

# Survey - Post Implementation Review of the Storage of Carbon Dioxide Regulations

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| <b>Demonstration projects</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <p><b>1. How effective are current regulations in facilitating demonstration projects?</b></p> <ul style="list-style-type: none"> <li>• Please rate your answer in the range 1-4. where 4 is very effective and 1 is not effective at all.</li> <li>• Please provide reasoning and evidence for your answer, including evidence on the costs and benefits associated with the regulatory requirement where possible.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <p>1</p> <p>Current regulations do not enable knowledge-sharing, which ultimately limits the potential benefits demonstration projects can provide.</p> <p>Demonstration projects can be defined as those that lead to the development of future commercial scale storage projects. As such demonstration may be needed to verify geological environments, to assess new injection strategies and to test and evaluate new technologies.</p> <p>The storage industry is still in an embryonic stage with no active commercial-scale projects currently injecting CO<sub>2</sub> in the UK (though these are expected in the next 2-3 years). In this context demonstration projects will be very valuable in supporting longer term industry development.</p> <p>A key requirement is to build trust with the public that CO<sub>2</sub> storage can be undertaken in a safe manner that leads to permanent storage without environmental harm. In this way demonstration projects can be very useful.</p> <p>Furthermore, demonstration projects can also be used to evaluate and prove innovative technologies and thereby provide significant knowledge and data that can be used by the research community to further understand often complex multi-scale processes and address knowledge gaps that may otherwise limit development. However, this does require that the data, knowledge and methodologies are shared openly (under appropriate constraints if necessary).</p> |
| <p><b>2. To what extent do you agree that the carbon storage licence and permit requirements should not apply to projects storing less than 100 kilo tonnes of CO<sub>2</sub> for research, development, or testing purposes?</b></p> <ul style="list-style-type: none"> <li>• Please rate your answer in the range 1-4, where 4 is strongly agree and 1 is strongly disagree.</li> <li>• Please provide reasoning and evidence for your answer, including evidence on the costs and benefits associated with the regulatory requirements where possible.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <p>4</p> <p>This is an important question that the British Geological Survey (BGS) has explored in significant detail. The BGS were appointed as technical lead in the Natural Environment Research Council's CO<sub>2</sub> Storage Research Facility (CSRF). The CSRF was designed to provide a research facility to study the injection, storage and monitoring of CO<sub>2</sub> at industrially relevant scales (i.e. the deep injection of CO<sub>2</sub> at up to 100 kt). Importantly it also offered the chance to undertake a site-closure "dry-run" which would provide knowledge to both operators and the NSTA on appropriate closure methodologies and the evidence required to enable transfer of liability. This would be undertaken in a research environment, where "higher risk" activities (e.g. trialling new, mid-TRL monitoring technologies) could be undertaken. Although the project did not proceed beyond the</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

feasibility stage due to costs which NERC were unable to accommodate, we explored the extent to which the facility should adhere to the UK's CO<sub>2</sub> storage regulations. We concluded that current regulation would have constrained the operation for the following reasons: In order for the facility to be as relevant to industry as possible, it would have adhered to the principles of the regulations but would have constrained the injection mass to below the 100 kt threshold. The regulations require clear plans for injection and monitoring, which would limit the innovative, open-research requirements that apply to R&D projects. Therefore, in conclusion we agree that the key test here is the intent. If the intent is geological formation testing prior to commercial-scale injection, then the regulations should be applied. However, if the intent is R&D then a permit should not be required, to give freedom to experiment (subject to appropriate levels of environmental and HSE protection).

### **Definitions related to leakage**

**3. As defined in the Storage of Carbon Dioxide Regulations etc.) 2010, my organisation understands what is meant by “leakage.”**

- *Please rate your answer in the range 1-4, where 4 is strongly agree and 1 is strongly disagree.*
- *Please explain your answer.*

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BGS has been at the forefront of research into the concepts of leakage for decades. We contributed to the original definitions of leakage during the creation of the European Storage Directive on which UK legislation is based. Our research, either in the laboratory, using computer simulations, or using data provided by early demonstration projects, has covered a range of leakage topics including:

- Assessing risks of leakage
- Leakage processes, and potential for natural attenuation of leaked CO<sub>2</sub>
- Geological requirements to prevent leakage
- Monitoring, detection and quantification of leaked CO<sub>2</sub>, both in the subsurface, in the soil and seawater environments, and in the atmosphere. We designed and operate the IEAGHG's online, free-to-access monitoring selection tool, that provides a resource for users to understand what monitoring technologies are available, how they have been used in previous CCS projects, and what might be appropriate for their specific projects. The tool is used by industry to “audit” their monitoring plans, and by students learning to design MMV plans.
- The impacts of leakage on marine and terrestrial environments
- Recommendations and best practice for mitigating and remediating leakage

**3a. As defined in the Storage of Carbon Dioxide Regulations etc.) 2010, my organisation understands what is meant by “no significant risk of leakage. “**

- *Please rate your answer in the range 1-4, where 4 is strongly agree and 1 is strongly disagree.*
- *Please explain your answer.*

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Storage licence holders are being successfully awarded storage permits which seek to demonstrate there is no significant risk of leakage, prior to project construction and operation.

The BGS has acted as impartial reviewer of storage risk assessments for some storage licence holders, at NSTA's request. These risk assessments are an initial activity during the range of studies that are needed to develop a body of evidence to submit as part of their permit application. Although the concept is tested during the CO<sub>2</sub> storage permit application process, it has yet to be tested during site closure. Tests could be undertaken in a research project to simulate site closure, that would provide scientific evidence to further inform regulatory and industrial approaches to demonstrating the absence of leakage risk.

Discussions with storage operators and the insurance industry indicate that there is a need for the scientific knowledge generated by many research projects in this topic to be assimilated, integrated and interpreted to support the development of insurance services for this emerging industry. BGS have developed a concept for such an initiative and have sought funding to deliver it.

Understanding what might constitute a significant risk of leakage has been a key research topic, and there remains uncertainty on the likely future levels of sufficient evidence that will be needed by storage operators to enable site closure. The Containment Risk Assessment, an early task during permit development provides an overview of future likely risk of leakage, proposed mitigations during site-selection and appraisal, and during project design and operation. Nevertheless, a demonstration of site closure, including necessary lines of evidence to adequately demonstrate acceptable levels of risk of leakage, would be very valuable to the storage industry, and potential investors and insurers.

**4. The Storage of Carbon Dioxide Regulations do not quantify leakage, for example, leakage requiring corrective measures. Does this affect your business practices?**

- *Please include evidence on the costs and benefits associated with the regulatory requirements where possible.*

As a research organisation, the lack of quantified leakage definition or thresholds, do not directly affect our business. However, we offer the following insights which may be helpful:

- Natural variations in CO<sub>2</sub> concentrations are far above current detection limits and can lead to significant changes in CO<sub>2</sub> concentration over daily, seasonal and longer timescales. They can also be affected by external factors. This makes defining fixed leakage thresholds, applicable across all storage projects inappropriate.
- We recommend that storage operators establish appropriate baseline conditions through long-term environmental monitoring. The BGS has previously led international consortia which have produced guides on this topic, outlining appropriate methodologies based on experimental studies which have determined the potential impacts of leakage in the marine environment<sup>1,2</sup>. Once baseline conditions, and the full potential range of

naturally-occurring CO<sub>2</sub>, have been determined, then site-specific thresholds could be set. The operator's monitoring plan would also seek to identify when corrective measures would be applied and which corrective measures are initiated depending on the leakage scenario.

1. A guide to potential impacts of leakage from CO<sub>2</sub> storage. Jonathan Pearce (editor), 2013. Available for download here: <http://www.riscs-co2.eu/SciPublicationsData.aspx?IdPublication=22&IdType=183>
2. Four factsheets available here on a range of leakage topics: [WP6 Sharing best practice and knowledge | SECURE | Subsurface Evaluation of CCS and Unconventional Risks](#)

## Post closure transfer requirements

### **5. How feasible does your organisation find it to demonstrate that “all available evidence indicates that the stored CO<sub>2</sub> will remain completely and permanently contained”, as required after site closure?**

- Please rate your answer in the range 1-4, where 4 is completely feasible and 1 is not feasible at all.
- Please provide reasoning and evidence for your answer including, evidence on the costs and benefits associated with regulatory requirements where possible.

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This is a key foundation of the regulatory framework for CO<sub>2</sub> storage. For CO<sub>2</sub> storage to be a feasible option to reducing atmospheric emissions, the CO<sub>2</sub> must be effectively and permanently stored. Providing the appropriate levels of evidence is the prime objective for operational monitoring during the injection of CO<sub>2</sub>. The evidence will be comprised predominantly of forward-look simulations of future site behaviour, focussed on longer-term migration and trapping of CO<sub>2</sub> within the storage complex. These simulations will be constrained by direct observations, of the site, taken during injection, so that there is a close agreement between observed behaviour and the predictions. In this way, scenarios of future site evolution (in terms of pressure evolution, CO<sub>2</sub> migration, solution and mineral trapping) will be shown to be robust because these simulations can closely match the observations.

A thorough evaluation of credible leakage scenarios must be undertaken to demonstrate that for a range of scenarios of future evolution, the CO<sub>2</sub> is expected to be completely and permanently contained. These simulations can be further supported through the presence of naturally-occurring barriers and engineered barriers introduced during site closure (i.e. the plugged and abandoned wells).

## Post closure monitoring

### **6. Has the flexibility (or lack thereof), of post-closure monitoring requirements affected your organisation's business practices?**

- Please provide reasoning and evidence for your answer, including evidence on costs and benefits associated with regulatory requirements where possible

No comment

### **7. What proportion of overall project costs do you anticipate will be associated to post-closure monitoring requirements?**

0-5%, 6-10%, 11-15%, 16-20%, 21%+

- Please provide reasoning and evidence for your answer, including evidence on the costs and benefits associated with regulatory requirements where possible

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| No comment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Financial security requirements</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <p><b>8. How flexible do you consider the financial security requirements in the Storage of Carbon Dioxide (Licensing etc.) Regulations 2010 to be, for example in the form that security may take or how it may be assessed?</b></p> <ul style="list-style-type: none"> <li><i>Please rate your answer in range 1-4, where 4 is highly flexible and 1 is not at all flexible.</i></li> <li><i>Please provide reasoning and evidence for your answer, including evidence of costs and benefits associated with regulatory requirements where possible.</i></li> </ul> |
| No comment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Value for money requirements</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <p><b>9. To what extent has the absence of value for money considerations in the regulations impacted your business practices?</b></p> <ul style="list-style-type: none"> <li><i>Please rate your answer in the range 1-4 where 4 is large impact and 1 is no impact.</i></li> <li><i>Please provide reasoning and evidence for your answer, including evidence of costs and benefits associated with regulatory requirements where possible.</i></li> </ul>                                                                                                          |
| No comment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Overlap of regulatory responsibilities</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <p><b>10. What has been your experience of the carbon dioxide licensing processes, with respect to the clarity on requirements, roles and responsibilities of the different regulatory bodies and organisations involved.</b></p> <ul style="list-style-type: none"> <li><i>Please explain your answer.</i></li> </ul>                                                                                                                                                                                                                                                |
| No comment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Additional Questions</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <p>Are there any other aspects of the regulations that you consider to be burdensome for business?</p> <p>As part of this we would value reasoning evidence for answers given, including evidence on the costs and benefits associated regulatory requirements where possible.</p>                                                                                                                                                                                                                                                                                    |
| No comment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Do you have files or images to support your responses?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |