Review of different regulatory frameworks and how they have dealt with long-term predictability

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Outline

1. Background
2. Demonstration of CO$_2$ Safety
3. Well Abandonment
4. Overall Abandonment Steps and Transfer of Liability
5. Current Review of the EU CCS Directive
1. Background

“International regulatory requirements on CO₂ geological storage and site abandonment” in the CO₂CARE project.

The main objective of this document is to present the regulations covering carbon dioxide storage with a special focus on CO₂ storage site post-abandonment period.
CO\textsubscript{2} storage regulations reviewed

**International regulations**

London Convention and the London Protocol
OSPAR Convention, OSPAR Decision 2007/2 update allowing for CO\textsubscript{2} storage
OSPAR Framework for Risk Assessment and Management of CO\textsubscript{2} Streams in Geological Formations (FRAM)

**EU regulations**

EU Directive 2009/31/EC and the accompanying guidance documents
National legislation including
  - UK’s Storage of Carbon Dioxide (Licensing etc.) Regulations 2010
  - Spain’s CCS Act 40/2010
  - Danish CCS Bill
  - draft legislation
  - Norwegian Pollution Control Act (1981, 1996)

By 2013 all MS notified transposing measures and complete transposition in the majority of MS (now conformity check)

7 MS partial non-communication of transposing measures (AT, CY, HU, IE, SE & SI: reasoned opinion in November 13; PL: reasoned opinion in April 14)
CO₂ storage regulations reviewed

Regulations in the USA

EPA Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide Geologic Sequestration Wells (2010); Interstate Oil and Gas Compact Commission (IOGCC) CO₂ Storage; World Resources Institute Guidelines for CO₂ Capture, Transport, and Storage (2008); Legislation from the states of Washington, Wyoming, Texas, North Dakota, Louisiana and Montana

Australian regulations

Australian Regulatory Guiding Principles for CO₂ Capture and Geological Storage; Offshore Petroleum Amendment Bill 2008 and associated Impact Statement and guidelines; Victoria onshore and offshore legislation; Queensland Act and Regulation; New South Wales Bill

Canadian regulations

2. Demonstration of CO₂ safety post injection

There is great variation in how prescribed this stage is by the regulators. Requirements include:

- The monitored CO₂ plume is behaving as expected compared to model predictions
- No leakage is detected
- The CO₂ plume is stable or evolving towards stability
- No environmental problems
- Integrity of the injection well
- Integrity of wells within the area of impact

To meet these requirements it is necessary to carry out a combination of monitoring, modelling and risk assessment activities.
2. Demonstration of CO₂ safety post injection

Conclusions

Modelling, risk assessment and monitoring

- There is large variation in the requirements between the regulations.
- It is standard to require approval as part of a plan submitted to the authority. This allows the authority flexibility in what it requires as technology improves and experience is gained.
- However, prescribing what is required from monitoring, modelling and risk assessment provides the operator with a clearer picture of what is expected of them.
- To allow for updated technologies and methodologies, it is undesirable to specify particular modelling techniques in regulations. Instead, specifying outcomes of the risk assessment process will provide desired results in a flexible environment.
- The ‘OSPAR FRAM’ provides an excellent basis for modelling and risk assessment. The framework is referenced in other regulations (e.g. ‘EU directive 2009/31/EC’, ‘IEA model regulations’) and it would be desirable if all operators/authorities referenced the framework when constructing risk assessments.
2. Demonstration of CO₂ safety post injection

Conclusions

Modelling, risk assessment and monitoring

- Similarly for monitoring, it is largely undesirable to specify particular methods. Instead, specifying the outcomes of monitoring is a more flexible method of achieving an up to date and site-specific monitoring plan. For example the ‘IEA model regulations’ and ‘EU directive 2009/31/EC’ list the considerations/outcomes of monitoring.
- There are some site properties, which are easy and necessary to monitor, such as injection pressures, stream compositions etc. These are specified in some regulations and such requirements are desirable to achieve a constant base level of monitoring in all sites. Regulations such as the ‘EPA UIC’ and the ‘IEA model regulations’ provide a good balance of strictly prescribed monitoring and flexible monitoring.
- The purpose of modelling, risk assessment and monitoring is to demonstrate the safety of the CO₂ storage. Therefore, when assessing these plans, the major consideration should be whether the plans can demonstrate the safety of the CO₂ storage to acceptable standards. If they cannot then the plans should be reconsidered.
2. Demonstration of CO₂ safety post injection

Conclusions

CO₂ safety

- The wording of requirements on CO₂ safety varies. However, they can be summarised into three main points which should be included in regulations in one form or another:
  - demonstration of no leakage,
  - demonstration of conformity with modelling predictions and
  - demonstration of long term stability.

- Some regulations contain additional requirements:
  - demonstrating no environmental problems,
  - demonstrating that the plume will not encounter any leakage pathways and
  - demonstrating well integrity.

These conditions are implicitly included in the previous requirements.

- Considering the no leakage requirement, demonstrating this is heavily dependent on what monitoring has been used. It is therefore important for the monitoring plan that has been approved to be of sufficient quality to detect leakage. If the monitoring plan is not good enough, then no leakage may be detected even though leakage is occurring.
2. Demonstration of CO$_2$ safety post injection

Conclusions

CO$_2$ safety

- The ETS requires quantification of leakage. However, the accuracy with which this can be achieved is difficult to quantify. Furthermore, no regulation permits any leakage, although it may be necessary for authorities to permit minor leakage in some cases.

- The ‘EU directive 2009/3/EC’ classifies leakage as any release of CO$_2$ from the storage complex (the complex includes secondary containment formations). In this context the no leakage condition is reasonable. However, if leakage was defined as CO$_2$ release from the primary confining layer as in the ‘WRI Guidelines’, then secondary containment is not permitted.

- Considering the model conformity requirements. It may be desirable that the authorities quantity this. e.g. X% difference between model and monitoring over Y years, where X and Y are variable to be determined.

- Considering the stability requirement. The ‘EPA UIC’ regulations require complete stability which may be an overly strict requirement.
2. Demonstration of CO₂ safety post injection

Conclusions

**CO₂ safety**

- The Australian ‘OPA’ regulations are more prescriptive in how safe a site must be than other regulations by specifying no ‘adverse effects on navigation, fishing etc’. These conditions may be slightly unnecessary, however, an appropriate ‘no leakage’ condition will implicitly include the ‘no adverse effects on navigation, fishing etc’ conditions.

- The Australian regulations also require demonstrating long-term consequences as well as suggesting future measures after liability has been transferred. This latter step in particular could be a very useful addition to other regulations.

- There is variation in the time period over which safety must be shown in different regulations. It is difficult to conclude an optimum time period but this time period should be flexible. The main consideration when setting a time period should be how much monitoring time is required to demonstrate safety.
3. Well abandonment

The first stage of well abandonment is removal of any downhole equipment from the wellbore. Then the wellbore is cleaned of debris by flushing the wellbore with a circulation fluid. The next and major stage is the creation of plugs in the well to create impermeable barriers.

Variables are the type of plugging material used, the method of plugging, the size of plugs, the depths of plugs and the number of plugs.

There are different grades of cement used which are based on mechanical requirements at the different temperatures and pressures experienced at different depths. Additives can be used to enhance Portland cement properties to meet these requirements.

There are a number of different methods available for plugging including: balanced plug, the dump bailer method, the two-plug method and squeeze cementing.

The depth and sizes of plugs will be largely dependent on the depths and thicknesses of permeable formations. Similarly, the number of plugs will be site specific, though typically at least three plugs will be used.

After the well has been plugged, it must be tested to ensure that it is functioning correctly. Once plug testing has been performed, the well can be capped and, if onshore, then backfilled with soil.
3. Well abandonment

Conclusions

- CO₂ storage specific regulations only provide detail on enforcing well plugging and some details on the removal of surface equipment.
- They do not provide detail on the particular mechanisms that should be used for plugging.
- Specific details on plugging are provided by regulations on the abandonment of hydrocarbon wells and sometimes other injection wells. It is often unclear whether these regulations will directly apply to CO₂ storage wells. However, in the absence of further information these regulations provide the best available guidance for CO₂ storage well abandonment.
- Most well abandonment regulations contain similar details. The main variations are in the extent of required plug and the particular placement of them.
- These general abandonment regulations are likely to be applicable to CO₂ storage wells. However, they may require updating to:
  - Specify plugging across the injection zone and the caprock
  - Update plugging material requirements using knowledge gained from the performance of standard plugging materials in CO₂ environments
  - Require the removal of tubing.
4. Overall abandonment steps and transfer of liability

Liability takes different forms and can be summarised as follows:

- **Operational liability**, i.e. the cost and responsibility for remediation and monitoring.
- **Environmental/climate liability**, i.e. liability for CO\textsubscript{2} release causing harm to the global climate or affecting credits for CO\textsubscript{2} reduction agreements.
- **In-situ liability**, i.e. liability for CO\textsubscript{2} release affecting the natural environment: humans, drinking water, contaminated hydrocarbon reserves etc.
- **Trans-border liability**, i.e. issues related to liability issues that affect multiple countries caused by CO\textsubscript{2} release in one country.

The type of liability referred to in regulations is typically not clear. The term ‘responsibility’ is also used to refer to ‘liability’ in regulations.

After liability has been transferred, the state/authority may continue to monitor the site. The ‘IEA model regulatory framework’ contains a clause that the operator should also provide suggestions for monitoring after liability transfer.

Some regulations contain a mechanism for which operators contribute to a collective fund. This fund is then used to cover the states/authorities costs after liability has been transferred.
4. Overall abandonment steps and transfer of liability

Conclusions

- Regulations typically contain a provision for liability of the site to be transferred once safety (CO₂ and well plugging) has been demonstrated. An argument against this is that operators may make decisions differently if they know they will not be liable in the future. An argument in favour of liability transfer is that without such a provision, operators may be deterred from investing in CO₂ storage.

- Provided that safety of the site has been demonstrated rigorously then issues of liability should not arise.

- The ‘EU directive 2009/31/EC’ requires further monitoring after liability transfer as a backup measure, while other regulations (e.g. ‘EPA UIC’) do not. Despite this difference both require safety to be shown before liability transfer.

- Some regulations do not specify a value of the financial contribution required by operators. While this is beneficial in that the true costs will not yet be clear, it may be beneficial to indicate supposed costs, so as not to deter operators.

- The ‘IEA model regulatory framework’ contains a clause that the operator should also provide suggestions for monitoring after liability transfer. This is a desirable condition for abandonment regulations.
5. Current review of the EU CCS Directive

Art 38 requires a review report to be delivered March 2015:

- The aim is to examine whether the Directive is fit for purpose (namely to assess effectiveness, relevance, efficiency, coherence and EU-added value)
- Besides Art. 38 will consider the broader EU energy & climate policy, CCS related policy & legislative activities by the EU & MS
- It is considered an open ended exercise

The process involves two steps:

- **External consultants** (Triple E Consulting, Ricardo-AEA and TNO) to provide retrospective assessment and recommendations for possible improvements to the current legal framework and/or its application by the national authorities and industry
  - Conduct literature review, on-line consultation, interviews, (May – July)
  - stakeholder meetings (Sept), case studies, recommendations (Dec 2014)
- **Commission report** (March 2015) followed by a proposal for revision or other CCS measure, if and where appropriate.
5. Current review of the EU CCS Directive: Extract of questions regarding its objectives

The original Impact Assessment for the CCS Directive described a number of objectives for it.

Do you think that these objectives are appropriate?

How well do you think the current Directive has performed against each of these?

Do you think some of the objectives of the CCS Directive would be better addressed by Member States (MSs) at the national level?

- Addressing safety concerns
- Addressing environmental concerns
- Addressing health concerns
- Addressing public acceptance concerns
- Helping to create harmonised procedures to ensure a common approach
- Helping to increase the speed and scale of CCS uptake
5. Current review of the EU CCS Directive: Extract of questions regarding storage

What is your view, on the following statements on whether geological storage of CO\textsubscript{2} leads to permanent containment of CO\textsubscript{2} in such a way as to prevent and reduce as far as possible negative effects on environment and human health, and any resulting risks for environmental and human safety?

- There is a lack of consensus on the definition of "permanent" containment of CO\textsubscript{2}.
- The term ‘permanent’ should be replaced by a number of years like 500 or 1000 years.
- The Directive should make a distinction between the risk of minor leakage and major leakage.
- Do you think the criteria for the transfer of responsibility are sufficiently well defined?
- Are the criteria established for the transfer of responsibility workable, given the current level of knowledge on the performance of underground storage projects?
- Are the recommended default periods for the post-closure Pre-transfer phase and for the absence of significant irregularities practicable?

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5. Current review of the EU CCS Directive: Extract of questions regarding storage

In the last five years (since the entry into force of the CCS Directive), how well do you think knowledge has progressed on the following CO$_2$ storage issues?

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<th>Very good progress (world class)</th>
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<th>Minor progress</th>
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Thank you very much for your attention!

Financial support by the European Commission

and by our industry partners

is gratefully acknowledged.