Facts on CO_2 Capture and Storage

A Summary of a Special Report by the Intergovernmental Panel on Climate Change

CARBON DIOXIDE CAPTURE AND STORAGE (CCS) is a technique by which CO2 could be stored underground in order to limit greenhouse gas emissions. How does it work? Could it really help addressing climate change?

A summary by:

GreenFacts
Facts on Health and the Environment

What is carbon dioxide capture and storage?

Carbon dioxide (CO_2) 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.

One technique that could limit CO_2 emissions from human activities into the atmosphere is carbon dioxide capture and storage (CCS). It involves collecting, at its source, the CO_2 that is produced by power plants or industrial facilities and storing it away for a long time in underground geological 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.

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 CO_2 produced, combined with other efforts, could help stabilize greenhouse gas concentrations in the atmosphere and fight climate change.

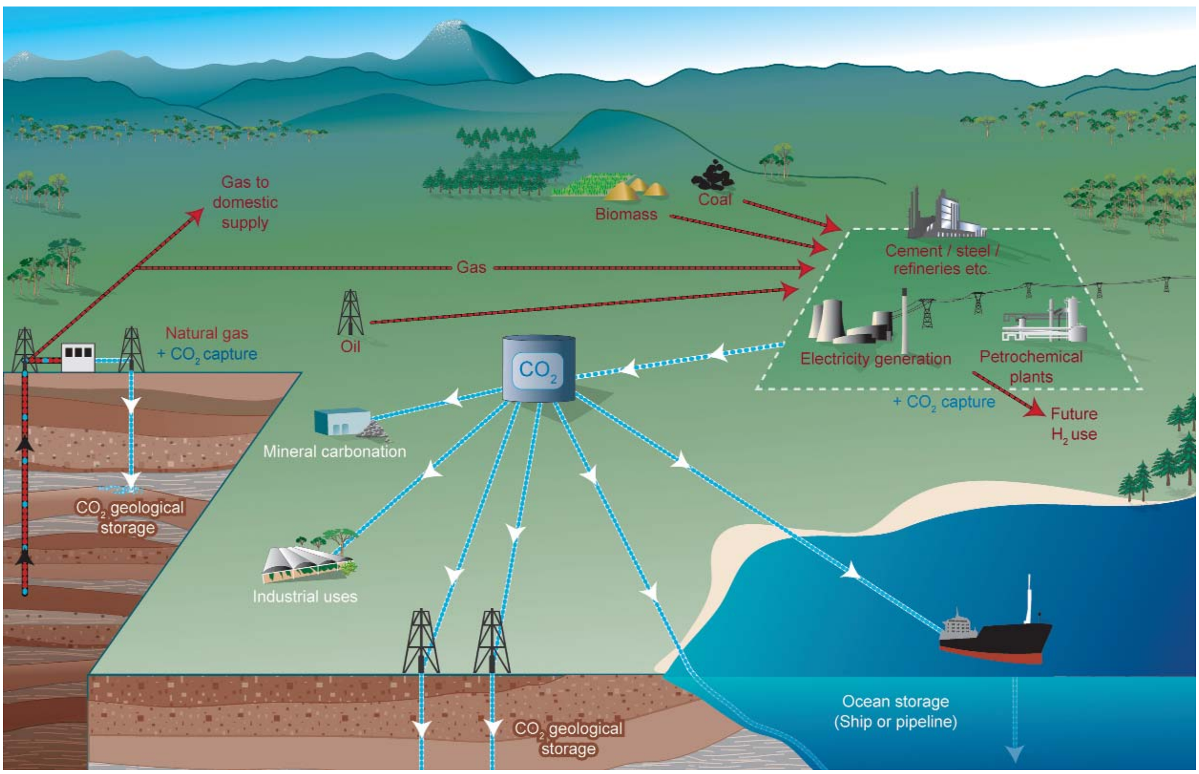


Diagram of possible CO_2 Capture and Storage (CCS) systems.

What sources of CO_2 emissions are suitable for capture and storage?

Carbon dioxide could be captured from power plants or industrial facilities that produce large amounts of carbon dioxide. Technology for CO_2 capture from small or mobile emission sources, such as home heating systems or cars, is not sufficiently developed yet.

A significant proportion of the CO_2 produced by fossil fuel power plants could potentially be captured. By 2050 the amount captured could represent 21 to 45% of all the CO_2 emitted by human activities.

Coal power plants are a good example of a large point source of CO_2 emissions.

How can CO_2 be captured?

To capture carbon dioxide (CO_2) 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 CO_2 must then be purified and compressed for transport and storage.

It is possible to reduce the CO_2 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 CO_2 stream is produced, the cost per tonne of CO_2 captured is lower.

How can CO_2 be transported once it is captured?

Except when the emission source is located directly over the storage site, the CO_2 needs to be transported. Pipelines have been used for this purpose in the USA since the 1970s. CO_2 could also be transported in liquid form in ships similar to those transporting liquefied petroleum gas (LPG).

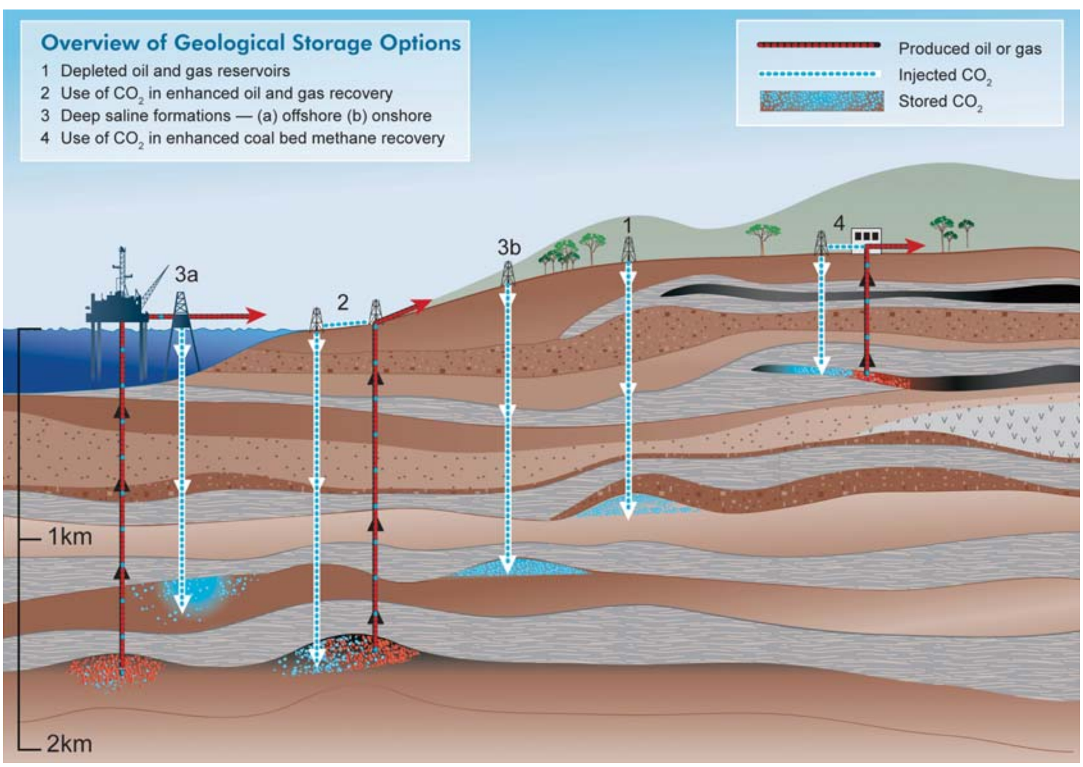
For both pipeline and marine transportation of CO_2, costs depend on the distance and the quantity transported. For pipelines, costs are higher when crossing water bodies, heavily congested areas, or mountains.

How can CO_2 be stored underground?

Compressed CO_2 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. CO_2 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.

Storage in geological formations is the cheapest and most environmentally acceptable storage option for CO_2.



Courtesy of CO2CRC

Geological Storage Options.

This text is a faithful summary, by GreenFacts, of the IPCC Special Report on Carbon Dioxide Capture and Storage.
A longer, more detailed summary can be found on www.greenfacts.org/en/co2-capture-storage/.

Could CO_2 be stored in the deep ocean?

Oceans can store CO_2 because it is soluble in water. When the concentration of CO_2 increases in the atmosphere, more CO_2 is taken up by the oceans.

Captured CO_2 could potentially be injected directly into deep oceans and most of it would remain there for centuries.

CO_2 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, CO_2 storage in oceans is generally no longer considered as an acceptable option.

How can CO_2 be stored in other materials?

Through chemical reactions with some naturally occurring minerals, CO_2 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 CO_2 in minerals. However, the large amounts of energy and mined minerals needed makes this option less cost-effective.

It is technically feasible to use captured CO_2 in industries manufacturing products such as fertilisers. The overall effect on CO_2 emissions, however, would be very small, because most of these products rapidly release their CO_2 content back into the atmosphere.

How cost-effective are different CO_2 capture and storage options?

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.

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 the CO_2 produced by some industrial processes such as hydrogen production can be cheaper than for power plants.

Hydrogen could be used in fuel cells, including in the transport sector. This would centralize CO_2 emissions and facilitate capture.

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 CO_2 permanently stored brings the same benefit as one tonne of CO_2 not emitted, one tonne of CO_2 temporarily stored brings far less benefit.

The methods currently available for national greenhouse gas emissions inventories can be adapted to accommodate CO_2 capture and storage systems. Some issues remain to be addressed through national and international political processes.

Conclusion: The future of CO_2 capture and storage

CO_2 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.

If knowledge gaps are filled and various conditions are met, CO_2 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 CO_2 emissions**. If it were deployed, the cost of stabilizing the concentration of greenhouse gases in the atmosphere would be reduced by 30% or more.

GLOSSARY

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Atmosphere – The mass of air surrounding the Earth. The atmosphere consists of nitrogen (78%), oxygen (21%), and traces of other gases such as argon, helium, carbon dioxide, and ozone. The atmosphere plays an important role in the protection of life on Earth; it absorbs ultraviolet solar radiation and reduces temperature extremes between day and night.

Carbon dioxide (CO_2) – A colorless, odorless, non-combustible gas, present in low concentrations in the air we breathe (0.03% by volume). Carbon dioxide is produced when substances containing carbon, such as wood or fossil fuels, are burned. It is also released to the atmosphere through respiration and decay of organic materials. Plants absorb carbon dioxide through photosynthesis. Carbon dioxide is a major greenhouse gas that contributes to global warming.

Climate change – Defined by the United Nations Convention on Climate Change as "change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".

Fossil fuels – A general term for buried combustible geologic deposits of organic materials, formed from decayed plants and animals that have been converted to crude oil, coal, natural gas, or heavy oils by exposure to heat and pressure in the Earth's crust over hundreds of millions of years.

Greenhouse gas – A gas in Earth's atmosphere, be it of natural or human origin, that absorbs heat radiated by the earth and warms the atmosphere, creating what is commonly known as the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere.

Mineral carbonation – The reaction of carbon dioxide with magnesium and calcium containing silicate minerals to form geologically stable, environmentally benign carbonate minerals (calcite and magnesite), allowing for the storage of CO_2 in a stable, inert and solid form.

Facts on this publication

This publication presents a faithful summary of the ***Intergovernmental Panel on Climate Change (IPCC) Special Report on Carbon Dioxide Capture and Storage*** (2005), a leading scientific consensus reports on the topic. This summary was written by GreenFacts and peer-reviewed by three independent experts.

The IPCC was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). It has produced over the years a number of reports on various aspects of climate change that are widely used references. Its publications can be found on the IPCC website: www.ipcc.ch

*A more detailed summary can be found on **www.greenfacts.org/en/co2-capture-storage/** in English & French.*

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GreenFacts – Facts on Health and the Environment

GreenFacts is an independent non-profit organisation that publishes faithful online summaries of scientific consensus documents produced by international bodies such as the Intergovernmental Panel on Climate Change, the Millennium Ecosystem Assessment or the World Health Organization.
www.greenfacts.org | 2007@greenfacts.org | Tel: +32 (0)2 211 34 88

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Cover picture: The Esbjerg power station, a CO_2 capture site in Denmark. (DONG Energy)

Editeur responsable: Patrick G. Poty, GreenFacts asbl/vzw, Rue des Palais 44 Paleizenstraat, 1030 Brussels, Belgium – Registered office: 163 Bld Reyerslaan, 1030 Brussels ■ **Concept & layout:** beëlzePub ■ Printed on 100% recycled paper