Ministry of Economic Affairs and Climate Policy

Notification: 'Risk assessment of hydrogen storage in a conglomerate of salt caverns in The Netherlands'

Organization: Ministry of Economic Affairs and Climate Policy (MEA)

Reference: KEM-28 | 202111034

Purpose of the notification
The purpose of this notification is to determine whether there are parties interested to perform the research as described below.

Objective
Hydrogen is expected to become essential in the future Dutch energy system as a clean energy carrier, by assisting the integration of renewable energies and decarbonizing specific applications in hard-to-abate sectors, such as industry, mobility and the residential sector. For large-scale energy storage in the order of GWh-TWh, underground hydrogen storage (UHS) in salt caverns and porous reservoirs will be needed. Up to now there are no UHS sites in The Netherlands, but the first tests with cyclic hydrogen injection in a salt cavern are being executed.

TNO has recently made an inventory of risks associated with UHS and compared them with those of underground storage of natural gas. Possible risks of UHS that can impact the safety of the surrounding area are, among others, leakage, blow-out, geochemical and microbial processes (that can lead to e.g. formation of H_2S), and ground motion (subsidence). Further research on the following aspects is needed:

a) The long-term durability of rocks and well materials when subjected to hydrogen under an alternating pressure regime that can cause mechanical and thermal stresses.
b) Understanding whether UHS in salt caverns can interfere with nearby underground storage and/or production facilities, such as producing gas fields, interactions among salt caverns in a conglomerate used for hydrogen storage, interactions with other salt caverns used for compressed air energy storage (CAES), and interactions with geothermal projects and gas fields used for CO_2 storage (so called "stacked mining" activities).

It is thus crucial to assess the specific risks associated with UHS in a conglomerate of salt caverns and to develop strategies for management and mitigation of those risks, as well as better understand interference with other means of underground storage and/or production sites in the Netherlands that can be expected. The analysis should take into account the typical characteristics relevant to the Netherlands situation, such as type of formation, depth, pressure, temperature, rock and fluid compositions. Additionally, specific research questions should be answered focused on the use of underground hydrogen storage in salt caverns as part of the Dutch energy transition (see chapter 4. Schedule of Requirements).

Background information
There is extensive and ongoing research into risks, primarily focused on the hydrogen transport via pipelines, reusing natural gas pipelines for hydrogen transport, blending of hydrogen in natural gas, distribution of hydrogen, use of hydrogen in confined spaces such as tunnels, hydrogen production facilities such as electrolysers, and maritime applications. However, research on risks on UHS is still at early stages.

There are several recent studies that provide a good insight into the techno-economic possibilities and challenges of UHS. A recent study looking into the energy storage needs of The Netherlands towards 2050 has established that large-scale underground hydrogen storage will be required. In 2030, the storage demand will be relatively small and could be accommodated in 1-4 salt caverns. However, between 2030 and 2050 this storage need will increase drastically and could require up to 60 salt caverns and/or storage in several gas fields. For the regulation, monitoring and supervision of such long-term application and scale-up, and for the selection of technically suitable geological formations as a UHS location, basic safety criteria regarding the geological conditions should be established. Knowledge of underground geochemical and microbial processes associated with stored hydrogen and the geological conditions of the caverns, as well as geomechanical behaviour during storage, and effects of pressure and temperature are needed to assess the risks and establish their relation to safety.

Findings of the KEM-17 research project on the long-term behaviour of brine filled caverns should be taken into this assessment. The choice of exploitation parameters, including the choice of injection and withdrawal pressures, taking into account characteristics of specific salt formations in The Netherlands with high potential for underground storage, their surroundings and possible interaction, as well as individual characteristics of the caverns are of key importance.

The current knowledge about the likelihood of occurrence of ground motion (subsidence and induced seismicity), possible effects and mitigation strategies for construction, operation and abandonment of a large number of salt caverns for UHS is limited.

Research questions
The main research question is: *"What are the risks and its likelihood associated with underground hydrogen storage in a conglomerate of salt caverns for hydrogen storage in the Netherlands, either by using existing salt caverns, by developing new ones or by a combination of both options and what is the recommended strategy for risk management and mitigation?".*

This research aims at quantifying and ranking the risks based on various failure scenarios, taking into account the likelihood of their occurrence and the effects, and identifying measures to mitigate those risks. Knowledge of risks associated with natural gas and oil storage in conglomerates of salt caverns should be used as the starting point for a better understanding of hydrogen storage.

Specific research questions:

- What are the incremental effects of having conglomerates of salt caverns for UHS in the Northern and North-eastern Netherlands on the current levels of induced seismicity and subsidence, and how do they affect the stability of the existing and new to construct salt cavern field(s)? Here considerations must be given to how the brine can be processed in a safe way in case that there will be no market for such large amounts of salt.

- What are the effects on the long-term durability of rocks and well materials when subjected to hydrogen under an alternating pressure regime and what are associated risks?

- What are potential interactions between the stored hydrogen with the salt cavern itself, caprock, and the well infrastructure? Factors such as possible permeation, effects of temperature and pressure fluctuations during the cyclic operation of the storage location, and the long-term effects on the installations should be taken into account.

- What are the possible interactions of the conglomerates with other nearby underground storage and/or production facilities, such as producing gas fields, salt caverns for compressed air energy storage (CAES) and gas fields used for CO_2 storage?

- What are recommendations for risk management and mitigation? This should include design criteria for dimensions, shape and depth of new caverns, distance between caverns, surface installation considerations, interaction with other underground storage facilities such as CAES and CO_2-storage, brine processing, etc.

Deliverables expected
This research will deliver a report in four parts, answering the research questions stated above:

- A literature study on hazards and risks of UHS in conglomerates of salt caverns in the Northern and North-eastern Netherlands (focusing on the Zechstein salt layer). This should contain a literature review report and a database of (near-)accidents occurred in the construction and operation of conglomerates of salt caverns for gas and/or oil storage, identifying the causes and consequences and an analysis of the likelihood of occurrence. This review should include insights from other projects around the world (for example the salt caverns in Rudersdorf and Etzel in Germany and the salt caverns in operation with hydrogen in the US and UK). Finally, a detailed research plan, containing list of research questions, methodology and tools, and deliverables should be provided.
- Report section on a geomechanical study on the stability of the cavern field, seismicity and induced seismicity assuming that a conglomerate of salt caverns are used for storage of hydrogen and other underground storages (CAES, natural gas, CO_2) or salt cavern production.

- Report section on a quantitative, if possible otherwise a qualitative, risk analysis, in terms of health, safety and environment, related to UHS in conglomerates of salt caverns in the Zechstein salt of the Northern Netherlands.
- A recommended strategy for risk management and mitigation of conglomerates of UHS in salt caverns onshore, including criteria for spatial planning, locations of salt caverns, and design regarding dimensions, shape and depth of new caverns, distance between caverns, surface installation considerations, interaction with other underground storage facilities such as CAES and CO_2-storage and brine processing. Also, recommendations for further study in order to better asses the risks of UHS storage in conglomerates of salt caverns should be given.

The research should lead to a final report in which answers are given to the hypotheses for testing and the research questions. The final report must be an independently readable report that is suitable for external publication and should contain a description of all activities performed during the project. The report should contain sufficient details so that the results can be reproduced by a third party. Any underlying data must also be made available to the Contracting Authority. The final report must be submitted digitally in English (PDF file).

Timeline
The research will be split into two phases.

1. The first phase is the literature review, which should shape the rest of the project. The first phase will take a maximum of 3 months. Finally, a detailed research plan, containing list of research questions, methodology and tools, and deliverables should be provided. At this point a go/no go decision will be made based on the proposed research plan. Based on the quality of the research plan, methodology and tools the decision will be made to proceed or not.

2. The second phase will take a maximum of 12 months. Monthly technical progress report meetings will be planned with at least the technical team and a member of the KEM scientific panel. Additionally, KEM has two annual meetings where progress on the research will be presented.

The duration of this research is maximum 15 months.

Expertise and tools preferred for the team
- Knowledge about the Dutch subsurface and underground storage in general.
- Knowledge on salt behaviour, hydrogen storage, induced seismicity, subsidence and cavern stability.
- Experience with geomechanical modelling of (multi) cavern stability and integrity as well as wellbore stability/integrity.
- Experience with risk analysis.
- Project management.
- High proficiency in communicating (writing/speaking) in English.

Application
Interested companies / consultants, fitting the above mentioned requirements, are invited to respond to the Procurement Office of the Ministry of Economic Affairs and Climate Policy, to the attention of Jordy de Kleer by e-mail iucezteam5@rvo.nl.
You do not have to send documents, only an e-mail if you are interested.

Interested parties will receive the request for the tender by e-mail as soon as possible after the deadline for responding to this notification.

The deadline for responding to this notification is set at February 14th 2022.