CO_2 CAPTURE AND STORAGE – AN UPDATE ON ONGOING EUROPEAN R&D

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1. Introduction

Capture and storage of CO_2 can, in the short to medium term, play a part in capturing already concentrated CO_2-streams, such as from natural gas treatment or from ammonia and hydrogen plants. An early option is to use this CO_2 to enhance oil recovery from fields approaching the end of production, thereby storing the CO_2 away from the atmosphere. In the longer term, underground CO_2-storage may provide an important route to achieve the reductions in greenhouse gases required to limit anthropogenic climate changes.

The first decision to apply underground storage of CO_2 captured from natural gas was taken by Statoil (operator) and partners in the Sleipner North Sea licence in 1993. The second such decision was taken by Statoil (operator) and partners in the Snohvit licence in the Barents Sea in the autumn of 2001.

Based on ten years of studies, laboratory research and pilot plant tests, Statoil in co-operation with the Norwegian government is now discussing the more difficult task of CO_2-capture in connection with power generation. The construction of an industrial scale CO_2-capture demonstration plant at one of Statoil's gas terminals or refineries is being planned.

2. The Sleipner and Snohvit CO_2 injections

At the **Sleipner** gas field in the North Sea (Fig. 1), CO_2 has been stripped from the produced natural gas (containing about 9% CO_2 – too much to be sold without treatment) and injected into an overlying aquifer (the 'Utsir' formation) since 1996. The CO_2 is injected into a large high permeability sand body (between 850 and 1050m deep, occupying 2.5×10^4 km^2) which is overlaid by a thick shale succession. Shales have very low permeability and are expected to provide an effective seal to the injected CO_2 for at least a few thousand years (see next chapter).

The Sleipner project is the first commercial application of CO_2 storage in deep saline aquifers in the world. Since 1996 nearly 7 million tonnes of CO_2 have been injected without any significant operational problems. To monitor the injected CO_2, a separate EU supported project (<u>S</u>aline <u>A</u>quifer <u>C</u>O_2 <u>S</u>torage, SACS, see next chapter) was established in 1998. Since 2003

the third phase, studying the long term behaviour of CO_2 at Sleipner and making a feasibility study of four other possible European storage sites (Kalundborg, Denmark; Valleys, South Wales, UK; Mid-Norway, Norway and Schwarze Pumpe, Germany), is ongoing.

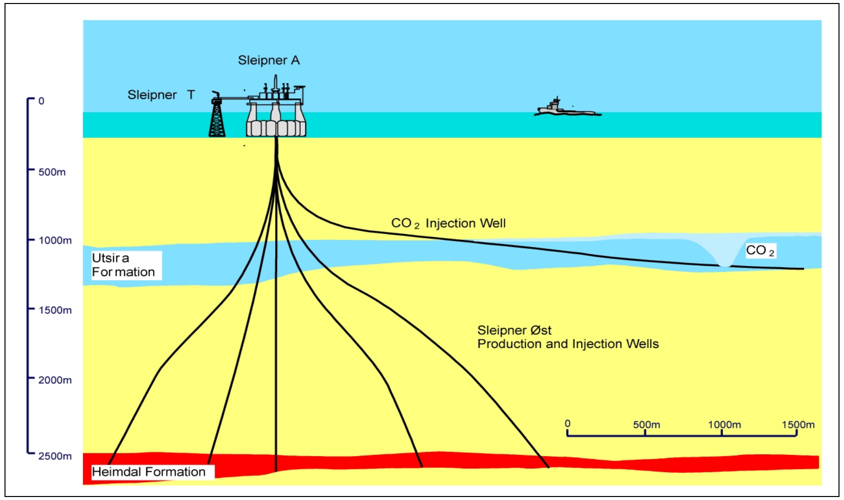

Fig. 1: The Sleipner CO_2 injection scheme

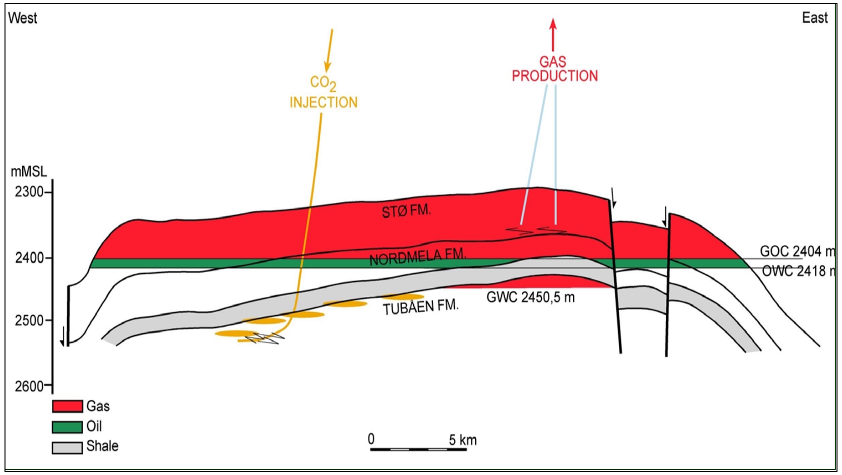

Fig. 2: The Snohvit CO_2 injection scheme

The **Snohvit** natural gas field (Fig. 2) in the Barents Sea off North Cape in Northern Norway, which will come on stream in 2006, consists of a fully sub-sea offshore development, a 160-kilometer multiphase pipeline to shore, a gas liquification plant to produce LNG for shipment to the USA and Continental Europe and – last but not least – a 160-kilometer CO_2 pipeline back to the gas field to store 0.7 million tonnes per year of CO_2 captured from the natural gas during the processing to LNG.

3. The Saline Aquifer CO_2 Storage programme

In order to learn as much as possible from the injection and, at the same time, involve a wider group of expertise from many countries, Statoil took the initiative to start the Saline Aquifer CO_2 Storage programme (SACS) for monitoring the Sleipner injection. This R&D programme, run under the European Union R&D Framework programme, involves a large number of European geological survey institutions and energy companies. The goals of this programme are to

- verify under what circumstances CO_2-storage in an aquifer is safe and reliable,
- validate models for geology, geochemistry, geophysics and reservoir tools,
- initiate new R&D related to the above topics, and
- start development of a 'Manual of Good Practice'.

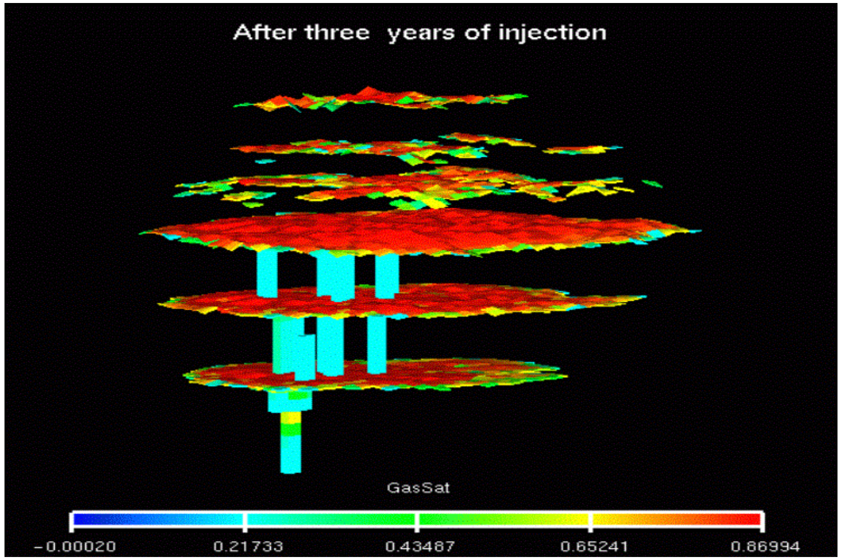

Fig. 3: Seismic monitoring of CO_2 in the Sleipner gas field: Simulation of the distribution of CO_2 three years after start of injection. The largest bubble is 800 m wide and the total 200 m high (Ref: SINTEF Petroleum 2001)

So far the SACS program has carried out three seismic surveys (in 1999, 2001 and 2002) in addition to the pre-injection survey (in 1996). The time-lapse 3D seismic surveying has been successful in monitoring the CO_2. As expected, the injected CO_2 has migrated upwards towards the top of the reservoir (Fig. 3). The reservoir simulation tools to describe the migration of the CO_2 have shown themselves capable of replicating the position of the CO_2 and can now be used to simulate its future behavior.

In addition, the geology and geochemistry of the 'Utsira' formation has been mapped and the experts from the six European geological institutes involved in SACS have concluded that there is every reason to expect the CO_2 to stay in the reservoir at least for the next few thousand years.

4. Use CO_2 commercially? – The vision of CO_2-free energy from fossil fuels

The Kyoto protocol and the European decision to comply with it, together with the EU Directive on emission trading which, from the year 2005, will put a price on CO_2 emissions, have changed the situation. At the same time some of the oil and gas fields in the North Sea have reached the later stages of production where, by using CO_2, 5–10% more oil could be extracted. This practise of enhanced oil recovery using CO_2 has already been in use in the USA and Canada since the 1970's. These changes have created a new situation with a market for CO_2.

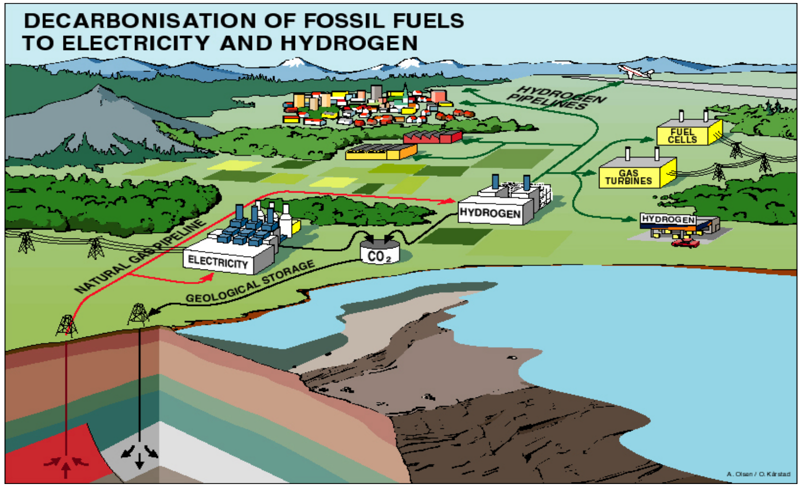

Fig. 4: Idealised illustration of how fossil fuels, like natural gas, can be transformed into the two CO_2-free energy carriers electricity and hydrogen

Fig. 4 shows an idealised illustration of how natural gas (or oil/coal) could be used to manufacture the two CO_2-free energy carriers electricity and hydrogen. The new element is that processes are incorporated that capture the produced CO_2 and that this CO_2 is then stored long-term in an underground formation. Though very simplified such a 'vision' is useful in pointing out directions for long-term research, development and demonstration.