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

Isabelle Czernichowski-Lauriol

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

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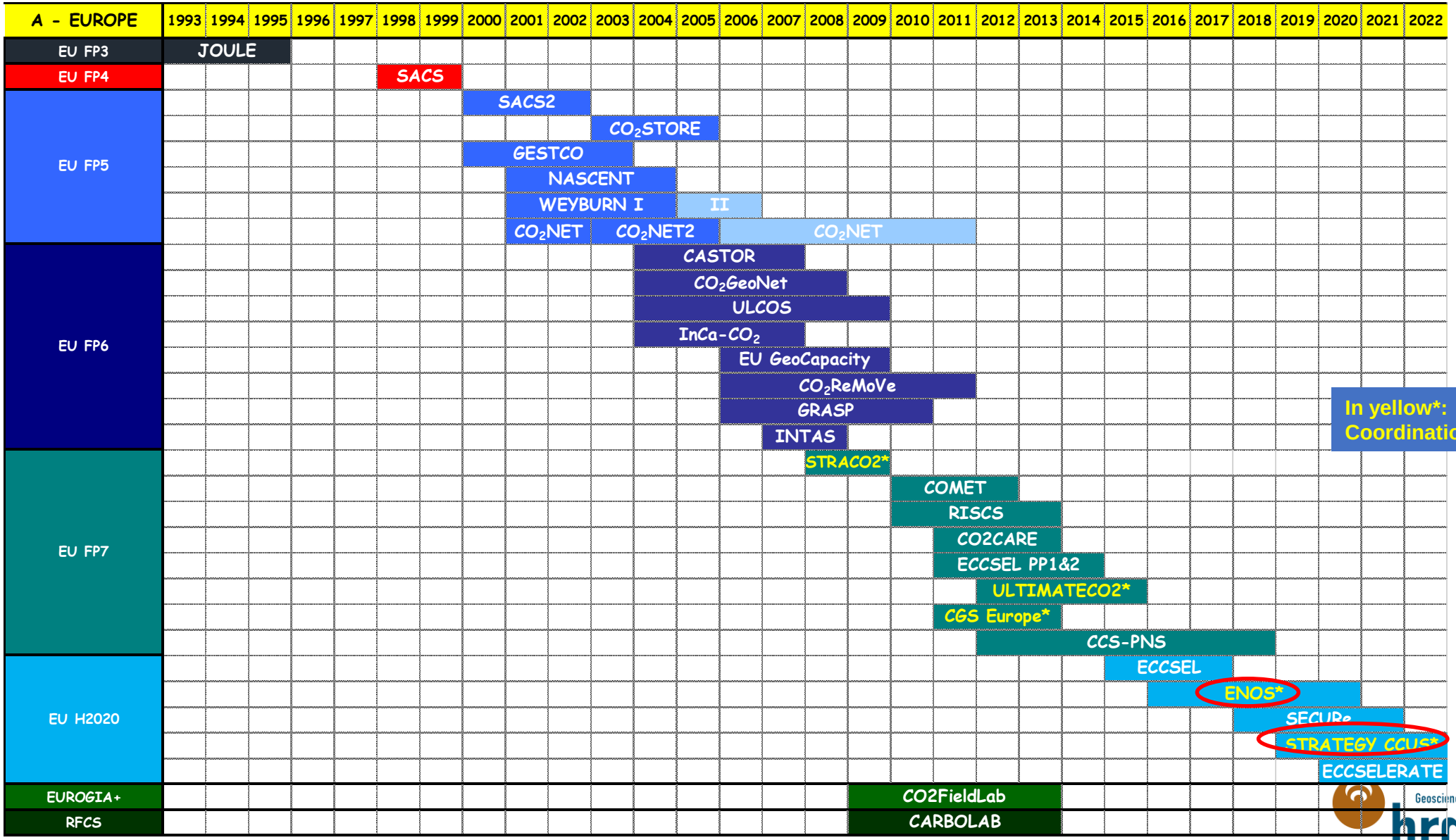
BRGM in European research projects: since the very beginning…



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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

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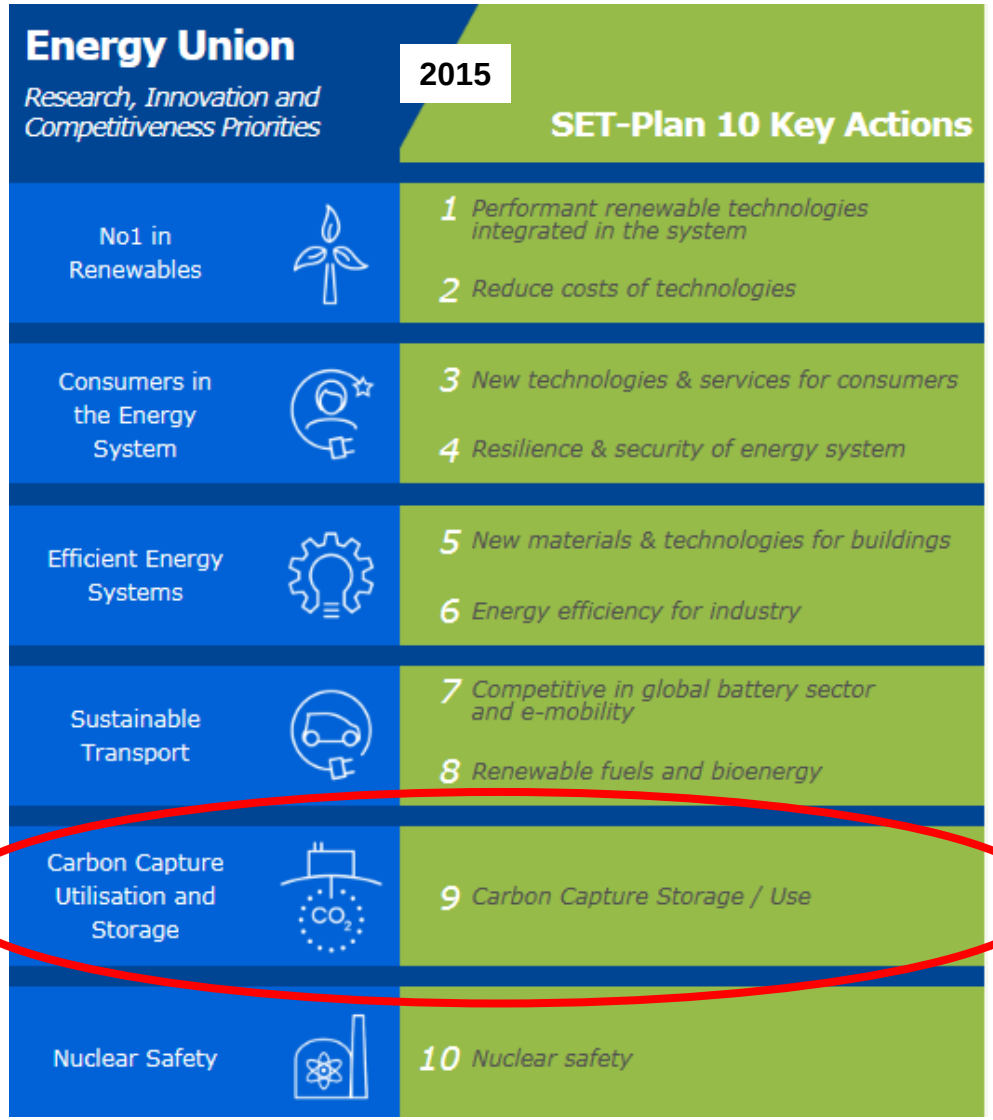
EUROPEAN ENERGY UNION AND STRATEGIC ENERGY TECHNOLOGY PLAN (SET-PLAN)



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

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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 CO_2 transport infrastructure, for example related to storage in the North Sea
5. A European CO_2 geological storage atlas
6. At least 3 new CO_2 capture pilots, including bio-CCS
7. At least 3 new CO_2 storage pilots
8. At least 3 new CO_2 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 $MtCO_2$/year in industry** and produce about **ten $MtCO_2$ 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 CO_2 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 CO_2 storage onshore in Europe
- **CHEERS** (coord. IFPEN) to test, through a pilot in China, CO_2 capture by chemical looping
- **3D** (coord. IFPEN) to demonstrate a demixing solvent for CO_2 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 CO_2-Dissolved concept , combining CO_2 storage and geothermal heat production
- **CO2SERRE** (coord. BRGM) - Use and storage of CO_2 from biomass processing for greenhouse cultivation

H2020 STRATEGY CCUS (2019-2022)

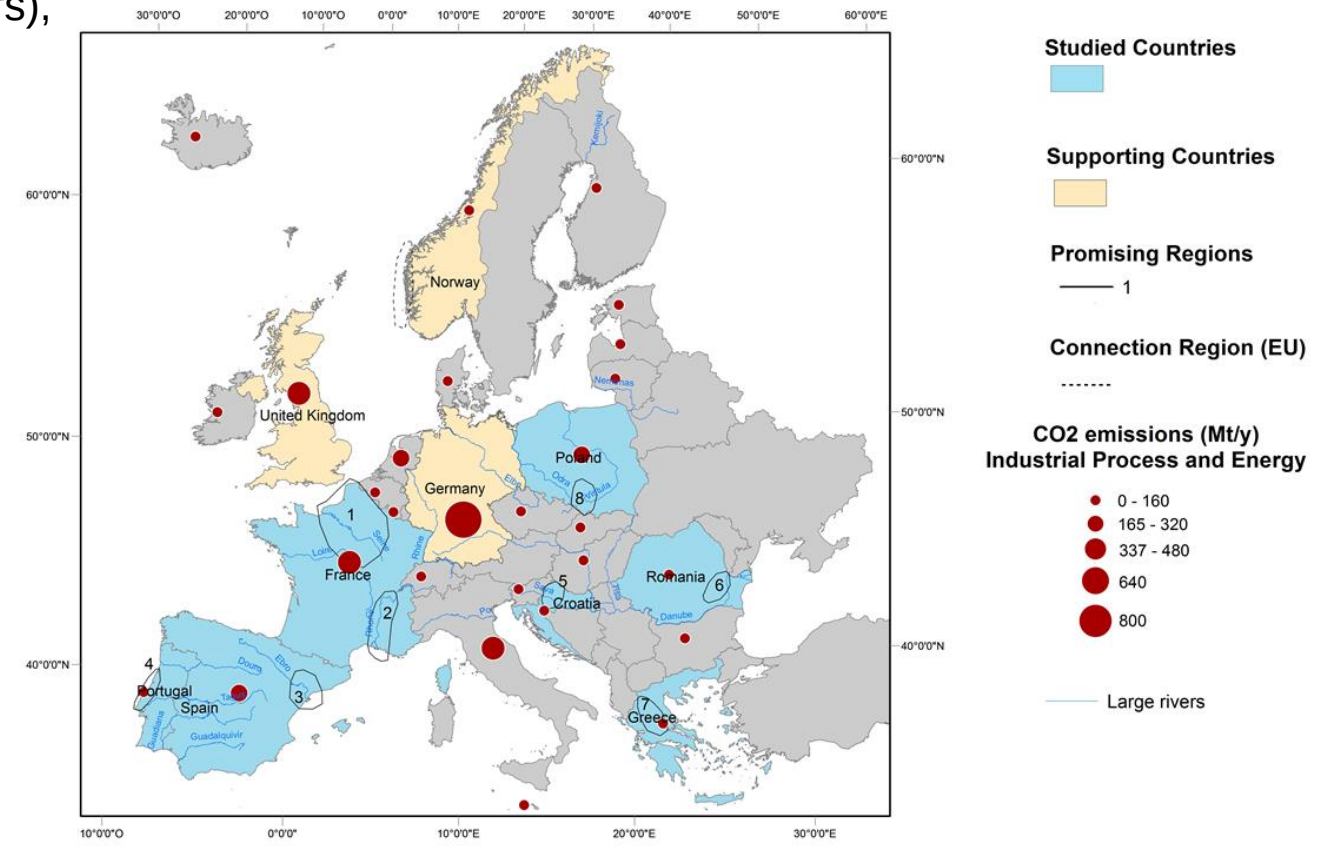
STRATEGY CCUS
A viable solution for a sustainable future

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

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



8 promising start-up regions

- Presence of an industrial cluster
- Possibilities for CO_2 storage and/or utilization
- Potential for coupling with H_2 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

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

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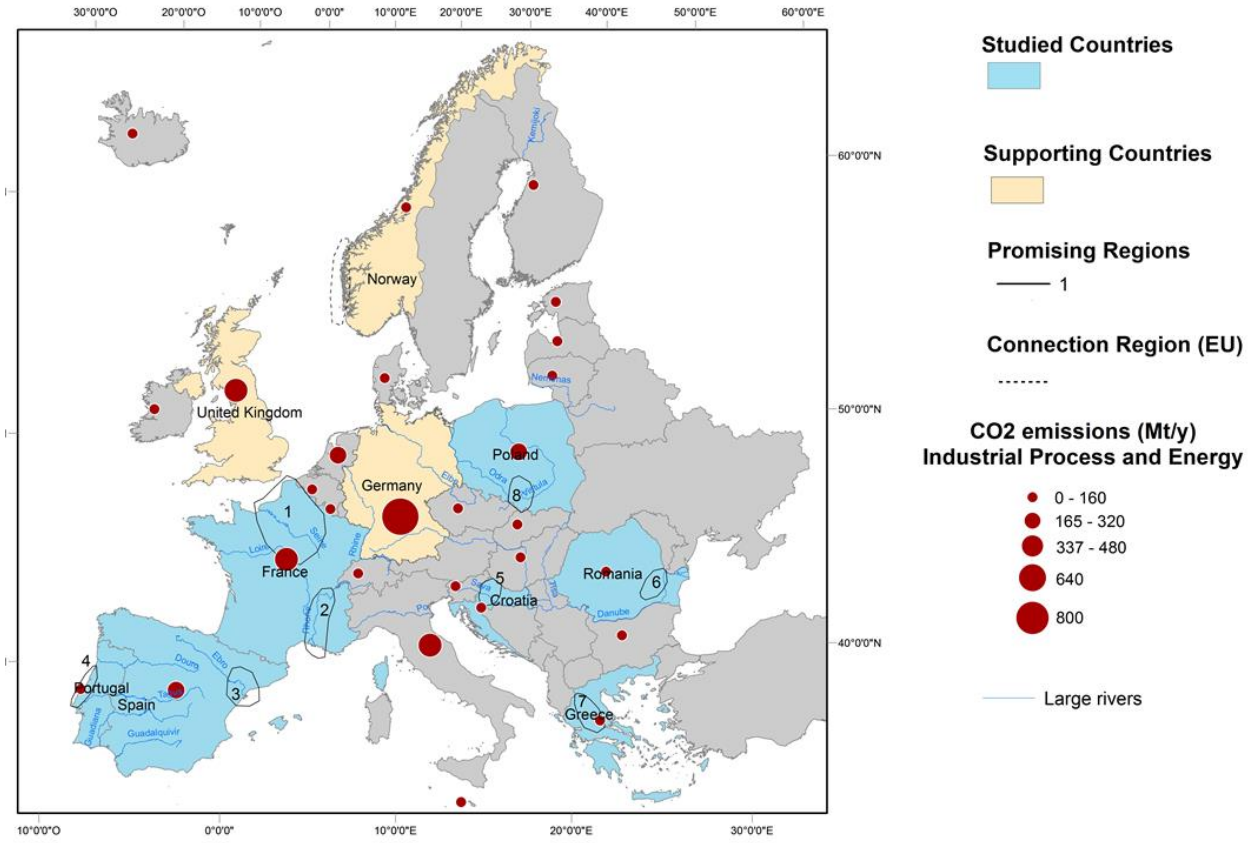
H2020 STRATEGY CCUS (2019-2022)

STRATEGY CCUS
A viable solution for a sustainable future

Promising start-up regions studied

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

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 CO_2 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)



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

STRATEGY CCUS
A viable solution for a sustainable future

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.

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

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CO2SERRE - Use and storage of CO_2 from biomass processing for greenhouse cultivation

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

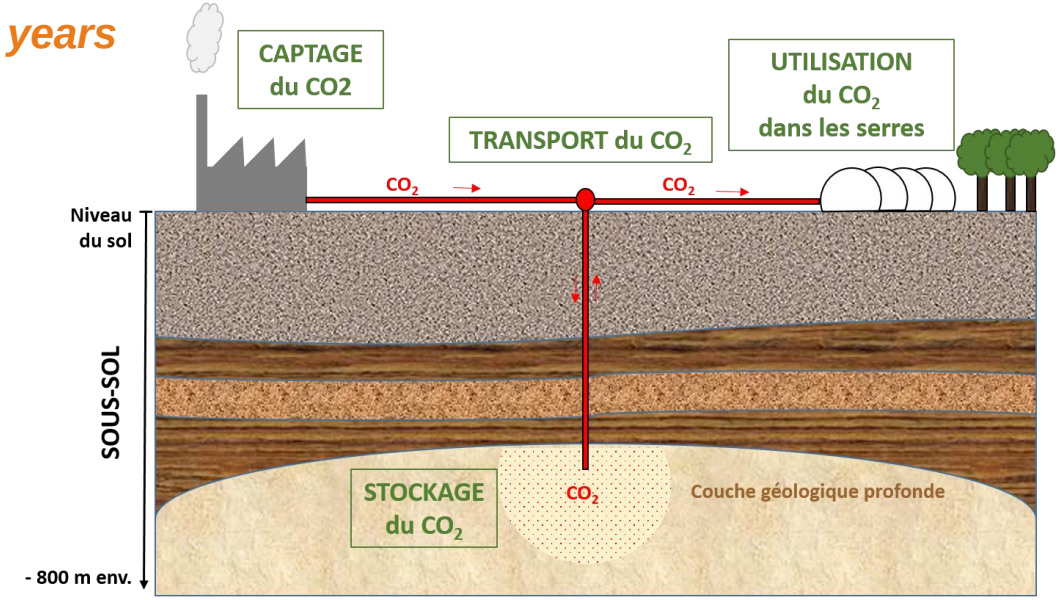
Centre-Val de Loire
www.regioncentre-valdeloire.fr

Objective: technical, economical and environmental feasibility study

Started in October 2019 for 3 years

CO_2 CAPTURE at a biomass energy plant and a sugar plant close to Orleans

Optimization of capture costs according to the CO_2 source and quality required for greenhouses



CO_2 GEOLOGICAL STORAGE

- Identification of where to permanently store the excess CO_2 nearby
- Investigation of reversible storage, in the event of a time lag between the production and consumption periods of CO_2 requiring buffer storage

CO_2 UTILISATION in greenhouses

Already a common practice as CO_2 stimulates plant growth and improves yields.

Currently, the CO_2 used in greenhouses is:

- recovered from the combustion of natural gas (uncontrolled composition),
- or purchased from a supplier (pure CO_2, but at a high price)

The objective is therefore to provide greenhouse growers with good quality CO_2 at a competitive cost.

dalkia GROUPE EDF
CRISTAL UNION
LÉO Laboratoire d'Économie d'Orléans
Centre Sciences — Centre régional de promotion de la Culture Scientifique, Technique et Industrielle de la région Centre-Val de Loire — www.centre-sciences.org
CVETMO
Agreen Tech Valley — LA VALLÉE NUMÉRIQUE DU VÉGÉTAL
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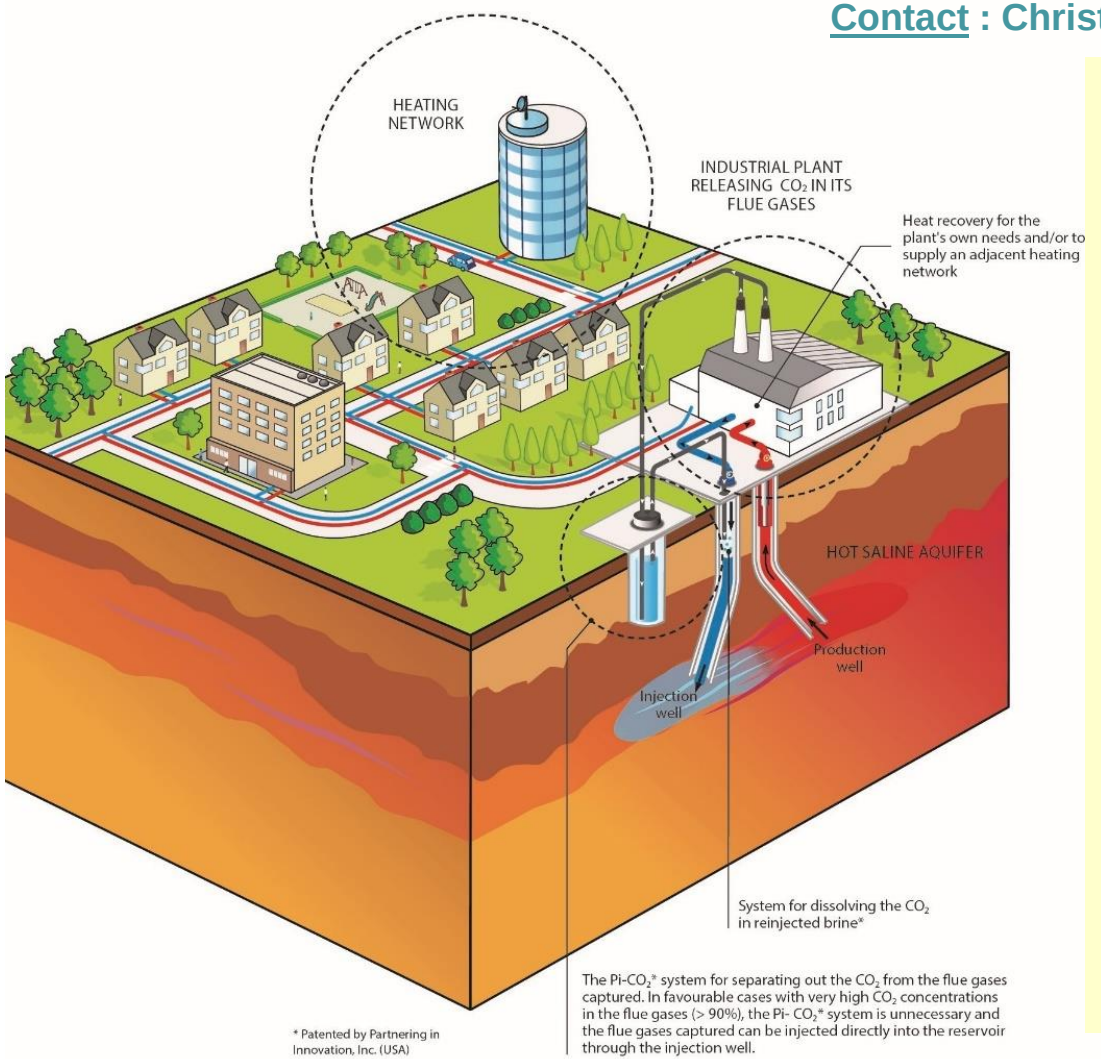
GEOCO2 - Potential in the region of the CO_2-Dissolved concept , combining CO_2 storage and geothermal heat production

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



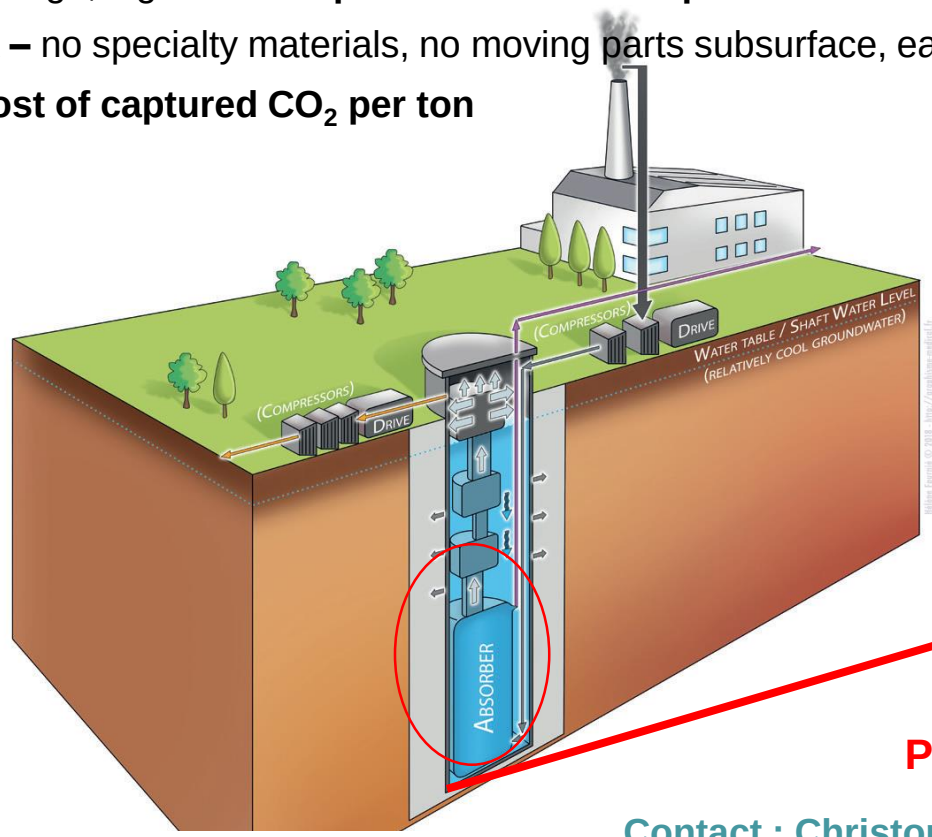
- **Principle:** Dissolution of CO_2 in brine, reinjected in a geothermal doublet, combined with heat recovery
- **Advantages:**
  - S**toring CO_2 as being entirely dissolved**, offers many advantages in terms of safety and, hopefully, social acceptance
  - Economic and environmental benefits by combining CO_2 geological storage with geothermal energy
- **Constraints:**
  - Only applicable in areas with deep geothermal potential
  - Amount of CO_2 injected limited by its maximum solubility in brine
- **Target:** Small CO_2 emitters (<150 kt/y) located near a heat and/or cooling need (industrial processing or district network) and overlying deep geothermal potential
- **CO_2 capture:**
  - Compatible with any technology on the market
  - Preferential use of the 'Pi-CO_2' patented system

http://co2-dissolved.brgm.fr/

THE Pi-CO_2 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 CO_2 solubility
- **Elegantly simple system:** gas separation based on differential solubility at high pressure
- Unique design, high value **in-process hazardous pollutant removal** (SOx, NOx, Hg)
- **Low risk –** no specialty materials, no moving parts subsurface, ease in testing & scaling
- **Lower cost of captured CO_2 per ton**



Prototype at BRGM's lab in Orléans

Contact : Christophe Kervévan c.kervevan@brgm.fr

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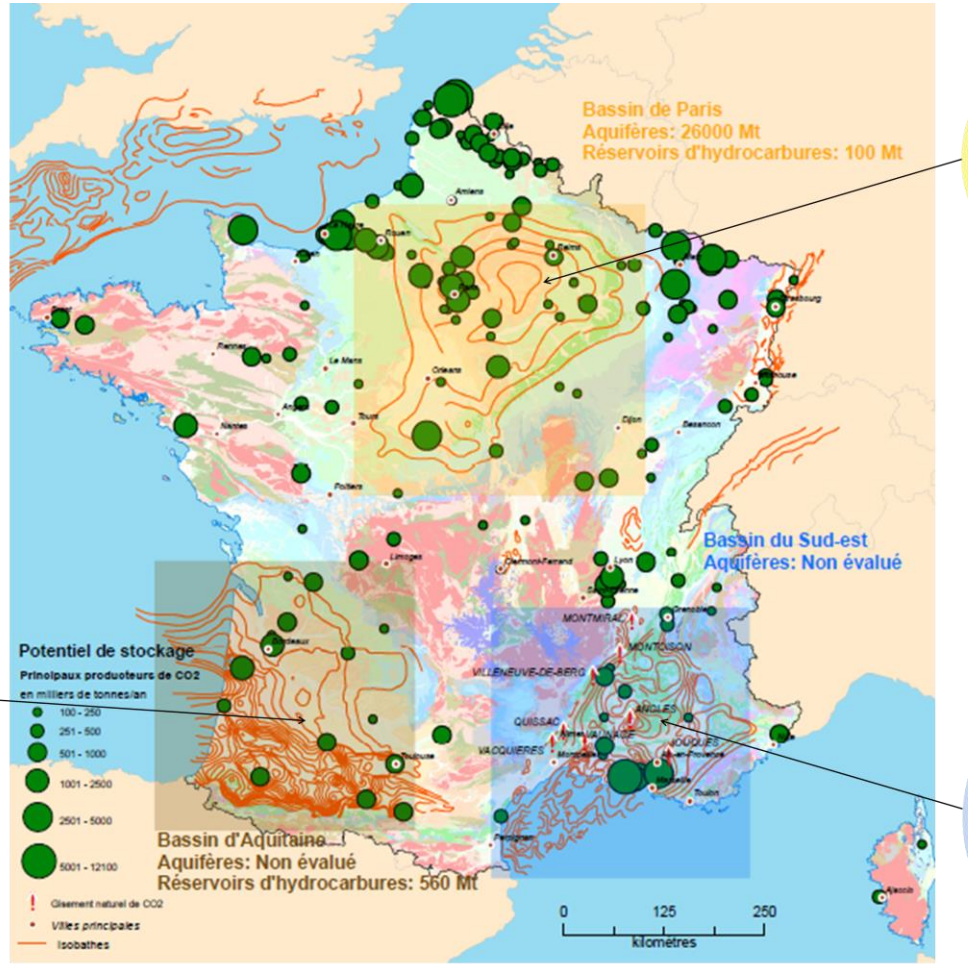
Development potential for CO_2 geological storage in France



In the Paris basin, several structures with storage capacities of 50-100 Mt CO_2 were assessed through dynamic calculations

In the Aquitaine basin, the Lacq-Rousse CCS pilot operated by TOTAL injected 51 Kt of CO_2 into a depleted gas field

In the South-East basin, a) natural CO_2 occurrences have been studied b) a feasibility study for CCUS in the industrial area of Fos-Marseille was performed

Ref: METSTOR project, 2007

Major CO_2 emitters and CO_2 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 CO_2 emissions in kt/a.

The Paris, Aquitaine and South-East sedimentary basins offer significant CO_2 storage potential.

France is investigating three complementary approaches:

- large storage offshore (e.g. North Sea (ca. 10 Mt/a) – *CO_2 stored in supercritical phase*
- medium storage onshore (ca. 1 Mt/a) – *CO_2 stored in supercritical phase*
- small decentralised storage combined with heat recovery (ca. 80-150 kt/a) - *CO_2 stored in a dissolved form in water*

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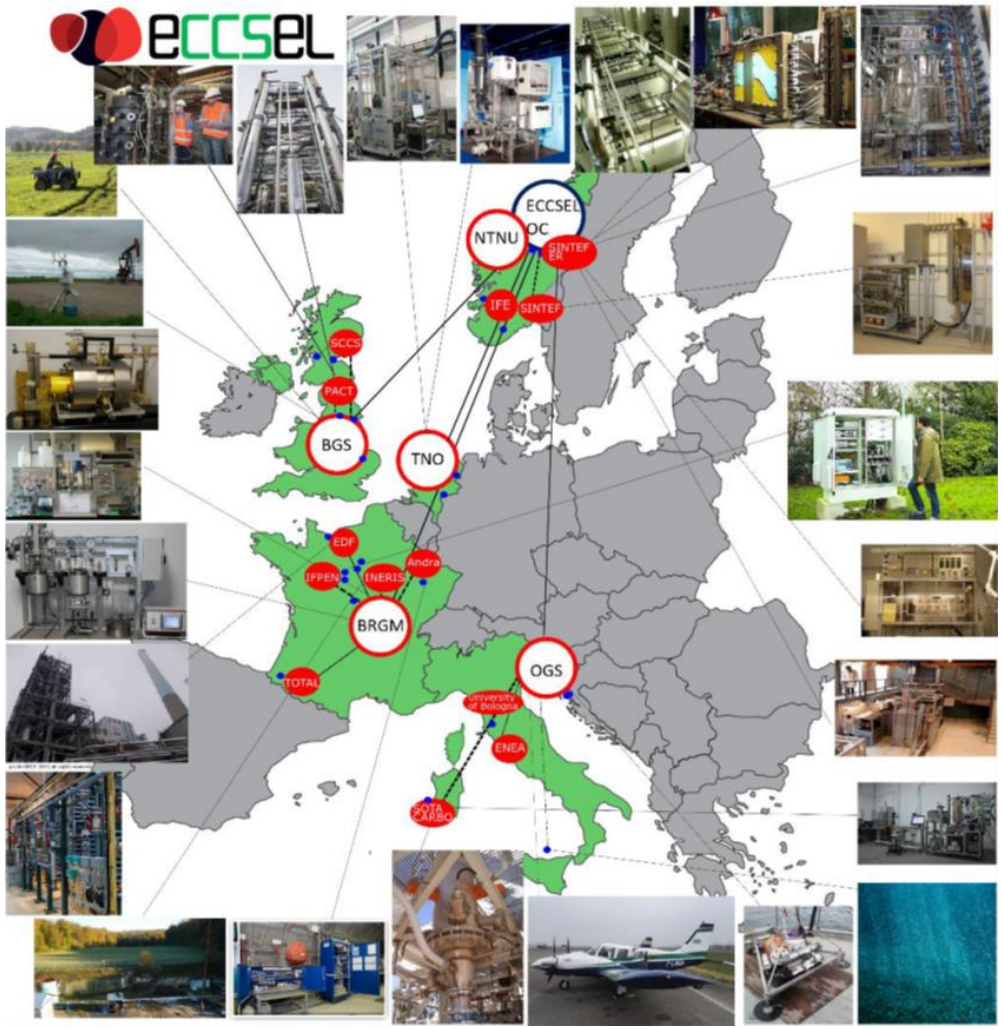
ECCSEL, the European CCS Research Infrastructure, available for access by worldwide scientists



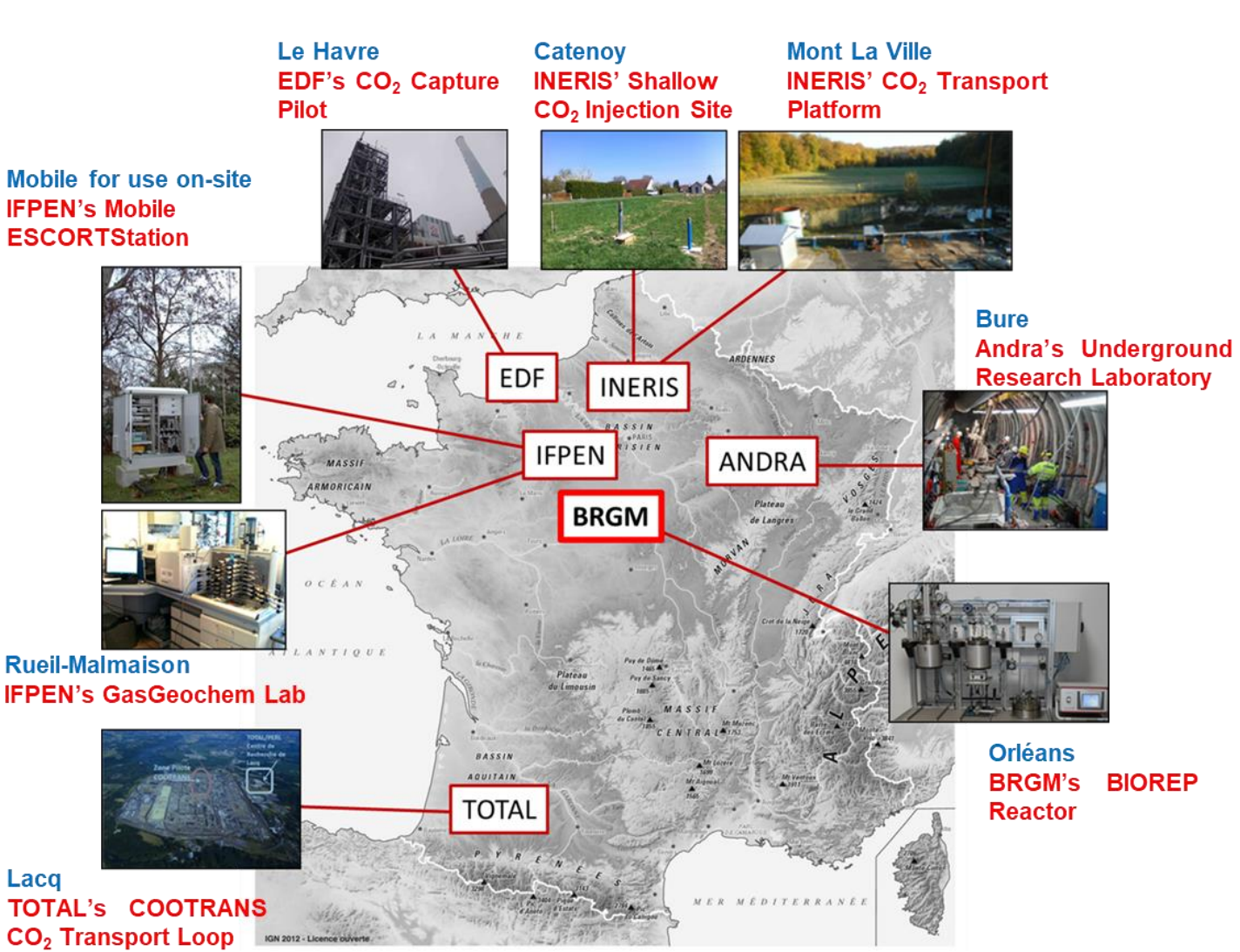
European Carbon Dioxide Capture and StoragE Laboratory Infrastructure

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



Coordination BRGM

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

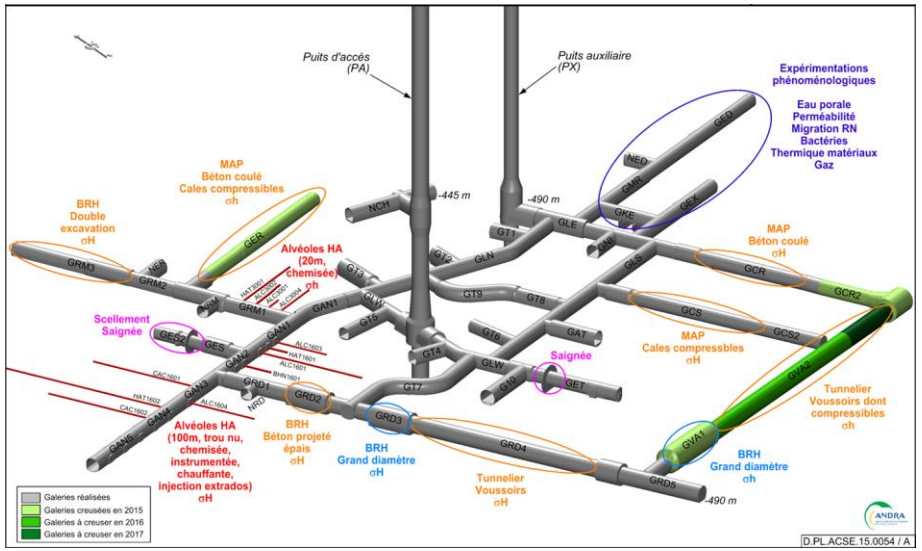
'Underground laboratories for CO_2 geological storage research'

- **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 CO_2 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 CO_2 storage site.

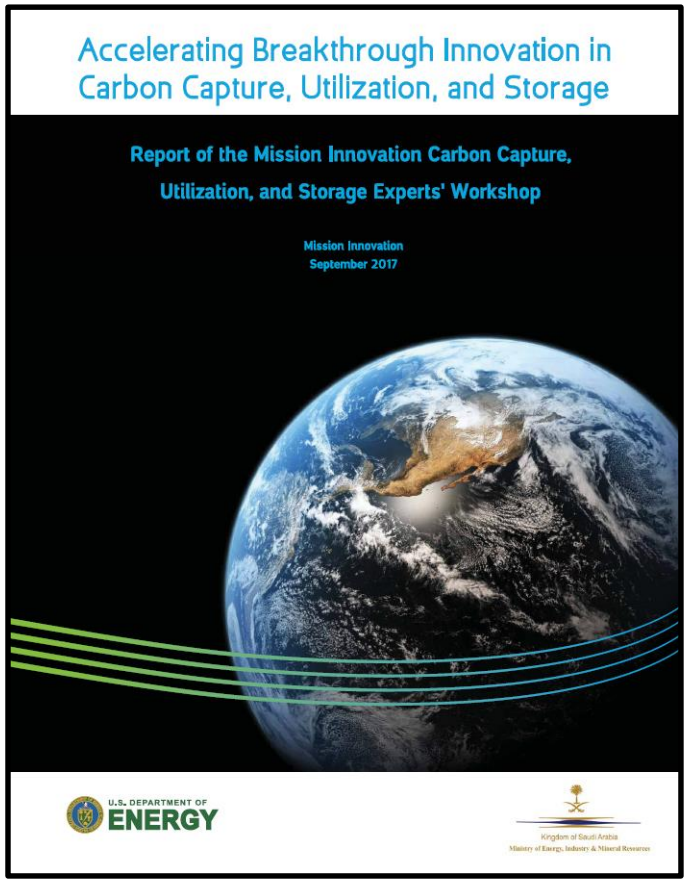


Presentations available at:
www.eccsel.org

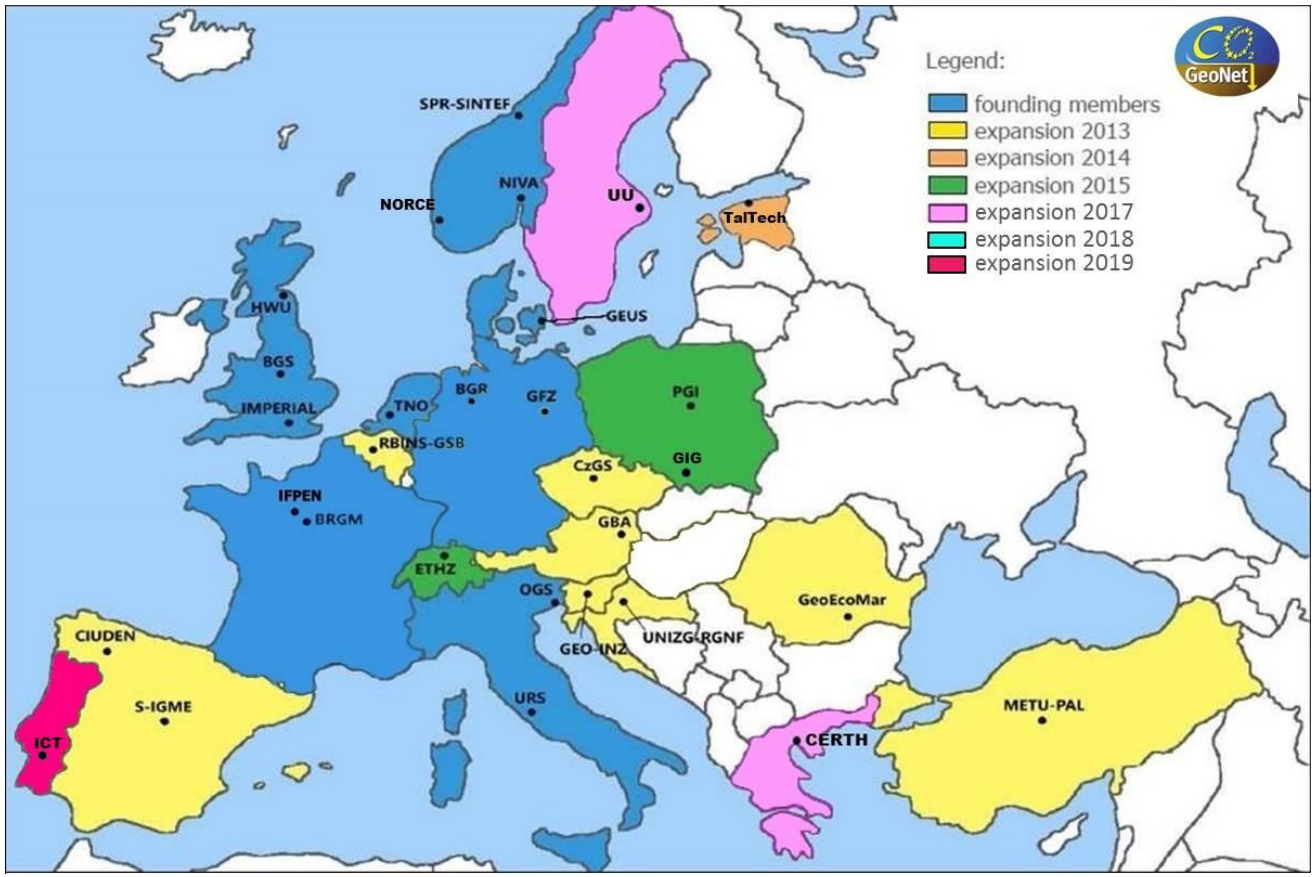
Some extracts from the Mission Innovation CCUS report

- 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 CO_2 injection.



CO_2GeoNet European Netwok of Excellence on CO_2 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 CO_2GeoNet 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

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