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BES – BERLIN'S NATURAL GAS STORAGE FACILITY

AN URBAN REAL-LIFE LAB FOR A CO_2-NEUTRAL FUTURE

The GASAG Group in numbers

€ 155 million
EBIT

€ 1.11 billion
Revenue

€ 113 million
Investment amount

GASAG
NETZGESELLSCHAFT BERLIN-BRANDENBURG
EMB
GASAG SOLUTION +
BES Berliner Erdgasspeicher
spreegas
BAS KUNDENSERVICE
GASAG BIO ERDGAS SCHWEDT
dse
GASAG GRUPPE
BEGATEC Berliner Gasanlagen · Messtechnik
SW FORST
GASAG WIND

529,144
Gas customers
182,831
Power customers

1,632
Employees

11
Subsidiaries

11,031
km
of supply network lines

340,262
Building connections
784,997
Installed gas meters

Shareholder: VATTENFALL ENGIE e.on

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Data as per Annual Report 2017

GASAG Group – Committed to a CO_2-neutral future

EU climate target 2050:
Reduction[1)] of greenhouse gas emissions by 80% to 95%

National climate target 2050:
Reduction[1)] of greenhouse gas emissions by 80% to 95%

Berlin climate target 2050:
Reduction[1)] of greenhouse gas emissions by at least 85%

GASAG:
2020: Reduction[2)] of CO_2 by 2 million tons: trailblazer for the Berlin/Brandenburg region as part of the energy transition

Energy transition hub / Berlin natural gas storage facility:
Potential for the sustainable use of aquifer reservoirs as a link connecting renewable energy generation and sustainable sales

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1) as compared to 1990
2) as compared to 1998

GASAG Group – How we contribute to reducing CO_2

Concept for an urban quarter: The EUREF CAMPUS

Wind energy generated in Brandenburg

Solar-cell power generated in Berlin

Eco-mobility – electrically and natural-gas powered vehicles

CO_2 neutrality is achieved by a biomethane-fired cogeneration module and a logical energy concept

- 1,350 kW electricity
- 1,573 kW thermal energy, until 2018: 6.5 Megawatt
- During the final expansion stage, 25 buildings totaling a floor space of 165,000 square meters will be supplied.

Green power using three wind turbines in Wahlsdorf

- 7.5 MW electricity
- ~21,500 MWh per year
- ~11,300 fewer tons of CO_2 emitted per year
- CO_2-free supply of ~15,000 households

Green power using ~8,000 solar cell modules in Mariendorf (largest solar-cell system in Berlin)

- 2.0 MW electricity
- ~1,800 MWh per year
- ~1,000 fewer tons of CO_2 emitted per year
- CO_2-free supply of ~2,000 households

Environmentally friendly mobility using electrically powered vehicles and natural-gas filling stations

- 11 natural-gas filling stations
- Electrically powered smart cars available to be leased, a project pursued with Daimler AG
- Easy access to e-charging stations providing green power for mobility purposes in cooperation with Ubitricity

BES - Berlin natural gas storage facility: Facts and figures

Site / address
Glockenturmstrasse 18,
14053 Berlin

Owner
Gasag (wholly-owned subsidiary)

Managing director
Holger Staisch

Employees
28 employees (annual average of the company in 2016: 30)

Capacity
1.6 billion kWh working gas volume

Commencement of operations
1993

History

During the Cold War, the storage facility was planned in the 1980s by the Allied Control Council for purposes of supplying West Berlin and was intended as a strategic and self-sufficient reserve storage. However, the facility was placed into operation only in 1993.

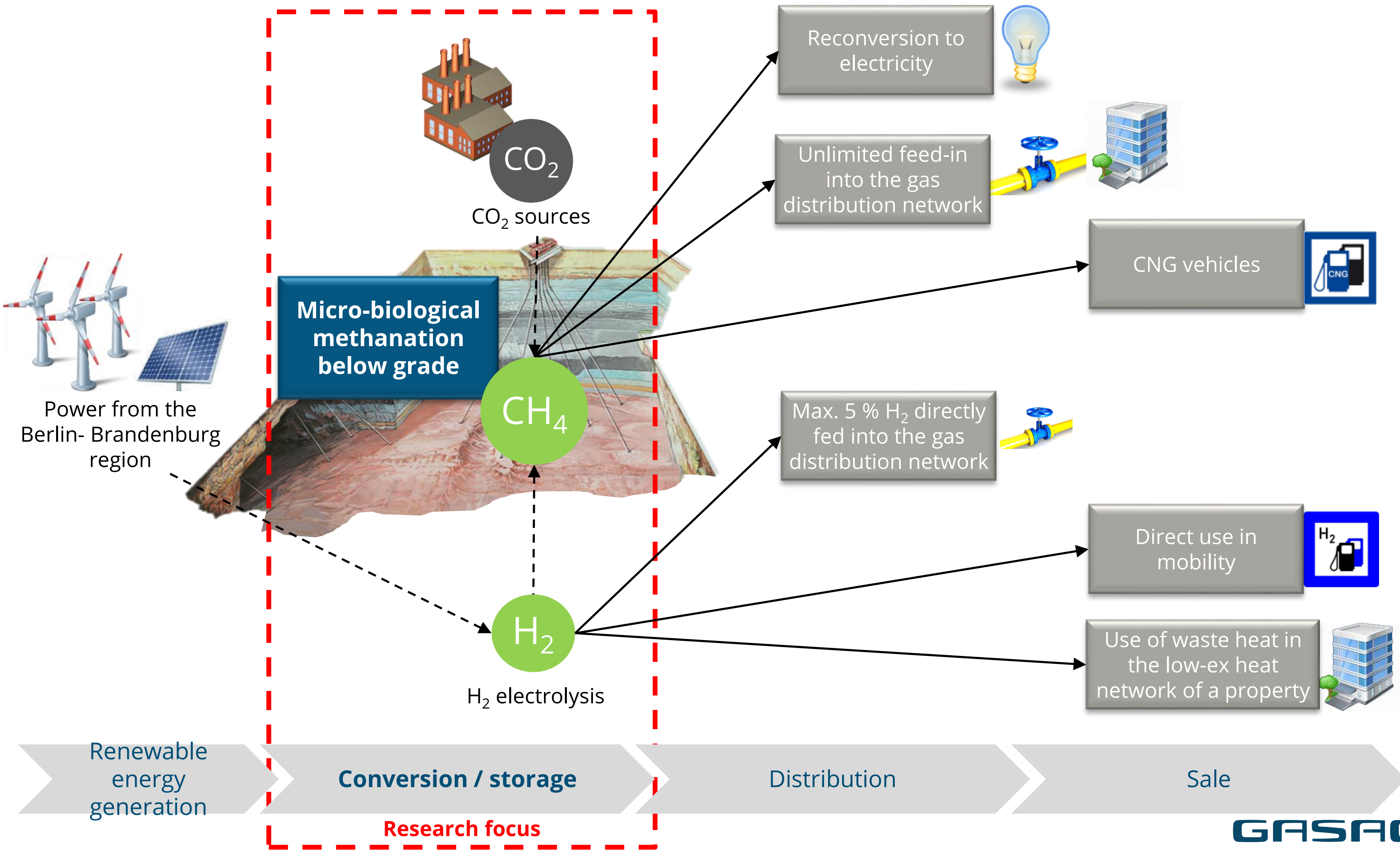
Geology

- The storage reservoir is 800 meters deep and has a working gas volume of 150 million m³.
- It is an aquifer reservoir, i.e. it has a massive, porous sandstone base without any larger cavities, in which water (24%) is displaced by gas, meaning that the gas is stored at 100 bar.
- 17 production wells (13 active)
- Maximum withdrawal: 225,000 m³/h

Usage opportunities / Current update

- In 2012, the valuation of the natural gas storage facility was reduced – in spite of its increasing significance in political terms – by a write-off of around € 144 million as a consequence of the low income in fees that it was generating.
- The storage facility served solely as a buffer and for trading purposes and was no longer profitable.
- Following the resolution, adopted in December of 2016, to decommission the storage facility, gas injection has ceased since the summer of 2017. The intention is to complete the decommissioning process by 2025 at the latest.

BES: An integrated concept



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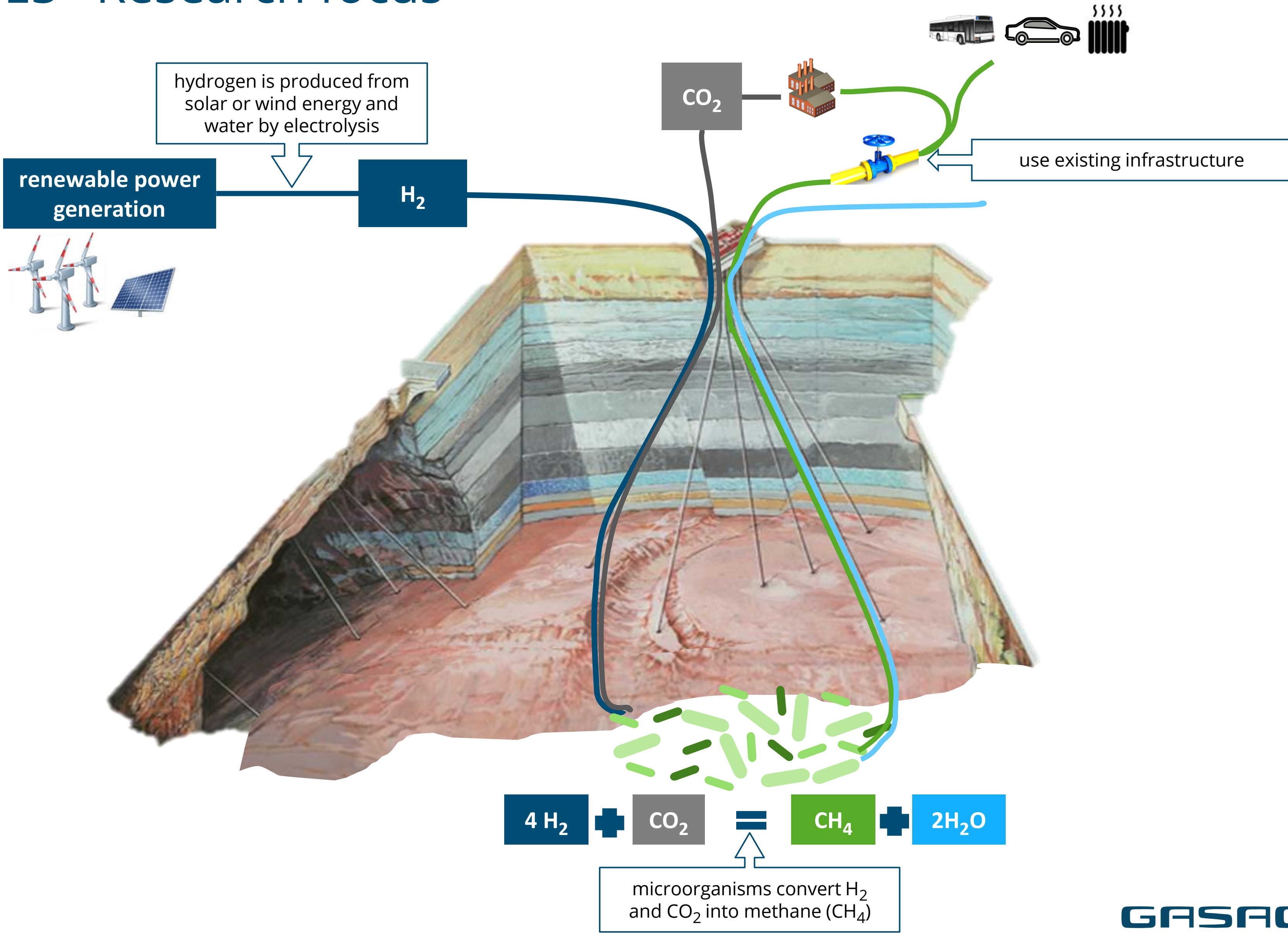
Input

Output

BES –Research focus



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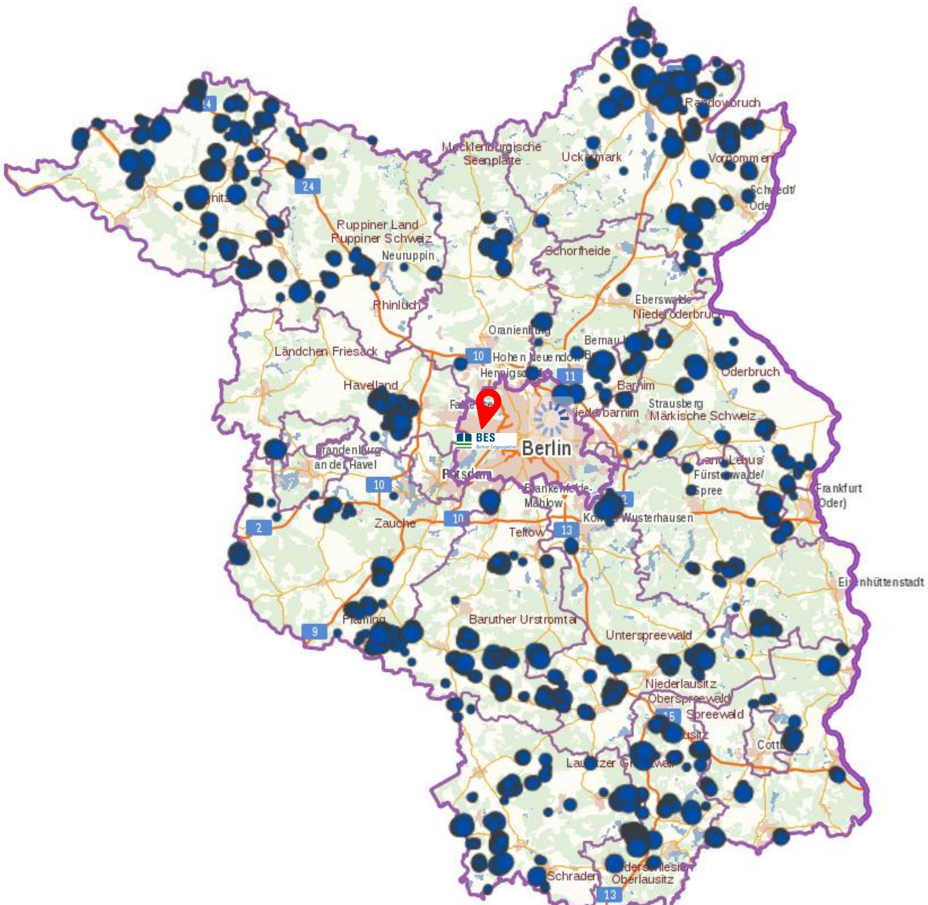
Wind energy in the federal state of Brandenburg



- 3,734 wind turbines
- 6,794 MW total installed output
- 9,765 GWh/a of generated power
- 16.9% share in the gross power generation in Brandenburg
- **423 GWh** loss of electricity production in 2017 in Brandenburg because of feed-in management measures

Thus, electrolysis theoretically is able to generate **6.7 million kg of H_2**

This corresponds to 670 million km $H_{2\text{-Automobile}}$ or **80,000 fewer tons of CO_2 emitted**

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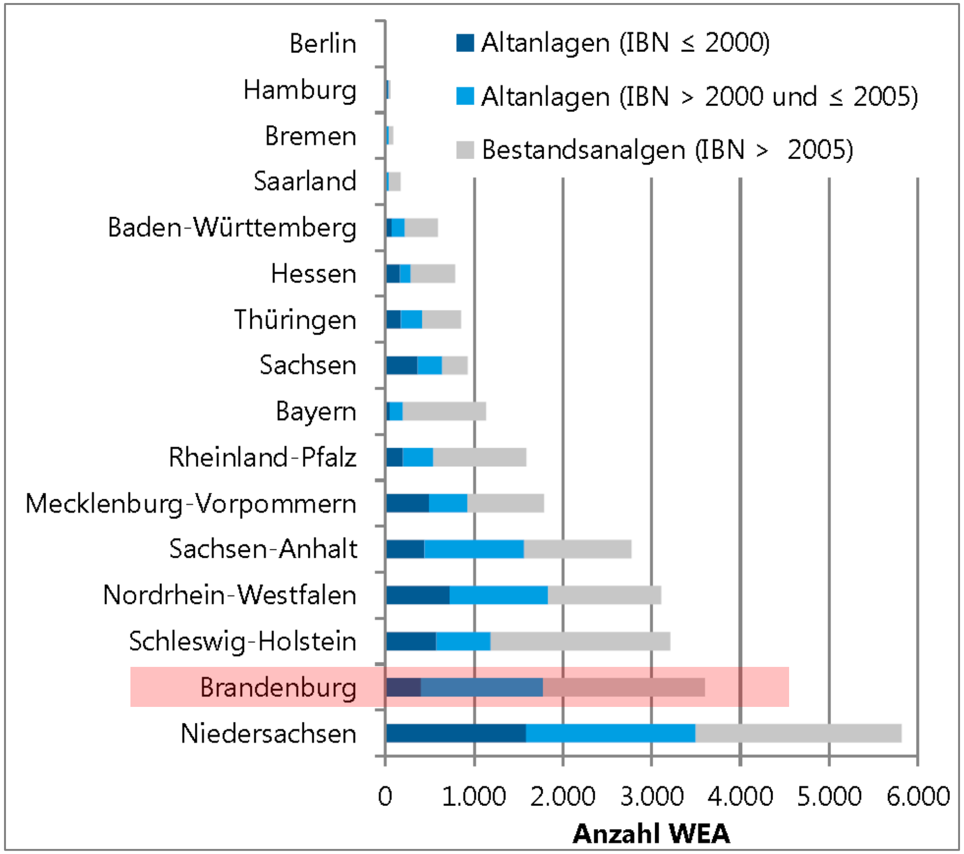
Wind energy in Brandenburg



WEA = Number of wind turbines
Altanlagen (IBN<2000) = Old systems taken into operation before or in the year 2000
Altanlagen (IBN>2000) = Old systems taken into operation after the year 2000 and before or in 2005
Bestandsanlagen = Existing systems taken into operation after the year 2005
Source: WindGuard 2016

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- 1800 wind turbines will cease to benefit from the preferential feed-in rights pursuant to the German Renewable Energy Act (EEG) in 2026.
- This corresponds to 2200 MW total installed output
- or 3100 GWh/a of power
- These facilities are seeking new marketing options or will be decommissioned.
- If the operation of these turbines does not continue, there will be no net expansion of wind energy generation onshore from 2020 onwards.
- Power-to-gas may open up an opportunity for these systems to remain on the market.

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Research objective

Synthetic natural gas generation by microbiological methanation in the underground

- **H_2 generated using renewable sources** is stored subsurface together with **CO_2** and is converted into **CH_4** by **microbiological processes** that take place in the underground
- It is intended to perform research into the **key factors** making up this process:
  - Identify the relevant micro-organisms
  - Explore potential to optimize and control the biogenic process

<u>Significant advantages:</u>

+ Elimination of the expensive catalytic conversion
+ Utilization of CO_2 from industrial processes, sewage treatment plants or biogas facilities + reduced consumption of fossil fuels → **national carbon footprint** is reduced
+ Flexible use of renewable energy enabled by storage: mobility, heating, industrial processes
+ Sustainable use of **existing infrastructure**
+ New opportunities for aquifer storage facilities which are today no longer profitable
+ Positive results will give a strong impact to the energy transition

Project stages (1/3)

- Technical stage, laboratory

1. Analyze the storage reservoir (fluids, rocks) as concerns the living conditions of micro-organisms in circumstances involving H_2-storage and methanation, in terms of mineralogy/geochemistry, biochemistry
2. Analyze the storage reservoir as concerns the integrity of the rock formations in light of tightness and potential leaching processes
3. Investigate the stimulation and inhibition of the micro-organisms resulting from the H_2
4. Upscale the laboratory to field scale using numerics regarding implementation potential, operating regime, risk analysis
5. Inspect technical equipment to determine H_2-CO_2 compatibility from the production well up to the surface process plant
6. Develop and adjust processing technologies serving to separate the accompanying components from the withdrawn gas

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Project stages (2/3)

- Technical stage, real life

1. Select a limited geological area of the original storage facility (reduction of the storage facility's size to an isolated geological area)
2. Inject into the storage facility low concentrations of H_2 and CO_2, serving as tracers, together with the natural gas; monitor leak-proofness of the overburden formations
3. Plan, construct, and operate electrolysis system and ancillary facilities
4. Inject mixtures of pure H_2 and CO_2 and characterize the biogenic processes in the underground

Project stages (3/3)

- Systemic questions

1. Power generated from renewable sources and the requirements to be derived therefrom for electrolysis
2. Explore the potential given in industry and municipalities to make available CO_2 (regenerative or fossil) from urban areas by way of performing potential analyses
3. Analyze the generation path regarding the costs and efficiencies of a power-to-gas system and the opportunities to influence it

BES – Project (option): Hydrothermally used geothermal energy as part of a low-ex heat network

1. Use the potential for geothermal energy above the gas storage layers
2. Develop low-ex heat supply
3. Install heat pumps in the properties
4. Operate the heat pumps using energy generated using renewable sources
5. Cogeneration of the exhaust heat from electrolysis will increase efficiency from the maximum of 60% given today to 80% to 90%.

Project phases and financial volume

- **Phase 0 Period: Q4/2018**
  - Develop roadmap

- **Phase 1 Period: Q2/2019 – Q2/2020**
  - Prepare feasibility study on the basis of available data and laboratory analyses
  - Obtain permits from the authorities

- **Phase 2 Period: Q2/2020 – Q2/2022**
  - Perform in-situ tests of the facility without H_2/CO_2 production (purchase of technical gases)
  - Convert two production wells
  - Gas purification technology
  - Compressor
  - Research operation for one year

- **Phase 3 Period: Q2/2022 – Q2/2026**
  - Construct electrolysis facility
  - Research operation for three years

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Supervision by public bodies – Board of Trustees

Supported by:
EU
Federal Government
Land of Berlin
GASAG AG

Other stakeholders:
Klimaschutzrat Berlin
Land-owned utility companies (e.g. BWB, BSR, BVG,...) and other players like Vattenfall,...

Proposal for discussion

Other experts:
GFZ German Research Centre for Geosciences, Potsdam
Institute for Ecological Economy Research
Technical University of Berlin, *Institut Energietechnik* (Department of Energy Systems)

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Questions / Next Steps

- Which EU funding program is compatible for the scope of the project?
- Does the timeline for the project fit to any funding program?
- Is it possible to combine EU-funds with other funds (e.g. a national funding program)?

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