GEOLOGICAL STORAGE OF CO_2

Key questions and answers

At a glance

- Reducing global CO_2 emissions into the atmosphere is now a matter of urgency.
- One solution being considered is to capture the CO_2 released in industrial flue gases and inject it underground.
- Some industrial storage sites are already in operation across the world.
- All existing processes for capturing, transporting and storing CO_2 could be deployed on a large scale as from 2020.
- Specific laws and regulations are in place to govern and control storage sites selection and operation for industrial or research purposes.

Why is CO_2 a problem?

Since the 19th century, emissions of carbon dioxide - CO_2 - have greatly increased. The reason is the increasingly intensive use of fossil fuels (oil, natural gas and coal) in industry, transport and housing.

CO_2 is part of flue gases from industrial processes boilers and vehicles. CO_2 is now the main greenhouse gas produced by human activities and considered to be largely responsible for climate change.

But CO_2 is also essential to life...

Carbon dioxide is captured by plants and forests, which – by photosynthesis – produce the oxygen that other living beings need in order to breathe. Carbon dioxide also keeps the sun's warmth in the atmosphere: this is the "greenhouse effect" without which life could not exist on Earth. But if there is too much CO_2, the greenhouse effect will intensify.

According to the IPCC, an international panel of climate change experts, unless immediate and drastic measures are taken to reduce CO_2 emissions, the average world temperature is likely to rise by 2.4°C to 6.4°C by 2100. To keep the increase below +2°C, considered as the critical threshold for humans and the environment, CO_2 emissions worldwide must be cut by at least 50% before 2050.

CO_2 emissions produced by human activities have now reached 30 billion tonnes per year, of which only half is naturally trapped by oceans, soils and forests. Two thirds of CO_2 emissions worldwide are released by industrial facilities: coal and gas-fired power plants, iron and steel manufacture, cement works, refineries, etc.

For example, a coal-fired power plant releases 4.5 million tonnes of CO_2 a year to produce enough industrial and household electricity for a city of 750,000 people.

What about France?

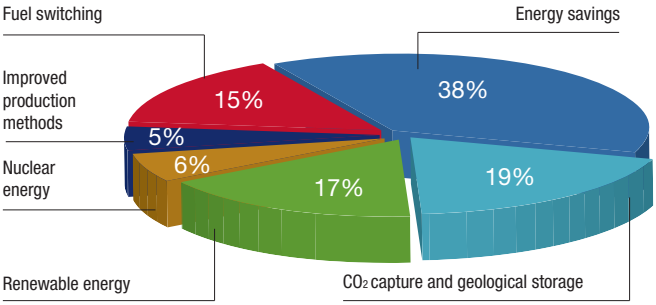
Human activities release about 360 million tonnes of CO_2 per year.
About one third is from transport, followed by housing, industry and the energy sector.

What can we do?

There is no single solution to achieve the necessary massive reduction in CO_2 emissions. According to the International Energy Agency, 38% of the effort needed by 2050 could come from energy savings and 17% from using renewable energy.

Another solution would be to capture the CO_2 released by industrial facilities and store it permanently in deep layers of the subsurface, where it would be sealed off from the atmosphere.

CO_2 geological storage, as this is known, could contribute 19% to the necessary emission reductions by 2050.



Solutions for reducing global CO_2 emissions by 2050, International Energy Agency 2010

What does CO_2 capture and geological storage involve?

Thanks to a succession of innovative technologies, CO_2 can be separated from other industrial flue gases, compressed to take up less space, and transported by ship or pipeline to the storage site, either onshore or offshore, where it is injected deep underground through wells. The targeted facilities are those releasing more than 100,000 tonnes of CO_2 per year.

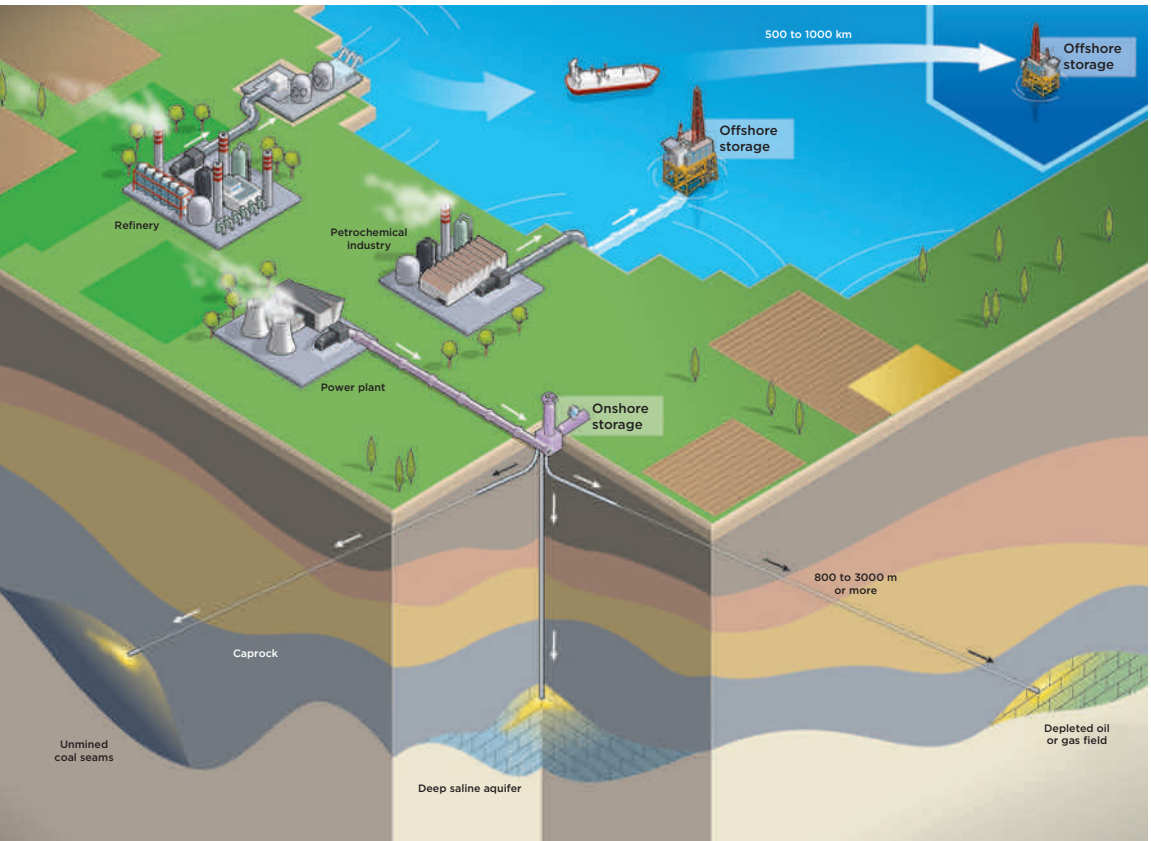
What about France ?

France has committed to a fourfold reduction in its CO_2 emissions by 2050, compared to 1990 levels. CO_2 capture and geological storage are necessary options, especially to reduce emissions from industrial facilities, for which there are few other technical solutions, if any.

Can CO_2 emissions from vehicles, or from housing, be stored as well?

No - they are too diffuse to be captured for storage. These emissions account for about a third of the total worldwide.

From industrial facilities to geological storage



What about France ?

Developing CO_2 capture and storage could help to maintain employment in the industrial regions concerned (Lorraine, Lower Seine, Paris region, Nord-Pas-de-Calais and Provence-Alpes-Côte d'Azur). For the many different industries concerned, the goal is also to develop know-how for export.

Where can CO_2 be stored?

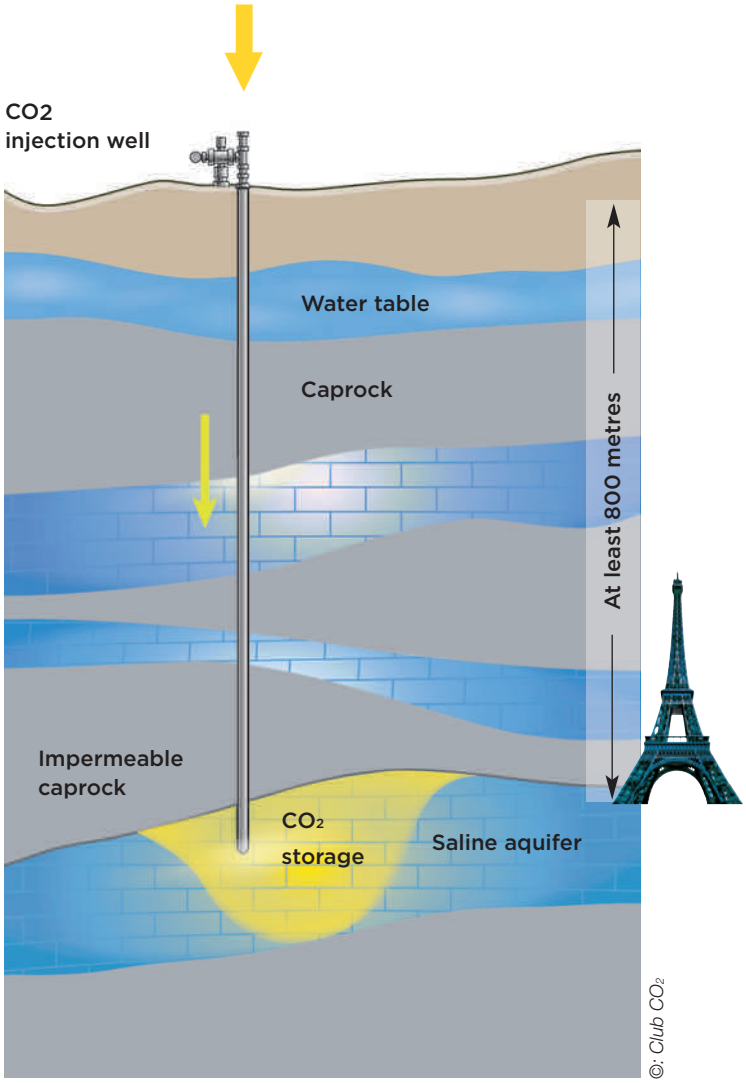
CO_2 has to be injected to depths of more than 800 metres to increase its density and thus reduce its volume. Zones with suitable characteristics for CO_2 storage include:

- Deep saline aquifers: these "reservoir rocks" are porous rock layers containing brine (salt water) which is unfit for consumption. These are the largest potential reservoirs for CO_2 storage.
- Depleted hydrocarbon reservoirs (oil or natural gas).
- Coal seams too deep to be mined.
- Some specific rock types, such as basalt.

There are a great many potential reservoirs for geological CO_2 storage across the world: total storage capacity could be as high as 10,000 billion tonnes.

What about France?

France has a number of depleted hydrocarbon reservoirs as well as large sedimentary basins (Paris, Aquitaine and the south-east Basins). Some of these zones could be suitable for CO_2 geological storage. In January 2010, an initial demonstration site at Lacq (south-west France) began injecting CO_2 into a depleted natural gas reservoir to a depth of 4500 metres. Several other demonstration projects, supported by the Environment and Energy Management Agency (ADEME) are under development.



Cross-section of underground CO2 storage in a saline aquifer, showing impermeable layers alternating with porous and permeable layers in the subsurface.

What happens over time?

In a saline aquifer, for example, the injected CO_2, which is lighter than water, will rise as far as the impermeable caprock, which prevents it from rising further. Some of the CO_2 is trapped in the smallest (microscopic) pores in the reservoir rock.

Some is dissolved in the brine and will tend to migrate downwards. After a few thousand years, the dissolved CO_2 will form other mineral substances as it reacts with the reservoir rock. The relative importance of these different mechanisms depends on the geology of each site.

Storing CO_2 seems a strange idea...

Not really! There have been natural deposits of CO_2 in some sedimentary basins for millions of years, for example in south-east France at Montmiral in the Drôme Department. Some deposits contain over a billion tonnes of CO_2.

How do we know if the CO_2 is securely trapped?

By the observations and measurements made at sites in operation. The five large-scale industrial storage sites around the world are equipped with such monitoring tools, e.g. Sleipner in Norway (operating since 1996) and In Salah in Algeria (since 2000). Each of these two sites is storing around one million tonnes of CO_2 per year. All future sites will be monitored.

What about risk management?

Capturing CO_2 and storing it underground involves new technologies that have to meet safety requirements throughout the process, at and below the surface and in the short and long term. Safety systems for CO_2 capture and transport are well proven and their management is governed by the legislation applying to industrial facilities. CO_2 Geological storage, which is more recent, is governed by an EU directive issued in 2009 and now transposed into French legislation.

This directive requires storage to be permanent, environmentally safe and capable of preventing and controlling any rise of the CO_2 towards the surface, while limiting disturbance to the underground environment. To comply with these requirements, any storage site under consideration is analysed to ensure that it meets every safety guarantee, especially regarding geological stability (low seismic risk) and caprock impermeability.

Rigorous risk prevention measures are applied both during injection and when the site is closed. Prior to injection and for several decades after closure, a range of monitoring is used in order to follow how the CO_2 storage is evolving and to check that no leakage is occurring. If any sign of rising gas is detected in the intermediate layers, appropriate corrective measures are applied before it reaches the surface.

What would be the risks if injected CO_2 leaks into the atmosphere?

CO_2 is not explosive or inflammable. It is harmless at low concentrations but becomes dangerous (loss of consciousness, asphyxia) when ambient concentrations are higher than 5% (confined spaces, hollows in the ground).

Are we aware of all the health and environmental impacts?

Partly.
Assessments are continuing through many research projects on the different types of storage sites, both in the laboratory and in the field.

How are people informed about projects for CO_2 geological storage?

In France, local information and follow-up committees (CLIS) or public consultations are organised for each project, right from the site research and prospecting stage. Environmental information continues to be publicly available during the operational stage.

How can I find out more?

The Club CO_2 website provides a great deal of information about CO_2 capture and geological storage technologies:

www.captage-stockage-valorisation-co2.fr

Club CO_2, with its 30 members from industry and research, is an umbrella organisation for activities in France on CO_2 capture, re-use and storage (CCUS). It is a forum for discussion and exchange of information and initiatives among its members.