

Enabling subsurface H2 storage: Effects of geo- and biochemical reactions

Publieke samenvatting / Public summary

Aanleiding

Hydrogen is a versatile energy carrier that can be produced from renewable electricity, and then used as a fuel to (re-)generate electricity and/or heat, or as feedstock for the chemical industry. A key advantage of H2 is that it can be stored underground in salt caverns and potentially also in porous reservoirs (depleted gas fields, aquifers) in large quantities, thereby offering services to society in the form of balancing solutions for unavoidable intra- to inter-seasonal variations in energy supply and demand and strategic energy reserves. Currently, salt cavern storage is one of the few technologies considered mature enough to be applied for storing H2 in such large quantities, although little is known about the long-term risks of potential geo- and bio-chemical reactions with H2. However, a large number of salt caverns will be required to create the estimated storage capacities, which will meet with serious technical, market, societal and spatial constraints. Therefore, storage of H2 in depleted gas fields may be also required. Although it is in many ways similar to storage of natural gas in depleted gas fields, at present the feasibility of this technology is not yet proven.

Doelstelling

In this project, we aim to advance our fundamental understanding of the technical feasibility of subsurface H2 storage, in salt caverns and porous reservoirs, by investigating the effects of geo- and bio-chemical reactions of H2 with rocks, fluids and micro-organisms in the subsurface, which may: •

Projectinformatie / Project information

Projectnummer / Project number
TKITOETKI2021-01-GE

Subsidiebedrag / Grant amount
€ 500.000,00

Algemene informatie / General information

Penvoerder / Secretariat
TNO

Publicaties en materialen / Publications and attachments

• 01.10.2024

**Eindrapport HyStoreReact
(TKI2021-01-GE)**

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Produce toxic and/or corrosive fluids (e.g. H₂S) that pose a threat to environment, health, safety, injection and production facility integrity, project economics and overall feasibility; • Reduce the porosity and/or permeability of the reservoir and more specific the near-wellbore area by precipitation of minerals and microbial growth, affecting the reservoir performance and loss of H₂ injectivity; • Lead to loss of H₂ by microbial activity and consequential contamination of the stored H₂ with other gases (CH₄, H₂S, etc.) in the reservoir that are co-produced upon withdrawal from storage. As the geo- and biochemical reactions to be investigated can occur in depleted gas fields and in salt caverns, the results, as obtained in this project from experimental laboratory studies under relevant subsurface storage conditions, will be vital in further de-risking subsurface H₂ storage.

Korte omschrijving

To fundamentally study and determine the kinetics of geo- and biochemical reactions of H₂ with rocks, fluids and micro-organisms in the subsurface, the following activities are foreseen: • Laboratory experiments (high pressure/high temperature) to study reaction kinetics of (a) Pyrite reduction by H₂, and (b) synthetic Hematite reduction by H₂, (c) the H₂S scavenging potential of FeCO₃ and Fe₂O₃ in the presence of Pyrite, and (d) influence of CO₂ on reaction kinetics, at reservoir temperature and pressures and for a range of H₂ concentrations; • Laboratory experiments consisting of high pressure/high temperature anaerobic incubations to study biochemical reactions of H₂ with natural microbial consortia and relevant formation water composition to obtain relevant microbial consortia and determine the dependency of their growth and activity kinetics on temperature (40-100°C) and different H₂ partial pressures, with gas compositions with 0.5%, 5%, 10%, 50%, 100% H₂ and potentially varying ionic water composition. A Design of Experiments (DOE) approach is aimed for, allowing for upscaling the empirical data and relations obtained for application in field-scale models.

Resultaat

The main outcome of the project consists of an integrated dataset containing:

- Kinetic rates and activation energy of Pyrite with H₂ that generates H₂S and their dependence on the H₂ concentration, pH, temperature, pressure, water saturation and the presence of CO₂ (naturally present in depleted gas reservoirs, and potentially a cushion gas for pressure support) to enable assessment of the risk of H₂S generation over the lifetime of the storage site;
- Kinetic rates of reduction of hematite to magnetite by H₂, that also sequester H₂S and produce water. Rate dependence on the parameters mentioned above will be performed, to enable assessment of the risk of loss of hydrogen;
- Window of viability of the different microbial metabolisms (sulfate reduction, methanogenesis, and acetogenesis), and the community structure (DNA & RNA sequencing) of the derived microbial consortia;
- Kinetic rates of microbial growth and activity (specific growth rates, growth yields, K_s values, etc.) of the microbial metabolisms impacted by H₂ and their dependences on relevant environmental parameters (e.g. temperature, ionic composition, presence of CO₂) as expected for subsurface H₂ storage.

De data in deze applicatie is afkomstig van de Rijksdienst voor Ondernemend Nederland (RVO) en wordt in samenwerking met de Topsector Energie ontsloten.

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