DET NORSKE VERITAS

Energy Report
Review of report TNO-034-UT-2009-02024: Inventory of potential locations for demonstration project CO_2 storage

Ministerie van Economische Zaken

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Summary:

This report contains a review of f the updated TNO report "TNO-034-UT-2009-02024: Inventory of potential locations for demonstration project CO_2 storage." This review was commissioned by "Interdepartementale Projectorganisatie CCS ('poCCS')".

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1 REPORT SCOPE AND OBJECTIVE

The Project Organisation CCS (poCCS) from the Ministerie van Economische Zaken (Min. EZ) in the Netherlands has mandated Det Norske Veritas (DNV) to assess the methodology that has been used by TNO to select and rank Dutch gas fields for CO_2-storage in a demonstration project. Based on an initial review, the comments made by DNV were sent to TNO, upon which they issued an updated report. This report evaluates the updated report: "TNO-034-UT-2009-02024: Inventory of potential locations for demonstration project CO_2 storage", dated 28th October 2009.

DNV is coordinating a Joint Industry Project (JIP) which develops a guideline that shall serve as a reference document for project developers and authorities for selection and qualification of sites for geological storage of CO_2. According to this guideline, the objective of the work by TNO corresponds to the pre-feasibility phase, i.e., the first part of the initial screening stage. The objective of the screening stage is defined as follows:

> "Site screening should evaluate the potential for CO_2 Geological Storage in a selected region. The screening process aims to identify sites that may be suitable for CGS with an adequate level of certainty to enable the decision to invest in further site assessment. To this end, the level of uncertainty in capacity estimates and other relevant storage performance parameters for the selected sites should be estimated and documented.
>
> The deliverable from the screening stage should be a screening report with a list of identified storage sites that, based on a preliminary high-level site evaluation, are anticipated to serve as secure sites for long term storage of CO_2. Any site from this list should be eligible for further characterization."

The TNO report only covers the initial part of the site screening, for which the purpose may be expressed as follows: "*identify a sufficient number of candidate storage sites so that the likelihood of not finding a suitable storage site among the identified sites is very low.*" The focus here is to determine if the prospective sites satisfy specified screening criteria, which should include criteria relevant for assessing containment, capacity, injectivity and monitoring potential. Further site characterization activities will then be needed to assess the suitability of these sites for geological storage of CO_2.

The TNO report has applied the following screening criteria:

1. Oil or gas field (onshore or offshore) in the Netherlands
2. Availability for CO_2 storage by end of 2012 at the very latest
3. Storage capacity between 0.5 and 10 Mt CO_2
4. Cost effectiveness (determined mainly on distance between source and sink)
5. AMESCO criteria for capacity, containment and injectivity, as well as surface features and uses
6. Accessibility for adequate monitoring and well intervention
7. Options for combining smaller and larger fields
8. Transport routes and timing (timely matched capacity between source and sink)

In the next section we will comment on the appropriateness of these criteria how they have been assessed. Finally, in Section 3 we interpret the results of the screening study and evaluate to what extent the TNO report can be regarded as successful in meeting the objective of the pre-feasibility phase: "identify a sufficient number of candidate storage sites so that the likelihood of not finding a suitable storage site among the identified sites is very low."

2 COMMENTS ON SCREENING CRITERIA ASSESSMENT

1. DNV regards Criteria 1-2 to be reasonable with regard to the objective that this project should serve as a demonstration project with start of injection in 2013. Indeed, this short timeframe strongly suggests that only well characterised sites, such as depleted oil and gas fields, should be considered.
2. *Criterion 3 (Storage capacity)*: The capacity constraints are motivated by the fact that the capacity should be large enough to allow injection of 0.2 Mt per year for at least two years, and small enough to "maximise the learning curve of the demonstration project, including all stages of storage." This may suggest looking for a pair of sites, where one of the sites – the primary site – should have relatively low capacity so that it could be "filled up" in a few years, and a secondary back-up site to continue injection after the primary site is full. The maximum of 10 Mt capacity is then primarily relevant for selection of the primary site, and less important for selection of the secondary back-up site. The statement that "substantial learning has to be obtained by 2015" may also suggest that the primary storage site should have effective capacity significantly less than 10 Mt, perhaps less than 2 Mt.
3. *Criterion 4 (CO_2-efficiency)*. This criterion reflects that the project should have a maximum climate benefit, which relates to the overall objective of CCS. In the report, CO_2-efficiency is reflected by the transport distance (and implicitly by the energy needed for CO_2 compression along the pipeline). However, at the onset of this project it was decided by poCCS that this criterion should be called cost-effectiveness. The reasoning for this was that the ultimate objective of this criterion was that the cost of the demonstration project should not be too high, i.e., should allow the project to go ahead in a commercially viable way with financial support from the government.

   Whereas cost-effectiveness of potential candidate storage sites will normally be used to differentiate candidate storage sites at a later stage in the screening process, DNV agrees that it is appropriate to introduce cost-effectiveness as a screening parameter for this type of demonstration project. Furthermore, based on the assumption that the existing infrastructure (wells) can be re-used at the storage site, it is appropriate to use pipeline transport distance as a key indicator for cost-effectiveness. This criterion led TNO to define a 150 km limit on the transport distance since they assess the cost of building and operating a 150 km pipeline as an upper limit on the costs that could be justified for this type of demonstration project. DNV supports this assessment.

   DNV would like to note, however, that the implication of this constraint is that less potential candidate sites will be identified. The appropriateness of this constraint should therefore also be measured against the objective to "*identify a sufficient number of candidate storage sites so that the likelihood of not finding a suitable storage site among the identified sites is very low.*" If it is assessed that this objective is not met, then it should be considered if it is necessary to relax the transport cost threshold and expand the scope of study.
4. *Criterion 5 (AMESCO criteria):* The AMESCO criteria applied provide examples of typical screening criteria, although it can be debated whether the criteria with regard to surface features and land use are relevant to consider at the screening stage. DNV would argue that the land use above reservoir should not alone disqualify otherwise good sites (with adequate capacity, containment, injectivity and monitoring potential) unless risks have been identified

that have direct consequences for the local environment on the surface. Such assessments would generally be made later in the site characterization. Similarly, the significance of proximity to vulnerable objects (in terms of risks of negative impact) would generally be assessed at a later stage, and cannot be assessed based on the gathered data for this study.

Furthermore, as indicated by TNO, the ranking of the various criteria relative to other sites generally needs to be based on site specific evaluations. The primary value of the AMESCO criteria is that they allow identification of the site-specific features that may need to be subject to further assessment in order to assess suitability for CO_2 storage.

5. *Criterion 6 (Monitoring potential):* This criterion is considered especially important for a demonstration project, as it will be important to be able to monitor how the site performs. TNO points out that this implies that sites with two accessible wells should be preferred. DNV would state this stronger, i.e., that sites should have at least two accessible wells, one for injection and one for additional monitoring. This implies that for sites with only one well accessible there is a need to consider drilling a new well, implying potentially higher costs. TNO argues that the drilling of new wells is not a realistic option for the demonstration project due to the cost involved. This implies that sites with only one accessible well should be disregarded as potential candidates for the demonstration project based on this criterion.

   DNV agrees that monitoring on surface, e.g., using geophysical techniques such as surface seismic response surveys, should not be a priori mandated – the project developer should need to demonstrate the adequacy of the monitoring programme. However, the accessibility for surface monitoring is one of the key parameters for assessing monitoring potential and should therefore be considered in the pre-feasibility study. Indeed, this may be particularly relevant for assessing the suitability of sites for demonstration projects in the Netherlands.

6. *Criterion 7 (Combining fields)*: This criterion is particularly relevant for this study, as it is stated that "the learning curve of a demonstration project preferably should include all the stages of storage, from initial injection into a depleted gas field until the maximum allowed pressure will be reached, when injection will cease and the storage site may be closed and further monitored." This indicates a preference for choosing a "primary" site with "low" capacity and a "secondary" back-up site which can be used when the low capacity has been filled up, i.e., subject to the constraints for safe and responsible site management.

7. *Criterion 8 (Transport routes & timing):* This criterion partly overlaps with Criterion 2, but also considers availability of transport routes and back-up sites.

3 EVALUATION OF PRE-FEASIBILITY ASSESSMENT

The screening exercise performed by TNO meets the general level of detail for a pre-feasibility study and DNV finds the conclusions in the TNO report to be generally sound and justified. TNO concluded that the following two combinations appear to meet all the screening criteria applied:

1. Barendrecht with Barendrecht-Ziedewij.
2. P6-South with P6-D.

The Min. EZ may evaluate if this result meets their expectations, or if they would like the scope of the study to be expanded, e.g., by increasing the 150 km limit on transport distance. It should be noted, however, that since the sites have served as gas-reservoirs, it is highly likely that it can be demonstrated that they will provide good containment of CO_2 provided they are properly managed. The question is more whether the Min. EZ is satisfied with having limited the number of potential candidate sites for the demonstration project to only two.

Sites that do not meet the screening criteria may still be well suited for geological storage of CO_2. The intention behind such screening criteria is to rapidly narrow down the options in order to more quickly identify the best available options with regard to the purpose at hand. In this case, the objective has been to identify the sites that are best suited for a demonstration project in the Netherlands with start of injection in 2013 at the latest. DNV finds that the screening criteria applied are appropriate for this purpose.

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