

# Accelerating CCS Technologies

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## 4th ACT knowledge sharing workshop, Athens 6-7 November 2019

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691712

**Project title:**  
ACT – Accelerating CCS  
Technologies

**Instrument:**  
ERA-NET Cofund Actions

**Project start date:**  
1 February 2016



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programme

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Aage Stangeland 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 fueled 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 2020) thirteen countries/regions participate in ACT:

Canada/Alberta region (ERA), Denmark (EUDP), France (ADEME), Germany (Jülich, FZJ/PtJ), Greece (GSRT), the Netherlands (RVO), Norway (RCN and Gassnova), the Nordic Region (NER),

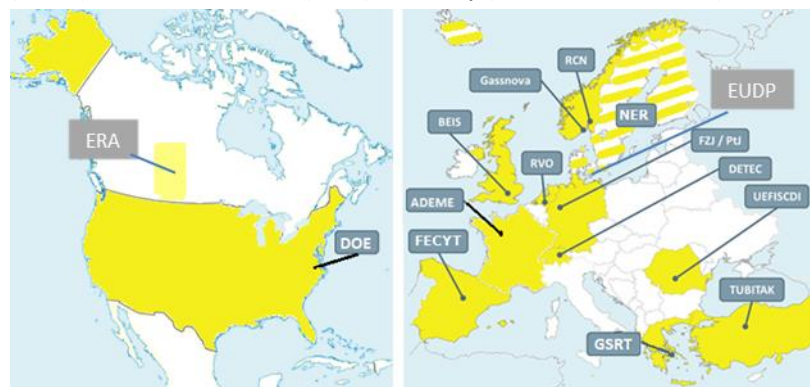


Figure 2: Partners of ACT

Romania (UEFISCDI), Spain (AEI), Switzerland (DETEC), Turkey (TUBITAK), UK (BEIS), and the USA (DoE).

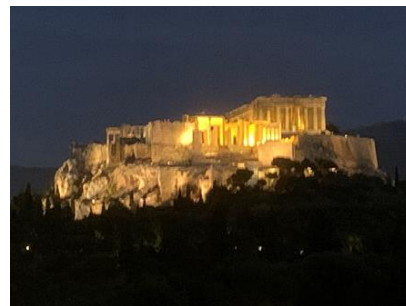
The Research Council of Norway (RCN) is coordinating ACT.

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 4th Knowledge sharing workshop of ACT. Four 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).

On 6 and 7 November 2019, ACT organised the 4th ACT Knowledge sharing workshop in Athens, Greece. The Greek Secretary General for Research and Technology, representatives from the European Commission and the Project Managers from the current 20 ACT projects (including a representative from the first project to complete; ACORN) and experts from industry and academia attended the meeting.



The workshop was dedicated to get updating from the 8 funded projects from the call in 2017 and the 12 newly awarded projects from the second call in 2019. 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.

CCUS experts outside the ACT consortium and ACT projects were welcome to take part in the knowledge sharing at this event in Athens. The first day, 6 November, was an open workshop, whereas the second day, 7 November, was an internal workshop for ACT projects. The agenda for both days of the workshop is shown in Annex 1 and Annex 2, respectively.

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

The event in Athens 6-7 November 2019 gathered close to 100 participants.



## Get Together

Most of the attendees arrived on the 5 November and joined the welcome reception at The Divani Acropolis Palace Hotel in the evening.

The participants from many projects and funding organisations know each other very well, but a great number of people know each other only through e-mails, telephone conversation or skype meetings. So, this reception offered truly opportunity to let people informally introduce each other and discuss projects. The Cocktail Welcome as good warmup has contributed to the fruitful and success of the knowledge sharing workshop.

Great people and delicious food – a marvelous start of the two following days of work and knowledge sharing.

### Get together and have fun



**ACT**

[www.act-ccs.eu](http://www.act-ccs.eu)

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Commission within  
the Horizon 2020



## Setting the stage

The first part of the workshop was dedicated to welcoming and opening of the workshop, but also to an introduction to the Greek CCUS initiatives and the new Green deal in EC.

Ragnhild Rønneberg (The ACT coordinator, RCN, Norway) addressed a warm welcome to all participants and thanked the ACT-partner GSRT for hosting the workshop.

The European Commission was represented by Project Officer Mr. Vassilios Kougionas, who talked about the CCUS under the new Horizon Europe Programme.

CCUS-initiatives in Greece were very well presented by Prof. Athanasios Kyriazis, Secretary General for Research and Technology in Greece and Dr. Kyriakos Panopoulos, Coordinator of the Energy Platform for Smart Specialisation in Greece.

Espen Bernhard Kjærgaard, adviser at the Norwegian Ministry of Petroleum and Energy, gave the Norwegian perspective on CCUS and updates on the full-scale CCS project.

## Projects program

Day 1 consisted of several informative sessions about the progress of the ACT1 projects so far and parallel sessions discussing Storage and Capture. It also included an introduction to the new ACT2 projects, including an ‘elevator-pitch’ session where all 12 Project Managers in 2 minutes pitched and described their project.

Day 2 included a more detailed presentation of the ACT2 projects and the organisation of a “speed-dating” amongst the coordinators of these projects to foster collaboration between ACT-funded projects.

During this second day, attendees also had the opportunity to attend a “lessons learned” session and poster sessions. During the poster sessions, there were informative and lively discussions between ACT1 and ACT2 projects and Consortium members exchanged views and experiences.

Many participants discovered possibilities for synergies and collaboration between ACT1 and ACT2 projects, or ACT2 – ACT2 combinations through upcoming calls and other forms of collaboration. ACT was happy to see a better gender balance with the PrISMa, DETECT and ANICA projects being presented by Susana García, Marcella Dean and Carina Hoffman.

The Workshop was a well-attended and successful event providing an excellent opportunity for knowledge sharing and networking in the CCUS field.

## Presentations

Find more about the ACT projects and the 4th Knowledge Sharing Workshop and all the presentations and posters of the event on our website <http://www.act-ccs.eu/archive>.

During the workshop **Vegard Stokset** (Gassnova) tweeted and took pictures. Many thanks to him for these efforts. His twitter activity at the ACT Workshop in Athens 6-7 November 2019 generated 12.600 tweets. GSRT as hosting organisation, also covered and advertised the event and received 2.788 views on Facebook and important interaction during the two days of the conference. This shows the lively interest also in Greece for ACT and CCUS.



The workshop was inaugurated by the host country and Prof. Athanasios Kyriazis, Secretary General for Research and Technology, GSRT, Greece welcomed the attendees and underlined the importance of the workshop taking place in Athens. GSRT has a strong mission in designing implementing and monitoring of the National Strategy for Research, Development and Innovation.

GSRT plays essential role in CCS development in Greece through financial support and facilitation of institutions in participating in joint international research projects.

### Below are some points from the presentations and/or tweets:

1. Exciting project updates at Athens workshop today. More than 10 countries collaborate on ACT (Accelerating CCS Technologies) to fund research and innovation projects worth more than €80 million so far in carbon capture and utilisation to progress this climate mitigation tool. We had two successful calls and have made very good progress, says Rønneberg, ACT coordinator at the start of this year's workshop in Athens.  
- Our aim is to pave the way for [#CCUS](#) deployment.



2. Kyriakos Panopoulos [@CERTHellas](#) gives updates from Greece carbon capture projects in energy intensive industries like the cement industry at today's ACT knowledge sharing workshop in Athens







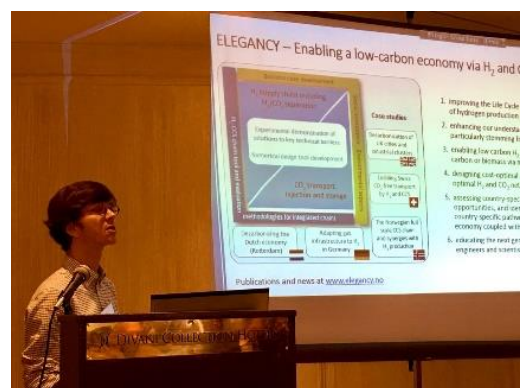
3. CCUS (carbon capture and utilisation) has a crucial role to close the circle for a net-zero economy, says Vassilios Kougioukas, EU Commission at Athens ACT workshop.

He is also very satisfied with what ACT has achieved, it is a success, he says.

4. We are on track for an investment decision next year, says Espen Bernhard Kjærgård from the Norwegian Ministry of Petroleum and Energy, talking about the planned full-scale carbon capture project at Athens ACT knowledge sharing workshop today.



5. We see good progress and results in the [@ELEGANCY ACT](#) project with Germany, The Netherlands, Norway, Switzerland, UK, Belgium and Sweden. The project is not only about [#CCS](#), it also considers hydrogen as a CO<sub>2</sub>-free energy carrier in the future low-carbon economy; Sven T. Munkejord at ACT Athens Knowledge Sharing Workshop.



6. We have good collaboration with other ACT and [@EU H2020](#) projects and many dissemination activities- even our own YouTube channel, says Peter van Os from the [@alignccus](#) €21 mill. project, with partners from 19 countries. One of the campaigns is currently running at [@TCMCO2](#)

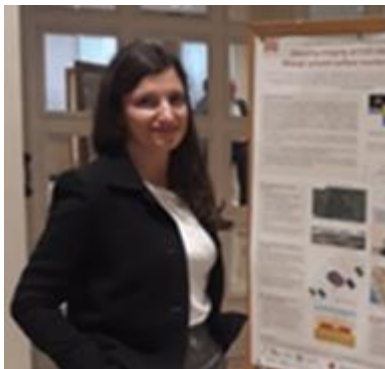




7. Jörg Maier from [@Uni\\_Stuttgart](#) gave a brief presentation of the new ACT project **AC2OCEM**, with focus on carbon capture in the cement industry. AC2OCEM aims to lower the cost of carbon capture in the cement industry, says Jörg Maier, [@Uni\\_Stuttgart](#). In Norway [@HC\\_Norway](#) is hoping to be implemented **#CCS** by 2023/24.



8. To ensure the safety of CCS sites is the top priority for policy makers, regulators and general public. Dr. Guttorm Alendal (University of Bergen) presented the **ACTOM** (ACT on Offshore Monitoring) project, a research project focusing on pre-operational web-based toolkit enabling the derivation of optimal monitoring strategies. The project will assess how to combine different monitoring technologies, define tools for detecting anomalies in data streams, assess consistently and communicate capabilities, limitations, knowledge and uncertainties of monitoring.



9. Decreasing the costs of CCS technologies is essential in accelerating CCS technologies. Dr. Carina Hofmann (Technische Universität Darmstadt) presented the **ANICA** (Advanced Indirectly Heated Carbonate Looping Process) project. The project will develop a novel technology with very low energy penalty and costs - namely the indirectly heated carbonate looping (IHCaL) process. The project aims at decreasing cost for CO<sub>2</sub> capture from lime and cement plants and achieving negative CO<sub>2</sub> emissions by utilising waste derived fuels with a high biogenic fraction.

10. Arvid Nøttvedt from [@NORCEresearch](#) presented the new ACT funded project **DIGIMON** for monitoring carbon capture storage projects **#CCS** at ACT knowledge sharing workshop. Our aim is to accelerate the implementation of **#CCS** by dev. affordable, flexible and smart digital monitoring of CO<sub>2</sub> storage project; Arvid Nøttvedt [@NORCEresearch](#) - presenting the new ACT funded DigiMon project at Athens Knowledge sharing workshop.





11. For the general public CO<sub>2</sub> is waste, but scientists want to transform CO<sub>2</sub> into added-value carbonate products for the cement and agricultural sectors by a mineral carbonation process. Dr. Tommaso (Queen Mary University) presented the **FUNMIN** (Fundamental Studies of Mineral Carbonation with Application to CO<sub>2</sub> Sequestration) project. The project will focus on discovering and optimising conditions for speeding up MgCO<sub>3</sub> formation.

12. The **MemCCSea** is a project focusing on Innovative membrane systems for CO<sub>2</sub> capture and storage at sea, says Dr. Georgios Skevis. The project will develop hyper compact membrane systems for flexible operation and cost-effective post-combustion CO<sub>2</sub> capture in maritime and offshore applications. A feasible design and pilot demonstration optimised for maritime applications will be carried out in the project.



13. 2700 waste-to-energy plants expected to be operational by 2027. Big potential for carbon capture, says Mathieu Lucquiaud from [@EdinburghUni](#), **NEWEST-CCS** project, at ACT programme workshop.

In Norway [@FortumNorge](#) hopes to implement **#CCS** by 2023/2024



14. Energy consumption is one of the challenges in solvent-based CO<sub>2</sub> capture process. The project **PRISMA**, presented by Dr. Susana Garcia (from Heriot-Watt University), aims 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 for a range of different CO<sub>2</sub> sources and CO<sub>2</sub> use/destinations.





15. Dr. Jens Wollenweber (from TNO) presented **REX-CO2** (Reusing existing wells for CO2 storage operations) project.

The project would provide decision makers with mechanisms and information to evaluate re-use potential of existing oil and gas well infrastructure. The project will provide decision makers with mechanisms and information to evaluate the potential re-use of existing oil and gas well infrastructure.



16. Bahman Bohloli from Norwegian Geotechnical Institute presents one of the new ACT **#CCS** projects - **SENSE**, focusing on satellite monitoring of onshore and offshore CO2 storage sites.

From space to sub-surface!

17. Prof. Sevket Durcan (Imperial College London) presented **SUCCEED** (Synergetic Utilisation of CO2 storage Coupled with geothermal Energy Deployment). The project will test and demonstrate at pilot scale the state-of-the-art measurement, monitoring and verification technologies that can be used in geothermal fields where CO2 is injected into the reservoir either in supercritical state or as dissolved gas in the re-injected geothermal fluid.

It aims to develop and demonstrate an effective technology that allows this sector to benefit commercially from its deployment.



18. The main storage-related challenges for accelerated deployment of CCS are capacity, confidence and cost. Peder Eliasson (Sintef) presented the **Pre-ACT** project an industry-driven research project with a strong focus on improving strategies for monitoring and management of pore pressure distribution to address these challenges. Pre-ACT will develop pressure-driven decision support protocols (Pre-ACT 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.





19. Marcella Dean (Shell) presented the **DETECT** project which 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.

The results from this study will be incorporated into CCS industry leading guidance documents



20. The project **3D-CAPS**, presented by Robert de Boer (TNO), targets a productivity increase of an order of magnitude in two sorbent-based technologies for CCS.

This will lead to a substantial decrease in overall equipment size and costs. This will be achieved using the latest available techniques for materials production: additive manufacturing, commonly known as 3D-printing.



21. Shahriar Amini from [@SINTEF](#) talked about the ACT funded project **GASTECH** - CO<sub>2</sub> capture by gas switching technologies, at the ACT Programme workshop in Athens [@NTNU](#) [@ETH\\_en](#)



22. CCS worldwide needs a boost! says Roman Berenblyum from NORCE, presents his project **ECOBASE** aiming at establishing CO<sub>2</sub> enhanced oil recovery in South Eastern Europe.

23. CCS can be used in a range of industries and i.e. hydrogen has been gaining increasing attention, said David Pilbeam from **ACORN** [@AcornCCS](#), a low cost **#CCS** system in NE Scotland which could be operational by 2023 and exploit redundant North Sea gas distribution assets. The ACORN project was successfully finished in January 2019, according to plan.





## Poster session

The poster session provided project participants the opportunity to hold both introductory and in-depth discussions on the technical details.

During this session and day 1 presentations, it became clear that 3 ACT2 projects, Digimon, SENSE and ACTOM, have some similarities related with CCS site monitoring technologies.

They conclude that they can connect and will have more project knowledge share in the coming years.



## Lessons learned: Feedback session

The Knowledge Sharing Workshop provided a good opportunity for feedback between the research institutes, companies and national funding organisations. This is especially relevant during this workshop, since the participants are from both ACT 1 and ACT2 projects, and thus brings together both operational and start-up experiences. In the session, fruitful discussions took place on the current operation, the challenges and potential improvements in the future.



Transnational collaboration, communication, evaluation, transparency, reporting and monitoring procedures, and value for money for projects were the major topics covered.

All agreed that continuous suggestions for improvement of the ACT programme are indispensable.

## Guided Tour

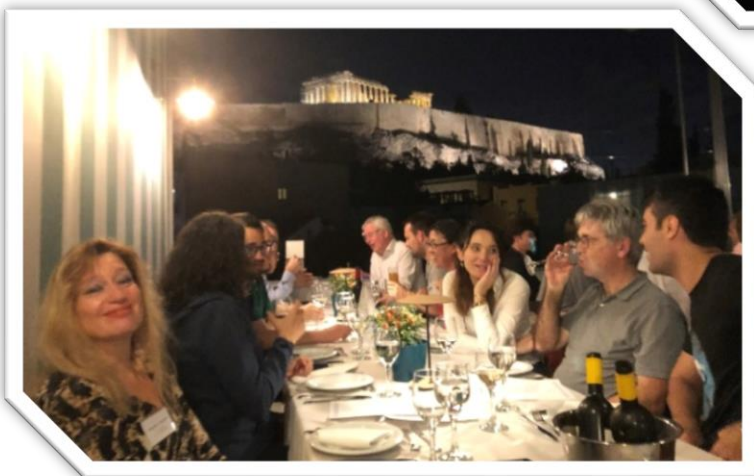
Greece is the cradle of western civilisation, as the birthplace of democracy, western philosophy, western literature, political science, mathematical principles, geometry, and drama. Athens, an European culture city, much can offer: from ancient civilization to modern arts, sciences and philosophy; from sunny climate to olive, wine and healthy cuisine.

Most of the participants of the workshop were in Athens for the first time, and everybody was eager to have time to visit the Acropolis. After two intensive working days, just before sunset, the participants had a guided tour in the area around the Acropolis. Everybody was impressed by the beauty of Acropolis, and Athens, hometown of Socrates, Plato and Aristotle.



The thoughtful arrangements by the host, our Greek partner GSRT, brought the joy and happiness to all participants throughout the knowledge sharing event.

The dinners organised during the KSW gave the attendants the opportunity to further interact in a more relaxed atmosphere, taste delicious traditional Greek food and enjoy a magnificent view of the Acropolis.





## Acknowledgements

*This workshop has been organized very well by Anna Rosenberg and Evi Afentaki at GSRT 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 NER for their contributions.*

*The ACT consortium was very pleased that Vassilios Kougionas, representing the European Commission took active part in the meeting and shared the progress of the Green Deal program in the European Commission.*



Some of the participants.....lining up at the stairs in front of Acropolis

## Annex 1: The 4th ACT Knowledge sharing workshop, 6 Nov. 2019

**Accelerating  
CCS  
Technologies**

**4th ACT Knowledge Sharing Workshop**

ACT is an international initiative aiming to accelerate and mature CCUS technology by funding transnational research and innovation projects.


ACT is a collaboration of research and innovation funding organisations in ten European countries (France, Greece, Germany, The Netherlands, Norway, Romania, Spain, Switzerland, Turkey, United Kingdom) and the USA. In addition, the Nordic Energy Research is a partner. The first Call for projects in 2016 resulted in 8 international projects within CO<sub>2</sub> Capture, Utilization and Storage (CCUS). The second Call was concluded in spring 2019 and 12 new CCUS projects are due to commence autumn 2019.

The ACT consortium organises the Knowledge Sharing Workshops to ensure fruitful knowledge sharing and increase collaboration between the ACT funded projects and other CCUS initiatives.

The first day, 6 November, is an open workshop for CCUS experts. The second day, 7 November, is an internal workshop for ACT projects.

Find more about ACT on our webpage <http://www.act-ccs.eu/>

# 4th ACT Knowledge Sharing Workshop


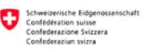











## 6-7 November 2019





**Divani Palace Acropolis Hotel**  
19-25 Parthenonos Street, 117 42 Athens

**ACT**

Co-funded by the European Commission within the Horizon 2020

## 6 November 2019

## Morning session

Chair: Brian Allison (BEIS, UK)

08.30 – 09.00 Registration

09.00 – 09.10 Welcome by Host country and ACT Coordinator  
Athanasios Kyriazis, Secretary General for Research and Technology, GSRT and Ragnhild Rønneberg, The Research Council of Norway09.10 – 09.20 CCUS under the new Horizon Europe program  
Vassilios Kougianos, The European Commission09.20 – 09.40 CCUS in Greece: potential, development and status  
Kyriakos Panopoulos, CERTH, Co-ordinator of the Energy Platform for Smart Specialisation in Greece09.40 – 09.45 The Norwegian CCS project  
Espen Bernhard Kjærgård, adviser, Norwegian Ministry of Petroleum and Energy

## ACT projects – presentations and discussions

09.45 – 10.30 ELEGANCY – Enabling a Low-Carbon Economy via Hydrogen and CCS  
Svend Tollak Munkejord, SINTEF Energy

10.30 – 10.50 Coffee break

10.50 – 11.40 ALIGN – Accelerating Low carbon Industrial Growth through CCUS  
Peter van Os, TNO

11.40 – 12.20 Presentation of the new ACT-2 projects

**AC2CEM** - Jörg Maier, Universität Stuttgart  
**ACTOM** - Guttorm Alendal, University of Bergen  
**ANICA** - Carina Hofmann, Technische Universität Darmstadt  
**DIGIMON** - Arvid Nættvedt, NORCE  
**FUNMIN** - Devis Di Tommaso, University of London  
**LAUNCH** - Peter van Os, TNO  
**MemCCSea** - Georgios Skevis, CPERI/CERTH  
**NEWEST-CCS** - Mathieu Lucaquaud, University of Edinburgh  
**PRISMA** - Susana Garcia, Heriot-Watt University  
**REX-CO<sub>2</sub>** - Jens Wollenweber, TNO  
**SENSE** - Bahman Bohlali, Norwegian Geotechnical Institute  
**SUCCEED** - Sevet Durucan, Imperial College London

12.20 – 14.00 Lunch and Posters Session

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## 6 November 2019

## Afternoon parallel sessions

Session A: Storage  
Chair: Gerdi Breembroek14.00 – 14.30 Pre-ACT – Safe and efficient CO<sub>2</sub> storage  
Peder Eliasson, SINTEF Industry14.30 – 15.00 DETECT – CO<sub>2</sub> storage risk mitigation  
Marcella Dean, Shell

15.00 – 15.30 Tea and coffee break

Session B: Capture  
Chair: Anna RosenbergGASTECH – CO<sub>2</sub> capture by gas switching technologies  
Shahriar Amini, SINTEF Industry3D-CAPS – 3D printing of capture materials  
Robert de Boer, ECN/TNO

## Afternoon session: Plenary

15.30 – 16.00 ECOBASE – Establishing CO<sub>2</sub> enhanced Oil recovery in South Eastern Europe  
Roman Berenblyum, NORCE16.00 – 16.30 From ACORN to sapling – Chain integration in the UK,  
David Pilbeam, Pale Blue Dot

16.30 – 17.30 Wrap-up and key messages

Mid-term review of ACT projects, Gerdi Breebroek, RVO

ACT impacts, Aage Stangeland, RCN

Discussion Chaired by Brian Allison, BEIS

17.30 Informal get-together with the posters, networking opportunities

20.00 Dinner  
Chocolat Royal Restaurant,  
27, Apostolou Pavlou Str., Thessaloniki

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## Annex 2: Agenda for the 7 Nov. 2019

ACT Knowledge Sharing Workshop Programme 7 <sup>th</sup> November	
09.00 – 09.15	<b>Welcome by ACT Coordinator</b> <i>Ragnhild Rønneberg, The Research Council of Norway</i>
<b>Presentation of the 12 new ACT-2 projects</b>	
09.15 – 10.45	<b>Presentations of five new ACT-2 projects - Chair: Gerdi Breembroek, RVO</b>  <b>NEWEST-CCS</b> - Negative emissions in the waste to energy sector <i>Mathieu Lucquiaud, University of Edinburgh</i>  <b>AC2OCEM</b> - Oxyfuel technology in cement production <i>Jörg Maier, Universität Stuttgart</i>  <b>ANICA</b> - Carbonate looping process in cement industry <i>Carina Hofmann, Technische Universität Darmstadt</i>  <b>DIGIMON</b> - Digital monitoring of CO <sub>2</sub> storage projects <i>Arvid Nøttvedt, NORCE</i>  <b>SUCCEED</b> - CO <sub>2</sub> storage coupled with geothermal energy deployment <i>Sevket Durucan - Imperial College London</i>
10.45 – 11.05	Tea and coffee break
11.05 – 12.15	<b>Presentations of four new ACT-2 projects- Chair: Mark Ackiewicz, DoE</b>  <b>MemCCSea</b> - Membrane systems for CO <sub>2</sub> capture and storage at sea <i>Georgios Skevis, CPERI/CERTH</i>  <b>PrISMa</b> - Sorbent materials for energy efficient carbon capture <i>Susana Garcia, Heriot-Watt University</i>  <b>ACTOM</b> - Offshore monitoring <i>Guttorm Alendal, University of Bergen</i>  <b>FUNMIN</b> - CO <sub>2</sub> mineralisation into anhydrous MgCO <sub>3</sub> <i>Devis Di Tommaso, University of London</i>
<b>Programme 7<sup>th</sup> November, continued</b>	
12.15 – 13.15	<b>Lunch and poster session</b>
13.15 – 14.15	<b>Presentations of three new ACT-2 projects- Chair: Gunter Siddiqi, DETEC</b>  <b>LAUNCH</b> - CO <sub>2</sub> capture in various industries <i>Peter van Os, TNO</i>  <b>REX-CO2</b> - Reusing existing wells for CO <sub>2</sub> storage <i>Jens Wollenweber, TNO</i>

	<b>SENSE</b> - CO <sub>2</sub> storage sites - ground surface monitoring <i>Bahman Bohloli, Norwegian Geotechnical Institute</i>
<b>14.15 – 15.00</b>	<b>Speed dating</b> – Chair: Aage Stangeland, The Research Council of Norway
14.15 – 14.30	Project leaders from four ACT-2 projects will be available for dialogue with the audience. The project leaders will be placed in each of the corners of the room and the audience will circulate and speed date with the project leaders:  <i>Devis Di Tommaso, University of London - FUNMIN</i> <i>Mathieu Lucquiaud, University of Edinburgh – NEWEST-CCS</i> <i>Arvid Nøttvedt, NORCE – DIGIMON</i> <i>Jens Wollenweber, TNO – REX-CO2</i>
14.30 – 14.45	A new round of speed dating with four ACT-2 projects:  <i>Bahman Bohloli, Norwegian Geotechnical Institute - SENSE</i> <i>Sevket Durucan - Imperial College London – SUCCEED</i> <i>Susana Garcia, Heriot-Watt University - PrISMa</i> <i>Jörg Maier, Universität Stuttgart – AC2OCEM</i>
14.45 – 15.00	A last round of speed dating with the last four ACT-2 projects:  <i>Guttorm Alendal, University of Bergen – ACTOM</i> <i>Peter van Os, TNO - LAUNCH</i> <i>Carina Hofmann, Technische Universität Darmstadt – ANICA</i> <i>Georgios Skevis, CPERI/CERTH – MemCCSea</i>
15.00 – 15.30	Networking during tea and coffee break
<b>15.30 – 16.40</b>	<b>Lessons learned</b> - Chair: Gerdi Breembroek, RVO and Brian Allison, BEIS
15.30 – 16.30	The <b>Lessons learned session</b> will be a discussion where all project leaders participate to ensure fruitful knowledge sharing
16.30 – 16.40	Wrap-up  <i>Ragnhild Rønneberg, ACT Coordinator</i>
20.00	Dinner

## Annex 3: Participant List

### From the ACT Consortium

Germany	PTJ	Hannes Stadler
Greece	GSRT	Anna Rosenberg Evi Afentaki
The Netherlands	RVO	Gerdi Breembroek Harry Scheurs Li Hua Peter Balemans
Norway	RCN	Ragnhild Rønneberg Aage Stangeland
	Gassnova	Vegar Stokset Tore Hatlen Ingrid Melaaen Kari-Lise Rørvik
NER	Nordic Energy Research	Sofia Elamson Jun Elin Wiik
Spain	AEI-FECYT	Daniel Ruiz Iruela Beatriz Gomez
Switzerland	DETEC	Gunter Siddiqi
United Kingdom	BEIS	Brian Allison Hannah Lord
United States	DoE	Mark Ackiewicz Angelos Kokkinos David Hopkinson

### From Projects Funded

ALIGN	Peter van Os
ELEGANCY	Svend Munkejord
PRE-ACT	Peder Eliasson
ECO-BASE	Roman Berenblyum
ACORN	David Pilbeam
DETECT	Marcella Dean
3DCAPS	Robert de Boer; Jaap Vente
GASTECH	Shahriar Amini
AC2OCEM	Jörg Maier
ACTOM	Guttorm Alendal
ANICA	Carina Hofmann
DIGIMON	Arvid Nøttvedt
FUNMIN	Devis Di Tommaso
LAUNCH	Peter van Os
MemCCSea	Georgios Skevis
NEWEST-CCS	Mathieu Lucquiaud
PrISMa	Susana Garcia
REX-CO2	Jens Wollenweber
SENSE	Bahman Bohloli
SUCCEED	Sevket Durucan

**From the European Commission**

European Commission	Vassilios Kougionas, Project officer
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**Ministry of Development and Investments, GSRT, GREECE**

GSRT	Prof. Athanasios Kyriazis, Secretary General for Research and Technology
GSRT	Maria Christoula, Head of S&T Cooperation Directory
GSRT	Vassiliki Mesthaneos, Head of Bilateral and Multilateral Relations
GSRT	Paraskevi Afentaki, ERANET Coordinator
GSRT	Anna Rosenberg, ACT project officer at GSRT
CERTH	Kyriakos Panopoulos, Co-ordinator of the Energy Innovation Platform for Smart Specialisation in Greece

**Ministry of Petroleum and Energy (OED), Norway**

OED	Espen Bernhard Kjærgaard, senior adviser
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## Annex 4: Information to the Knowledge Sharing Workshop



### This is ACT

ACT is an international initiative based on the Horizon 2020 European Commission funding scheme. Its aim is to accelerate and mature CCUS technology by making available funds for transnational research and innovation projects. Carbon Capture, Utilisation and Storage (CCUS) is a valuable and necessary part of the toolbox for combatting climate change.

ACT, coordinated by The Research Council of Norway, is a collaboration of research and innovation funding organisations in Europe (France, Greece, Germany, The Netherlands, Norway, Romania, Spain, Switzerland, Turkey, United Kingdom) and the USA. In addition, the Nordic Energy Research is a partner.



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

**ACT**

Co-funded by the  
European  
Commission within  
the Horizon 2020



## ACT Calls

ACT has launched two successful calls. For the first ACT Call, 9 European countries together with the European Commission made a total of € 36 M available for 8 high quality CCUS research and innovation projects for up to 3 years. The ACT funding has generated projects worth € 50 M. These projects in total cover all aspects of the CCUS chain. For the second ACT call, 12 new projects, with a combined budget of €31 million are due to commence autumn 2019. Some projects have included R&D partners from countries outside ACT such as: Sweden, Belgium, Iceland, Italy, Australia and Japan.

Detailed information about all the funded projects can be found on our web: [www.act-ccs.eu](http://www.act-ccs.eu) – and on the following pages.

## 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.

The ACT consortium organises the Knowledge Sharing Workshops (KSW) to ensure fruitful knowledge sharing and increase collaboration between the ACT funded projects and other CCUS initiatives. The 4th KSW is organised in Athens, Greece from 6 to 7 November 2019.

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. We plan to launch additional Calls, with a third Call in 2020.

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))

Look at [www.act-ccs.eu](http://www.act-ccs.eu) and find your national contact point.



## ACT-1 Projects

Project	Activities	ACT, M €	Norway	Netherlands	UK	Germany	Romania	Switzerland	Spain	Turkey
ALIGN	Chain integration, clusters	14,5	x	<b>X</b>	x	X	X			
ELEGANCY	Chain integration, hydrogen	8,9	<b>X</b>	x	x	X		x		
PRE-ACT	CO2 storage, pressure handling	4,5	<b>X</b>	x	x	X				
ACORN	Full chain CCS / infrastructure	2,0	x	x	<b>X</b>					
DETECT	CO2 storage, risk assessment	2,0		<b>X</b>	X	X				
ECOBASE	CO2-EOR SouthEast Europe	1,2	<b>X</b>	x			x			x
GASTECH	Gas switching technology	1,7	<b>X</b>	x			x	x	x	x
3D-CAPS	3D printed sorbents	1,5	X	<b>X</b>			x			

(X's indicates partners in the project. Highlighted X's indicate the country of the project leader)

Project	Activities	Coordinator
<b>3D CAPS</b>	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.	<b>TNO</b>
<b>ACORN</b>	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 an EU PCI project.	<b>Pale Blue Dot</b>
<b>ALIGN-CCUS</b>	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.	<b>TNO</b>
<b>DETECT</b>	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.	<b>Shell</b>
<b>ECOBASE</b>	The project will develop revenue streams and business models for CO2-EOR in South-Eastern Europe and therefore supporting large scale CCUS deployment.	<b>NORCE</b>
<b>ELEGANCY</b>	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.	<b>SINTEF Energy</b>
<b>GASTECH</b>	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.	<b>SINTEF Industry</b>
<b>PRE-ACT</b>	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.	<b>SINTEF Industry</b>



## ACT-2 Projects

Projects	Activities	ACT, M €	France	Germany	Greece	Netherlands	Norway	Romania	Spain	Switzerland	Turkey	UK	USA
AC2COM	Oxyfuel capture	3,0	x	x	x		x			x			
ACTOM	Offshore monitoring	1,5				x	x					x	x
ANICA	Carbonate looping	2,4		x	x							x	
DIGIMON	Storage monitoring	5,0		x	x	x	x	x				x	x
FUNMIN	CO <sub>2</sub> mineralisation	0,7	x						x			x	
LAUNCH	Capture in industries	5,1		x		x	x					x	x
MemCCSea	Membrane systems	1,7		x	x		x						x
NEWEST-CCS	Capture	2,2		x		x	x					x	
PRISMA	Capture	2,1					x			x		x	x
REX-CO2	Wells for CO <sub>2</sub> storage	2,5	x			x	x	x				x	x
SENSE	Storage monitoring	2,7	x	x			x		x			x	x
SUCCEED	Storage & geothermal	2,5				x					x	x	

Project	Activities	Coordinator
AC2COM	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.	Universität Stuttgart
ACTOM	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.	University of Bergen
ANICA	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.	Techn. Univ. Darmstadt
DIGIMON	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> .	NORCE
FUNMIN	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.	University of London
LAUNCH	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.	TNO
MemCCSea	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.	CPERI/CERTH
NEWEST-CCS	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.	University of Edinburgh
PRISMA	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.	Heriot-Watt University
REX-CO2	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.	TNO
SENSE	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.	Norwegian Geotechnical Institute
SUCCEED	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 vented to the atmosphere under standard geothermal operations.	Imperial College London

### Acknowledgement:

ACT is an initiative granted under Horizon 2020, COFUND scheme project no 691712, for implementing the first call and achieving a 5-year knowledge sharing and collaboration amongst the ACT partners.



Co-funded by the  
European  
Commission within  
the Horizon 2020





## Annex 6: One-sliders from ACT2 projects

## Accelerated Carbon Capture using Oxyfuel technology in Cement Industry AC<sup>2</sup>OCem Project

## Main Objectives

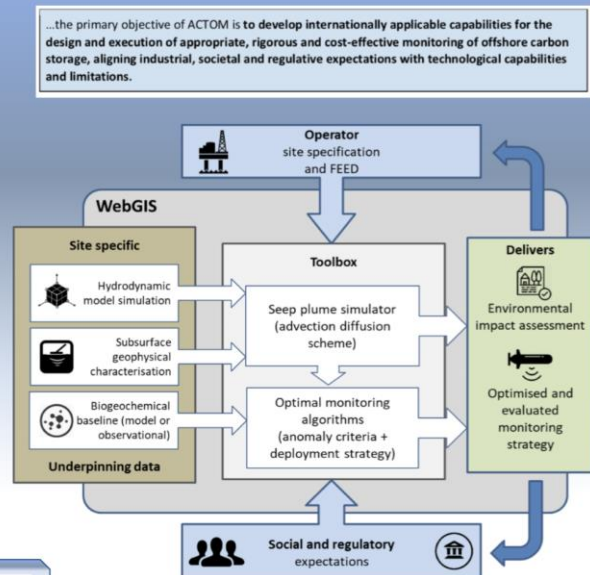
- **Advanced Oxyfuel Clinker Production** using up to 100 % alternative fuel with a high biogenic share **BioCCU/S**.
- **Experimental & Techno-Economic Evaluation** of new-build (2<sup>nd</sup> generation) and retrofitted (1<sup>st</sup> generation) oxyfuel cement plants
- **Life Cycle Assessment** of new-build and retrofitted oxyfuel cement plant
- Project Duration: **36 months** (starting on 1 October 2019)
- ACT Project No.: **299663**
- Total budget: **4.273.911 euros**
- 11 Project Partners from 5 European Countries



# ACTOM

### Act on offshore monitoring

- Enable regulators to quantifiably assess that a proposed monitoring strategy delivers an acceptable standard of assurance.
- Enable operators to properly plan, cost and adapt monitoring strategies to site specific circumstances, hence accelerate the planning phase and implementation.
- Enable regulators and operators to communicate to the effectiveness of proposed monitoring strategies to enable informed societal consensus in view of marine spatial planning.

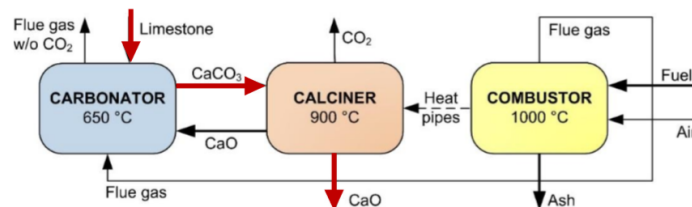


## ANICA - Advanced Indirectly Heated Carbonate Looping Process



TECHNISCHE  
UNIVERSITÄT  
DARMSTADT

Innovative process for CO<sub>2</sub> capture from lime and cement plants



- **No air separation unit (ASU) needed**
- Using synergies of both processes by **integration of heat and mass streams**
- **High CO<sub>2</sub> purity** in separated gas stream

### Main objectives

- Reduce CO<sub>2</sub> avoidance costs compared to state-of-the-art technologies
- Aiming net negative CO<sub>2</sub> emissions
- Pilot testing in 300 kW<sub>th</sub> plant under realistic industrial conditions

Carina Hofmann, *Advanced Indirectly Heated Carbonate Looping Process*, 4th ACT Knowledge Sharing Workshop, Athens.

© TU Darmstadt Institut for Energy Systems & Technology



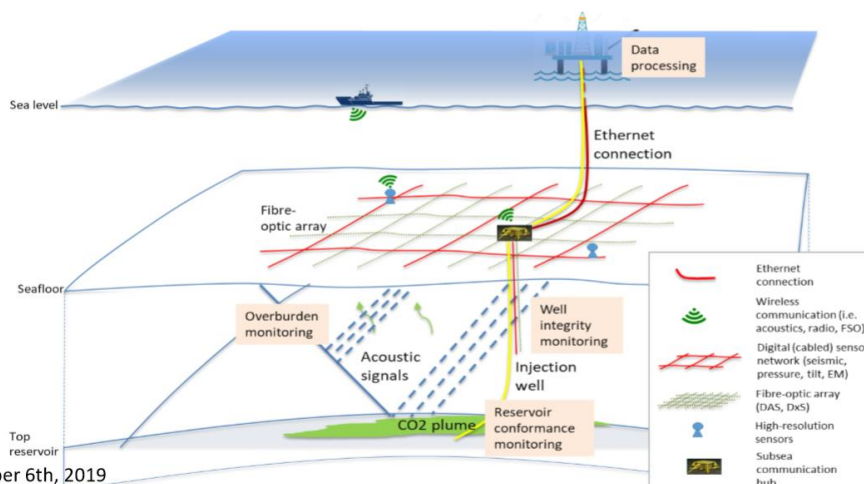
## ACT CCS 2 project no 299622

### Digital Monitoring of CO<sub>2</sub> storage projects



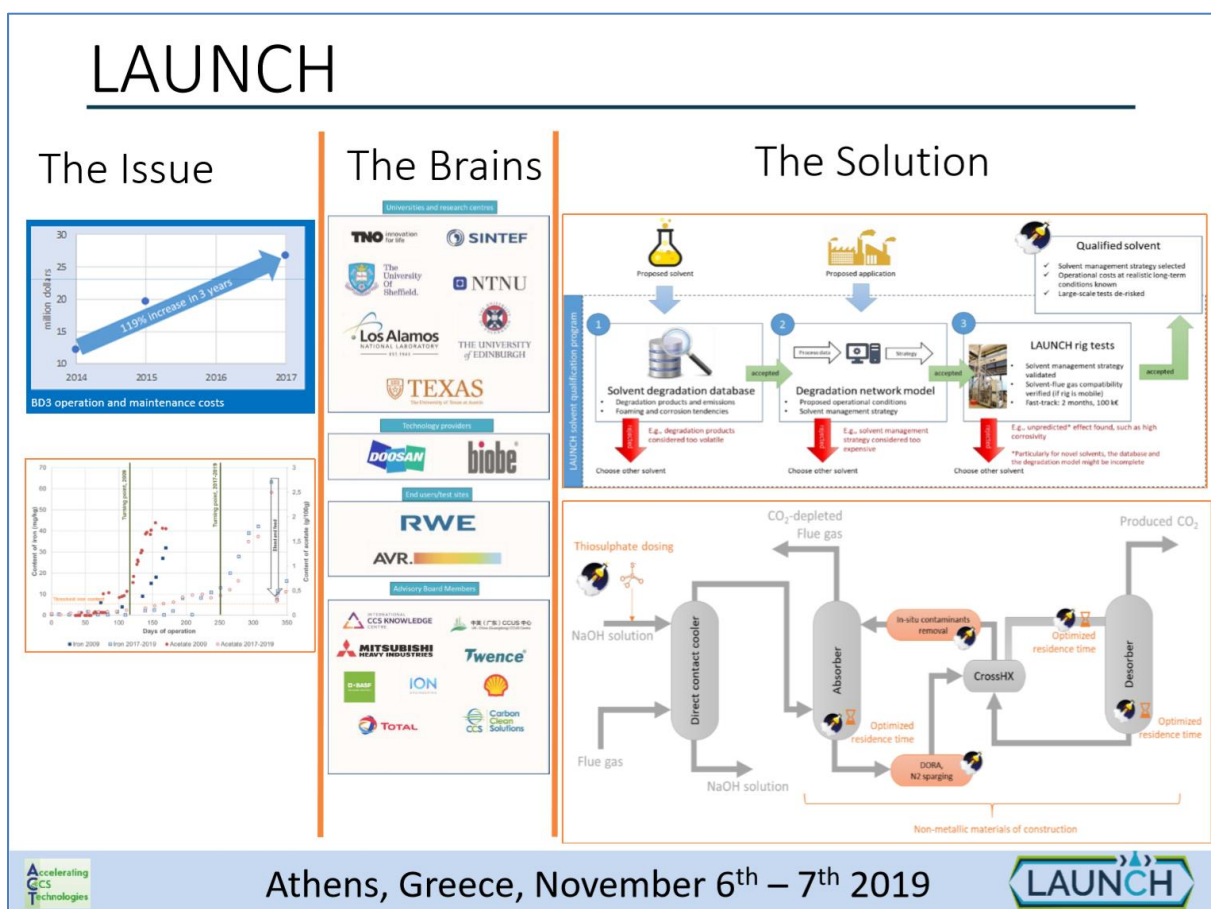
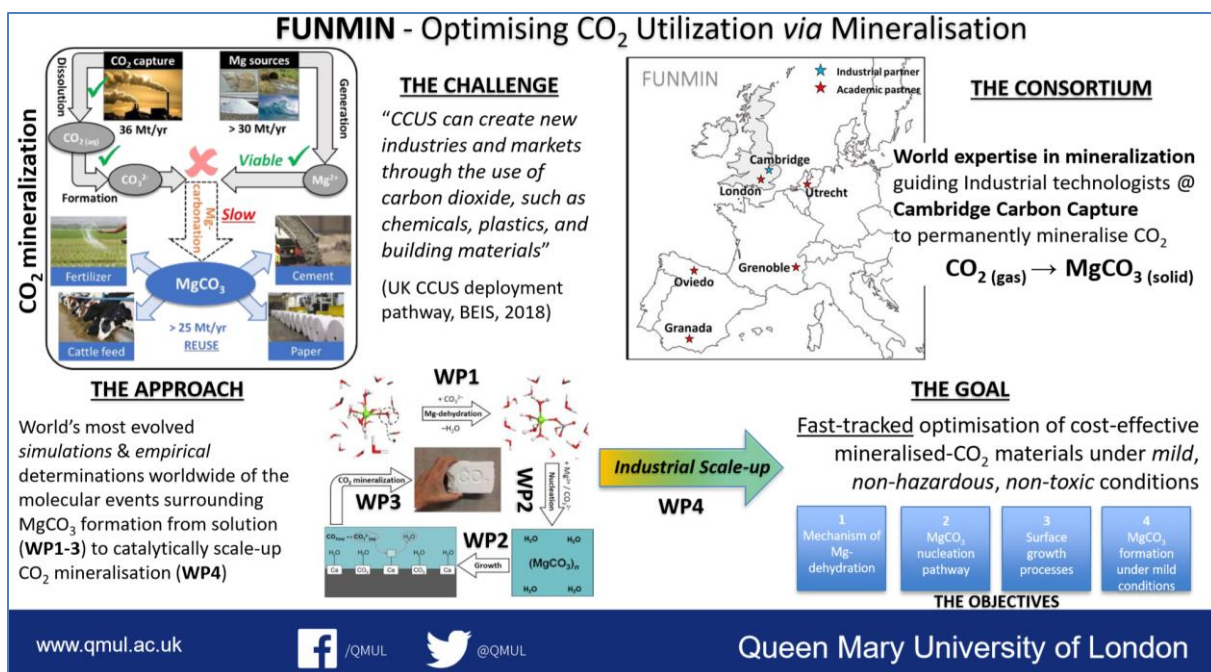
### DigiMon

- Monitoring the plume movement in the reservoir (Conformance monitoring).
- Monitoring well integrity (Containment and Contingency monitoring).
- Monitoring the overburden, including early detection of CO<sub>2</sub> leakage anomalies (Containment and Contingency monitoring).




Athens, November 6th, 2019  
Arvid Nøttvedt, NORCE



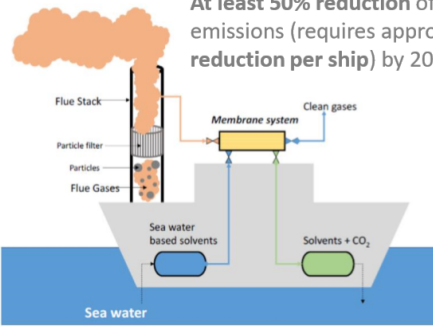






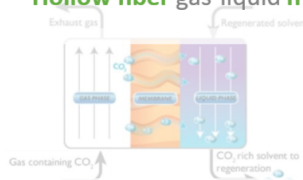
**MemCCSea**  
Innovative membrane systems  
for CO<sub>2</sub> capture and storage at sea

At least 50% reduction of total annual GHG emissions (requires approximately 85% CO<sub>2</sub> reduction per ship) by 2050.

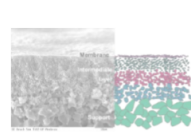


**Key innovation**


**Hollow fiber gas-liquid membrane contactors & permeators**




**Advanced customized ceramic and polymeric high performance, high stability membranes**



**Process marinization** addressing the unique challenges of maritime environment



**Partners:** NTNU, DBI GUT, Fraunhofer IKTS, CERth, CPERI, DNV-GL




<http://memccsea.certh.gr>

**Budget 1.98 M€ Project duration 30M**



**Key targets**

- Recovery of **main engine CO<sub>2</sub> emissions greater than 90%**
- Overall **CO<sub>2</sub> emissions reduction** (including added emissions by capture plant and utilities) **greater than 50%**
- **A 10-fold reduction of system volume** and a **reduction of operating costs greater than 25%** compared to conventional amine-based systems.



**MemCCSea**

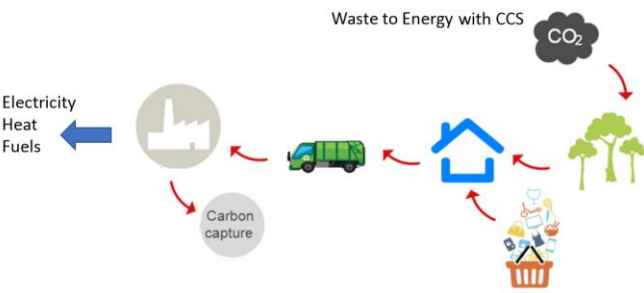
Project Coordinator: Dr G. Skevis  
CPERI / CERth

4th ACT Knowledge Sharing Workshop  
Athens, 6-7 November 2019

## Negative Emissions in the Waste to Energy Sector: Technologies for CCUS

Waste to Energy with CCS



**Quantify the atmospheric CO<sub>2</sub> reduction potential**







- Assess the European market for WtE+CCUS
- New methodology to quantify negative emissions

**Oxyfuel - 3 ways**

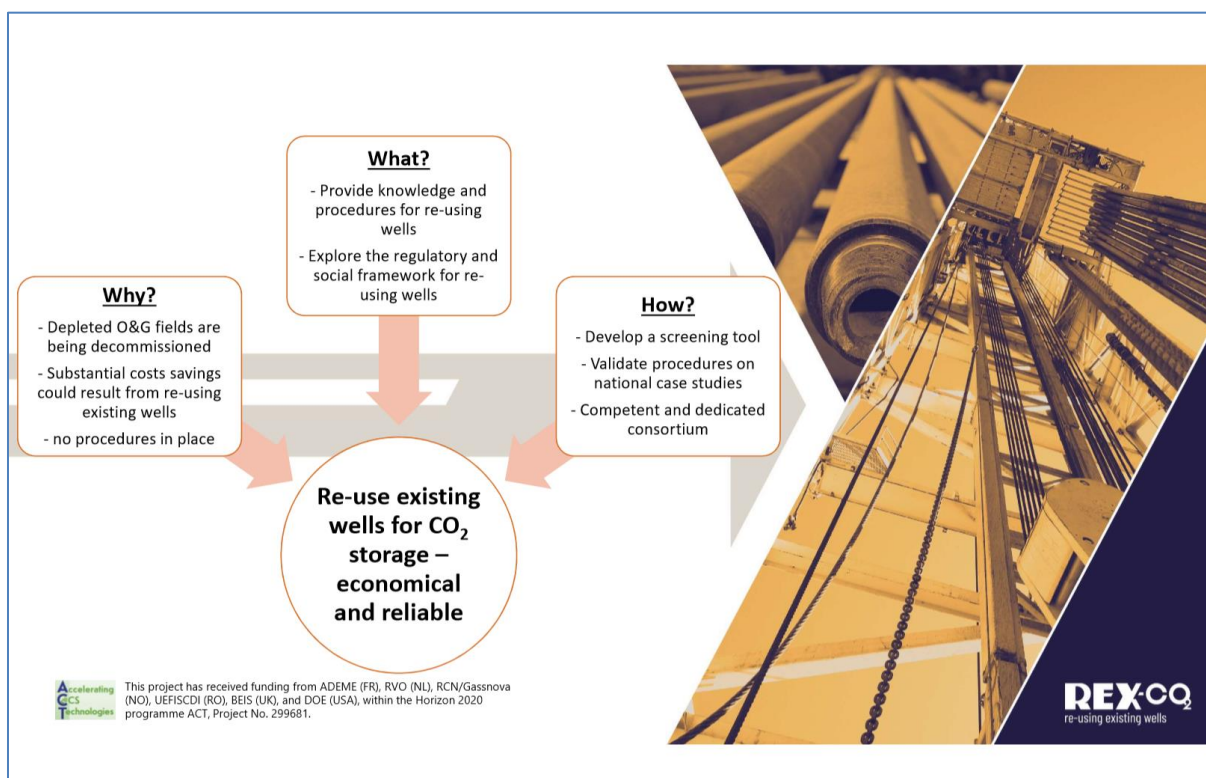
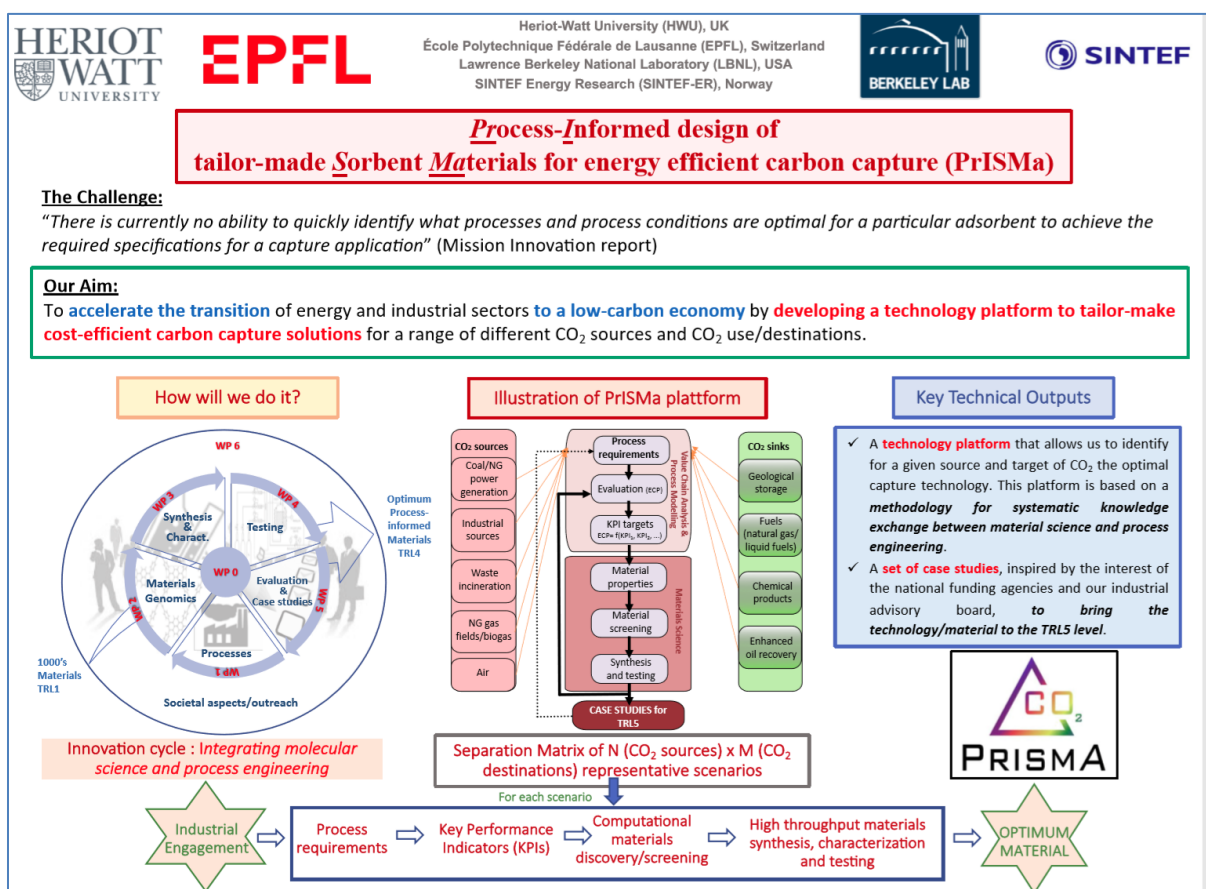
- Circulating fluidized bed combustion
- Bridge knowledge gap on waste combustion for grate-fired boilers
- Membranes for oxy-combustion of grate-fired boilers

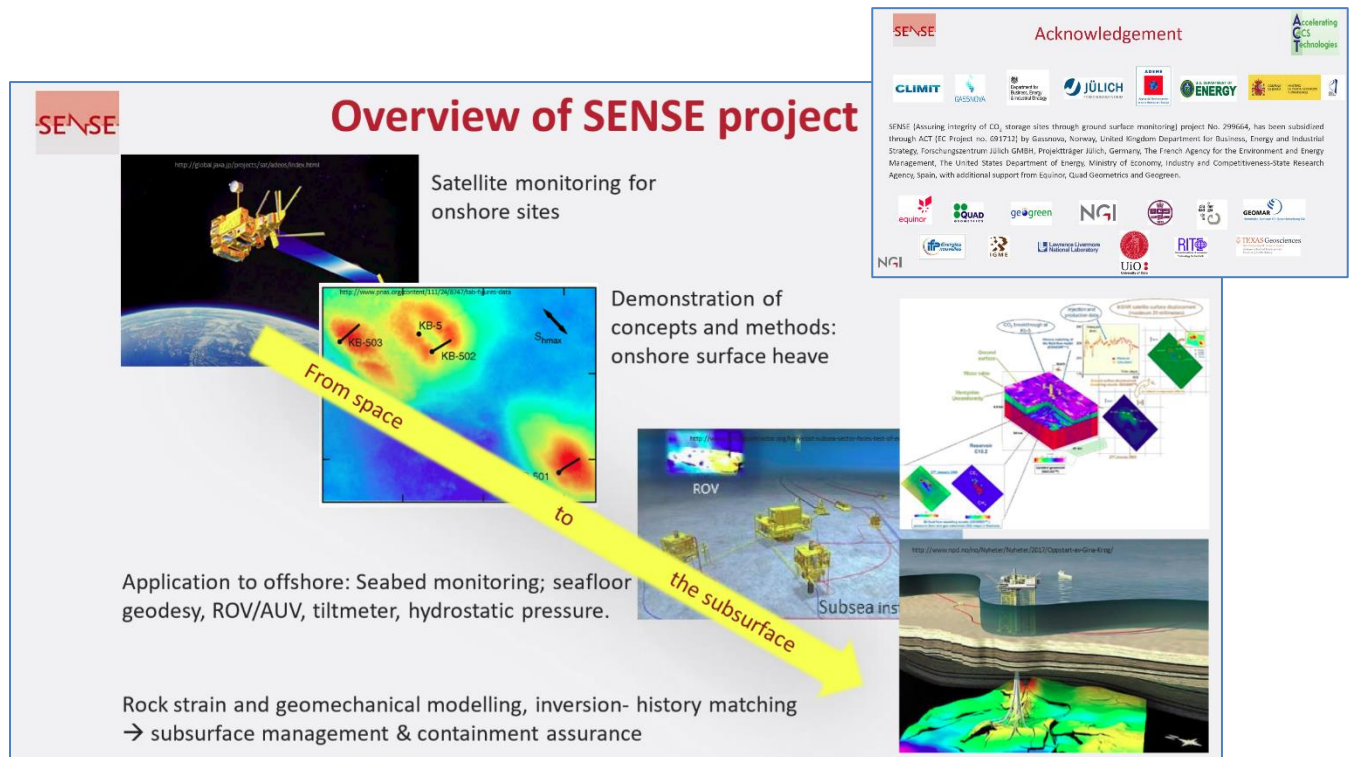
**Solvents: 3 solvents, 3 facilities, 3 scales**

- Waste wood - 1tCO<sub>2</sub>/day scale - 30%wt MEA
- Waste wood - 1tCO<sub>2</sub>/day scale - CCSL proprietary solvent
- Municipal Solid Waste - 10tCO<sub>2</sub>/day scale - CCSL proprietary solvent
- Synthetic flue gas - Bench scale - 3rd generation solvent









## Synergetic Utilisation of CO<sub>2</sub> Storage Coupled with Geothermal Energy Deployment – **SUCCEED**

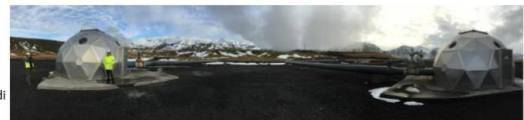
An industrial CO<sub>2</sub> storage project utilising the existing wells and infrastructure at producing geothermal fields in Kizildere (Turkey) and the CarbFix technology site Hellisheidi (Iceland).

**The objectives of the project include:**

- i) to research and demonstrate the feasibility of **utilising produced CO<sub>2</sub>** for re-injection into a **carbonate** reservoir to **maintain reservoir pressure** and **improve geothermal performance**, while also storing the CO<sub>2</sub>, 
- ii) to develop further, test and demonstrate **innovative monitoring** technologies applicable in all CO<sub>2</sub> storage field sites:
  - a. the new higher signal-to-noise ratio **Distributed fibre-optic Acoustic Sensing** systems iDAS and Carina®
  - b. the new permanent and **highly repeatable** and environmentally friendly seismic monitoring **EM-vibrators** to provide **semi-continuous** seismic monitoring capability at **HPHT** environments,
- iii) to investigate **rock-fluid interactions** under simulated **HPHT** conditions in the laboratory and determine **geochemical**, **geomechanical** and **geophysical** response of the reservoir rocks to **supercritical CO<sub>2</sub>**,
- iv) to model and investigate **injected CO<sub>2</sub>** and **reservoir rock** behaviour in the geothermal reservoir,
- v) to develop strategies for **pressure management** in geothermal reservoirs through **supercritical CO<sub>2</sub>** injection at the **Kizildere** field site. 
- vi) to develop reliable **technoeconomic** and **life cycle environmental impact** assessment methodologies for **CO<sub>2</sub> storage** in geothermal projects and implement these models to evaluate the **geothermal resource** in the Büyük Menderes Graben.



SUCCEED is funded through the ACT Programme Project No 294766. Financial contributions made by the Department for Business, Energy & Industrial Strategy UK (BEIS), the Rijksdienst voor Ondernemend Nederland (RVO), the Scientific and Technological Research Council of Turkey (TUBITAK), Orkuveita Reykjavíkur/Reykjavík Energy Iceland (OR) and Istituto Nazionale di Oceanografia e di Geofisica Sperimentale Italy (OGS) are gratefully acknowledged.



Imperial College  
London Middle E

 seismic mechatronics  
The Electric Seismic Source Company



## Annex 7: Pictures from the poster session





