Storing CO_2 Underground

Once the CO_2 has been captured and transported to a suitable storage site, we need to ensure that it will stay underground. There are several mechanisms that ensure the storage is permanent, and this information sheet aims to describe these in broad terms.

Site Selection

The first thing to determine is where to store the CO_2. There are several physical things necessary for this, and the site selection process will ensure that only the best, safest and most secure sites are selected. These sites will have a suitably sized storage formation in which the CO_2 can be injected, with a suitably impermeable cap rock above it to prevent the CO_2 from escaping upwards through the ground. Other factors will be considered during site selection, such as accessibility, proximity to capture plant and ease of transport, but also other factors such as geological stability (not in an area prone to earthquakes), and other technical requirements.

Rock Types

The storage formation, or 'reservoir rock' itself will be permeable so the CO_2 can be injected into it, porous, so there is enough space to store the CO_2, and deep enough that the CO_2 has no opportunity to escape to higher levels, and ultimately the atmosphere.

The cap rock will lie directly on top of the storage formation, and will act as a barrier so that the CO_2 cannot pass out of the storage formation. A good analogy for these two rocks is that the storage formation acts as a sponge, and the CO_2 can be held within it, and the cap rock is like a rubber sheet, not allowing any liquids or gas to pass through it.

Storage Formation Options

Storage formations come in two types – depleted hydrocarbon reservoirs (oil and gas fields) or deep saline formations. The deep saline formations simply hold very salty (brine) water that has no value for anything, whereas the depleted hydrocarbon reservoirs would originally have held oil or gas. Other than that, the basic geology is the same – both will be rocks similar to sandstone, and have lots of little spaces between the grains which the CO_2 will be stored in. The main differences between the two options will be in terms of location, capacity, and how easily the CO_2 can be injected.

Current Projects

Although this will be subject to change, in 2013, there are a number of projects in operation around the world, and in Norway there are two projects operating at a commercial scale, injecting and storing millions of tonnes of CO_2 every year. One of these, the Sleipner Project has been operating since the 1990's separating CO_2 from natural gas extracted from beneath the sea floor, and the separated CO_2 is then re-injected into an overlying formation. The natural gas is then piped to shore for further processing. There is an extensive monitoring project in operation around the injection programme, and much has been learnt about CO_2 and its behaviour when underground.

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While the cap rock initially prevents the CO_2 from escaping, over time, other mechanisms come into play.

Residual Trapping

As the CO_2 moves through the formation (because more is injected), some becomes trapped as small bubbles between the rock grains, and is unable to move any further.

Dissolution Trapping

Some CO_2 will be dissolved into the salty water that is in the storage formation. This CO_2 and water mix is then heavier than the normal water, and sinks to the bottom of the formation.

Mineral Trapping

Lastly, the CO_2 can react with the rock grains themselves, forming minerals within the rock. These minerals take a long time to form, but once formed, they effectively lock the CO_2 in place for millions of years.

With these mechanisms in place, and once the capacity of the formation has been reached, the wells are blocked off and sealed, and the CO_2 is effectively contained without any chance of escape.

Summary

The physical process of storage is relatively straightforward, and with the different storage mechanisms that take effect over time, the longer the CO_2 remains in the reservoir, the more confidence there is that it will never escape. Monitoring will still take place to detect leaks and enable operators to fix them, but as time goes by, storage can be relied upon more and more as permanent.