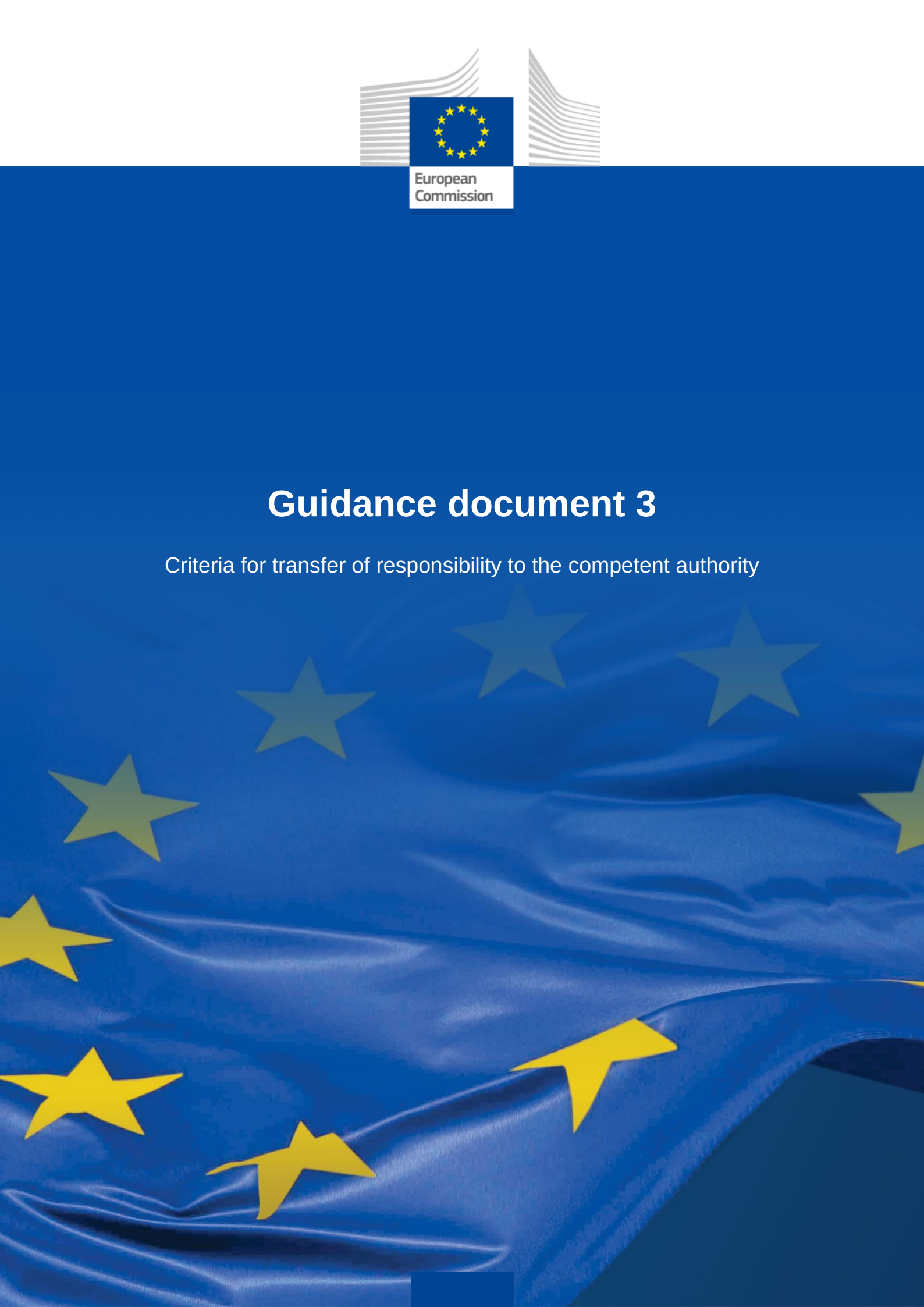
European Commission

Guidance document 3

Criteria for transfer of responsibility to the competent authority



EUROPEAN COMMISSION

Directorate-General for Climate Action

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Guidance document 3

Criteria for transfer of responsibility to the competent authority

Directorate-General for Climate Action

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The aim of this guidance document is to contribute to a better understanding of the requirements of Directive 2009/31/EC on the geological storage of carbon dioxide. It has been prepared by the European Commission on the basis of the views and knowledge provided by stakeholders. The purpose of this guidance is explanatory and illustrative. It does not create any rights or obligations.

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Contents

1. Revision history

Key changes since the previous version
• Clarifications on obligations that are being transferred. • Clarification on interpretation of the terms ‘permanence’ and ‘long-term stability’. • Guidance added on how to reach agreement on a shorter closure period. • Guidance added on transfer requirements for sites not principally relying on structural trapping. • Clarifications on requirements for monitoring facilities for site sealing.

2. Purpose and scope of guidance documents

This guidance document (GD) forms part of a set of guidance documents as follows:

- Guidance document 1: CO_2 storage life cycle and risk management framework;
- Guidance document 2: Characterisation of the storage complex, CO_2 stream composition, monitoring and corrective measures;
- Guidance document 3: Criteria for transfer of responsibility to the competent authority;
- Guidance document 4: Financial security and financial contribution.

The aim of these GDs is to improve understanding of the requirements of Directive 2009/31/EC on the geological storage of carbon dioxide (the 'CCS Directive') and give indications on how it can be implemented. They should therefore facilitate a correct and uniform application of the CCS Directive across the EU. The guidance does not represent an official position of the Commission and is not legally binding. The binding interpretation of EU legislation is the exclusive competence of the European Court of Justice that can make final judgments concerning the interpretation of the CCS Directive.

GD 3 addresses transfer of responsibility from a site operator to the competent authority or authorities of Member States under Article 18(1) for 'all legal obligations relating to monitoring and corrective measures pursuant to the requirements laid down in the CCS Directive, the surrender of allowances in the event of leakages pursuant to Directive 2003/87/EC and preventive and remedial action pursuant to Articles 5(1) and 6(1) of Directive 2004/35/EC'.

Note: See GD 1, Section 2.4, for interpretations of the main defined and non-defined terms used in the CCS Directive.

3. Legislative context

After a storage site is closed, the operator remains liable for monitoring, reporting, taking corrective measures and surrendering allowances in the event of leakage, until these obligations are transferred to the competent national authorities in accordance with Article 18 of the CCS Directive.

This guidance clarifies the following obligations:

- Article 18(1)(a), 18(1)(d) and 18(2)(a)-(c): Submission of a transfer report documenting that the following conditions have been met:
    - all available evidence indicates that the stored CO_2 will be completely and permanently contained;
    - the storage site has been sealed and the injection facilities have been removed;
    - the actual behaviour of the injected CO_2 conforms to the modelled behaviour;
    - there is no detectable leakage;
    - the storage site is evolving towards a situation of long-term stability.
- Article 18(1)(b): A minimum period determined by the competent authority has elapsed. This minimum period is to be no shorter than 20 years, unless the authority is convinced that the criterion in 18(1)(a) is met before the end of that period.

4. Guidance on compliance with legislative requirements

4.1. Article 18(1)(a): Complete and permanent containment

This section provides guidance on the interpretation of Article 18(1)(a) by clarifying what may be required to demonstrate permanent containment and to meet at least the three conditions listed in Article 18(2):

a) the actual behaviour of the injected CO_2 conforms to the modelled behaviour;

b) there is no detectable leakage; and

c) the storage site is evolving towards a situation of long-term stability.

Note: Third-party certification of CO_2 storage is an emerging field. Such certification can help establish confidence that storage complies with the conditions for transfer of responsibility. The CCS Directive does not prevent the competent authority from outsourcing evaluation of compliance to third parties. Nor does it suggest that operators should seek third-party certification as part of the process for transfer of responsibility.

4.1.1. Article 18(2)(a): Conformity with models

Any assessment of containment permanency will be based on models and observations obtained through monitoring. The models and monitoring used to demonstrate compliance with Article 18(2)(a) should have been approved by the competent authority as part of the storage permit and subsequent updates (see GD 2), in accordance with Articles 9 and 11. The modelling and monitoring should provide sufficient understanding of the containment performance of the storage complex to assess its future development with a high degree of confidence. The acceptable margin of conformity between models and observations should take account the modelling approach and site-specific characteristics, and may be decided by the competent authority in consultation with the operator. Since the behaviour of the injected CO_2 will be influenced by other activities going on in the same hydraulic unit, the competent authority should ensure that site operators have enough data about other activities to accurately model the CO_2 behaviour and the response of the storage complex. The following guidance can help determine compliance with Article 18(2)(a).

- **Model validity.** A model can be considered reliable and valid if:
    - recent history-matched models have provided forward predictions that match, to an acceptable margin, observed behaviour within estimated uncertainty ranges for key containment performance parameters; and
    - backcast predictions obtained using the final history-matched dynamic models are consistent, to an acceptable margin, with the observed behaviour throughout the project.
- **Model changes.** The competent authority should review the changes made to the model and the model's projections over the last few years before the transfer to verify that the model has been able to match recent history without significant

changes to either the static geological model or the dynamic model derived from the static model.

The static geological model should remain significantly unchanged for 5 years prior to transfer. This 5-year period may start before closure (definite cessation of CO_2 injection). The operator should specify the range of uncertainty in the key parameters for the static geological model. Altering key parameters outside the specified range of uncertainty would constitute a significant change to the model.

Significant model changes are changes that alter the understanding of the storage complex containment performance and corresponding flow, geochemical and geomechanical behaviour in ways that invalidates any of the results of previous risk assessments for the storage project. Tuning model parameters such as permeability, porosity, elastic properties or rock strength properties in ways that do not substantially alter the understanding of the performance of the storage complex is not considered to be a significant model change. An example of a significant change would be the introduction of a previously unmapped fault into the static geological model that either impacts capacity through compartmentalisation or represents a previously unidentified leakage pathway.

The judgement of significant change should be based on the characteristics of the individual storage complex, the specific nature of the change and developments in scientific knowledge about site characterisation and dynamic modelling.

- **Modelling projections.** Modelling projections should demonstrate that the CO_2 will remain contained through various trapping mechanisms in the storage complex over the modelled time period, and that there is no significant risk of future leakage[1]. To this end, it should be demonstrated that model realisations indicating a significant risk of future leakage can be rejected with confidence. The operator must demonstrate a trend showing that historical model predictions for key parameters, such as CO_2 plume migration, CO_2 dissolution and pressure, match observations within acceptable uncertainty ranges. It must also demonstrate that the need to recalibrate static and dynamic models to achieve an adequate history match has been reduced or eliminated. The acceptable range for the various parameters should take account of site-specific characteristics and may be decided by the competent authority in consultation with the operator.
- **Documentation.** Documentation of the predictive capability of the models and history matching for the storage site should cover:

[1] In the CCS Directive, 'significant risk' means a combination of a probability of occurrence of damage and a magnitude of damage that cannot be disregarded without calling into question the purpose of the Directive for the storage site concerned. The 'magnitude of damage' that can be caused by individual leakage risk scenarios is site-dependent, and includes both the possible amount of leakage that can occur related to the risk scenario and the impact on human health or the environment resulting from the possible leaked amount. While this GD does not make a distinction between the possible impact of leakage in on- and offshore environments, the nature of the impact on human health and the environment is generally different.

- how monitoring data have been collected and interpreted, including measurement errors and confidence intervals for all monitored parameters;
- how site-specific geological models and the associated geomechanical, geochemical and flow simulation models have been calibrated through history matching and other adjustments; and
- how site performance has evolved relative to the predictions, based on available monitoring data. This could include:
    1) injection pressures and volumes at each injection well;
    2) the measured pressures throughout the storage complex;
    3) the vertical and horizontal location and movements of any CO_2 plumes;
    4) changes in the composition of formation fluids and geochemical reactions that have occurred with rocks in the storage complex;
    5) changes in processes within the storage complex that impact the security of storage, such as dissolution and mineralisation;
    6) any observed earth deformation and seismicity;
    7) an interpretation of the fate of displaced formation fluids; and
    8) a description of the estimated fraction of injected CO_2 that is trapped by the various trapping mechanisms, i.e. structural buoyancy trapping, residual saturation trapping, dissolution, mineralisation and adsorption.

4.1.2. Article 18(2)(b): Absence of any detectable leakage

A key aspect of containment is that there is no detectable leakage from the storage complex, including leakage through geological or man-made pathways (see GD 1). ‘Detectable’ is interpreted to mean ‘can be detected by direct monitoring observations based on the approved monitoring plan or can be inferred from modelling that conforms to monitoring data’ in line with GD 1 (Section 2.4).

All monitoring technologies have limitations in terms of spatial and temporal resolution and sensitivity to changes. Therefore, approval of a monitoring plan implicitly gives approval to an accepted detection limit. While a broader or more extensive monitoring programme may improve this limit, it comes at additional cost. The approved monitoring plan for evaluating compliance with Article 18(2)(d) should therefore be clearly set out in the updated and approved post-closure plan in line with Article 17(3)(a) and (c).

There should be no detected leakage for a 10-year period immediately before the time of transfer. This period can start before closure (definite cessation of CO_2 injection). The operator can present a case to the competent authority for a shorter period if a leakage event has occurred during an extended period with no other leakage, and there is very low likelihood of future leakage along the same pathway. This could apply, for instance,

if leakage occurred during a well workover operation or well abandonment operation, and the well has subsequently been properly sealed.

The specific metrics for determining the absence of leakage from the storage complex would need to be selected by the competent authority, in consultation with the operator based on site-specific characteristics. Examples of metrics that could be used by operators to assess the absence of detectable leakage include:

- well integrity - no well integrity issues[2];
- overburden monitoring - no sign of abnormal or unexpected pressure or other conditions associated with leaks to zones above the storage complex;
- conformity monitoring - no detection of any remaining CO_2 plume outside the storage complex or outside any structural barrier within the storage complex;
- groundwater and biosphere[3] monitoring - no detection of CO_2 above expected natural levels.

The absence of leakage should be determined relative to a pre-project baseline, or, if leakage has occurred, a baseline representing the state of the environment 10 years prior to the evaluation of compliance with Article 18(2)(b). The baseline should provide a reference against which project performance is measured. The baseline should identify and describe receptors that may be impacted by leakage so that changes attributable to the storage project can be differentiated from changes that are not attributable to the project. The baseline may include characterisation of receptors outside the storage project area that are exposed to environmental factors similar to those that exist within the area.

4.1.3. Article 18(2)(c): Evolution towards long-term stability

Evolution towards a situation of long-term stability may be indicated when:

a) modelling of continued evolution of the storage complex (dispersion of any remaining CO_2 plume, pressure influence from the storage project, and geochemical reactions) does not show any significant risk of future leakage of CO_2 or negative effects on human health or the environment[4]; and

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2 For wells that have not been sealed following closure, well integrity issues can be detected by well logs or geophysical monitoring technologies (e.g. seismic, electrical, gravity or electromagnetic surveys). Well integrity issues for wells not available for entry can be detected by groundwater and biosphere monitoring.

3 ISO 27914:2017 defines the biosphere as the ‘realm of living organisms including the atmosphere, on the ground surface and in soils, in oceans and seas, in surface waters such as rivers and lakes, and in the subsurface above the storage complex’.

4 Evolution towards a situation of long-term stability includes situations where a CO_2 plume continues to move or disperse, but where there is confidence that trapping mechanisms will be effective, i.e. there are no significant risks of future leakage or negative effects on human health or the environment.

b) key monitored parameters are within a predetermined range or trend of the future stable values (as predicted by modelling).

Model realisations indicating a significant risk of future leakage should be rejected with confidence. Sensitivity studies exploring alternative model realisations should be performed, with a firm conclusion that model realisations indicating possible leakage are improbable. Further changes in any remaining CO_2 plume should not lead to contact with new potential leakage pathways for which confidence in barriers to leakage has not been firmly established, such as legacy wells without verified well barriers. For geochemical modelling, the emphasis should be on providing evidence to exclude the possibility of geochemical reactions with wells or sealing geological formations that might have a material impact on the risk of leakage. Pressure in the injection zone will generally be on a declining trend after injection has ceased. This also implies the risk of leakage caused by pressure influence to, e.g. wells and faults will be gradually reduced.

The key monitored parameters that should be considered for assessing evolution towards long-term stability are:

- pressure within the storage complex;
- movement of any remaining CO_2 plume and residual CO_2 saturation; and
- integrity of materials used to construct or seal the wells.

The acceptable range of further changes for key monitored parameters should be determined by the operator on a site-specific basis, and noted at the time of the storage permit, subject to any required changes based on actual operational history (i.e. to account for any corrective measures, updates, etc.). Evidence must also be provided to the competent authority to show that corrective measures carried out during the operation and post-closure periods will remain effective after transfer.

4.2. Article 18(2) Transfer report

The transfer report should include a description of all the parameters monitored during the post-closure, pre-transfer period and should be based on the updated post-closure monitoring plan (see GD 1). Table 1 shows documentation that the competent authority may require operators to supply in the transfer report to show that the condition in Article 18(1)(a) has been met.

Table 1: Required documentation in transfer report.

Evidence for complete and permanent storage	**Required documentation from the operator**
Conformity with models	1) For at least a continuous 5-year period immediately before the transfer, there has been no need to significantly change the 3D static geological model assumptions for the characteristics of the storage complex during history matching exercises incorporating parameters monitored at regular intervals.

	2) Demonstration that backcast and forecast predictions obtained using the final history-matched dynamic models are consistent with observed behaviour, where any observed discrepancies do not impact confidence in storage security.
Absence of any detectable leakage	For at least a continuous 10-year period immediately before transfer, show that: integrity of all wells (monitoring and injection) remains without any leaks or unexpected deterioration or damage; monitoring data based on the approved monitoring plan indicates that there is no leakage.
Evolution towards long-term stability	The models project stability of any remaining CO_2 plume within the storage complex. Key monitored parameters are within a predetermined range of the future stable values.

The time frames given in Table 1 are indicative and need to be specified by the competent authority. The time periods referred to may start before the closure of the site. In addition to the documentation listed in Table 1, the transfer report may also provide the competent authority with a final summary of the geological storage activities that have taken place in the storage complex for posterity. This could include the following items (based on Chadwick et al., 2006 and ISO 27914):

- narrative history of the storage site activities, including site characterisation, injection facility construction, operations, any corrective measures, and monitoring;
- a revised, finalised storage complex characterisation report, including information from the final static and dynamic models, and a description of historical storage performance relative to iterative predictions from modelling and simulations;
- a quantification of the modelled contribution of the various trapping mechanisms[5] to deliver permanent containment at the time of transfer and evolution in the future;
- an updated project risk database showing how individual risk scenarios have evolved throughout the project, including a description of the reasons for upgrading or downgrading risks; and
- compilation of results and conclusions drawn from monitoring, modelling and risk assessments to help demonstrate that the criteria for transfer of responsibility have been met, including proof that applicable trapping mechanisms are effective and that injection facilities have been removed.

Many of the items listed above may be reported to the competent authority as part of the annual reporting as required under Article 14. In that case, the transfer report could refer to the appropriate annual reports (put in an annex).

[5] Structural buoyancy trapping, residual saturation trapping, dissolution, mineralisation and adsorption.

4.3. Article 18(1)(b) Minimum period for post-closure monitoring

Article 18(1)(b) of the Directive states that the post-closure, pre-transfer phase should be at least 20 years, unless the competent authority is convinced that all available evidence indicates that the stored CO_2 will be completely and permanently contained before the end of that period. On the other hand, the authority can always determine a longer period than 20 years if it considers this appropriate.

To facilitate a possible handover prior to the end of a 20-year post-closure period, it is suggested that the operator specify in the post-closure plan quantitative key performance indicators used to measure compliance with the criteria for transfer (Article 18(1)(a) and 18(2)(a)-(c)). These indicators should be discussed and agreed with the competent authority. This can be done as part of the evaluation of the provisional post-closure plan (in accordance with Article 7(8) and Article 9(7)) and its subsequent update and approval prior to closure in accordance with Article 17(3). The quantitative key performance indicators should be based on the site-specific context and consider: (i) the evolution of containment risk over time; and (ii) the effect of modelling and monitoring during the project on constraining the forecast bounds of any residual leakage risk.

4.4. Article 18(1)(d) Site sealing and removal of injection facilities

The updated post-closure plan should contain details of how a site should be sealed and how injection facilities at the site should be removed[6]. However, the transfer report may note any additional changes to this updated plan based on any new information gathered on the approach to the site sealing and removal of the injection facilities.

Under Article 18(3), the draft decision approving the transfer of responsibility must specify the method used for determining that the site has been sealed and injection facilities have been removed. The draft decision must also specify any updated requirements pertaining to Article 18(1)(d) (e.g. transfer of data and any other legal issues). The competent authority may consult the operator and may approve a method suggested by the operator if the authority considers it suitable for determining compliance with the conditions in Article 18(1)(d), as well as any updated requirements for the sealing of the site and the removal of injection facilities.

The following requirements should be considered when determining if the site has been properly sealed:

- Any well under the responsibility of the operator which penetrates the storage complex, or which has been identified as a CO_2 migration risk, and which will not

[6] The CCS Directive does not explicitly specify any requirements for removal of monitoring facilities. The competent authority may decide or request that certain monitoring facilities or wells are not removed or sealed so that they can be used for post-transfer monitoring in accordance with Article 18(6).

be used for post-transfer monitoring should be sealed using appropriate best practices and materials[7]. The sealing of wells should take into account possible geochemical reactions and geomechanical effects that could have an impact on the integrity of well materials. Guidance on evaluating legacy wells as part of site characterisation, including legacy decommissioned wells, is provided in GD 2 Section 3.3.7.

- The monitoring facilities to be maintained in order to continue monitoring beyond transfer or for other nearby storage sites should be determined based on the final site-specific risk assessment. This should weigh the potential leakage risk from any penetration of the seals above the injection zone against the potential risk reduction from maintaining the monitoring facilities.

The competent authority will be responsible for carrying out any post-transfer monitoring and verification. The financial contribution (see GD 4) must cover at least the cost of any such monitoring and verification for a period of 30 years after injection ceases. Monitoring facilities that will not be used post-transfer should be removed and the surface areas reclaimed.

4.5. Transfer of data and models

In connection with the transfer of responsibility, the operator will have to transfer data about the site to the competent authority. This is in addition to the information in the transfer report. There are no specific provisions on data retention and ownership in the CCS Directive.

Issues regarding data retention, availability and ownership will need to be resolved by each Member State and should be set out in the storage permit. Some data and analysis will be provided to the competent authority as part of the regular reporting requirement. However, once the responsibility is transferred to the competent authority, it is expected that the operator will also hand over all of the relevant documents and raw data (including core samples, drill cuts, construction material samples, and other key material samples extracted from the site).

Member States may also set requirements and procedures for transfer of relevant models, including the final static and dynamic models. This will enable the competent authority to make well-informed intervention decisions post-transfer if required, or to make the models available to other operators working in the same hydraulic unit, or who may perform such work in the future. To this end, the Member State should clarify time

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[7] Member States may review and use existing abandonment procedures for oil and gas wells, if they are deemed sufficient. Such practices are described in documents such as NORSOK D-010:2021 *Well integrity in drilling and well operations*, and ISO 16530-1:2017 *Petroleum and natural gas industries* - Well integrity - Part 1: Life cycle governance. Additional guidance specific to abandonment of wells for CO_2 storage operations can be found in ISO 27914:2017 – *Carbon dioxide capture, transportation and geological storage* – Geological storage Clause 7.8, DNV-RP-J203 *Geological storage of carbon dioxide*, Section 7, and OEUK *Guidelines: Well Decommissioning for CO_2 storage*, 2022.

frames for ownership of proprietary models in line with intellectual property and commercial competition rules.

In setting time frames for proprietary ownership of data, Member States should balance the rights of the operator against the potential to help to improve knowledge of reservoirs and their performance over time, based on commercial rules and/or applicable practice in the oil and gas industry. Within the European Union, the competent authorities in each Member State could also consider exchanging data with each other in order to learn from experience in other countries.

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