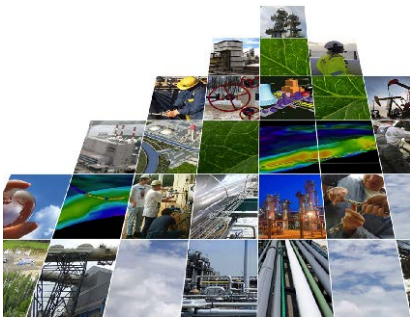
Report from CCS for EII task force

CSLF Technology Roadmap (TRM) 2017

- Objective
  - Provide recommendations to Ministers of the CSLF countries on technology developments that are needed to accelerate the deployment of CCS
- Contents
  - Emphasis on importance and urgency of CCS in light of COP21
  - Sections on industrial CCS, infrastructure, hubs and clusters, transport, storage and utilisation
  - Section on other applications:
    - BioCCS / H_2 production w/CCS



https://www.cslforum.org/cslf/sites/default/Files/2017CSLFTechnologyRoadmap.pdf

CSLF launched a task force on CCS on EII

Show how **CCS** in Energy Intensive Industries will contribute to the double target of **economic growth** and **climate change mitigation**

- The role of EII in economic growth and energy transition.
- Identify the most emitting EIIs and describe their emissions.
- For those EII,
  - identify the challenges and opportunities for CCS
  - and describe the development status of CCS
    - from lab scale to…
    - …large scale facilities

Our work is supported by commitments

- From a wide range of countries:
  - Norway, Canada, France, UAE, Saudi Arabia, Germany, Netherlands, USA.

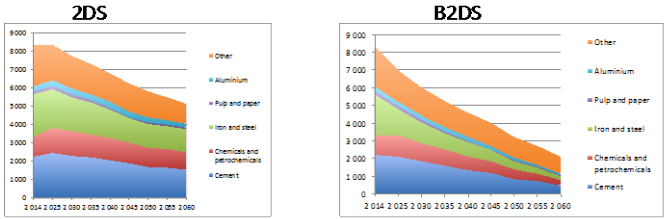
- From a wide range of professional and technical expertise:
  - Oil and Gas (upstream and downstream), Cement, Steel, Hydrogen, Chemicals, Fertilizers, Waste to Energy

- Special mention for Norway:
  - Fortum Oslo Varme, Norcem, Yara

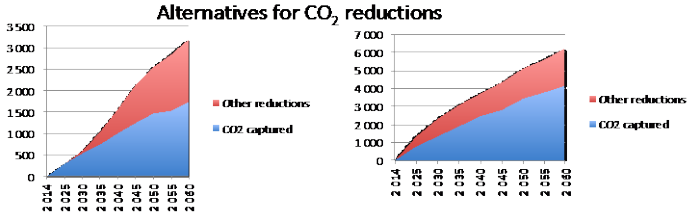
The role of CCUS in EII for CO2 emissions reduction

- World needs EII
- EII needs CCS
  - 40% reduction in 2DS
  - 75% reduction in B2DS

CO_2 emissions from EII, in Mt/year
(IEA Energy technology Perspectives 2017)



World needs CCS for EII



- Industries which are considered
  - Steel, cement, fertilizers, refining, natural gas, heavy oil, waste-to-energy, hydrogen, other chemical industries

IN WHAT IS CCS on EII = or ≠ Power ?

- Power emissions are significantly larger than individual EIIs' emissions, but cumulative EII's emissions are comparable to Power emissions.

- Significant CO2 emissions from EII are not linked to energy consumption.

  cement : $CaCO_3$=>$CaO + CO_2$ (60% of CO_2 emissions)

  steel : $2Fe_2O_3+3C$=>$4Fe+3CO_2$ (0.6t CO_2/tFe)

  hydrogen from SMR : CH_4+2H_2O=>$4H_2+CO_2$ (5,5tCO_2/tH_2)

  CO_2 from natural gas : separation from natural gas

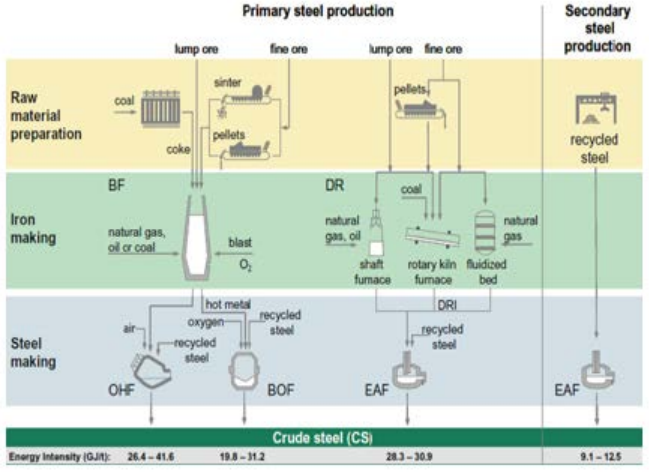
- CO_2 emissions characteristics depend very much on which EII and on which process of a given EII.

- More alternatives exist for Power than for most of EII.

A relevant level of description of EII emissions (quantity is not the full story)?

Example of a steel plant

	Primary energy[2] (GJ/t)	Direct energy[3] (GJ/t)	Total CO_2 emission[4] (tCO_2/t)	Direct CO_2 emission[5] (tCO_2/t)
Coke plant	6.827	6.539	0.824	0.794
Sinter plant	1.730	1.549	0.211	0.200
Pellet plant	1.204	0.901	0.075	0.057
Blast furnace	12.989	12.309	1.279	1.219
BOS plant	-0.253	-0.853	0.202	0.181
Electric arc furnace	6.181	2.505	0.240	0.240
Bloom, slab and billet mill	2.501	1.783	0.125	0.088
Hot strip mill	2.411	1.700	0.120	0.082
Plate Mill	2.642	1.905	0.133	0.098
Section Mill	2.544	1.828	0.127	0.084
Pickling line	0.338	0.222	0.016	0.004
Cold mill	1.727	0.743	0.075	0.008
Annealing	1.356	1.086	0.070	0.049
Hot dip metal coating	2.108	1.491	0.104	0.059
Electrolytic metal coating	4.469	2.619	0.208	0.046
Organic coating	1.594	0.758	0.074	0.003
Power Plant	12.173	12.173	1.989	1.989



	Blast Furnace	Basic Oxygen Furnace
CO2 concentration	25%	20%
Pressure	50mbar	20mbar
Temperature	30°C	30°C
Humidity	100%	100%
Impurities	Dust, H2S,…	Dust
Others	CO (25%)	CO (60%)

Is there a unique point of emission or are there multiple points?
CO2 stream characteristics : concentration, pressure, impurities

Steel – preliminary findings

- CO2 emission reductions are being performed without CCS:
  - Continuing with a fossil fuel based metallurgy
    - Increased recycling
    - Coal-to-gas
    - Change of steel making route
  - Shifting to a non-fossil based metallurgy
    - Use of carbon from sustainable biomass
    - Switch to H_2 as reducing agent, produced from electrolysis with carbon-free electricity

- **But it is only with CCS that CO2 emissions will be achieved in line with**
  - 2DS (55 to 60 % reduction) or B2DS (>80%),
  - or a net zero emissions target for this sector,
  - or even a net negative emissions target via BECCS

Some findings (1/2)

- EII are essential for the future economic growth
  - How to build 1 Shanghai every 4 months without cement and steel?
  - How to increase food production without fertilizers?

- And for energy transition
  - How to increase hydrogen production without fossil energy?
  - How to increase natural gas production without separating CO2 from natural gas?
  - How to build new energy generators and infrastructure without steel and cement?

- In most EII, CO2 emissions are not due to fossil fuel combustion only
  - For these types of emissions, low-carbon energies are not an alternative and alternatives will be either a change of process, or a substitution of one product to another one with the same characteristics without CO2 emissions.
  - Process CO2 streams may offer better characteristics than combustion CO2 (higher concentrations)

=> **Energy Intensive Industries could be requalified as Emission Intensive Industries**

Some findings (2/2)

- Almost all the industrial sectors will grow significantly in the next decades particularly in emerging countries.

- A particular case to be noted : Hydrogen production is anticipated to multiply by a factor higher than 5 until 2050.

- The most advanced industries are :
  - Natural gas treatment (by far the largest area for CCS industrial projects),
  - Hydrogen, steel, fertilizer, ethanol production industries have developped CCS projects.
  - Cement industry and waste to energy have no project yet, but… Norway!

- Beyond technology-linked challenges to be met, business models will have to be invented by the industries itself with the support of the public authorities.

Status and way forward for CSLF task force

- Draft versions of most EII chapters prepared
- Still some missing bricks.
- The target is still to be ready to publish the report ahead of the next annual CSLF meeting this fall.

Thank you for your attention


Club CO2
SAVE THE DATE
International overview of CO2 Utilisation
Symposium
2 July 2018, Paris

Club CO_2* is pursuing its involvement in the promotion of CO_2 utilisation (CCU) as a means of **reducing the carbon footprint of the economy**.

Recycled CO_2 can be used as a raw material in the manufacture of high added value products, materials or energy. After the first event held in Le Havre in May 2015, the second event held in Lyon in October 2016 and attended by experts and professionals from various backgrounds, **Club CO_2 will be organising a Symposium on "International overview of CO_2 Utilisation" on Monday 2nd July 2018 in Paris, France**.

The symposium will be break out in two events. The first one will be a Forum on "International status of CCU". The aim is to have a wide overview of CCU developments presented by Americas, Europe, Middle-East and Asia. The second event will be a workshop on "Which tools to enhance CCU ?". The focus will be an exchange among participants on standardisation and LCA as levers for the deployment of CCU.

Club CO_2 looks forward to your participation in these discussions on future prospects for CO_2 reuse.

*Club CO_2 is the French national hub in the field of CO_2 capture, transport, use and storage (CCUS) bringing together the major stakeholders from industry and research (website : www.captage-stockage-valorisation-co2.fr/en/home)
Contact : contact.clubco2@ademe.fr

ANNEX

Agreement of Paris

Reach global peaking of GHG emissions as soon as possible

Achieve a balance between anthropogenic emissions and removals by sinks of GHG in the second half of this century

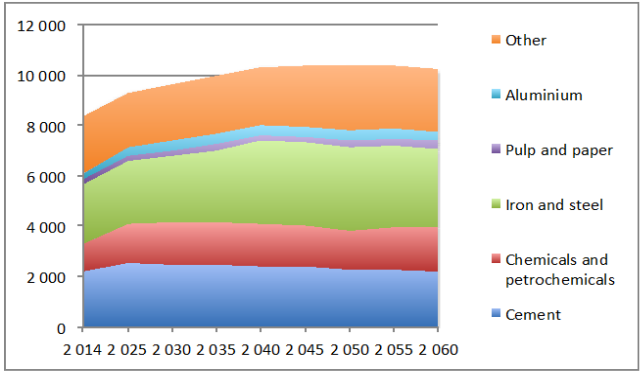
World needs CCS…

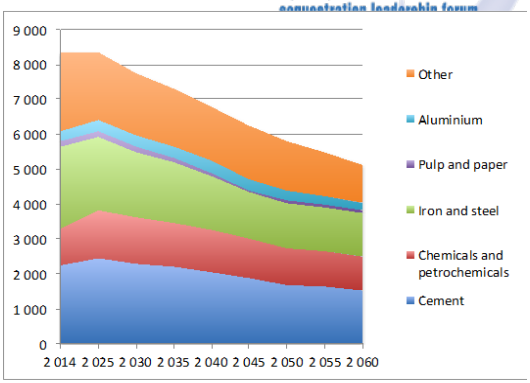
Balance between emissions and sinks means that owing to CCS : some sectors might not be zero emissions,

- But certainly not the Energy Intensive Industries,
- Need to develop negative emissions projects (an opportunity for EII?)

=> EII needs CCS

Which industries to consider?





- Cement
- Steel
- Chemicals
- Refining
- Natural gas
- Heavy oil
- Hydrogen
- Fertilizers
- Waste to energy

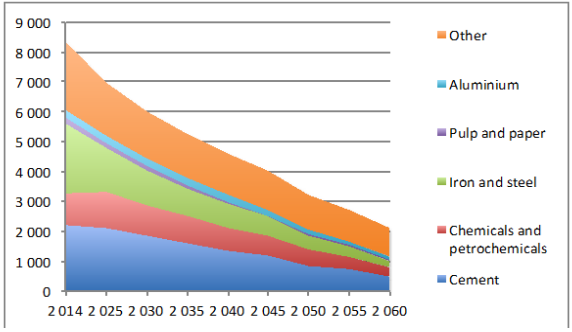
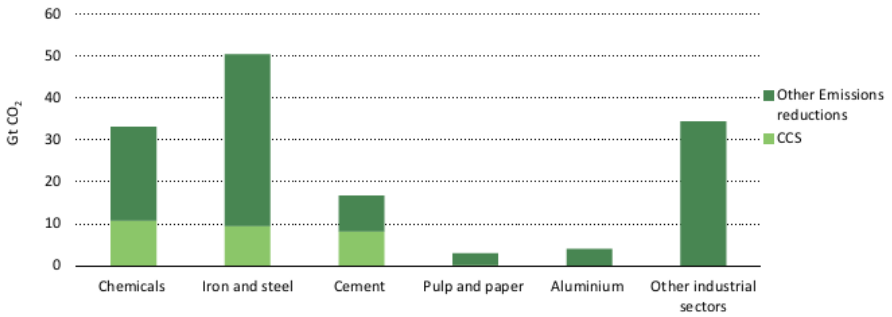


Figure 1.2. CO_2 emissions in Mt CO_2/year from industry in RTS (upper left), 2DS (upper right) and B2DS (lower) scenarios (from IEA, 2017).

Why CCUS for industry is an important issue

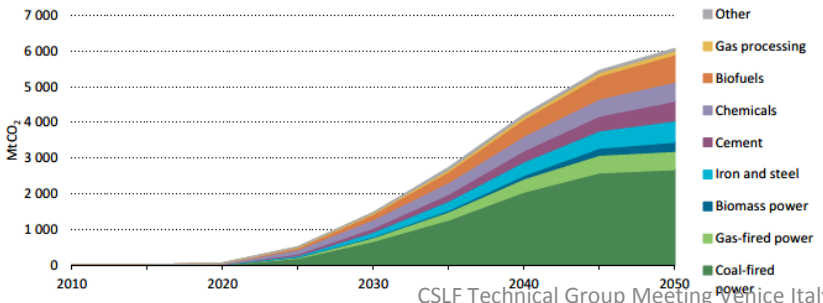
Example :
CaCO3 => CaO+CO2

Figure 2.3 • Cumulative emissions reductions from CCS in industry (2DS relative to 6DS)



Source: Derived from IEA (2016b), *Energy Technology Perspectives 2016*.
Note: There are 97 $MtCO_2$ captured from pulp and paper production

Figure 2.2 • Power and industry are the predominant sources of CO_2 captured in the 2DS



Source: Derived from IEA (2016b), *Energy Technology Perspectives 2016*.

CCS industry = CCS power

Source : IEA