of the German Government[2] outlines the way how to achieve these objectives.

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

➔**Targets only achievable with PtG-H2 and PtG-Methane.**

➔**Further increase of RE then planned.**

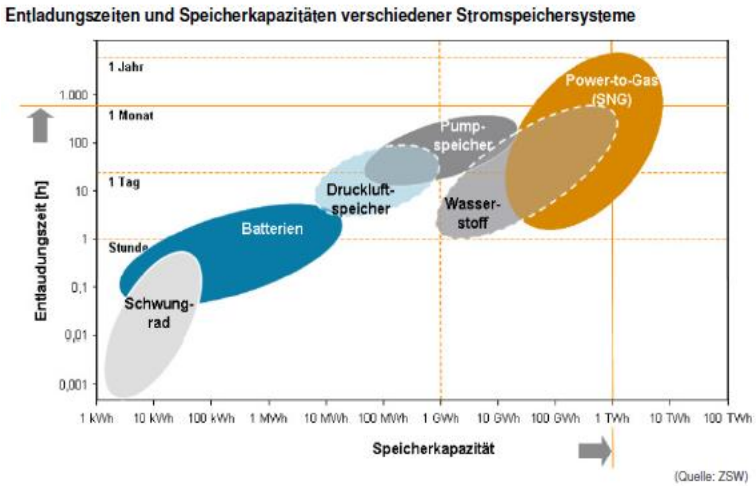
➔**Large scale storage for Hydrogen is inevitable.**



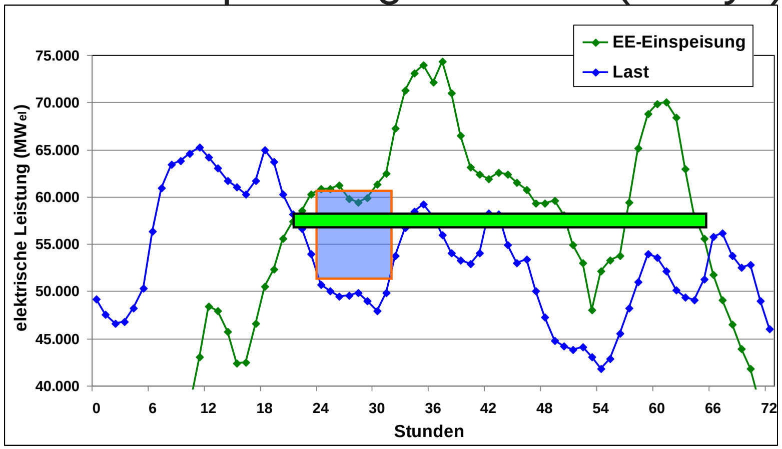
Hydrogen as storage medium for volatile energies

- 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

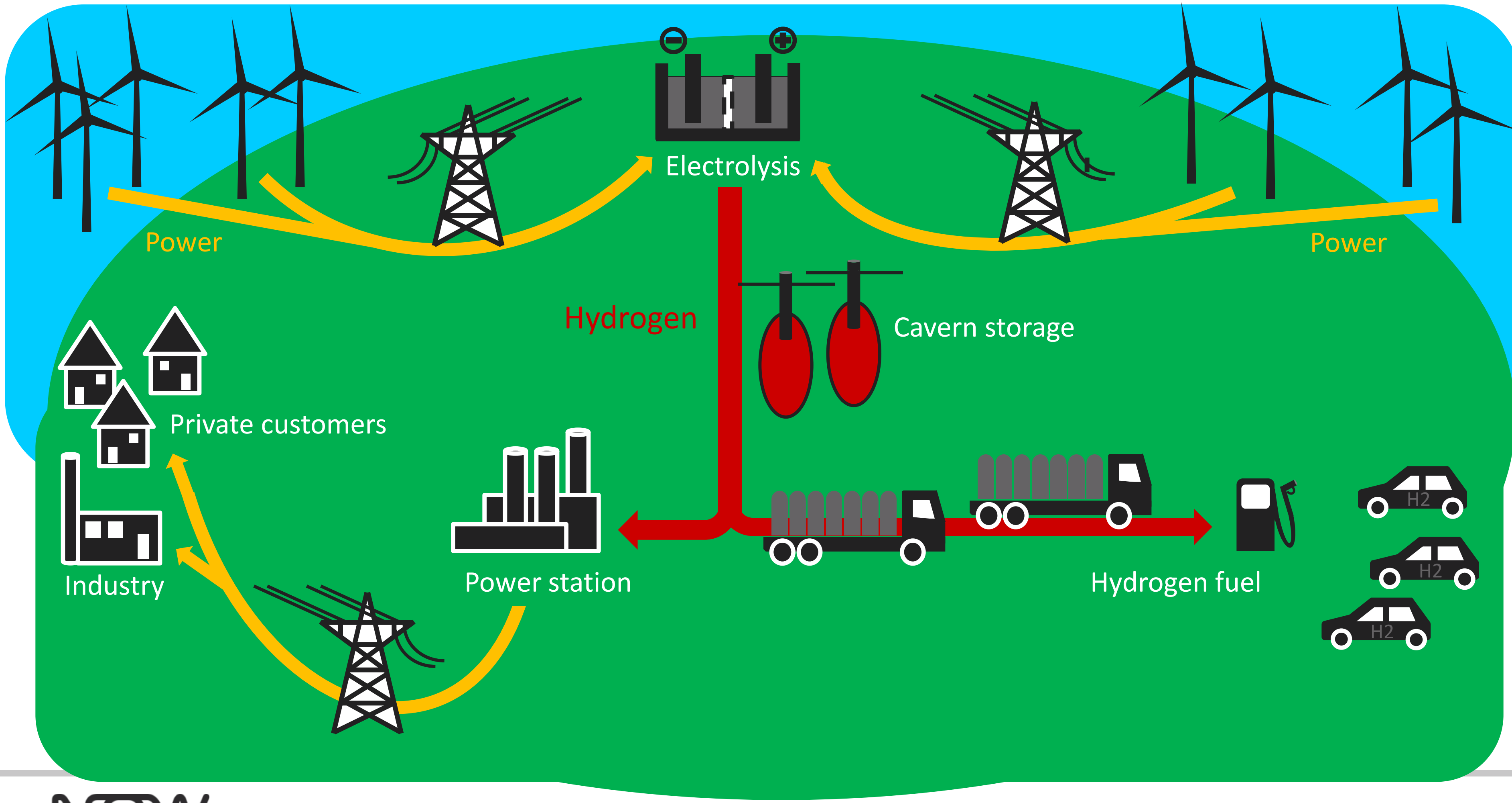
➔ Hydrogen has to play a major role to store the excess energy of volatile energy sources.



Water Pump Storage in 2030 (3 days)



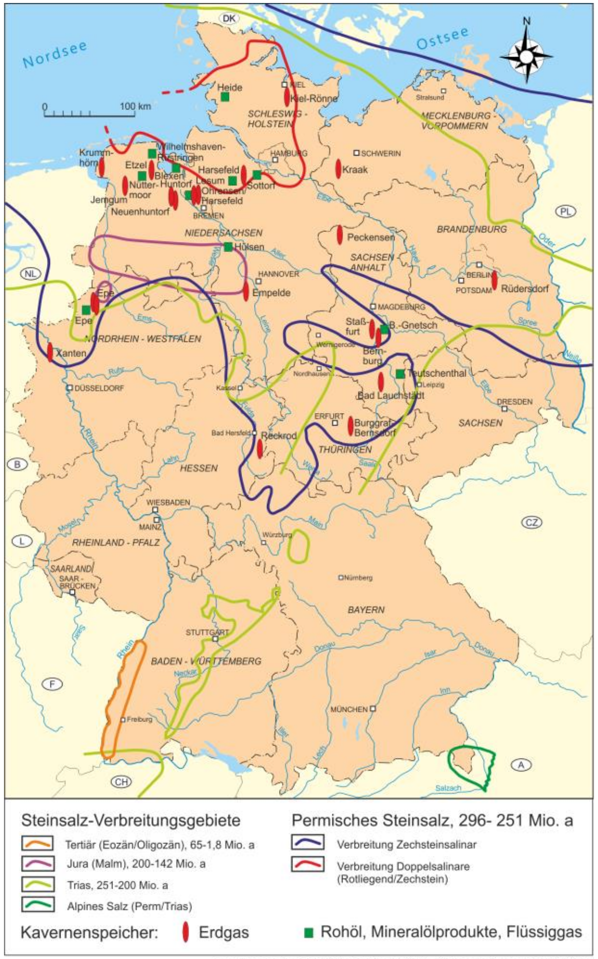
Utilise Surplus Wind Energy via Hydrogen in the Northern Part of Germany



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.

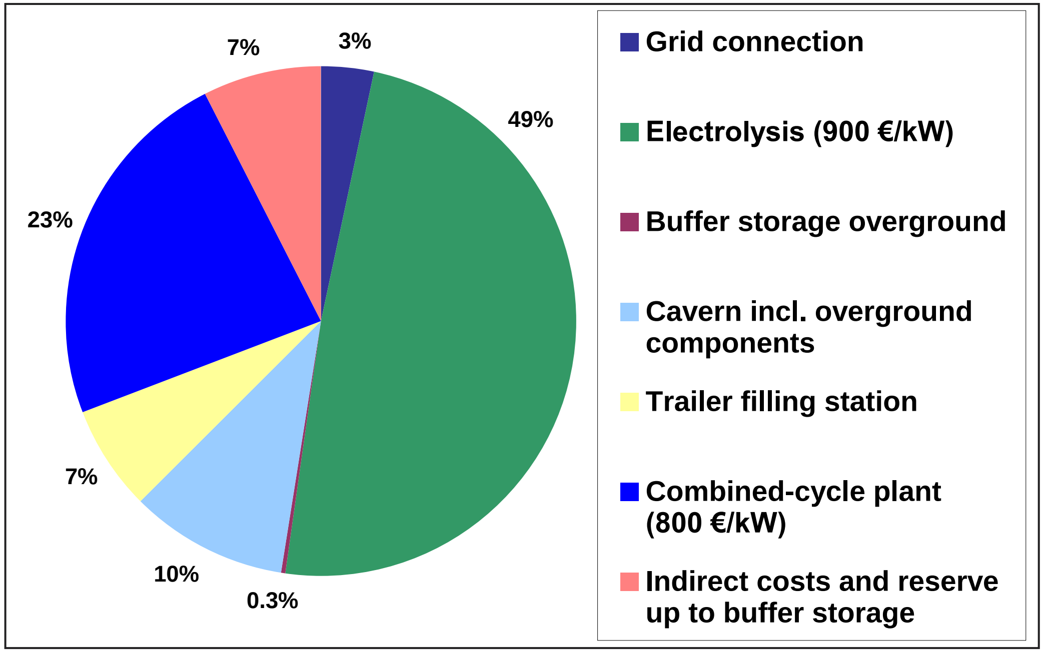


Key Facts of the assumed Salt-Cavern Storage

Storage assumptions:
- Volume: 500.000 m³
- Working gas: 4000 t H_2
- Working pressure: 58 -175 bar
- Max. Output: 13,5 t/h (450 MW)
- Charge: 16 days (empty)
- Discharge: 12 days

Technical assumtions:
- η-Electrolyser: 70%
- η-GuD : 60%
- Electrolyser: 900 €/kW
- GuD: 600 €/kW

Investment: 923 million €



- Deprecation at 8% over 30 years (combined cycle plant 20 years)

  → 110 million €/year for annuity and fixed operating & maintenance costs

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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	

Conclusion

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.

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Thank you very much!

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download: www.now-gmbh.de

Back-up

Wind Hydrogen Project RH_2-WKA

nip

Renewable Hydrogen- Werder/Kessin/Altentreptow

WIND-projekt

WiWa

Demonstration of Wind-H_2- System

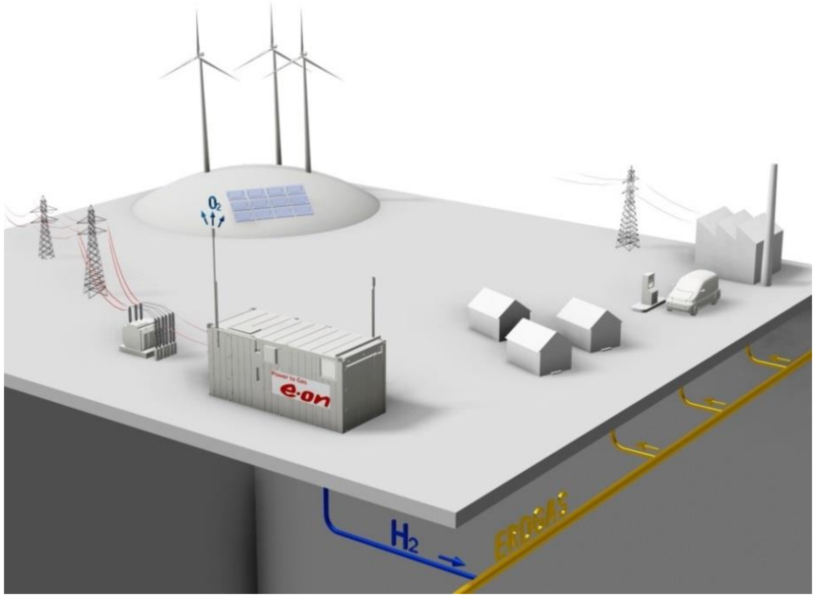
- conception, construction and operation
- electricity supply for wind power plants at times of calm

plant design

ground-breaking ceremony July 2011

start of trial H_2-production December 2012

Project „Power-to-Gas for Hamburg“



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

ground-breaking ceremony June 2013

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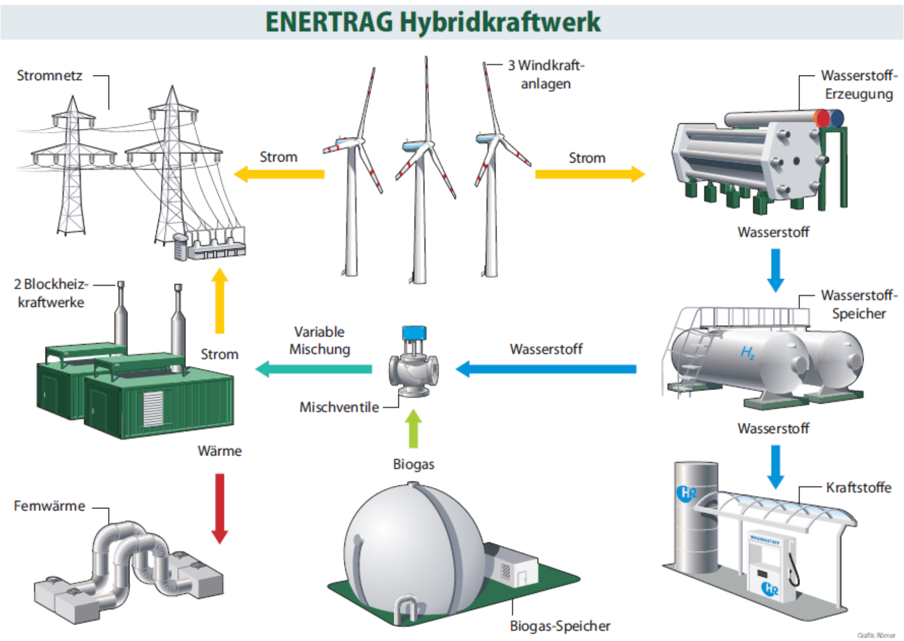
Fuel Cell Technologies
DLR Deutsches Zentrum für Luft- und Raumfahrt
Fraunhofer ISE

Demonstrating Wind-Hydrogen for Mobility

Clean Energy Partnership CEP

Ein Projekt im Nationalen Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie nip

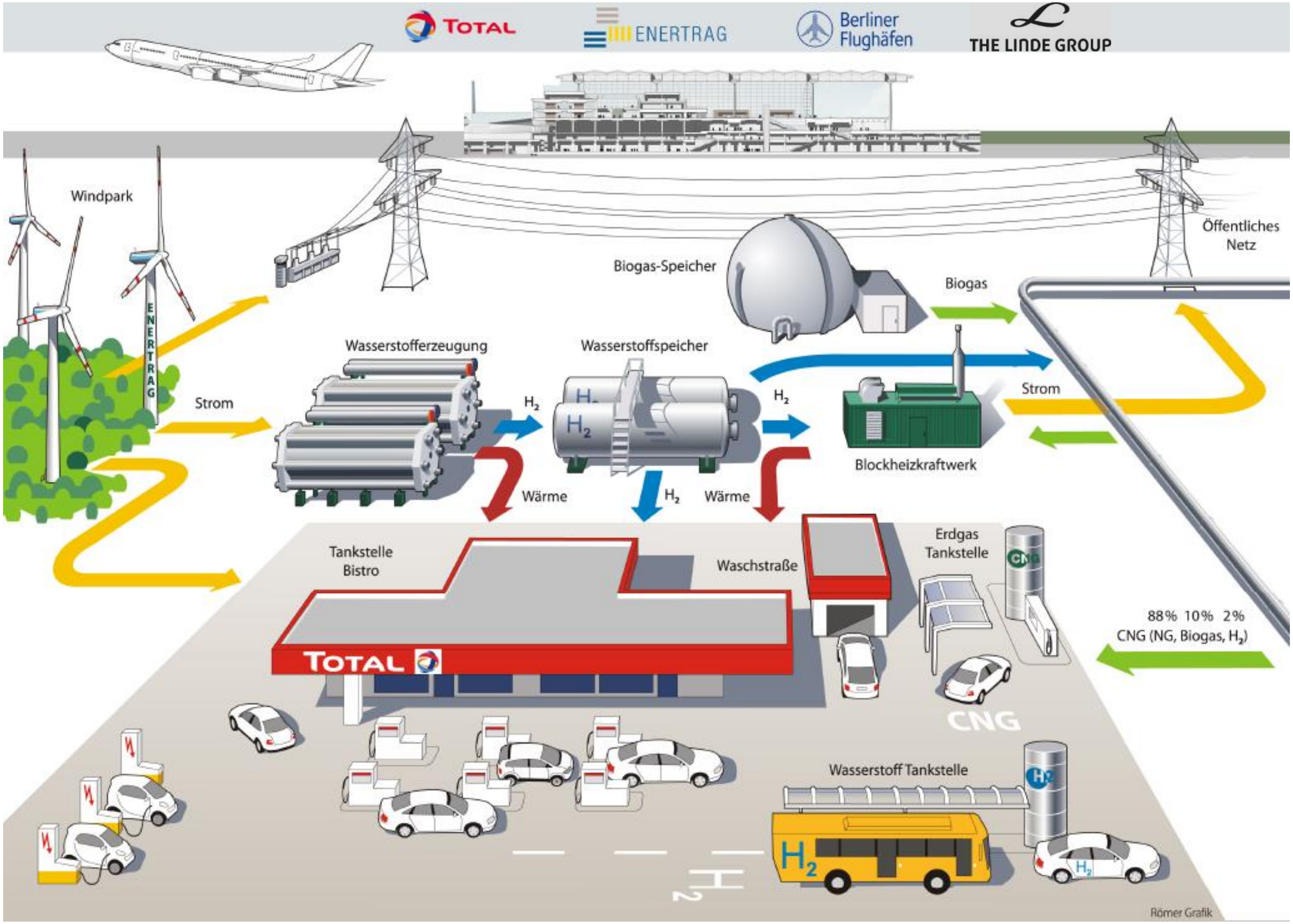
hydrogen as part of an integrated energy system ⇨ **renewable hydrogen as fuel**



Enertrag: Hybrid Power Plant

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

BER – Multienergy filling station



Possible political support

support measure

performing energy
BÜNDNIS FÜR WINDWASSERSTOFF

1. Liberalize power for electrolyzes from feed-in tariff allocation
2. On-top bonus (per kWh) in case of re-submitting power to the grid
3. Feed-in tariff for hydrogen from renewable energies when fed in NG-grid
4. Consider hydrogen in biofuels quota

H_2 Mobility

5. tax exemption for hydrogen as fuel
6. subsidies / loans for hydrogen infrastructure build-up
7. Early mover protection / license model
8. Public procurement initiative for zero emission vehicles / FCV
9. Ensure continuous R&D basis

Challenges of Implementation

Energy law

- Energy tax costs (EEG-Cost allocation; electricity tax; etc.)
- Feed in payment for Biomass will be lost in combination with hydrogen / change of energy law (EEG) required
- Not currently economically / no compensation of losses and additional investments (missing of storage reimbursement regulations) / only in the mobility (f-cell) sector competitive

Building law

- No experience by the licensing authorities
- No regulations for construction of hybrid power plants outside zoning plans

Technical challenges

- Balance of component-sizing
- Adjustable electrolysers over a range of 100%
- Determining the required control speed
- Full automatic energy control system / own development of control system
- Reducing investment costs