



European Carbon Dioxide Capture and Storage Laboratory Infrastructure European
Research Infrastructure Consortium

ECCSEL ERIC
ANNUAL REPORT

2018

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DIRECTOR'S HIGHLIGHTS OF 2018

The European Carbon Dioxide Capture and Storage Laboratory Infrastructure, ECCSEL, has been included on the official European Strategy Forum for Research Infrastructures (ESFRI) Roadmap since 2008.

In the 2018 Roadmap update, ECCSEL ERIC finally was successfully approved as a Landmark in accordance with ESFRI's maturity, business and sustainability criteria.

2018 was the first whole year in operation as a separate legal entity after being accepted as a European Research Infrastructure Consortium (ERIC) by the European Commission in 2017.

Consisting of 60 world-class research facilities from Universities, Research Institutes and Industry in the five ECCSEL ERIC member countries, the Consortium provides researchers across the globe open (trans)national access to all those facilities through its website, www.eccsel.org.

Throughout 2018 the ECCSEL facilities were increasingly accessed by diverse users, ranging from single students to groups of researchers from larger joint research projects. One of the Key Performance Indicators of ECCSEL is the number of actual research facility users.

Furthermore, with input and support from the industry and scientific advisory boards, the research strategy was updated with special emphasis on capture, industry applications and CO₂ use.

National funding schemes and infrastructure investments are generally in line with the joint ECCSEL plans and priorities. Thus, new and upgraded complementary facilities are continuously being included, exceeding an investment value of more than 100 million EURO until 2018.

Our application for Horizon 2020 INFRADEV-3 funding in 2018 (1st call December 2017) resulted in scores well above threshold, but regrettably no grants due to limited amount of funding available.

The General Assembly decided that ECCSEL ERIC should submit an improved proposal for the 2nd call

announced in December 2018. Thus, by March 2019 we resubmitted the Infradev-3 proposal with improvements in line with feedback from the EC evaluation of our previous proposal.

The ERIC Forum, a partnership of 20 ERICs including ECCSEL, submitted a joint proposal for H2020 INFRASUPP grants, with a successful outcome. Covering common topics and challenges such as RI visibility, KPIs, HR, contractual issues, funding of transnational access etc., ECCSEL ERIC is expected to benefit substantially from the project, which started 1. January 2019.



*Sverre Quale, Director, ECCSEL ERIC
Photo: Vibeke Ann Pettersen, NTNU*

Several initiatives were taken, and plans made for further development of ECCSEL ERIC with additional members/partners. Resulting in a couple of new facility providers in 2018, we expect further expansion the next couple of years.

The economy in 2018 was healthy, accumulating a sufficient equity buffer for payment of bills despite some delayed income from membership fees.

ECCSEL ERIC has been involved in and promoted through numerous publications and events throughout 2018, resulting in increased interest and publicity.

All in all, 2018 was a good year for ECCSEL ERIC, thanks to the joint effort and support within the ECCSEL member- and partnership.



Sverre Quale

Director, ECCSEL ERIC



ECCSEL ERIC exhibition stand at the GHGT-14 conference in Melbourne, Australia, October 2018

Photo: ECCSEL ERIC

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OUR MISSION

ECCSEL vision:

Enabling low to zero CO₂ emissions from industry and power generation to combat climate change.

Main objectives:

- Develop, coordinate and operate a world-class distributed CCUS Research Infrastructure in Europe
- Integrate, upgrade and construct CCUS research facilities
- Enhance European science, technology development, innovation and education in the field of CCUS
- Enable spin-off activities and generation of new business

RESEARCH INFRASTRUCTURE

ECCSEL has implemented, operates and develops a distributed, integrated European Research Infrastructure (RI) based on a selection of the best research facilities in Europe for Carbon Capture, Transport, Utilisation and Storage (CCUS). The current 60 individual research facilities which are part

of the ECCSEL ERIC RI are located in 5 countries and are owned by 16 different facility operators. The number of countries, operators and facilities will increase over time.

Examples of transnational collaboration and use of ECCSEL facilities

Facilities belonging to the ECCSEL RI have been used for many different research projects during 2018. Here is an example of transnational use of ECCSEL facilities:

ALIGN-CCUS Project - Accelerating Low carbon Industrial Growth through CCUS



ALIGN-CCUS is an ERA ACT project where 30 partners from

industry, university and research institutes work on accelerating the full-scale implementation of CCUS in European industrial clusters. ECCSEL facilities are being used mostly in the work package dealing with CO₂ capture technologies.



ECCSEL ERIC, nodes and facility locations
Photos © respective facility owners

Aerosol Characterisation Equipment (NL1.6) from TNO is used to get a better understanding and more knowledge about the origin and growth of aerosol particles, leading to unwanted emissions from capture plants. Part of the equipment is also used on-site to investigate different flue gases at various locations in Europe. The goal is to develop countermeasures to minimise emissions at full-scale.



TNO's Miniplant (NL1.1) is used to investigate solvent management technologies, including measures to control solvent degradation. Solvent degradation can lead to a significant increase of operational costs because (part) of the solvent needs to be replaced or cleaned regularly.

Also, regarding solvent management, a measurement campaign at the PACT facility (UK2.1) from the University of Sheffield in the UK is planned to investigate solvent degradation with another flue gas.

The Tiller pilot plant (NO3.5) from SINTEF in Norway is used to investigate control strategies for dynamic operation of capture plants and to prepare a solvent campaign with the *CESAR1* solvent at Technology Centre Mongstad (TCM).



ALIGN is a good example how ECCSEL facilities from different countries are being used seamlessly to accomplish the goals of a research project which requires a range of facilities from different operators.

OUR RESEARCH FACILITIES

The ECCSEL ERIC Research Infrastructure consists of research facilities from Universities, Research Institutes and the Industry in the five ECCSEL member countries. ECCSEL ERIC provides

researchers across the globe easy access to all those facilities through its website as well as it coordinates facility upgrades and new builds.

Category	Technology	Countries	No of facilities & scale
Capture	Membranes	France, Italy, Netherlands, Norway, UK	7 Laboratory facilities
	Solvents		4 Solvent Pilots
	Sorbents		
	Combustion		
	Cryogenic		
Transport	Full chain systems		
	Security/troubleshooting		
	Fluid characterisation		
	Flow characterisation		
	Material testing		
	CO ₂ pipeline transport and integrity		
Storage	Shipping of CO ₂		
	Pressure/injection		1 laboratory
	Migration		1 laboratory
	Caprock/well integrity		1 laboratory
	Leakage mitigation/remediation		1 laboratory
	Micro-seismicity		
	Reactivity/mineralisation		1 laboratory
Use	Leakage		1 mobile facility, 1 laboratory facility
	Thermochemical Conversion and Hydrogenation of CO ₂		
	Electrochemical and Photochemical Conversion of CO ₂		
	CO ₂ Conversion to Solid Carbonates		
	Smart integrations with carbon capture and re-use into valuable products		

Detailed lists of the ECCSEL RI facilities and their operators / owners are provided under FACTS.

INNOVATION AND INVESTMENTS

ECCSEL has a Research Strategy Document which aims to identify key research challenges and strategic objectives for the ECCSEL Research Infrastructure for the period 2016-2026. This Strategy covers all areas of CO₂ Capture, Transport and Storage (CCS), and is currently extended with CO₂ utilisation (CCUS). It will facilitate building a technical activity plan in these areas by providing a prioritised list of research topics to meet

predicted user needs up to 2021, as well as a horizon scan to 2026. It is based on contributions from, and therefore reflects the views of, the fourteen partner institutes from the nine countries participating in ECCSEL's Implementation Phase 2015-2017.

The Strategy sets out national research activities and interests before synthesising those into key research

priorities for capture, transport, storage and (soon) utilisation, that will need to be addressed to facilitate broad scale deployment of CCUS, and that are of common interest. Where appropriate, the key research infrastructure towards which ECCSEL could usefully focus resources, design and development efforts in the medium term are identified and, if appropriate, are ranked according to priority and shortlisted.

ECCSEL has performed a gap analysis showing current CCS research gaps as well as related existing facility gaps. Based on the gap analysis combined with input from national CCS roadmaps, facility upgrades and new builds have been planned and, in many cases, funding has been approved and construction has commenced. Upgraded and new capture, transport and storage research facilities are in the pipeline to apply for becoming a part of ECCSEL over the next 12 months. A selection of facilities known to become available are listed under **FACTS**.

Italy:

A call dedicated to implement high priority Research Infrastructures was launched in March 2018 by the Italian Ministry of University and Research (MIUR). This was the PON-RI call and consisted of national funds to be spent mainly to implement RIs located in Southern Italy.

ECCSEL ERIC, through its Italian representing entity (OGS), was among the eligible beneficiaries. Therefore, in June 2018 OGS submitted the IPANEMA project (Implementation of **Panarea Natural laboratory of ECCSEL and MA**rine observatory), that was approved in March 2019.

The project will be mainly dedicated to the implementation of the Panarea NatLab and CTMO ECCSEL facilities, with new and relevant equipment. Some innovative and high-tech instruments will be purchased, such as an AUV, a ROV and a drone. A new marine observatory will then be implemented off-shore, with the aim to better monitor CO₂ emissions.

The project budget is 8.8 M€. Project partners are INGV, INFN and SZN from Italy. The project will start in summer 2019.

The support from the Italian Ministry of Economic Development (MISE) and of Sardinia Region has been relevant for the development and valorisation of Sotacarbo's activities and facilities in Carbonia. €4M

have been issued by Sardinia Region in 2018-2019 (FSC 2014-2020 funds) with the aim to implement its "Excellence Centre for Clean Energy". MISE annually issues €2.2M through the Electric System Research funds, in order to finance activities on CCS; from 2019 these funds will be dedicated also to Utilisation.

Sotacarbo's IOSTO pilot unit for H₂S conversion into H₂SO₄ in flue gas from oxy-combustion) is currently being upgraded and is expected to be available again in 2020.

The Italian Ministry of University and Research continues supporting OGS activities with the annual contribution dedicated to research infrastructures, specifically to the two natural laboratories of Panarea and Latera (ECCSEL NatLab – Italy project). Contribution in 2018 was €500K.

ENEA's ZECOMIX facility for decarbonisation of flue gas by using calcium looping technology (size: 500kW; operation modes: pre- and post-combustion) and the University of Bologna's (DICAM) membrane characterisation facility for bench-scale characterisation of polymeric membranes (permeability, permeance, diffusivity, selectivity) were included in the ECCSEL RI. This represents a very important result for the Italian National Node, because with two new partners the Italian CCS community is now strongly linked to ECCSEL.

Norway:

The Research Council of Norway (RCN) has funded investments in upgrades and new facilities in two phases. Of the 8 facilities (upgrades / new builds) financed by the Phase 1 project, seven are now operational (**Capture Laboratories** -Absorption: 'Extension of lab scale absorption equipment', 'Extension of absorption pilot'; -Membranes: 'Extension of polymer membrane lab', 'Extension of high temperature membrane lab'; -Solid sorbents: 'Extension of solid sorbent lab'; -Combustion: 'Oxy-GT'; **Transport labs** 'Depressurisation facility'). So far there have been only a few users coming from organisations other than those owning them (NTNU, SINTEF).

Of the 15 facilities (upgrades / new builds) financed by the Phase 2 project, many are still in build or test phase. Already operational are **Capture Laboratories** - Absorption: 'Flexible flue gas source for CO₂-capture pilot facility'; -Membrane laboratories: 'Low temperature membranes', 'High temperature membranes'; -Low temperature separation laboratories: 'Low temperature

separation pilot'; **Storage Laboratories** -Storage integrity laboratories: 'Geochemistry Labs at IFE'. An additional five facilities will become operative in 2019 (**Capture Laboratories** -Combustion: 'High pressure combustion facility'; -Solid sorbents laboratories: 'Lab scale moving bed temperature Swing Adsorption'; **Storage Laboratories** -Monitoring laboratories: 'Upgrading of the CO2 Field Laboratory at Svelvik'; - Storage integrity laboratories: 'Well integrity lab facilities'; -Reservoir laboratories: 'Test tank for trapping mechanisms').

RCN had a new call for national research infrastructures in autumn 2018 and an application for around €18M CCS infrastructure funding was sent by SINTEF Energy Research together with the partners (SINTEF Industry, IFE, NORSAR, University of Oslo) in 2018. This application was supported by ECCSEL. The result of the call will be announced the autumn 2019.

UK:

The UK government announced its new approach to carbon capture, usage and storage in the Clean Growth Strategy. The approach is designed to enable the UK to become a global technology leader for CCUS and ensure that government has the option of deploying CCUS at scale during the 2030s, subject to costs coming down sufficiently.

To progress this ambition, the government has set out action under 3 themes:

- Re-affirming our commitment to deploying CCUS in the UK subject to cost reduction

- International collaboration on CCUS
- CCUS innovation

The UK is in the process of mapping its research infrastructure landscape ahead of the development of its first RI roadmap.

Work has started to include key facilities from SCCS (located in Scotland) which is the largest CCS research group in the UK, into the ECCSEL RI.

OPERATIONS

Operations Centre

With its statutory seat in Norway, the ECCSEL ERIC Operations Centre has its offices at NTNU in Trondheim. Its main responsibilities and tasks are "central management and planning as well as coordination of the infrastructure access, operations and development":

- Coordinate the ECCSEL Research Infrastructure across Europe
- Coordinate and facilitate the required upgrades and new builds of research facilities in support of the scientific and technological objectives of ECCSEL
- Act as the central user entry point for researchers and scientists wanting to use the facilities which are part of the ECCSEL RI
- Strengthen the identity of ECCSEL
- Facilitate outreach as well as training and mobility for its members, users and facility operators



ECCSEL Operations Centre tasks

National Nodes





Italian Node

Italy joined ECCSEL already for its first preparatory phase in 2010 and ultimately became a founding member of ECCSEL ERIC. The active partners during these initial phases have been OGS and Sotacarbo.

OGS was elected as the Italian representing entity in ECCSEL ERIC and coordinates the Italian National Node.

Italy currently holds seats on the General Assembly (OGS) and Research Infrastructure Coordination Committee (OGS and Sotacarbo) and provides in-kind staff contribution to the ECCSEL Operations Centre in Trondheim (OGS).

The Italian Node currently consists of fourteen CCS facilities owned and operated by four Italian institutes:

OGS	Eight CO ₂ storage research facilities	 ISTITUTO NAZIONALE DI OCEANOGRAFIA E DI GEOFISICA SPERIMENTALE
Sotacarbo	Three CO ₂ capture facilities and one CO ₂ storage research facility	 SOTACARBO SUSTAINABLE ENERGY RESEARCH CENTRE
ENEA	One CO ₂ capture facility	
The University of Bologna (DICAM)	One CO ₂ capture facility	

Activities in 2018 were focused on the Italian community expansion.

Contacts with undergoing projects have been established, particularly with CLEANKER (CLEAN clinKER production by calcium looping process). LEAP research centre is an active project partner and their facilities may be included in ECCSEL ERIC in the future.

Contacts with EPOS and EMSO ERIC have been ongoing, to enhance collaboration activities and to promote the joint use of facilities. Agreements with them will be formalised soon.

The link with ICDI, the Italian initiative connected to EOSC, is maintained, to better align policies regarding data and IPR at a national and a European level.

The Italian National Node is involved in the Italian Energy cluster, grouping all the energy actors and discussing about energy issues.

At a national level, the Italian National Node has been coordinating the signature of the ECCSEL Access Agreements, interacting with the Operation Centre in Trondheim. An active contribution has

been given in the definition of the contents of the access documents and of the policy.

The Italian National Node plays an important role also in the European and international context. Particularly to mention are EERA-CCS JP, CO2GeoNet, Mission Innovation and SET-PLAN initiatives. Relating to Mission Innovation, Italy has recently accepted the challenge on Carbon Capture, thanks also to the additional importance given to CCS by ECCSEL ERIC. Referring to SET-PLAN, the two Italian members of the Working Group on CCS/CCUS are from Sotacarbo. In 2018 they organised and chaired the 1st meeting of the National Coordination Group on CCUS in Rome. The aim was to collect the feedback from the CCS community, to be reported to the SET-PLAN. An ECCSEL presentation was given by the Italian National Node coordinator. The Italian representative in Mission Innovation was also invited at the meeting.

The Italian National Node was active in project proposal preparation during 2018. The H2020

ECCSELERATE project was submitted by ECCSEL ERIC, with OGS and Sotacarbo as partners. Specific activities will be dedicated to the National Nodes implementation and interactions. Another effort in 2018 has been the submission of IPANEMA project, dedicated to the implementation of strategic RIs (for more details see “innovation and investments” section).







Objectives have been set for 2019 and related activities have been planned.

French Node

The French node has the largest number of national partners with six facility operators/providers.

France has been involved in the development of the ECCSEL RI since 2008, and from 2017, the year of ECCSEL ERIC creation, the French node (ECCSEL-FR) has been officially constituted and structured around four public research institutes (ANDRA, IFPEN, INERIS, BRGM) and two private companies (EDF, TOTAL).

The node is coordinated by BRGM through a partnership agreement and on the behalf of the French Ministry of Research. ECCSEL-FR provides eight facilities. Seven are existing operational facilities (Category 1) while one is still at project level (Category 3). These facilities cover the whole CCS chain:

EDF	CO ₂ capture pilot at a coal power plant	
INERIS	SAFETY experimental platform (CO ₂ transport) & CATLAB (CO ₂ leakage simulation)	
TOTAL	COOTRANS transport loop (CO ₂ transport) - planned	
URL-Andra	Underground Research Laboratory (CO ₂ storage)	
BRGM	BIOREP reactor (CO ₂ storage)	
IFPEN	ESCORT Mobile equipment for CO ₂ monitoring & GasGeoChem laboratory of gas analysis	

The node has been proactive on national and international levels to promote its extension and the use of all ECCSEL facilities through presentations at national and international conferences (3 in 2018) as well as the participation in the “Rendez-vous Carnot” in Lyon on 17-18 October 2018. The latter is a national business convention: it gathers all the actors in R&D support for innovation for companies. For the 1st time a “Village of research Infrastructures” was included giving the possibility to national IRs to have a booth

and arrange a series of B2B meetings. Furthermore, late 2018 the French node had the idea to start organising an international workshop on “Underground laboratories for CO₂ geological storage research”, to be held in Nancy in France in 2019. Objective is to encourage researchers worldwide to use the URL-Andra unique research facility close to Nancy, knowing that the recent Mission Innovation Report on CCUS mentions the usefulness of using Underground Research Laboratories (URL) for addressing the

Priority Research Directions (PRDs) for CO₂ storage required for accelerating breakthrough innovation in CCUS.

ECCSEL-FR has been included in the national roadmap for Research Infrastructures since 2016 (status “in project”). On 17 May 2018 a national event was held at the Ministry of Research to announce the publication of the 2018 edition of the National Roadmap of Research Infrastructures: ECCSEL was now given the status of “Research Infrastructure” (i.e. equivalent to landmark in ESFRI nomenclature).

To answer a new request from the Ministry for all RIs, all the ECCSEL-FR partners performed in 2018 a standardised accounting valuation for each of their facilities to update data provided in 2017. Those assessments have been validated by the French ministry and have helped to structure and refine the cost and price of the services that are provided.

A brainstorming meeting gathering all the ECCSEL-FR partners was held in Paris on 30 January 2018 to elaborate the French node’s point of view on the Research Strategy Roadmap of ECCSEL ERIC. A





PowerPoint presentation summarising the French node’s point of view was sent in February 2018 to all ECCSEL members as input in order to help developing the ECCSEL ERIC’s “Research Strategy Roadmap”, as requested by the General Assembly in December 2017.

In 2018 one person is providing in-kind contribution to the ECCSEL Operations Centre, and this was renewed for 2019.

The Norwegian Node

Norway, represented by NTNU and SINTEF together with the Research Council of Norway (RCN) and the Norwegian Ministry of Research and Higher Education (KD), were the initiators of ECCSEL that was included on the ESFRI Roadmap in 2008 as one of three new RIs within the energy domain. Since 2011, NTNU has coordinated the development of ECCSEL. NTNU was the host of the inauguration ceremony of ECCSEL ERIC that took place in Trondheim on 12th June 2017 and is also the coordinator of the Norwegian node.

The Norwegian node of ECCSEL consists of the 3 research institutes and one university:

NTNU (Norwegian University of Science and Technology)	Two CO ₂ capture facilities	
SINTEF Industry (merger of former SINTEF Materials and Chemistry and SINTEF Petroleum)	Five CO ₂ capture facilities and three CO ₂ transport facilities	
SINTEF Energy	Four CO ₂ capture facilities and six CO ₂ storage facilities	
Institute for Energy Technology (IFE)	One CO ₂ storage facility	

The Norwegian node is continuously working to expand and attract other Norwegian universities and research institutes through national meetings/workshops and research project collaboration.

ECCSEL is included in the Norwegian Roadmap for Research Infrastructures. Together with the existing RIs, the partners of the Norwegian node of ECCSEL

will soon be operating more than 20 RIs within CO₂ capture, transport, storage and use, that are made available for the research community worldwide through ECCSEL ERIC.



The UK node

The UK has participated in ECCSEL since 2010 and ultimately became a founding member of ECCSEL ERIC.

The UK node, coordinated by BGS, has been proactive in engaging and promoting ECCSEL to policy and research stakeholders, potential RI users and UK CCS facility owners. Information on ECCSEL’s ambitions, activities, strategy and future plans have been communicated regularly throughout ECCSEL’s evolution at national and international CCS events.

The UK has a busy schedule of biannual CCS research and policy events. Aligning with these opportunities has proved extremely successful in securing engagement, participation and buy-in amongst UK stakeholders.

The UK node currently consists of eleven CCS facilities owned and operated by two UK institutes:

British Geological Survey (BGS)	Five CO ₂ storage research facilities	
PACT (Pilot-scale Advanced Capture Technology) is a collaboration between six UK universities	Six pilot-scale CO ₂ capture facilities	


Seven of these facilities were new additions at the launch of ECCSEL ERIC. The UK node has also coordinated with additional UK CCS groups wishing to contribute facilities to ECCSEL and will apply to expand the UK node accordingly via the RICC in 2019.

The UK holds seats on the General Assembly (BGS and Department for Business, Energy & Industrial Strategy (BEIS)) and Research Infrastructure Coordination Committee and provides in-kind staff contribution to the ECCSEL Operations Centre in Trondheim.

The Dutch Node

Netherlands, represented by TNO together with the Dutch RVO (Rijks Dienst voor ondernemend Nederland) as representative of the Dutch Ministry of Economic affairs and climate (EZ), were involved from the early phases of ECCSEL. TNO has been involved in the development of ECCSEL since 2011 and became a part of ECCSEL ERIC in 2017.

The Dutch node of ECCSEL consists of TNO and the Dutch CATO (CCS) program. ECCSEL is on the Dutch research agenda via the CATO program support by RVO.

TNO	Five CO ₂ storage research facilities	
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Currently the setup of the Dutch RI is mainly concentrated on solvent base absorption technologies and are located in Delft. The Dutch node will be extended with existing research facilities located in Petten, which will be assessed to be part of ECCSEL. The predominant technical focus is CO₂ adsorption separation technologies. Currently several large-scale CO₂ capture demonstration projects are under development at two different locations in connection to waste incineration. For both demonstration units ECCSEL RI have been a crucial element in this deployment, since both technologies are underpinned

with fundamental and applied research activities obtained via the ECCSEL research facilities.

Currently a large-scale CO₂ storage demonstration program is under development at three different location in the Netherlands. The most likely location for a first common carrier and storage infrastructure will take place in industrial cluster of Rotterdam, so called the Porthos Project. Next to this H-vision project (H₂-CCS) is now underdevelopment, this project is started by the ERA-ACT Elegancy project and will soon go into a next much more progressive phase of development. ECCSEL will be connected to these developments and

will support when it can help de-risking the projects and reduce cost of the upcoming developments.

FACILITY ACCESS

Facility usage reporting and monitoring which started in the second half of 2017 was continued in 2018. For 2018 usage information for the full year was collected. Below is a selection of some of the research projects carried out in 2018 using facilities which belong to the ECCSEL Research Infrastructure. National and

European Projects and Initiatives like (ACT (Accelerating CCS Technologies) an ERA-NET Cofund, NCCS (Norwegian CCS Research Centre) and others) used ECCSEL facilities for their research projects in 2018.

Project	Facility	Facility owner	Country of facility	Researcher employed in Country
The synthesised copolymer of vinylimidazole and butyl acrylate is crosslinked to form poly(ionic liquid) membranes for CO ₂ separation	MEMB-PERM	NTNU-IKP	Norway	Denmark
Measurement of species and temp in HP oxy-Fuel combustion	HIPROX	SINTEFER	Norway	France
Chinese-European emission-reducing solutions	M-Lab	SINTEF	Norway	China
Project to determine gas flux by new equipment and methods using acoustic and optic techniques, to facilitate the generation of new methods for determining gas flux which will be applicable to both natural vent systems, and also in detecting leakages associated with Carbon Capture and Storage. The equipment and methods developed will be applied in the EU consortium STEMM-CCS, specifically in May 2019 in the North Sea.	Panarea NatLab Italy	OGS	Italy	UK
CO ₂ capture from cement industry	SEPPIL	SINTEFER	Norway	NA
Innovative sorbents for the sorbent enhanced water-gas shift process	SLab	SINTEF	Norway	NA
Shaping of advanced materials for CO ₂ capture processes	SLab	SINTEF	Norway	NA
Demonstration of the Swing Adsorption Reactor Cluster (SARC) for simple and cost-effective post combustion CO ₂ capture	SLab	SINTEF	Norway	NA
Characterize performance of surfactants for mobility control of CO ₂ by foam stabilization	SCAL	SINTEF	Norway	NA
Development of laboratory infrastructure for flow in fracture networks	SCAL	SINTEF	Norway	NA
Development of CO ₂ EOR technology	PVT	SINTEF	Norway	NA
Testing of nano-material for mobility control	PVT	SINTEF	Norway	NA
Enabling technology for the Development of moving bed Temperature swing adsorption process for post combustion CO ₂ capture	PP-Lab	SINTEF	Norway	NA
Capturing CO ₂ using heat pumps	PP-Lab	SINTEF	Norway	NA

Demonstration of the Swing Adsorption Reactor Cluster for simple and cost effective post-combustion CO2 capture	PP-Lab	SINTEF	Norway	NA
Distributed Hydrogen Injection and Combustion Technology for Next Generation Pre-Combustion CCS Schemes	M-Lab	SINTEF	Norway	NA
Novel molten/solid composite oxygen transport membranes for CO2 capture	M-Lab	SINTEF	Norway	NA
Novel molten carbonate/ceramic composite materials for sustainable energy technologies with CO2 capture and utilization	M-Lab	SINTEF	Norway	NA
High temperature steam electrolyzers with novel tubular cells and stacks geometry for pressurized hydrogen production	M-Lab	SINTEF	Norway	NA
Novel solvents for biogas-upgrading	ABSEQ	NTNU-IKP	Norway	NA
Solvent development	ABSDEG + ABSEQ	NTNU-IKP	Norway	NA

Italy

OGS had several requests of access to the Panarea NatLab in 2018 and has already requests for 2019.

The international research team NOC Southampton plans to use their own funds and/or other project's funds for their experiments in Panarea.

The number of accesses to the Panarea NatLab will rapidly increase during the activities of the IPANEMA project.

UK

The BGS Near-Surface Gas Monitoring (Gas Mon) facility was deployed to Ailano in the autumn of 2018 to carry out further instrument inter-comparisons with researchers from University of Rome La Sapienza. The project was funded by the European Commission project "Enabling Onshore CO₂ Storage in Europe".

University of Oslo also completed their access to the BGS Rock Mechanics and Physics Laboratory

(RMPL) that started under the H2020 Infradev-3 Transnational Access Programme but was cut short due to equipment failure. The access was self-funded by BGS and took place early in 2018. Peer-reviewed papers are in preparation.

France

An Argentinian Gas company (HYCHICO) has realised several accesses to the BIOREP facility (BRGM) in 2018 through a private project dedicated to CCUS, which started in 2016.

Norway

Projects with national and international funding (NCCS Norway, ACT ERA NET Cofund and others) have been accessing the ECCSEL RI. Many of the Norwegian facilities have been used considerable for research projects. Most of those were national research projects and around 20% were projects receiving international financing.

LOOKING AHEAD

The balance of the year 2018 is positive for ECCSEL ERIC. Activities initiated and planned during the implementation phase -the last H2020 Infradev-3 project- and during the first operational months in 2017 have continued, in line with agreed plans.

Objectives have been adapted according to the last GA decisions, particularly the future inclusion of CO₂ Utilisation among the priorities and in the updated Research Strategy comprised of the Research Prioritisation together with the Facilities Development / investment Plan.

The new Infradev-3 project proposal "ECCSELERATE" offers the opportunity to balance targeted goals, re-think some ECCSEL objectives and adjust the strategy considering the ECCSEL operational experiences so far as well as the changed priorities towards CCUS.

The plans for ECCSEL for the future include:

- Increase accessibility to the excellent range of facilities belonging to the ECCSEL RI, extending

the user group and connecting to the wider research and industrial community

- Ramp up marketing activities, specifically to increase Transnational access
- Assess the future development and needs for CCUS research and use this for development and innovation of its facilities, to meet future user requirements
- Facilitate access to national and regional funds for enhancing existing and building new research facilities and/or performing research and innovation activities
- Better anchor ECCSEL ERIC in national and regional policies
- Increase ECCSEL ERIC membership
- Secure the long term financial sustainability of ECCSEL ERIC
- Implement the ECCSEL strategy

Some actions have already been set in motion to rapidly meet these goals.

Discussions have continued between the ECCSEL Director and Japanese Ministry representatives that may lead to formal collaboration between Japan and ECCSEL ERIC as well as with CSIRO in Australia with the goal of collaboration.

A research prioritisation and strategy update is ongoing, not least to best include CO₂ Utilisation and to assure the appropriate filling of identified innovation, technology, research and facility gaps.

To have attractive and innovative facilities to offer to the users is the key to success for an RI and in this

way ECCSEL wants to move forward. Goal is to increase the use of the ECCSEL facilities substantially. Attractiveness will be better highlighted through extensive promotion, using a wide range of channels. Communication will also be better targeted in the future, even though it has already brought good results.

A coordinate action is planned to better set up priorities and define the future development of ECCSEL. Participation of ECCSEL Member States in this process is key for success.

FINANCIAL SUMMARY

This is the second Annual Financial Report since the creation of ECCEL ERIC. It is however the first full year report. The previous Annual Financial Report covered only a period of 4 month because after the establishment of ECCSEL ERIC in June 2017, Income (Membership contributions) and Expenses (personnel and other costs) only started accruing from 1st September 2017 due to the financing provided by the H2020 Infradev-3 "ECCSEL Implementation" project, which was running until the end of August 2017.

The Annual Financial Statements for 2018 were prepared by the Authorised Accountant "SpareBank 1 Regnskapshuset SMN AS", Kjøpmannsgata 50, 7010 Trondheim, Norway. The Annual Financial Statements for 2018 can be found in the Annex of this annual report.

All accounts have been audited by the External Auditor "BDO AS", Klæbuveien 127B, 7031 Trondheim, Norway. BDO AS was reappointed as auditor by the ECCSEL ERIC General Assembly during their fourth meeting on 14th December 2018. The Report of the External Auditor is in the Annex of this annual report.

The Annual Financial Report 2018 highlights the financial status of ECCSEL ERIC. There were no unexpected income or expenses during 2018.

Budget

The Budget for the financial year 2018 was agreed on during the ECCSEL ERIC General Assembly meeting on 24. November 2017.

The approved budget for 2018 was €480,000. Norway, as the hosing country of the ERIC has agreed to pay 1/3 of the total membership fees. The remaining 2/3 are being split equally between the other member countries.

It was approved that four countries would provide in-kind personnel contributions at/to the OC (Italy, France and the UK would provide a 25% position contribution each and the Netherlands would provide a 20% position). The membership fee would accordingly be discounted by €25,000 for the three countries providing a 25% position in kind contribution and by 20,000 for the country with a 20% position in kind contribution in 2018 (value of the in-kind contribution).

Foreseen total cash income (from membership fees) was therefore €385,000. Membership fees were divided as per table below.

Against those earnings, expenses of €480,000 were foreseen. Of those were €385,000 cash expenses and €95,000 for in-kind personnel contributions. Those in-kind contributions and their costs are not visible on the balance sheet as they were accounted for by member fee reduction.

Budgeted expenses for 2018 and foreseen breakdown into main expense categories are displayed in the table below.

2018 Budget - Membership fees (EURO)			
Member / Category	Cash income and expenses - expected	In-kind - expected	Total
Income			
Norway (1/3 as host)	160 000,00		160 000
France*	55 000,00	25 000,00	80 000
The Netherlands*	60 000,00	20 000,00	80 000
Italy*	55 000,00	25 000,00	80 000
UK*	55 000,00	25 000,00	80 000
Total Income	385 000	95 000	480 000
Expenses			
Operations Centre personnel**	295 000	95 000	390 000
IT system***	5 000		5 000
Office renting***	5 000		5 000
Travel	25 000		25 000
Outsourced services	55 000		55 000
Total Expenses	385 000	95 000	480 000

* 3 countries providing a 25% in-kind position each, 1 a 20% in-kind position at/for the OC, paying a reduced membership fee in cash

** Start-up with secondment of Director and administrative personnel from NTNU plus in-kind contributions from other countries

*** Office renting, general administrative support and IT from NTNU from 1.9.2018

2018 budget showing Income (membership fees (Euro) and in-kind contributions) as well as planned Expenses

Planning Period	2019	2020	2021	2022	2023	2019-2023
5 years ECCSEL ERIC Budget build-up from 2019						
EXPENDITURES						
Operations Centre personnel*	390 000	490 000	590 000	690 000	690 000	2 850 000
IT system		10 000	15 000	15 000	15 000	55 000
Office renting	10 000	10 000	15 000	15 000	15 000	65 000
Travel	25 000	40 000	45 000	50 000	50 000	210 000
Outsourced services**	55 000	75 000	75 000	80 000	80 000	365 000
Total Expenditures (€)	480 000	625 000	740 000	850 000	850 000	3 545 000
INCOME						
Hosting Country (Norway)	160 000	208 333	246 667	284 000	284 000	1 183 000
Member & Observer States	320 000	416 667	493 333	566 000	566 000	2 362 000
Total income (€)	480 000	625 000	740 000	850 000	850 000	3 545 000
COSTS PER MEMBER						
Number of Members (excl. host)	4	6	8	10	11	
Costs per Member (€)	80 000	69 445	61 667	56 600	51 455	319 166
*) In 2019 secondment of Director and Adm. Manager from NTNU + 1 In-kind person-year (split in 2,3 or 4 positions)						
**) Includes Auditor, Accounting, NTNU support/service; Adm., HR, Contracts etc						

5-year future budget prediction 2019-2023

The table above shows the forecasted annual costs and income contributions (€) for the coming 5 years

Actual Income and Expenses

The annual accounts have shown a total operating revenue of €399,148 and total operating expenses of €299,248 for ECCSEL ERIC in 2018.

€385,000 of the total operating revenue of €399,148 came from membership fees. The remaining other operating income of €14,148 originated from foreign exchange gain related to the operational revenue (€2,960) and from extraordinary income (€11,188). This related to a bill for finding and recruiting a permanent director for ECCSEL ERIC. The funds for paying this bill came from NTNU and were accounted for as extraordinary income. Additional extraordinary funding of activities by institutes in member countries which reduced ECCSEL spending to some degree, is not visible in the ECCSEL income and expense statements as payments were made directly and not to ECCSEL.

All membership fees for 2018 are paid in full.

Total operating expenses for 2018 were €299,248. This was below the budgeted expenses mainly due to lower than budgeted travel expenses, meeting expenses, personnel expenses and office rental expenses. This was due to exceptional circumstances in 2018 (see above). Office rental charges did not start before 1.9.2018. Additionally, less office space than planned was used and charged for. Due to exceptional circumstances was the personnel cost in 2018 lower than anticipated. The main expense for 2018 was salary, which accounted for €272,047. This was for the secondment of Sverre Quale (100%), Volker Röhling (100%) and Debbie Koreman van den Berg (5%). This amount covers salaries and related costs (like insurance and pension), IT systems and support and travel expenses.

Other expenses (€27,201) accounted for meetings (meeting room and catering costs), travel of OC staff (OC in-kind staff only as travel of main OC staff is included in salary costs above), payment to auditor (€2,995) and accountant, for use of the online

of operation of ECCSEL ERIC, as per December 2018.

accounting system and costs for banking services in relation to the bank accounts of ECCSEL.

In 2019, costs are expected to be higher and in line with the total budgeted amount. Travel and meeting expenses are foreseen to be higher. Increased marketing activities are also planned for 2019 and 2020.

It has proved to be valuable to have a solid financial buffer to bridge eventual delays in member fee payments and delays in claiming back Value Added Tax. Additionally, some reserves for planned irregular future expenses are required.

Other Income

No other income was generated in 2018 apart from the one mentioned above.

Procurement and Tax Exemption

According to Article 16 of the Statutes, shall ECCSEL ERIC shall treat procurement candidates and tenderers equally and in a non-discriminatory way, independent of whether they are based in the European Union, or not. During 2018 no major investments or purchases were done. Office space was made available from NTNU and is a minor expense. There was a payment of €5,945 in 2018 for the office space used by ECCSEL ERIC.

In accordance with the ERIC Regulation (Official Journal L 206, 2009) and the Norwegian ERIC law ("ERIC loven") shall an ERIC benefit from tax exemption. Article 16 of the ECCSEL ERIC Statutes states that tax exemptions based on Norwegian Act relating to value added tax of 19. June 2009 No. 58, § 10-3 be limited to the value added tax for such goods and services which are for official and exclusive use by ECCSEL ERIC and are wholly paid and procured by ECCSEL ERIC or by Members States of ECCSEL ERIC.

ECCSEL ERIC requests quarterly the refunding of charged value added tax. For 2018, ECCSEL ERIC got refunded the in Norway paid value added tax.

FACTS

ECCSEL ERIC Member States, representing Entities and National Nodes

Member State	Member States' Representing Entity	National Node Coordinator
Norway (ERIC statutory seat)	Norwegian University of Science and Technology (NTNU) cooperating with SINTEF Energy Research (SINTEF ER)	Morten Grønli (NTNU)
France	The French Geological Survey (BRGM)	Isabelle Czernichowski-Lauriol (BRGM)
Italy	National Institute of Oceanography and Experimental Geophysics (OGS)	Michela Vellico (OGS)
The Netherlands	Netherlands Organisation for Applied Scientific Research (TNO)	Jan Hopman (TNO)
United Kingdom	British Geological Survey (BGS)	Helen Taylor-Curran (BGS)

ECCSEL GENERAL ASSEMBLY

Member Country	Name	From	Type	Role
United Kingdom	Jonathan Pearce	BGS	Representing Entity	GA Chair
Norway	Sverre Quale	ECCSEL ERIC	ERIC Management	ECCSEL ERIC Director
France	Xavier Montagne	Ministry of Education, Higher Education and Research (MESRI)	Ministry	Vice Chair
France	Isabelle Czernichowski-Lauriol	BRGM	Representing Entity	Member
Italy	Salvatore La Rosa	Ministry of Education, University and Research (MIUR)	Ministry	Member
Italy	Michela Vellico	OGS	Representing Entity	Vice Chair
The Netherlands	Gerdi Breembroek	Netherlands Enterprise Agency (RVO)	Ministry	Member
The Netherlands	Jan Hopman	TNO	Representing Entity	Member
Norway (ERIC statutory seat)	Åse Slagtern (shared with Espen Bernhard Kjærgård)	The Research Council of Norway (RCN) Norwegian Ministry of Petroleum and Energy (OED)	Ministry	Member
Norway	Nils Røkke	SINTEF ER	Representing Entity	Member
United Kingdom	Brian Allison	Department for Business, Energy and Industrial Strategy (BEIS)	Ministry	Member
United Kingdom	Helen Taylor-Curran	BGS	Representing Entity	Member

ECCSEL RESEARCH INFRASTRUCTURE COORDINATION COMMITTEE (RICC)

The task of the Research Infrastructure Coordination Committee is to strengthen the cooperation between the facilities and their contributions to experimental research. This is done by overseeing the

implementation of ECCSEL ERIC's strategies and plans, by contributing to them, and by proposing measures that can enhance the functioning of ECCSEL ERIC.

Member State	Institute	ECCSEL ERIC RI's National Node Coordinator
Norway (ERIC statutory seat)	Norwegian University of Science and Technology (NTNU)	Morten Grønli (NTNU)
France	The French Geological Survey (BRGM)	Sébastien Dupraz (BRGM)
Italy	National Institute of Oceanography and Experimental Geophysics (OGS)	Cinzia de Vittor (OGS)
The Netherlands	Netherlands Organisation for Applied Scientific Research (TNO)	Peter van Os (TNO)
United Kingdom	British Geological Survey (BGS)	Audrey Ougier-Simonin (BGS)

OTHER ECCSEL ADVISORY BOARDS AND COMMITTEES

ETHICS AND ENVIRONMENTAL ADVISORY BOARD (EEAB)

The EEAB is a group of three to five eminent, independent and experienced scientists. Its main tasks are:

- Review and approve a document with Ethics guidelines which apply as a minimum standard

to all facilities that are part of ECCSEL as well as to all research being done through ECCSEL.

- Review any ethics and environmental issues that arise during research performed through ECCSEL national or transnational access.

Name	Country	Institute	Involvement
Behnam Taebi (Ph.D.)	The Netherlands	Delft University of Technology	Associate Professor Ethics of Technology, Faculty of Technology, Policy and Management, Delft University of Technology http://ethicsandtechnology.eu/taebi/ Associate, Belfer Center for Science and International Affairs, Kennedy School of Government, Harvard University http://www.belfercenter.org/person/behnam-taebi Member of The Young Academy of the Royal Netherlands Academy of Arts and Sciences (KNAW)
Derek Taylor	Belgium / UK	DMT Energy Consulting sprl	DMT Energy Consulting sprl & Honorary Professor of Geo-Energy (Nottingham University)
Øyvind Mikkelsen	Norway	NTNU	Chair of "The National Committee for Research Ethics in Science and Technology (NENT)

INDUSTRY ADVISORY GROUP (IAG)

The IAG consists of senior industry representatives. Its role is to provide an effective interface between the industry group and the

ECCSEL community, to provide guidance on industrial topics and priorities and to report progress to the ECCSEL Operations Centre.

Name (First, Last)	Institute / Company / University	Country
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Oscar Graff	Aker Solutions	Norway
André Marblé	TOTAL	France
Valérie Czop	EDF	France
Hege Rognø	Statoil	Norway
Mouloud Behloul	Lafarge	France
Fulvio Canonico*	Buzzi Unicem	Italy
Barthold Schroot	EBN	The Netherlands
Chris Gittins*	Taqa Energy BV	The Netherlands

*from 2019

SCIENTIFIC ADVISORY BOARD (SAB)

The Scientific Advisory Board is a permanent Committee that reports through the Director to the General Assembly. Its main task is to provide input to the GA through (solicited and unsolicited) advice

on the scientific quality of the services offered by ECCSEL ERIC, the RI's scientific policies, procedures and future plans.

Name (First, Last)	Institute / Company / University	Country
Axel Liebscher	Deutsches GeoForschungsZentrum GFZ Potsdam (Helmholtz-Zentrum Potsdam)	Germany
Adam Smolinski	Central Mining Institute GIG (Główny Instytut Górnictwa)	Poland
Sergio Persoglia	Independent	Italy
Eric Favre	University of Lorraine	France

ECCSEL Operations Centre (OC)

Name	Role	Organisation
Sverre Quale	Director	ECCSEL ERIC
Volker Röhling	Manager	ECCSEL ERIC
Debbie Koreman van den Bergh	50%	NTNU / ECCSEL ERIC
Helen Taylor-Curran	25% position (in kind)	BGS
Michela Vellico	25% position (in kind)	OGS
Sébastien Dupraz	25% position (in kind)	BRGM
Robert de Kler	20% position (in kind) (25% from 1.1.2019)	TNO

APPENDIX I
FINANCIAL REPORT
AUDITORS REPORT

ECCSEL

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APPENDIX II-VI

II ECCSEL OC STAFF

III OUR RESEARCH FACILITIES

VI FACILITY OPERATORS/OWNERS

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VI ACRONYMS AND ABBREVIATIONS

ECCSEL

APPENDIX II ECCSEL OC STAFF

Sverre Quale

Sverre was coordinator and Project Director for the ECCSEL preparatory and implementation phases for 5 years until summer 2017 when he was appointed Director of ECCSEL ERIC. Previously he has held several senior positions in both the petroleum industry and the transport sector, including as head of HSE in Saga Petroleum, Director of the National Accident Investigation Board, CEO at the major Engineering company Multiconsult and CEO of the Norwegian Airports an Air Traffic Control.



Volker Röhling

Volker is Manager of Operations and Administration of ECCSEL ERIC since its implementation on the 9th June 2017. Before that, he was Project Manager at NTNU responsible for the ECCSEL Infradev-3 (H2020) and ECCSEL PP2 (FP7) projects.



Debbie Koreman van den Bergh

Debbie is a Higher Executive Officer working for the Department of Energy and Process Engineering at NTNU since 2009. She works currently 50% of her time for the ECCSEL ERIC Operations Centre as Administrative Coordinator. Before she already worked a small percentage of her time in the ECCSEL Infradev-3 and ECCSEL PP2 projects as in-kind of NTNU-EPT.



Helen Taylor-Curran

Helen has been a geochemist with BGS since 2001 and now manages the ECCSEL CAT-1 facility BGS Near Surface Gas Monitoring. She is the UK National Node coordinator of ECCSEL ERIC and holds a 25% in kind position at ECCSEL ERIC Operations Centre. She is also responsible for coordinating ECCSEL's Research Strategy Document.



Michela Vellico

Michela is a senior technologist working for OGS since 2003. She is the Italian National Node coordinator of ECCSEL ERIC and holds a 25% in kind position at ECCSEL ERIC Operations Centre. She is also co-vice chair in the ECCSEL ERIC GA and is responsible for the Italian project "ECCSEL NatLab Italy", aimed at the implementation of two ECCSEL Italian facilities.



Sébastien Dupraz

Sébastien is attached to the Laboratory Directorate of BRGM. He is an (bio)-geochemist expert on reservoir issues and the RICC representative for the French Node. Since 2018, he holds a 25% in kind position at ECCSEL ERIC Operation Centre on matters related to the coordination and access to ECCSEL ERIC Facilities. In May 2018, he was also appointed co-vice chairman of the ECCSEL ERIC RICC.





Robert de Kler


Robert has been active for more than 20 years in the power industry, including CCS activities. His main contributions & experiences are large scale technology demonstration projects. Successfully managed: an industrial CCS NER300 project application, the Nuon (Vattenfall) CCS programme - pilot test plant at Buggenum IGCC and a full-scale demo at the Magnum plant (2006-2009). He has been almost for 10 years responsible for the research and development activities at Nuon (Vattenfall). Currently Mr. de Kler is involved in several innovations, including CCUS projects and developments of new technology pathways. In 2018 he also held a 20% in kind position at ECCSEL ERIC Operation Centre.




APPENDIX III OUR RESEARCH FACILITIES

COUNTRY	INSTITUTION	CATEGORY	Tech	SHORT NAME	LONG NAME
France 	EDF	Capture	Solvent Pilot	EDF's CO ₂ Capture pilot	CO ₂ Capture Pilot at EDF power plant in Le Havre
	INERIS	Transport	Flow	SAFETY	CO ₂ Transport research facility and safety platform: Mont la Ville experimental site in Oise
	Andra	Storage	Reservoir	MHM URL	Meuse/Haute-Marne Underground Research Laboratory
	BRGM	Storage	Environmental	BIOREP	BIO-Reactor for Deep Environments. Monitoring of microbiological and geochemical processes in high pressure and dynamic conditions
	INERIS	Storage	Reservoir	CATLAB	CATenoy experimental site and gas-water-rock interactions LABORatory in Oise
	IFPEN	Storage	Migration	ESCORT	Equipment for soil CO ₂ origin tracking
	IFPEN	Storage	Reservoir	GasGeoChem	Instrumentation and expertise to analyse and interpret gas geochemistry data


COUNTRY	INSTITUTION	CATEGORY	Tech	SHORT NAME	LONG NAME
Italy 	OGS	Storage	Environment	DeepLab	DeepLab Sea Floor Landers for meteoceanographic physical and geochemical data collection
		Storage	Monitoring	Aircraft	Research aircraft equipped with high-tech remote sensing instruments
		Storage	Environment	BioMarineLab	Ecological laboratory for mesocosm experiments
		Storage	Migration	Panarea NatLab	Panarea Natural Laboratory
		Storage	Migration	Latera NatLab	Latera Natural laboratory
		Storage	Well integrity	PITOP	Borehole Geophysical Test Site
		Storage	Environment	EXPLORA	Research vessel equipped with geophysical and oceanographic instruments
		Storage	Environment	CTMO	Marine metrology and calibration facility
	SOTACARBO	Capture	Solvent Pilot	COHYGEN	COHYGEN (Coal to Hydrogen Generation) pilot plant with new completed upgrade: Integration of the existing COHYGEN plant
		Capture	Utilisation	PEC Lab	Photoelectrochemical reduction laboratory (CO ₂ recovery)
		Capture	Solvent/Membrane pilot	XtL Pilot plant	Integrated system with gasification, membrane separation and syngas/CO ₂ -to-liquids
		Capture	Combustion	IOSTO plant	IOSTO pilot unit for H ₂ S conversion into H ₂ SO ₄ in flue gas from oxy-combustion. Currently undergoing upgrades, available again in 2020
		Storage	Reservoir	Rock Analysis Lab	Multi-stage triaxial test system for rock characterisation; advanced automatic uniaxial and triaxial test laboratory (rock testing)
ENEA	Capture	Sorbent Pilot	ZECOMIX	Pilot plant dedicated to the decarbonisation of flue gas by means of calcium looping (CaL) technology	
University of Bologna – DICAM	Capture	Membrane/Sorbent	Membrane characterisation	Bench-scale unit for the characterisation of polymeric membranes and solid materials	

COUNTRY	INSTITUTION	CATEGORY		SHORT NAME	LONG NAME
Netherlands 	TNO	Capture	Solvent	Mini Plant	Mini Plant for solvent preparation & testing
		Capture	Solvent	Qscan	QSCAN solvent test street
		Capture	Sorbent	CLC	CLC fixed bed facility
		Capture	Sorbent	High-P abs&des	High pressure absorption and desorption pilot

		Storage	Monitoring	MobSeis	Mobile Seismic Array
		Capture	Environment	ATCM – Aerosol Test and Counter Measure	Aerosol counter measure development facility at lab scale in Delft

COUNTRY	INSTITUTION	CATEGORY		SHORT NAME	LONG NAME
Norway 	NTNU	Capture	Membrane	MEML	Membrane laboratories include: <ul style="list-style-type: none"> MEM-FAB Facilities to fabricate polymer-based membranes MEM-PERM Facilities to test membrane gas permeation performance Extension of polymer membrane lab
		Capture	Solvent Pilot	ABSL	Absorption laboratories include: <ul style="list-style-type: none"> ABSKIN Absorption Kinetic Studies ABSDEG Solvent degradation laboratory ABSEQ Thermodynamic studies package Extension of lab scale absorption equipment Extension of absorption pilot
	SINTEF ENERGY RESEARCH	Capture	Combustion	CLC Hot Rig	Chemical Looping Combustion Rig
		Capture	Combustion	COMBLAB - HIPROX	High pressure Oxy-Fuel Combustion Facility – HIPROX
		Capture	Liquefaction	SEPPIL	Low temperature separation pilot - in test phase: Available for access after summer 2018
		Transport	Therm. Prop	CO2Mix – VLE	Facility for accurate phase equilibrium measurements of CO ₂ -rich mixtures
		Transport	Flow	DEPRESS	Depressurisation facility - in test phase from May: Available for access after summer 2018
		Transport	Therm. Prop	VISC-DENS	Viscosity and density apparatus: Test phase in autumn 2018. In operation late 2018
		Transport	Flow	HP-C-VLE	New facility: High-pressure phase equilibrium measurements
	SINTEF Industry	Capture	Sorbent	SINTEF S/CHLab	Sorbent laboratories SLab for CCS includes: <ul style="list-style-type: none"> High throughput preparation and testing laboratory for materials in CCS related technologies Sorbent based and Chemical looping laboratories Sulphur laboratory for material and component testing Extension of solid sorbent lab CHLab: In situ characterisation of solid materials for CCS
		Capture	Sorbent	SINTEF PPLab	Powder processing laboratories for CCS includes: <ul style="list-style-type: none"> Pellet/particle formulation of solids

		Capture	Membrane	SINTEF Mlab	Membrane laboratories for CCS includes: <ul style="list-style-type: none"> • Ceramic- and metallic based membranes laboratories for H₂, O₂ and CO₂ separation • Sulphur laboratory for material and component testing • Extension of high temperature membrane lab
		Capture	Solvent	SINTEF SDR	Solvent Degradation Rig
		Capture	Solvent	SINTEF Tiller Pilot	Tiller Pilot Plant - Tiller Post Combustion Lab pilot
		Storage	Migration	SVELVIK	New facility: CO ₂ Field Laboratory
		Storage	Migration	SCAL	Core Flood (SCAL) laboratory
		Storage	Reservoir	pVT	Fluid (pVT) laboratory
		Storage	Reservoir	RESLab	SINTEF-NTNU Reservoir laboratory, including μ -CT
		Storage	Well	WILab	SINTEF-NTNU Well Integrity laboratory
		Storage	Reservoir	FPLab	SINTEF Formation Physics laboratory
	IFE	Storage	Reservoir	GeoChem	New facility - Geochemistry Labs at IFE

COUNTRY	INSTITUTION	CATEGORY		SHORT NAME	LONG NAME
UK 	BGS / UKRI	Storage	Flow	TPRL	Transport Properties Research Laboratory
		Storage	Reservoir	RMPL	Rock Mechanics and Physics Laboratory
		Storage	Migration	HTL	Hydrothermal Laboratory
		Storage	Monitoring, Migration/Leakage	Gas Mon	Near surface Gas Monitoring
		Storage	Reservoir, monitoring	Micro Lab	Geomicrobiology Laboratory
	PACT	Capture	Combustion	PACT-PF	25 kW Air-Oxy Combustion Plant
		Capture	Combustion	PACT-ACP	250 kW Air Combustion Plant
		Capture	Combustion Pilot	PACT-OCP	250kW Oxyfuel Combustion Plant
		Capture	Solvent	PACT-GMF	Gas Mixing Facility
		Capture	Combustion	PACT-GT	Gas Turbine
		Capture	Solvent	PACT-SCCP	Solvent-based Carbon Capture Plant

INNOVATION AND INVESTMENTS

PLANS FOR UPGRADED AND NEW CAPTURE FACILITIES	CATEGORY	COMMENT ON COMPLETION / AVAILABILITY
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CP14	SINTEF ER Combustion lab – NO This lab currently consists of facilities COMBLAB (HIPROX) and CLC Hot Rig. One upgrade is being constructed (3 more are planned): <ul style="list-style-type: none"> High Pressure Oxy-Gas turbine facility – NO (SINTEF ER) 	Upgrade	Access in Q3 2019
CP17	Flexible Flue gas source for CO ₂ capture pilot facility in Tiller, (Trondheim) – NO (SINTEF INDUSTRY/NTNU)	Upgrade	Under testing, access Q3 2019
CP18	Lab Scale moving bed temperature swing adsorption in Oslo – NO (SINTEF INDUSTRY)	New	Under testing, access Q4 2019
CP19	Low Temperature membranes for CO ₂ capture in Tiller, (Trondheim) – NO (SINTEF INDUSTRY)	New	
CP20	High temperature membranes for CCS in Oslo – NO (SINTEF INDUSTRY)	Upgrade	Under construction. Access: 01.01.2019
	PACT2: Upgrades and New built facilities for CO ₂ capture research - UK	New	Under construction. Access TBC

PLANS FOR UPGRADED AND NEW TRANSPORT FACILITIES		CATEGORY	COMMENT ON COMPLETION / AVAILABILITY
TP6	SINTEF ER Thermophysical property lab. – NO This lab currently includes CAT1 facilities CO ₂ Mix – VLE and VISC-DENS. There are large synergies in co-locating the different property measurements. 2 new setups are being constructed (4 additional ones are proposed): <ul style="list-style-type: none"> Test rig for solid phase low-temperature equilibria to measure accurate phase equilibria data in the range between -30 and -130 °C in temperature and up to 100 bar in pressure for mixtures relevant for CCS, with capabilities to detect formation of possibly analyse solids and hydrates. Relevant for capture, transport, and injection. Trondheim – NO (SINTEF ER) 	New	Under construction (partially), testing starts 2020
TP5	<ul style="list-style-type: none"> High pressure phase equilibria apparatus: Phase equilibria up to 500-1000 bar in pressure, -60 to 150 °C in temperature, for CCS relevant fluids including electrolytes. In Trondheim – NO (SINTEF ER) 	New	Under construction, access Q2 2020

PLANS FOR UPGRADED AND NEW STORAGE FACILITIES		CATEGORY	COMMENT ON COMPLETION / AVAILABILITY
SP5	AUV-based atmospheric detection of CO ₂ – UK (BGS)	Upgrade	Tested in Lab, undergoing field testing
SP6	Test facilities for developing new subsurface in-reservoir and in-overburden mitigation and remediation technologies to control geologically mediated migration – GeoEnergy Test Bed, UK (BGS)	New	Construction is ongoing, operating from June 2020
SP16	Test tank for CO ₂ monitoring studies (NTNU) – NO	New	Under construction, access Q2 2020
SP17	Well integrity lab facilities (SINTEF Industry) – NO	New	Under construction, access Q4 2019

SP20	CO ₂ Flow labs upgrade (SINTEF Industry, Reservoir Lab) – NO	Upgrade	Under construction, access Q1 2020
SP21	Test tank for trapping mechanisms/fluid flow tank facility (SINTEF Industry) – NO	New	Under construction, access Q4 2019
SP22	Sulcis Fault Lab (SOTACARBO, Carbonia) The facility has been funded by the Regional Government of Sardinia through the “Centre of Excellence on Clean Energy – Phase II” project. – IT	New	The Sulcis Fault Lab for CO ₂ injection tests through a fault will be completed by the end of 2019 and it will be fully operational in 2020
SP23	Multiple percolation cells devices to test triplicates at the same time (BIOREP, BRGM)- FR	Upgrade	Under construction access 01.09.2019

APPENDIX IV

FACILITY OPERATORS/OWNERS

France

BRGM (National Node Coordinator – France)

BRGM, France's leading public institution in the Earth Science field, has three main activities: scientific research, support for government policy, and international cooperation and development assistance.

BRGM has been among the pioneers in research on geological CO₂ storage, participating from 1993 in the first European research project (Joule II) and in the first pilots worldwide (Sleipner, Weyburn, In Salah, Nagaoka, Ketzin, Hontomín, Lacq-Rousse, etc.).

BRGM also carries out research at natural CO₂ fields, such as Montmiral in France, and at natural CO₂ seepage areas in Italy, Germany and France. Its fields of expertise are site selection and characterisation, predictive modelling, risk analysis, monitoring and safety management, thus addressing a wide range of the issues related to CO₂ geological storage.

BRGM also performs some research on CO₂ capture and on CO₂ use.

BRGM is the coordinator of the French node of ECCSEL ERIC, composed of 4 research institutes (BRGM, IFPEN, INERIS, Andra) and two industrial companies (EDF, TOTAL), as well as of the H2020 STRATEGY CCUS project starting in April 2019, the H2020 ENOS ongoing project, and the completed FP7 ULTimateCO2 and CGS Europe projects. BRGM is a founding member of the CO₂GeoNet European Network of Excellence on the geological storage of CO₂, initiated in 2004 through an EC FP6 contract, now a legally registered Association under French law with statutory seat in BRGM offices. BRGM is President of the national Club CO2 and is deeply involved in CCS international initiatives such as ZEP, EERA CCS, CSLF, IEAGHG.



Andra

The French national radioactive waste management agency (Andra) is responsible of the long-term

management of radioactive waste produced in France. As part of this mission, Andra puts its expertise and know-how at the service of the State to: find, implement and guarantee safe management solutions for all French radioactive waste in order to protect present and future generations of the risk of this waste. Created in 1979, Andra became a public industrial and commercial establishment by the law of December 30, 1991 whose missions were supplemented by the law of June 28, 2006 relating to the sustainable management of radioactive materials and waste. It is placed under the supervision of the ministers in charge of energy, research and the environment respectively.



EDF

As a global leader in low-carbon energy, the EDF Group covers every sector of expertise, from generation to trading and transmission grids. EDF builds on the expertise of its people, its R&D and engineering skills, its experience as a leading industry operator and the attentive support of its customers to deliver competitive solutions that successfully reconcile economic growth with climate protection.



IFPEN

IFP Energies nouvelles (IFPEN) is a major research and training player in the fields of energy, transport and the environment.

From research to industry, technological innovation is central to all its activities, structured around three strategic priorities: sustainable mobility, new energies and responsible oil and gas.

Mission: As part of the public-interest mission with which it has been tasked by the public authorities, IFPEN focuses on:

- providing solutions to take up the challenges facing society in terms of energy and the climate, promoting the transition towards sustainable mobility and the emergence of a more diversified energy mix;
- creating wealth and jobs by supporting French and European economic activity, and the competitiveness of related industrial sectors.

An integral part of IFPEN, its graduate engineering school – IFP School – prepares future generations to take up these challenges.



INERIS

Established by the French Government in 1990 as the national competence centre for Industrial Safety and Environmental Protection, Ineris has developed expertise in the areas of accidental risks, chronic risks, and ground and underground risks. Ineris is the result of a restructuration of the Centre of Studies and Research of Collieries of France (Cerchar) and the Institute of Applied Chemical Research (Ircha), the Institute capitalises upon nearly 70 years of expertise and know-how. Thus, Ineris has an acknowledged know-how in the fields of mines, energy and chemistry.

Research activities support public policy and services supporting businesses contribute to the evaluation and prevention of the risks that economic activities induce for the environment, health and safety of people and goods. The Institute also accompanies innovation by taking into account upstream the risks generated by new products, new technologies or processes. For instance, Ineris has been involved for many years in CCS research projects funded by France or Europe.

Our 24-hour a day operational services such as the Emergency situations support unit (CASU), PRév'air (forecasting pollution at a national scale) and Cenaris (National Monitoring Centre for Ground and Underground risks) illustrate the very operational nature of the Institute's expertise.



Italy

OGS (National Node Coordinator - Italy)

OGS, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (National Institute of Oceanography and Applied Geophysics) is an internationally oriented public research institute. It operates in the European Research Area (ERA) and internationally and develops its own mission prioritising basic and applied research fields of oceanography (physical, chemical and biological aspects), geophysics and marine geology, seismology and experimental and explorative geophysics.

OGS owns important multidisciplinary research facilities, such as ECCSEL NatLab-Italy natural laboratories of Panarea and Latera, the oceanic research vessel OGS Explora, the borehole geophysical test site (PITOP), an aircraft equipped for remote sensing, a calibration centre for marine instruments (CTMO) and a centre for processing and archiving large geophysical data sets.

All these facilities are widely used to boost cooperation and mobility of people and ideas and bring together the best European and worldwide scientists to strengthen their skills, enhance their career development and create a network of potential future leaders.

Most of these facilities are part of ECCSEL ERIC, which OGS has helped implement since its conception. OGS has been one of the project partners in the two Preparatory Phases and in the Implementation Phase and it is now the Italian representing in ECCSEL ERIC. OGS has also a strong expertise in CCS; since 2004, it has taken a leading role (as a WP leader) in 13 CCS-related EU projects and it has been the coordinator of 15 national projects.

The Institute works for environmental protection, sustainable economic development and societal inclusion through tailor-made initiatives to evaluate and prevent geological, environmental and climatic risks, with the aim of spreading scientific culture and knowledge, building capacities and transferring knowledge.

All these efforts are also made in collaboration with European and international institutions, with private high-tech industries and qualified enterprises, aimed at developing innovative capacity building activities to attract both industrial stakeholders and the research community.



ISTITUTO NAZIONALE
DI OCEANOGRAFIA E DI GEOFISICA SPERIMENTALE

Sotacarbo is a research and development company (shareholders: Enea – the Italian National Agency for New Technologies, Energy and Sustainable Economic Development – and Sardinian Regional Administration) on clean energy and carbon capture, utilisation and storage (CCS).

Recently, Sotacarbo has been designed by the Sardinian Regional Government as the regional and national reference on the development of technologies for the sustainable use of fossil fuels (coal in particular) and clean energy (including carbon capture and storage), with the aim to collect knowledge and research facilities to support and boost Italy's energy policy. The activities programme of the technological pillar includes theoretical and experimental studies on zero emissions technologies for power generation, production of energy carriers from coal, biomass and CO₂, pre-, post- and oxy-combustion for CCS. Since 1988, Sotacarbo represents Italy in the International Energy Agency – Clean Coal Centre.



Sotacarbo

ENEA

ENEA is the National Agency for New Technologies, Energy and Sustainable Economic Development, a public body aimed at research, technological innovation and the provision of advanced services to enterprises, public administration and citizens in the sectors of energy, the environment and sustainable economic development.

ENEA has highly qualified personnel, advanced laboratories, experimental facilities and excellent instruments for the realisation of projects, studies, tests, assessments, analyses and training services, with particular reference to product and process innovation and the valorisation of results to contribute to the development and competitiveness of the national economic system.

Its focus sectors are energy technologies (renewable sources, energy storage, smart grids), for which the Agency is also the coordinator of the Energy National Technology Cluster, nuclear fusion and nuclear safety (the Agency is the reference national research coordinator), energy efficiency (with the National Agency for Energy Efficiency), technologies for cultural heritage, seismic protection, food safety, pollution, life sciences, strategic raw materials, climate change.



UNIBO - DICAM

The Department of Civil, Chemical, Environmental and Materials Engineering (DICAM) is the result of a large aggregation of research skills and laboratory facilities of diverse but interrelated engineering branches traditionally developed at the University of Bologna. The department integrates the scientific expertise of various research groups, such as Structural, Transport, Hydraulic, Survey and Territory Engineering, Applied Chemistry and Materials Science, Chemical, Mining, Petroleum and Environmental Engineering. The mission of the Department is to create and develop advanced research in the areas of civil, chemical, environmental and materials engineering, starting from evaluation, design, construction and service of manmade structures and infrastructures

(including industrial production facilities), through the study and characterisation of the constituent materials, up to the environmental analysis and impact assessment of the footprint on the territory and the environment.

The high quality, interdisciplinary nature and collaborative work of the research groups enable the Department to provide, worldwide, an effective answer to the demands of today's modern society and of professional world. The Department faces many challenges for its future. Continuing its quest for excellence, with real impact in science and technology, is a clear goal.



The Netherlands

TNO (National Node Coordinator - the Netherlands)

TNO (Netherlands Organisation for Applied Scientific Research) is an independent research organisation whose expertise and research make an important contribution to the competitiveness of companies and organisations, to the economy and to the quality of society as a whole.

TNO's unique position is attributable to its versatility and capacity to integrate this knowledge. In April 2018, TNO merged with ECN in the Netherlands. This will strengthen the position of TNO in the international CCUS community.

TNO is one of the major contract research organisations in Europe. With a staff of approximately 4,000 and an annual turnover of 600 million Euros, TNO carries out research to achieve impact on the following seven themes: Healthy Living, Industrial Innovation, Mobility, Energy, Built Environment, Information Society, and Defence, Safety and Security.

TNO functions as an intermediary between basic research organisations and industry. By translating scientific knowledge into practical applications, TNO

contributes to the innovation capacity of businesses and government. TNO is involved in many international projects (about 30% of the market turnover), including EU-funded collaborations.

Since the early 1990s TNO has been a partner in many international research programs, global research networks and business-to-business consultancy on CO2 capture from flue gases and CO2 storage in hydrocarbon reservoirs, coal beds and aquifers. The Oil & Gas and Geo-energy departments are actively involved in all areas to support innovation processes to increase the energy efficiency of industrial processes, to reduce CO2 emissions, to innovate the process of oil and gas production and to reduce the costs to produce renewable energy. As such, TNO is the leading research institute in the Netherlands on Carbon Capture and Storage, providing state-of-the-art knowledge on the entire chain of CO2 capture, transport and storage. TNO has been active in many relevant projects on CCS as leader or major partner. Projects with a strong TNO involvement are: CESAR, OCTAVIUS, iCAP, CAPRICE, ECCSEL, Hipercap, CO2Europipe, CO2ReMoVe, CEMCAP, projects for IEA GHG, and multiple project in the 2016 ERANET ACT call. TNO is coordinator of the largest project in that program (ALIGN CCUS)

TNO is organised around five focus areas. The focus area Energy has been involved in CCS for nearly 20 years and has become a world leader in CO2 capture and underground CO2 storage. Other CCS-related expertise is in clean combustion technologies, materials studies for transport, decision support systems, HSE studies, and monitoring of the climate effect of energy transition by means of in-situ and remote earth observation techniques.

The Geological Survey of The Netherlands, part of TNO Geo Energy, is involved in the pre-qualification study of some 12 CCS pilot plants both on- and off-shore The Netherlands, in aquifers and depleted oil and gas fields.



Norway

NTNU (National Node Coordinator - Norway)

NTNU (The Norwegian University of Science and Technology) is a fully integrated university with emphasis on technology and engineering. It is the main technical university in Norway with over 80% of its Master- and PhD-degrees awarded in science and technology.

Over the last 30 years NTNU and the research institute SINTEF have jointly developed a research area covering 10,000 square metres hosting a € 50M research facility, where 750 people work on mitigating emissions like CO₂, NO_x, SO_x and other greenhouse gases. This includes removing such emissions from oil and gas production processes and from use in industry, buildings and transport. A secondary research line has been to crosslink this research with the development of new clean renewable energy technologies.

NTNU is involved in a series of national projects (BIGCO₂, BIGH₂, BIGCLC, BIGCCS) and EU projects (ENCAP, DYNAMIS, DECARBit, iCap). NTNU has been the coordinator of the ECCSEL initiative since it first appeared on the official ESFRI Roadmap in 2008 until 2017 when ECCSEL ERIC was established as a legal entity.



SINTEF Energy Research

SINTEF Energy Research (SINTEF ER) is an independent Norwegian research institute affiliated under the SINTEF Foundation. Its main office and activities are located in Trondheim, Norway, sharing facilities with the Norwegian University of Science and Technology (NTNU). SINTEF ER has a staff of 244, including more than 190 research scientists. SINTEF ER had an annual turnover of NOK 466 million in 2017.

SINTEF ER covers a full range of energy technologies, both renewable and Oil & Gas as well as related fields (e.g. energy economy and policy). SINTEF ER has been involved in projects related to CCS technologies since 2001, and that it has been the coordinator of several large integrated projects in the field of CCS

under the European Framework Programmes (FP4 – FP7) and in H2020. As a major European player on the scene, SINTEF also contributes to actively influence the European R&I agenda, in coordination with Norwegian authorities and industry raising the voice on behalf of Norway in dialogues with the European Commission and other stakeholders.

SINTEF ER has extensive experience from Norwegian and EU CCS projects in FP7 and H2020 projects (ECCSEL Infradev-3, CEMCAP, CHEERS, GATEWAY, ENCAP, Dynamis, DECARBit, ECCO, IMPACTS) as well as the ERANET ACT project ELEGANCY. Most of these projects were coordinated by SINTEF ER. In addition, the research institute has its competence built up over many years in the International CCS Research Centre BIGCCS and the Norwegian CCS Research Centre, NCCS – both hosted by SINTEF ER and being major research efforts on CCS. Through NCCS, SINTEF ER also hosts the Trondheim CCS conferences, which are one of the most important international meeting places within CCS. The research institute has a leading role in Zero Emission Platform (ZEP) and the European Energy Research Alliance' Joint Programme on CCS (EERA JP CCS). SINTEF's Director of Sustainability Nils Røkke is the Chairman of EERA. Within CCS, SINTEF ER has particular focus on CO₂ transport, transient and interfacial phenomena between, liquefaction and low-temperature separation technologies, CLC capture, high pressure combustion / oxyfuel technologies, and value chain / techno-economic analysis.

The mission of SINTEF Energy Research is to “shape tomorrow's energy solutions”.



SINTEF Industry

The research institutes SINTEF Materials and Chemistry and SINTEF Petroleum Research merged on 1st January 2018. The new institute is called SINTEF Industry. SINTEF Industry has around 460 employees, with about 90% being scientists and technicians. The Industry division has extensive activities in the fields CO₂ capture, transport and

storage, and experience from several national and European R&D programs within FP5-7 and H2020 as coordinator and core partner.

SINTEF Industry performs contract research and delivers solutions and services that create value for customers. With their cross-disciplinary knowledge base and advanced laboratories as a base, SINTEF Industry develops – in close collaboration with their customers – technology and solutions within a broad range of research areas and industries:

- Advanced materials
- Oil and gas
- Applied chemistry and biology
- Process industry
- Renewable energy
- Sustainable transport
- Metallurgy
- Manufacturing
- Biotechnology and nanotechnology
- Marine resources and technology

Sustainable development and value creation is fundamental to all their activities.

Tel-Tek Foundation in Porsgrunn merged into SINTEF as a research group in SINTEF Industry. Through this merger, SINTEF is brought even closer to industry in the region, and brings valuable cutting-edge expertise in powder technology, CO₂ capture and storage, early-stage cost estimation and biogas.

SINTEF Industry is part of the SINTEF Group, one of the largest research groups in Europe. SINTEF has more than 1200 employees with international top-level expertise in science and technology and an annual turnover of NOK 1600M (~ € 200M) originating from industrial research contracts as well as European and National research projects. SINTEF is an independent and non-commercial corporation. Any profit from their contract research is invested in new research, scientific equipment and competence.



Institute for Energy Technology (IFE)

The Institute for Energy Technology (IFE) is an independent foundation and one of the world's foremost research communities on energy, located in

Halden and Kjeller in Norway. IFE has developed unique skills over 70 years with world-leading researchers and outstanding international projects in their reactors and laboratories.

Their research reactors have led to better nuclear safety in neighbouring countries and around the world, and are also key in leading research on energy and materials in Norway. IFE looks into materials in new ways. They develop and produce cancer medicine. IFE is also far ahead in the pursuit of next-generation battery technology and contributes to better solar, wind and hydrogen solutions. Offshore, IFE has developed low-emission petroleum technology and advanced digital solutions for management, security and communication.

The knowledge, innovation and development at IFE has created hundreds of billion NOK in values for Norway and improved safety, environment and climate both at home and abroad.

When the next chapter in Norway's story is to be written, it will be about how we convert. It has always been the great strength of IFE. IFE will continue to bridge the gap between research, education and industrial enterprises. It will continue to research – for a sustainable future.

IFE's main tasks:

- Develop profitable, safe and environmentally friendly technologies in renewable energy, petroleum extraction and CO₂ handling (CCS)
- Maintain and further develop national nuclear expertise based on the Halden and JEEP II reactors.
- Basic science in physics based on the JEEP II reactor at Kjeller.
- Safeguard and further develop the production of ground-breaking cancer medicine and other nuclear medicine.
- Offer IFE's unique expertise in VR, AR, digitalisation and nuclear safety technology to other industries and government agencies.



UK

BGS (National Node Coordinator - UK)

The British Geological Survey is a component organisation of the United Kingdom of Research and Innovation (UKRI). The British Geological Survey (BGS) was founded in 1835 and is the world's longest established national geological survey. BGS seeks to advance the understanding of the structure, properties and processes of the solid Earth system through interdisciplinary surveys, monitoring and research for the benefit of society.

BGS is a public-sector organisation responsible for advising the UK government on all aspects of geosciences, as well as providing impartial geological advice to industry, academia and the public. It is the UK's premier provider of objective and authoritative geoscientific data, information and knowledge for sustainable use of natural resources, reducing risk and living with the impacts of environmental change.

BGS is a leading research organisation in the field of geological CO₂ storage. They have a leading research role in a number of major EU/industry and government funded projects. In the last two years BGS have carried out more than forty (40) CO₂ storage projects for the EU, industry and the UK and overseas governments, with an annual CCS budget of over £1M. Recent projects include Weyburn project; Nascent project; CO₂ReMoVe project; monitoring programmes, European storage sites; site monitoring tool, IEAGHG; review of monitoring technologies for CO₂ storage, UK government; reviews of Otway Basin and Gorgon CO₂ storage projects, Australia; Lead Author IPCC Special Report on CO₂ Capture and Guidelines for Compiling National Greenhouse Gas Inventories.

BGS has been the technical advisor for storage for the UK Government, for a full-chain, full-size CCS demonstration project. BGS has led assessments of storage capacities and capability building for the UK Near Zero Emissions China project and has also been involved in the FP6 COACH project. BGS was the coordinator of the FP7 RISCs project; has undertaken geological interpretation and modelling of onshore and offshore UK storage sites for the CASSEM project;

drilling advice and expertise for the QICS controlled subsea release of CO₂, participant in the UK Storage Capacity Appraisal project and technical lead for the CO₂stored online database, and leader and contributor to two CCS research studies of the opportunities and development of CCS offshore Scotland funded by Scottish Government and industry consortiums and led characterisation and dry-run licence application for an offshore multi-store site for the FP7 SiteChar project.



PACT

PACT is a collaborative activity between the Universities of: Cranfield, Edinburgh, Imperial College, Leeds, Nottingham and Sheffield. It forms part of the UK Carbon Capture & Storage Research Centre (UKCCSRC) (www.ukccsrc.ac.uk) jointly funded by the Department of Energy and Climate Change (DECC) and the Engineering and Physical Sciences Research Council (EPSRC).

The University of Sheffield has a global reputation for pioneering high impact research and is ranked as a world top-100 university with 86% of its research considered as internationally recognised or World leading. Its Engineering departments are ranked in the top five in the UK for the impact and quality of research.

The University of Sheffield is a founder member of the UK CCS Research Centre and manages and operates the UK national CCS test facilities: PACT. The PACT facilities are internationally renowned specialist facilities for R&D in bioenergy, advanced fossil-fuel energy, and carbon capture and storage/utilisation technologies for power generation and industrial applications.

Established in 2012 with funding from UK Department for Business, Energy & Industrial Strategy and the

Engineering and Physical Sciences Research Council, PACT has a range of integrated pilot-scale test rigs including: gas/biogas turbine CHP units, pulverised coal/biomass air/oxyfuel combustion rig, biomass grate boiler and synthetic gas mixing facility for modulated/synthetic flue/process gasses; all integrated with 1 tonne a day amine-based post combustion plant; and state of the art online and lab-based analytical facilities; and supporting system and process modelling capability.

The facilities provide a platform for cutting-edge integrated systems R&D, technical feasibility studies and the testing of design concepts for scale-up to enable and catalyse technology development and commercialisation. PACT works with a wide range of stakeholders in the UK and around the world including research organisations, universities, SMEs and large national and multinational companies. It is involved in national and international R&D and training projects with total projects value in excess of over £40m.

PACT is internationally recognised for its work in carbon capture and energy technologies as reflected by its UK-representative membership of ECCSEL and the International CCS Test Centre Network, and the operational management and research service provision for the International Flame Research Foundation with prestigious global membership some 130 organisations representing the power generation, petroleum refining, iron and steel, cement, glass, and chemical manufacturing industries as well as combustion equipment manufacturers, fuels producers and distributors, research institutes, universities, trade associations, and energy policy makers. The University of Sheffield additionally hosts the UK Centre for Carbon Dioxide Utilisation (CDU) and manages CO₂Chem – the world's largest networking and research community for academics and industrialists interested in CO₂ conversion. It is also a partner in the national PhD training centre (Centre for Doctoral Training) for CCS and bioenergy, providing regular training for PhD students and UKCCSRC applicants.

PACT

APPENDIX V PUBLICATIONS AND EVENTS

Below is a selection of publications and events. More extensive information can be found on the ECCSEL website.

Presentations at conferences:

Isabelle Czernichowski-Lauriol, Robert de Kler, Sébastien Dupraz, Morten Grønli, Sverre Quale, Volker Röhling, Helen Taylor, Peter van Os, Michela Vellico. **“Access through ECCSEL ERIC to a world-class research infrastructure in Europe for developing CCS technologies”**. Applied Energy Symposium and Forum, Carbon Capture, Utilisation and Storage, CCUS 2018, 27–29 June 2018, Perth, Australia (presentation given by Isabelle Czernichowski-Lauriol).

Helen Taylor, Michela Vellico, Ceri Vincent, Isabelle Czernichowski-Lauriol, Keith Bateman, Robert de Kler, Cinzia De Vittor, Sébastien Dupraz, Jonathan Pearce, Sverre Quale, Volker Röhling. **“The European CCS research laboratory infrastructure (ECCSEL) and its contribution to future geological CO₂ storage in Europe”**. 5th CO₂ Geological Storage Workshop; Utrecht; Netherlands; 21 - 23 November 2018.

Fabio Moia, Francesca Colucci, Alberto Plaisant, Arianna Maiu, Alberto Pettinau, Silvana Fais. **“Geological and numerical fluid dynamic modelling of Sulcis basin in Sardinia for CO₂ geological storage”**. Proceedings of the SGI-SIMP Conference, Catania, Italy, September 12-14, 2018.

“International overview of CO₂ Utilisation” Symposium, Paris, 2 July 2018: poster presentation
Czernichowski-Lauriol I., Czop V., Dupraz S., Gombert P., Lafortune S., Marblé A., Delprat-Jannaud F., Rouchon V., Huret E. - **CCS research facilities in France available for access by the global scientific community through ECCSEL ERIC.**

“Green & Blue Hydrogen for the Clean Energy Transition”

Joint SCCS-SHFCA seminar. Tues 27th Nov 2018, at ECCI Edinburgh. Oral presentation: **Microbial activity with hydrogen storage**. Sébastien Dupraz, BRGM.

JOURNEE « 20 ANS DU PARTENARIAT ANDRA/BRGM » (‘20 years of Andra/BRGM partnership’ Event, 12 November 2018 in Antony: oral presentation by Isabelle Czernichowski-Lauriol. **“ECCSEL, l’Infrastructure de Recherche européenne sur le Captage et Stockage de CO₂”**

Business Congress « Les rendez-vous Carnot », 17 and 18 October 2018, Lyon. **ECCSEL Stand**. Isabelle Czernichowski-Lauriol, Sébastien Dupraz (BRGM) and Valérie CZOP (EDF).

Helen Taylor. **“ECCSEL – phase II and phase III: research platforms to support CCS roll-out in Europe”**. CO₂GeoNet Open Forum Growing CCS for a sustainable future, San Servolo, Italy, 24-25 April 2018

Helen Taylor, David I Schofield, Jonathan M Pearce, Ceri Vincent. **“EPOS and ECCSEL: Geoenergy Test Beds in European Distributed Research Infrastructures”**. Resources for Future Generations, Vancouver, Canada, 16-21 June 2018.

Helen Taylor, Michela Vellico, Ceri Vincent, Isabelle Czernichowski-Lauriol, Keith Bateman, Robert de Kler, Cinzia De Vittor, Sébastien Dupraz, Jonathan Pearce, Sverre Quale, Volker Röhling. **“The European CCS research laboratory infrastructure (ECCSEL) and its contribution to future geological CO₂ storage in Europe”**. 5th CO₂ Geological Storage Workshop; Utrecht; Netherlands; 21 - 23 November 2018.

Posters at conferences:

Thomas Le Guenan, Isaline Gravaud, Juan Carlos de Dios, Lionel Loubeau Gavilanes, Flavio Poletto, Sonsoles Eguillor, Antonio Hurtado, **“Determining Performance Indicators for Linking Monitoring Results and Risk**

Assessment – Application to the CO₂ Storage Pilot of Hontomin, Spain". Proceedings of the 14th International Conference on Greenhouse Gas Control Technologies – GHGT-14, Melbourne, Victoria (Australia), October 21-26, 2018.

Mauro Mureddu, Elisabetta Rombi, Luciano Atzori, Francesca Ferrara, Alberto Pettinau. **"Preparation of different copper and zinc oxide-based nanocatalysts and their application in CO₂ hydrogenation to methanol"**. Proceedings of the 9th International Freiberg Conference on IGCC & Xtl Technologies, Berlin, Germany, 3-8 June 2018. Award for the Outstanding poster – 3rd place.

Simonetta Palmas, Laura Mais, Michele Mascia, Annalisa Vacca, Simona Corgiolu, Francesca Ferrara, Alberto Pettinau. **"On the electrochemical reduction of CO₂ at boron doped diamond electrodes in aqueous media"**. Proceedings of the 3rd E3 Mediterranean Symposium: Electrochemistry for Environment and Energy, Madrid, Spain, 2-5 July 2018.

Mauro Mureddu, Elisabetta Rombi, Luciano Atzori, Francesca Ferrara, Alberto Pettinau. **"Advanced catalysts for methanol production from CO₂ and renewable hydrogen"**. Proceedings of the 16th International Conference on Carbon Dioxide Utilization (ICCDU XVI), Rio de Janeiro, Brazil, 27-30 August 2018.

Francesca Ferrara, Mauro Mureddu, Alberto Pettinau. **"Catalytic hydrogenation of CO₂ to dimethyl ether: Project description and preliminary experimental results"**. Proceedings of the 16th International Conference on Carbon Dioxide Utilisation (ICCDU XVI), Rio de Janeiro, Brazil, 27-30 August 2018.

Maria Chiara Tartarello, Sabina Bigi, Francesca Colucci, Dario Civile, Michela Giustiniani, Flavio Accaino, Fabio Moia, Alberto Plaisant, Silvana Fais, Enrico Maggio, Alberto Pettinau, A. Conti, Livio Ruggiero. **"Characterisation of fractured rocks for the design of a pilot-scale CO₂ injection site in the Sulcis Basin, Italy"**. Proceedings of the 14th International Conference on Greenhouse Gas Control Technologies – GHGT-14, Melbourne, Victoria (Australia), October 21-26, 2018.

Alberto Plaisant, Sabina Bigi, Antonio Conte, Salvatore Lombardi, Enrico Maggio, Diana Multineddu, Alberto Pettinau. **"The Sotacarbo Fault Lab (Italy) for experimental studies on CO₂ migration through a fault"**. Proceedings of the 14th International Conference on Greenhouse Gas Control Technologies – GHGT-14, Melbourne, Victoria (Australia), October 21-26, 2018.

13th CO₂GeoNet Open Forum, 24-25 April 2018: poster presentation

Czernichowski-Lauriol I., Czop V., Dupraz S., Gombert P., Marblé A., Delprat-Jannaud F., Rouchon V., Huret E. - **CCS research facilities in France available for access by the global scientific community through ECCSEL ERIC.**

Applied Energy Symposium and Forum, Carbon Capture, Utilization and Storage, CCUS 2018, 27–29 June 2018, Perth, Australia: poster presentation and extended abstract

Czernichowski-Lauriol I., de Kler R, Dupraz S., Grønlic M., Quale S., Röhling V., Taylor H., van Os P., Vellico M. - **Access through ECCSEL ERIC to a world-class research infrastructure in Europe for developing CCS technologies.**

Invited lecturers:

Alberto Pettinau. **"The Italian centre of excellence on low carbon emissions"**. Proceedings of the 9th International Environment Forum for CCS, Seoul, South Korea, November 6, 2018.

Alberto Pettinau. **"Carbon capture, utilisation and storage for low CO₂ energy conversion"**. Invited lecture at the Korea University, November 8, 2018.

Other:

Sabina Bigi. **“Scientific diving training for underwater monitoring”**. CO₂ GeoNet Highlights, 15, October 2018.

Events:

- Capture Workshop – Amsterdam, 13 November 2018
- GHGT – Melbourne, Australia
- 1st ENOS Spring School on CO₂ Geological Storage – Latera, OGS ECCSEL NatLab Italy laboratory, 14 – 19 May 2018
- Presentation of the new Excellence Centre on Clean Energy: results and perspective - Carbonia, Sotacarbo Research Center, 10 April 2018. This event was focussed on the presentation of the new centre, lead by Sotacarbo and included a talk about the Italian National Node and its activities
- 1st summer school on "Methodology utilised to sample and monitor the marine coastal ecosystem" - Panarea, OGS ECCSEL NatLab Italy laboratory, 9 – 14 June 2018
- CCS Summer School 2018 - Carbonia, Sotacarbo Research Center, 18 - 22 June 2018
- 1st meeting of the National Coordination Group on CCUS – Rome, 5 July 2018
- 3rd Diving Scientific Summer School – Panarea, OGS ECCSEL NatLab Italy laboratory, 19 – 27 September 2018
- Seminar cycle on climate changes devoted to Sulcis local population, organised by Sotacarbo

Publications:

Massimiliano Molari, Katja Guilini, Christian Lott, Miriam Weber, Dirk de Beer, Stefanie Meyer, Alban Ramette, Gunter Wegener, Frank Wenzhöfer, Daniel Martin, Tamara Cibic, Cinzia De Vittor, Ann Vanreusel, Antje Boetius. **“CO₂ leakage alters biogeochemical and ecological functions of submarine sands”**. Science Advances 2018; 4: eaao2040, February 2018. DOI: 10.1126/sciadv.aao2040.

Giorgio Cau, Vittorio Tola, Francesca Ferrara, Andrea Porcu, Alberto Pettinau. **“CO₂-free coal-fired power generation by partial oxy-fuel and post-combustion CO₂ capture: techno-economic analysis”**. Fuel 2018;214:423-435.

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APPENDIX VI

Acronyms and Abbreviations

CCS:	Carbon (Dioxide) Capture, Transport and Storage
ECCSEL:	European Carbon Dioxide Capture and Storage Laboratory Infrastructure
EEAB:	Ethics and Environmental Advisory Board
ERIC:	European Research Infrastructure Consortium
ESFRI:	European Strategy Forum for Research Infrastructures
GA:	General Assembly
IAG:	Industry Advisory Group
Node:	ECCSEL ERIC country node responsible for coordinating activities on country level
OC:	ECCSEL Operations Centre
RI:	Research Infrastructure
RICC:	ECCSEL Research Infrastructure Coordination Committee
SAB:	Scientific Advisory Board

APPENDIX VII
RESEARCH
INFRASTRUCTURE

ECCSEL

ERIC



ECCSEL European Research Infrastructure Consortium (ERIC), was approved by the European Commission in June 2017 (Commission implementing decision (EU) 2017/996 of 9. June 2017)

ECCSEL ERIC is registered in Norway in the Company Registry with the organisation number 919298243