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Developing a Hydrogen Infrastructure for Transport in France and Germany

A Comparison

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German-French Office for Renewable Energies (DFBEE - OFAEnR)

"Hydrogen as energy carrier, an industrial approach for 'Energiewende' in France and Germany: A Dream or Reality?"

Tuesday, 24 June 2014

French Embassy Berlin, Wilhelmstraße 69

Outline

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1. Developments in France
2. Developments in Germany
3. Comparison
   - Status
   - Perspectives

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1 H_2 Mobilité France

A national implementation roadmap

- Supported by the French government and gathering:
  - ⇒ National and EU associations
  - ⇒ Labs and universities
  - ⇒ Utilities
  - ⇒ Electrolyser manufacturers
  - ⇒ Hydrogen and service station manufacturers
  - ⇒ OEM, FC and car manufacturers
  - ⇒ Representatives of regions

From energy to end user

Source: H2 Mobilité France

1 H_2 Mobilité France

Mobilité Hydrogène France

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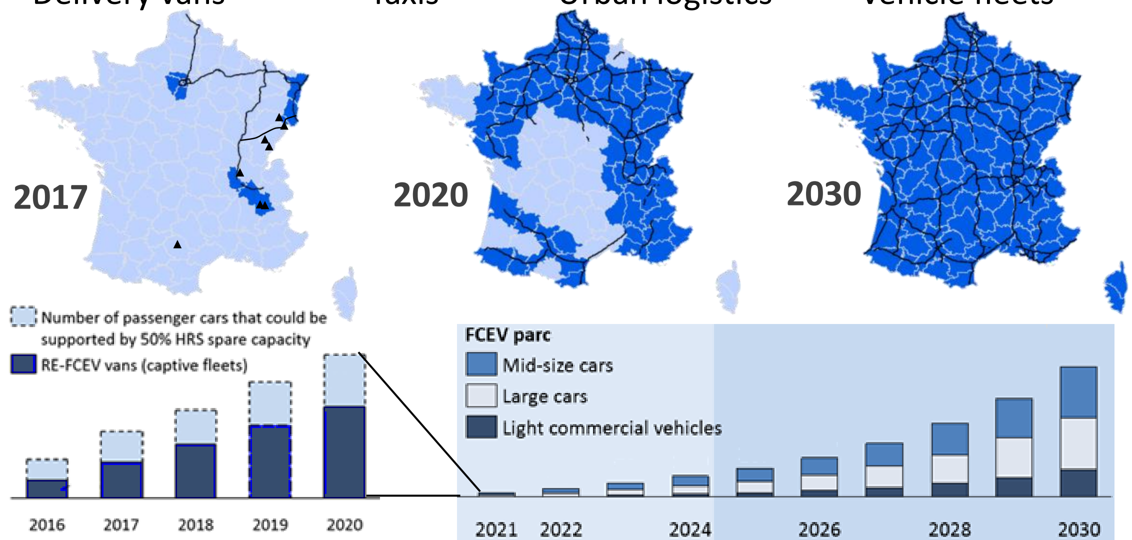
"Cluster" approach focusing on captive fleets

- Driving cycles and charging profiles are well predictable
- Limited number of stations with a high utilisation rate already in the starting phase
- Usually 35 MPa
  35 – 70 MPa in cross-border areas
- Taking into account EU TEN-T corridors
- An roadmap for the early phase. No contradiction with other European « H_2 Mobilities »

Delivery vans | Taxis | Urban logistics | Vehicle fleets



Phase 0: Clusters | Phase 1: connexion entre clusters | Phase 2: déploiement massif

Source: H2 Mobilité France

⇒ *Easier to reach economic viability*

⇒ *Approach is different and complementary to German H_2 Mobility*

1 Range Extenders

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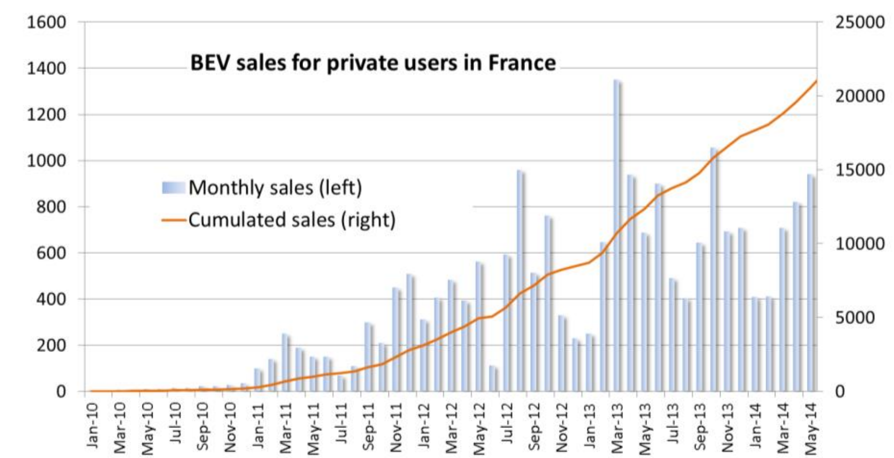
BATTERY ELECTRIC DRIVE WITH AN H_2/FC RANGE EXTENDER

- **Strategy for the early transition phase** enabling:
  - ⇒ Limited investments in infrastructure
  - ⇒ To reduce dependency on FC costs
  - ⇒ A better use of the good efficiency of the battery
- Battery electric vehicles (BEV) sales are limited but growing in France
- Range extenders are simple to be implemented for car manufacturers with experience in BEVs

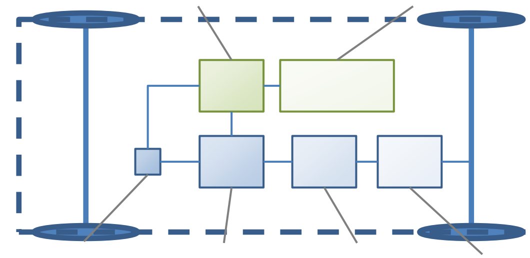


Source: CCFA

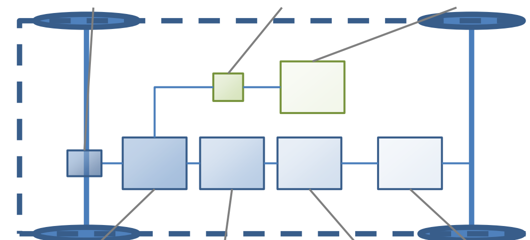
B-Class F-Cell

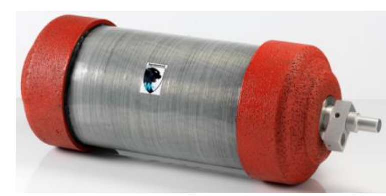
Hy Kangoo

Hybrid



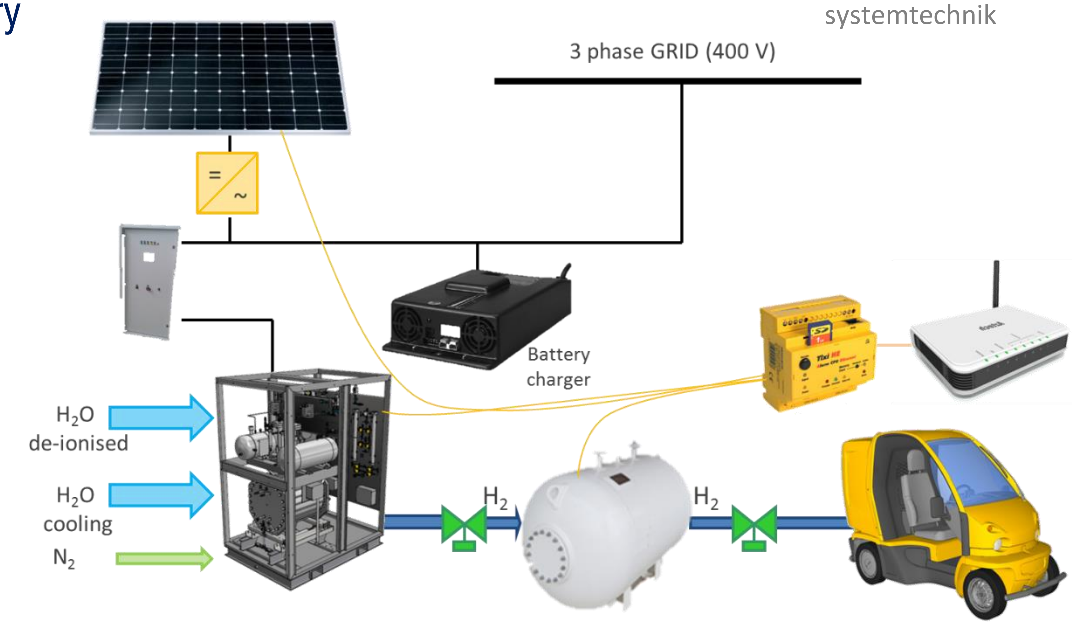
Plug-in Hybrid





1 Example: The MobyPost Project

- Demonstrate interest of H_2 mobility in mail delivery for rural areas
- Develop local and sustainable mobility concept "from sun to wheel"
- Develop 10 FCEVs for special needs of La Poste (ergonomics, speed, range…)
- Develop and implement 2 service stations with onsite hydrogen production



Source: UTBM, EIFER

FEEDBACK

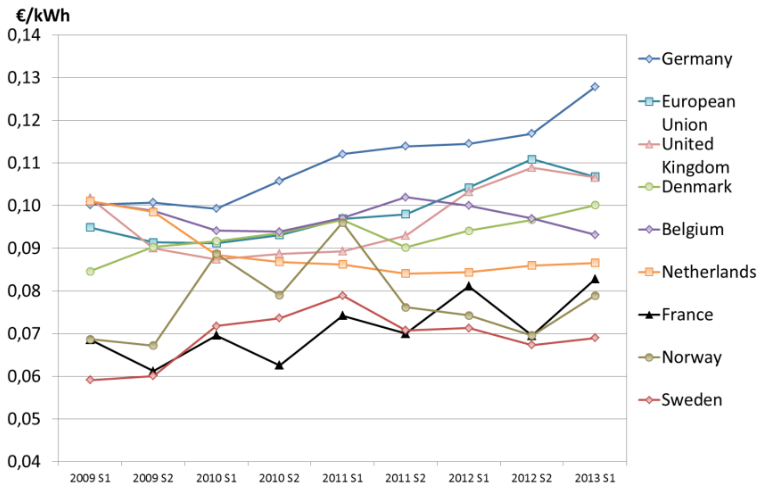
⇒ H_2 Mobility FR can be implemented through **industrial operators of captive fleets**

⇒ In analogy with the « Plan national pour le développement des véhicules électriques et hybrides rechargeables », 50,000 BEVs acquired by different industry users and coordinated by UGAP since 2010

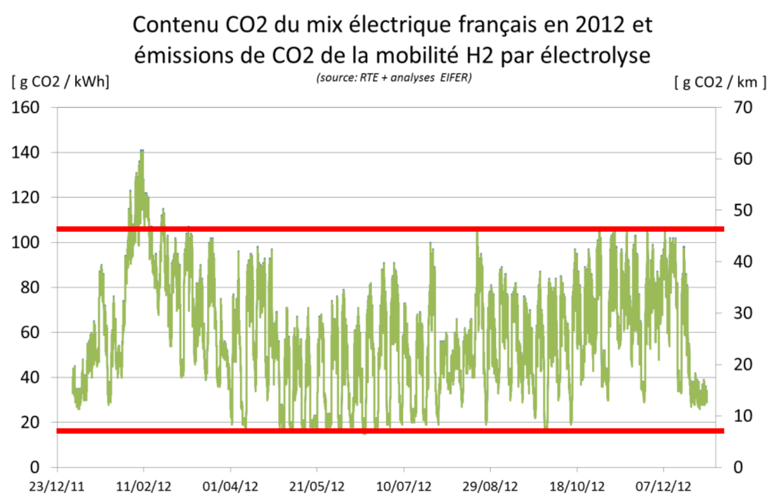
⇒ Range extender enables to optimize FC operation and reduction of size

⇒ Electrolysis offers flexibility to electrical grid and integration of fluctuating renewable electricity

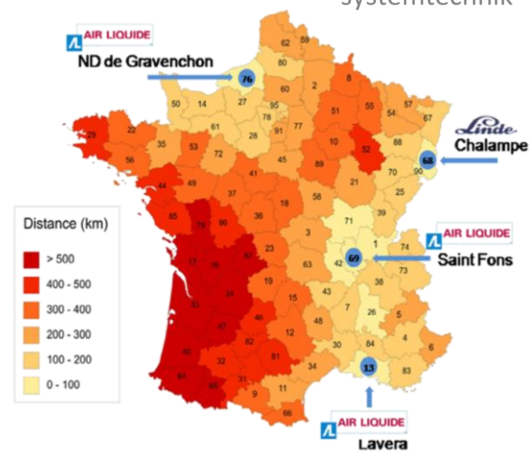
1 Potential of Electrolysis for France



Source: Eurostat



Source: data: RTE, analysis : EIFER



Sources: *Phyrenees, ADEME. Projet VabHyogaz*

- ⇒ Low electricity generation costs
- ⇒ Remoteness of regions to central steam reformers
- ⇒ Open capacity market by 2016: grid services
- ⇒ CO_2 emissions
  - *H_2 from electrolysis: **10 – 45 g_{CO_2}/km***
  - *H_2 from steam methane reforming : > **60 g_{CO_2}/km***
- ⇒ In French context, decarbonisation is optimal for hydrogen from **electrolysis**
- ⇒ **Optimization strategies for renewable electricity** to enable:
  - *optimization of the **decarbonisation** of transport*
  - *optimization of the **utilization rate** of local resources and/or*
  - *provision of additional **grid services** to electricity grid (Power-to-Gas)*

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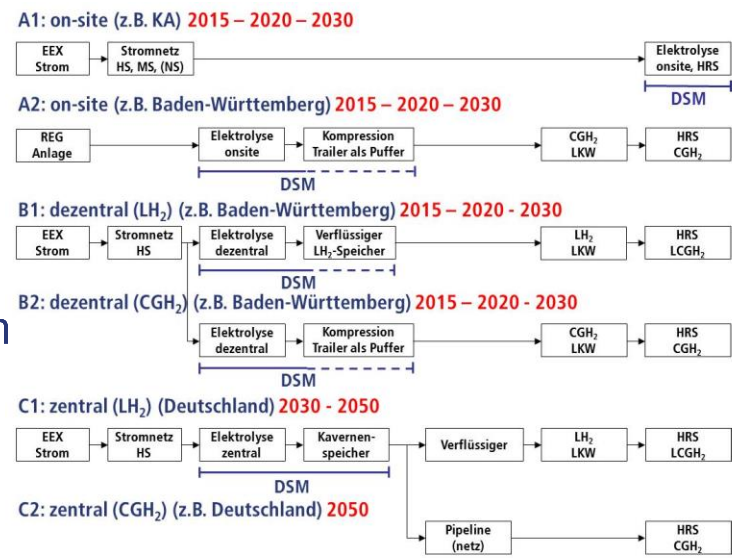
2 REN to H_2 – A Utility's Perspective

- Conditions for business cases for REN electricity to hydrogen:
  - Dynamic, load flexible and low cost (PEM-)electrolysers
  - Low electrolysis CAPEX with $\geq 4{,}000$ operating hours per year
  - Favourable policy conditions (such as no grid fees)
- Possible H_2-cost parity with hydrogen from SMR ($\leq$3 €/kg_{H2})
  - In addition to above: very high electricity purchase price volatility in long term
- Sufficiently high industry / political interest to develop combined business cases for hydrogen for transport and Power-to-Gas
- Most favourable options:
  - Centralised production with large scale storage in salt caverns where applicable (low spec. storage costs)
  - Onsite production (no hydrogen distribution costs, flexible/robust business model for electric utilities)
- Liquid hydrogen supply not sufficiently flexible for decentralised delivery concepts
- Sufficient hydrogen demand expected and synergies from common use of hydrogen distribution infrastructures
- Regional infrastructure differentiation probable



Source: "EE to H_2 – Integration von erneuerbaren Energien und H_2-Elektrolyse in Deutschland und Baden-Württemberg", LBST study for EnBW, 2011

2 GermanHy – German H_2 Roadmap 2009

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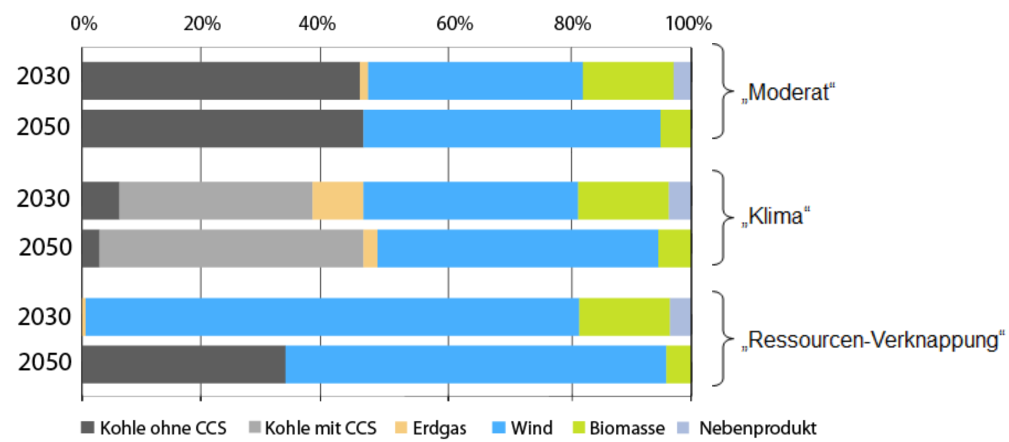
- ‘Moderate’, ‘Resource’ and ‘Climate’ scenarios pull hydrogen from various primary energy sources
- Political goals & framework and technical achievements have major impact on hydrogen mix
- Hydrogen from coal is no longer a German option as CCS has been discarded in the meantime
- Hydrogen infrastructure roll out from ‘population centers’ to ‘the countryside’

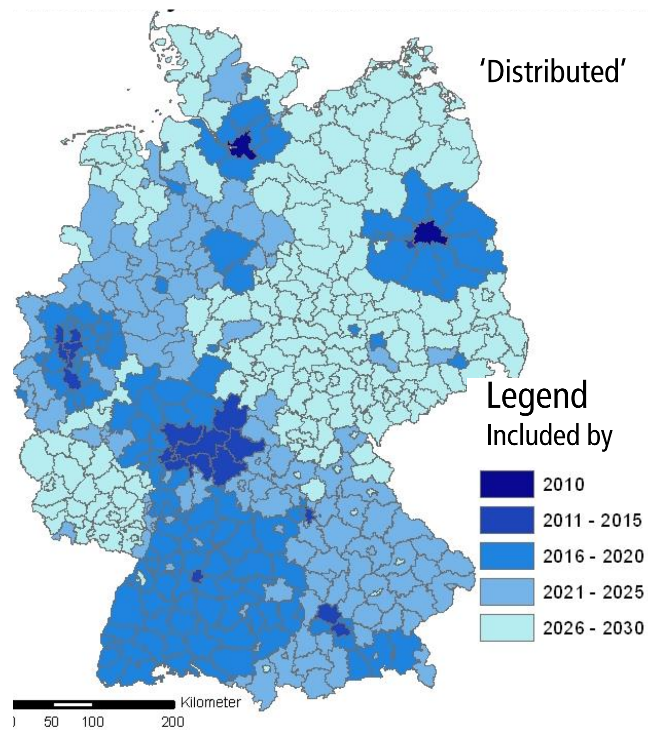
Hydrogen production portfolio



Source: GermanHy – Study to answer the question „Where will the hydrogen come from in Germany by 2050?“, for the German Ministry of Transport (BMVBS) and NOW, 2009

Hydrogen infrastructure analysis

Year of inclusion in network



2 MKS – Roll of Power-to-Gas for Transport

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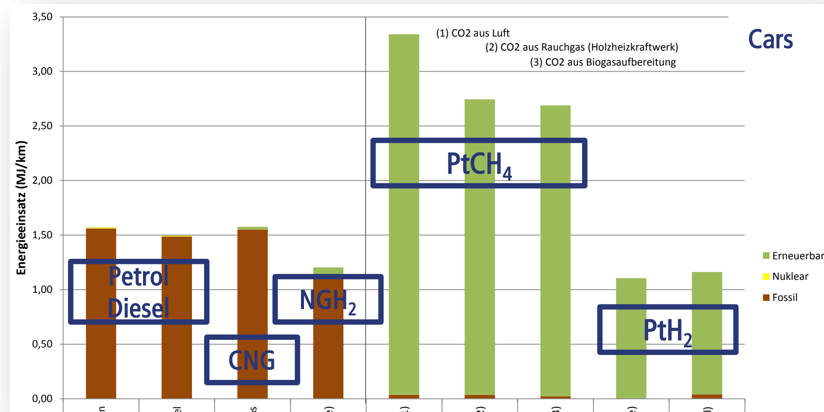
Energy policy goals

- Use of hydrogen in FCEVs significantly more energy efficient than of methane in internal combustion engines, BUT higher challenges for hydrogen infrastructure development (resource intensity!)
- Bundling ancillary services with PtG (storage!) possible

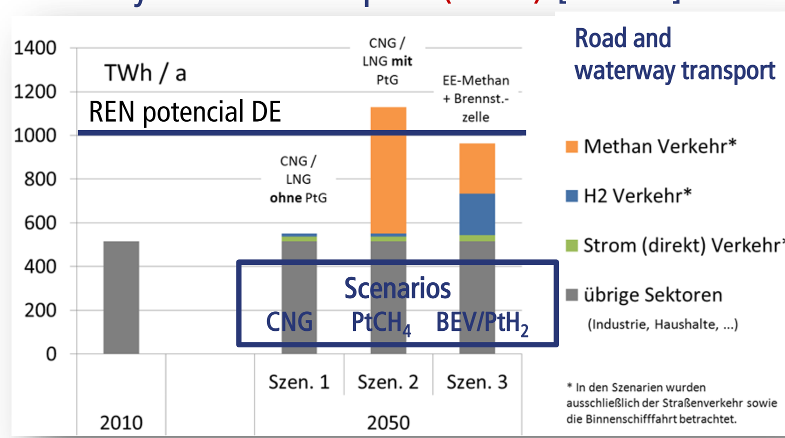
Scenario results

- Mobility as part of global energy systems can contribute to 'Energiewende' through Power-to-Gas
- Transport energy demand decreasing in all scenarios, yet only an ambitious use of BEVs and FCEVs helps to reach 40% of transport energy reduction (scenario 3)
- Electricity demand for transport can supersede demand from all other sectors (caused by switch to fuel provision)
- Ambitious use of e-mobility can outgrow REN electricity potential Germany (-> imports required)

Primary energy demand (2030) [MJ/km]



Electrity use for transport (2050) [TWh/a]



Source: Power-to-Gas (PtG) in transport, Status quo and perspectives for development, Study for the Federal German Ministry of Transport and Digital Infrastructure (BMVI)
http://www.bmvi.de/SharedDocs/DE/Artikel/UI/UI-MKS/mks-wiss-studien-ptg.html

2 HyUnder – Large Scale Storage in Europe

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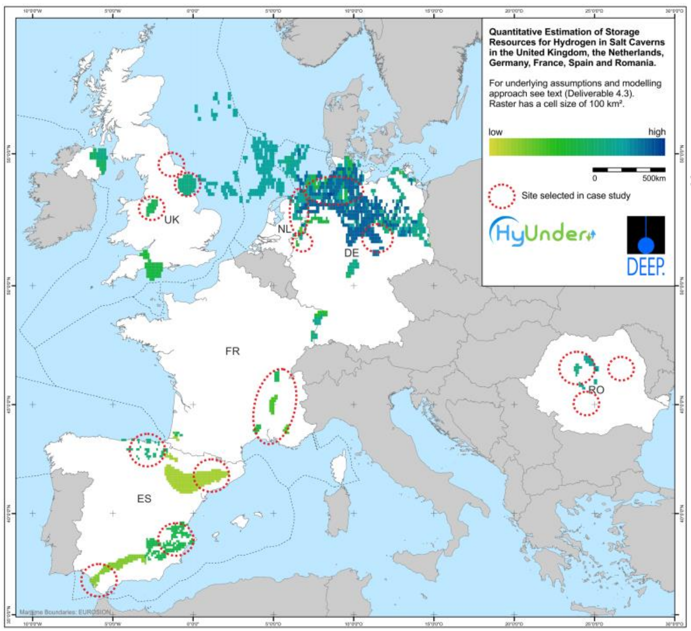
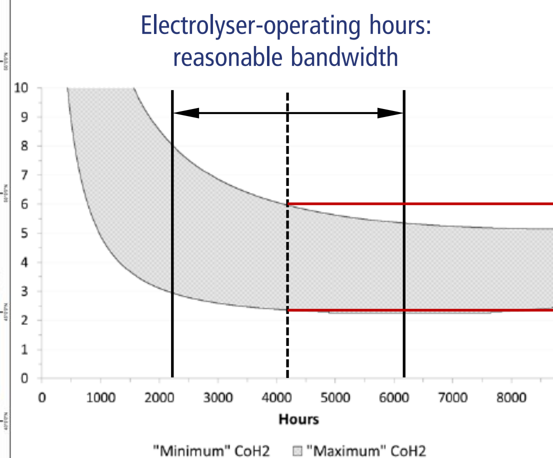
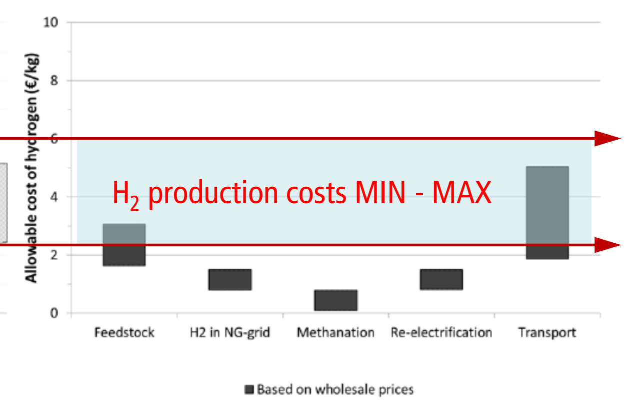
- Hydrogen underground storage can become technically & economically feasible (initiated by large scale storage of REN electricity over weeks/months):
  - in regions with feasible geology and in existing natural as caverns / cavern fields,
  - when developing xx TWh scale of fluctuating REN-electricity/surplus (for longer periods of time),
  - if supplying hydrogen to different markets (transport, industry, re-electrification),
  - for low electrolyser CAPEX and electricity costs and
  - with an adapted policy-framework (e.g. rising CO_2-certificate prices, support of e-mobility & FCEVs)



Case Study Netherlands (representative for all 6 countries)



Hydrogen production costs



Achievable hydrogen market prices

Source: Assessment of the Potential, the Actors and Relevant Business Cases for Large Scale and Long Term Storage of Renewable Electricity by Hydrogen Underground Storage in Europe", EU-funded R&D project, 2014, www.HyUnder.eu

2 H_2 Mobility – Refuelling Infrastructure

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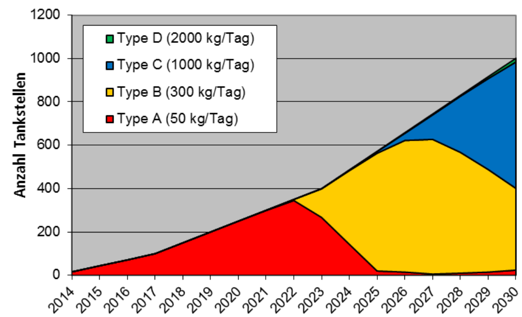
H_2 Mobility

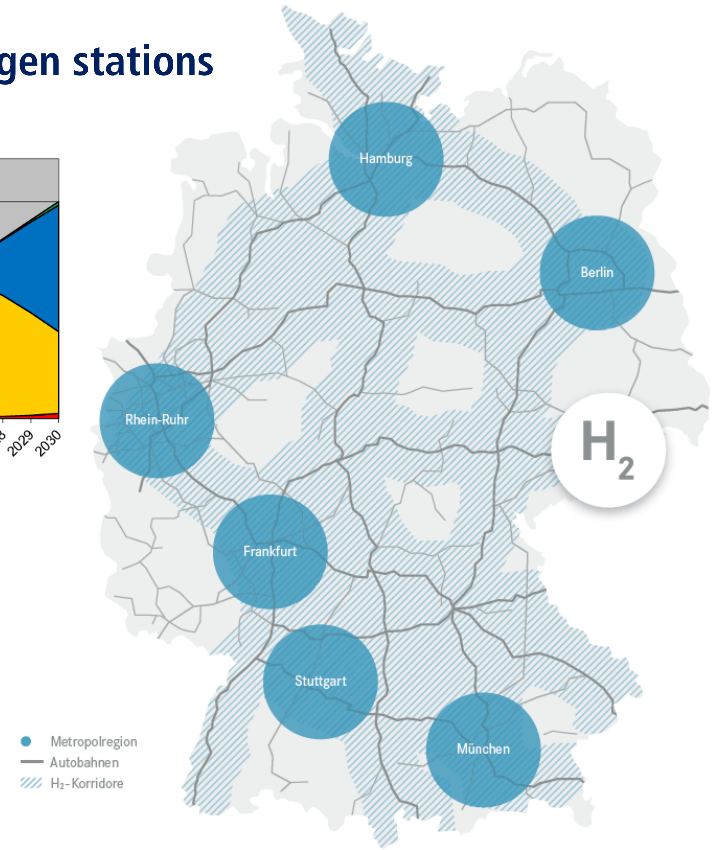
- **Early introduction**
  - Focus on regions with high station utilization (cities) and trunk roads
  - Captive fleet supply
  - Combination of 35 MPa und 70 MPa (buses, cars) depending on needs
  - Policy support required
  - One retail consortium
- **Long term**
  - Supplying also low population regions
  - Up to 4,000 fuelling stations (today ca. 14,000 conventional stations)
  - Gradually phase out policy support
  - Open market and free competition

Size distribution of hydrogen stations
(Example Germany LBST)



Station planning:

TODAY: 15
2015: 50
2017: 100
2023: 400
2025: > 500



~400
Stationen
soll das öffentliche Wasserstoff-Tankstellennetz in Deutschland bis 2023 umfassen

~90
Kilometer
liegen dann zwischen den einzelnen H_2-Tankstellen auf den Autobahnen rund um die Ballungsgebiete

>10
Wasserstoff-Tankstellen
werden 2023 in jeder Metropolregion zur Verfügung stehen

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3 Comparison – Status

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National context	Different energy supply structures, geographical conditions and distribution of roles between political actors
Principle goal	Common set of goals set by EU framework (decarbonising energy supply, developing renewable shares), but with differences in weighting and other timelines
Principle approach	Introduction of EU TEN-T-corridors with different roll-out strategies in short-term (industry- versus population centers) but similar long-term scenarios (e-mobility for mass market, (P)HEV, BEV and FCEV, hydrogen: 35/70 MPa)
H_2 stations - design	35 MPa for buses and fleet vehicles (e.g. range extender) 70 MPa for cars, H_2 stations from 100 kg_{H2}/day (initial) to 1,000 kg_{H2}/day (broad market)
H_2 sources/delivery	By-product hydrogen if available, hydrogen from natural gas (central) Electrolysis (preferably decentralised and for grid services)
	Delivery via high pressure trailer, (from case to case as cryogenic liquid) or onsite
Actors	Industry interested in value chain (hydrogen and fuel cells) but with differing branch focus
	Politics with broad federal and regional interest (local value creation as well as usage)
Potential customers	Serving mass markets in long term, differing introduction pathways for private and industry customers in short term (fleet operators, municipal service providers)
Financing	Industry and politics need to develop framework for market introduction jointly (planning for series production, policy measures), possibly in public private partnerships (PPP)

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3 Comparison – Perspectives

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- **Similar long-term vision**
  - 35 MPa and 70 MPa in both countries
  - Industry- and private customers as focal groups
  - Hydrogen supply to become carbon neutral
- **Transition phase could be accelerated through coordinated joint approach**
  - Development of cross-border infrastructure (Phase 1 based on HIT)
  - Sharing national insights (PtG, range extender)
  - Joint contribution to common EU approach by communication interface (shared fuelling station webpage)
- **Joint studies could accompany and support transition**
  - Comparison of transition strategies to support European e-mobility in roll-out phase
  - Potential utilisation of synergies by shared hydrogen infrastructures (‘energy station ’)
- **Cooperation boost could foster ‘Airbus like’ strategy**
  - Identification of most relevant industry sector to plan for ‘Hydrogen Airbus’

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