Mission Innovation Workshop

Trondheim, Norway

June 19-20, 2019

Prepared by Rune Aarlien, SINTEF Energy Research

Presented by Lars Ingolf Eide, Research Council of Norway

MISSION INNOVATION

Workshop summary

- Date: June 19-20, 2019
- Place: Trondheim, Norway
- Venue: Scandic Nidelven Hotel
- Organized by:
  - Department for Business, Energy & Industrial Strategy, UK
  - SINTEF Energy Research, Norway

- 135 attendees
- 6 topics
- 6 group work sessions
- 7 introductory presentations
- 1 report – recommendations for actions and topical summaries

Topics discussed

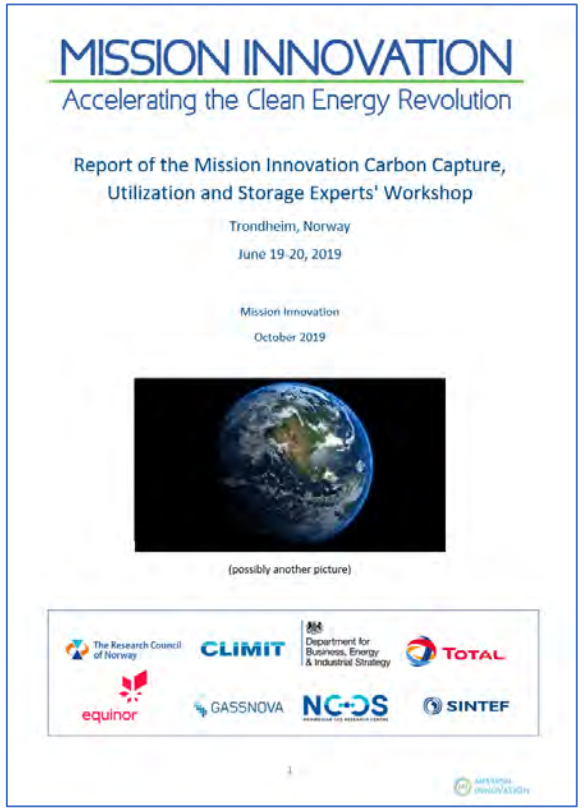
- Decarbonizing industry sectors (1)
- The role of CCS in enabling clean hydrogen (2)
- Storage and CO_2 networks (3)
- Storage monitoring (4)
- Going climate positive (5)
- CO_2 utilization (6)

Questions addressed

The groups were asked to answer the following questions:

1. Which opportunities are identified from an industrial point of view?
2. How do we most effectively get from research to commercial product?
    a. What steps are needed?
3. What joint activities could be established to accelerate technology development and implementation?
    a. How can joint action accelerate deployment?
    b. Business models: What funding instruments are/could/would be effective?
    c. Mobilizing national efforts towards international efforts
    d. Public-private partnership, co-funding, etc.

Final Report


MISSION INNOVATION

Accelerating the Clean Energy Revolution

Report of the Mission Innovation Carbon Capture, Utilization and Storage Experts' Workshop

Trondheim, Norway

June 19-20, 2019

Mission Innovation

October 2019

(possibly another picture)

The Research Council of Norway · CLIMIT · Department for Business, Energy & Industrial Strategy · TOTAL · equinor · GASSNOVA · NCCS · SINTEF

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2. Contents

Link to report:
https://www.sintef.no/globalassets/sintef-energi/arrangemeng_events/mission-innovation-final-report-final_v2_report-only.pdf
Appendix: https://www.sintef.no/globalassets/sintef-energi/arrangemeng_events/mission-innovation-final-report-final_v2_complete-appendix-section.pdf
All orlkshop results: https://www.sintef.no/en/events/mission-innovation-ccus-workshop/

Some answers to the questions

1. Which opportunities are identified from an industrial point of view?
   - Political targets and requirements for a low-.carbon society/economy
   - CCUS may be the fastest, cheapest, most flexible and sometimes only way to reduce industrial CO_2 emissions
   - CO_2 geological storage key sink, may create business opportunities
   - Markets of all sizes for CCU
   - CCU, particularly fuel production, can be a commercial bridge to negative emissions (or climate positive) technologies
2. How do we most effectively get from research to commercial product?
   - Knowledge and experience sharing
   - Sharing data and IP, transparency
   - Funds to cross “valley of death” and go on to TRL>7
   - Pilots and demonstrations for maturing technologies and methods
   - LCAs and success stories, particularly for CCU
3. What joint activities could be established to accelerate technology development and implementation?
   - Public-private partnerships
     - Common test centres, joint projects
     - Common demonstration and commercial projects, industry clusters and infrastructure
   - Joint development of legislation, regulations, standards, policies and business models
   - International cooperation to improve public acceptance
   - Market creation

Recommendations:

Decarbonizing industry sectors (topic 1)

Recommended short-term actions (within 1 year)

1. Establish joint initiatives, bringing multiple stakeholders from different sectors.
2. Implement guidelines, standards, and financial structures to accelerate deployment.

Recommended medium-term actions (1 – 3 years)

1. To transfer learnings between countries/regions.

Recommended long-term actions (> 3 years)

1. To implement incentives for low CO_2 value products that encourage consumers to buy low CO_2 footprint products could enhance the business models.

Recommendations:

The role of CCS in enabling clean hydrogen (topic 2)

Recommended short-term actions (within 1 year)

1. Fund existing ideas and plans for industry clusters and infrastructure for transport of H_2 and transport and storage of CO_2.
2. Initiate careful safety and impact analysis for design and operational phases as part of gaining public acceptance.

Recommended medium-term actions (1 – 3 years)

1. Accelerate RD&D activities to reduce the cost and carbon footprint of H_2 production with CCS.
2. Cary out Front-end engineering and design (FEED) for industrial clusters with H_2 production and CCS.
3. Implement policies and regulations that encourage hydrogen as a substitute for fossil fuels and at the same time spur the use of CO_2.

Recommended long-term actions (> 3 years)

1. Implement detailed design for large-scale industrial clusters and infrastructure.
2. Start construction, commissioning and operation of large-scale clusters and infrastructure.

Recommendations:

Storage and CO_2 networks (topic 3)

Recommended short-term actions (within 1 year)

1. Engage strongly with the public authorities of each Mission Innovation country, raise awareness of carbon sink technology to be included it Nationally Determined Contributions (NDCs) and strategies to mitigate climate change.
2. Urge initiation of pilots, demos and real projects (beyond lab-scale) for field-testing and technology development in real conditions.

Recommended medium-term actions (1 – 3 years)

1. Launch an international cooperative project that could be named “Earth Geonome Project” or “Underground Carbon Sink Project. This could address topics too expensive to be addressed by each participant alone, such as providing a big international test site.
2. Address the perception issue of CO_2 storage, which still exists among public authorities and the general public.
3. Launch a Mission Innovation Platform for sharing stories, knowledge, data and case studies, and demonstrate transparency and openness.

Recommended long-term actions (> 3 years)

1. Establish one or more internationally recognized CO_2 storage open-source software, as done with climate models.
2. Mature an international certification process for bankable CO_2 storage resource.
3. Engage with the insurance and financial communities to build confidence in CO_2 storage, manage the risks, incentivize implementation of CO_2 storage and transport networks, and to manage penalties if promises are not achieved.

Recommendations:

Storage monitoring (topic 4)

Recommended short-term actions (within 1 year)

1. Develop innovative ways to show plume stabilization that avoid limitations of "tracking plume boundaries" through international collaboration on pilot closure projects.
2. Develop terrestrial sensors for deployment at shallow depths that can measure several parameters of interest at once for process-based approaches to identifying and attributing near surface anomalies.
3. Develop methods to combine tools that take physical measurements for locating offshore features (e.g. chimney-form leakage plumes) concurrently with geochemical measurements for attribution and quantification of associated signals.

Recommended medium-term actions (1 – 3 years)

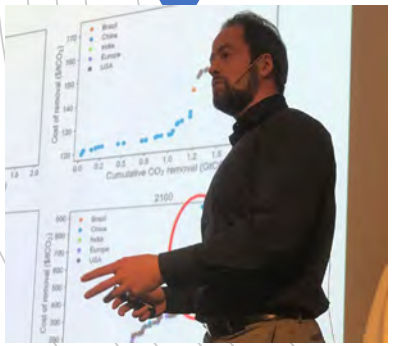
1. Produce useable outcomes from large data sets to look at artificial intelligence and how other industries (e.g. medical) manage large data sets.
2. Develop smart-monitoring solutions for locating legacy wells (onshore and offshore) that have been plugged and cut off below surface and for assessing their integrity during and after storage operations.

Recommended long-term actions (> 3 years)

1. International collaboration to reduce risk and cost on offshore CO_2 demonstration injection project(s) in diverse settings.
2. Decide how much and what types of data to collect to reduce costs and provide assurance using environmental monitoring.

Recommendations:

Going climate positive (topic 5)



Recommended short-term actions (within 1 year)

1. Establish R&I activities at scale for climate positive solutions at national and global level.
2. Quantify bio-char possibilities and the global implications and the actual potential of BECCS in a complete sustainability context.
3. Support the deployment of climate positive solutions for waste-to-energy plants, the modularity of these and how long-term storage can be secured for the captured CO_2.

Recommended medium-term actions (1 – 3 years)

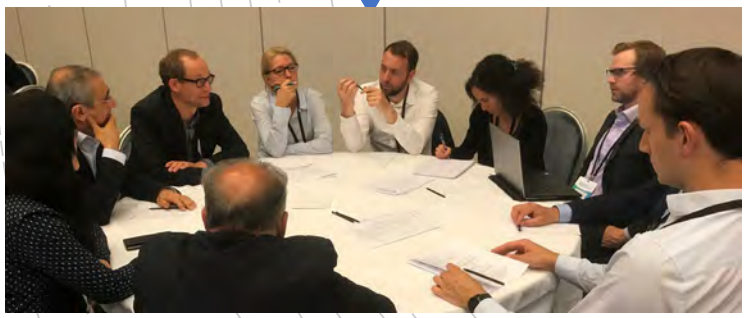
1. Establish a separate climate positive innovation challenge, MI Challenge #9 - climate positive solutions (CPS).
2. Underpin activities to establish a global stocktake (terrestrial and marine-unconventional biomass) of photosynthesis-based materials.
3. Design a quota and certificate system for net removal of carbon dioxide.
4. Establish acknowledged LCA analyses for the various pathways and solutions proposed.

Recommended long-term actions (> 3 years)

1. Start operating pilot plants and demonstration plants for the less mature/high potential technologies.
2. Build systems that allow for investment into CPS based upon business models that pay for carbon stored and isolated from escaping into the atmosphere.
3. Raise the awareness of the need of these kinds of solutions as complementary to the primary measures like efficiency, solar, wind, etc. They must never be used as a substitute for direct measures.

Recommendations:

CO_2 utilization (topic 6)



Recommended short-term actions (within 1 year)

1. Review mid-term and long-term selection of CCU technologies: CO_2-based fuels could be the best case and achievable scenario for specific sectors (aviation, marine, etc.).

Recommended medium-term actions (1 – 3 years)

1. Re-deploy public research funding to low TRL CCU projects to address 2050 carbon neutrality targets and place CCU in the technology portfolio.
2. Collect and finalize LCA and TEA best practices to evaluate the most promising CCU routes, disseminate and convey a better understanding of these tools to policy makers.

Recommended long-term actions (> 3 years)

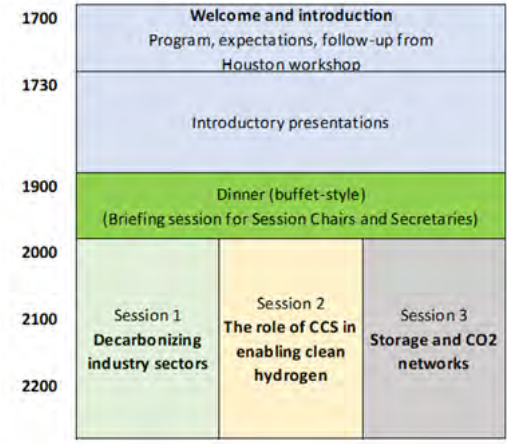
1. Once most promising routes have been selected and proven, build up on international cooperation to spur investment on R&I and seek to reduce regulatory barriers on selected and most promising CCU routes.

Acknowledgement

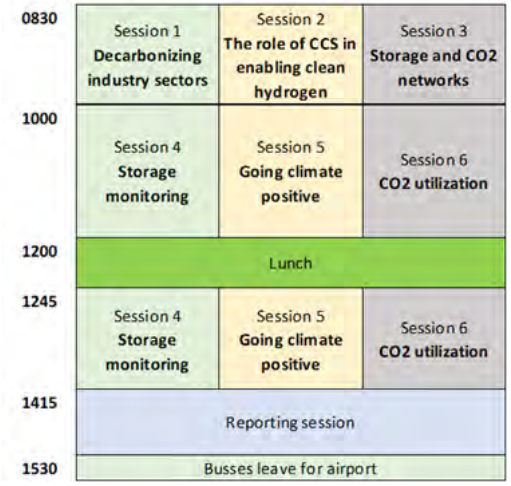
- We would like to acknowledge the direct financial support to the workshop from Research Council of Norway (RCN), Department for Business, Energy and Industrial Strategy (BEIS) UK, TOTAL, The CLIMIT Programme, Gassnova, Equinor, The Norwegian CCS Research Centre (NCCS), and SINTEF Energy Research.
- In planning and preparing the workshop programme we had several telephone conferences with the Steering Group of the Mission Innovation Challenge CCUS. Your guidance was instrumental and was highly appreciated!
- A special thanks goes to the following:
  - The *Workshop Co-Chairs*: Nils A. Røkke (SINTEF, Norway) and Brian Allison (Department for Business, Energy and Industrial Strategy, UK).
  - The *Session Chairs*: Mike Monea (CCS Knowledge Centre, Canada), Lars Ingolf Eide (Research Council of Norway), Isabelle Czernichowski-Lauriol (BRGM France), Katherine Romanak (University of Texas, USA), Niall MacDowell (Imperial College London, UK), and Paul Bonnetblanc (Ministry of Ecological Solidarity Transition, France)
  - The *Session Secretaries*: Stefania Osk Gardarsdottir (SINTEF, Norway), Gerdi Breembroek (Netherlands Enterprise Agency), Peter Zweigel (Equinor, Norway), Tim Dixon (IEAGHG), Nils A. Røkke (SINTEF, Norway) and Aicha El Khamlichi (ADEME, France)
  - The *Introductory Speakers* at the workshop: Monica Garcia (IEAGHG), Sigmund Størset (SINTEF, Norway), Phillip Ringrose (Equinor, Norway), Tip Meckel (Gulf Coast Carbon Center, USA), Niall MacDowell (Imperial College London, UK) and Jaap Vente (TNO, Netherlands)

Workshop program

June 19



June 20



JUNE 19

17:00 **Welcome and introduction** (program, expectations for the workshop)
Nils A. Røkke, SINTEF and Brian Allison, BEIS UK

17:10 **Status of Challenge #3** (recap of Houston workshop, Houston report, etc.)
Brian Allison, BEIS UK

17:30 **Introduction to topics (12 minutes each)**
Session Chair: Brian Allison, BEIS; UK

1. Topic 1: Decarbonizing industry sectors (power, cement, refineries, steel, fertilizers…)
   - Introductory speaker: Monica Garcia, IEAGHG
2. Topic 2: The role of CCS in enabling clean hydrogen
   - Introductory speaker: Sigmund Størset, SINTEF
3. Topic 3: Storage and CO_2-networks
   - Introductory speaker: Phillip Ringrose, Equinor
4. Topic 4: Storage monitoring
   - Introductory speaker: Tip Meckel, Gulf Coast Carbon Center
5. Topic 5: Going climate positive (biomass, waste to-energy, resources and technology)
   - Introductory speaker: Niall MacDowell, Imperial College London
6. Topic 6: CO_2 Utilization
   - Introductory speaker: Jaap Vente, TNO
   - "Success story" speaker: Mark Summers, Emissions Reduction Alberta (ERA)

19:00 **Dinner (buffet-style)**

Briefing session for Session Chairs and Secretaries (separate room)

20:00-22:00 **Group work over topics 1-3**

Session/Topic 1: Decarbonizing industry sectors (power, cement, refineries, steel, fertilizers…)

Chair: Mike Monea, CCS Knowledge Centre
Secretary: Stefania Osk Gardarsdottir, SINTEF

Session/Topic 2: The role of CCS in enabling clean hydrogen
Chair: Lars Ingolf Eide, Research Council of Norway
Secretary: Gerdi Breembroek, Netherlands Enterprise Agency

Session/Topic 3: Storage and CO_2-networks
Chair: Isabelle Czernichowski-Lauriol, BRGM
Secretary: Peter Zweigel, Equinor

JUNE 20

08:30-10:00 **Group work over topics 1-3 (cont'd)**

(Same Chairs, Secretaries and rooms)

10:00-12:00 **Group work over topics 4-6**

Session/Topic 4: Storage monitoring
Chair: Katherine Romanak, University of Texas
Secretary: Tim Dixon, IEAGHG

Session/Topic 5: Going climate positive
Chair: Niall MacDowell, Imperial College London
Secretary: Nils A. Røkke, SINTEF

Session/Topic 6: Utilization
Chair: Paul Bonnetblanc, Ministry of Ecological Solidarity Transition
Secretary: Aicha El Khamlichi, ADEME

12:00-12:45 **Lunch**

12:45-14:15 **Group work over topics 4-6 (cont'd)**

(Same Chairs, Secretaries and rooms)

14:15-15:25 **Reporting (10 minutes each)**

(To be conducted by the *Session Chair*, *Session Secretary* and *Introductory Speaker)*

- Topic 1: Monica Garcia, Mike Monea, Stefania Osk Gardarsdottir
- Topic 2: Lars Ingolf Eide, Gerdi Breembroek
- Topic 3: Phillip Ringrose, Isabelle Czernichowski-Lauriol, Peter Zweigel
- Topic 4: Tip Meckel, Katherine Romanak, Tim Dixon
- Topic 5: Niall Mac Dowell, Nils A. Røkke
- Topic 6: Jaap Vente, Paul Bonnetblanc, Aicha El Khamlichi

15:25 **Summary and conclusion**
Nils A. Røkke and Brian Allison