US - NORWAY
COLLABORATION ON CCS/CCUS

US-Norway Bilateral Meeting – CO_2 Capture workshop

May 3, 2018

Location: Research Council of Norway, Drammensveien 288, Lysaker, Oslo, Norway

All presentations are uploaded on the US-Norway MoU website.

Opening Session

The opening session for the capture workshop was combined with the 3rd International workshop on Offshore Geological CO_2 storage.

The workshop participants were welcomed by **Torgeir Knudsen**, Norwegian Ministry of Petroleum and Energy. He pointed out that Norway has 20 years CCS experience related to Sleipner and Snøhvit. A lot of knowledge is gained from the projects. He also pointed out that the bilateral CCS cooperation between USA and Norway under the MoU (Memorandum of Understanding) as a very valuable international cooperation in addition to CSLF, Mission Innovation, and IEA , which are also very important. Further, he informed about the full scale CCS in Norway that is under development and the expected decision in the Parliament in June.

Steve Winberg, US Department of Energy, had the opening speach at the workshop. He explained that the USA energy policies embraces that there is vast amount of untapped fossil resources in the USA. Boosting energy production and energy security are important. This must go hand in hand with stewardship of the environment. USA is therefore committed to advance CCS.

Steve Winberg ensured that CCS can create jobs and energy security and the USA will continue to work with international partners. In a CCUS summit last November that was co-chaired by US Secretary of Energy Rick Perry and IEA it was called for a new push for CCS. In the December CSLF meeting in Abu Dhabi USA together with others announced strategies for the global deployment of CCS.

USA has a robust CCUS R&D programme. Focus is on reducing capture cost, ideally by 50 %. Key strategies include national labs, academia and international cooperating.

Within capture, the USA are developing advanced polymeric membranes, cryogenic systems, non-aqueous solvents. Testing at Technology Center Mongstad (TCM) is an important part of the DOE

NETL program. The USA also address both utilization and geological storage as well as EOR. Within storage focus are developing monitoring technologies and pressure management during injection.

The USA is moving forward with infrastructure for large scale CO_2 storage throughout the country. This includes going forward with potential storage in the Gulf of Mexico. Residual oil zones (ROZ) and organic rich shales are also being researched.

Steinar Eikaas, Statoil, presented Statoil's new strategy addressing hydrogen production from reforming of natural gas and couple it with CCS.

There are two important steps in the new strategy:

- Step 1 – establish CCS infrastructure
- Step 2 – utilize CCS infrastructure to produce hydrogen and store CO_2

Statoil sees three flagship hydrogen projects

- Hydrogen for power generation
- Hydrogen for heating
- Liquid Hydrogen for transport

Statoil are pursuing the presented model based on natural gas because Statoil is a natural gas producer.

Ryozo Tanaka, RITE, informed about emerging hydrogen value chains for Japan.

Japan has a long history of R&D on hydrogen. The country has more than 200 000 units installed since 2009, including on site fuel cells based CHP for houses.

A strategic roadmap for hydrogen and fuel cells has been established. The ambitions include large scale deployment of fuel cells by 2030. This will require large scale hydrogen production. Ryozo Tanaka informed about Kawasakis ambitions within hydrogen and their hydrogen concept from brown coal in Australia.

Brian Hill, SSEB – Gave a presentation on "Fast tracking infrastructure development for future offshore CO_2 storage". The US 45Q regulatory framework includes tax credits for storing CO_2 and for CO_2 EOR. The value of the tax credits are USD 35 per ton CO_2 for utilization like EOR and USD 50 per ton CO_2 stored.

There are many onshore and offshore areas in the Central Gulf Coast Region that could benefit from CCUS. 45Q is a potential enabler. The economic potential is large. The federal government would receive about USD 25 bn of royalty revenues from the extra oil produced using Gulf of Mexico (GoM) CO_2 pipeline systems.

CO_2 Capture workshop

Chairs: **Lynn Brickett**, DoE, and **Bjørn-Erik Haugan**, Gassnova

The capture workshop focused on advancing the technology development of capture processes. Several of the presentations focussed on experience from and planning for testing at TCM (Technology Centre Mongstad). Four US companies have projects with CLIMIT funding including collaboration with SINTEF and five companies are preparing to test at the Technology Centre.

Mongstad (TCM). ION has completed their campaign. Aker Solutions built the amine unit at TCM and has also completed their campaigns. Tests at TCM are very valuable and the arrangement offers good opportunities for both the technology developer side as well as TCM. Learnings from yesterday's capture breakout session on US-Norway collaboration were a part of the discussions. On 4th May a delegation from the Capture workshop travelled to Bergen and visited TCM to explore the site for future cooperation.

Bjørn-Erik Haugan, Gassnova, informed about TCM, its strategy and activities. TCM has internal non-proprietary test campaigns and baseline testing for MEA tests that are published widely. In addition, an important part is a competence centre for technology developers. Aker Solutions, Alstom, Cansolv, ION Engineering and Carbon Clean Solutions have tested and developed their technology at TCM. The five new companies are planning for testing at TCM are Fluor, MTR, SRI, TDA and TRI.

Frank Morton, NCCC, Southern Company, informed about the National Carbon Capture Centre (NCCC). NCCC focus on advancing technologies in the 0.1-1MW size. The site is next to an Alabama coal plant and has its own permanent staff for test execution. More than 30 post-combustion technologies have been tested at their site in addition to also pre-combustion. Technology developers from 6 different countries have been at their site.

Carbon capture, Utilization and Storage activities in Aker Solutions was presented by **Oscar Graff**, Aker Solutions. Aker Solution covers the whole value chain from capture to storage and has worked with this since 1996. Oscar Graff informed about the development of Aker Solutions capture technology and its newly launched modular capture plant Just Catch.

Ion Engineering has executed their test campaigns at TCM after fruitful collaboration and testing at the SINTEF Tiller rig. **Buz Brown**, ION, informed about technology development, achievements and experience from the collaboration with SINTEF and campaigns at TCM.

RTI are working both on non-aqueous solvent technology and solid sorbent technology. RTI has worked with SINTEF for 5 years on development of their non-aqueous solvent technology. **James Zhou**, RTI, informed about solvent development, degradation studies and testing at Tiller. RTI are now planning for testing their technology at TCM. **James Zhou** also gave a talk on the project and plans for large scale testing at TCM.

Fluor offer various gas processing solutions including CO_2 capture technologies. **Sadish Reddy**; Fluor, explained about Fluor's development of a water lean solvent technology through DOE funded projects. They have now a project for further development together with SINTEF. Phase two of this project will be demonstrating the technology at TCM.

Svein Nodeland, Air Products, gave a presentation about Air Products and their activities in the membrane marked. Air Products has a Norwegian subsidary which e.g. are responsible for engineering and manufacturing of marine nitrogen membrane systems. Air Products has licensed the NTNU technology on CO_2 selective membranes and has tested the technology on cement flue gas at the Norcem plant. They are now working on further advancing and commercialization of the technology.

SRI is founded by Standford and has developed a mixed salt solvent technology. **Indira Jayaweera**, SRI, presented their newly funded project by DOE on the further development under US-Norway partnership. A process summary was given with the demonstrated benefits. SRI are also seeking funds for collaboration with SINTEF in its development.

MTR offers membranes for post- combustion capture. **Tim Merkel**, RTI, informed about the technology development and the timeline. This development is also supported bye DOE. The technology has been tested at NCCC and they have executed an integrated test at B&W. The next step will be advanced testing at TCM.

Ambal Jayaraman, TDA, informed about TDA's membrane sorbent hybride system. Development of the sorbent has been done together with University of California. MTR are their membrane partner. The goal of the newly funded project is to perform a 1MW scale testing for 9 month. The test unit is planned to be tested at TCM.

Mike Matuszewski, NETL, presented Carbon Capture Simulation Initiative (CCSI2) , a modelling toolset to maximize learnings for each stage of technology development. CCSI2 had its open source release in March this year. The toolset is open to be used all the way from early R&D, pilot scale and Demo scale processes. They collaborate closely with national labs, academia and industry. The model can predict both steady state as well as dynamic modelling.