



Research efforts across Europe to develop CCUS technology to mitigate climate change

Isabelle Czernichowski-Lauriol

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Bergen CCUS Seminar, 'CCUS and the Net-Zero Society', Bergen, Norway, 3-4 December 2019

EFFORTS ACROSS EUROPE TO DEVELOP CCUS TECHNOLOGY TO MITIGATE CLIMATE CHANGE

Dr. Isabelle Czernichowski-Lauriol, BRGM - French Geological Survey, Orléans, France

Research and Public Policy Chief Officer

CO₂GeoNet President Emeritus

ECCSEL French node Coordinator

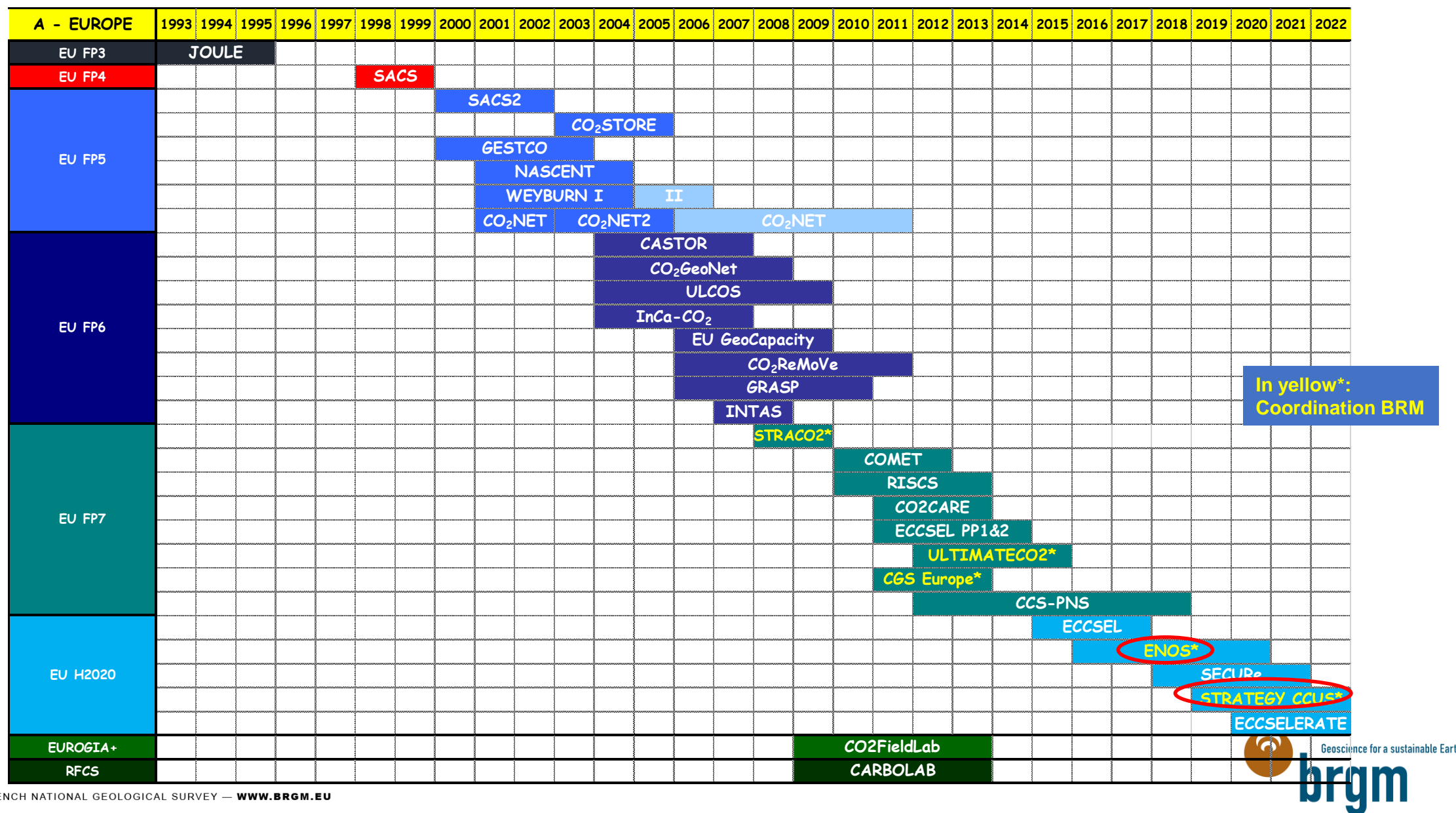
Email: i.czernichowski@brgm.fr



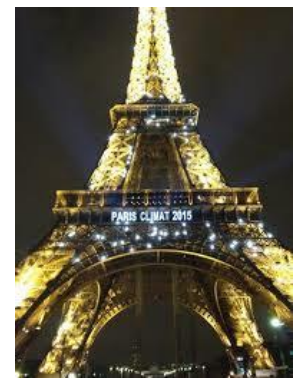
Geoscience for a sustainable Earth

brgm

BRGM in European research projects: since the very beginning...




The Paris climate agreement



- Limiting global warming to **well below 2° C** with ambition to limit to **1.5° C** (Article 2)
- ...achieve a balance between anthropogenic emissions by sources and removals by **sinks** of greenhouse gases in the second half of this century (Article 4)
- Communicate nationally determined contributions (NDC) every five years. Recognize and implement mitigation actions with respect to anthropogenic emissions and removals (Article 4)
- Strengthen **cooperative action on technology development and transfer** for the implementation of mitigation and adaptation actions (Article 10)
- Capacity-building should enhance the capacity and ability of developing countries to implement adaptation and mitigation actions, and should facilitate **technology** development, dissemination and deployment (Article 11)

All this calls for stronger efforts in technology development, transfer and capacity-building

EUROPEAN ENERGY UNION AND STRATEGIC ENERGY TECHNOLOGY PLAN (SET-PLAN)

Energy Union <i>Research, Innovation and Competitiveness Priorities</i>		2015	SET-Plan 10 Key Actions
No1 in Renewables		1 Performant renewable technologies integrated in the system 2 Reduce costs of technologies	
Consumers in the Energy System		3 New technologies & services for consumers 4 Resilience & security of energy system	
Efficient Energy Systems		5 New materials & technologies for buildings 6 Energy efficiency for industry	
Sustainable Transport		7 Competitive in global battery sector and e-mobility 8 Renewable fuels and bioenergy	
Carbon Capture Utilisation and Storage		9 Carbon Capture Storage / Use	
Nuclear Safety		10 Nuclear safety	

- **Implementation plans for each Key Action agreed in 2017:**
 - Research & Innovation Activities
 - Flagship project
 - Monitoring mechanisms
 - Pathways to 2020, 2030 and beyond

CCS and CCU Implementation Plan



[SET-Plan ACTION n°9 - Implementation Plan – 21 09 2017](#)

SET-PLAN TWG9 CCS and CCU Implementation Plan

SET-PLAN TARGETS FOR CCS AND CCU BY 2020

1. At least 1 whole chain **Power CCS operating project**
2. At least 1 FEED on **Industrial CCS project**
3. **Feasibility studies for CCS on industrial clusters completed by SET Plan countries** (at least 5 clusters in different regions of the EU)
4. At least 1 active EU Project of Common Interest (PCI) for **CO₂ transport infrastructure**, for example related to storage in the North Sea
5. **A European CO₂ geological storage atlas**
6. At least 3 new **CO₂ capture pilots**, including bio-CCS
7. At least 3 new **CO₂ storage pilots**
8. At least 3 new **CO₂ utilisation pilots**
9. Setup of 1 Important Project of Common European Interest (IPCEI) for demonstration of different aspects of **industrial CCU**, possibly in the form of **Industrial Symbiosis**
10. Member States having identified, if applicable, **the need to apply CCS** to fossil fuel power plants and/or energy and carbon intensive industries **in their integrated national energy and climate plans for after 2020**, in order to make their energy systems compatible with the 2050 long-term emission targets

EXTRACTS FROM FRANCE'S NATIONAL LOW-CARBON STRATEGY

(DRAFT, DECEMBER 2018)

Revised National Low-Carbon Strategy to reach « carbon neutrality »

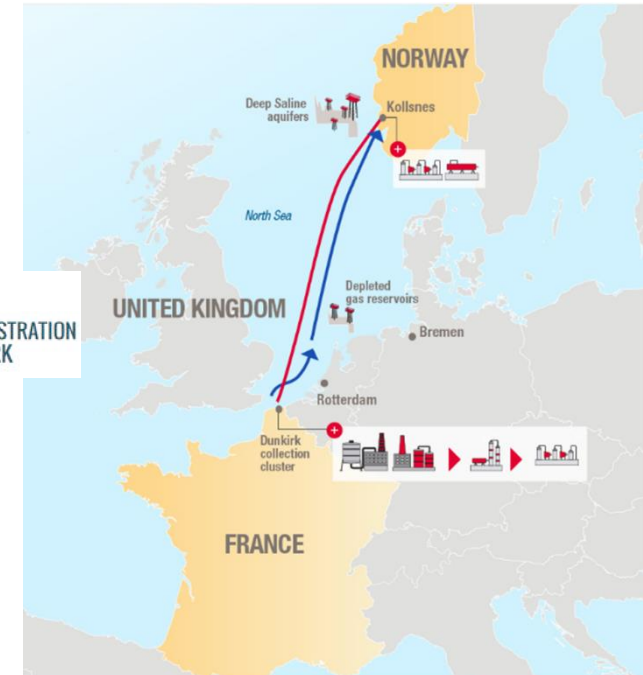
- By 2050, a certain level of emissions seems incompressible, particularly in the non-energy sectors (agriculture in particular).
- These emissions must be offset by **carbon sinks**:
 - Optimized and sustainable land sink (forest and agricultural land)
 - **CCS**
- **CCS** technologies are conservatively mobilized in the baseline scenario:
 - **By 2050**, they would avoid about **6 MtCO₂/year in industry** and produce about **ten MtCO₂ of negative emissions annually** from biomass energy production facilities (BECCS).
- Guideline I 2: Initiate today the development and adoption of **disruptive technologies** to reduce and if possible eliminate residual emissions:
 - including « **Support the development of pilot and possibly commercial units in carbon capture and storage (CCS) and carbon capture and use (CCU) with the use of CO₂ as a raw material in the manufacture of fuels or chemicals.** »

Current remarkable research projects coordinated by France

European H2020 projects



- **ENOS** (coord. BRGM) to enable CO₂ storage onshore in Europe
- **CHEERS** (coord. IFPEN) to test, through a pilot in China, CO₂ capture by chemical looping
- **3D** (coord. IFPEN) to demonstrate a demixing solvent for CO₂ capture at the ArcelorMittal steelworks site in Dunkirk
- **STRATEGY CCUS** (coord. BRGM) to elaborate strategic plans for CCUS development within promising start-up regions in Southern and Eastern Europe



Regional projects (funded by Centre-Val de Loire region)



- **GEOCO2** (coord. BRGM) – Potential in the region of the CO₂-Dissolved concept, combining CO₂ storage and geothermal heat production
- **CO2SERRE** (coord. BRGM) - Use and storage of CO₂ from biomass processing for greenhouse cultivation



H2020 STRATEGY CCUS (2019-2022)

Objective

To elaborate **strategic plans for CCUS development** in **Southern and Eastern Europe** at short term (up to 3 years), medium term (3-10 years) and long term (> 10 years):

- Local CCUS development plans
- Connection plans between local CCUS clusters, and with the **North Sea CCUS infrastructure**

8 promising start-up regions

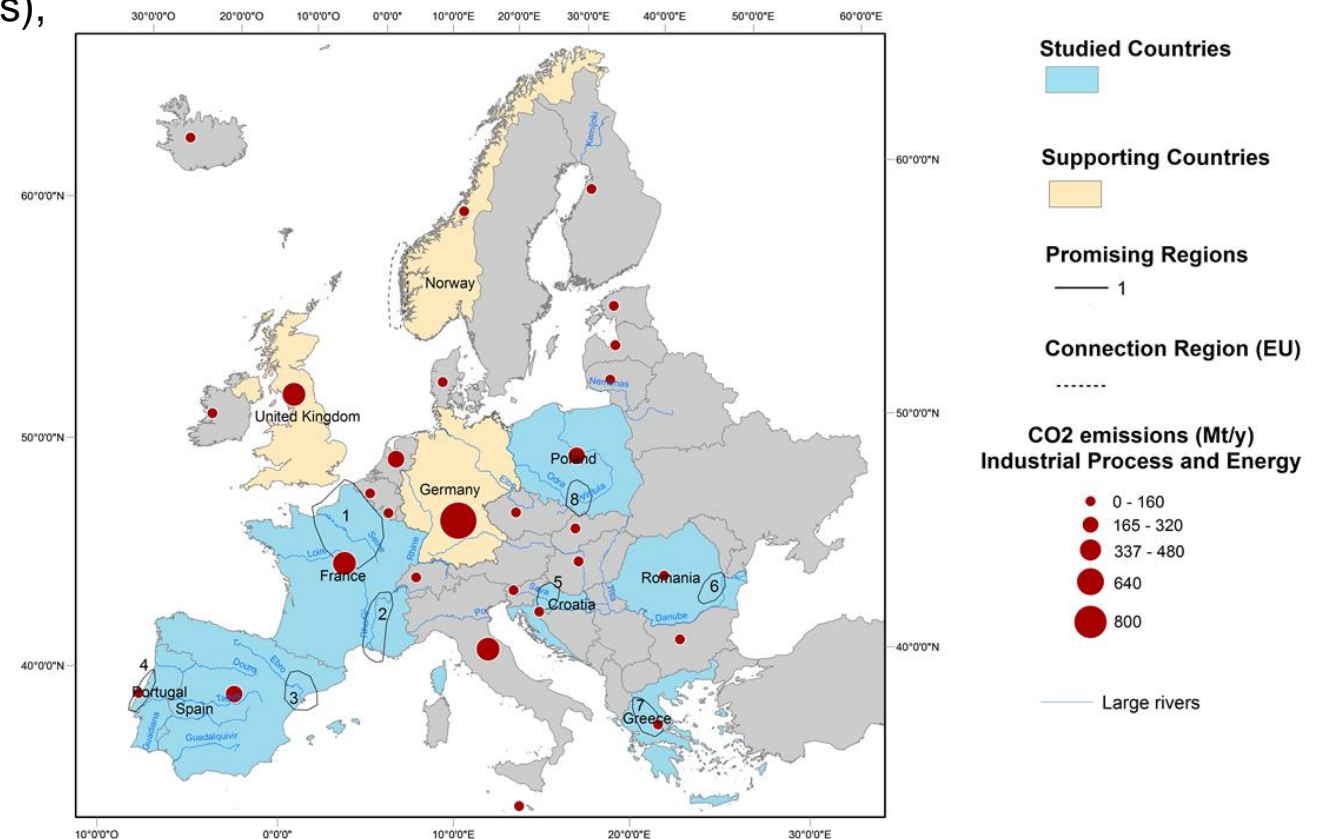
- Presence of an industrial cluster
- Possibilities for CO₂ storage and/or utilization
- Potential for coupling with H₂ production and use
- Previous studies carried out
- And a political willingness!

Budget: 2.96 M€ (CSA)

Partners

FR: BRGM, IFPEN, TOTAL; **ES:** IGME, CIEMAT; **GR:** CERTH; **HR:** UNIZG-RGNF; **PO:** GIG; **PT:** UEVORA, FCT-NOVA, DGEG, CIMPOR; **RO:** SNSPA, GeoEcoMar; **DE:** Fraunhofer-ISI; **NO:** **NORCE**; **UK:** UEDIN

Contact : Fernanda Veloso (coordinator) f.veloso@brgm.fr

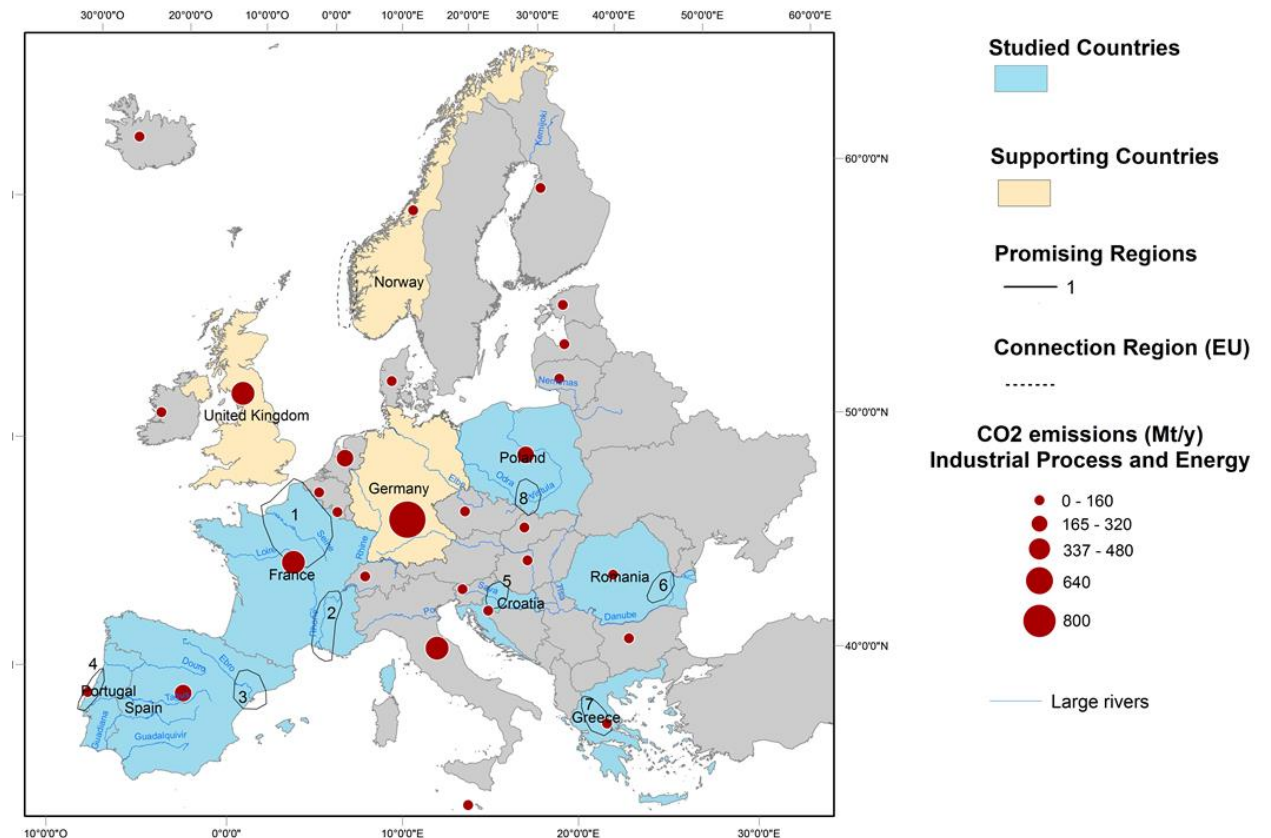


H2020 STRATEGY CCUS (2019-2022)

Promising start-up regions studied

1. **Paris basin in France** (including Le Havre CCS cluster targeted SET Plan Action 9, Dunkerque, Paris urban area and Orleans agricultural area)
2. **Rhône valley in France** (including the Fos-Berre/Marseille CCU cluster targeted by the SET Plan Action 9 (as a Flagship Project), and Lyon metropole)
3. **Ebro basin in Spain** (including Tarragona industrial area, North Castellón and North Teruel areas)
4. **Lusitanian basin in Portugal** (including the CO₂ sources in the Leiria -Figueira da Foz axis, and extending to the Lisbon industrial region)
5. **Northern Croatia** (including Zagreb and the Croatian part of Pannonian basin)
6. **Galati area in Romania** (including Galati, a port town on the Danube river, and its surroundings)
7. **West Macedonian area in Greece** (including the Kozani and Ptolemaida industrial areas).
8. **Upper Silesia in Poland** (including the industrial areas of Katowice, Rybnik and Bedzi)

Contact : Fernanda Veloso (coordinator) f.veloso@brgm.fr



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 837754

H2020 STRATEGY CCUS - STRATEGIC PLANNING OF REGIONS AND TERRITORIES IN EUROPE FOR LOW-CARBON ENERGY AND INDUSTRY THROUGH CCUS



Contact : Fernanda Veloso (coordinator) f.veloso@brgm.fr

Methodology

- **Bottom-up approach**: making first scenarios for CCUS clusters in sub-national regions in order to favour industrial symbiosis and circular economy, and then considering connection of clusters at national and transnational level
- **Integration of experience** of what is currently being done in CCUS clusters around the North Sea
- **Technical potential** assessed first, then the **economical aspects**, and finally the **environmental and regulatory aspects**
- **Social acceptance** and **stakeholder needs & concerns** also assessed for scenarios tailored to local context
- **Common specific methodologies and approaches**:
 - estimating bankable storage capacities
 - developing business models
 - carrying out impact assessment studies (LCA, TEA, MRIO)
 - involving and engaging local and regional stakeholders
- **CCUS development plans will be elaborated in close cooperation with stakeholders**, through the Regional Stakeholder Committees and the Industry Club, to ensure plans can be implemented, i.e. socially acceptable.



CO2SERRE - Use and storage of CO₂ from biomass processing for greenhouse cultivation

Contact : Isaline Gravaud (coordinator) i.gravaud@brgm.fr



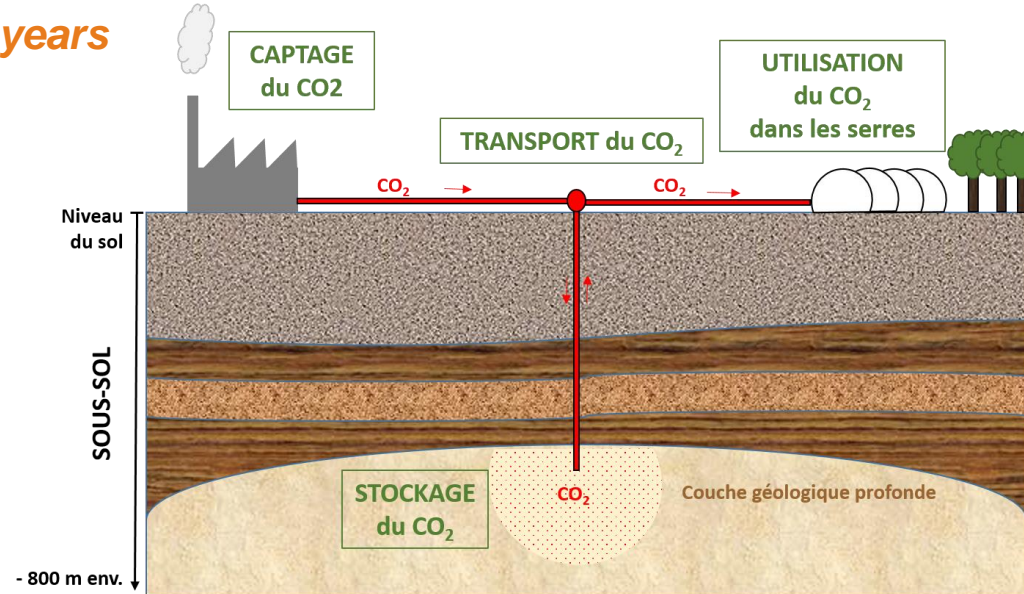
Objective: technical, economical and environmental feasibility study

Started in October 2019 for 3 years



CO₂ CAPTURE at a biomass energy plant and a sugar plant close to Orleans

Optimization of capture costs according to the CO₂ source and quality required for greenhouses



CO₂ GEOLOGICAL STORAGE

- Identification of where to **permanently store the excess CO₂** nearby
- Investigation of **reversible storage**, in the event of a time lag between the production and consumption periods of CO₂ requiring buffer storage



CO₂ UTILISATION in greenhouses

Already a common practice as CO₂ stimulates plant growth and improves yields.

Currently, the CO₂ used in greenhouses is:

- recovered from the combustion of natural gas (uncontrolled composition),
- or purchased from a supplier (pure CO₂, but at a high price)

The objective is therefore to provide greenhouse growers with **good quality CO₂** at a **competitive cost**.

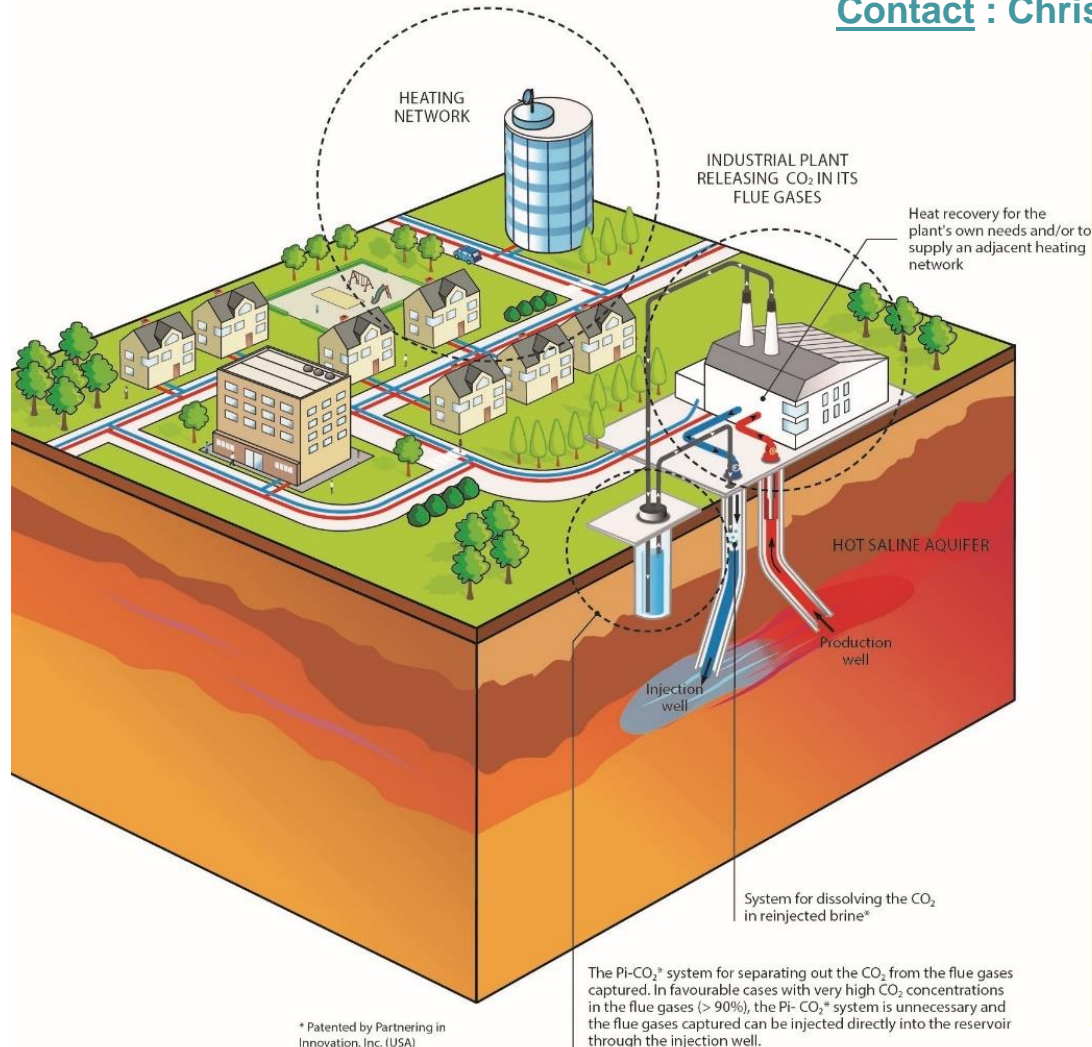


BRGM — FRENCH NATIONAL GEOLOGICAL SURVEY — WWW.BRGM.EU



GEOCO₂ - Potential in the region of the CO₂-Dissolved concept , combining CO₂ storage and geothermal heat production

Contact : Christophe Kervévan (coordinator) c.kervevan@brgm.fr

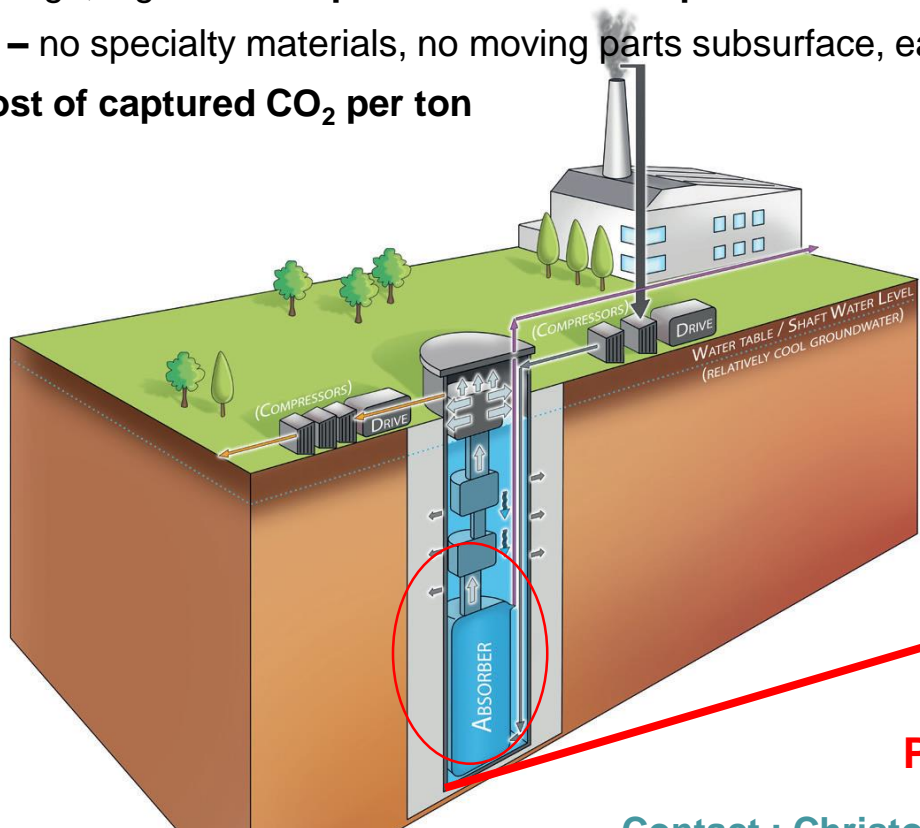


- **Principle:** Dissolution of CO₂ in brine, reinjected in a geothermal doublet, combined with heat recovery
- **Advantages:**
 - Storing CO₂ as being entirely dissolved, offers many advantages in terms of safety and, hopefully, social acceptance
 - Economic and environmental benefits by combining CO₂ geological storage with geothermal energy
- **Constraints:**
 - Only applicable in areas with deep geothermal potential
 - Amount of CO₂ injected limited by its maximum solubility in brine
- **Target:** Small CO₂ emitters (<150 kt/y) located near a heat and/or cooling need (industrial processing or district network) and overlying deep geothermal potential
- **CO₂ capture:**
 - Compatible with any technology on the market
 - Preferential use of the 'Pi-CO₂' patented system

THE Pi-CO₂ CAPTURE TECHNOLOGY

(Partnering in Innovation, Inc, USA)

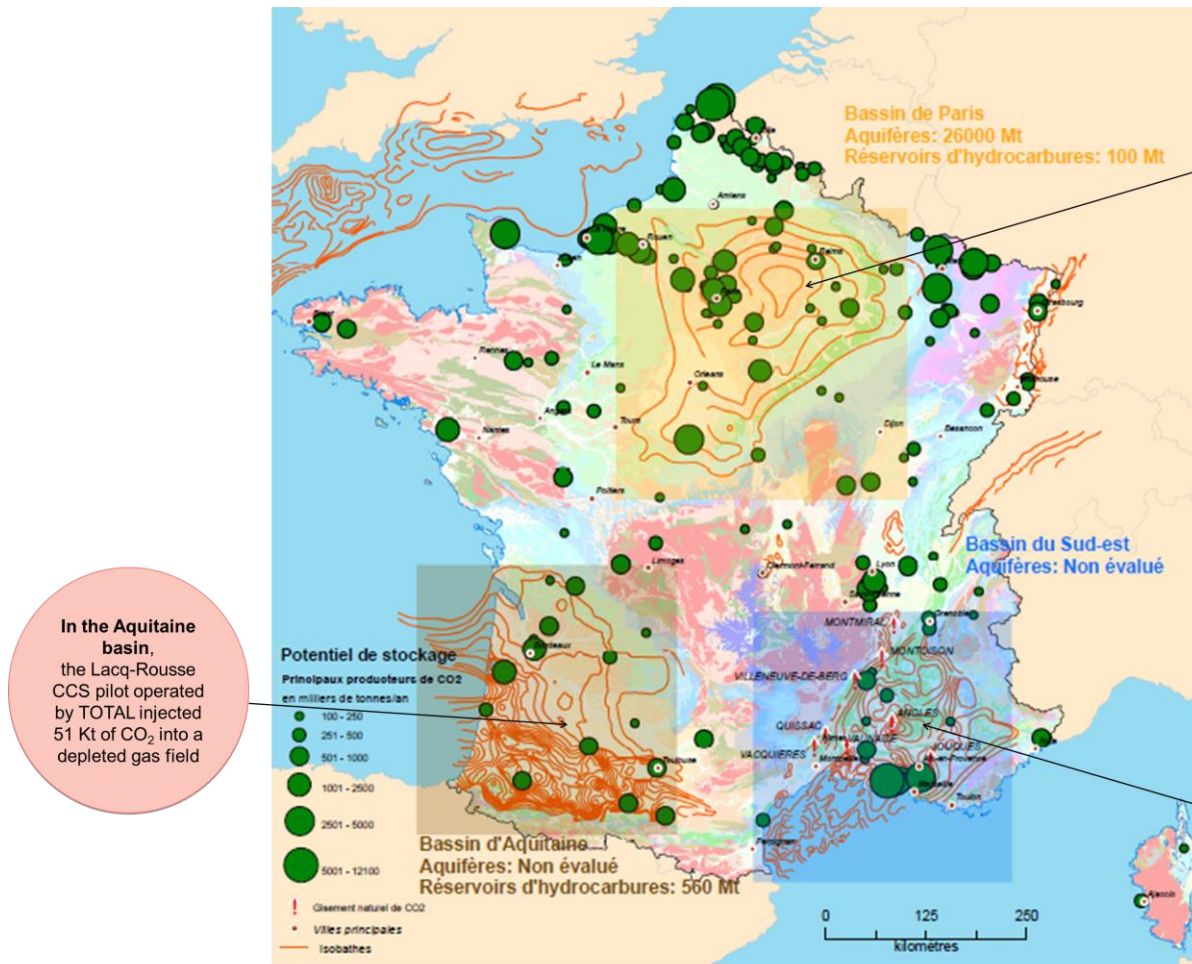
- More environment-friendly because **water** is the only solvent used. **No chemicals.**
- Uses the **high hydrostatic pressure** of a deep water column to increase CO₂ solubility
- Elegantly simple system:** gas separation based on differential solubility at high pressure
- Unique design, high value **in-process hazardous pollutant removal** (SO_x, NO_x, Hg)
- Low risk** – no specialty materials, no moving parts subsurface, ease in testing & scaling
- Lower cost of captured CO₂ per ton**



Prototype at BRGM's lab in Orléans

Contact : Christophe Kervévan c.kervevan@brgm.fr

Development potential for CO₂ geological storage in France



In the Paris basin, several structures with storage capacities of 50-100 Mt CO₂ were assessed through dynamic calculations

In the Aquitaine basin, the Lacq-Rousse CCS pilot operated by TOTAL injected 51 Kt of CO₂ into a depleted gas field

In the South-East basin, a) natural CO₂ occurrences have been studied b) a feasibility study for CCUS in the industrial area of Fos-Marseille was performed

The Paris, Aquitaine and South-East sedimentary basins offer significant CO₂ storage potential.

France is investigating three complementary approaches:

- **large storage offshore**
(e.g. North Sea (ca. 10 Mt/a) – CO₂ stored in supercritical phase
- **medium storage onshore**
(ca. 1 Mt/a) – CO₂ stored in supercritical phase
- **small decentralised storage combined with heat recovery**
(ca. 80-150 kt/a) - CO₂ stored in a dissolved form in water

Major CO₂ emitters and CO₂ storage potential in France

3 sedimentary basins offer storage capacities. Theoretical estimates are indicated for deep saline aquifers and hydrocarbon reservoirs.

Green dots indicate major CO₂ emissions in kt/a.

ECCSEL, the European CCS Research Infrastructure, available for access by worldwide scientists

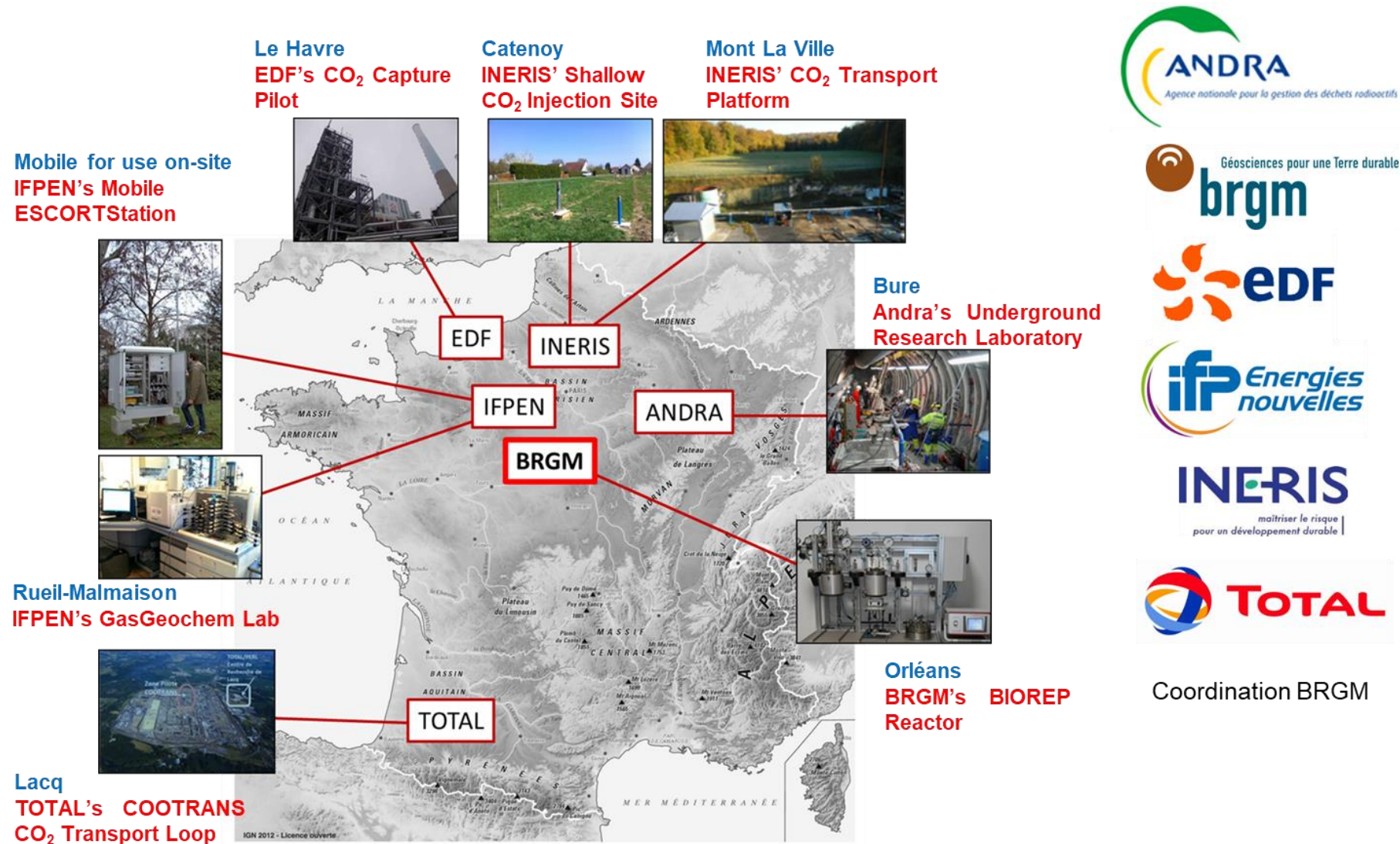


ECCSEL ERIC legal entity

- ***Founded in 2017, seat in Norway (Trondheim)***
- ***5 member countries***
Norway, France, Italy, Netherlands, UK
- ***21 owners of research facilities***
- ***77 unique research facilities*** *(capture, transport, storage)*

Website: www.eccsel.org

ECCSEL French node – facilities available for access in France



ECCSEL Workshop, 5-6 June 2019, Nancy, France

‘Underground laboratories for CO₂ geological storage research’

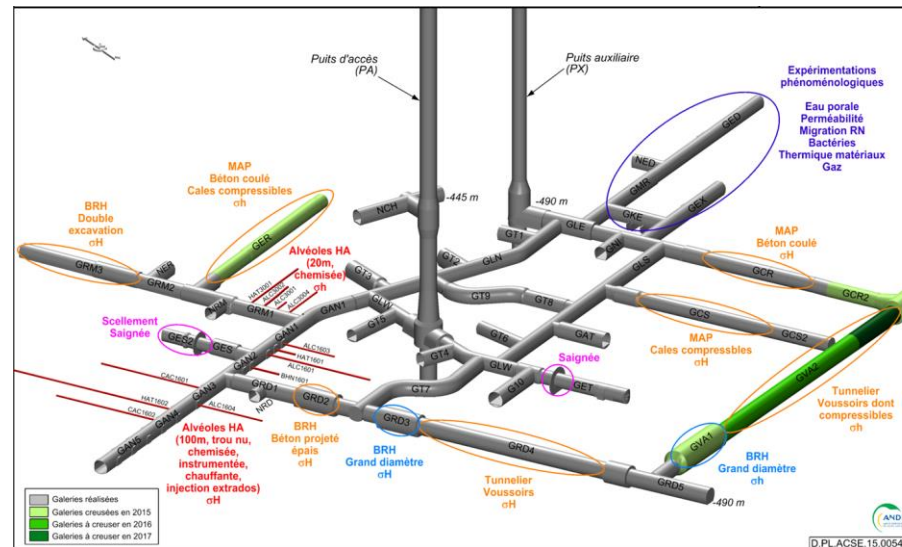
- **Objective:** Encourage researchers to use URL-Andra unique research facility to address Mission Innovation’s Prioritized Research Directions (PRDs)
- **Programme:**
 - Visit to the URL-Andra Underground Research Lab in Bure
 - Overview of current research at underground laboratories, either directly linked or that could inspire CO₂ storage research
 - Brainstorming/Break-out sessions: Ideas for experiments at URL-Andra



Bure

Andra's Underground Research Laboratory

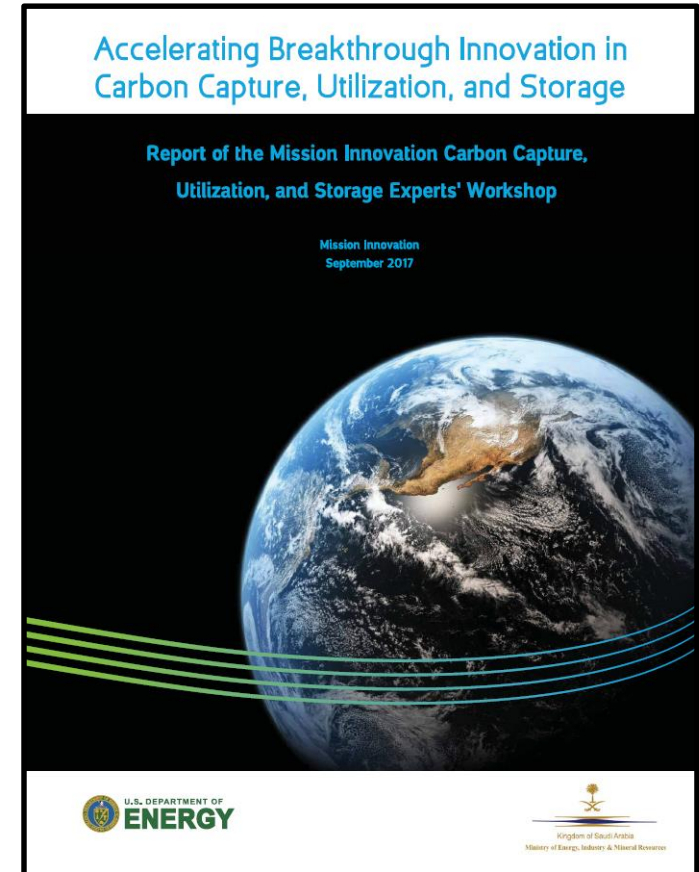
- in situ experiments in a deep clay formation
- 500 m depth
- conditions representative of a caprock of a CO₂ storage site.



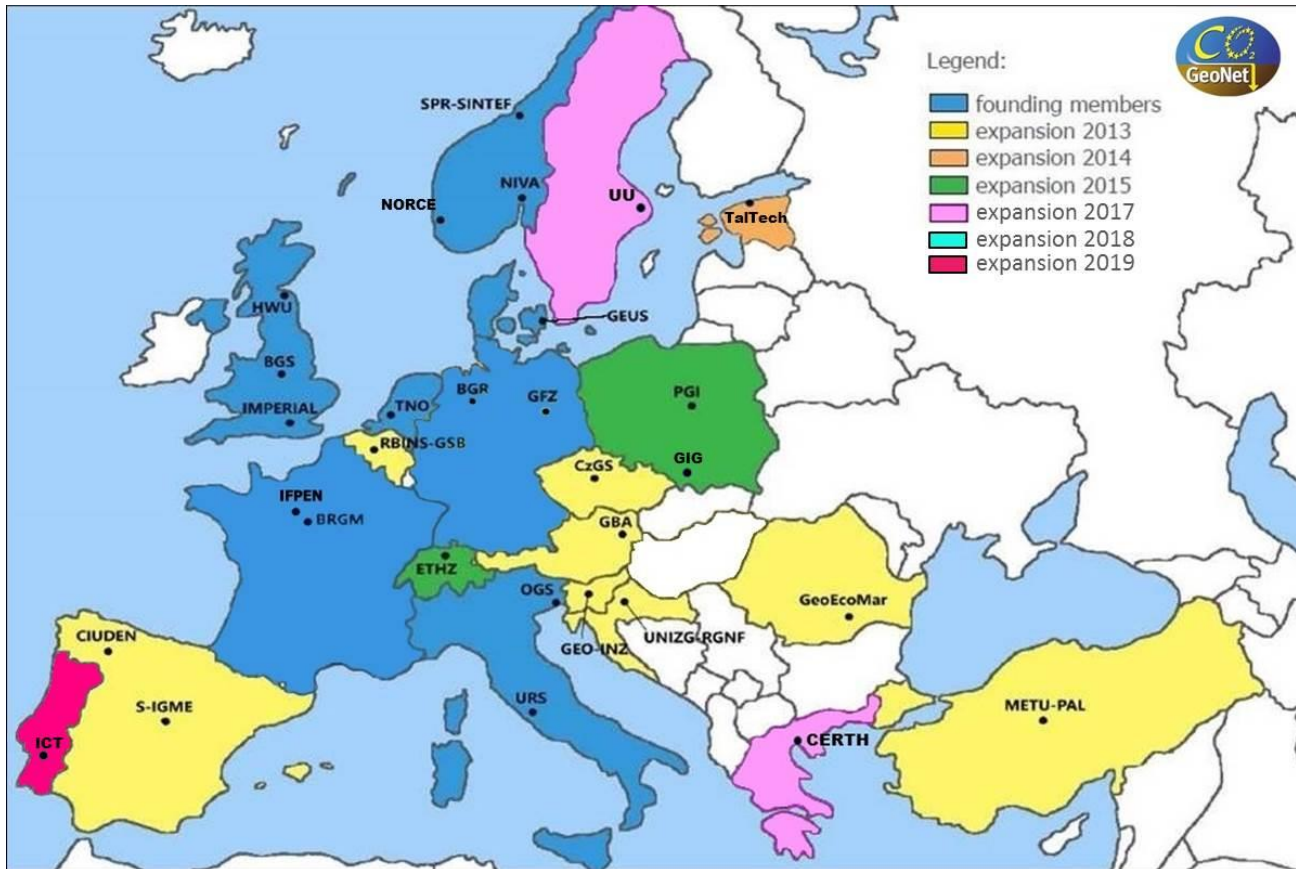
Presentations available at:
www.eccsel.org

Some extracts from the Mission Innovation CCUS report

- Improve understanding of **induced fractures** (hydraulic and thermal) and other **near-well treatments** to enhance **injectivity** using combined laboratory, theoretical, and field research including the use of **underground laboratories** (e.g., the US Sanford Underground Research Facility or the Swiss Mont Terri and Grimsel laboratories).
- In situ experiments and **underground laboratory experiments** on **fault properties and their evolution** under stress may allow the development of new fault-displacement tools and new fault-property measurement tools. The collective advances in technology in this research field are needed **to support gigatonne/year-scale CO₂ injection**.



CO₂GeoNet European Network of Excellence on CO₂ Geological Storage



<http://www.co2geonet.com>

- Created as a EU FP6 Network of Excellence in 2004
- A legal association since 2008, registered in France



Stand + Side-event on CCS

Save the date:
15th CO₂GeoNet Open Forum
Venice, Italy
May 11-15 2020

- An accredited UNFCCC Research NGO, participating in **COP conferences**
- Current membership: **30** research institutes from **21** countries
- Activities: 1) Joint research, 2) Scientific advice, 3) Training, 4) Information and communication