Ministry of Economic Affairs and Climate Policy

Notification: 'Study within the Mining Effects Knowledge Program (KEM-39) on the cyclic storage of gases in the Netherlands'

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

Reference: KEM-39 | 202202137

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
The objective of the proposed study is to re-assess the causes of seismicity, specific risk factors including chemical processes in the reservoir, and safe operational bandwidths for reservoir storage conditions during pressure (non) cycling of underground storage of CO2, H2, and N2 in depleted gas fields.

This study is a follow-up of the KEM-01 study[1], where safe operational bandwidths were given for storage of natural gas. This research focuses on the specific issues related to the storage of other gases, such as to which extent does geochemical dissolution effects cause mechanical weakening of the reservoir or faults in the caprock? How is the formation pressure affected differently for the different types of storage fluid (fluid viscosity, density, compressibility)?

Storage of CO_2 ,H_2, N_2 in depleted gas fields may be a necessary measure in the energy transition. CO_2 storage is currently being pursued offshore (Porthos) in the Netherlands. Research on hydrogen storage is currently focused on storage in salt caverns (UHS) but also storage in abandoned gas fields will be considered in the future. Nitrogen is currently being stored in a salt cavern near Heiligerlee. The nitrogen is being used to convert high-calorific gas to low-calorific gas to be used in the Dutch households for heating and cooking. During the cyclic or more permanent storage of CO_2, H_2, and N_2, seismicity could occur depending on the geological and operational parameters and chemical reactions in the reservoir.

In this study, the factors controlling the reactivation of faults during storage of gasses is assessed for insights into the risks of energy storage. Buoyance effects or mixing effects with residual gases are not specifically taken into account for this study. This study will provide first insights in the difference between (cyclic) storage of other than natural gases on the probability of seismicity during storage.

Background information
Natural gas in the Netherlands is stored in underground gas storage (UGS) facilities to manage gas demand and supply on a seasonal and daily basis. This study focusses on the geomechanical and geochemical factors that may cause fault slippage and seismicity on faults in and around the reservoirs that are used for storage. Gas storage in salt caverns is not part of this project. Currently there are four such UGS facilities operational in the Netherlands: Bergermeer, PGI Alkmaar, Norg and Grijpskerk. Three of these reservoirs have experienced multiple seismic events during gas extraction.

[1] https://kemprogramma.nl/blog/view/33d9f684-27ef-4e30-bde0-54487d91bdd9/kem-01-geomechanical-factors-determining-fault-criticality-during-pressure-cycling-of-underground-gas-storage-in-reservoirs-finished

The reservoirs were subject to geomechanical studies before receiving storage licenses and validated storage plans.

Previous studies (see references on the final page) examined the geomechanical conditions of fault reactivation causing the observed seismicity during the depletion and re-injection phases, based on which monitoring and risk management programs were installed. The KEM-01 project has looked at the safe operational bandwidth for storage of natural gas. This project will focus on other types of gasses (CO_2, H_2, N_2) and the difference with respect to the KEM-01 study.

Research questions
The main research question is: *'Which main factors control the reactivation of faults and seismicity under permanent or cyclic storage conditions of CO_2, H_2, N_2?'*

Specific research questions:

- To which extent are the mechanisms for seismicity similar to the mechanisms during natural gas storage?
- To which extent can geochemical dissolution effects cause mechanical weakening of the reservoir or faults in the caprock?
- To which extent is the formation pressure affected differently for the different types of storage fluid (affected by fluid viscosity, density, compressibility)?
- Relate to the existing conclusions of KEM-01. Which conclusions still stand for gasses other than natural gas (CO_2, H_2, N_2)? Which conclusions change?
- Identify, if possible, generic guidelines for a safe operational bandwidth (e.g. pressure range/rates) of CO_2 (permanent and cyclic), N_2 (cyclic), H_2 (cyclic) storages in depleted gas fields.

Deliverables expected

a) Inventory of the factors causing unforeseen seismicity from global CO_2, H_2, N_2 storage operations (i.e., lessons learned elsewhere).
b) Description of the changes with respect to the KEM-01 study, underpinned with geomechanical or geochemical models where needed.
c) A report containing conceptual model results, interpretations, and underpinning deliverable a & b.
d) A recommendation toward a recipe (formulation of a ranking system) for determining safe operational bandwidth, regarding seismicity, including the main factors and their weight for the cyclic storage of H_2, and the storage of CO_2 and N_2.

Expected use
The results will be used for:
1. Insight in different risks for other than natural gas storages. This insight can be used by storage operators, the competent authority and supervisory bodies.
2. Communication to the public. The deliverables/reports will be open-access; publication of project results is encouraged.

The research should lead to a final report in which answers are given to 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 duration of this research is maximum **four months**, with the following milestones:

- Project kick-off meeting in the first month (M1).
- Project process meeting halfway through (end M2).
- Concept report on deliverables a, b, c and d in the fourth month (M4).
- Final project presentation during a KEM meeting (timing depends on half-yearly KEM meeting).

The maximum budget for this research is **€70.000** exclusive of VAT.

Expertise and tools preferred for the team

- Knowledge on the storage of natural gas, CO_2, H_2 and N_2 in depleted gas fields
- Experience with (conceptual) geomechanical modelling
- Experience with (conceptual) geochemical modelling
- Project management
- High proficiency in communicating (writing/speaking) in English

Quality assurance, Organisational and communication requirements
A representative of the KEM panel as well as a member of MEA will be involved in the progress meetings from the onset of the project ensuring continuity and reporting to the KEM panel. The project will be presented at the bi-annual KEM meeting.

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 Ms. Dzenaida Husaric 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 28TH of March 2022.

References

1. Safe operational bandwidth of gas storage reservoirs reports, Teatini et al., 2019 (KEM-01)
2. Embry, J.M., Guises, M, 2015, Dynamic geomechanical modeling of the Bergermeer Underground Gas Storage - the effect of the 150 bar scenario on fault-slip behaviour, Baker Hughes for TAQA Energy.
3. Muntendam, A.G., Wassing, B.B.T., Geel, C., Louh, M. and van Thienen-Visser, K. 2008, TAQA Bergermeer seismicity, TNO.
4. CATO and CATO-2 program (CO2 - CATO - CATO Programme)
5. Ondergrondse Gasopslag Norg seismisch risicobeheerssysteem – NAM report EP201703226547
6. Unraveling the causes of the seismicity induced by underground gas storage at Castor, Spain, Geophys. Res. Lett. 48, Doi 10.1029/2020GL092038
7. Heinemann et al. (2021), Enabling large-scale hydrogen storage in porous media – the scientific challenges, Energy Environ. Sci. 2021, 14, 853, https://pubs.rsc.org/en/content/articlepdf/2021/ee/d0ee03536j