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 CO_2 capture

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

The Capture Breakout session was welcomed by Bjørn-Erik Haugan (Technology Centre Mongstad) and John Lytinski (Department of Energy - DOE) who expressed their appreciation for the growing interest and all the valuable projects that has been done under the US-Norway Bilateral agreement. Seven companies were mentioned that have tested or plan to test their technology at Technology Centre Mongstad (TCM) - IoN, Fluor, RTI, SRI, MTR (TCM approved), TDA (TCM approved), and Innosepra. Gassnova and NETL signed a Cooperative Research and Development Agreement (CRADA) in February this year. Fruitful collaboration has been achieved between DOEs announcement for projects and the Norwegian funding scheme CLIMIT, and USA has now joined ACT (Accelerating CCS Technology), an international scheme for common calls, through their national labs. The Test Centre Network was also mentioned as an important tool for the cooperation.

It was emphasized the importance of continuing the dialog on technology development, possibilities to combine technologies developed in the respective two countries to further develop the cooperation and accelerate the CCS. In the US there is an increased focus on CCS from the industrial sector, an area that already has been a major point in Norway.

The subjects for this meeting was the following

- Capture systems for demands of load following and intermittent operation
- Experiences from US industry
- Emerging and enabling technologies
- Testing, assessment criteria and qualification of technologies for industry
- Scaling up for industry, incl. modularization

Capture systems for demands of load following and intermittent operation

Aslak Einbu, SINTEF presented experience on flexible operation and how models for process control could improve the efficiency and give savings during operation of the capture process.

Matt Adams from NETL presented a conceptual design of a pulverized coal plant for flexibility and showed that low cost options could affect flexibility options available with existing technology.

Experiences from US industry

Sallie Greenberger for ADM, *Katherine Dombrowski*; Trimeric, *Jeff Bobeck*; Carbon Capture Coalition, *Betty Pun*; Chevron shared their experience from the US industry. The importance of collaboration through the whole value chain was emphasized, from capture to storage. Also of ultimate importance is the ability to be able to predict the future when designing the process and doing the investment in order to take account for changes in flexibility needs and other future changes in requirements. It was pointed out that testing at TCM actually is large enough up-scaling for several relevant industry tests, such as compressor station, recirculation of CO_2 from EOR, power use for refining industry. From a policy point of view, the US 45Q tax was pointed at as an enabler for industry. However, further incentives are needed, e.g. is there still uncertainties regarding timeframe and return on investments.

Emerging and enabling technologies

G. Alptekin presented TDA's hybrid process to be tested at TCM. The process combines membranes with sorbents. The gas is first cleaned by membranes and then the sorbents separate out the remaining part. The current plan is a 1MW pilot plant.

Torleif Madsen presented Compact Carbon Captures 3C solvent technology. The technology is independent of type of solvent. The technology is based on modularized design, and rotating adsorption and desorption. The solvent process intensification results in a process with much lower footprint, lower cost and improved efficiency.

Richard Blom from SINTEF gave broad overview of the benefits and challenges with sorbent technologies. He pointed at the following main issues for further improvement of sorbent technologies: Novel sorbent material with improved isotherms, efficient heat transfer/integration systems to ensure low energy requirement, reduced cycling time for overall reduced footprint.

Testing, assessment criteria and qualification of technologies for industry

Johnny Stuen; Fortum Varme, shared their experience from technology assessment, criteria selection, contractual issues and negotiations for the large-scale CO_2 capture FEED project at the Klementsrud Waste Incineration plant.

Michael Matuszewski, Aristosys, Inc presented DOE's experience using Sequential Design of Experiment to Guide Field Testing of Solvent-Based CO_2 Capture Systems. He showed that the use of the $CCSI^2$ tool and experimental design used on solvents technologies before pilot plant testing would give a more effective experimental program and improved modeling tool for up-scaling of the process.

Scaling up for industry, incl. modularization

The last subject of the capture breakout session concentrated on up-scaling and modularization for industry. *Tim Merkel* from MTR showed the effect from membrane module business on large volume manufacturing and the following reduction in production cost. He gave an example from UoP Separex membrane module unit for natural gas separation, whose gradual improvement has reduced the cost over 20 years. CCS technologies are currently at the high end and require large volume manufacturing and incremental improvements to go down the same cost curve.

Eirk Bjørnsen from Biobe presented their effort to develop internals for absorbers and currently with focus on CO_2 capture technologies.

Lynn Brickett from DOE presented the current US's new focus on capture of CO_2 from industry and emphasized the possibility to expand the US-Norway collaboration in this direction. She underlined that the US focus on capture from large-scale power plant for several years, also benefits the future focus on industry capture and that technologies developed benefit also smaller scale industry capture.

There was also given a presentation on behalf of Aker Solutions showing their modular design of a up to 100 000 tons/year capture. The technology is delivered as a standard design and improved efficiency and low footprint is achieved.

Discussions and future collaboration

After the presentations and discussion, a focused discussion around the following questions was followed:

- What R&D would be most impactful for a commercial-scale industrial capture project?
- To our Norwegian colleagues: given what you've seen on US R&D projects at our conference, are there any collaborative opportunities that stand out?

One point that was emphasized to achieve impactful R&D for a commercial-scale industrial capture project, was to identify what is specific for industry. Further it was pointed at process intensification, 3D printing, multifunctional sorbents, modularization for design and manufacturing. Specific for industry purposes is to optimize the integration of the capture technology into the industry process design as well as identify specific technologies that are beneficial for certain industries. Another area for collaboration that was identified was up-scaling of sorbents.

For future new collaborative opportunities capture from industrial sector was identified as specifically important. Several areas were identified and it was suggested to arrange workshops for invited people to discuss these areas in more detail:

  - on additive manufacturing
  - on modeling and
  - on process control
  - on up-scaling of sorbents (e.g. MOFs)

US joined the ACT (LINK) for the second call in 2018 with the US national labs as eligible for applying for funding. Further development of the relation between the National Labs (NLs) and Norwegian R&D actors was looked upon as a new opportunity to prepare for future ACT calls.