

## Status of capture activities within the US-Norway bilateral agreement on CCUS

*Issue: Organize workshops defined during storage and capture breakout sessions, to be held over the next 18 months until the next meeting. Areas that were identified within capture included:*

- ***additive manufacturing***
- ***modeling and***
- ***process control***

Status:

*Consider possible webinars autumn 2020/spring 2021*

*Issue: Interest in creating a utilization focal area in addition to capture and storage to be investigated.*

Status:

*Funding for utilization without permanent storage is not possible for Norway. Could be a cooperation, e.g. in ACT3, where the Norwegian partners focus on capture part with support from Norway, and the US partners handle the utilization.*

*Issue: Identifying collaboration opportunities within areas specific for industry to achieve impactful R&D for a commercial-scale industrial capture project, including **optimizing the integration of the capture technology into the industry process design; identifying specific technologies that are beneficial for certain industries; up-scaling of sorbents; process intensification; 3D printing; multifunctional sorbents; and modularization for design and manufacturing.***

Status:

Several activities are on-going between US and Norwegian partners:

- TCM is working with NETL on process simulation using Carbon Capture Simulation Initiative (CCSI) for the Cesar solvent used in the ACT-project Align. This is in connection with use at a gas power plant as balancing power. This is a call-off on CRADA.
- Projects due at TCM include modeling, process control, sorbents, MOF, and modularized technology
- Compact Carbon Capture (3C) has had progress since the Pittsburgh August 2019 meetings, including the NETL conference proceeding the bilateral:
  - Letter of support from Occidental Petroleum (Oxy): The letter can be used towards potential US costumers. It opens possibilities to offer a complete CCUS chain solution with capture, transport and EOR/storage in areas where Oxy operates pipelines. The contact was established at the NETL conference.
  - 3C has signed a non-disclosure agreement (NDA) with ION Clean Energy. The partners are in the process of establishing potential collaboration on technical as well as business matters. 3C

- and ION are pursuing the opportunity for a combined application for funding, possible a DOE call, to look at ION's capture material in the 3C technology.
- 3C has had progress regarding potential collaboration with RTI on solvent testing in their Labrig. This came as a result of opportunities at the NETL conference.
  - Fortum Oslo Varme AS has been invited to an industry conference on CCS in US in June 2020. They have also had contact with Canadian company Svante (former Inventys) regarding a solid absorbent technology.
  - Work towards potential applications to CLIMIT Demo include:
    - Sorbents, with USA/Total involved
    - MTR and membrane technology with Norfrakalk
    - Returkraft, Kristiansand, Norway, has mentioned membrane technology in cooperation with USA as a possibility
  - SINTEF and ION Engineering submitted application to CLIMIT Demo regarding 3D but did not succeed.
  - SINTEF has also had contact with Lawrence Livermore Nat. Lab. (LLNL) regarding potential collaboration on 3D manufacturing and modularization but nothing has materialized.
  - SINTEF has had commercial projects with US industry (Fluor)
  - SINTEF has established contacts with the University of California at Berkeley on MOFs but nothing has materialized
  - SINTEF and the University of West Virginia is part of the CLIMIT R&D project MACH-2. The CCSI2 and IDEAS initiatives are also involved through this, as they will be using tools developed as part of these programs.

On the sideline of the core activities under the MoU: SINTEF is actively and continuously collaborating with a major DoE lab (Sandia NL), they have weekly meetings on topics related to ammonia/hydrogen combustion.

*Issue: Collaboration within ACT.*

Status:

There are several examples cooperation in CLIMIT and/or ACT 2 projects. ACT 2 with participation from US and Norway are:

- LAUNCH – Solvent Degradation - (<http://www.act-ccs.eu/launch>), headed by TNO and involving Los Alamos National Lab. And the University of Teaxs from USA and SINTEF, NTNU and BIOBE from Norway. The primary objective of LAUNCH is: To accelerate the implementation of CO<sub>2</sub> capture in various industries and the development of novel solvents by establishing a fast-track, cost-effective de-risking mechanism to predict and control degradation of capture solvents.
- MemCCSea - Membrane for offshore applications - (<http://memccsea.certh.gr/>), headed by CPERI/CERTH, Greece, and involving NETL from USA and NTNU and DNV GL from Norway. The MemCCSea project aims at developing hyper compact membrane systems for flexibly operational and cost-effective post-combustion CO<sub>2</sub> capture in maritime and offshore applications.
- Prisma - Integration of molecular and process engineering for optimal CO<sub>2</sub>-solutions – (<http://www.act-ccs.eu/prisma>), headed by Heriot-Watt, and involving Lawrence Berkeley National Lab. from USA and SINTEF from Norway The primary objective of the PRISMA project is to accelerate the transition of energy and industrial sectors to a low-

carbon economy by developing a technology platform to tailor-make cost-efficient carbon capture solutions.

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.

*Issue: Points to consider in the collaboration between US and Norwegian organizations*

*1. US organizations qualified for collaboration in ACT*

Only NETL laboratories are qualified for ACT from the US side. This applied in ACT 2 and is presently the case for ACT 3. The NETL labs are highly qualified research organizations that will bring valuable competence and capacity to ACT projects. However, experience shows that also US research organizations and/or universities will appreciate the opportunity work together with Norwegian R&DD organizations within ACT. This can perhaps be solved by allowing non-NETL US partners to be sub-contractors to NETL labs (example: Univ. of Texas and Lawrence Livermore Nat. Lab in ACT2 storage project SENSE).

*2. Commercial partners*

Testing at TCM is the step before commercialization, therefore it will be important to include in the applications manufacturing and user industries that recognize the industrial benefits of the technologies.

*3. Complementary versus competitive competence and technologies*

It is important to identify collaborative topics where the organizations work on technologies and issues for mutual benefit.

*4. Differences between US and Norwegian calls*

US calls are often directed more towards specific topics than are the Norwegian calls. This may make it easier to identify partners. It also opens for the opportunity to hold workshops on the topic before the application deadline, as happens in USA. It is, however, difficult to change the Norwegian approach, as the total amount of funding is significantly less than in USA.

*Issue: Possible new topics for collaboration (mentioned by Norwegian parties)*

Negative emissions and CCS on biomass.