CCS - Carbon dioxide (CO_2) Capture and Storage

Fossil fuels (oil, gas and coal) are still the most widely used energy sources today, accounting for more than 80% of worldwide energy consumption. Their undisputed leadership is, however, responsible in part for the problem of carbon dioxide (CO_2) emissions into the atmosphere, regarded as the main cause of **climate change**. Sixty per cent of the CO_2 produced by man originates from combustion of fossil fuels (which consequently is not the only activity that produces CO_2).
Thus the need to satisfy growing world demand for energy, among the emerging nations in particular, goes hand in hand with the need to combat the risks to the climate stemming from increased production of CO_2.

The first solution, and the most immediately practicable approach in the short term, is **energy efficiency**: that is to say, measures, attitudes and technologies that help us reduce consumption.
Another possible solution is to use **alternative energy** sources, which so far, despite research and investment, play a relatively modest role. Biomass and related materials (woody substances, various types of waste) cover 10% of our total energy requirement, a percentage that will remain steady. The situation is similar in nuclear energy, which, together with hydroelectric power, covers 8% of the total requirement. Use of renewable energy sources (wind and solar energy, for example) is increasing, but currently satisfies 1% of the Earth's energy requirement.
Fossil fuels, in other words, will continue to dominate the world energy sector for decades to come. To achieve a significant reduction in CO_2 emissions just over the long term, direct action must be taken now on the use of these emissions.

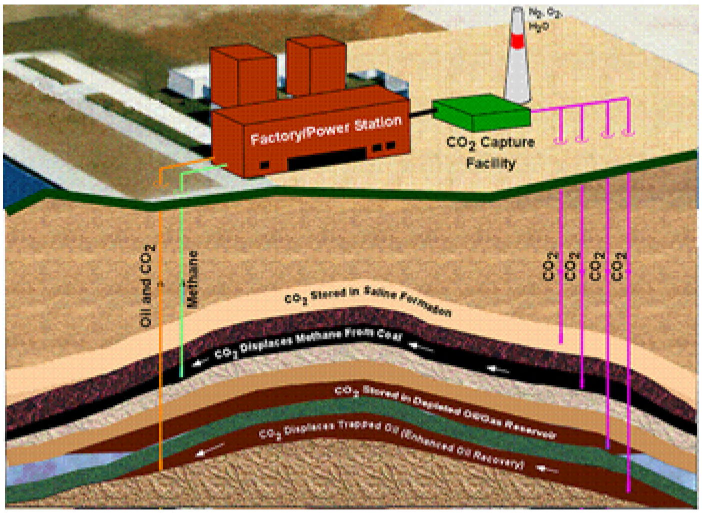
CO_2 capture & storage technology

CO_2 Capture & Storage technology (CCS) is used to **sequester CO_2 generated by fossil fuels, thereby reducing emissions into the atmosphere**.

As far as **CO_2 capture** is concerned, a number of technologies are already in use in the petrochemicals industry and others are being developed. At the moment, there are three main methods of CO_2 capture:

- **post-combustion**. Post-combustion capture separates the CO_2 from combustion exhaust gas previously purified with special treatment systems. Separation is obtained with a solvent that absorbs the CO_2 from the gas at a low temperature, and subsequently releases it for heating purposes, generating a virtually pure CO_2 stream. According to process estimates, the energy efficiency loss for a coal post-combustion cycle is 9-11 percentage points;

- **pre-combustion**. With this method, the CO_2 is removed before combustion. Gasification of the fossil fuel with oxygen and subsequent treatment of the gas produced generates a stream of hydrogen and CO_2; the CO_2 is separated and the hydrogen used for combined-cycle power generation or for other purposes as an energy vector. In this case, the energy cost of CO_2 capture can be quantified as an efficiency loss of 8-10 percentage points.
- **oxycombustion**. The fossil fuel is combusted in oxygen rather than in air, producing an exhaust gas consisting largely of CO_2 and water vapour, which is re-circulated in part through the combustion system. The water vapour is condensed and separated, and the concentrated CO_2 stream can be compressed and stocked. The efficiency loss on this capture process is estimated at 9-10 percentage points.

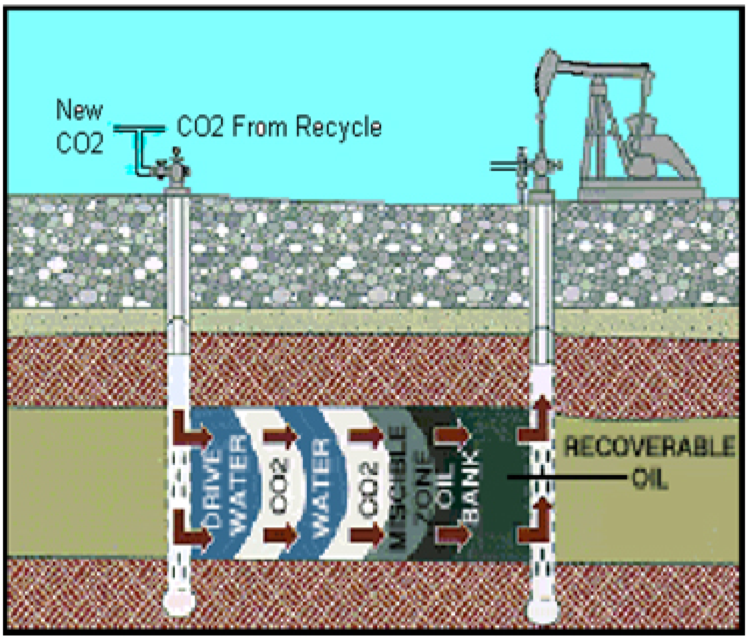


Plant for CCS, EGR and EOR

Once the CO_2 has been captured and compressed, it is piped to the **storage** site and injected below ground at a depth of about one kilometre. Depleted hydrocarbon fields and saline aquifers (deep layers of water-bearing materials with an enormous CO_2 absorption capacity) are suitable deposits for permanent geological sequestration of carbon dioxide.

Global CO_2 emissions produced by man currently amount to approximately 25 billion tons (Gigatons): depleted hydrocarbon fields offer a CO_2 storage capacity of at least 2,000 Gigatons, and saline aquifers offer a significantly larger capacity. For example, since 1996 Sleipner's pioneering work in Norway has stored more than 10 million tons of CO_2 in the Utsira saline aquifer, without any significant CO_2 leakages over the years.

The CO_2 is injected at high pressure enabling it to attain a supercritical state, similar to a gas in terms of ability to penetrate rapidly through the porous geological strata, and similar to a liquid in terms of density and stockability. In depleted oil or gas fields, the CO_2 penetrates the pores in which the hydrocarbons were trapped. If significant quantities of hydrocarbons are still present, injection of the CO_2 may actually assist oil and gas production (**Enhanced Oil Recovery** and **Enhanced Gas Recovery** process – EOR and EGR).



Plant for CCS and EOR

A number of difficulties still need to be resolved in actual deployment of CCS, mainly relating to **costs**.

The initial CO_2 capture phase has a high energy and economic cost, representing approximately 80% of the total technology cost. Positive management of this phase requires plants emitting large volumes of CO_2, at high concentrations and at local level.

Once the CO_2 has been captured, it is transferred to the storage site, which needs to be close enough to keep costs down. Transportation over distances in the order of tens of kilometres accounts for approximately 15% of the total cost.

Although the final stage, underground injection, represents 5% of the total cost, it is the most delicate phase of the entire operation in terms of safety, and has a significant impact on the sustainability of the CCS process. CO_2 injection is, nevertheless, a consolidated technique in the oil industry, which leads the way in technological and geological advances; for decades, the oil companies have been re-injecting CO_2 produced from acid gas treatment into hydrocarbon fields at various stages of maturity, in order to maintain pressure and support production.

The oil industry is fully equipped to identify the best CO_2 storage sites, for example: to indicate the porosity characteristics that define potential storage volume; to assess the impact on mechanical stability and possible seismic effects; to determine the characteristics of the rock used to cover the site and ensure long-term sequestration of the injected CO_2 (simulation models are being developed to enable specialists to forecast significant CO_2 losses).

Use of saline aquifers to store CO_2 is a less well developed option requiring further research, given that this type of site has not been as widely studied as hydrocarbon fields. On the other hand, aquifers are present in areas with no oil and gas production and offer considerably greater storage potential than exhausted or depleted hydrocarbon fields.

Eni and CCS

Eni boasts outstanding (and in Italy unrivalled) know-how in every area of CO_2 capture and storage technology. It is conducting important **R&D work and short- and long-term engineering projects**. For many years, Eni has also been a member of the international **CO_2 Capture Project** (CCP) consortium, together with most of the oil majors.

For Eni CO_2 capture and storage is a necessary option for a long-term contribution to improve the sustainability of energy production in terms of impact on the climate and the environment.

Moreover, development of CO_2 injection technologies is a strategic consideration for Eni, because it can enhance oil and gas recovery rates (where the formation of the field permits this). In this case too, a significant portion of the injected CO_2 remains permanently stored in the reserve.

Eni operations and cooperation with Enel

Eni is conducting **geochemical modelling**, assessing the compatibility of existing wells and analysing monitoring methods in preparation for a forthcoming pilot operation injecting CO_2 into a gas storage site. Through **cooperation with Enel**, the test will be combined with a pilot unit capturing CO_2 from the combustion exhaust gases of a thermoelectric station. Another pilot unit will be set up in the same context, to study CO_2 pipelining.

As far as short- and long-term engineering activities are concerned, Eni is performing **feasibility studies on CO_2 injection** as a technique to boost the productivity of hydrocarbon fields. In cooperation with Enel it will also conduct feasibility studies on large-capacity integrated projects where carbon dioxide produced and captured in an Enel power station and piped to the site is injected into hydrocarbon fields or saline aquifers.

Eni plays an active role in **monitoring developments in national and international laws** governing CCS. In cooperation with Enel, it plans to conduct a detailed analysis of the various national CO_2 storage options with respect to the main emission sources.