Long Term Integrity of CO₂ Storage - Well Abandonment

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The IEA Greenhouse Gas R&D Programme (IEA GHG) is a major international collaboration, investigating technologies that could reduce greenhouse gas emissions. This poster provides an overview of a recently completed study report completed on IEA GHG’s behalf by TNO in the Netherlands.

Background to the Study
IEA GHG recently commissioned TNO in The Netherlands to conduct a review of abandonment procedures and methodologies from around the world in order to determine whether the predominant factor influencing the methods used is regional location and regulatory led, or if it is purely down to operator preference. The study also included an assessment of best practice for long term well abandonment.

CO₂ geological storage projects will likely incorporate a range of well types, from injection and production wells, to abandoned and previously completed wells. While newly drilled and completed wells are likely to be governed by and subject to regulations designed to uphold the integrity of storage sites, wells completed and abandoned in the past may have been subject to less strict governance, and it is these wells that are, therefore, considered to be the greater threat to long term storage integrity.

Storage in deep saline aquifers may minimise risks, as the number of wellbores expected to be encountered during a storage project should often be minimal. However, the greater developed and understood option for geological storage of CO₂, and likely to be encountered during a storage project, is likely to be abandoned or operational wells, both on and off shore. While the historical exploration of oil and gas fields creates the very potential for geological storage of CO₂, if storage is to take place in these reservoirs, it may have given rise to the greatest threat to the storage operation. For example, wellbores for CO₂ injection into depleted oil and gas reservoirs is likely to incorporate a greater number of wells perforating the caprock of the reservoir due to the historical exploitation of these fields.

While the historical exploration of oil and gas fields creates the very potential for geological storage of CO₂, to take place in these reservoirs, it may have given rise to the greatest threat to the storage operation. For example, wellbores for CO₂ injection into depleted oil and gas reservoirs is likely to incorporate a greater number of wells perforating the caprock of the reservoir due to the historical exploitation of these fields.

The study was undertaken by TNO in The Netherlands, with the project team being led by Tjitte Benedictus.

Case Studies
The study covered case studies of abandonment practices at various sites, including:
- • Proposed storage of CO₂ in the depleted De Lier field, The Netherlands.
- • Well evaluation at Gulf Coast and SACROC, Texas, USA.
- • The Alberta Basin, Alberta, Canada.

These case studies were chosen as they represent a range of different types of wellbores; the potential impact these have on storage operations.

Of these case studies, the De Lier field was deemed to be not feasible for further development due to geological constraints, and urban and industrial development above numerous abandoned wells. Additionally, many wells were abandoned several metres below ground, making identification and re-entry more difficult.

Regulatory Review
The report also looks at several examples of regulatory regimes in place around the world aimed at controlling CO₂ storage operations and ensuring accountability for leakage and problems over the longer site lifetime. Assessment of current regulatory frameworks can help to determine and evaluate abandonment practices only, and provide a basis for longer term changes to legislation mean that during the lifetime of a commercial scale CO₂ storage project it is conceivable that well abandonment practices would change. It is also unlikely that regulatory regimes will stipulate the exact abandonment methods for all wells encountered in a field, rather than that it would develop that the site specific survey would be required for each potential storage site, and site selection criteria would likely remove some potential sites from the reckoning due to excessive remedial costs for abandoned wells.

The report looks at 11 different regulatory regimes from European, Australian, and American countries, and also assesses the London Convention and Protocol and the OSPAR Convention, with the role they play at an International level. From this review, it is clear that there is a large repository of regulatory information and tools available to regulators of CCS activities, and much of this has evolved from the legislation governing petroleum well abandonment.

Generally, the regulators in place provide guidance on abandonment methods for existing wells, and although the review shows that there is a need for a cement plug, the length of cement plug varies greatly, from a minimum of 15m in Canada, to up to 100m in some European scenarios. Other areas where variation is apparent is verification of abandonment of abandoned wells, provisions made for CO₂ storage, and data availability.

The single most difficult hurdle encountered by TNO when assessing international regulatory positions, was the language barrier that exists. Many countries do not offer their regulations in anything but their native language, and any translation is deemed unofficial. TNO recommend in the report that to facilitate international cooperation, all regulations should be provided with an official English language translation, and therefore further discussion should be entered into as to whether such regulations should be freely available for those that wish to read them.

Best Practice Recommendation
Carlsten and Abdollahi (2007; In Randhol et al., 2007) describe a methodology for abandonment that is shown in figure 2 below. The process involves removing the tubing and packer before placing a cement plug at the bottom of the well, and then inspecting a specially designed flip the near well to the area and avoiding CO₂ contamination with the best wellbores, and wellbore materials. The casing is then pulled to the level of the caprock and cement injected into this open section to prevent leakage along microannular between casing and cement paste. The well is then filled with non corroding fluid. If secondary seals are present, then an additional cement barrier should be placed at this point.

Review of Plugging Techniques
The report includes a high-level overview of the variety of techniques that are employed around the world to facilitate the plugging of abandoned wells. The purpose of this section is to highlight the drawbacks and limitations of the methods. These are summarised in the table below.

Abandonment Method Description Benefits / Limitations
Cement Plug
A method commonly used in the petroleum industry whereby cement is placed in the hole to close off the well. This is the most effective method for plugging the well, but it is also the most costly. It is also the most flexible, as it can be adjusted to meet the specific needs of the well.

Cement Slurry
Cement slurry is commonly used in the petroleum industry to plug abandoned wells. It is a mixture of cement and water, and it is used to create a solid plug in the well. It is less effective than cement plugs, but it is also less costly.

Dump Bailer
A method that involves dumping a large amount of cement into the well. It is less effective than cement plugs, but it is also less costly.

Tapping
A method that involves tapping the well to remove the cement. It is less effective than cement plugs, but it is also less costly.

Best Practice Recommendation
Abdollahi (2007; In Randhol et al., 2007) recommend the following steps for well abandonment:

Abandonment

1. Remove the tubing and packer from the well
2. Place cement in the wellbore
3. Ensure that the cement is placed at the correct depth
4. Ensure that the cement is placed in the correct location

Cement Slurry

1. Ensure that the cement slurry is placed in the wellbore
2. Ensure that the cement slurry is placed at the correct depth
3. Ensure that the cement slurry is placed in the correct location

Dump Bailer

1. Ensure that the cement is dumped into the wellbore
2. Ensure that the cement is dumped at the correct depth
3. Ensure that the cement is dumped in the correct location

Tapping

1. Ensure that the well is tapped
2. Ensure that the cement is removed from the wellbore
3. Ensure that the cement is removed at the correct depth
4. Ensure that the cement is removed in the correct location

References:

