# MID-TERM REPORT – No 2

**CONTRACT N° :** **ENK6-1999-00014**

**PROJECT N° :**

**ACRONYM :** **SACS2**

**TITLE :** **Saline Aquifer CO2 Storage 2**

**PROJECT CO-ORDINATOR :** **Statoil**

**PARTNERS :** **BP, ExxonMobil, Norsk Hydro, Vattenfall, BGS, BRGM, GEUS, IFP, SINTEF, NITG-TNO, IEA GHG, GECO**

**REPORTING PERIOD: FROM 1 April TO 31 December 2000**

**PROJECT START DATE : 1 April 2000** **DURATION : 24 months**

**Date of issue of this report :** 16 February 2001

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## *1. Table of Contents*

## *2. Executive publishable summary*

### Objectives

The SACS2 project will follow-up Sleipner CO2 injection to demonstrate technologies necessary and capable to verify the safe injection and long term stability and capture of CO2 in saline aquifers. From this major demonstration, running since October 1996, extended monitoring will verify how CO2 behaves in the aquifer, at 1000 meter depth below sea bottom. Data will be collected by repeated seismic surveys to verify the extension of the CO2 "bubble" after 2 more years of injection. The project will also verify the functionality of monitoring methods and simulation models. Further to document the long term stability of the reservoir and the CO2 capture; of high importance to environment protection authorities and non-governmental organisations. The same is valid for energy companies contemplating injection projects.

A first version “Best-Practice-Manual” will be issued towards the end.

### Description of the work

The offshore gas field Sleipner, has been injecting 1 Mt CO2 per year since September 1996. It is injected into a salt water containing sand layer, called Utsira formation 1000 meter below sea bottom. During 1998 a group of energy companies together with scientific institutes and environmental authorities in NO, DK, NL, FR and UK formed the SACS. In 1999 the Thermie/SACS project established a baseline of CO2 behaviour by shooting a first 3D seismic.

The SACS2 – this project - aim for taking this baseline into verification of available models and tools originally developed for hydrocarbons and water, now to be applied to a CO2 and water system. The major difference being that CO2 is soluble in water and methane is not.
Scientific work in geology, geochemistry, geophysics and reservoir simulation is closely interdependent and will have to be done iteratively. Basic proof is the repeated geophysical monitoring of CO2 movements in the saline aquifer. Close co-ordination between the scientific institutes is needed. Inter-continental co-operation is done through IEA.
GOAL: Develop a consensus about the monitoring results and validity of available methods and tools. National environmental authorities is part-funding and engaged in the interpretation. This will be the basis for a first version of a "Best- Practice-Manual".
A major milestone early 2001 will be to decide to run the seismic survey summer 2001.

### Expected results and Exploitation Plans

The project will generate a method for technical and environmental evaluation, to satisfy authorities and the general public as to the feasibility, safety, and reliability of subsurface CO2 storage.
Scientific results will be published. A first version “Best-Practice-Manual” will comprise evaluation procedures on the feasibility of CO2 storage in other areas/industries.
Dissemination is done by own publications and through the thematic network CO2NET.

### Results obtained

Work commenced as planned spring 2001 and has followed plans during 2001.
A major effort was the 7 SACS presentations given in a special session in the 5.GreenHouseGas Technology Conference in Cairns in August. Monitoring, i.e. the results from the interpretation of the seismic survey done October 2000 were presented at two major geophysical conferences.
They document that the CO2 behaviour can be clearly monitored and quantitative measurements of CO2 accumulations based on these data is the next step. No other major geo-scientific conclusions.

## *3. Objectives and strategic aspects*

**The goal of the project:**
Beginning in 1996, 1 million tons of CO2 per year has been stored at the Sleipner Field in the North Sea. This is the first case of industrial scale CO2 storage in the world. Being the first case, careful monitoring is necessary of the behaviour of the CO2 storage facility - a thick saltwater-bearing sandstone at a depth of approximately 1 kilometer. Data will be collected to model and verify the distribution of the CO2 'bubble' for three years, and methods will be demonstrated for prediction of the destiny of the CO2 thousands of years into the future.

In addition to demonstrating the long term feasibility of storage of CO2 in the Sleipner field case, it is a particular aim of the project also to provide a solid scientific documentation of CO2 storage as a method. This may be applied in other geographical areas, and in other industries such as power generation.

**Expected Results:**
*A best-practices-manual comprising evaluation procedures on the feasibility of CO2 storage in other geographical areas or large point sources in other industries.
* The project will generate a working methodology for evaluation of subsurface CO2 storage from a technical and an environmental point of view, in order to satisfy authorities and the general public as to the feasibility, safety, and reliability of the CO2 storage process.

**The project consists of these Work Packages (WP):**

| | |
|---|---|
| WP 1 – Geology | lead by BGS |
| WP 2 – Reservoir Simulation | lead by SINTEF |
| WP 3 – Geochemistry | lead by BRGM |
| WP 4 – Monitoring Well Asses. | lead by SINTEF |
| WP 5 – Geophysical Monitoring | lead by TNO |
| WP 6 – Reports & "Best-Practice." | lead by Statoil |
| WP 7 – Petro-Acoustic… | lead by IFP |
| WP 8 – Base Interpretation | lead by Geco |
| WP 9 – Time Lapse 1 Interpret. | lead by Geco |
| WP 10 – Time Lapse 2 Interpret. | lead by Geco |
| WP 11 – Synchronisation Res.Sim. | lead by Geco |
| WP 12 – Steering Committee | lead by Statoil |

The goals of the SACS project have become increasingly important for the European Union and the Member Countries during the period since its commencement in autumn 1998. The Kyoto Protocol is limiting the CO2 emissions. The ECCP – European Climate Change Programme is trying to put this into practical policy. CO2 sequestration is now being included as a possible longer term tool.

## *4. Scientific and technical performance*

### 4.1 Technical state of research.
As of now there is no sign that the research will not be able to complete its tasks as planned.

One temporary problem has evolved: There seems to be a discrepancy between volumes of CO2 in the "CO2 bubble" in the Utsira formation, calculated in two ways. One way being reservoir simulation based on injected volumes, the other seismic data. The discrepancy can well be explained by uncertainty in Utsira temperature data. The temperature measurements are of good quality, but there are uncertainties in their depth positioning. The topic will be studied closer.

After having explored and concluded the structure and behaviour of the “Utsira” formation itself, including its internal shale layers, the attention has moved to the overlaying cap rock. There is no cap rock core available from the Sleipner area. The need for such material for examination is strongly felt. The concern is that to take such a core could cost in the range of 0.5 million Euro, and Can only be taken in close co-ordination with other well drilling at the Sleipner field. Statoil is looking into the possibilities to make core material available. In the meantime availability of other core material from the region has been explored in several countries, with meagre success so far.

**4.2 Comparison of achieved and planned objectives, milestones, deliverables.**

Deliverables expected:

| | | |
|---|---|---|
| 1. Geology: | Deliverables | 1.3, 1.4, 1.6 |
| 2. Reservoir Simulation: | - " - | 2.2 |
| 3. Geochemistry: | None | |
| 4. Observation well: | None | |
| 5. Geophysics: | Deliverables | 5.1, 5.6, 5.8 |
| 6. Best Practice Manual: | None | |
| 7. Petro-Acustic: | None | |
| 8-11 Geco div: | Deliverable | 8.1 |

Most deliverables have been covered by the Work Area reports attached. Deliverable 1.4 characterising cap rock is still ongoing and 5.8 micros-seismic monitoring study is delayed, but expected to catch up soon. Deliverables 9.1 Distribution of CO2 at time of first survey and 11.1 Prototype software implementations were delivered earlier than planned.

## *5. List of deliverables*

See Annex 1.

## *6. Dissemination and Use of results*

The expected results of SACS are building of confidence in the concept and verification of tools and methods; all extracted into a “Best-Practice-Manual”. The actual use of it is dependent of the “Kyoto process”. With today’s economic circumstances there are other, far less expensive, mitigation actions available. Sequestration of CO2 will depend on new political circumstances. The SACS project is drawing on the ongoing injection at the Sleipner field now, to be ready if and when large scale sequestration is needed. In the meantime dissemination of scientific results is done.

A major effort was the 7 SACS presentations given in a special session in the 5.GreenHouseGas Technology Conference in Cairns in August. Monitoring, i.e. the results from the interpretation of the seismic survey done October 1999 were presented at two major geophysical conferences. They document that the CO2 behaviour in the underground can be clearly monitored.

## *7. Management and co-ordination aspects*

The “kick-off” meeting was arranged 13 April 2000 in Statoil (co-ordinators) offices in Stavanger, NO and Steering Committee Meetings 27 September in BRGM, Orleans, FR and 8 February 2001 in Norsk Hydro in Bergen, NO. The September meeting in Orleans was combined with a two-days Technical Session, where the participants of the different Work Areas could exchange results, discuss and co-ordinate their further work.

Results, papers and reports are made available to all participants continuously on the SACS Intranet home page (administered by SINTEF Petroleum). With this and extensive use of e-mails, the co-operation is tight. This can also be seen on the papers, all with authors from several participating institutes.

## *8. Conclusions and possible work plan review*

Work is generally progressing according to plans. A couple of tasks are slightly delayed, a couple are finished ahead of plan. There is no indication that work can not be concluded as planned.

The most important major activity summer 2001 is the repeated 3D seismic survey of the injected CO2 at Sleipner field. Plans are progressing.

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## **9.** *Glossary*

"Utsira formation" – geological structure consisting of loose sand where space between the grains are filled with salt water (brine).
"Sleipner field" – gas-condensate producing field in the middle of the North Sea, operated by Statoil with ExxonMobil, Norsk Hydro and TotalFinaElf as licence partners.
"Thermie" – demonstration part of the non-nuclear sub programme of EU 4.Framework RTD Programme 1996-1998.

## *10. Annexes*

I. WP 1: Geology
II. WP 2: Reservoir Simulation
III. WP 3: Geochemistry
IV. WP 5 & 7: Geophysics
V. WP 8 – 11: Geco-Geophysics

Table 1: Man Power and Progress Follow-up Table

Table 2: Budget Follow-up Table