MAPPING THE COST OF CCUS TECHONOLOGIES: FROM PARTIAL CAPTURE TO NEGATIVE EMISSIONS

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Motivation: how to explain the slow development of CCS ... and BECCS ?

How to build up a sustainable business model for CCS ?

- Such a business model requires:
  - A low-cost carbon source
  - A convenient carbon sink
  - A profitable carbon use
  - A suitable transport network
- And:
  - Operators at each step of the CCS chain
  - Public Support
- By now, only EOR has had the ability to mobilize all these leverages in order to build up a complete CCS chain.

BECCS: from partial capture to negative emissions

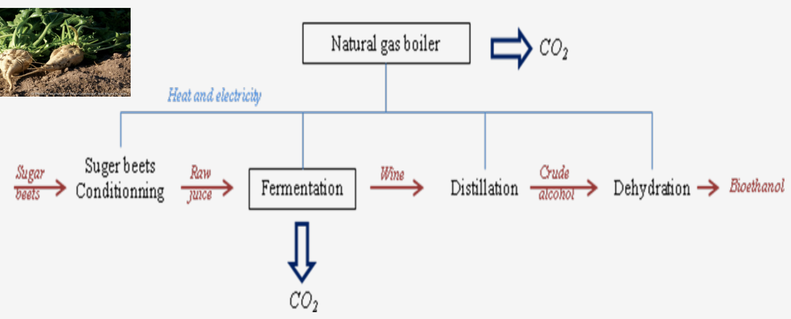
- Partial capture could help an earlier development of CCS at a lower cost than total capture
- Carbon use could also encourage CCS deployment.
- Bioenergy with carbon capture and storage (BECCS) has both abilities to develop partial capture process at a low cost, and then to reach negative emissions... At a higher cost

An alternative technical design: add geothermal energy to CCS

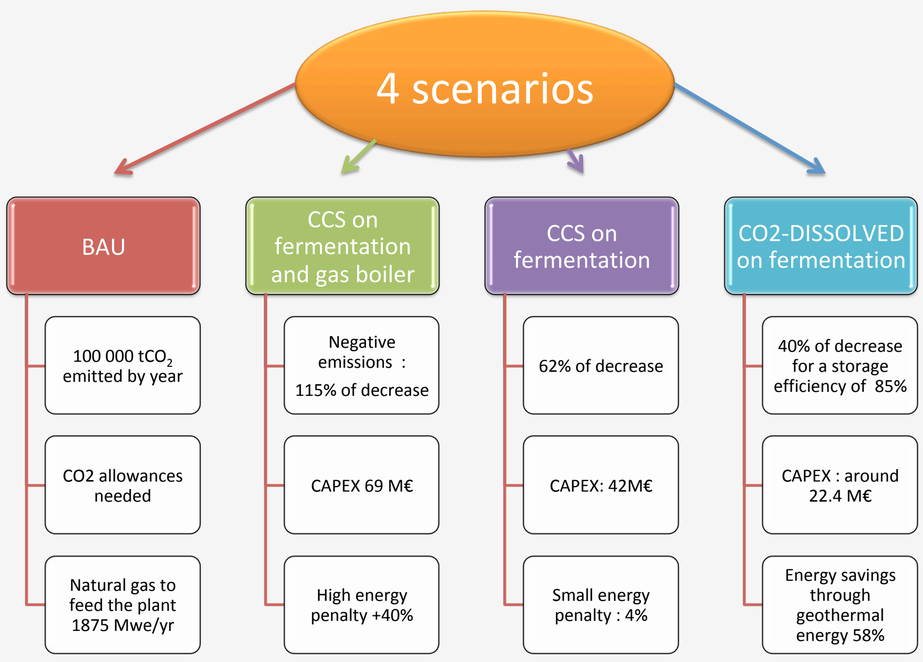
- Combining CCS with geothermal energy could reduce this cost
- This is proposed by the CO2-DISSOLVED technology
- The reduction cost leads to lower CO_2 storage cost than « usual » CCS
- A first techno-economic analysis is provided on a biorefinery producing bioethanol

The case study : CO_2-DISSOLVED on a bioethanol plant

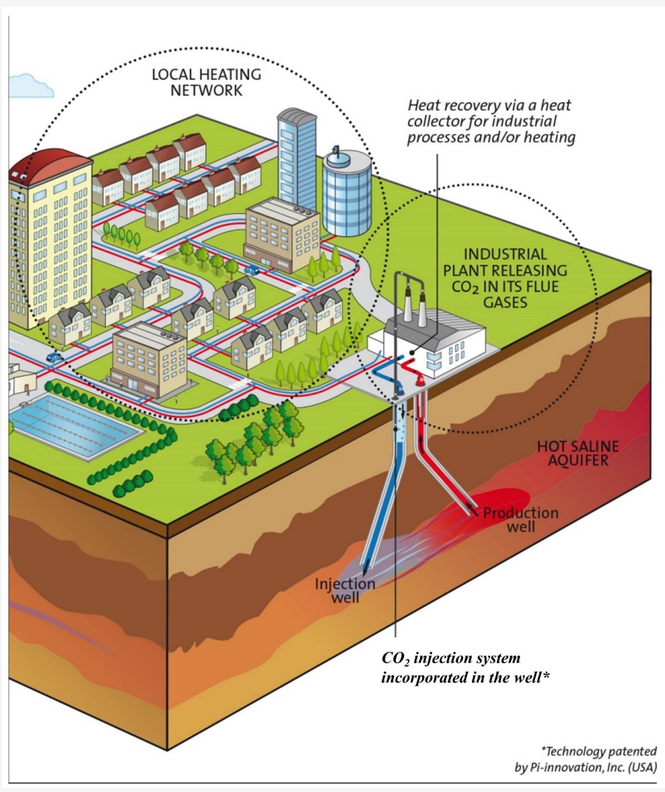
The case study : bioethanol from sugar beets



2 sources of CO_2 on this factory : fermentation and natural gas boiler that feeds it.
Negative emissions happens only for CCS on both sources



A Synergy between CCS and geothermal energy



The flue gas emitted from the fermentation process by the plant is almost pure CO_2 that is captured, compressed, and then dissolved in the reinjected cold brine (highly salted water) to be definitively stored in the exploited aquifer.
The second well (the production well) retrieves the warm brine from the aquifer. The brine heat is recovered trough a heat exchanger system and can be used, either for feeding part of the plant energy needs or for another domestic use (e.g.: heating network).

Advantages of CO_2-DISSOLVED

- Less expensive
- Designed for small emitters
- Reduced energy penalty
- Increased safety of storage

Real Option Modelling

NPV of CO_2-DISSOLVED

$\sum t=2020\uparrow 2050 \blacksquare q\downarrow avoided\ P\downarrow c\ (t)+q\downarrow saved\ gas\ P\downarrow g\ (t)-OPEX/(1+r)\uparrow t-2020\ -K$

Decision rule:

if $V(t) > \mathbb{E}[V(t+1)]$, *I invest at t*
Otherwise, I wait

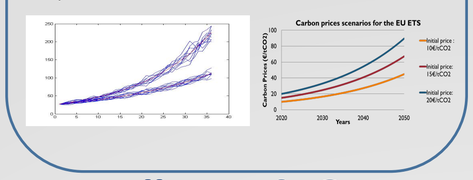
$V(t)$ Value of the project (NPV for the specific simulation) at t

$\mathbb{E}[V(t+1)]$, Expectancy value of the project at t+1

Carbon price simulation:

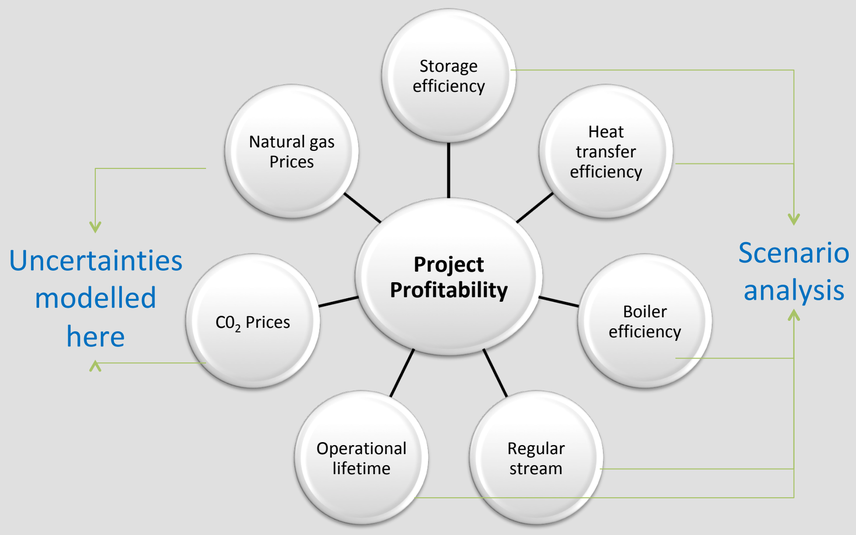
Mean reverting process, volatility yearly of 5%

Example of simulation :



Calibration and Results

Economic results are depending on a whole set of hypothesis, see Laude et al (2011) and Royer-Adnot and Le Gallo (2017)



Operational lifetime of 20 years

AVERAGE

Gas Price \ Carbon price	10	15	20
18			
26			
31			

HIGH

Gas Price \ Carbon price	10	15	20
18			
26			
31	82	89	95

Operational lifetime of 30 years

AVERAGE

Gas Price \ Carbon price	10	15	20
18			83
26		78	91
31		84	94

HIGH

Gas Price \ Carbon price	10	15	20
18		86	96
26	81	94	99
31	89	98	99

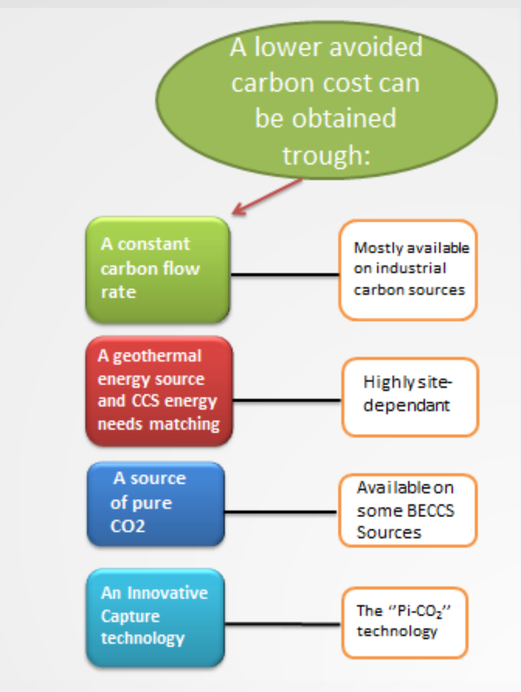
Operational lifetime and storage efficiency have considerable effects on investment. With the best assumption, the project is profitable, almost whatever the initial prices.

Probability of investment below 50%

Probability between 50% and 75%

Probability above 75%

Towards a "best case" study?



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