Stefan Bergander

Large scale hydrogen storage systems

eMove360° H2 & FCEV Conference 2019, München, 17. Oktober 2019

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Bundesministerium für Bildung und Forschung
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H Y P O S HYDROGEN POWER STORAGE & SOLUTIONS EAST GERMANY

1. HYPOS-Initiative

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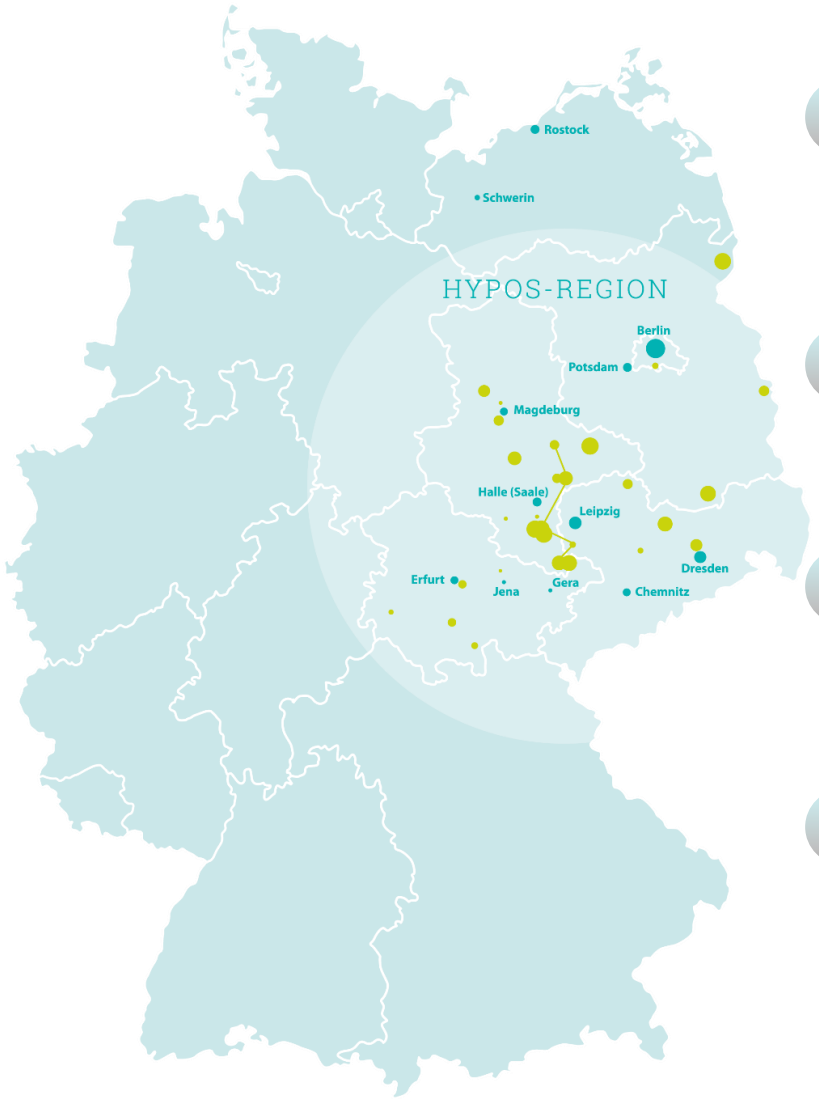
H Y P O S HYDROGEN POWER STORAGE & SOLUTIONS EAST GERMANY

HYPOS – The Region



Second longest H2 pipeline in Germany

- 150 km, spreading between Zeitz and Bitterfeld
- connecting H2 production with consumption

Salt Caverns for large-scale storage

- high storage potential in underground storage units
- caverns just 20 km away from H2 pipeline

Existing high hydrogen demand

- 3,6 bn. m^3/a in the Middle German Chemical Triangle
- 1,25 bn. m^3/a substitutable

High potential for Renewables

- 105 TWh/a onshore wind power
- 33 TWh/a photovoltaic

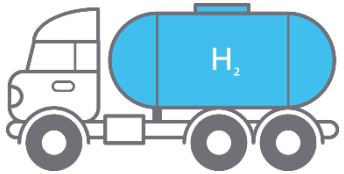
Utilization of existing infrastructure

HYPOS

HYPOS – The Idea

Vision
Constitution of a widespread **Green Hydrogen Economy.**

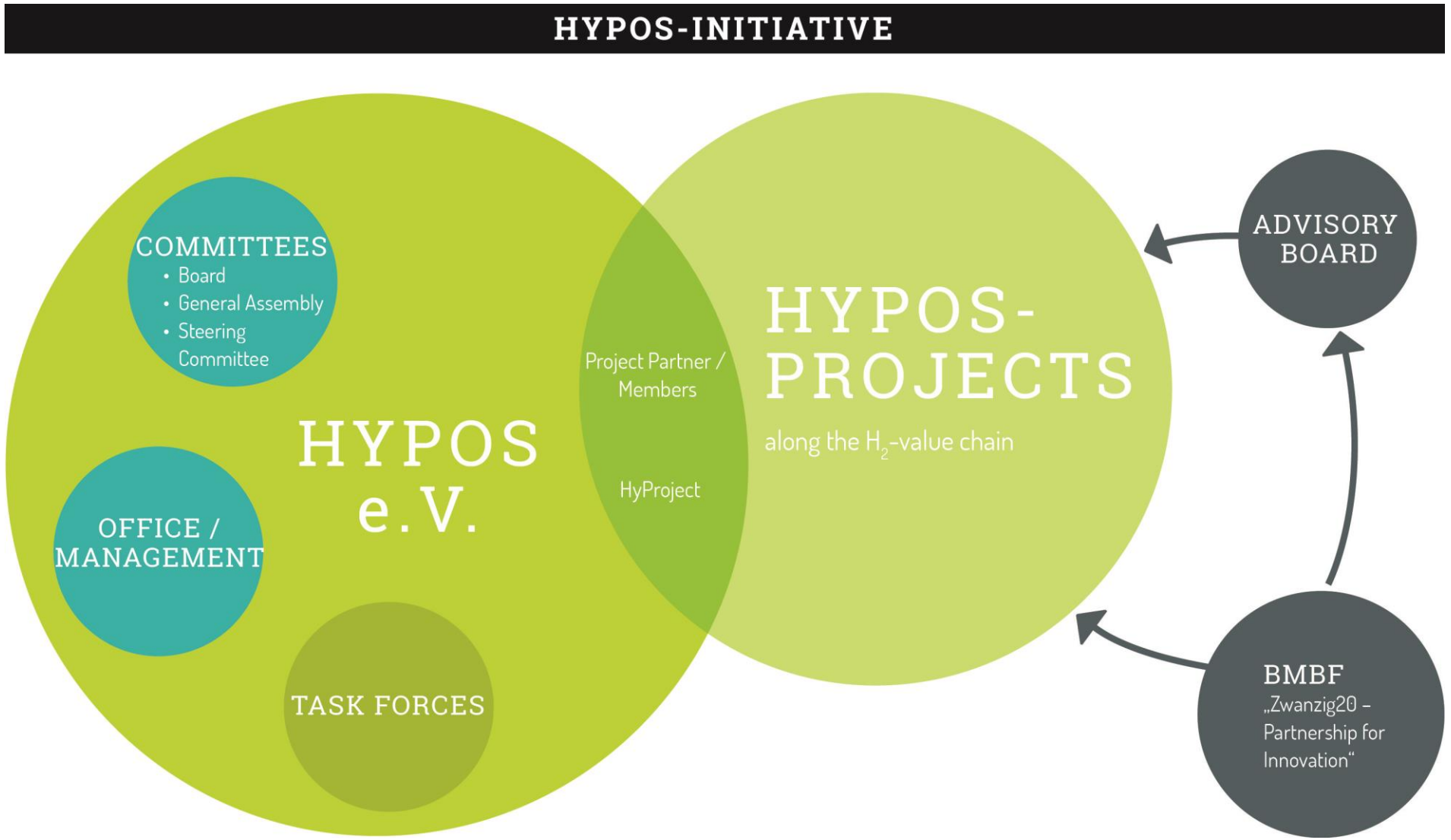
Mission
HYPOS is connecting the power, natural gas and chemical grid in East Germany via Green Hydrogen. Through systemic innovation and research Green Hydrogen applications will reach **economic efficiency.**



Mission statement
HYPOS is a **long-term network** of small, medium and major sized companies as well as research institutions working on the entire hydrogen supply chain of **production, transportation, storage and utilisation.**

HYPOS

HYPOS – The Structure



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HYPOS – The Projects

Chemical Conversion

PEM Electrolysis

MegaLyseurPlus: System design of 1.25 MW electrolysis unit and optimisation of power electronics and compression devices

ElyKon: Continuous degradation analysis of dynamic operation of PEM-electrolysis

Alkaline Electrolysis

ELKE: Continuous process of coating for electrodes

Reversible Electrolysis

rSOC: Demonstration of reversible high temperature electrolysis

REVAL: Development of reversible alkaline membrane electrolysis

Other Systems

COLYSSY: Process development of CO-electrolysis

H2-Flex: Flexibilisation of chloralkali process

RWTrockner: Drying of hydrogen by radio waves

Transport & Storage

Grid

H2-PIMS: Conversion of natural gas infrastructure for hydrogen

H2-MEM: Development of carbon based membrane to separate natural gas and hydrogen

H2-Netz: Demonstration of hydrogen distribution grid based on synthetic materials

HyProS: Process and security sensor technology for hydrogen along the value chain

Storage

H2-UGS: Standardisation for assessment of underground cavern storage units

H2-Forschungskaverne: Construction and demonstration of hydrogen storage within an underground salt cavern

Storage Technology

MMH2P: Development of mobile storage solution including energy management system

H2-HD: Development of 1000 bar storage as trailer

Utilization & Distribution

Energy supply

H2-Home: Development of fuel cell cogeneration unit based on PEM

Mobility

LocalHy: Development of hydrogen combustion engine and decentral hydrogen tank station concept

ImplaN: Design of optimal extension schedule for hydrogen tank stations in Germany

Chemicals and Refinery

COOMet: Development of one-step process for methanol production

FRAGRANCES: Decentral production of CO with reverse water-gas shift reaction

Hythanol eCO2: Development of double membrane reactor for methanol production

eKeroSyn: Conceptual study on renewable kerosene production

INES: Multidisciplinary safety analysis

H2-Index: Multidisciplinary economic efficiency analysis

H2-Chancendialog: Multidisciplinary research of acceptance conditions

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2. Energy Storage

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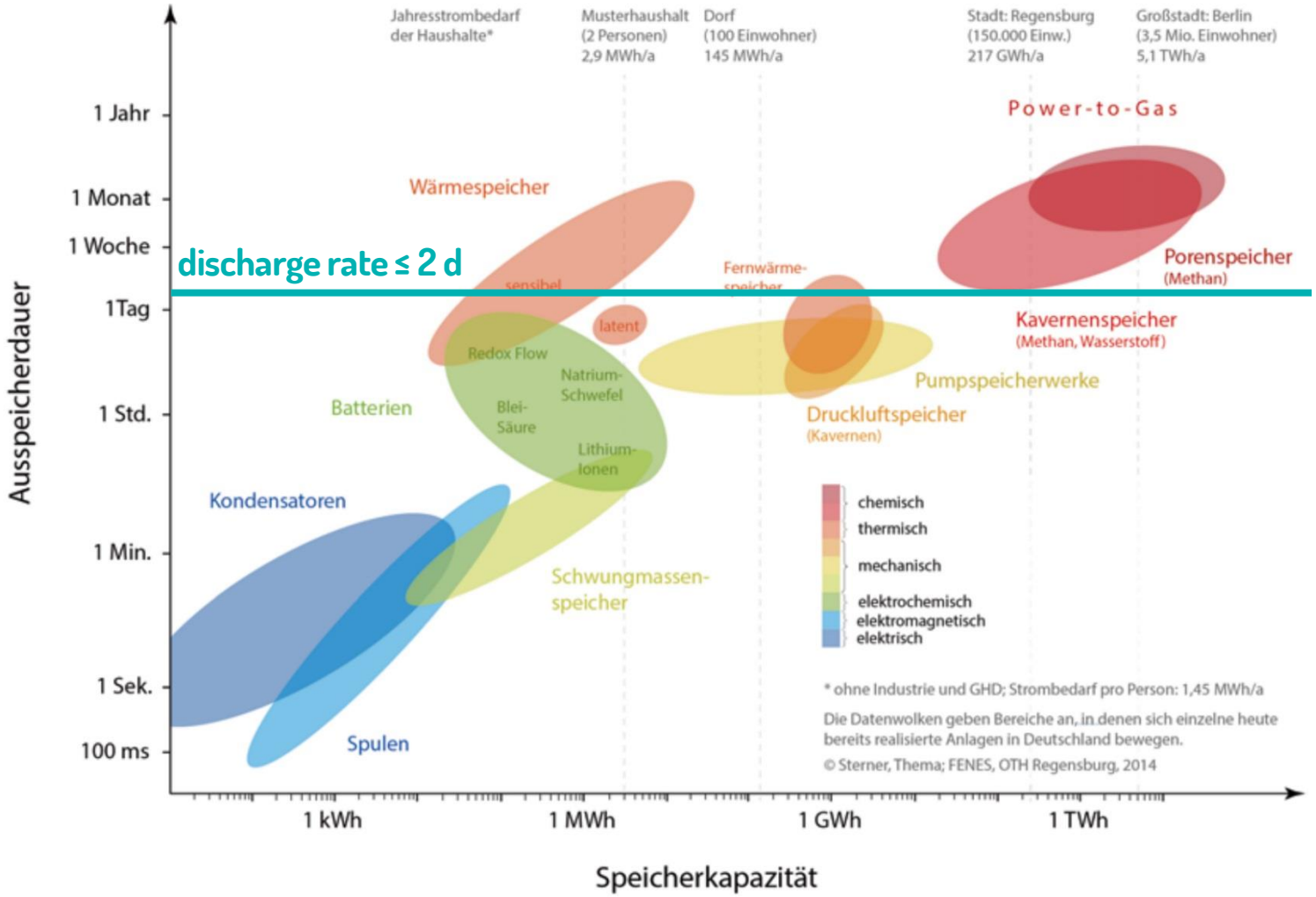
Technology – Large-scale Energy Storage



Quelle: Sterner/Stadler 2014

- different qualification
- ➢ **in future most likely all technologies are necessary**

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Technology – Large-scale Energy Storage

Porous reservoir storage

- seasonal storage with great capacities
- former deposits or acquifer
- gas-tight top level rock formation
- technically challenging

➢ **not-suitable for hydrogen**

Speicher von BVEG-Mitglieds-unternehmen	Speichertyp	Arbeitsgas-volumen Mio. m³ (Vn)
Rehden	ehem. Gasfeld	4.400
Bierwang	ehem. Gasfeld	1.000
Breitbrunn-Eggstätt	ehem. Gasfeld	992
Uelsen	ehem. Gasfeld	860
Bad Lauchstädt	ehem. Gasfeld	440
Inzenham-West	ehem. Gasfeld	425
Wolfersberg	ehem. Gasfeld	365
Schmidhausen	ehem. Gasfeld	154
Eschenfelden	Aquifer	72
Sandhausen	Aquifer	30
Fronhofen-Illmensee	ehem. Ölfeld	10
sonstige Porenspeicher in Deutschland		367
Summe		**9.115**

Quelle: BVES 2019

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Technology – Large-scale Storage

Cavern storage

- facilities for trading activities
- high flexibility to charge/discharge
- artificial hollow space in salt domes
- through drilling and leaching with fresh water

➢ **suitable for hydrogen**

Speicher von BVEG-Mitglieds-unternehmen	Anzahl Kavernen	Arbeitsgas-volumen Mio. m³ (Vn)
Etzel / ESE - Uniper	19	1916
Epe-Uniper	39	1804
Nüttermoor	21	1316
Bernburg	31	979
Jemgum-astora	9	754
Bad Lauchstädt	15	720
Staßfurt	9	649
Epe-innogy H-Gas	10	405
Jemgum-EWE	8	366
Empelde	5	355
Peckensen	5	349
Huntorf	7	308
Epe-NUON	7	300
Katharina	6	296
Epe-innogy NL	6	294
Kraak	4	259
Epe-Trianel	4	194
Epe-innogy L-Gas	4	178
Xanten	8	177
Krummhörn	3	154
Bremen-Lesum-Storengy	2	147
Harsefeld	2	110
Reckrod	3	110
Rüdersdorf	1	100
Kiel-Rönne	3	72
Bremen-Lesum-Wesernetz	2	68
Summe	**233**	**12.380**

Quelle: BVES 2019

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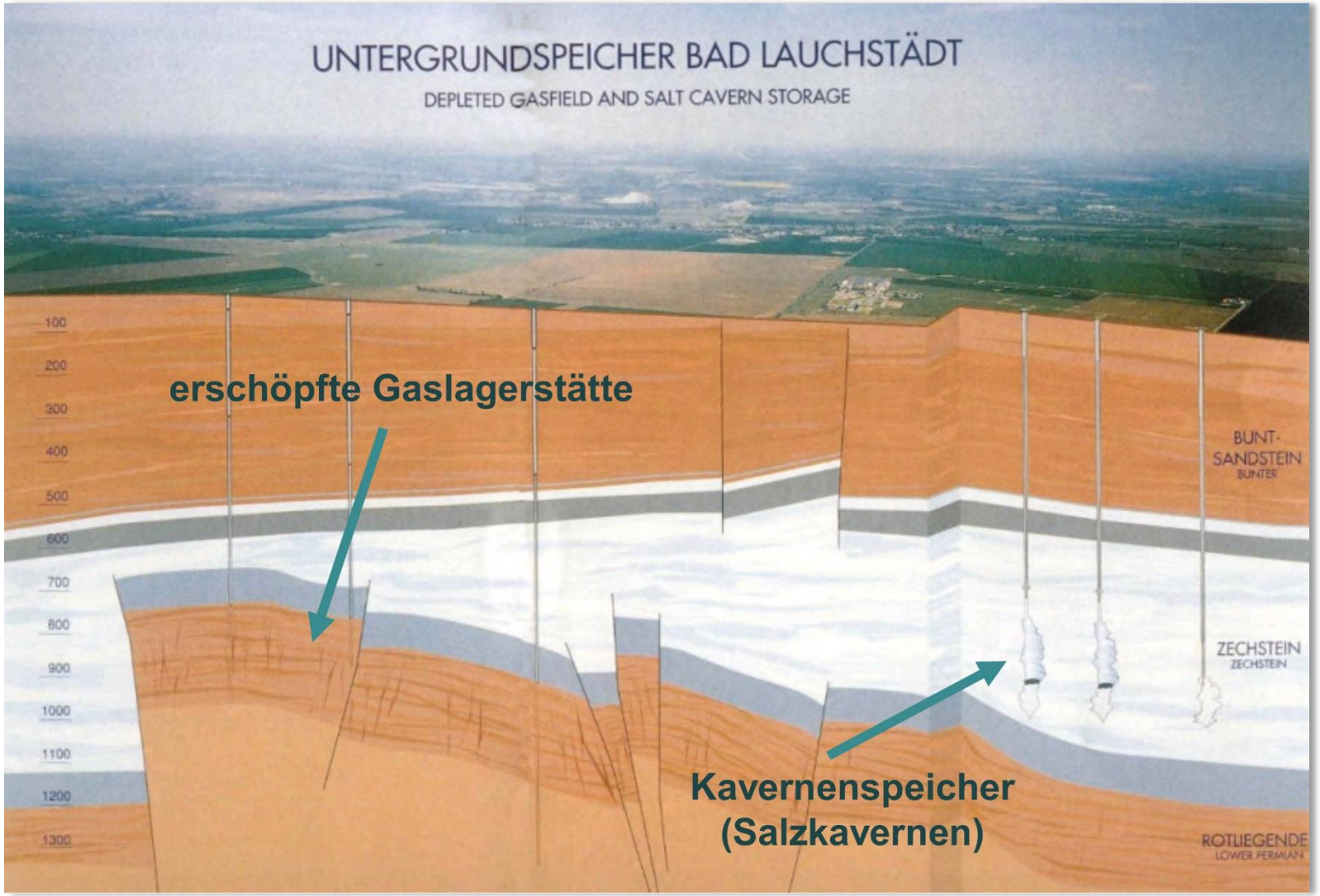
Technology – Large-scale Energy Storage



Quelle: VNG 2015

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3. Hydrogen Storage in Salt Caverns

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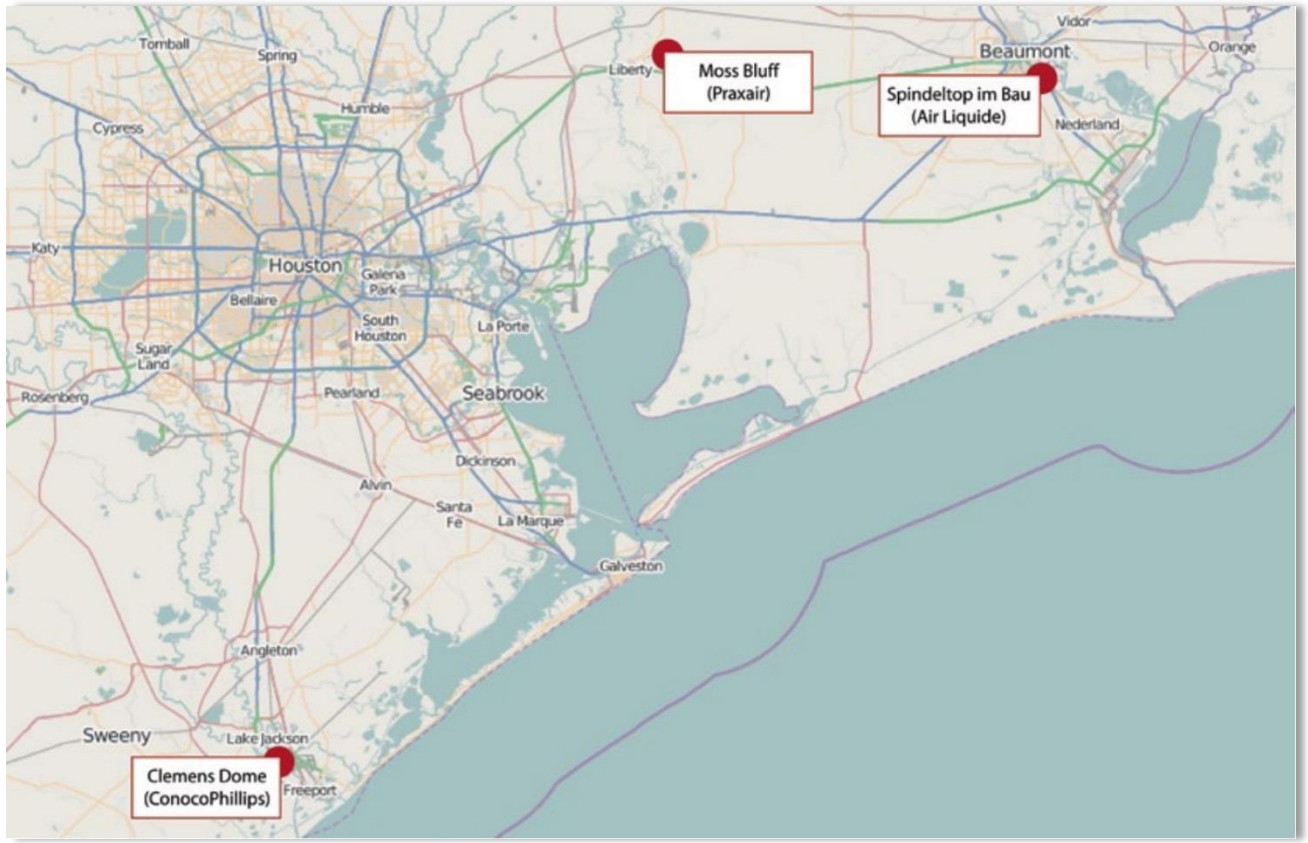
H2-Cavern – Basics

State of the Art

- H2-caverns are in operation in UK and USA
- no detailed information available
- other legislative requirements and different storage idea



Quelle: KBB UT

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H2-Cavern – Technology

Requirements

- no fundamentally different requirements than with natural gas:
  - geomechanics
  - drilling construction
  - cementation
- but certainly **hydrogen suitable materials** necessary:
  - resistance and durability
  - impermeability

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H2-Cavern – R&D Demand

Geomechanics

- hydrogen infiltration
- experimental assessment, in-situ tests
- modelling
- evaluating up-scaling options

Microbiology

- characterisation of life-forms
- laboratory assessment, in-situ tests
- methods to hinder microbiological activity

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H2-Cavern – R&D Demand

Thermodynamics

- gaschemics
- gas valuation
- modelling
- hydrogen adsorption

Storage Integrity

- degradation safety
- corrosion
- impermeability criteria
- operation scheme
- storage design
- associated facilities: purification, grid, etc.

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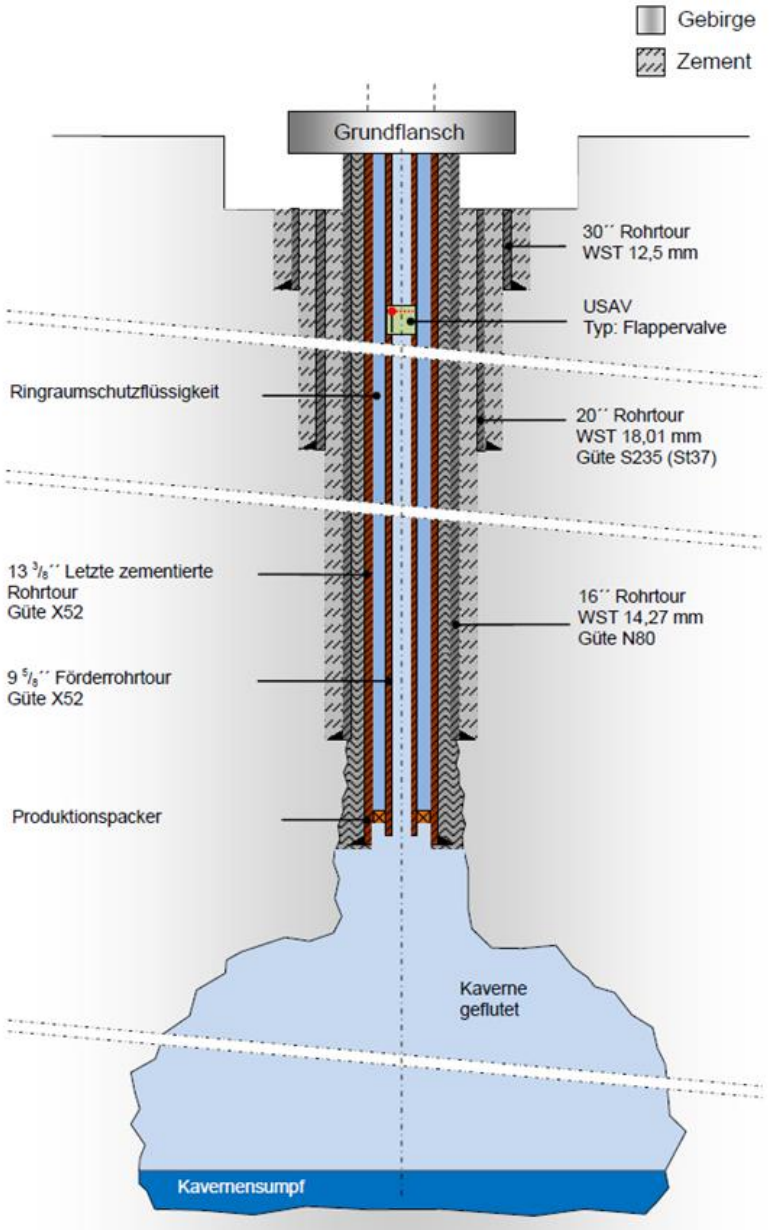
H2-Cavern – Technology

Underground Facilities

- drilling in rock to access cavern with more than one casing string
- cementation and tightening

Surface Facilities

- charge-/discharge facilities
- hydrogen purification
- hydrogen transportation



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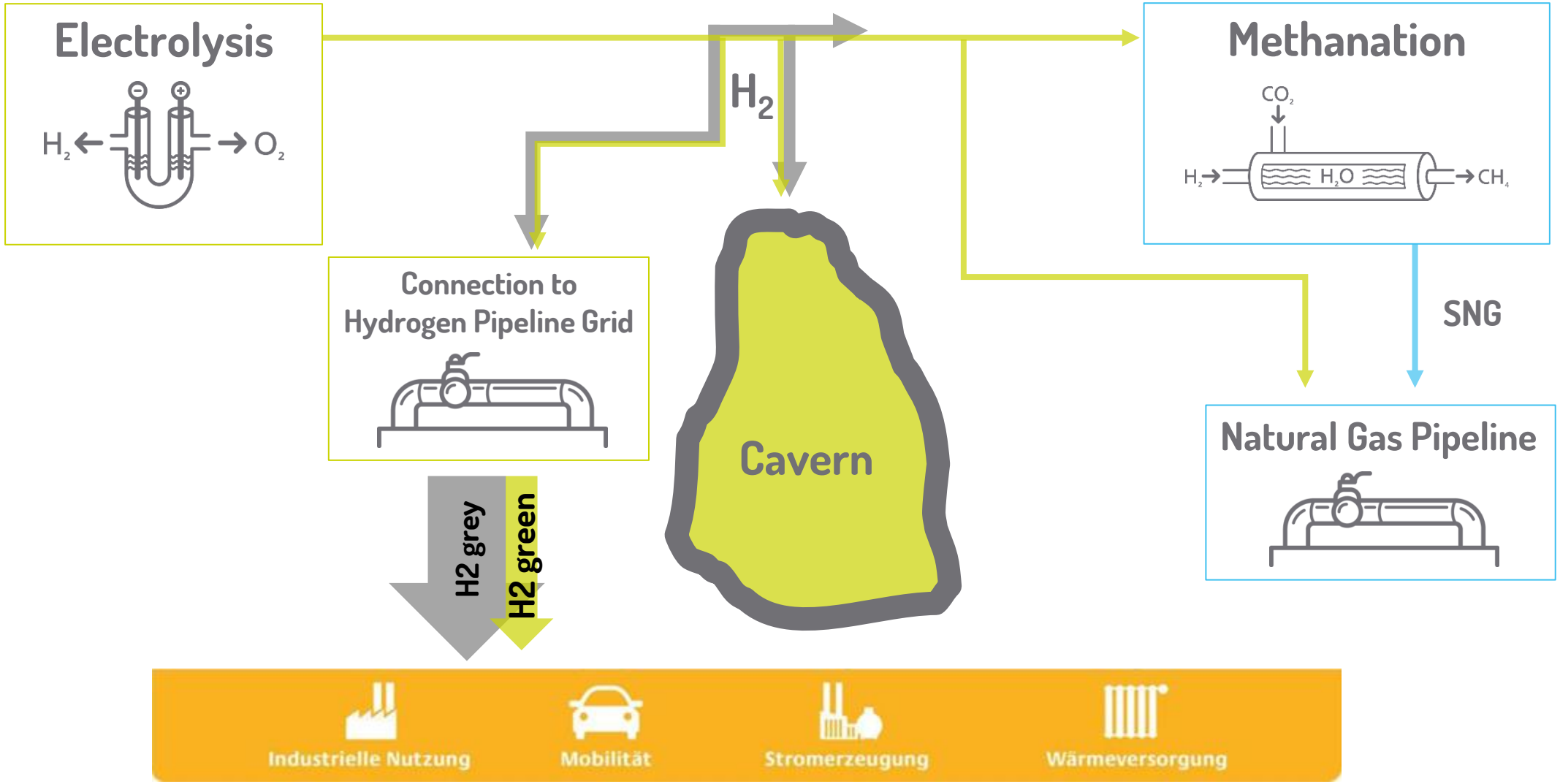
H2-Cavern – Integration with Energy System



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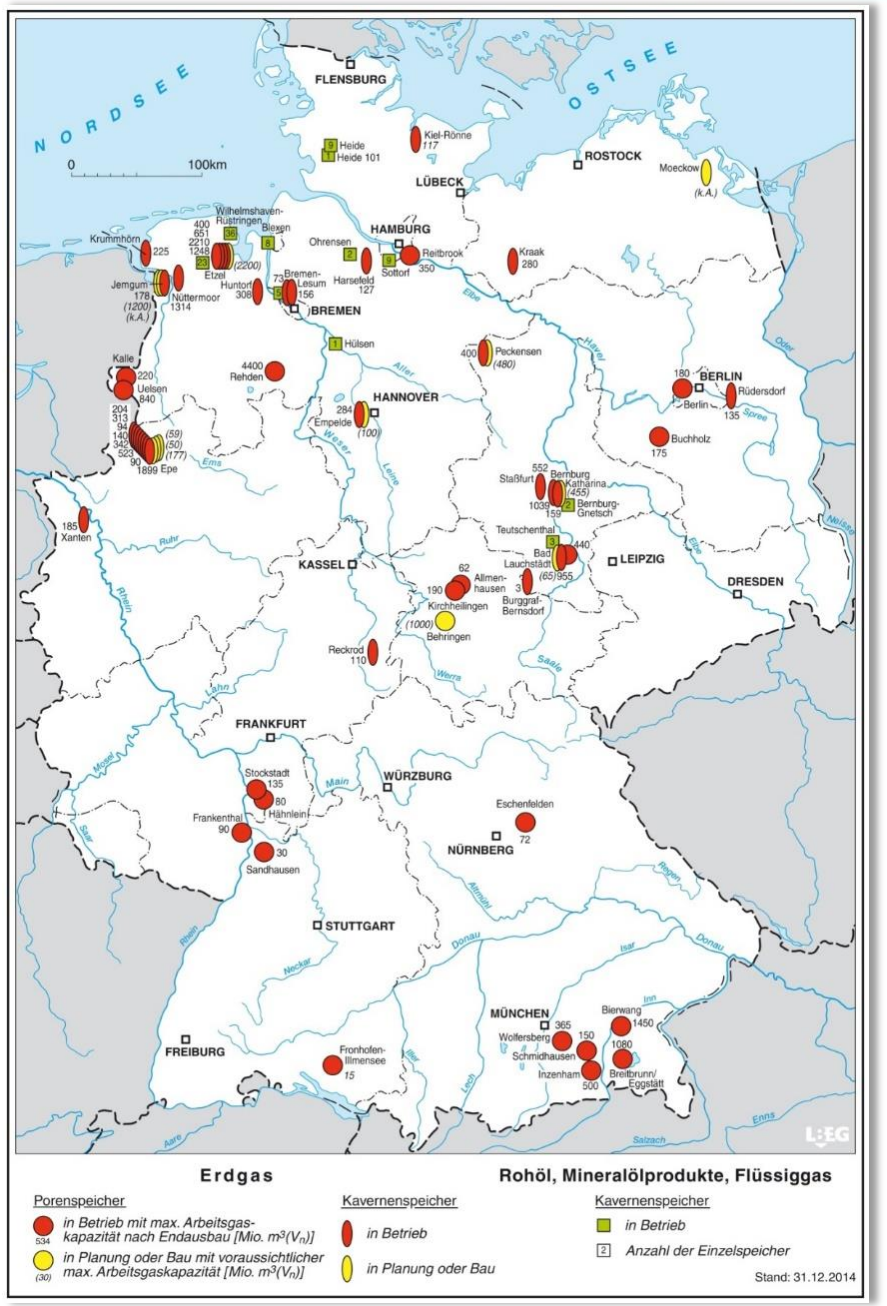
H2-Cavern – Grid Connection

Utilisation of existing natural gas grid

- grid length: 479,000 km
- storage volume: 260 TWh_{th}

- bridge technology:
  fuel switch to natural gas

- key technology:
  content switch to hydrogen



Quelle: Krause 2018, bdew 2017, LBEG 2015

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4. H2-Forschungskaverne

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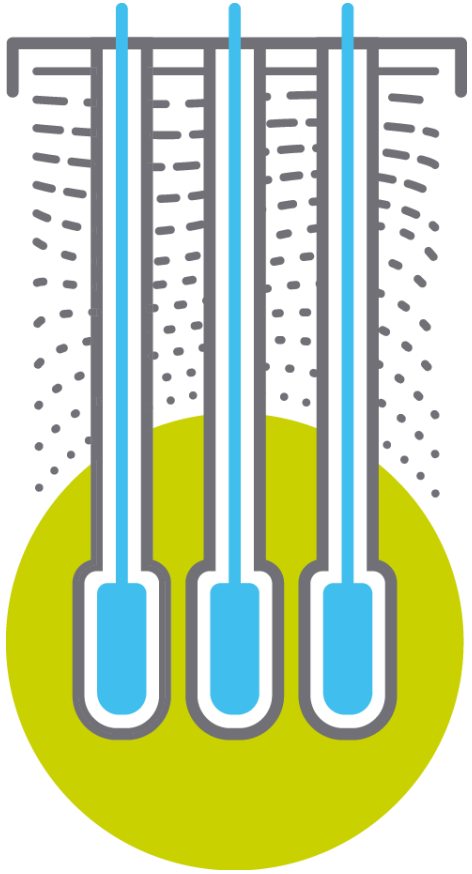
HYPOS – H2-Forschungskaverne



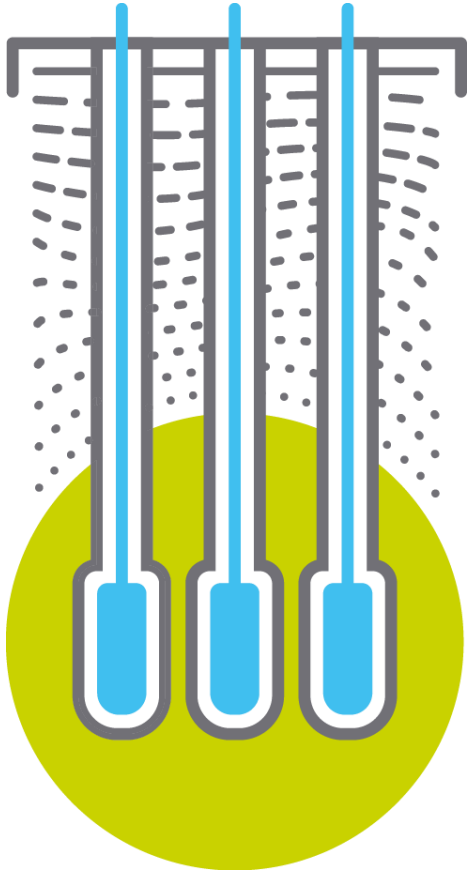
Development and construction of a large-scale underground storage for Green Hydrogen for 50 Mil. Nm³ H2

- Conversion of a salt-cavern in Bad Lauchstädt/Saxony Anhalt
- Conjunction with on-shore wind farm and multi-MW electrolysis
- Connection to natural gas grid and hydrogen grid

- Realisation within three project phases
- First filling scheduled for 2022

DBI GTI Gastechnologisches Institut · Fraunhofer IMWS · VNG Gasspeicher · ontras Gastransport GmbH · IfG · THE LINDE GROUP · HYPOS

HYPOS – H2-Forschungskaverne



Total Volume	560.000 m³
Cavern status	Filled with brine and blanket
Cavern neck	850 - 905 m
Cavern hight	905 - 1108 m
Cavern pressure	30 - 140 bar
Working pressure	30 - 115 bar
Storable H_2 Volume	cushion gas: 15.5 Mio. Nm³, 1,380 t **working gas:** **49.9 Mio. Nm³, 4,486 t**
H2 charging rate H2 discharging rate	10,000 Nm³/h 100,000 Nm³/h
Gas quality after cleaning, washing, etc.	99.999 % H2

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THANK YOU FOR YOUR ATTENTION

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5. HYPOS-FORUM

IN DER MESSE DRESDEN

HYPOS FORUM

5. & 6. NOVEMBER 2019

JETZT ANMELDEN

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BACKUP

HYPOS – H2-UGS

- **General methodology to construct hydrogen storage cavern**
- scientifically proven and location-independent assessment of aptitude

➢ **catalogue for future investors and approval authorities**

- standardisation
- transferability
- reduction of economical obstacles
- increase of overall economic efficiency

Reallabor, Energiepark Bad Lauchstädt

Infrastructure, Power

- **30 MW PEM electrolyser**
- island operation:
  40 MW_{peak} wind power
- grid connection:
  - GOOs for green power
  - substation
    Bad Lauchstädt

VNG Gasspeicher · ontras Gastransport GmbH · terrawatt · DBI GTI Gastechnologisches Institut · uniper · HYPOS

Reallabor, Energiepark Bad Lauchstädt

Infrastructure, Gas

- existing natural gas pipeline Bad-Lauchstädt – Leuna
- 20 km, DN 500, PN 55 bar, operational pressure 30 bar

- connection to hydrogen pipeline grid at Leuna

VNG Gasspeicher
ontras Gastransport GmbH
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DBI GTI Gastechnologisches Institut
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Reallabor, Energiepark Bad Lauchstädt

Zusammenfassung

- 80 MW electrolysis power
- 50 Mio. Nm^3 hydrogen storage capacity
- carbon cycle technologyíes
- direct utilisation for intermediate products and final products
- transporation capacities via natural gas and hydrogen grid
- utilisation of existing infrastructure

➢ **closed cycle to demonstrate sector coupling**

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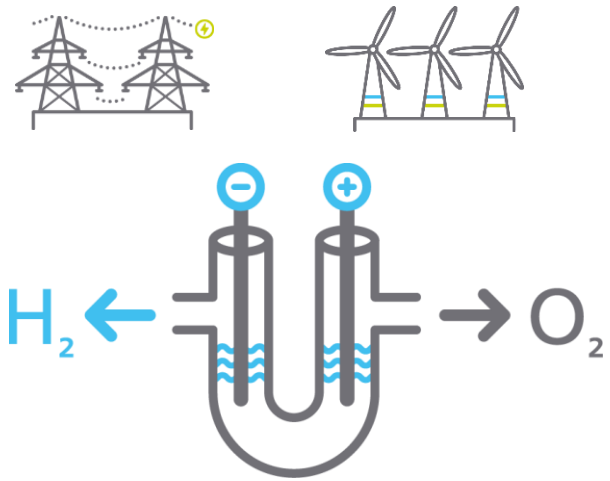
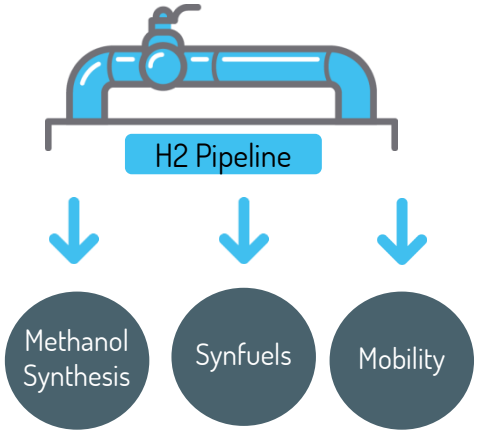
Reallabor – Approaches from the HYPOS-Region

GreenHydroChem Leuna



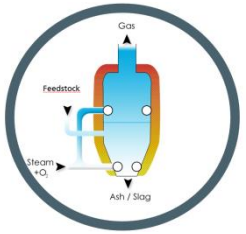


Carbontrans Leuna

2t carbon/h
from waste, biogenous residues and lignite

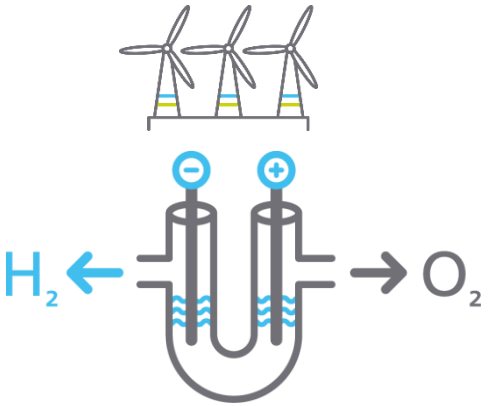
C_xH_y

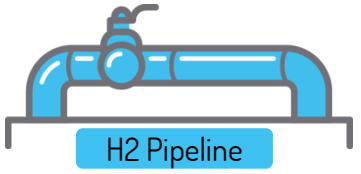
pretreatment

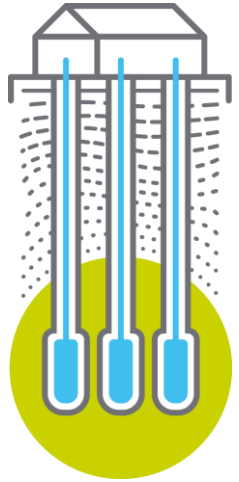


CO/H2

Energiepark Bad Lauchstädt







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HYPOS – The Services

Services

- Extensive networking for hydrogen activities
- Increasing Visibility for model region Middle Germany
- Presence at fairs, events and conferences
- Support for search of project partners
- Presentation of research results
- Monitoring of relevant research and funding programs
- Contributions and publication in journals and periodicals
- Regular newsletters and press releases

Website

- HYPOS-Blog with news, dates, calls and studies
- English version available
- scheduled H2-project-, stakeholder- and expert catalogue with integrated search and filter functionality

Events

HYPOS DIALOG

HYPOS FORUM

HYPOS

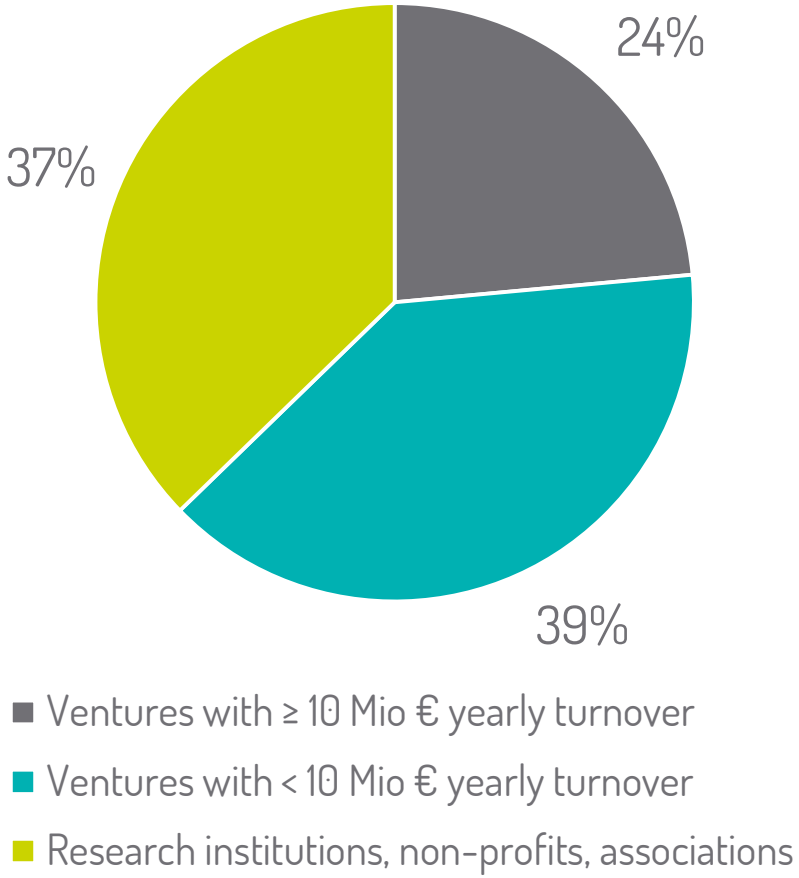
HYPOS – The Members

102 Members

- 28 major enterprises
- 38 SME
- 36 research institutions, non-profit organisations and associations

- 76 members from East Germany
- 25 members from West Germany
- 1 member from outside EU

- 3 honorary member



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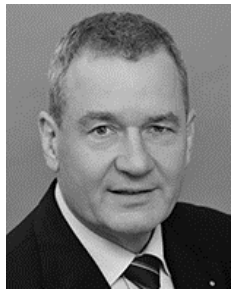
HYPOS – The Board



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Stefan Kauerauf

Nouryon Industrial Chemicals GmbH

Kay Okon

VNG Gasspeicher GmbH
Co-opted Boardmember

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Juliane Renno

Association and Network Management

Stefan Bergander

Project and Knowledge Management

Florian Thamm

Marketing and Public Relations

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