



US - NORWAY COLLABORATION ON CCS/CCUS

US-Norway Annual Bilateral Meeting 2019

Date: August 29, 2019

Location: David L. Lawrence Convention Center, Pittsburgh, Pennsylvania, USA

Breakout session on CO₂ storage

1. Follow up of projects with joint financing

Chairs: **Darin Damiani**, DoE, and **Philip Ringrose**, Statoil

Darin Damiani introduced this year's themes:

Identifying R&D for offshore storage (EOR/saline) that would have the greatest impact and benefit in the short term.

- Characterization - new methods for cost-effective site selection decisions
- Monitoring Verification and Accounting - making it smarter and more cost-effective
- Wellbore construction, materials, integrity - smart wells, re-use of old wells, P&A technologies
- Simulation and modeling - better quantification and forecasting of CO₂ in the subsurface

Northern Lights Project was presented by **Eva Halland**, NPD and **Philip Ringrose**, Equinor. Eva Halland explained background to 1st Storage exploration licence (EL001) that was awarded in January 2019. Funds for drilling the exploration well were granted by the Norwegian parliament in spring 2019. After evaluation of several candidate structures, much based on the Norwegian CO₂ storage atlas, the license was awarded for the Johansen formation, based on expected sand distribution. There is a huge aquifer in the license area. The license conforms to Regulatory frameworks in place (Norway, EU, and London). It is publicly available in Norwegian. As well as English and can be found [at https://www.npd.no/en/facts/carbon-storage/exploitation-permits/](https://www.npd.no/en/facts/carbon-storage/exploitation-permits/).

The license has some conditions for maturing the prospect.

Philip Ringrose had given a summary update of the Northern Lights Project in a plenary session at the NETL conference. He stated that the storage confirmation well will be drilled in Q4 2019. Further details can be found online at <https://Northernlightsccs.no>

CO₂ Storage Data Consortium was presented by Philip Ringrose, Equinor. This collaborative project was started two years ago. It is Co-funded by CLIMIT and USDOE, and led by Sintef, University of Illinois and Equinor. The effort are on sharing data from pioneering CO₂

storage projects and make it easy for researchers to find. The sets should be targeting on specific issues. First dataset is Equinor/Sleipner dataset updated in early 2019 with the Sleipner 2019 reference model, updated seismic data. Illinois Basin - Decatur Project possible next dataset? Access to the data sets is granted for those willing to be “pilot” users.

Other datasets are welcome and the consortium is seeking other countries/projects to join – and provide additional financial support.

Well Integrity Atlas was presented by Susan Carroll, Lawrence Livermore National Laboratory (LLNL). The project is a partnership between LLNL, LANL and Sintef. Its objective is to improve understanding of issues related to well integrity by collating issues to target future research. A questionnaire had been sent to operators of 52 sites (anonymous) and so far 16 responses have been received. Over 100 wells are covered in the database, including legacy wells. The identified issues are manageable. A few of the mapped issues are major but most are medium to low impact. Risk factors for legacy wells have been mapped, and cost and usefulness of monitoring methods also captured in the survey.

Illinois-NORSAR Cooperation was presented by Bettina Goertz-Allmann, NORSAR.

The project is a collaboration between NORSAR, SINTEF and the University of Illinois that continues to perform detailed analysis of microseismic data from Illinois Basin – Decatur Project. The challenges for storage, related to microseismic monitoring were presented. The case studies were:

- Experience from In Salah site - limited detectors, but good correlation between injection and seismicity
- Decatur IBDP project research based on much better detection array – were able to identify seismic activity bursts
- Norway – experience from Oseberg oilfield monitoring (PRM array) and from Grane PRM array. Offshore nodes used to augment onshore array and improve detection - but improved offshore and onshore arrays will be needed

The experience from these cases will be applied to develop concepts for monitoring Northern Lights project

Cypress Pressure Analysis Toolkit: A Success Story was presented by Josh White LLNL.

The project is a co-operation between LLNL and Equinor. It is a workhorse tool used to probe reservoir properties and structure away from the well that has been tested on Snøhvit pressure gauge dataset. The toolkit focuses on CO₂ injection case (different fluid Equation of State, EOS), and very affected by Pressure/Temperature corrections. A test case of calibration and forecast was applied to the Snøhvit data. The toolkit is an open source software and available for potential for future use and enhancement.

2. Emerging areas for future R&D

Seeking first projects in the offshore, Tip Meckel UT Austin BEG

Global offshore storage is huge. For the US offshore, screening is done by the NETL CarbonSAFE program, which shows that there is ample offshore storage capacity. The Gulf of Mexico is rapidly evolving as a CCS hub, particularly around the Texas-Louisiana border, and infrastructure for CO₂-EOR is in place. There are already three Texas CO₂ hubs, but they lack storage (which is available near shore). Some ideas for what are goals of offshore projects are

- Demonstrating value chain – and de-risking
- Incentivizing hubs

- Developing monitoring plans

It is essential to find ways to engage stakeholders in CCS.

Monitoring and modelling CO₂ plume at Sleipner, Amir Ghaderi, Sintef

The presentation gave an overview of monitoring activities at Sleipner, with focus on seismic. It stressed the insights gained from the excellent 4D amplitude response, and that gravity monitoring (3 repeats) also gave important insights. Controlled-source electromagnetic (CSEM) was not so successful, but recent work on removing pipeline effects suggest some future potential. The presentation raised the question “What is value of quantitative monitoring?” and partly answered the question by showing Sintef work on convergence solutions, and value of Full-Waveform Inversion (FWI) seismic processing, and bringing in rock physics.

It was stated that Sleipner monitoring dataset is widely used and published.

Update on modeling the CO₂ plume at Sleipner, Odd Andersen, Sintef

A history of data releases was presented, as well as a summary of a new full field model with two million cells and quite computationally demanding. Initial simulations have been done by Sintef to test the usability of the model. Industry needs better confidence in their simulation approaches for CCS., and Gassnova has taken an initiative on CO₂ plume dynamics by inviting researchers to participate in a CO₂ plume dynamics modeling challenge, based on the 2019 Sleipner Benchmark Model. Unfortunately, the invitation is in Norwegian only. There are plans for workshops in 2020.

Advances in foam cement for wellbore construction, Barbara Kutcho, NETL

Foamed cement is a mix of cement, foaming agents and N₂ gas that

- Gives low-density corrosion-resistant, gas tight cement
- Has been used in shallow wells, geothermal etc. – and in 90% of Gulf of Mexico (GoM) wells
- Is much under scrutiny after Macondo disaster

The project started with a detailed lab analysis, and improvement plan, including collection of field samples. The field data collection involved many suppliers and operators, much now published in SPE papers.

The conclusion was that field cements were better quality than the lab cases – and led to better practice.

Norway projects on well technology & integrity, Colin Beharie, Wellcem

The objective of the work is to develop environmentally friendly resin for remediation of wells. A test program to test durability of resins, that included tests on cores with hairline cracks has been performed. The project has succeeded in showing 100% sealing of cracks back to lower than native cement permeability. The Wellcem team is experienced: Over 600 in situ well workover jobs in the track record – and has now worked on a CO₂-specific polymer resins

Can we achieve gigatonne CO₂ storage?, Sarah Eileen Gasda, Norce

The presentation had focus on reduction of uncertainties and pressure management. It stressed that real storage domains have complex geologies and pressure barriers, and discussed applications of multi-level Monte Carlo (MS) simulations. The Utsira was used as an example of a regional model, and generated P-distribution for capacity or time to pressure limit. Lower permeabilities create more challenging system (multi-modal outcome). The conclusion is that one needs a combination of maths and geology to solve Gt-storage problem, and that there is potential to working on advanced model approaches (multi-level MC, VE).

3. Discussion – summary of themes for future R&D

The discussions during the day and at the end indicates some potential themes for future co-operative R&D within storage:

1. Identifying learnings for emerging CCS hubs – de-risking
 - Bigger risk issues for offshore, e.g. slope stability
2. Modeling Sleipner benchmark – workshops in 2020 and possible joint paper?
3. Adding further to operator experience to well integrity atlas
 - More need to look at approaches to handle legacy well issues
4. Real-time machine-learning applications (pressure analysis, etc)
 - New geophysical sensing / monitoring methods
5. Solving Gt-scale storage problems – focused on pressure development
 - Data handling challenge for major basin-scale projects and hubs
6. New ACT projects give good vehicle for further collaboration
7. Scaling up to handle the large data volumes