



Notification: “Monitoring requirements for CO2 storage sites on the Dutch Continental Shelf (KEM-27)”

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

Reference: KEM-27 | 202205006

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 this proposal is to provide guidance to CO2 storage operators, the competent authority and supervisory bodies regarding best practice monitoring plans for CO2 storage in offshore depleted gas fields and saline aquifers. The work should include detailed technical analysis of available monitoring tools and techniques, and the most appropriate means of applying them as part of an integrated risk management system for storage sites. The evaluation of the monitoring tools should also include potential innovations that as of yet cannot be considered best practice, but show promise with regards to their application in CO2 storage activities.

The monitoring applications covered should include, but not necessarily limit to, tools for assessing conformance, well integrity, plume migration, (micro-)seismicity and leakage detection, localization and quantification. A clear distinction should be made between monitoring strategies under normal operating conditions, and additional contingency monitoring in case of deviations from modelled behaviour. The monitoring strategies should specify baseline monitoring, monitoring during injection, post-closure and long-term monitoring after storage permit relinquishment.

Where multiple monitoring techniques can be considered, an evaluation should be made of the foreseen benefits and disadvantages of each. The approximate costs and list of suppliers should be provided for each type of monitoring tool and instrumentation. The monitoring strategies should be tailored to the specific requirement of CO2 storage in depleted fields as well as saline aquifers, and include consultation with (potential) storage operators, oil and gas service providers, the competent authority (MEA) and supervisory bodies (the Dutch State Supervision of Mines, SSM).

Background information

Monitoring is a key activity in the implementation of a CO2 storage project. Monitoring is essential to assess whether injected CO2 is behaving as expected, whether any migration or leakage occurs, and whether any identified leakage is damaging the environment or human health. A site-specific monitoring plan must be submitted by any project developer during the application for a geological CO2 storage permit. The requirements of CO2 storage permits and monitoring plans for CO2 storage projects in Europe are covered by a limited number of national, international and European legislative acts.

The applicable regulation for the monitoring of CO2 storage sites does not prescribe the use of specific monitoring tools and techniques, but requires the operator to apply the prevailing ‘best practice’ at the time of operation. So far there is limited experience in the monitoring of CO2 injected into depleted gas fields. Monitoring of CO2 injection has taken place at the K12-B gas field in the Netherlands,



where primarily pressure and temperature were monitored, but also tracers were used. In this case the amount of CO₂ injected was relatively small (80 ktCO₂). While the K12-B project can be considered a success, the scale of the project and the injection strategy (low pressure gas phase) is not comparable to the planned large-scale CO₂ storage projects which will involve high-pressure (liquid) CO₂ injection. There have been monitoring plans developed for the P18-4 gas field in the Netherlands, and also the Goldeneye gas field in the United Kingdom, however these projects have as of yet not been implemented. In addition, CO₂ storage operations in saline aquifers, both onshore and offshore, as well as CO₂ enhanced oil recovery operations have already been performed (e.g. Sleipnir and Snøhvit in Norway) and can therefore provide useful insights into appropriate monitoring techniques. Moreover, there are expected to be a number of tools and techniques developed for conventional oil and gas production which can be adjusted/adapted for application in CO₂ storage projects.

Both a lack and a shortage of 'best practices' for monitoring of injected CO₂, for depleted gas fields and saline aquifers respectively, may lead to delays during the permitting process. This work is therefore particularly important for the competent authority in assessing whether a monitoring plan submitted as part of a CO₂ storage license application is fit for purpose. Accordingly, a comprehensive evaluation of the efficacy as well as the associated costs of different monitoring tools, will assist with determining effective and balanced monitoring plans which do not lead to excessive costs to the operator.

Research questions

- **Task 1: Technical review of monitoring tools and techniques**

Conduct a comprehensive technical review of the range of potentially suitable monitoring tools and techniques for CO₂ storage in depleted offshore gas fields and saline aquifers. Provide an elaborate textual overview as well as a schematic overview of their purpose, application, costs, advantages and disadvantages (such as practicability or expected data quality). The review should include market ready and high-Technology Readiness Levels ($\geq$ TRL6¹) monitoring techniques. The technical review should encompass all facets of monitoring and include, but not necessarily limit to, conformance monitoring, well integrity, plume migration and leakage detection, localization and quantification including seabed and environmental monitoring. In addition, monitoring tools and techniques for detecting (micro-)seismicity and accurate localization of seismic (micro-)events should be included, hereby taking into account the possibility of deploying a local network of seismometers. Where innovative monitoring techniques are to be considered, recommendations on future R&D actions and testing should be given.

- **Task 2a: Recommendations for monitoring plans in depleted gas fields**

Based on the findings from Task 1, recommendations should be made for appropriate monitoring plans for CO₂ storage activities in offshore depleted gas fields. The recommendations for monitoring plans should cover at least all aforementioned facets of monitoring (conformance monitoring, well integrity, plume migration, leakage detection, localization and quantification, seabed and environmental monitoring). Monitoring plans should contain recommendations regarding (micro-)seismic acquisition instruments, configurations and modus operandi. Clear distinctions should be made between baseline-

¹ TRL6 refers to a technology that has been demonstrated in a relevant environment



monitoring (pre-injection), monitoring during injection, monitoring post-closure and long-term monitoring. In addition to a 'base-case' monitoring plan, a set of hypothetical, but realistic storage site risks (or site non-conformance) should be provided, for example the monitoring of legacy wells, spill-points, potential fault reactivation, induced or triggered seismicity and suspected leakage to the marine environment. Recommendations should be made for contingency monitoring in case of deviations from modelled behaviour or scenarios involving suspected leakage or induced seismicity. Moreover, the report should include a scenario that includes offshore wind turbines and related infrastructure (e.g. cables, substations) above or close to a CO₂ storage site, taking into account the additional risks and operational limitations this might pose. Total cost indications should be given for each of the proposed monitoring plans.

- **Task 2b: Recommendations for monitoring plans in saline aquifers**

Due to potentially larger uncertainties in the containment of CO₂, separate recommendations should be made for appropriate monitoring plans for CO₂ storage activities in offshore saline aquifers. Similar to Task 2a, a 'base-case' monitoring plan as well as a set of hypothetical, but realistic storage site risks (or site non-conformance) should be provided. Distinctions should be made between standard operation and contingency monitoring, and between the baseline, injection, post-closure and long-term monitoring requirements. Total cost indications should be given for each of the proposed monitoring plans.

Deliverables expected

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).

- a) Report on Task 1
- b) Report on Task 2

Expected use

The final documents will be used in discussion between storage operators, the competent authority and supervisory bodies for the identification of appropriate monitoring plans for CO₂ storage sites. Recommendations on innovative technologies will be used in policy developments by the competent authority to target R&D developments through policy intervention.

The deliverables/reports will be open-access; publication of project results is encouraged.



Timeline

The duration of this research is maximum **12 months**, with the following milestones:

- Project kick-off meeting (M1)
- Project inception report (M1)
- Project progress meeting (M4)
- Task 1 review meeting (M8)
- Task 2 review meeting (M11)
- Final project presentation (M12)

The maximum budget for this research is **€ 250.000** exclusive of VAT.

Requirements

Companies/consultants meet at a minimum the following requirements:

- Professional proficiency in communicating (writing/speaking) in English.
- Verifiable experience with offshore CO2 storage (CCS) projects.

Moreover, it is preferred companies/consultants meet the following requirements:

- Practical experience with offshore activities (for example: the production of oil and gas and preferably, CO2 storage activities)
- Familiarity with instrumentation used for controlling offshore activities (including pressure and temperature monitoring, seismic surveys, well integrity monitoring and seabed monitoring techniques).
- Familiarity with the legal requirements for monitoring plans for CO2 storage (in particular EU Directive on the geological storage of CO2 2009/31/EC).
- Familiarity with risk management assessments.

NB. A consortium of companies and research institutes may be necessary in order to acquire the relevant expertise. If you cannot perform the contract independently, there is the option to submit an offer in cooperation with other companies. An offer can be submitted in cooperation with other companies in two ways:

- Either as a partnership ('combination') in which each partner is individually and jointly and severally liable for the performance of the obligations arising from the offer as well as any performance of the agreement. Your offer must show who the consortium leader of the partnership is, who the partners are and who may act as authorised representative towards the contracting authority.
- Or as main contractor-subcontractor construction in which the main contractor acts as the contracting party and is liable for performing all obligations, so including the obligations that are subcontracted. Your offer must show who the subcontractors (third parties) are.

We would like to hear whether you intend to submit an offer. If possible, we would like to hear upfront whether you intend to submit an offer in collaboration with other parties and which other parties.

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 Mr. Ramon van Dijk by e-mail at iuc.accountezk@rvo.nl.

You do not have to send documents, only an e-mail if you are interested. The procedure following up this notification will be determined based on the number of interested parties.

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 June 17th, 2022.

References

1. Bacci, V.O., O'Brien, S., Frank, J., Anderson, M., 2017. Using a Walk-away DAS Time-lapse VSP for CO2 Plume Monitoring at the Quest CCS Project. Shell Canada, Calgary, Canada.
2. European Commission, 2016. Commission Opinion of 20.1.2016 on a draft permit for the permanent storage of carbon dioxide in the depleted Goldeneye gas condensate field located in blocks 14/28b, 14/29a, 14/29e, 20/3b, 20/4b and 20/4c on the United Kingdom Continental Shelf, in accordance with Article 10(1) of Directive 2009/31/EC of 23 April 2009 on the geological storage of carbon dioxide. C(2016) 152 final, Brussels.
3. Harris, Kyle, Don White, Dave Melanson, Claire Samson, and Thomas M Daley, 2016. "Feasibility of time-lapse VSP monitoring at the Aquistore CO2 storage site using a distributed acoustic sensing system." International Journal of Greenhouse Gas Control, 2016: 248-260.
4. IEAGHG; Review of Offshore Monitoring for CCS Projects; 2015/02. July, 2015
5. Mikunda, T & Dixon, T. 2017. Review of Project Permits under the London Protocol – An Assessment of the Proposed P18-4 CO2 Storage Site. Energy Procedia, 2017, V.114, 7431-7442
6. Vandeweyer, V.P., van der Meer, B., Hofstee, C., Mulders, F., D'Hoore, D., Graven, H., (2011). Monitoring the CO2 injection site: K12-B. Energy Proc. 4, 5471-5478.
7. Fugro; Safety Study CCS and offshore wind farms (2022) - Project Technical Outline. Commissioned by Ministry of Economic Affairs and Climate Policy.