# Potential of CO2 capture and geological storage in the world

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***In Les Cahiers du CLIP* n°17, IDDRI, Paris, 2005/09.**

## Abstract

Large scale use of fossil fuels as primary energy source has resulted in large $CO_2$ emissions. It is now generally admitted and proved that emissions of greenhouse gases (GHG) or more precisely the increasing atmospheric concentrations of GHG cause a temperature rise and are likely to influence global climate.

An important sector regarding GHG emissions is power generation, accounting for almost 40% of the world total energy related $CO_2$ emissions. $CO_2$ emissions are either concentrated or diffuse. Many methods exist for carbon capture and storage, adapted either to concentrated sources of carbon emissions (geological storage) or to both concentrated and diffuse sources (biological storage). This study focuses on geological carbon storage and its potential for carbon capture for $CO_2$ emitted from electricity production. Two main objectives are studied : the first aim of this study is to assess, from now to 2050, the potential for carbon capture at the global scale, for emissions coming from electricity production form fossil fuels (coal, oil and gas); the second aim is to compare capture and storage potentials. In order to estimate the potential for carbon storage once captured, this study focuses on storage in oil and gas fields, which are the best known at the time.

### *Capture potential*

The first step for such a study is to estimate power generation from now to 2050. The IPCC B1 scenario was used, from which the power generation in 2050 was estimated to 60000 TWh, almost 4 times the 2000 electricity production. To define the capture scenarii, newly installed power plants have to be identified for each year of the time frame, in order to adapt the scenarii to the new capture technologies. Capture efficiency may indeed vary significantly between technologies adapted to existing power plants (post-combustion) and technologies adapted to new power plants (pre-combustion). Several assumptions have been taken into account :

- the life time of a power plant is supposed to be 40 years,
- the annual growth of the power demand from fossil fuels is supposed to be supplied for by newly installed power plants,
- capture equipment is supposed to be in use after 2020, at a rate of 100% for new plants and 10% annually for existing plants under 30 years,
- all plants above 200 MW and 5000 hr/yr are equipped for capture,
- for any plant installed between 2000 and 2020, electric efficiencies are supposed to be equal to the present values, whereas for all plants installed between 2020 and 2050, a decrease in fuel consumption is taken into account, equal to 7% in case of a plant using coal or oil, and 10% for a plant using natural gas.

Without capture starting from 2020, the B1 scenario leads in 2050 to almost 25 Gt $CO_2$/yr emitted by power generation from fossil fuels, that is to say 3.5 times the 2000 emission level. Coal power plants, especially in China, represent 60% of the total amount. Cumulated emissions between 2000 and 2050 rise up to 870 Gt $CO_2$. With those optimistic assumptions and if the storage capacities are supposed large enough, it would be possible to sequester 66% of the 2050 emissions and so doing to limit the growth of $CO_2$ emissions from electricity production at 16% of the B1 level along the time frame 2000-2050. During this period, the capture of emitted $CO_2$ could avoid 375 Gt $CO_2$, or 45% of cumulated emissions. But capture implies also an energetic cost, and consequently supplementary emissions. Those emissions could rise up to 3.5 Gt $CO_2$ in 2050, or to 85 Gt $CO_2$ if cumulated between 2000 and 2050.

### *Storage potential*

Here are taken into account storage potentials from $CO_2$ injection in oil and gas fields. As for oil fields, $CO_2$ injection may at the same time store carbon and increase the oil recovery

depleted fields. Storage estimates in oil fields are based here on several studies, that give the quantity of additional oil recovered and of carbon stored during injection, depending on fields properties. Storage may vary between 0,2 and 2,8 kg $CO_2/m^3$ of oil in ground for small fields and between 1,5 and 8,8 kg $CO_2/m^3$ of oil in ground for large fields, depending on the technology used. The global storage potential is the sum of the potentials of all fields. As for natural gas fields, this study doesn't take into account the size of the fields, but the potential storage lies between 1,5 and 8,8 kg $CO_2/m^3$ of natural gas.

Based on those assumptions, the potential storage may be between 560 and 1170 Gt $CO_2$. Middle East and Russia are the two main regions in terms of storage potential, with 60% of the total world potential.

***Potential comparison at the regional scale***

At the global scale, the storage potential could be enough to absorb the 460 Gt $CO_2$ captured between 2020 and 2050. Nevertheless, at the regional scale, disparities are large between possible capture and storage. Three main groups can thus be distinguished :

- Region of large surplus, for which the potential storage is at least 3 times larger than the total amount of captured $CO_2$ (Middle East, former USSR, South America, North and West Africa). But the total capture potential of those region represents only 17% of the world capture potential from now to 2050.
- Region of surplus, where the potential storage is larger than captured emissions, but with a ratio lower than 3 (OECD Europe, Oceania, South East Asia and Central America). The potential difficulty for those regions are the necessary investments for the introduction of $CO_2$ capture in 2020, because more than 80% of the potential storage are in offshore fields, that may be mature before 2020.
- Overdrawn regions, where the storage in oil and gas fields is not enough to absorb captured emissions (Eastern Europe, Canada, USA, South Asia of which India, Eastern Asia of which China, Japan, South Africa and Eastern Africa). Those regions represent 83% of the capture potential but only 9% of the storage potential.

If a threshold of 1000 km is taken into account between the source of emissions and the storage location, the resulting potential for carbon capture and storage is significantly reduced. The countries representing 80% of the global capture potential could only store 126 Gt $CO_2$, in other words avoid 16% of their emissions from power generation cumulated between 2000 and 2050. Among those countries, China, India and USA, representing 53% of the world capture potential, could only store 72 Gt $CO_2$ that is to say avoid 14% of their emissions from power generation cumulated between 2000 and 2050.

The development of capture and storage of carbon in the power sector implies to overcome several difficulties from now to 2020, as well from an economical point of view as from a technical point of view. The potential of such technologies to reduce $CO_2$ emissions depends on the real capacities of saline aquifers and unusable coal mines, that are both little known at the time. Taken into account the slow development as well as the uncertainties of this technology, carbon capture and storage may only be a partial solution in the long term. Other policies are needed, such as electricity demand control and the use of more controlled alternatives (renewable energy use, cogeneration).