**KEM Research Question (max. 4 pages + annex)**

**KEM-54 Interactions between salt caverns with different storage cycles**

**Objective**

*Maximum 200 characters (short description of the objective of the research question, which knowledge gap is resolved)*

The objective of this research is to investigate the stability of a cluster of caverns that could be leached asynchronously as well as be converted into storage caverns asynchronously. In the future there may be salt domes with multiple storage caverns. Gas storage salt caverns may be operated next to hydrogen storage caverns, or compressed air storage caverns or salt production caverns. All of these have their own operational envelopes and pressures. In order to asses the safety of making and operating these different caverns next to each other more knowledge about possible interactions and the stability of cavern clusters is needed.

**State of the art, background**

*Maximum 400 characters (description of state of the art knowledge, practices and flaws, including link to references documents, data, models).*

In KEM-28 a risk assessment was performed for hydrogen storage in a conglomerate of salt caverns in a salt dome. The sensitivity study clearly indicated favourable over unfavourable configurations of salt caverns for hydrogen storage. Additionally, KEM-28 concluded that there is a need to further research into the analysis of the stability of a cluster of caverns that could be leached asynchronously as well as converted into storage caverns asynchronously with different storage cycles. These can all be factors that influence the stability of a cavern field. As the behaviour of multiple caverns is governed closely by site specific information it is proposed to use salt characteristics of the Zuidwending salt dome in the north of the Netherlands.

**Research Question**

*Maximum 400 characters (what to be addressed and what not AND Link to KEM Research Agenda)*

The overarching research question is h*ow do different storage and production activities within a salt dome interact and affect the structural and containment integrity of the salt caverns over time*? Using the salt characteristics of the Zuidwending salt dome, a layout of two caverns will be modelled in 3D to address this question. The two caverns vary in size and use:

- One is a gas storage cavern, the other also a gas storage cavern
- One is a production cavern, the other a gas storage cavern
- One is a gas storage cavern, the other a hydrogen storage cavern

It is assumed that the gas caverns are operated with a seasonal cycle, the hydrogen caverns are operated at a smaller demand cycle (one per 3 months, one per month and one per week) where the cycles do not need to be fully empty/full but are determined by more realistic demand figures. The project will include activities to answer the following sub-questions.

What kind of interactions are visible?

- How does the state of stress develop between the caverns?
- What failure criteria may occur?
- Is there leakage of the stored material?
- Does pressure equalization occur?
- Is there additional permeation in the salt pillars?

What is the influence of:

- Pressure solution creep
- Threshold for pressure solution creep
- Thickness of the salt pillars between the caverns
- Dimensions of the salt caverns
- Extraction velocity (for salt production and storage caverns)
- Injection velocity (for storage caverns)
- Salt internal structure

Based on the above activities the following research questions will be addressed

1. How does the operation of different storage and production activities within one salt dome affect the structural and containment integrity of the salt dome and caverns?
2. What is the influence of …. on the stability of the salt dome
    a. Geometrical setup of the caverns
    b. Salt internal structure
    c. Extraction and injection velocity
3. What is the probability that stored products in salt caverns may leak into other caverns?

**Deliverables expected**

A final written report (in English) with a management summary preferably in Dutch. The report must include descriptions of the assumptions and models used, with a level of detail that ensures reproducibility of the results.

**Timeline**

12 months for the project work and an additional 3 months for finalizing the project within the KEM.

**Expected use**

The results will give a better insight into the stability of clusters of caverns with asynchronous production and injection cycles.

**Expertise and tools preferred for the team**

Knowledge on:
- Fracture mechanics
- Geomechnics
- Salt mechanics
- Salt behaviour
- Numerical modeling

**Quality assurance, Organisational and communication requirements**

A technical guidance group will be formed consisting of one or two representative(s) of the KEM panel ensuring continuity and reporting to the KEM panel, as well as a representant of the ministry of KGG. Progress meetings will be held at least once every 3 months. The report will be evaluated by the KEM panel. The KEM panel encourages scientific papers from the KEM projects.

The project will be presented at the bi-annual KEM meetings.

Additionally, the results of the project should be reviewed by independent researcher(s) with demonstratable knowledge on this subject, organized by the project team. The reviewer should be known at the start of the project.

**Remarks and Suggestions**

*Maximum 200 characters (extra information concerning the Innovation/Research question)*

**References**

*No limit (reference list of papers, tools and reports)*
- KEM-28 project reports (KEMprogramma.nl)