CO_2 emissions reduction in industries with CCU technologies ?

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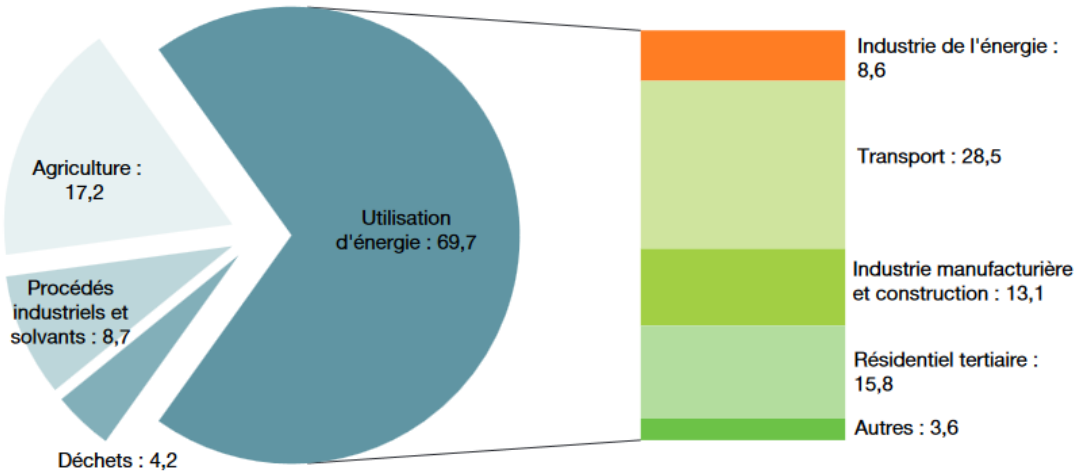
CO_2 emissions

In 2015, CO_2 emissions from fossil fuel combustion and industry reached 35.7±2 Gt CO_2, +60% since 1990.
Stable emissions between 2014 and 2016
In 2017, emissions have increased at 36.8±2.0 Gt CO_2 (Source: Global Carbon Project)

RÉPARTITION PAR SOURCE DES ÉMISSIONS DE GES (HORS UTCF) EN FRANCE EN 2014

En %



Source : *Citepa, juin 2016*

Example of emission for industries at European level:
- cement sector: around 14% of CO_2 emissions in Europe = 130 Mt_{CO2}

- steel sector: around 20% of CO_2 emissions in Europe = 191 Mt_{CO2}

Key challenges for industries

- **CO_2 emissions reduction:**
  - ➢ Energy efficiency
  - ➢ Switch to renewable energy
  - ➢ New process (through breakthrough technologies)
  - ➢ CCS/CCU for residual emissions

- **CO_2 Utilization in the global mitigation initiatives and efforts:**
  - ➢ Current Utilization:

    180 Mt CO_2(mainly for urea and inorganic carbonates manufacture) (Source: Armstrong & Styring, 2015)

    + 70 Mt CO_2 for EOR (Source: CO_2 Utilization Summit, San Antonio, 2015)

    = 250 Mt CO_2/yr utilization (0.7% 2015's emissions) could be used
  - ➢ If business models are relevant and regulations are in place: max 2 to 4% overall emissions could be utilized (eg: C1-building blocks, mineral carbonation…) → It is a way to deploy circular economy based on a robust industrial sector and infrastructure.
  - ➢ It will act as a complement to other solutions (storage, efficiency, renewable energies,…) with a potential that should be carefully assessed.

Policy background

- **European Climat- Energy Policy:**
  - Target 4 for France: 75% of GHG emissions reduction by 2050
- **National policy:**
  - Energy Transition Law for Green Growth,
  - Circular Economy Roadmap
- **International level- After Paris agreement:**
  - Revision of National Low Carbon Strategy to reach « carbon neutrality »

Key actors at policy level

- **DGEC: French Energy ministry : member of Mission Innovation –Challenge 3 -CCUS**
- **MESR: French Research ministry via participation to:**
  - ➢ new call of **ERANET ACT** (CCS and CCU)
  - ➢ Initiative Phoenix on CCU (Germany, Netherlands, France and Flanders):

    Main goal of PHOENIX is to build a business case with respect to CO_2 utilisation to ensure an optimal use of public funding and private investment.
- **National agencies: ANR (French Research Agency), ADEME (Environment and Energy Management agency) -> funding CCU projects via specific R&D program or generic program (energy or circular economy)**

Club CO2: the French team of CCUS

- **Club CO_2** is a forum for exchanges of information and initiatives concerning CO_2 capture, transport, underground storage and re-use (CCUS) between industrial, research and local government players in France -> WG CO_2 Utilisation

Website: http://www.captage-stockage-valorisation-co2.fr/

Overview on CO_2 Capture & Utilization

Carbon4Pur Conference

20 March 2019

AGENDA

1. Brief review of CO_2 Utilization technologies
2. Actions of Club CO_2's French CO_2 Utilization Working Group
3. Lessons learnt from the “International Overview of CCU Symposium” (Paris, France, July 2nd 2018)
4. Final Conclusions of the Symposium

BRIEF REVIEW OF CO_2 UTILIZATION TECHNOLOGIES

Definitions

CO_2 Utilization:

- **Genuine utilization of CO_2**, diluted, partially concentrated or highly purified, depending on the utilization processes
- Based on **physical**, **chemical** or **biological** processes

CO_2 Valorization: giving added-values to the Utilization (a step forward):

- CO_2 Valorization addresses the three pillars of **Sustainable Development**.
- **An environmental value**: by avoiding CO_2 emissions, limiting fossil fuel and raw materials requirements and improving the carbon footprint of products,
- **An economic value** with strong and reliable business models. Could be a way to deploy circular economy.
- **A societal value**, by protecting human health (mitigation of CO_2 emissions and other pollutants) and developing employment.

BRIEF REVIEW OF CO_2 UTILIZATION TECHNOLOGIES

Processes

Physical CO_2 Utilization routes:

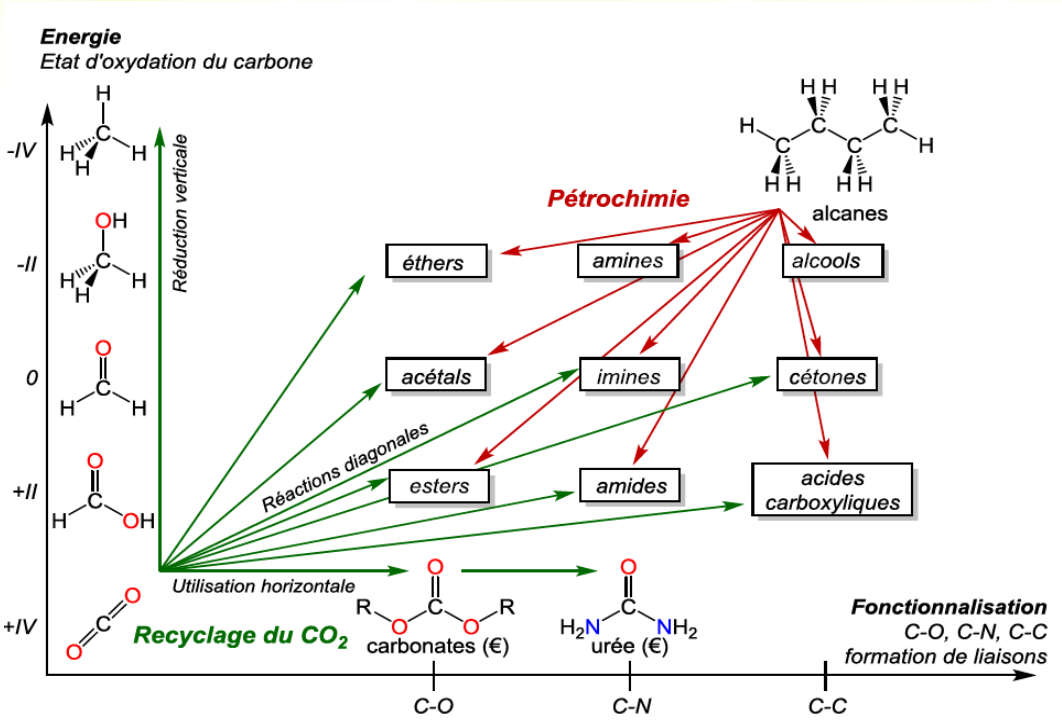
- EOR, EGR, CO_2-Fracturing for Hydrocarbon Recovery,
- CO_2-Assisted geothermal (cf. "Task Force on Utilization Options for CO2: Phase 2 Report")

(Mineral and Organic) Chemical CO_2 Utilization routes:

- Reduction of C,
- Functionalization,
- Mix reduction/functionnalization (« diagonal approach ») with catalysts

Biological CO_2 Utilization routes:

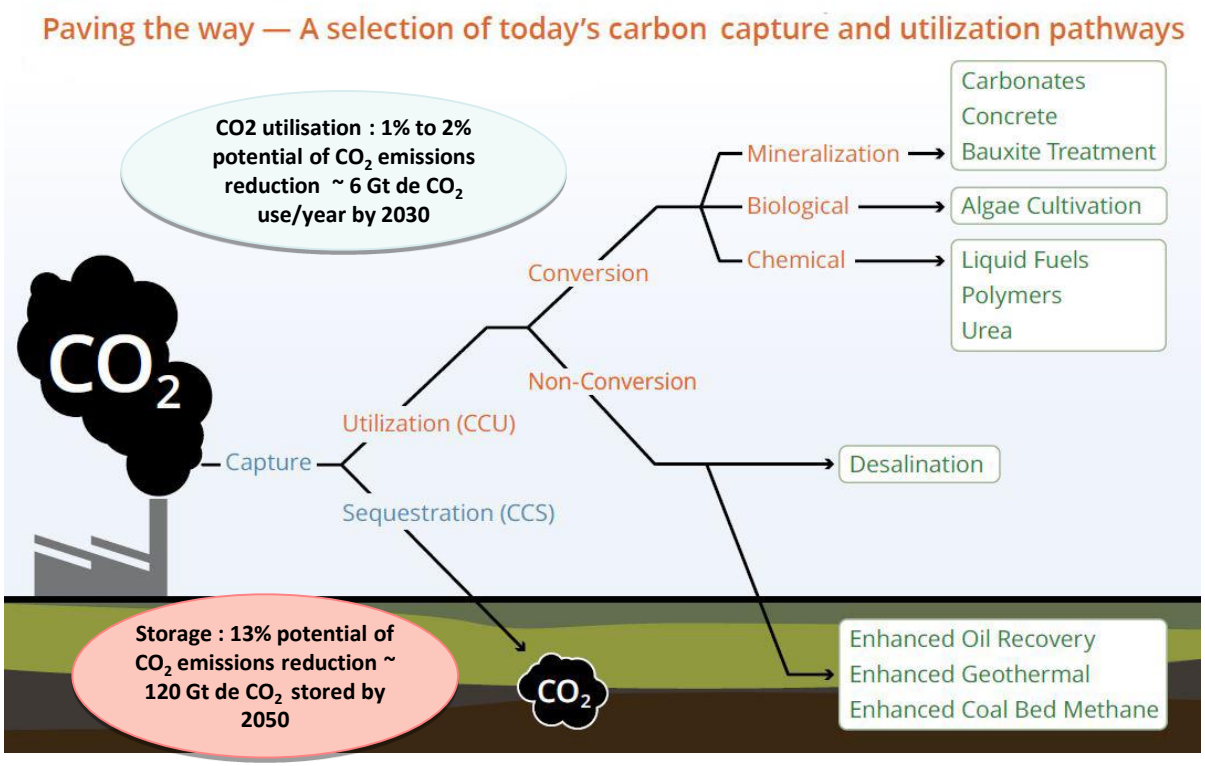
Utilization of organisms to convert CO_2 into chemicals (microalgae, bacteria,…)



Source : Blondiaux, "Recyclage du CO_2 : une alternative à la pétrochimie pour la synthèse de molécules azotées", 2015
Adapted from Cantat et al., "A Diagonal Approach to Chemical Recycling of Carbon Dioxide: Organocatalytic Transformation for the Reductive Functionalization of CO_2", Angew. Chem. Int. Ed. 2012, 51, 187 –190

The CCUS value chain: an efficient solution to reduce emission for the carbon-intensive industry

180 Mt_{CO2} are used today for manufactured products (mainly for urea and inorganic carbonates)



Focus on:

- Potential of CO_2 emission reduction taking into account the entire lifecycle
- Scale of the technologies and maturity
- Market size

From Pembina and ICO2N

ACTIONS OF CLUB CO_2'S FRENCH CO_2 UTILIZATION WORKING GROUP

11 actions completed or ongoing:

SWOT Analyses

Recommendations for COP21

Task 10 – Assessment of Environmental benefits of CCU

→ Workshop in Paris, March 30th 2018

→ International CCU Symposium, Paris, July 2nd 2018

CO_2 Utilon Workshops (2015, 2016)

- **Mapping of French Stakeholders**
- **Brochure of labs activities**

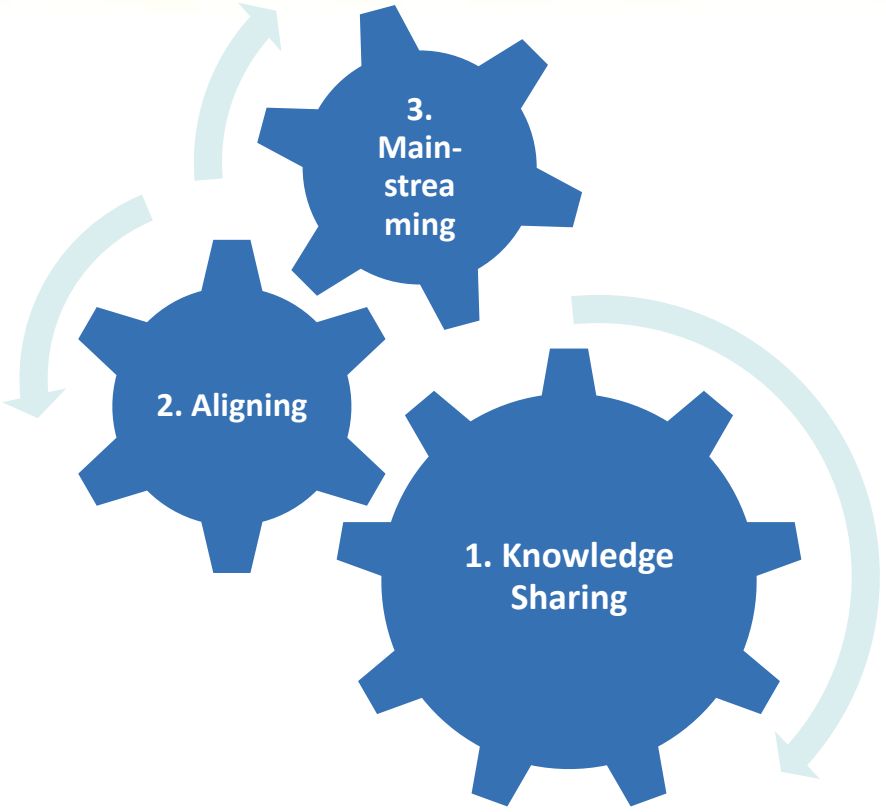
Task 9 – Video on CCU

→ On-going

ACTIONS OF CLUB CO_2'S FRENCH CO_2 UTILIZATION WORKING GROUP

Stakeholders and Objectives:

- Working Group of Club CO_2
- 24 members: industries (Majors and SMEs), public bodies (national and regional-level), public research
- Started in 2013
- Objective:
  - **Sharing** on CO_2 utilization technologies and their potential
  - **Aligning** on key learnings
  - **Mainstreaming** recommendations on CO_2 Valorisation for France



LESSON LEARNED FROM THE INT[AL] CCU SYMPOSIUM (PARIS, JULY 2018)

Facts & Figures

- **Paris, July 2nd 2018; 150 attendees ;** Symposium held before ISO TC/265 Paris' meeting

- **Introduction:**
  - **European context and regulatory framework:** Implications for research and innovation, EC-DG RTD
  - **Potential global market of CCU**, Global CO_2 Initiative
- **1 plenary session with a review per country** of:
  - Policies in terms of GES emissions reduction targets
  - Actors in CCUS
  - Key projects
  - Misc. Topics: international initiatives, questions,…
  - 11 pays presented: Australie, South Korea, China, India (not presented but slide deck available), Germany, The Netherlands, Norway, France, UK, Mexico (webex), Canada
- **Conclusions by IEA**

LESSON LEARNED FROM THE INT[AL] CCU SYMPOSIUM (PARIS, JULY 2018)

Facts & Figures

- **Status of LCA guidelines for CCU:**
  - EU-Methodology for quantifying GHG for fuels from CCU (JRC)
  - US-LCA Guidelines for CCU (NETL, webex)
  - International-LCA guidelines from CO2 Global Initiative (Aachen University)
- **1 Workshop session:**
  - 4 teams working on LCA barriers for CO_2-to-fuels, chemicals, mineralization, bioconversion
  - 1 team working on standardization

- More : **Zone poster of French CCU projects** + **Brochure of French labs working on CO_2 utilization**

- 88% of attendees satisfied or very satisfied by the symposium

LESSON LEARNED FROM THE INT[AL] CCU SYMPOSIUM (PARIS, JULY 2018)

Country	Key fact / project about CCU
Australia	Actors: **Mineral Carbonation International** Pty Ltd (MCi), a joint venture between the Greenmag Group, Newcastle University and Orica. Status: built and commissioned a **batch plant and a semi continuous plant** at the University of Newcastle
South Korea	1. **Korea CCUS Program** (2011-2020): 51 projects; 151 MUS$; **22% allocated to CCU for chemical and biological conversion** 2. National Strategic Project for Carbonization (2017~2022, 42 MUS$): • **Carbon Conversion Flagship** : Technology for separating and utilizing the C_1 gas of industrial by-product gas (US$ 23M) • **Carbon Mineralization Flagship**: directly utilizing low-concentration CO_2 emitted from a power plant to abandoned mine fillings (US$ 19M)

LESSON LEARNED FROM THE INT[AL] CCU SYMPOSIUM (PARIS, JULY 2018)

Reco #1	**Improve the definition of the "Goal and Scope"** (System boundaries, function, functional unit). **Application and local market should be identified in a first step to serve as basis for LCA.**
Reco #2	**Use LCA for screening and optimizing new CCU technologies at an early stage (even at lab scale).** It should not be the final analysis to perform after technology development at TRL9.
Reco #3	**Consider two different references for the reference scenario** (to be compared with the CCU-scenario): The current, most available process/technology, An environmentally competitive solution even if it's currently not economically viable.
Reco #4	**Make available more specific & reliable data,** eg CO_2 captured, data of CO_2 utilization processes, hydrogen,…
Reco #5	**A LCA is a multicriteria analysis to identify environmental burden transfer. Therefore, the global warming potential (GWP) should not be the only environmental impact assessed.** **The most relevant environmental impacts should also be assessed** (eg: land use, human toxicity, resource depletion, etc.). This assessment will be communicated to the **scientific community**. Specifically regarding CO_2, there is a need to figure out: 1. The amount of CO_2 utilized into the process 2. The amount of CO_2 avoided into the process 3. The GWP (considering upstream).

LESSON LEARNED FROM THE INT[AL] CCU SYMPOSIUM (PARIS, JULY 2018)

Reco #6	If it is decided to **aggregate the impacts:** • **An aggregation method of impacts should be agreed upon** • Or, at least, **a list of methodologies of aggregation should be clearly presented and defined** This assessment will be used by **policy makers to decide between technologies.**
Reco #7	**If system expansion is not considered, allocation of impacts should be done over the whole value chain from the CO_2 emitter to the actor using CO_2:** there is a need to define economic value creation/penalty and environmental benefits/burdens, and to share these values. **Make integrated assessments (economic and environmental)** even for low-TRL technologies.
Reco #8	**Make ISO technical prescriptions** of processes, properties and performances of products.
Reco #9	**Harmonized LCA guidelines for CCU processes through ISO standard should be define to address the main pitfalls (eg definition of FU, goal and scope,…).** **Technical prescriptions and standards may help to create a label for CO_2-based products/services.**

LESSON LEARNED FROM THE INT[AL] CCU SYMPOSIUM (PARIS, JULY 2018)

- CCUS plays a key role in achieving global climate targets: 15% to achieve 2°C, 32% to be below 2°C.

- The amount of CO_2 utilised and geologically stored is limited compared to global anthropogenic CO_2 emissions.

- CO_2 utilization is a subject for many countries linked to climate policies ; most of them plan to support research and demonstration projects in order to encourage new technologies and to improve their performances

- Eg : EU involvments:
  1. Horizon H2020 (240 M€ EU contribution), Horizon Europe (35G€ for tackling climate change)
  2. Inputs of SAM (EC Scientific Advisory Mechanism) based on existing research on the climate mitigation potential of CCU technologies
  3. ERANET ACT CCUS : international initiative to facilitate innovation, coordinated by Norway
  4. Initiative Phoenix on CCU: main goal is to link national and European RD&I activities
  5. ECCSEL gathers world-class research infrastructure in Europe for developing CCS technologies.
  6. Mission Innovation

LESSON LEARNED FROM THE INT[AL] CCU SYMPOSIUM (PARIS, JULY 2018)

- No CO_2 utilisation options are available today that meet the 3 criteria proposed by IEA (emission reduction, economic viability, market)

- However, according to Global CO_2 Initiative, market insights are promising:
  - By 2030 potential to utilize over 6 billion metric tons of CO_2 per year / generate $1US trillion/year.
  - Significant progress towards scalable technologies is needed.
  - Building materials, chemical intermediaries, fuels and polymers represent the biggest markets.

- CO_2 utilization addresses political and public acceptance drawbacks of CCS.

- Technologies of utilization and storage must be developed and deployed in parallel and not opposed.

Thank you for your attention