Position paper

October 2022

Carbon sinks

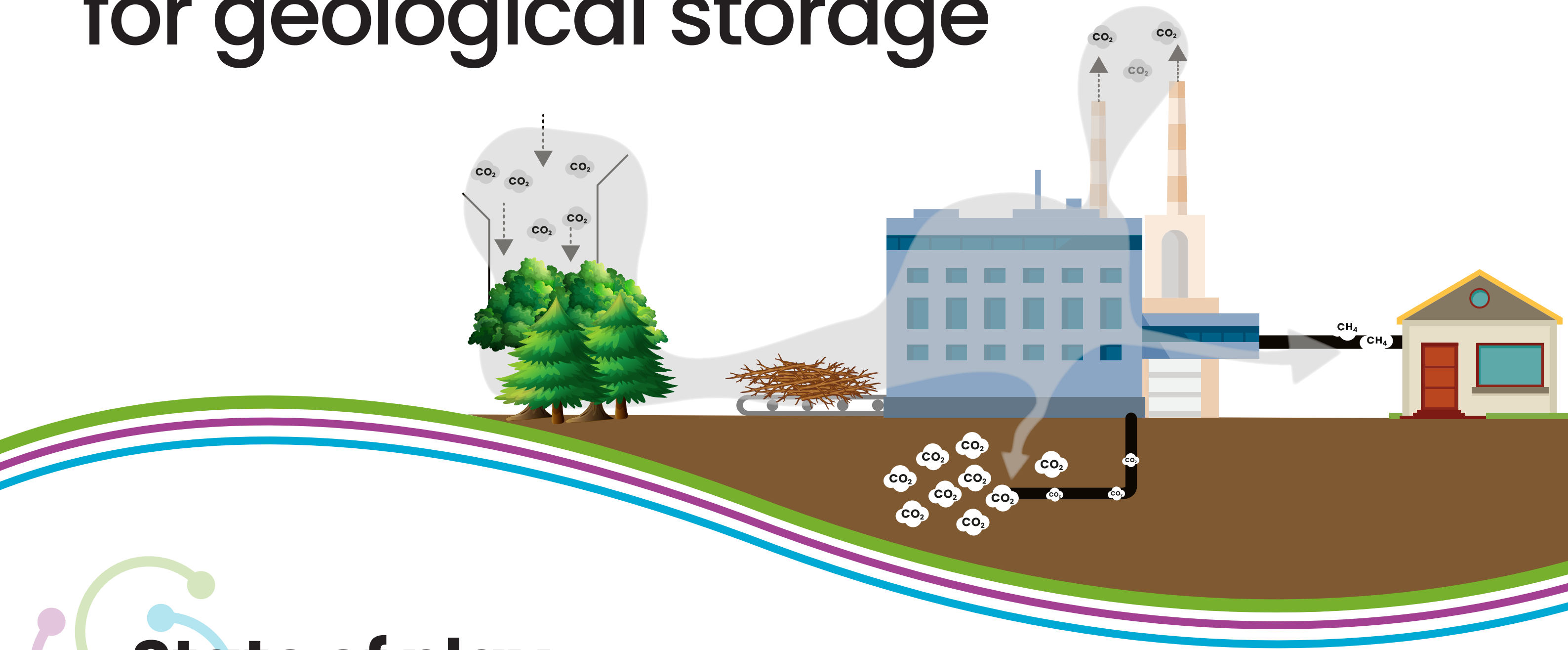
What role should research play in accelerating their development in France?

In order to remove CO_2 from the atmosphere, carbon sinks are a solution that is currently being considered as a unavoidable. Increasing but also preserving carbon sinks and, in some cases, restoring them, are priority issues. Based on a study by a group of experts from the ANCRE alliance, six major categories of carbon sinks have been identified for the French context: three categories of natural CO_2 capture solutions in more or less anthropised environments, and three categories of solutions integrating technological developments. The state of play, challenges, barriers and research recommendations for each of the solutions were highlighted in 7 worksheets.

The full report and each of worksheets are available on:
https://www.allianceenergie.fr/etudes-et-rapports/

ANCRE
Alliance Nationale de Coordination de la Recherche pour l'Énergie

Technological solutions for capturing atmospheric CO_2 for geological storage



State of play

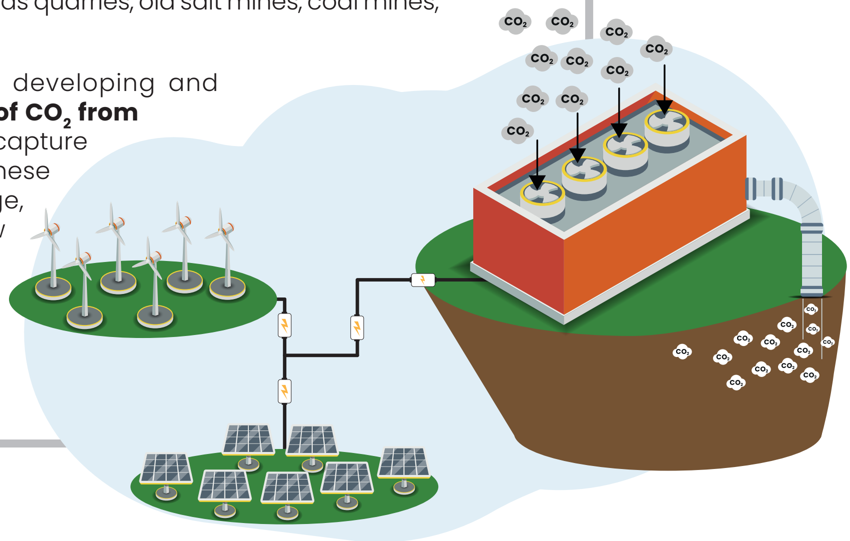
CO_2 capture and storage technologies2 not only reduce CO_2 emissions , but also reduce CO_2 in the atmosphere (i.e. achieve negative emissions) through:

- Bioenergy with Carbon Capture and Storage (BECCS) where CO_2, emitted by a combustion process using biomass as fuel or biomass-fuelled industrial processes, is captured and CO_2 is stored underground;
- Direct air capture (DAC), which consists of directly capturing CO_2 already present in the atmosphere and, ultimately, storing it permanently underground.

Bioenergy with CO_2 capture and storage (BECCS) is the most mature of the technologies for removing carbon from the atmosphere, as both bioenergy and CCS have been proven separately on a commercial scale. The principle is the capture and storage of biogenic CO_2 emitted by biomass combustion or bio-mass-fuelled industrial processes. Several installations are in operation around the world, most of them associated with fermentation for ethanol production.

An alternative to BECCS is the **recovery of solid carbon in the form of biochar** co-produced by the biomass pyrolysis process for the production of energy (heat, electricity, fuel) and chemical compounds (see e.g. Lambiotte in Prémery). Biochar is a biogenic carbohydrate concentrate that can be spread on agricultural or forestry soils (see sheet n°1) or stored in geological cavities such as quarries, old salt mines, coal mines, etc.

In addition, several companies are developing and marketing **direct capture processes of CO_2 from the atmosphere,** most of them using capture processes based on solid sorbents. These installations are still at the pilot stage, the most important can capture a few hundred to 4,000 tonnes of CO_2 /year. The advantage of direct CO_2 capture lies in the possibility of installing the capture system close to the storage area and/or to abundant and cheap decarbonised energy production.



Challenges

The challenges for bioenergy with CO_2 capture and storage include:

1 - the adaptation of capture technologies to the different concentration levels of biogenic CO_2 from bioenergy units;
2 - the scaling up of certain biomass conversion technologies not yet demonstrated on a commercial scale (hydrothermal conversion, biofuels from microalgae, etc.) ;
3 - the technical and economic feasibility of the entire BECCS system.

These different challenges will have to be accompanied by the control of the different carbon flows throughout the life cycle of the system so as to ensure a negative emissions balance.

The main challenge for direct air capture is to reduce the energy penalty of the process and its implementation cost, as the concentration of CO_2 in air (0.04%) is about 300 times lower than in flue gas.

Barriers

Among the challenges to be addressed as a matter of priority are, for bioenergy with carbon or CO_2 capture and storage :

STRUCTURING THE SUPPLY
of biomass resources in order to be able to increase capacity,

DEVELOPMENT OF FACILITIES
of flexible combustion systems adapted to the variability of biomass and to the heat requirements on site

THE DEVELOPMENT OF CO_2 CAPTURE PROCESSES
adapted to the constraints of the emissions in terms of composition and flow of the flue gases

THE INTEGRATION OF THE SEPARATION OF CO_2
for gasification and pyrolysis processes.

For direct air collection :

SCALING UP
and integrating the impact on energy resources and materials needed,

PROCESS INTENSIFICATION,
and energy optimisation and the availability of decarbonised energy sources,

MEDIA DEVELOPMENT
for CO_2 separation system with low environmental impact,

GEOGRAPHICAL LOCATION
of capture sites according to carbon regulations and the availability of renewable energies.

The principle of negative emissions requires long-term storage of atmospheric CO_2 in various forms (gas in underground reservoirs, solid in surface soils or in the form of materials, etc.). The challenges of storing CO_2 in geological formations are the same as those of CCS:

SOCIETAL PERCEPTION
for use of the subsoil to store CO_2 ,

THE AVAILABILITY OF STORAGE FACILITIES
in a timeframe compatible with the CO_2 injection needs of projects under development

THE DEVELOPMENT OF ASSESSMENT METHODS
of environmental impacts, risk prevention and remediation, and long-term monitoring technologies.

The challenges for the long-term storage of solid carbon in biochar (from biomass pyrolysis) in biomines are the study of the mechanical and chemical stability of the biochar, the environmental issues (leaching of compounds present in the biochar by water), and storage engineering (optimising the yield in terms of mass of densified carbon in the biochar per unit of available volume).

The barriers associated with storage in agricultural and forest soils are covered in Fact Sheet 1, and the barriers associated with storage in materials are covered in Fact Sheet 5Les verrous associés au stockage dans les sols agricoles et forestiers font l'objet de la Worksheet n°1, les verrous associés au stockage dans les matériaux font l'objet de la Worksheet n°5.

Actions

Research recommendations

Strengthe research and innovate

- Improve CO_2 capture and purification processes for the thermal and biochemical conversion of biomass and waste, including **adaptability to biomass variability.** In this sense, it is necessary to (i) consolidate and analyse databases characterising the properties of biomass (and combustion flue gases) and (ii) identify components or molecules likely to present a risk for known storage sites.
- **Reduce the energy penalty** of the process chain by improving the energy integration of atmospheric CO_2 capture processes in particular, as well as by reasoning the energy needs by valorising fatal or low-carbon heat when appropriate.
- Investigate the development of **modular capture** processes to enable cost reduction and CO_2 recovery from small installations
- Study the s**torage of biochars** in underground cavities (creation of biomines) on different interdisciplinary aspects: (i) storage engineering (optimising the density of carbon stored per unit of apparent volume), (ii) socio-economic interests (potential conflicts of use/conflict of uses at the country or territorial level), (iii) environmental impacts (stability of the carbon, study of gaseous and liquid emissions).

Identify and quantify suitable storage capacity

- Continue the exploration, selection and characterisation of **storage sites** (deep geological reservoirs, old mines/quarries, etc.) on French territory (mainland France, French overseas departments and territories; onshore and offshore) as well as the availability of cross-border storage capacities.

Developing demonstration projects

- Validate the **performance of** existing **bioenergy technologies** (biomass plants, biofuel units) with a view to their connection to a CCS system; but also demonstrate innovative BECCS systems on new advanced bioenergy technologies (biojet, biomethane, multi-product biorefineries, etc.).
- **Optimise the logistical** solutions for the various flows (CO_2 , biomass): (i) integrate the existing transport networks in France and cross-border networks (gas pipeline, oil pipeline, sea/river routes, etc.) with regard to the sites of emissions, storage and use; (ii) define the sizing requirements of the transport networks with regard to the CO_2 flows and their seasonality.
- Testing the management of **CO_2 flows** (capture and transport) **on a small scale** (in locations potentially close to the biomass but far from storage locations).
- Develop **integrated direct air capture demonstrators** adapted to local conditions (access to decarbonised energy, access to a storage site or a CO_2 conversion site.)

Implementing recommendations

Develop impact analysis methods

- Develop methods of multi-criteria environmental analysis (in particular Life Cycle Analysis) based on mass balance (including carbon) and energy balances (from the demonstrators) allowing (i) the optimisation of processes (from soil to sequestered carbon, including all products); (ii) anticipate conflicts of use and potential impacts on the environment, land use and biodiversity; (iii) to extrapolate a large-scale deployment on the national territory.

Develop engagement strategies

- Deploy consultation and co-construction actions by civil society stakeholders on the different pathways and projects, particularly with a view to communicating and informing on the principle and risks of storage.

Support the launch of first of a kind industry

- that will help launch the industry, reduce risks and gain skills.