OFFSHORE NORGE

Input to GD 1:

CO_2 Storage Life Cycle Risk Management Framework

24th Feb 2023

Reference to text in Guidance Document / general comment:
General
Proposed changes:
Repeated reference is made to DNV report CO2AQUASTORE report from 2010 for risk management approach. However, there are several more recent documents where risk management for CCS is discussed. This includes RP DNVGL-RP-J203 from 2017 which includes the 2010 DNV document but also incorporates CO2WELLS –"Guideline for the Risk Management of Existing Wells at CO2 Geological Storage Sites (2011)." Additional standard where risk management is presented is ISO 27914:2017.
Justification:
Importance of a standard on the overall risk management approach of CCS projects.

Reference to text in Guidance Document / general comment:
TOC
Proposed changes:
Mismatch between chapter/section numbers in the body of the document to section/chapter numbers given in the TOC.
Justification:
N/a

Reference to text in Guidance Document / general comment:

GD 1 / Page 41 (as marked in the document) / Figure 3

Proposed changes:

More Guidance could be provided on how to define a risk matrix for CO2 storage (how to define the two axis)

Justification:

This would facilitate alignment between the CA and CO2 store operators

Reference to text in Guidance Document / general comment:

The pressure impacts and pressure interferences between various uses of the subsurface (including various CO2 Storage projects) in the same formation are not tackled by the Guidance Documents 1 & 2. Although the EU CCS directive has four mentions of hydraulic connections In Article 3, Article 9, Annex 1/Step 1 and Annex 1 /Step 2, GD1 does not address hydraulic units. As such how interferences between several operators within the same hydraulic unit is not addressed, nor the associated risks. Section 4.1 and 4.4: Pressure interferences between projects or various uses of the subsurface is not on the list

Proposed changes:

Guidance on how to practically evaluate the risks of pressure interferences, how the CA should anticipate the issue when making acreage available for licensing and how technical and legal challenges are to be addressed should be included in GD1 & GD2.

Justification:

Modeling hydraulic areas as part of the 3D model is highly challenging, as they can cover a significant fraction of the North Sea for some aquifers (Utsira in Norway, Gassum in Denmark, Bunter in UK for example) and contain various users (geothermal, other CCS project, HC production) with unknown current or future injection / extraction activities. Further, storage sites with possible pressure connection challenges either to third party activity (geothermal activity) or between different CO2 storage licenses have been identified.

Reference to text in Guidance Document / general comment:

"shall ensure that no conflicting use of the storage complex is allowed with other uses." + "During the characterisation phase the operator will carry out a characterisation and assessment of the potential storage complex and surrounding area " + "include cross-border implications"

Proposed changes:

Assessments of risk for a given storage site need to account for pressurization influence of existing neighboring stores that share the same Hydraulic Storage Pore Volume. i.e. shall take the pressure effects of already allocated Storage Resources for other subsurface Storage Sites into account.

Justification:

There is a need to understand the regional pressure effect local injection could have on neighboring licenses - can impact risk assessment in terms of containment risk, and induced seismicity etc. The pressure footprint extends much further (and faster) than the CO2 plume

Reference to text in Guidance Document / general comment:

Pages 10 and 25

Proposed changes:

"However exploration activities may usually be required for storage saline aquifer options." To avoid ambiguity remove “usually”.

"For saline reservoirs, an exploration program is usually likely to be required, which could take several years (depending on the level of available data and specific geological characteristics of a site), with expenditure that may cost up to several tens of millions of Euros (depending on local drilling and seismic costs)." Replace "usually likely" with “may”.

Justification:

The text gives an impression of significant exploration requirements and long evaluation times for saline aquifers. This may often be true but should not be generalized (cf. page 18 GD2).

Reference to text in Guidance Document / general comment:

pg 10, pg 25 ++ repeated mention of "injection tests" to characterize dynamic response of storage reservoir e.g pg 10

Proposed changes:

'Dynamic response of reservoir can be assessed by either injection or production test. Injection tests will often be simpler, but many factors are at play as to which type of test will be best suited

Justification:

Testing the dynamic reservoir response through either injection or production tests is associated with different pros and cons, both technical and cost and safety. The wording in GD1 implies that only injection testing should be considered.

Operationally it is much simpler and cheaper to perform an injection test (no requirement for artificial lift equipment in well when producing from hydrostatically pressured reservoir, no requirement for test equipment on rig, no disposal issues, no potential sanding-in issues ++). In an ideal world then the dynamic reservoir response information that can be obtained from both types of test should be the same (injection/production of brine in a brine filled reservoir). However, it can be argued that there are potentially more issues with the injection test that can lead to poorer quantification of the actual reservoir response. This includes:

- changing mobility in reservoir as injection progresses (difference in temperature and so viscosity of brine being injected compared to reservoir brine)
- issues with accessing the entire interval that has been drilled – likely that will not be injecting into the entire interval since no clean-up of perforations or of mud filtercake is performed prior to injection. Injection profile will not simple be governed by KH-profile and estimating what interval(s) have been tested may be quite difficult unless some other type of logging/investigation is performed afterwards.

Reference to text in Guidance Document / general comment:

Table 1; Footnote 8

Proposed changes:

Remove footnote 8

Justification:

Unnecessary, misleading since a 2-year period also possible for saline aquifer

Reference to text in Guidance Document / general comment:

Table 3

"No fluid flow data about reservoir performance will exist. Hence, significant testing of the reservoir will likely be required to estimate the long-term performance characteristics prior to final commitment to develop the site"

Proposed changes:

Injection performance may be unknown, and testing of the reservoir may be required prior to final commitment to develop the site.

Justification:

Aquifer quality may be well known. Unclear how testing will help to estimate *long-term* performance of the *reservoir*. The topic seems to relate to injectivity performance.

Reference to text in Guidance Document / general comment:

A clear distinction should be drawn between leakage / discharge to the surface and a leak from the storage complex that is still safely sequestered in the ground.

Proposed changes:

Leakage should be only used if there is an environmental or public and safety risk. Consider applying terms like migration out of storage complex or seepage (or similar) to characterize leaks that do not reach surface or fresh-water aquifers.

Justification:

CO2 can be safely stored within an aquifer outside of the storage complex but still considered as leaked. The term leakage could be negatively perceived by the public and limit public acceptance of CCS projects.

Reference to text in Guidance Document / general comment:

Activities and roles during LC phases - phase 3: site development. " Site development by the operator would be expected to take place when a storage permit is in place."

Proposed changes:

'use of the word "would" here suggests that drilling of wells and placement of infrastructure could be performed prior to granting of storage permit.

Justification:

reword so that any construction/installation cannot normally be started prior to granting of storage permit

Reference to text in Guidance Document / general comment:

section on "trapping types" '"buoyancy trapping, residual saturation trapping, dissolution, mineralisation and adsorption. The first two mechanisms are most important at timescales up to 100 years, whereas

dissolution and mineralisation processes will be important in very long term timeframes (1,000's -100,000+ years) and sensitive to site characteristics "

Proposed changes:

'needs some rewording

dissolution trapping can occur at quicker rates - and in some storage concepts this may be one of the most important trapping mechanims during the actual injection phase of project... i.e. with down dip injection in saline stores then structural trapping and residual trapping only become more important post injection cessation

Justification:

need to quantify contribution and timing of each trapping/storage mechanism to better quantify risk and propose effective MMV and risk mitigation strategies

Reference to text in Guidance Document / general comment:

'"geotechnical" appears several places in document

Proposed changes:

'is this the correct wording ? Would "geological" and/or "geomechanical" be more appropriate here ?

Justification:

In O&G business then geotechnical often has a separate specific meaning - more for shallower sections. However, in mining and other "shallow engineering" disciplines then these are often interchangable

if use of geotechnical is continued in document then it should be defined somewhere in the document(s)

Reference to text in Guidance Document / general comment:

3.2.2 "Role and Importance of saline aquifer" section title "Role and Importance of saline aquifer"

Proposed changes:

'remove "role and importance. Section should be titled "Saline Aquifer" to be aligned with other section naming for this chapter

Justification:

Reference to text in Guidance Document / general comment:

table 4 pg 31 "Depends on fracture gradient in caprock and pressure build-up in storage reservoir."

Proposed changes:

do not use poorly defined "fracture gradient" term. Maximum pressurization limit should be limited by minimum principal stress

Justification:

minimum principal stress shall be used to set pressure limits for safe injection. This is basis/common practice for safety design in Norsok D-010 for well integrity in drilling and well operations .

FG is poorly defined and is a system property that depends upon many factors. Minimum principal stress is a bulk formaction property

Reference to text in Guidance Document / general comment:

5.4.3 phase development "Baseline monitoring of the storage complex should be conducted and assessed to help determine whether the monitoring results during the injection phase are irregular. "

Proposed changes:

'what about baseline monitoring of natural seismicity ? may need much longer time period to determine this natural background behavior.. Better guidance required here

Also: GD1 Document should perhaps discuss the level of acceptable risk regarding seismicity (e.g., the level of seismicity onshore vs offshore)

Justification:

Being able to correctly differentiate between Induced seismicity vs natural seismicity. Connects to societal acceptance and acceptable operational parameters.

Reference to text in Guidance Document / general comment:

GD 1 / Multiple pages

Proposed changes:

Remove multiple repetitions in the document and reduce as much as possible the document length. For instance the definition of CCS is spelled out twice in the very first pages.

Justification: the document contains several repetitions creating lengthy and confusing sections.

Reference to text in Guidance Document / general comment:

GD 1 / Multiple pages

Proposed changes:

Keep the document focused on the scope and remove generic sections:

1. e.g., the chapter 3 “Life Cycle Framework for CO2 Storage Projects” could be simplified focusing on risk management only
2. e.g., the chapter 4 “Geological Context for CO2 Storage in Europe” could be simplified and to a larger extent refer to existing materials with similar information.

Justification: Some sections contain very general information that are not specific to the GD1 scope.

Reference to text in Guidance Document / general comment:

GD 1 / Section 2. Legislative Context

Proposed changes:

Define what constitute an insignificant irregularity

Justification:

Only significant risk is defined

Reference to text in Guidance Document / general comment:

GD 1 / Section 3.2 (among others)

Proposed changes:

Remove unnecessary descriptors and simplify the text.
e.g. Remove “extensive” from “This phase involves extensive detailed studies by the operator to define the geological framework of the storage site and complex and its surrounding area…”

Justification:

Simple is better

Reference to text in Guidance Document / general comment:

GD 1 / Section 3.2: Phases – Phase 4 Operation).

Proposed changes:

Clarify if requirement of yearly routine and non-routine inspection can be met via a CA approved inspection management system with inspection visits remaining on exemption basis.

Justification:

Yearly routine inspections are required during operations phase

Reference to text in Guidance Document / general comment:

GD 1 / Section 3.2: Phases - Milestone 4: Closure; document page 19

Proposed changes:

"The costs for this are expected to be taken from the appropriate financial security instrument(s) provided by the operator as a condition for the storage permit."

Re-phrase as: "The costs for this are covered from the appropriate financial security instrument(s) provided by the operator as a condition for the storage permit"

Justification:

According to the Directive, these costs are covered from the financial security

Reference to text in Guidance Document / general comment:

GD 1 / Section 6.2.1 Risk Identification and Assessment

Proposed changes:

A structured risk assessment should be conducted for both containment and induced seismicity risks.

Justification:

Hazard characterization does not cover induced seismicity

Reference to text in Guidance Document / general comment:

GD 1 / Section 3.2: Phases – Milestone 5: Transfer of Responsibility

Proposed changes:

Re-phrase as: Transfer can occur when the earliest of two conditions is met: (1) all evidence indicates the storage is permanent; (2) a fixed number of years (at least 20) defined by the CA have passed since the end of injection.

Justification:

Post-closure monitoring and transfer of responsibility is discussed. A “minimum period” of 20 years is referenced between the end of injection and the transfer of responsibility. However, it is not a minimum period if “all available evidence indicates that the stored CO2 will be completely and permanently stored.”

Reference to text in Guidance Document / general comment:

GD 1 / Section 2.3, phase II, page 9, second paragraph

Proposed changes:

Rewrite sentence to allow a broader range of storage options to not require exploration activities “in oil and gas fields” from the following sentence:
“Exploration activities may be required for any type of storage option. In some cases, they may not be necessary for storage options in oil and gas fields,”

Justification: Well data and even reservoir tests could exist in dry wells that are not tagged as "oil and gas fields".

Reference to text in Guidance Document / general comment:

GD 1 / Section 2.3, phase IV, the box on page 12

Proposed changes:

Rewrite with far simpler wording and better use of punctuation marks. Particularly the second last two sentences in the last paragraph.

Justification: Unnecessary complexity

Reference to text in Guidance Document / general comment:

GD 1 / page 20, last paragraph

Proposed changes:

Specify if the storage potential in UK and Norway is for the North Sea, and consider to include a better estimate for the storage capacity for Norwegian saline aquifers.

Justification:

It is unclear whether the capacity in Norway has been fully mapped as Norway was not really a part of the European GeoCapactiy study and the Norwegian Sea also has a large potential.