

# Accelerating CCS Technologies

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## 5th ACT Knowledge Sharing Workshop, Virtual Meeting 16-17 November 2020

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**Authors:** Hannah Lord (BEIS), Gerdi Breembroek (RVO) and Ragnhild Rønneberg (RCN)

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## What ACT is about

Since the industrial era the level of carbon dioxide (CO<sub>2</sub>) released into the atmosphere has increased significantly, and it is well documented that burning fossil fuels emits CO<sub>2</sub> with serious and negative impact on the climate. Carbon Capture, Utilisation and Storage (CCUS) is part of a portfolio of technologies to combat climate change. CCUS can help mitigate CO<sub>2</sub> emissions from electricity production and is a prerequisite for reducing CO<sub>2</sub> emissions from industry such as steel, cement, chemicals and petrochemical refining.

ACT will be Accelerating CCUS Technologies by making available funds for transnational research and innovation activities. CCUS will have an important role to play to make the transition to a low-carbon economy happen.

The CCS technology involves capturing CO<sub>2</sub> from large CO<sub>2</sub> emission point sources, such as fossil fuelled power plants and large, energy intensive industrial plants, compressing it for transportation and then injecting it deep into a rock formation at a carefully selected and safe site, where it is permanently stored. In addition, CCUS projects which deal with innovative and cost reducing utilisation of CO<sub>2</sub> are also in scope for ACT.



Figure 1: Geological storage of CO<sub>2</sub>

ACT is an international initiative based on the Horizon 2020 European Commission funding scheme. Nine European countries started this collaboration in 2015. The first Call for projects took place in 2016. Since then, ACT has expanded its collaboration beyond Europe, with USA and Canada/Alberta Region included in the consortium.

Currently (by January 2021) 16 countries/regions participate in ACT:

Canada/Alberta region (ERA), Denmark (EUDP), France (ADEME), Germany (Jülich, FZJ/PtJ), Greece (GSRT), India (DST), Italy (MUIR), the Netherlands (RVO), Norway (RCN and Gassnova), the Nordic Region (NER), Romania (UEFISCDI), Spain (AEI), Switzerland (DETEC), Turkey (TUBITAK), UK (BEIS), and the USA (DoE). The Research Council of Norway (RCN) is coordinating ACT.



Figure 2: Partners of ACT

ACT calls ask for RD&D projects that can lead to deployment of CCUS. Project proposals with high industrial relevance and industrial involvement are prioritised.

## Executive summary

This report summarises the 5th Knowledge Sharing Workshop of ACT. Five Knowledge Sharing Workshops have been held under ACT. The 1st took place 14 November 2016 in Lausanne (Switzerland) in conjunction with the IEAGHG-conference. The 2nd was held 24 October 2017 in Bucharest (Romania). The 3rd workshop took place on 13 November 2018 in Niederaußem (Germany) at the facilities of RWE (Rheinisch-Westfälisches Elektrizitätswerk power plant). The 4<sup>th</sup> workshop took place in Athens (Greece) on the 6<sup>th</sup> and 7<sup>th</sup> November 2019 and the fifth workshop was undertaken virtually (due to covid-19) on the 16<sup>th</sup> and 17<sup>th</sup> November 2020.

The workshop was dedicated to get updates from the 12 awarded projects from the second call in 2019, with the first day focusing on CO<sub>2</sub> Storage projects and the second day focusing on CO<sub>2</sub> Capture and Utilisation projects.

The ACT consortium organised this event with the aim to ensure fruitful knowledge sharing and increase collaboration between all the ACT funded projects and other CCUS initiatives. The agenda for both days of the workshop is shown in Annex 1 and Annex 2, respectively.

The Workshop was organised by the Netherlands consortium member (RVO) with valuable input of the Organising Committee and the contribution of all ACT Consortium Members.

## Setting the stage

The first part of the workshop was dedicated to welcoming and opening of the workshop, but also to a message from Vassilios Kougionas from the European Commission on the “**Impact and added value of ACT**”. He emphasized that CCUS will have an essential role in the ECs R&D strategies and in particular in the new Clean Energy Transition Partnership (CETP) being under development. CCUS is a crucial enabler for the net zero energy system, and this technology plays a significant role particularly in those sectors which cannot reduce the emissions otherwise. Kougianos acknowledged the work and results from ACT and he expect that the good work will continue under the frame of the CETP.

Ragnhild Rønneberg (The ACT coordinator, RCN, Norway) addressed a warm welcome to all participants and underlined the importance of meeting (even in difficult times) to update each other and share knowledge across borders and thematic fields in the CCUS domain. The extension of the ACT family, with new projects running, is important for the development and deployment of this technology globally. Thanks to all for the great results achieved together.

## Projects program

Day 1 consisted of several informative sessions and presentations about the progress of the ACT2 projects which focused on CO<sub>2</sub> Storage. It also included an interactive session led by Mark Ackiewicz (from the US DoE) where the ACT project leaders answered questions from the audience, with closing remarks from the meeting chair Gunter Siddiqi (from DETEC).

Day 2 included a keynote presentation on “**Large-scale CO<sub>2</sub> capture from the AVR waste-to-energy plant in Duiven, the Netherlands**”, delivered by Hans Wassenaar (AVR). It also consisted of the remaining ACT2 projects focusing on CO<sub>2</sub> Capture and Utilisation. Followed again by another interactive question and answer session for the ACT project leaders, led by Mark Ackiewicz, and

finally the event was drawn to a close with key messages from the chair Gerdi Breembroek (from RVO).

The Workshop was a well-attended without over 140 participants on both days, and it was a successful event providing an excellent opportunity for knowledge sharing in the CCUS field.

In the session of 16 November, the storage and monitoring projects presented themselves. One of the highlights certainly was the SUCCEED project with a set of pictures from the installation of fiber optic cable in Hellisheiði, Iceland, where CO<sub>2</sub> is injected together with the re-injection of geothermal fluid. The SENSE project had produced a video for the occasion, where all institutes involved in the project had contributed and explained their role. There were also status updates from Digimon – on digital monitoring techniques - , ACTOM – on offshore monitoring – and REX-CO<sub>2</sub> on reusing existing wells for CO<sub>2</sub> storage.

In the session of 17 November, the capture and utilization projects presented themselves. There was a video from the Prisma project, where Sauradeep Majumdar explained the concept of the project to us. One month later, Sauradeep was crowned FameLab International 2020 Champion, a communication competition to find the world's most talented new science communicators. Also, there were contributions from AC2OCCEM and ANICA, two projects directed mainly at the cement and lime industry, with impressive experimental facilities. The project FUNMIN looks into fundamentals of mineralisation with CO<sub>2</sub>. NEWEST-CCUS looks at CO<sub>2</sub> capture in waste incineration plants. LAUNCH looks at methods to de-risk new solvents faster, focusing on degradation. Existing pilots and miniplants are used for the experimental programme. MEMCCSEA finally looks at capture using membrane in space-limited situations such as onboard of ships.

During the sessions, it was always possible to pose questions, using sli.do. This was in principle a good instrument, but the chat of zoom proved an easier tool.

The interactive sessions focused on communication between ACT and the projects, the impact of Covid-19 on international work, the added value of ACT, ACT procedures and knowledge sharing. Notwithstanding the online meeting, it was an open and helpful exchange between projects and the ACT consortium.

## Lessons learned

All projects are very happy to have the opportunity to share knowledge and results with each other, learn from each other and potentially find synergies.

Project leads (and their WP leads) tell that they appreciate close interaction with their respective national funding agencies, which has been a standard way of operation in some countries.

In order to maximise the progress and output from all ACT projects, the ACT-consortium will strengthen and improve on this point, and unify it – if possible, in all countries.

## Presentations

Find more about the ACT projects and the 5th Knowledge Sharing Workshop and all the presentations of the event on our website <http://www.act-ccs.eu/archive>.

## Acknowledgements

*This workshop has been organized by Gerdi Breembroek, Li Hua, Aage Stangeland and Anna Rosenberg and has been planned and materialised in cooperation with ACT's national research and innovation program owners and managers. A word of thanks to DETEC, RVO and DOE and the other ACT members for their contributions.*

*The ACT consortium was very pleased that Vassilios Kougionas, representing the European Commission took active part in the meeting as well as Hans Wassenaar from AVR, Netherlands.*

## Annex 1: Agenda for Day 1; 16<sup>th</sup> November 2020

### CO<sub>2</sub> Storage

Program Monday 16<sup>th</sup> November 2020 – 14.00 CET – 16.15 CET

Chair: Gunter Siddiqi, DETEC

#### Introduction

- 14.00 Welcome  
*Ragnhild Rønneberg, ACT Coordinator*
- 14.05 Impact and added value of ACT  
*Vassilios Kougionas, the European Commission*

#### CO<sub>2</sub> Storage session

- 14.15 SENSE – Ground surface monitoring techniques to ensure storage integrity  
*Bahman Bohloli, Norwegian Geotechnical Institute*
- 14.30 DigiMon – New technologies for cost effective monitoring of CO<sub>2</sub> storage sites  
*Arvid Nøttvedt, NORCE*
- 14.45 ACTOM – Offshore CO<sub>2</sub> storage monitoring based on advanced mathematic  
*Guttorm Alendal, University of Bergen*
- 15.00 REX-CO<sub>2</sub> – Re-using Existing wells for CO<sub>2</sub> storage  
*Jan Hopman, TNO*
- 15.15 Break
- 15.25 Synergetic Utilisation of CO<sub>2</sub> storage Coupled with geothermal Energy Deployment  
*Sevket Durucan - Imperial College London*

#### Closing session

- 15.40 Interactive session. The ACT project leaders will answer questions from the audience  
*Discussion chaired by Mark Ackiewicz, US Department of Energy*

#### Closing session

- 16.10 Wrap up and key messages by meeting chair *Gunter Siddiqi, DETEC*

## Annex 2: Agenda for Day 2; 17<sup>th</sup> November 2020

### CO<sub>2</sub> Capture and Utilisation

Program Tuesday 17<sup>th</sup> November 2020 – 14.00 CET – 16.45 CET

Chair: Gerdi Breembroek, RVO

#### Introduction

- 14.00 Welcome  
*Ragnhild Rønneberg, ACT Coordinator*
- 14.05 Keynote presentation - Large-scale CO<sub>2</sub> capture from the AVR waste-to-energy plant in Duiven, the Netherlands  
*Hans Wassenaar, AVR*

#### CO<sub>2</sub> Storage session

- 14.15 AC2OCEM – Oxyfuel technologies for CO<sub>2</sub> capture at cement plants  
*Jörg Maier, Universität Stuttgart*
- 14.30 ANICA – Carbonate looping technologies for CO<sub>2</sub> capture at lime and cement plants  
*Jochen Ströhle, Technische Universität Darmstadt*
- 14.45 NEWEST-CCUS – Waste handling plants with no CO<sub>2</sub> emissions  
*Romain Viguier, Scottish Carbon Capture & Storage (SCCS)*
- 15.00 FUNMIN – Mineralisation of CO<sub>2</sub> to create valuable products  
*Devis Di Tommaso, University of London*
- 15.15 Break
- 15.25 LAUNCH – More effective amines for CO<sub>2</sub> capture  
*Peter van Os - TNO*
- 15.40 MemCCSea – Towards a Carbon Neutral Ship  
*Georgios Skevis, CPERI/CERTH*
- 15.55 PRISMA – Molecular science to design new CO<sub>2</sub> capture solutions  
*Susana Garcia, Heriot-Watt University*

#### Interactive session

- 16.10 Interactive session. The ACT project leaders will answer questions from the audience  
*Discussion chaired by Mark Ackiewicz, US Department of Energy*

#### Closing session

- 16.40 Wrap up and key messages by meeting chair *Gerdi Breembroek, RVO*



## Annex 3: Participant List

From an invitation list of 160 people, around 140 participated at the meeting the two days of event. However, we have not registered all. Below is the participants from the ACT-consortium, ACT-funded projects, EC and invited speaker.

### From the ACT Consortium:

<b>Alberta/ERA:</b>	Mark Summers
<b>Denmark/EUDP:</b>	Annika Fischer, Lærke Skov Hansen
<b>France/ADEME:</b>	Aïcha El khamlichi
<b>Germany/PtJ:</b>	Hannes Stadler
<b>Greece/GSRT:</b>	Anna Rosenberg, Evi Afentaki
<b>The Netherlands/RVO:</b>	Gerdi Breembroek, Harry Scheurs, Li Hua, Peter Balemans
<b>Norway/RCN:</b>	Ragnhild Rønneberg, Aage Stangeland, Åse Slagtern, Lars Ingolf Eide
<b>Norway/Gassnova:</b>	Tore Hatlen, Stein Bekken, Jørild Svalestuen, Ingrid Melaaen, Kari-Lise Rørvik
<b>Nordic/NER:</b>	Nicki Carnbrand Håkansson
<b>Romania/UEFISCDI:</b>	Nicoleta Dumitrache
<b>Spain/AEI-FECYT:</b>	Beatriz Gomez
<b>Switzerland/DETEC:</b>	Gunter Siddiqi
<b>United Kingdom/BEIS:</b>	Brian Allison, Hannah Lord
<b>United States/DoE:</b>	Mark Ackiewicz, Darin Damiani

**From the EC:** Vassilios Kougionas, Project officer

**Invited speaker:** Hans Wassenaar, AVR, The Netherlands

**From Projects Funded:** all Project coordinators as listed below and their WP leads:

<b>AC2OCEM:</b>	Jörg Maier
<b>ACTOM:</b>	Guttorm Alendal
<b>ANICA:</b>	Jochen Ströhle
<b>DIGIMON:</b>	Arvid Nøttvedt
<b>FUNMIN:</b>	Devis Di Tommaso
<b>LAUNCH:</b>	Peter van Os
<b>MemCCSea:</b>	Georgios Skevis
<b>NEWEST-CCS:</b>	Romain Viguier
<b>PrISMa:</b>	Susana Garcia
<b>REX-CO2:</b>	Jan Hopman
<b>SENSE:</b>	Bahman Bohlooli
<b>SUCCEED:</b>	Sevket Durucan

## Annex 4: Information to the Knowledge Sharing Workshop

### This is ACT

ACT is an international initiative with ambition to accelerate and mature CCUS technology by making available funds for transnational research and innovation projects.

ACT, coordinated by The Research Council of Norway, is a collaboration of research and innovation funding organisations.

The ACT partners are funding agencies from Alberta (Canada), Denmark, France, Greece, Germany, India, Italy, The Netherlands, The Nordic countries (Nordic Energy Research), Norway, Romania, Spain, Switzerland, Turkey, United Kingdom, and USA.



### Why ACT?

- Carbon Capture, Utilisation and Storage (CCUS) is a valuable and necessary part of the toolbox for combating climate change
- Knowledge sharing and international cooperation are necessary ingredients for success

**ACT's goal is to stimulate projects accelerating the deployment of CCUS in the energy sector as well as in energy intensive industries**

## **Ambitious Plans**

With two successful Calls and projects underway, the ACT partners have established themselves as a new multilateral funding scheme for research and innovation dedicated to CCUS.

ACT is a fit-for-purpose, partner-driven, flexible, and an easy-to-join multi-national funding scheme that serves our ambition to make CCUS a commercially viable climate mitigation technology.

New ACT calls are open and details are available at the ACT web site: <http://www.act-ccs.eu/calls>

Funding agencies from new countries are welcome to join ACT!

**The ACT Calls addresses the technological, environmental, social and economic challenges required to accelerate CCUS**

## **Stay informed – make contact**

Information on Calls and projects being funded are available at the ACT web site [www.act-ccs.eu](http://www.act-ccs.eu)

Questions can be addressed to the ACT coordinator at the Research Council of Norway:

Ragnhild Rønneberg ([rr@rcn.no](mailto:rr@rcn.no))

## ACT projects

The two first ACT calls in 2016 and 2018 resulted in 20 projects funded by ACT. Details for each project is available at the ACT web site, <http://www.act-ccs.eu/overview>

A brief description of the projects are listed below.

### *Projects from the first ACT call 2016*

Project	Activities	Coordinator
3D CAPS	Targets a productivity increase of an order of magnitude in two sorbent-based technologies for CCS. This will be achieved using the latest available techniques for materials production: additive manufacturing, commonly known as 3D-printing.	TNO
ACORN	The project has delivered a re-usable blueprint for the decarbonisation of NE Scotland, including an appraisal of subsea CO2 storage sites and options to re-use gas distribution assets. ACORN has been identified as a potential EU PCI project.	Pale Blue Dot
ALIGN-CCUS	A joint industry-led research initiative to accelerate the demonstration and implementation of the next-phase of European CCUS projects by addressing specific R&D gaps across the CCUS chain.	TNO
DETECT	Aims to significantly improve our ability to evaluate risks of leakage across faulted and fractured caprocks, so as to better inform operators, regulators and other stakeholders in their risk mitigation strategies.	Shell
ECOBASE	The project will develop revenue streams and business models for CO2-EOR in South-Eastern Europe and therefore supporting large scale CCUS deployment.	NORCE
ELEGANCY	The project addresses large-scale CCS infrastructure combined with infrastructure for the rapid introduction of H2 as an energy carrier. Focus on decarbonisation of heat and transport, commercial models, and public awareness.	SINTEF Energy
GASTECH	Investigate four gas switching technologies: combustion, reforming, water splitting and oxygen production. Accelerate the development of gas switching technologies by developing a business case for further technology scale-up.	SINTEF Industry
PRE-ACT	Develop pressure-driven decision support protocols which will be a cost-efficient system for reservoir monitoring that helps the operator maximize CO2 storage capacity and quickly turn monitoring data into corrective action.	SINTEF Industry

*Projects from the second ACT call 2018*

<b>Project</b>	<b>Activities</b>	<b>Coordinator</b>
<b>AC2COM</b>	Conduct pilot-scale experiments and analytical studies to advance key components of oxyfuel cement plants with the aim of reducing the time to market of the oxyfuel technology in the cement sector.	<b>Universität Stuttgart</b>
<b>ACTOM</b>	Advance offshore monitoring of stored CO <sub>2</sub> by building a unique web-based toolkit designed to optimize monitoring programs for offshore geological storage sites.	<b>University of Bergen</b>
<b>ANICA</b>	Develop a novel indirectly heated carbonate looping (IHCaL) process for lowering the energy penalty and CO <sub>2</sub> avoidance costs for CO <sub>2</sub> capture from lime and cement plants.	<b>Technische Universität Darmstadt</b>
<b>DIGIMON</b>	Develop and demonstrate an affordable, flexible, and intelligent digital monitoring early-warning system, for monitoring any CO <sub>2</sub> storage reservoir and subsurface barrier system receiving captured CO <sub>2</sub> .	<b>NORCE</b>
<b>FUNMIN</b>	Optimise the process of CO <sub>2</sub> mineralisation into Magnesite (MgCO <sub>3</sub> ) by combining simulation and experimental techniques to identify the key factors for catalysing the formation of MgCO <sub>3</sub> under mild, non-hazardous, and non-toxic conditions.	<b>University of London</b>
<b>LAUNCH</b>	Accelerate CO <sub>2</sub> capture technologies by establishing a faster and more cost effective method to predict and control the degradation of next generation solvents.	<b>TNO</b>
<b>MemCCSea</b>	Develop hyper compact membrane systems for cost-effective and flexible operation of post-combustion CO <sub>2</sub> capture in maritime applications such as on floating vessels used by the offshore oil and gas industry.	<b>CPERI/CERTH</b>
<b>NEWEST-CCS</b>	Accelerate the deployment of CCS in the European Waste to Energy (WtE) sector and develop guidelines for the selection of robust, fuel flexible technologies resistant to Municipal Solid Waste (MSW) impurities. The project will also assess the size of the WtE CCS market to create regional roadmaps.	<b>University of Edinburgh</b>
<b>PRISMA</b>	Integrate molecular science and process engineering to develop a technology platform that allows for customized carbon capture solutions to optimal separation for a range of different CO <sub>2</sub> sources and CO <sub>2</sub> use/destination options.	<b>Heriot-Watt University</b>
<b>REX-CO2</b>	Develop procedures and tools for evaluating the re-use potential of existing hydrocarbon wells for CO <sub>2</sub> storage to help stakeholders make informed decisions on the potential of certain wells or fields for CO <sub>2</sub> storage.	<b>TNO</b>
<b>SENSE</b>	Utilise new technologies and optimized data processing to develop reliable and cost-efficient monitoring programs based on ground movement detection combined with geomechanical modelling and inversion techniques.	<b>Norwegian Geotechnical Institute</b>
<b>SUCCEED</b>	Research and demonstrate at pilot scale the feasibility of utilising produced CO <sub>2</sub> for re-injection in a geothermal field to maintain and enhance reservoir pressure and improve performance, while also storing the produced CO <sub>2</sub> that would typically be vent to the atmosphere under standard geothermal operations.	<b>Imperial College London</b>