ZEP response to DNV's call for inputs to support the revision of the CCS Directive Guidance Documents

The submitted recommendations are based on the Zero Emissions Platform (ZEP) 's 2022 report "Experience in developing CO2 storage under the Directive on the geological storage of carbon dioxide" which highlights how the Guidance Documents could be made simpler, clearer and easier to use so as to support the work by regulators and project developers. The full reasoning behind the proposed recommendations is laid out therein.

We also call your attention to the ZEP 2010 report on the 'Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide', which contains earlier input to the Guidance Documents.

ZEP's response is supported by the Carbon Capture and Storage Association (CCSA), which brings together a wide range of specialist companies across the spectrum of Carbon Capture, Utilisation and Storage (CCUS) technology, as well as a variety of support services to the energy sector. The CCSA exists to represent the interests of its members in accelerating the commercial deployment of CCUS in the UK, EU and internationally through advocacy and collaboration to achieve net zero emissions by 2050.

Revision requests and their rationales for GD1:

We recommend that the Guidance Document (GD) 1 is updated on the subject of the information required from potential operator, including

a) the requirements potential operator(s) need to comply with in order to be proven technically competent for CO2 storage operation, and
b) the related evaluation criteria. Notably, the competent authorities (CA) should be fully transparent on the requirements that potential operator(s) need to submit to successfully demonstrate technical competence.

This could be supported by providing a detailed list of essential requirements and evaluation criteria that form the basis for their review. The details of the organisation – roles, legal entities, etc., which are typically not established at the early stage when application takes place – must not interfere with the more technical application.

Revision requests and their rationales for GD2:

We would like to recommend the following updates to GD 2.

On the characterisation of the storage site and complex:

- It is recommended that CAs engage from an early stage and regularly in the development of storage projects, specifically in relation to the definition of the boundaries of the project (i.e., storage site and storage complex), which, albeit defined in the Directive, are largely site specific, and regarding their acceptance (or otherwise of the operator's) containment assessment.

- New projects need to consult with ongoing projects. There should be the right to object to activities impacting the viability of an ongoing project (e.g., pipelines, power cables, wind farms, etc.). The Dutch North Sea Agreement ("Noordzeeakkoord") may provide a good structure to manage different uses of the Dutch North Sea sector.

On CO_2 purity and injection:

- The CA should clearly communicate the functional requirements for storage operations from the beginning – e.g., the type of maximum allowed pressure (initial, hydrostatic, etc.) and its reference (depth), and the expected pressure safety margin – taking into account site-specific geomechanical assessments and modelling.
- The GD should describe the considerations and possible limits that might apply for different aspects of the CCS chain, including corrosion and safety issues.
- As a definitive standard for CO_2 specifications cannot be established (and should therefore be agreed on a case-by-case basis), the GD should advocate for possible limits to certain impurities for Health, Safety & Environmental reasons, but leave the operability of the CO_2 stream to the projects. The purity of the CO2 stream should have a technical operational basis, not a legal or permitting basis.

On the required permit documents and updates:

- There is a need for a certain level of flexibility regarding potential updates of (interim) permit documents at a later stage, once new data becomes available (i.e., shortly after the commissioning phase). This may include changes to the monitoring plan, following improved insight in the storage system derived from early injection and monitoring data. Once again, mutual trust based on frequent communication between the CA and the operator will be a prerequisite for a successful permit application. Moreover, early engagement is essential to provide clarity (e.g., on the required level of detail in the interim documents/plans) and guidance where needed and to avoid misunderstandings and delays.

On seismicity and monitoring:

- EU-wide approved CCS-specific technical standards are generally very limited or not existent. It would be useful if the GDs could provide support by discussing the applicability of standards from other related activities. Relevant topics include well abandonment, seismic risk analysis and monitoring. The bow-tie risk assessment, for example, appears to be well suited to CO_2 storage projects.
- The sections on monitoring in the GDs could also discuss the level of acceptable risk (e.g., the level of seismicity onshore vs offshore).
- It would be beneficial to clarify the difference between "significant deviations" and "significant irregularities", as this will be critical to the design of monitoring and corrective measures plans.
- GDs could be updated regarding monitoring, taking on board recent advances, namely, on attribution monitoring – a suite of techniques for surface and near-surface monitoring that allows to determine whether anomalies of CO_2 emissions to atmosphere or water column arise from the stored CO_2 or from another origin such as biogenic sources. This is important because, as it is written, when monitoring under the Directive suspects a leak, it then triggers monitoring under the ETS Directive to quantify emissions, whether or not they are from the CO_2 storage site (Dixon

& Romanak, 2015[1]). It is therefore suggested to add an attribution step in the process before triggering quantification monitoring, adding the following text to GD2 (new text in **bold**):

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"Environmental monitoring for leakage out of the storage complex towards, at or near the surface, on land or offshore:

- **Detection of suspected leakage anomaly;**
- **Attribution of anomaly;**
- Quantification of leakage **(if attributed to the CO_2 storage project)**;
- Accounting and quantification of emissions from the storage complex for surrender of emissions trading allowances for any leaked emissions under EU ETS Directive 2003/87/EC **(if attributed to the CO_2 storage project)**;
- Safety and Environmental impacts **(if attributed to the CO_2 storage project)**."

Figure 5 – Monitoring Plan Elements (page 96)

"Environmental (Leakage)

- **Detection of suspected leak or anomaly**
- **Attribution of anomaly**
- Leak quantification
- Emissions/ETS impact
- Safety & Environmental impacts"

Figure 6 – Different methods and techniques suitable for monitoring (page 98)

"Environmental Onshore

- Leak and Anomaly Detection
    - …
    - Eddy covariance tower
    - **Attribution of anomaly**
    - **Isotopic analysis**
    - **Chemical tracers (natural and artificial)**
    - **Process-based method**
- …

"Environmental Offshore

- Leak **and anomaly** Detection
    - CO_2 flux and concentration monitoring

[1] Dixon, T., & Romanak, K. D. (2015). Improving monitoring protocols for CO_2 geological storage with technical advances in CO_2 attribution monitoring. *International Journal of Greenhouse Gas Control*, *41*, 29-40. https://doi.org/10.1016/j.ijggc.2015.05.029

- ...
- **Attribution of anomaly**
  - **Isotopic analysis**
  - **Chemical tracers (natural and artificial)**
  - **Stoichiometric methods**
- ..."

Page 103 (onshore)

"In near-surface systems on land, CO_2 fluxes and concentrations are determined by uptake of CO_2 by plants during photosynthesis, root respiration, microbial respiration in soil, deep natural outgassing of CO_2 and exchange of CO_2 between the soil and atmosphere (Oldenburg & Unger, 2003). Any surface leakage of CO_2 from a manmade CO_2 storage reservoir needs to be distinguished from the variable natural background (Oldenburg & Unger, 2003; Klusman, 2003a, c; **Dixon & Romanak, 2015**). Analysis of stable and radiogenic carbon isotope ratios in detected CO_2 can help this process, **also chemical tracers (natural and artificial) and process-based methods**. Most techniques require calibration or comparison with baseline surveys made before injection starts, e.g. to determine background fluxes of CO_2 emissions."

Revision requests and their rationales for GD3:

We would like to recommend the following updates to the GD3.

On the transition from the production of hydrocarbon to future CO_2 storage activities:

Depleted hydrocarbon reservoirs are becoming highly attractive for CO_2 storage projects. Therefore, the transition from previous production to future CO_2 storage activities needs to be planned in an appropriate manner.

Even after hydrocarbon production has ceased it can still be quite costly to maintain a platform – and even more to upgrade facilities to make them ready for CO_2 injection. Moreover, at the end of hydrocarbon production, rapid removal is always beneficial, as the older the platform the more corrosion takes place on legs and topsides. Finally, the safest well is a plugged and abandoned well. As a result, there production operators prefer to remove infrastructure as rapidly as possible. This is, however, is at odds with the desire to adapt multiple platforms and wells for CO_2 storage service in an orderly and planned way.

Three potential cases/situations can be distinguished, each leading to specific recommendations:

- When the current operator aims to stop its current activities in the current production license area
  - The intent of the current operator shall be reported to the CA upfront, such that other plans (e.g., re-use of existing infrastructure instead of decommissioning) can be made (depending on cost efficiency) and slack can be avoided.
  - The CA needs to decide on which liabilities sit with the asset owners and which belong to production or storage license holders- this is relevant for the period spanning between production cessation and the start of the storage license.
  - GD1 and GD2 recognise that "the availability of data from oil and gas exploration and production is advantageous for the characterisation of sites for storage, provided the data and knowledge of field performance are available for the storage activities". It follows that

a clear pathway needs to be developed such that future storage operators can access the information required to undertake site appraisal activities (e.g., re-use of wells, well maintenance records, annulus pressure data, reservoir performance, etc.).

- When the current operator intends to continue its activities, and start a CCS-project
    - The existing joint-venture partners need to be asked upfront to agree to give the production license back or become partners on the new project. Should existing partners do not want to continue, the State might decide to step in (or alternatively find new partners) by taking over their shares to ensure further progress in CCS.
    - In case of competition between the current operator and interested third parties, the CA needs to have smart strategy to evaluate all available project plans and therefore ensure that the permits are granted based on objective, transparent and non-discriminatory criteria.
    - Somewhat more clarity is needed on the priority given to exploration license holders – it must be clear that a storage exploration permit cannot be awarded or held for a potential storage site that is already producing and part of an existing production permit.
    - Where a store is in a different stratigraphic interval, questions start to arise around decommissioning of wells that potentially penetrate the store. It is recommended that Member States consider the consequences of overlaps and make it clear where responsibility lies for zonal isolation so that storage potential is not damaged. It is recommended that competition shall be limited to open acreage, or returned production license areas, but never for potential storage sites inside existing production licenses (in the same stratigraphic interval), to ensure no conflicting uses of areas with granted licenses.
- When the current operator is blocking the current license
    - It is recommended that operators holding production licenses are asked to annually publish their plans (or lack of plans) for CO_2 storage for every field.
    - A guideline should be published to provide advice on how to manage a field, and its abandonment, including subsurface isolation strategies as well as data acquisition recommendation.

On closure and transfer of responsibility to the competent authority:

Different storage sites have differing risk profiles. The difference in the risk profiles of the various storage types show that the criteria for transfer of responsibility should primarily be based on technical merits (i.e., elements of evidence showing that CO_2 will remain safely stored) rather than on a minimum period. It should be noted that the characterisation process, combined with monitoring during operation, is designed to reduce the chances of catastrophic leakage to near zero. It is highly likely, therefore, that closure and handover can proceed much faster than the indicated 20 years.

Thus, the following updates are recommended:

- Using a criteria-based approach rather than a time-based approach for determining when the transfer of responsibility can take place. Instead of establishing minimum periods, it would be more helpful if the GD could lay out the framework in the context of the relevant risks, so that the CA agrees first the criteria for demonstration of permanent storage and then agrees the format of the post-transfer to the state monitoring, if any.
- The competent authority should discuss and agree with the operator the criteria for the demonstration of permanent storage on a case-by-case basis, examining the evolution of

containment risk over time, and the effect of conformance and containment monitoring during project life on constraining the forecast bounds of the risk evolution.

Revision requests and their rationales for GD4:

On GD4, ZEP and CCSA would like to recommend the following updates.

On Financial Securities:

According to the Directive (and GDs), storage operators must set up a Financial Security (FS) to meet the obligations of the permit, and which should be valid before the start of injection, after closure and until the transfer of responsibility. The FS should cover the costs of permit requirements, both expected (e.g., monitoring during operations) and unexpected (those that arise in case of leakage or significant irregularity, e.g., implementation of corrective measures). The main issue with the FS is that its amount can vary a lot depending on interpretations. If a Member State requires a large FS, to be provided almost exclusively by the operator, this can constitute a barrier for smaller operators and increase the cost of CO_2 storage for society as a whole. The biggest issue in determining the correct range of amount in the FS is in dealing with the unexpected requirements (by design, with low or very low probability). Thus, it may be necessary to have different instruments for the "expected" and the "unexpected" parts. It is recommended that:

- The operator should set up insurance schemes that include public and private funding. If that is not possible, the operator should calculate the size of the fund based on a percentile of costs and not on expected values.
- FS should be fit for the type and likelihood of risk and flexible regarding type, timing, and amount and take into account taxation impacts. Independent expert review should be available for determining FS amounts (including review of risks). The type of FS should be defined by the operators in consultation with the CA.
- Adding clarity on the FS responsibility where projects have multiple participants in addition to the operator or multiple operators (see below).
- A thorough investigation of the insurance schemes offered by insurers, focusing on whether such offer meets the criteria described in the GD and would be available to operators. Sufficient access to these products will be essential for storage operators.
- National governments should have a robust and independent review of the risks and impose risk criteria for low-probability events.

Reflecting the nature of storage operators:

We note that a storage facility can be operated by more than one operator (e.g., a joint-venture (JV)); however, the description of financial securities appears to assume that only one company will operate a storage site. It should be clarified whether the described approaches to financial securities are also appropriate for joint-venture partnerships. Consideration should be given to the allocation of responsibilities across the JV partners as well as to the changes that trigger a review of financial securities (e.g., in the description of section 2.7 g)).

Adding a definition:

There is a missing definition in the Directive – 'Associated surface and injection facilities'. It would be very helpful if a definition could be added to GD4. ZEP and CCSA can recommend the following definition:

> 'Associated surface and injection facilities' means the well bores, the equipment inside the wells used for injection or monitoring of CO_2 and the wellheads. These make up part of the storage site until the wells are eventually sealed and the wellheads and casing down to regulated depth removed. These do not include any equipment or installations beyond the wellheads since these play no part in sealing CO_2 underground.

On the treatment of CO_2 storage in deep saline formation and depleted hydrocarbon reservoirs:

Finally, GD3 and GD4 have assumed storage in new deep saline formations (also known as virgin aquifers) rather than the possibility of depleted hydrocarbon reservoirs. For clarification, interpretation and to help avert a competent authority from 'over-interpreting' the GDs for application to depleted hydrocarbon fields, it is suggested to insert the following text in GD3 (at the end of the last paragraph in page 1) and GD4 (at the end of the last paragraph in section 1):

> "Note that the examples given in this guidance document are based upon CO_2 storage in a deep saline formation. Storage in depleted hydrocarbon reservoirs present a different risk profile and are likely to be easier to prove secure and permanent storage as required in the Directive Article 18.2(a-c), for example the Competent Authority may be able to agree a shorter minimum period for post-closure responsibilities and transfer of responsibility, as allowed for in the Directive Article 18.1(b)."

About the Zero Emissions Platform

ZEP is the advisor to the EU on the deployment of CCS and CCU – a European Technology and Innovation Platform (ETIP) under the European Commission's Strategic Energy Technologies Plan (SET-Plan).

ZEP supports the European Union's commitment to reach climate neutrality by 2050, defined as net-zero greenhouse gas (GHG) emissions by 2050. To this end, CCS technologies represent readily available and cost-efficient pathways for the decarbonisation of industrial and energy sectors in the European Union. Some applications of CCU – where CO_2 is stored in a manner intended to be permanent – can also contribute to this goal.