

**KEM Research Question (max. 4 pages + annex)**  
**TITLE Cumulative effects due to mining, general and in the Grijpskerk area**

**Objective**

To define and clarify the possible interactions between different subsurface activities in the northern part of the Netherlands.

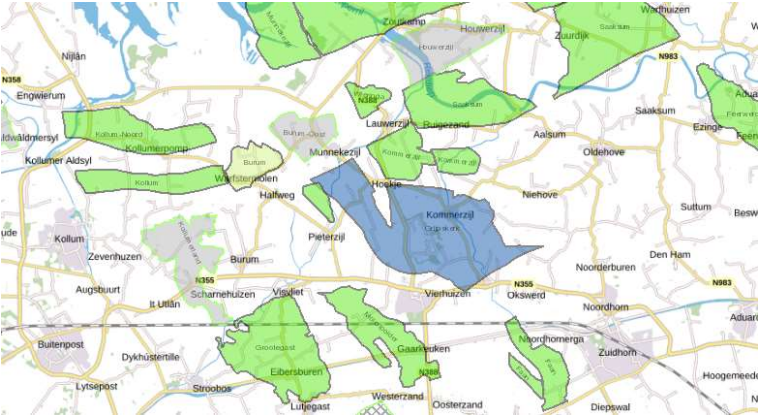
This research is defined with the assistance of some citizens in the Northern part of the Netherlands worried about the number of activities in their neighbourhood as well as the possible interaction between these activities. As such the research question will strive to give an independent answer to address these worries. The main concern of the people in the living environment is stated in the last research question: "What are the cumulative effects and interactions of the different mining activities around the Lauwers Sea trough and the interaction of the UGS Grijpskerk, the surrounding small gas fields and the Groningen gas field?"

This research aims to answer this question scientifically by defining the possible interactions between various activities in the subsurface. The research is divided in part I and part II. In part I a general answer to the possible interactions between different subsurface interactions is obtained. In part II the region close to the gas storage Grijpskerk (general "Lauwers Sea trough" area) will be studied in more detail concerning these possible interactions, including specific geology of the Lauwers Sea region (both shallow and deep, with old river beds, sand from the Wadden Sea), geological history, production locations of small gas fields and gas storage operations in the region.

**State of the art, background of the research question**

In the North of the Netherlands, many different mining activities are situated close to each other. There are many small gas fields as well as the largest gas fields in Northern Europe (Groningen), gas storages in former gas fields (Grijpskerk), the gas storage in Norg, salt production near Veendam, possible hydrogen storage in salt caverns at Zuidwending and Winschoten. For many people in the Northern part of the Netherlands, this raises the question whether effects may accumulate with undesirable consequences.

The UGS Grijpskerk (blue) is surrounded by small gas fields, such as Kommerzijl, Saaksum, Pieterzijl, Kollom , Molenpolder, Wieringa, Burum, Burum-East, Grootegast. Some are still producing, like Kommerzijl, Pieterzijl. Some gas fields are not in production anymore, like Burum East or not yet in production, like Burum. Most gas fields are produced through a number of wells per field, which may form possible pathways of gas leakage.



Source: nlog.nl

**Subsidence**

It is known that many subsurface activities, such as hydrocarbon production, salt mining and groundwater extraction, lead to subsidence. Seasonal storage may lead to subsidence-upheaval cycli. The subsidence bowls due to different subsurface activities have to be superimposed to obtain the cumulative subsidence. Different activities may have a different subsidence signature, including different subsidence areas and volumes, or evolution in time.

The gas fields cause subsidence in the Grijpskerk area which according to the latest report<sup>1</sup> on subsidence will be around 6 cm in 2030 in this area.

<sup>1</sup> <https://nam-onderzoeksrapporten.data-app.nl/reports/download/bodemdaling/nl/aa0e05c7-704a-4f9f-a02c-ea7ece904905>



Westeremden	08-08-2006	3,5
Huizinge	16-08-2012	3,6
Zeerijp	08-01-2018	3,4
Westerwijtwerd	22-05-2019	3,4

Source: KNMI database

#### Leakage

Gas fields that have a spill-over point may transfer gas from one field to a second causing additional depletion in the first gas field. Are there however more mechanisms that may cause leakage to occur from one activity to the other in the neighbourhood? What are the safe distances between subsurface activities, based upon the geology of the northern part of the Netherlands? Additionally, shallow leakages may occur due to damages to gas pipes.

SodM also recently<sup>2</sup> published a report on their website on methane leakages<sup>3</sup>. In this report, 1430 abandoned wells are examined. SodM concluded that 24 of the 1430 abandoned wells, all located in the western part of the Netherlands, could be leaking small amounts of methane due to shallow gas reservoirs, presence of methane in the subsurface and faulting. No abandoned wells in the North of the Netherlands were likely to form potential sources of leakage. In the research the technical review reports of the drilling and completion of the Grijpskerk wells have to be taken into account (for example Grijpskerk-43<sup>4</sup>).

In KEM-19<sup>5</sup> long term fluid migration, leakage risks and monitoring strategies were studied, specifically focussed on the abandonment phase of the gas fields. Part of this research was possible fluid migration along wells to the biosphere. It was concluded that a highly depleted reservoir is not a likely source of gas leakage, as long as the gas flow potential at the top of the reservoir is below the gas potential of the closest aquifer overlying the caprock. Small reservoirs with an active water-drive are more likely to lead to leakage due to the pre-pressurization of the gas after abandonment. Presence of gas at hydrostatic pressure in formations shallower than the target reservoir can however lead to methane leakage along a damaged cement sheath. The proposed risk analysis of KEM-19 can be used to assess the local wells in the Grijpskerk area (see below) for possible (future) leakages.

#### Other effects

Are there other possible effects or interactions related to mining activities? Such as interaction effects between subsurface and surface activities (gas transport and gas compression, vibrations).

#### Research Questions

##### Part I: General cumulative effects

1. What is known about the interactions between different adjacent underground activities and the cumulative effect of those interactions? Please divide it into the following topics:
  - a. Subsidence
  - b. Induced seismicity
  - c. Leakage
  - d. Other
2. What is the distance (both in depth as well as lateral) which would exclude cumulative effects between mining activities for subsidence, induced seismicity, leakage, other
3. What should be studied in more detail in phase II for the Grijpskerk area?

After part I deliverables 1-3 will be due including a project plan for phase II. The project plan should describe which research questions related to the Grijpskerk area will be studied in more detail as well as which questions can be answered using the results of phase I as well as the methods, intended results and planning of the second phase. These documents will form the basis of a go/no-go decision for part II.

##### Part II: Specific cumulative effects for the Grijpskerk area

4. What are the cumulative effects and interactions of the different specific mining activities (subsurface and surface) around the Lauwers Sea trough and the interaction of the UGS Grijpskerk, the surrounding small gas fields and the Groningen gas field?
  - a. Subsidence aspects to be considered:
    - i. Gas production from gas fields causing compaction of the reservoir, resulting in subsidence at the surface, possible liquid loading and salt creep due to changing stresses in the salt. Gas storage and groundwater extraction.
    - ii. Possible physical processes which take place during the lifecycle of the mining activities, e.g. drilling, operation and abandonment.
    - iii. Possible effects on surface waters: salinization and future sea-level rise.
    - iv. Shallow and deeper characteristics of soils (specific for the Grijpskerk region: river beds, sand from the Wadden Sea)

<sup>2</sup> [Methaanlekkages afgesloten olie- en gasputten miniem | Nieuwsbericht | Staatstoezicht op de Mijnen \(sodm.nl\)](#)

<sup>3</sup> <https://www.sodm.nl/documenten/rapporten/2022/07/20/kem-18-final-report>

<sup>4</sup> <https://www.nlog.nl/brh-web/rest/brh/document/803894003>

<sup>5</sup> [KEM-19 Long term fluid migration, leakage risks and monitoring strategies \(finished\) · KEM programma](#)

- v. Possible permanent changes in the (shallow) soil due to ultrasonic and low frequency noise vibrations caused by, for example, gas transport through transport pipes, operation of compressors, furnaces, etc.
- vi. Effects of subsidence and seismic activity on water-holding capacity of water supply aquifers.
- vii. Effect of subsidence on local infrastructure (gas/water pipes, bridges, etc.)
- b. Induced Seismicity aspects to be considered:
  - i. In what way can subsurface activities (drilling, hydraulic stimulations, workovers and abandonment) interact and cause additional stress in the subsurface, which may lead to induced seismicity?
  - ii. Is there pressure communication between the UGS Grijpskerk and surrounding small fields such as Kommerzijl and Pieterzijl that may lead to induced seismic events?
  - iii. Should seismicity occur, the rock around the seismic event would be subjected to a movement due to the seismic waves. Can this lead to interactions between different subsurface activities and fields?
  - iv. Can there be permanent changes in permeability of faults due to seismicity or fracking?
  - v. What are potential effects of pressure drawdown close to the well on nearby faults. Due to gas production, the depletion close to the well will be higher than further away in the gas reservoir. The relatively small area of lower pressure is dependent on the recovery velocity of the gas. Could this be an additional source of seismicity in the reservoir? Under which conditions? Can this be seen in the subsidence signature?
  - vi. Specifically, for Grijpskerk: could the transition from production to injection and vice versa lead to pressure changes close to the well and induce seismicity?
  - vii. Are events in the Grijpskerk area possibly induced by fracking?
  - viii. What are potential effects of specific soils in the Grijpskerk area leading to possible amplification of the seismicity signal.
- c. Leakage
  - i. Which wells in the Grijpskerk area could be potential sources of leakages? What is the risk of leakage?
  - ii. What is the expected reservoir-aquifer pressure and formation water redistribution after the abandonment of gas fields in the Grijpskerk area?

#### Deliverables expected

These deliverables are expected:

1. A literature study on the possible mechanisms of interactions among various subsurface activities, including worldwide experiences.
2. A general report on part I (research questions 1, 2 and 3), with clear conclusions and recommendations.
3. A Dutch summary of the main findings of part 1 which answers the research question in a clear and non-technical way.
4. A report on part II focussing on the Grijpskerk area and the specific questions for this area with clear conclusions and recommendations.
5. A Dutch summary of part II on the findings specific for the Grijpskerk area which answers the questions from the Dutch citizens in a clear and non-technical way.
6. Presentations on the progress of the project for the KEM panel (twice) and a final presentation for the KEM-panel (scientific) as well as other interested parties.
7. Presentation in clear language to the interested member of the environmental trajectory Grijpskerk (in Dutch *omgevingstraject Grijpskerk*), consisting of different stakeholders (citizens, spokespeople for action groups, local government) at the finish of the project.
8. Open sharing of data which contributed to this project

#### Timeline

The project will last a maximum of 18 months, 8 months for phase I and 10 months for phase II.

#### Expected use

This project will provide information about possible interactions. As the project is initiated together with people living in the Northern part of the Netherlands, they will receive answers to their questions. Additionally, the conclusions will be used by the Ministry, State Supervision of Mines, regional government, knowledge institutes.

#### Expertise and tools preferred for the team

- Knowledge of mining
- Knowledge of the Dutch subsurface
- Knowledge of gas production technology
- Knowledge of subsidence
- Knowledge on InSAR measurements

- Knowledge on seismicity
- Knowledge of shallow processes
- Knowledge of ground mechanics
- Knowledge on surface gas operation and the relation to subsurface activities

A consortium of partners with very specific knowledge will be needed to answer all research questions.

#### **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, a representative of the public, to follow progress of the project and ensure that the local questions are being addressed as well as the KEM coordinator for EZK and the KEM secretary.

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

The results of the project should be reviewed by independent researcher(s), organized by the project team.

#### **Remarks and Suggestions**

The inhabitants of the area would like to share specific observations with the research team. This file will be shared at the start of the research (including an English translation via google translate).

#### **References**

1. [Methaanlekkages afgesloten olie- en gasputten miniem | Nieuwsbericht | Staatstoezicht op de Mijnen \(sodm.nl\)](#)
2. *KEM-18* <https://www.sodm.nl/documenten/rapporten/2022/07/20/kem-18-final-report>
3. *KEM-19* [KEM-19 Long term fluid migration, leakage risks and monitoring strategies \(finished\) · KEM programma](#)
4. *Status rapport bodemdaling Noord-Nederland* (<https://nam-onderzoeksrapporten.data-app.nl/reports/download/bodemdaling/nl/aa0e05c7-704a-4f9f-a02c-ea7ece904905>)
5. *InSAR data in: Bodemdalingskaart.nl*
6. *Atlas leefomgeving*, Deep and Shallow subsidence maps