Let us speak about CCS (Carbon Capture Storage)

Although diffuse GHG (in particular those resulting from transports) remain difficult to manage, Carbon Capture Storage (CCS) seems to be one of the best answer to process significant CO_2 emissions (over 100,000 tons per year) such as those resulting from industry (cement, glass, iron, petrochemicals) or big thermal power plants.

After capturing CO_2 from point sources, it consists in transporting then re-injecting it into a dedicated geological formation (**Figure 1**).

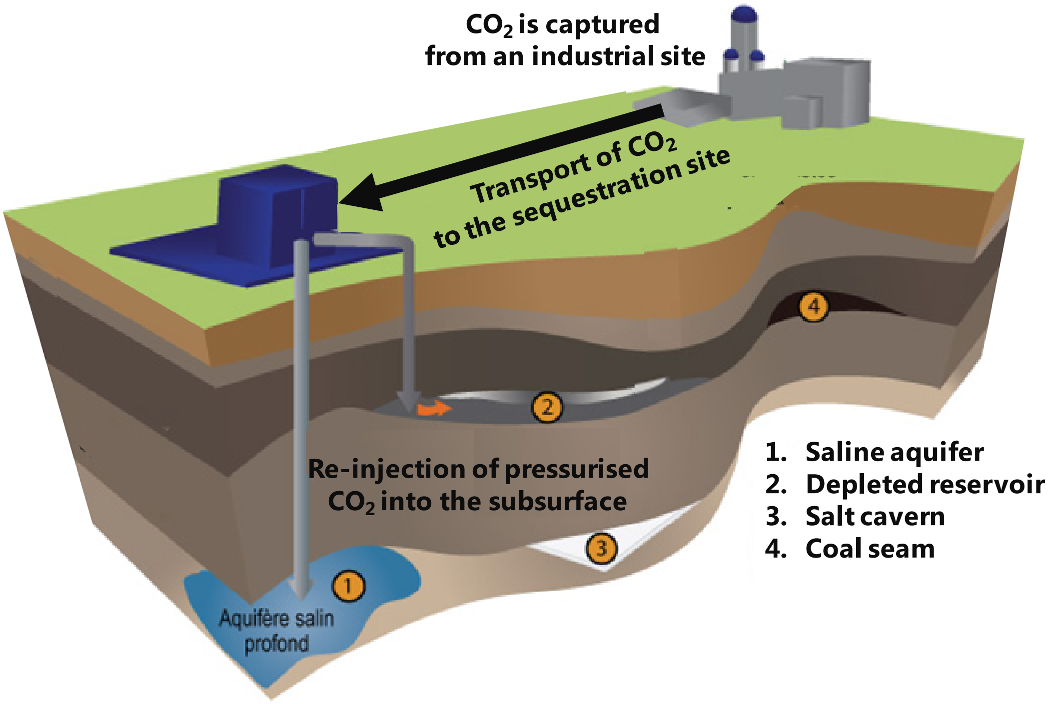

Figure 1 – Carbon & capture storage

As most industrial facilities use combustion with air, the CO_2 emitted is highly diluted by nitrogen. To capture CO_2 from flue gases, a liquid solvent such as Mono Ethanol Amine is used. Still at the experimental level, oxy-combustion consists in burning fuel directly with oxygen to produce a fuel gas with a high CO_2 (80% to 90% by volume) concentration, which can be re-injected without any treatment. This method requires, however, the production of oxygen which has a significant impact on the cost of the overall process.

Once captured, CO_2 can be re-injected into various types of geological formations such as saline aquifers, depleted oil reservoirs or coal seams. Key question are:

(1) the long term (hundreds to thousands of years) mechanical (fracturing) and chemical (reaction of faults to acid "attack") integrity of the overburden, leaving the CO_2 to migrate in the overlying formations to the surface

(2) the long term integrity of injection wells

(3) the very energy-intensive CO_2 capture and compression process which may increase the fuel needs of a power plant by 25 to 40%.

A number of pilot projects are underway. The oil and gas industry has been the pioneer and remains today by far the most proactive industry when it comes to promoting and implementing CCS plants (**Figure 2**). In 2012, among the 36Mtons of CO_2 injected per year, 80% came from oil & gas projects.

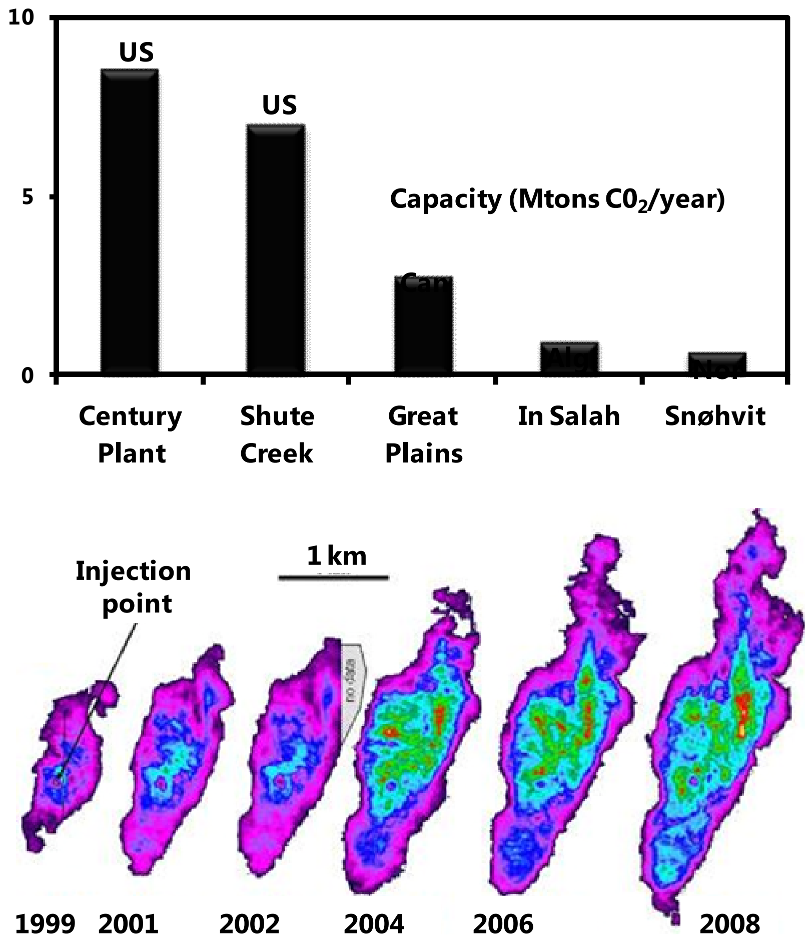

Figure 2 – Major CCS plants related to oil and gas
Visualization of CO_2 storage using 4D seismic (Sleipner field[1] – Norway)

The Sleipner field (Norway) for which the injection of CO_2 started in 1996, has been regularly monitored. The repetitive 3D seismic has established that the CO_2 was

[1] HB-Erik (2005) "Technology as a driving force in climate policy". *Cicerone*

contained in the formation with no leakage through the cap rock (**Figure 2**). The injected carbon dioxide currently covers about 3km^2 of the 26,000 km^2 roughly available in the Utsira formation.

Although the technology is not yet cost effective, it is expected to be commercially viable after 2030, providing that a favorable regulatory, commercial and political framework to be put in place.

From a global point of view, CCS could reduce cumulated CO_2 emissions of a power plant by 80% to 90%. According to IEA, it could contribute in 2040 to 14% of the total mitigation effort. The US National Energy Technology Laboratory[2] reported that North America has enough storage capacity for more than 900 years at current production rates. However, this would need to sequestrate in the subsurface 80 $Gtons_{CO2}$ to be compared to $30Mtons_{CO2}$ sequestrated in 2015 and the 106 $Mtons_{CO2}$ planned for 2020[3]. There is therefore a large gap between what is reasonable today and envisaged in the longer term.

Over the last decade, Europeans have remained relatively discreet in terms of CCS. Activity has mainly moved to the United States and China. In 2020 they will account for 82% of the sequestered volume.

Several blocking factors could penalize the future of CCS.

- the host formations are far fewer than originally assumed,
- the characterization of a reinjection site can take five to ten year
- Although CCS is perceived as a key technology to reduce future CO_2 emissions many stakeholders remain hostile to its implementation. In particular, they consider that the world experience is too limited. The various "pilot" trials will play a vital role in establishing a positive perception. It is also essential that authorities and project managers commit themselves to all stakeholders to demystify a technology that can sometimes be perceived as a threat.

The target of 14% by 2050 does not seem very realistic.

[2]NETL (2007) Carbon Sequestration Atlas
[3] Global CCS institute (2014) The global status of CCS