



Scientific Facts on CO₂ Capture and Storage

Source document:
IPCC (2005)

Summary & Details:
GreenFacts

Context - Carbon dioxide (CO₂) is a major greenhouse gas that contributes to Earth’s global warming. Over the past two centuries, its concentration in the atmosphere has greatly increased, mainly because of human activities such as fossil fuel burning.

One possible option for reducing CO₂ emissions is to store it underground. This technique is called Carbon dioxide Capture and Storage (CCS).

How does it work? Could it really help addressing climate change?

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This Digest is a faithful summary of the leading scientific consensus report produced in 2005 by the Intergovernmental Panel on Climate Change (IPCC): *"Special Report on Carbon Dioxide Capture and Storage: Technical Summary"*

The full Digest is available at: <https://www.greenfacts.org/en/co2-capture-storage/>

i This PDF Document is the Level 1 of a GreenFacts Digest. GreenFacts Digests are published in several languages as questions and answers, in a copyrighted user-friendly Three-Level Structure of increasing detail:

- Each question is answered in Level 1 with a short summary.
- These answers are developed in more detail in Level 2.
- Level 3 consists of the Source document, the internationally recognised scientific consensus report which is faithfully summarised in Level 2 and further in Level 1.

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1. What is carbon dioxide capture and storage?

1.1 Carbon dioxide (CO₂) is a greenhouse gas that occurs naturally in the atmosphere. Human activities, such as the burning of fossil fuels and other processes, are significantly increasing its concentration in the atmosphere, thus contributing to Earth's global warming.



Possible CCS systems
[see Annex 1, p. 6]

One technique that could limit CO₂ emissions from human activities into the atmosphere is Carbon dioxide Capture and Storage (CCS). It involves collecting, at its source, the CO₂ that is produced by power plants or industrial facilities and storing it away for a long time in underground layers, in the oceans, or in other materials. It should not be confused with carbon sequestration, which is the process of removing carbon from the atmosphere through natural processes such as the growth of forests.

1.2 It is expected that fossil fuels will remain a major energy source until at least the middle of this century. Therefore, techniques to capture and store the CO₂ produced, combined with other efforts, could help stabilize greenhouse gas concentrations in the atmosphere and fight climate change.

2. What sources of CO₂ emissions are suitable for capture and storage?

2.1 Carbon dioxide could be captured from power plants or industrial facilities that produce large amounts of carbon dioxide. Technology for CO₂ capture from small or mobile emission sources, such as home heating systems or cars, is not sufficiently developed yet.

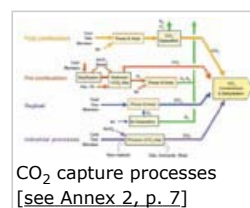


The Gibson coal power plant, a large stationary source.
Source: John Blair, valleywatch.net [see <http://valleywatch.net>]

2.2 A significant proportion of the CO₂ produced by fossil fuel power plants could potentially be captured. By 2050 the amount captured could represent 21 to 45% of all the CO₂ emitted by human activities.

3. How do CO₂ capture technologies work?

3.1 To capture carbon dioxide (CO₂) it is first separated from the other gases resulting from combustion or industrial processes. Three systems are available for power plants: post-combustion, pre-combustion, and oxyfuel combustion systems. The captured CO₂ must then be purified and compressed for transport and storage.



CO₂ capture processes
[see Annex 2, p. 7]

3.2 It is possible to reduce the CO₂ emissions from new power plants by about 80 to 90%, but this increases the cost of electricity produced by 35 to 85%. For industrial processes where a relatively pure CO₂ stream is produced, the cost per tonne of CO₂ captured is lower.

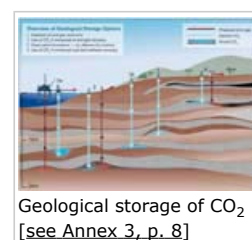
4. How can CO₂ be transported once it is captured?

4.1 Except when the emission source is located directly over the storage site, the CO₂ needs to be transported. Pipelines have been used for this purpose in the USA since the 1970s. CO₂ could also be transported in liquid form in **ships** similar to those transporting liquefied petroleum gas (LPG).

4.2 For both pipeline and marine transportation of CO₂, costs depend on the distance and the quantity transported. For pipelines, costs are higher when crossing water bodies, heavily congested areas, or mountains.

5. How can CO₂ be stored underground?

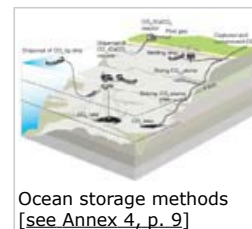
5.1 Compressed CO₂ can be injected into porous rock formations below the Earth's surface using many of the same methods already used by the oil and gas industry. The three main types of geological storage are oil and gas reservoirs, deep saline formations, and un-minable coal beds. CO₂ can for instance be physically trapped under a well-sealed rock layer or in the pore spaces within the rock. It can also be chemically trapped by dissolving in water and reacting with the surrounding rocks. The risk of leakage from these reservoirs is rather small.



5.2 Storage in geological formations is the cheapest and most environmentally acceptable storage option for CO₂.

6. Could CO₂ be stored in the deep ocean?

6.1 Oceans can store CO₂ because it is soluble in water. When the concentration of CO₂ increases in the atmosphere, more CO₂ is taken up by the oceans. Captured CO₂ could potentially be injected directly into deep oceans and most of it would remain there for centuries.



6.2 CO₂ injection, however, can harm marine organisms near the injection point. It is furthermore expected that injecting large amounts would gradually affect the whole ocean.

Note from the editor: Because of its environmental implications, CO₂ storage in oceans is generally no longer considered as an acceptable option.

7. How can CO₂ be stored in other materials?

7.1 Through chemical reactions with some naturally occurring minerals, CO₂ is converted into a **solid form** through a process called mineral carbonation and stored virtually permanently. This is a process which occurs naturally, although very slowly.

These chemical reactions can be accelerated and used industrially to artificially store CO₂ in minerals. However, the large amounts of energy and mined minerals needed makes this option less cost effective.

7.2 It is technically feasible to use captured CO₂ in **industries** manufacturing products such as fertilisers. The overall effect on CO₂ emissions, however, would be very small, because most of these products rapidly release their CO₂ content back into the atmosphere.

8. How cost-effective are different CO₂ capture and storage options?

8.1 It is expected that carbon capture and storage would raise the cost of producing electricity by about 20 to 50%, but there are still considerable uncertainties.



The Esbjerg Power Station, a CO₂ capture site in Denmark Source: DONG Energy

In a fully integrated system including carbon capture, transport, storage, and monitoring, the capture and compression processes would be the most expensive steps. Geological storage is estimated to be cheaper than ocean storage, the most expensive technology being mineral carbonation. Overall costs will depend both on the technological choices and on other factors such as location or fuel and electricity costs. Capture and storage of CO₂ produced by some industrial processes such as hydrogen production can be cheaper than for power plants.

9. How could emission reductions be quantified?

Methods are still needed to estimate and report the amounts of greenhouse gas emissions reduced, avoided, or removed from the atmosphere. While one tonne of CO₂ permanently stored brings the same benefit as one tonne of CO₂ not emitted, one tonne of CO₂ temporarily stored brings far less benefit.

The methods currently available for national greenhouse gas emissions inventories can be adapted to accommodate CO₂ capture and storage systems. Some issues remain to be addressed through national and international political processes.

10. Conclusion: the future of CO₂ capture and storage

10.1 CO₂ capture and storage is technologically feasible and could play a significant role in reducing greenhouse gas emissions over the course of this century. But many issues still need to be resolved before it can be deployed on a large scale.

Full-scale projects in the electricity sector are needed to build knowledge and experience. More studies are required to analyse and reduce the costs and to evaluate the suitability of potential geological storage sites. Also, pilot scale experiments on mineral carbonation are needed.

An adequate legal and regulatory environment also needs to be created, and barriers to deployment in developing countries need to be addressed.

10.2 If knowledge gaps are filled and various conditions are met, CO₂ capture and storage systems could be deployed on a large scale within a few decades, as long as policies substantially limiting greenhouse gas emissions are put into place.

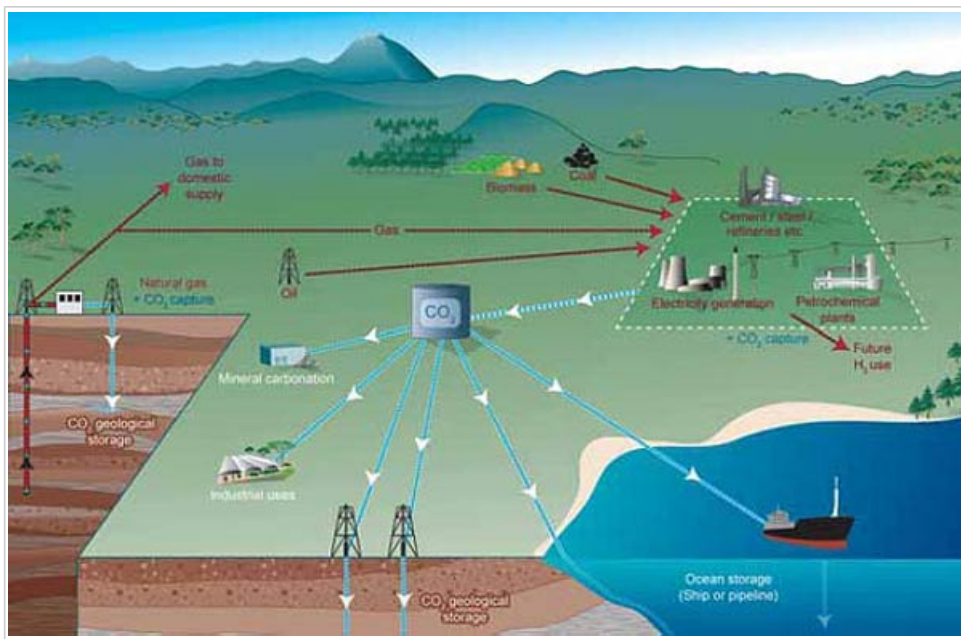
The scientific consensus views carbon capture and storage as one of the important options for reducing CO₂ emissions. If it were deployed, the cost of stabilizing the concentration of greenhouse gases in the atmosphere would be reduced by 30% or more.

Annex

Annex 1:

Figure TS.1. Schematic diagram of possible CCS systems

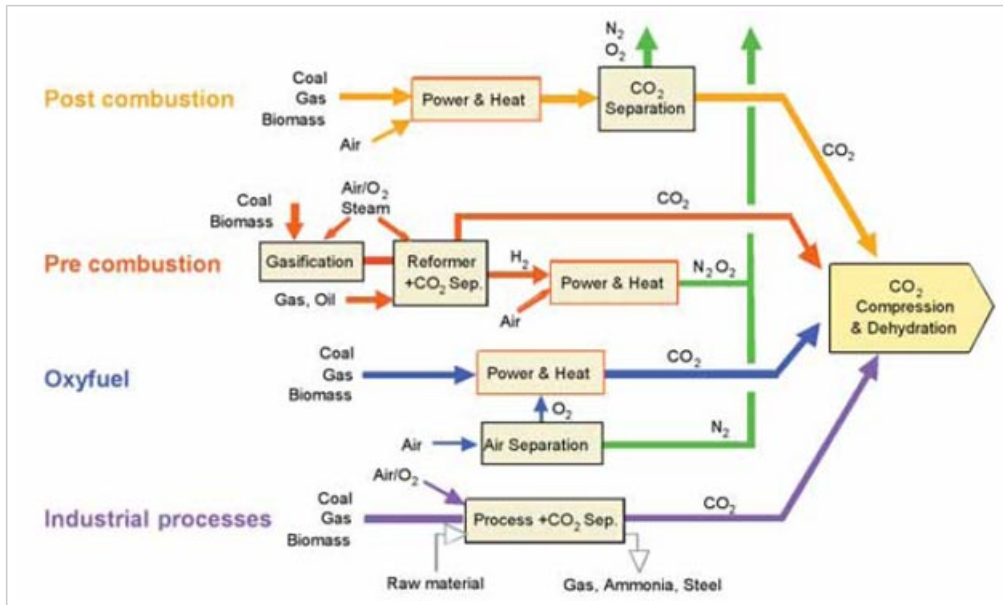
Schematic diagram of possible CCS systems showing the sources for which CCS might be relevant, transport of CO₂ and storage options (Courtesy of CO₂CRC).



Source: IPCC Carbon Dioxide Capture and Storage: Technical Summary (2005) [see http://arch.rivm.nl/env/int/ipcc/pages_media/SRCCS-final/SRCCS_TechnicalSummary.pdf]
1. Introduction and framework of this report, p. 18

Annex 2:

Figure TS.3. Overview of CO₂ capture processes and systems

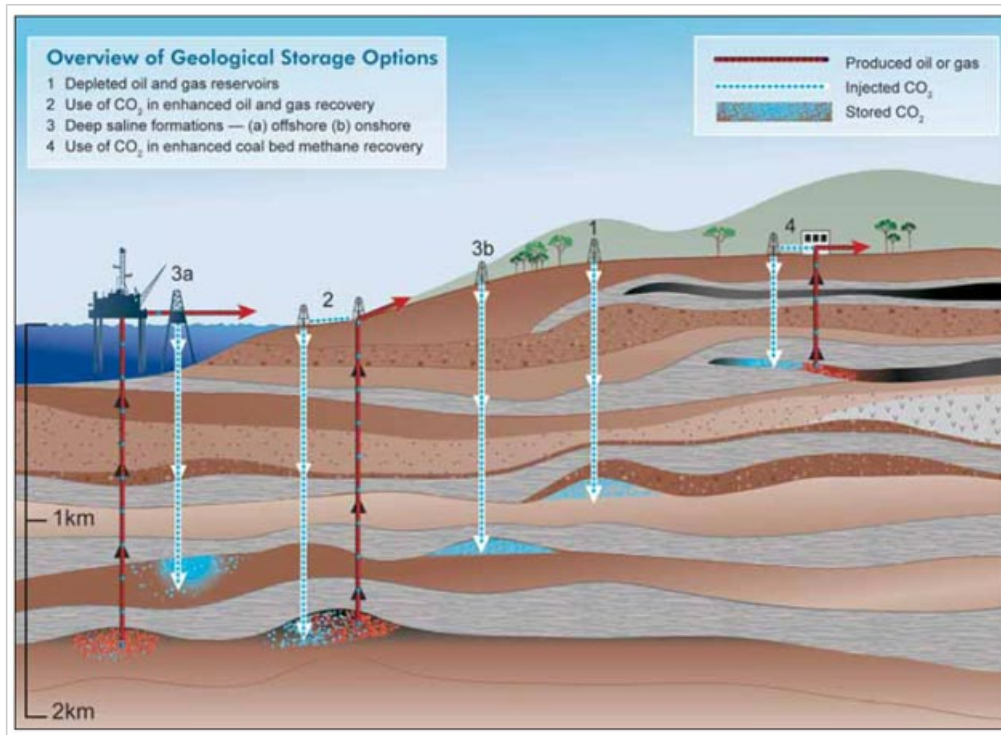


Source: IPCC Carbon Dioxide Capture and Storage: Technical Summary (2005) [see http://arch.rivm.nl/env/int/ipcc/pages_media/SRCCS-final/SRCCS_TechnicalSummary.pdf]
 3. Capture of CO₂, p. 25

Annex 3:

Figure TS.7. Methods for storing CO₂ in deep underground geological formations

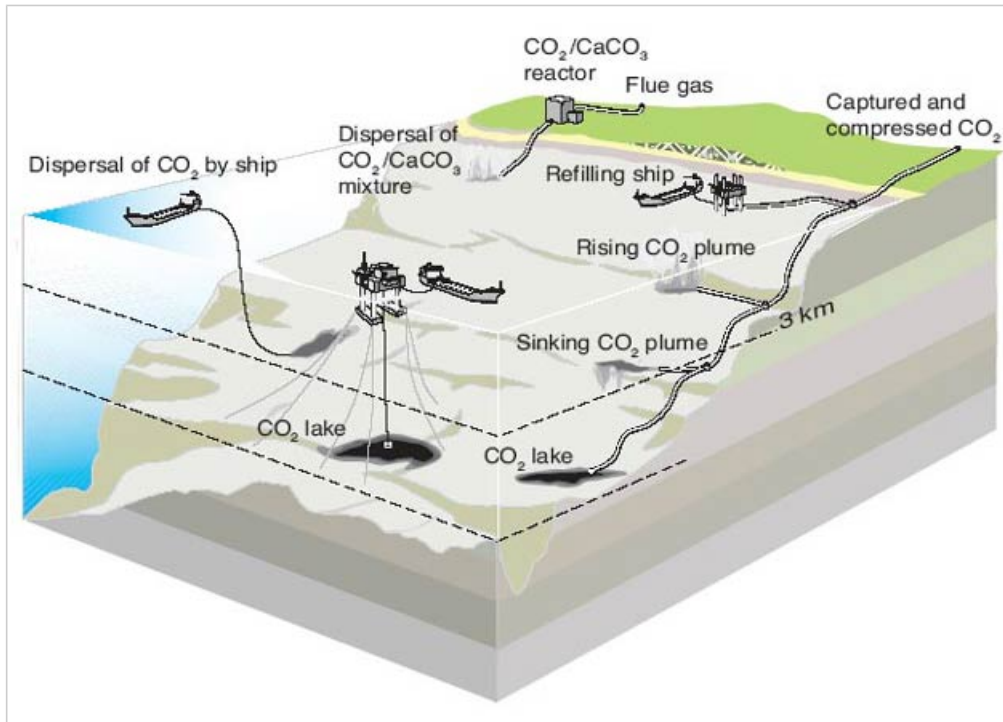
Methods for storing CO₂ in deep underground geological formations. Two methods may be combined with the recovery of hydrocarbons: EOR (2) and ECBM (4). See text for explanation of these methods (Courtesy CO₂CRC).



Source: IPCC Carbon Dioxide Capture and Storage: Technical Summary (2005) [see http://arch.rivm.nl/env/int/ipcc/pages_media/SRCCS-final/SRCCS_TechnicalSummary.pdf]
5. Geological storage, p. 29

Annex 4:

Figure TS.9. Methods of ocean storage



Source: IPCC Carbon Dioxide Capture and Storage: Technical Summary (2005) [see http://arch.rivm.nl/env/int/ipcc/pages_media/SRCCS-final/SRCCS_TechnicalSummary.pdf]
6. Ocean storage, p. 34

Partner for this publication

The Levels 1 & 2 are summaries written by GreenFacts with financial support from the **Swiss Agency for Development and Cooperation (SDC)**, the support of the Minister of Scientific Research of the **Brussels Capital Region** and from the **Institute for the encouragement of Scientific Research and Innovation of Brussels (ISRIB)**.

