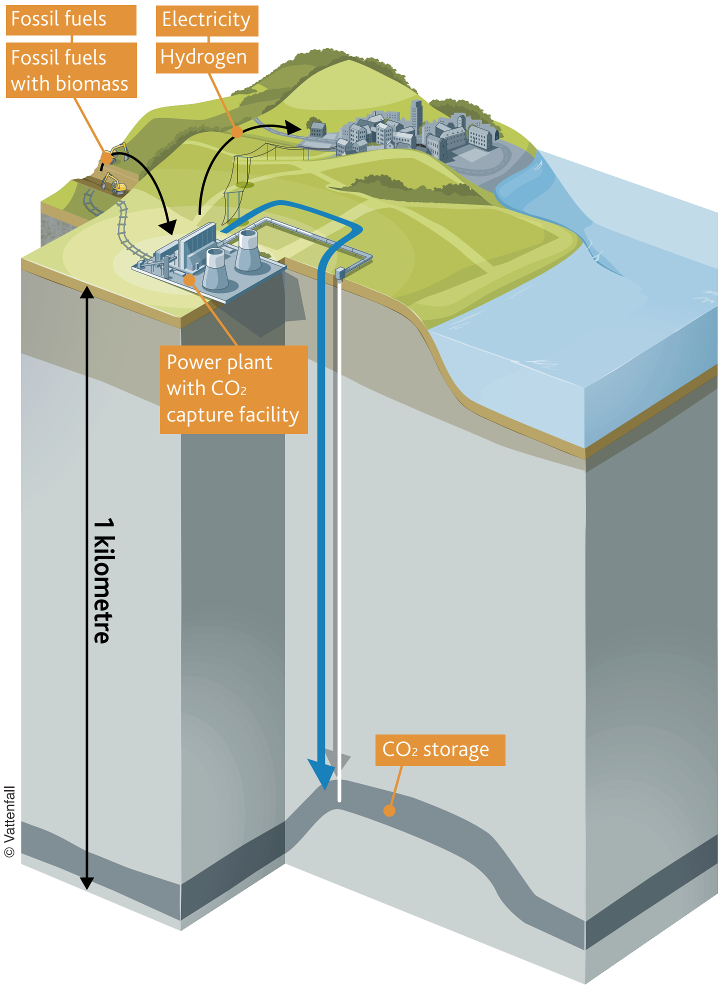
European Technology Platform for
Zero Emission Fossil Fuel Power Plants (ZEP)

What is CO_2 storage?

Putting carbon back where it came from…



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

Extracting and burning fossil fuels brings carbon out of the ground and into the atmosphere as CO_2 – CO_2 storage recycles it back into the ground again.

CO_2 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 (CO_2) emissions *by around 90%*.

Indeed, if implemented without delay, CCS could reduce CO_2 emissions in the European Union (EU) by over 50% by 2050.[1] This involves capturing the CO_2 at source, transporting it to storage sites and storing it in geological formations, deep underground.

CO_2 has been 'stored' underground for millions of years

The reason why CO_2 storage works is simple: it uses *the same natural trapping mechanisms which have already kept huge volumes of oil, gas and CO_2 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 CO_2 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 CO_2 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 CO_2 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 CO_2 storage worldwide

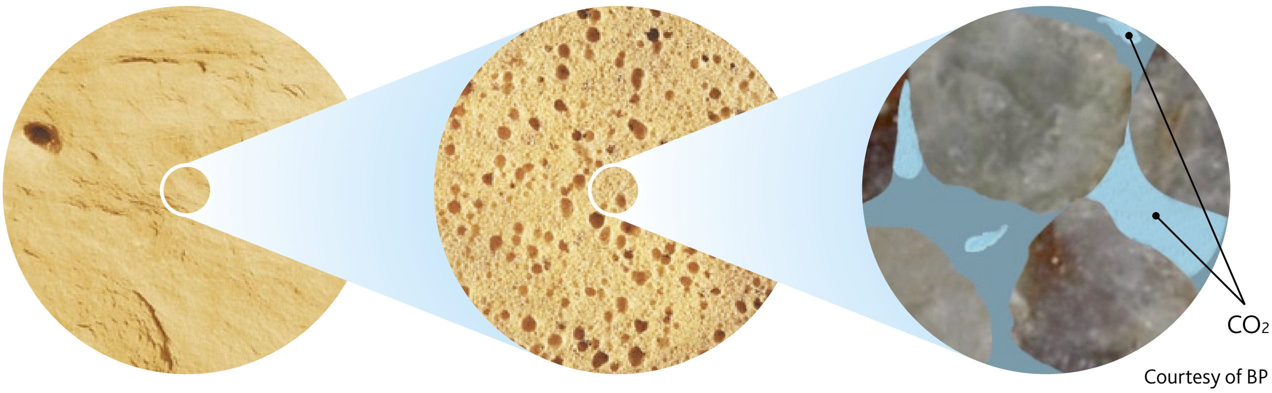
The European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP) opposes storing CO_2 in the ocean, while supporting the two main options for CO_2 storage available today:

- **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 CO_2 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 CO_2 emissions each year world-wide, it's important to know not just how much CO_2 can be captured using CCS, but for how long it will remain in storage. While any CO_2 captured will remain stored *indefinitely*, estimates indicate CCS could capture and store the equivalent of between 70 and 450 years[3] of man's current global annual CO_2 emissions.

CO_2 storage becomes even more secure over time

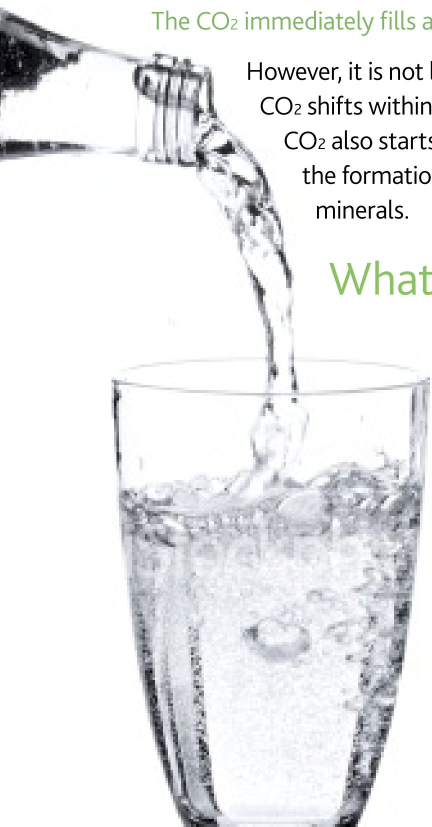
This is how it works: the CO_2 is compressed into a dense fluid then pumped – via one or more wells – into a porous geological formation, around a kilometre underground. At first, being more buoyant than water, it rises to the top of the formation, where it becomes trapped beneath a layer of impermeable cap-rock which acts as a seal – *the same cap-rock that has trapped oil, gas and CO_2 underground for millions of years.*



Courtesy of BP

The CO_2 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 CO_2 shifts within the formation, it becomes trapped in the tiny pore spaces of the rocks and does not move. The CO_2 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 CO_2 reacts chemically with the rocks to produce minerals.



What is CO_2?

CO_2 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 CO_2 burn or explode; in fact, it's a flame retardant commonly used in extinguishers. CO_2 is only problematic at very high concentrations – far higher than any leakages from CO_2 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 gasfields

Many mineral waters naturally enriched with CO_2 are bottled and sold as sparkling water!

Frequently Asked Questions

Storing enormous quantities of CO_2 underground must present some risk?

The geological formations that would be used to store CO_2 *diffuse* it, making massive releases extremely unlikely. Indeed, because the CO_2 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 CO_2 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 CO_2 storage increase the likelihood of seismic activity?

A detailed survey takes place to identify any potential leakage pathways before a CO_2 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 CO_2 does not exceed the strength of the rock by making the volume of CO_2 stored relative to that of the storage site.

CO_2 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 CO_2 leakage. But then CO_2 has remained undisturbed underground for millions of years – despite thousands of earthquakes.

Won't leaking CO_2 harm us and the eco-system?

The effects of CO_2 on terrestrial ecosystems are well known as there are many places in Europe where CO_2 seeps naturally to the surface before dispersing in the air. We also know that soils commonly contain high concentrations of natural CO_2 produced by the respiration of soil organisms and many soil animals are tolerant of CO_2 levels in the 10%-15% range. The effects on other animals and humans are also well known – man has been living in high CO_2 flux areas (e.g. near volcanoes) since prehistoric times.

CO_2 also leaks naturally into the ocean where it has only localised impact and the ecosystem quickly recovers once the CO_2 subsides. More significantly, marine organisms are already being affected by CO_2 emissions which are even now dissolving into and acidifying the ocean. CO_2 will only be stored in deep saline aquifers, which are not used for drinking water or agriculture.

How will we know if the CO_2 is leaking?

Before a CO_2 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 CO_2 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 CO_2 leaking through faults or fractures would be localised and simply withdrawn; and, if necessary, the well closed.

Who will be liable for CO_2 storage sites over the long term?

As the CO_2 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 CO_2 underground and keeping wells secure

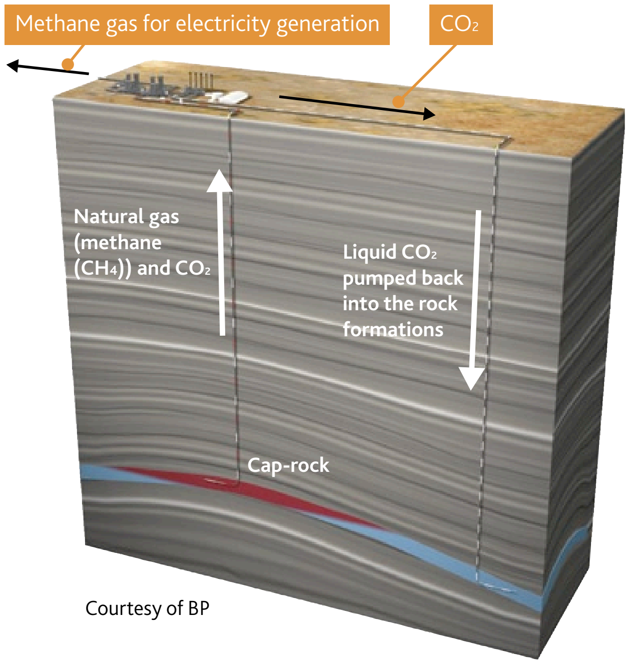
CO_2 storage has already been successfully tested worldwide

Many small-scale demonstrations of CO_2 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 CO_2 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 CO_2 have been stored in the North Sea from Enhanced Gas Recovery since 2004.
- **Ketzin, Germany** – Beginning in 2008, some 30,000 tonnes of CO_2 will be stored over several years in a deep saline aquifer in Europe's first onshore CO_2 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 CO_2 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.



Courtesy of BP

At In Salah in Algeria, 1 million tonnes of CO_2 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 CO_2. Once it reaches the surface, the natural gas is separated into methane (which is piped to a power plant to generate electricity) and CO_2 (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 publication is printed using environmentally friendly inks on 100 per cent recycled paper.

August 2008

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