

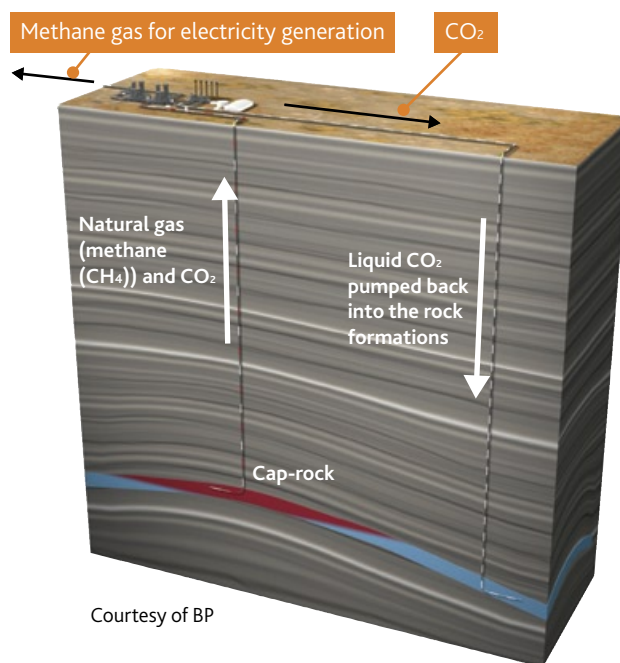
CO₂ storage has already been successfully tested worldwide

Many small-scale demonstrations of CO₂ storage are already in place across the globe. In Europe it has been occurring, safely and successfully, for over 10 years. Projects include:

- **Sleipner, Norway** – 1 million tonnes of CO₂ from the Sleipner gas field have been stored every year in the Utsira deep saline aquifer in the North Sea since 1996.
- **K12B, Netherlands** – Around 100,000 tonnes of CO₂ have been stored in the North Sea from Enhanced Gas Recovery since 2004.
- **Ketzin, Germany** – Beginning in 2008, some 30,000 tonnes of CO₂ will be stored over several years in a deep saline aquifer in Europe's first onshore CO₂ storage project.

It is now vital that we scale up and test the full range of storage options in a variety of geological and geographical settings across Europe.

This requires the urgent implementation of an EU Flagship Programme of 10-12 large-scale CO₂ Capture and Storage demonstration projects, as called for by the EU Heads of State. With over 20 projects already planned or being considered, Europe is ready.



At In Salah in Algeria, 1 million tonnes of CO₂ have been stored every year since 2004 in a producing gas field – equivalent to emissions from a quarter of a million cars. The natural gas produced from the geological formations is a mixture of methane and CO₂. Once it reaches the surface, the natural gas is separated into methane (which is piped to a power plant to generate electricity) and CO₂ (which is pumped back into the formations for storage).

European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP)

Founded in 2005 on the initiative of the European Commission, ZEP represents a broad coalition of stakeholders, united in their support for CCS as a key solution for combating climate change – within a portfolio of solutions, including energy efficiency and renewable energy. Members include European utilities, petroleum companies, equipment suppliers, scientists, geologists and environmental NGOs. Our goal: to make CCS commercially viable by 2020 and kick-start its wide-scale deployment in Europe.

This document has been prepared on behalf of the Advisory Council of the European Technology Platform for Zero Emission Fossil Fuel Power Plants. The information and views contained in this document are the collective view of the Advisory Council and not of individual members, or of the European Commission. Neither the Advisory Council, the European Commission, nor any person acting on their behalf, is responsible for the use that might be made of the information contained in this publication.

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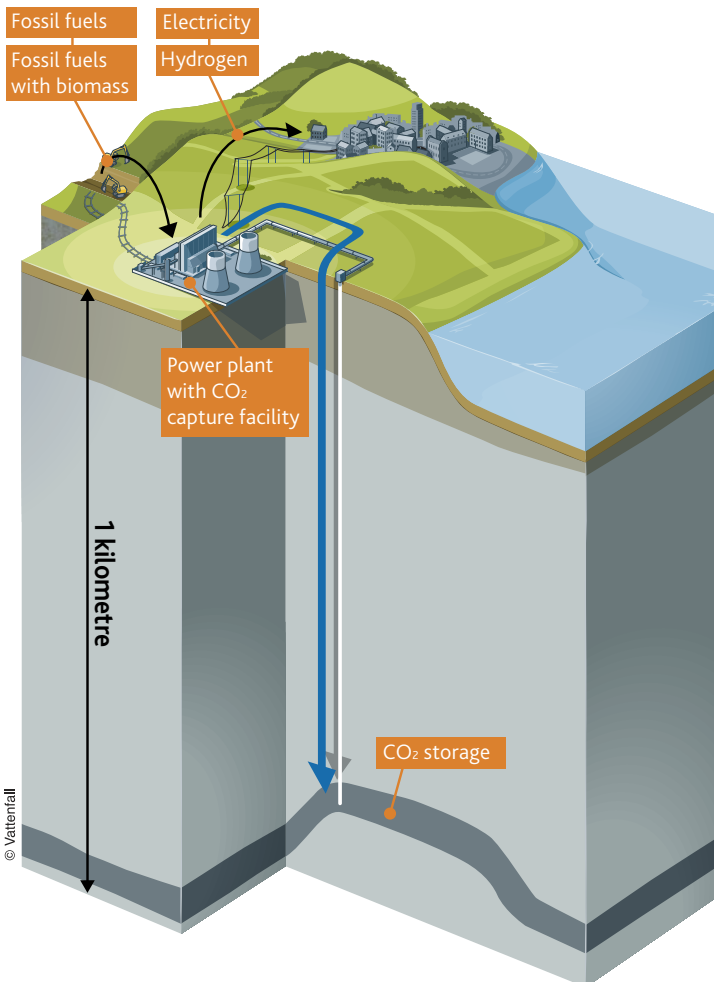
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What is CO₂ storage?

Putting carbon back
where it came from...



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Source: www.kjell-design.com, courtesy of Vattenfall

Extracting and burning fossil fuels brings carbon out of the ground and into the atmosphere as CO₂ – CO₂ storage recycles it back into the ground again.

CO₂ Capture and Storage (CCS) technology offers a key solution for combating climate change – while building a bridge towards a truly sustainable energy system. That's because it enables power plants and a wide range of other industries to reduce their carbon dioxide (CO₂) emissions by around 90%.

Indeed, if implemented without delay, CCS could reduce CO₂ emissions in the European Union (EU) by over 50% by 2050.¹ This involves capturing the CO₂ at source, transporting it to storage sites and storing it in geological formations, deep underground.

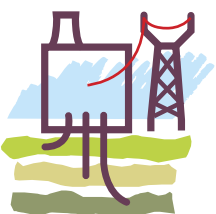
CO₂ has been 'stored' underground for millions of years

The reason why CO₂ storage works is simple: it uses *the same natural trapping mechanisms which have already kept huge volumes of oil, gas and CO₂ underground for millions of years.*

Nor is the technology new: it is almost identical to that used by the oil and gas industry for decades – to increase oil production by injecting CO₂ to 'push' oil towards producing wells, or store natural gas deep underground. Indeed, there are already hundreds of natural gas storage sites worldwide, many found in the most densely populated areas in Europe.

The Intergovernmental Panel on Climate Change (IPCC) therefore confirms it "very likely that the fraction of CO₂ retained will be more than 99% over the first 100 years and likely... (to) be more than 99% over the first 1,000 years".²

- 1 "A Model for the CO₂ Capture Potential", by Dr Aage Stangeland, The Bellona Foundation, published in the International Journal of Greenhouse Gas Control, Volume 1, Issue 4, August 2007
- 2 IPCC Special Report on Carbon Dioxide Capture and Storage, 2005



There is a huge capacity for CO₂ storage worldwide

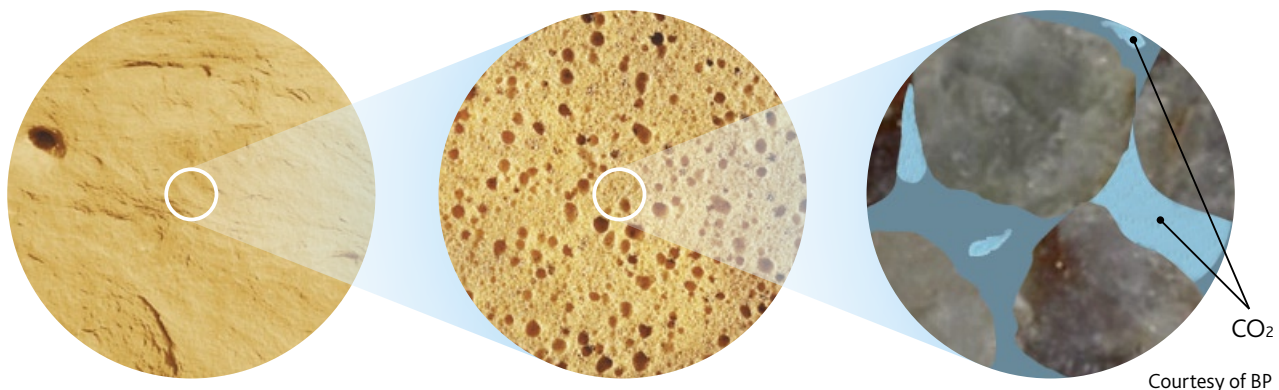
The European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP) opposes storing CO₂ in the ocean, while supporting the two main options for CO₂ storage available today:

- **Deep saline aquifers** (or formations) are porous rocks filled with very salty water, which make them unsuitable for drinking water or agriculture. They have an enormous capacity for CO₂ storage.
- **Depleted oil and gas fields** are also attractive because the geology is well understood and the existing infrastructure recyclable.

With human-related activities currently producing 27 billion tonnes of CO₂ emissions each year world-wide, it's important to know not just how much CO₂ can be captured using CCS, but for how long it will remain in storage. While any CO₂ captured will remain stored *indefinitely*, estimates indicate CCS could capture and store the equivalent of between 70 and 450 years³ of man's current global annual CO₂ emissions.

CO₂ storage becomes even more secure over time

This is how it works: the CO₂ is compressed into a dense fluid then pumped – via one or more wells – into a porous geological formation, around a kilometre underground. At first, being more buoyant than water, it rises to the top of the formation, where it becomes trapped beneath a layer of impermeable cap-rock which acts as a seal – *the same cap-rock that has trapped oil, gas and CO₂ underground for millions of years.*



The CO₂ immediately fills and then becomes trapped in the tiny pores of rocks, such as sandstone

However, it is not long before other trapping mechanisms also start to take effect: during injection, and as the CO₂ shifts within the formation, it becomes trapped in the tiny pore spaces of the rocks and does not move. The CO₂ also starts dissolving into the water and being heavier than the water around it, sinks to the bottom of the formation, trapping it indefinitely. Finally, the dissolved CO₂ reacts chemically with the rocks to produce minerals.

What is CO₂?

CO₂ is a major greenhouse gas, but it is also a fundamental and essential part of nature. Indeed, plants need it to grow, while animals and humans exhale it. It also leaks naturally from volcanoes and geysers. Nor does CO₂ burn or explode; in fact, it's a flame retardant commonly used in extinguishers. CO₂ is only problematic at very high concentrations – far higher than any leakages from CO₂ storage, which would probably not raise local concentrations much above normal atmospheric levels.

3 Based on estimated storage capacity of deep saline aquifers and depleted oil and gas fields

Many mineral waters naturally enriched with CO₂ are bottled and sold as sparkling water!



Frequently Asked Questions

Storing enormous quantities of CO₂ underground must present some risk?

The geological formations that would be used to store CO₂ *diffuse* it, making massive releases extremely unlikely. Indeed, because the CO₂ becomes trapped in the tiny pores of rocks, any leakage through the geological layers would be extremely slow, allowing plenty of time for it to be detected and dealt with. In fact, it would not raise local CO₂ concentrations much above normal atmospheric levels.

Higher concentration leaks could come from man-made wells, but the oil and gas industry already has decades of experience in monitoring wells and keeping them secure. Storage sites will not, of course, be located in volcanic areas.

But won't CO₂ storage increase the likelihood of seismic activity?

A detailed survey takes place to identify any potential leakage pathways before a CO₂ storage site is selected – if these are discovered, then the site will not be selected. In areas where some natural seismic activity is already taking place, we can ensure that the pressure on the CO₂ does not exceed the strength of the rock by making the volume of CO₂ stored relative to that of the storage site.

CO₂ storage has even proved to be robust in volcanic areas: in 2004, a storage site in Japan endured a 6.8 magnitude earthquake with no damage to its boreholes and no CO₂ leakage. But then CO₂ has remained undisturbed underground for millions of years – despite thousands of earthquakes.

Won't leaking CO₂ harm us and the eco-system?

The effects of CO₂ on terrestrial ecosystems are well known as there are many places in Europe where CO₂ seeps naturally to the surface before dispersing in the air. We also know that soils commonly contain high concentrations of natural CO₂ produced by the respiration of soil organisms and many soil animals are tolerant of CO₂ levels in the 10%-15% range. The effects on other animals and humans are also well known – man has been living in high CO₂ flux areas (e.g. near volcanoes) since prehistoric times.

CO₂ also leaks naturally into the ocean where it has only localised impact and the ecosystem quickly recovers once the CO₂ subsides. More significantly, marine organisms are already being affected by CO₂ emissions which are

even now dissolving into and acidifying the ocean. CO₂ will only be stored in deep saline aquifers, which are not used for drinking water or agriculture.

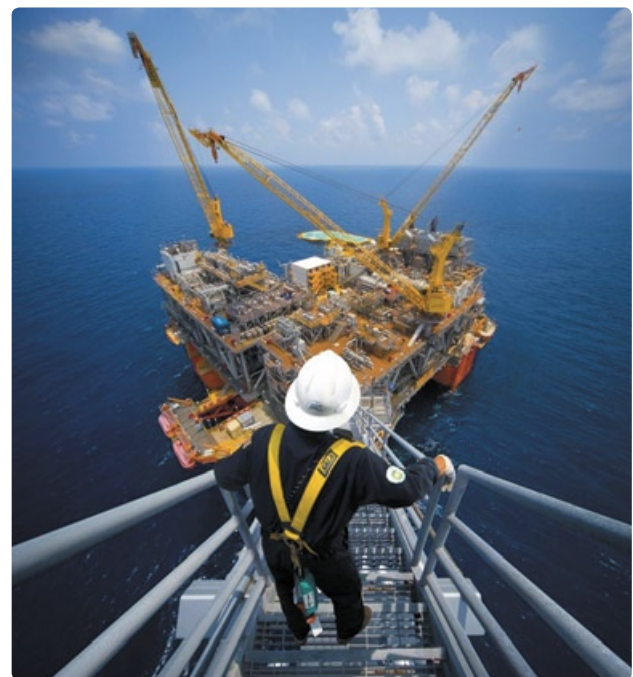
How will we know if the CO₂ is leaking?

Before a CO₂ storage site is chosen, a detailed survey takes place to identify any potential leakage pathways. If these are found to exist then the site will not be selected. In Europe, underground gas storage (natural gas and hydrogen) has an excellent safety record, with sophisticated monitoring techniques that are easily adaptable to CCS. On the surface, air and soil sampling can be used to detect potential CO₂ leakage, while changes underground can be monitored by detecting sound (seismic), electromagnetic, gravity or density changes within the geological formations.

The risk of leakage through man-made wells is expected to be minimal because they can easily be monitored and fixed, while CO₂ leaking through faults or fractures would be localised and simply withdrawn; and, if necessary, the well closed.

Who will be liable for CO₂ storage sites over the long term?

As the CO₂ will remain stored underground indefinitely, long-term liability will follow the example set by the petroleum industry, whereby the state assumes liability after a regulated abandonment process.



The oil and gas industry already has decades of experience in injecting CO₂ underground and keeping wells secure