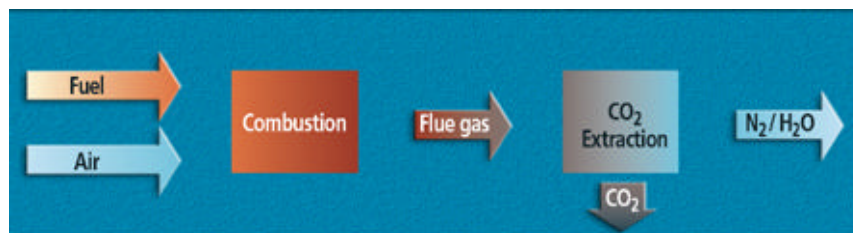




How can we capture CO₂ ?

CO₂ capture is already an industrial technology, used today notably to process natural gas. It is commonly called on in the manufacture of fertilizers, in the food-processing industry and in the energy sector (the oil and gas industry). The main problem is generally the low concentration of CO₂ in the flue gas. Depending on which industry is concerned, this concentration can range between a few percent and 20%. Other gases such as oxygen, water vapour or nitrogen also occur in flue gas. It would be out of the question to seek to compress them all for storage, from the standpoint of both energy and storage capacity. Separation methods are thus required so as to trap CO₂ preferentially. A large number of industrial capture processes exist on the market, each one with its own specific field of application with respect to the nature of the flue gas (composition, temperature and pressure) to be processed. Three main categories are recognized: post-combustion capture, oxy-fuel combustion capture and pre-combustion capture.

Post-combustion capture

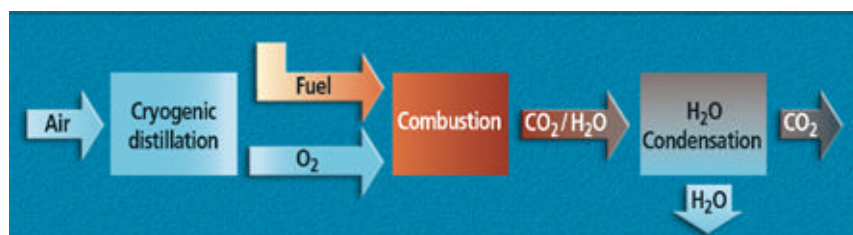


Post-combustion capture is designed to extract the CO₂ that is diluted in the combustion flue gas. It can be integrated into existing facilities without demanding any major modifications. The most common process is CO₂ capture by solvents, generally amines.

This is the capture process tested in Elsam power plant (Esbjerg) for Castor pilot.

Other processes are under consideration involving the calcium cycle and cryogenic separation. The former consists in quicklime-based capture that yields limestone; this is then heated, thereby releasing CO₂ and producing quicklime again for recycling. The cryogenic process is based on solidifying CO₂ by frosting to separate it out. CO₂ separation may also be obtained by contact with an adsorbent solid or through a membrane.

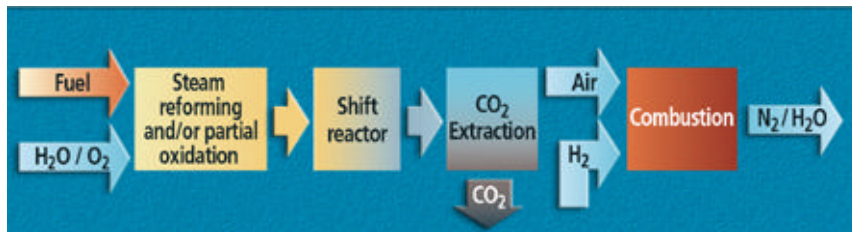
Oxy-fuel combustion capture



This technology is not CO₂ capture in the true sense of the term. Here, the process is applied at the input as opposed to the output stage: the objective is to obtain flue gas with a 90% CO₂ content by performing combustion in the presence of pure oxygen. Because it recycles part of the CO₂ as a substitute for the nitrogen in air, oxy-combustion is particularly well suited when an existing facility is

being retrofitted. However, separating out the oxygen from air, performed mainly using the cryogenic principle, is both costly and energy-consuming. To give an idea, the energy consumption involved in supplying pure oxygen to a 500 MW coal-fired power station that operates 8000 hours a year would represent 15% of the electricity it generates annually. To avoid the cost of separating out the oxygen from air, a promising technology is under consideration: chemical looping combustion. It consists in bringing the oxygen in the air into contact with a metallic medium that, when it circulates, transfers the oxygen.

Pre-combustion capture



With this type of process, the goal is to trap the carbon prior to combustion: the fuel is converted on entering the installation into synthesis gas – a mixture of carbon monoxide (CO) and hydrogen. The two main techniques are steam reforming of natural gas in the presence of water and partial oxidation in the presence of oxygen. The CO present in the mixture reacts with the water during the shift conversion stage to form CO₂ and hydrogen. The CO₂ is separated from the hydrogen, which can then be used to produce energy (electricity or heat) without giving off CO₂.

Progress & prospects

Improving techniques

Substantial research & development efforts are now in progress aimed at improving capture technologies so as to render them more efficient and more cost-effective. Supported by private international consortia like the "CO₂ Capture Project" (CCP) or by the European Castor and Encap projects, the research concerns all technological aspects, ranging from the energy consumption involved in the processes (capture currently results in a significant over-consumption of energy) to solvent performances (their stability, regeneration potential and selectivity) and including systems to remove impurities, membrane technologies, designing new catalysts or capturing CO₂ as a hydrate.

Integrating capture into industrial processes

The search for the best integration of the capture process into the industrial production plant is a major challenge. Additional power is required to separate and compress the CO₂. The amount of energy needed depends on both the intrinsic performance of the CO₂ capture system adopted and an efficient energy management throughout the plant. For example, in the post-combustion process involving amines, regenerating the solvent currently requires an energy supply of approximately 3 or 4 billion joules per tonne of CO₂, mainly in the form of water vapour. Two options exist for supplying the vapour: a boiler used solely for this purpose or the retrieval of vapour from the plant's low-pressure stage. This latter option provides better energy management, with the challenge of maintaining a high output of the production plant.

Reducing costs

Costs necessarily depend on the composition of the flue gas, the volume of emissions being processed and the type of CO₂ capture technology used. A general idea can nevertheless be gained by considering the cost of CO₂ post-combustion capture by chemical solvents, currently the best

developed techniques from an industrial point of view. Economic analyses, generally carried out in the context of electricity generating plants, yield an average capture cost that includes CO₂ compression, of 30 to 60 euros per tonne of CO₂ for a 500 MW power station, which corresponds to a 50 to 70% increase in production costs per kWh. The target is to reduce the capture cost to around 20 to 30 euros per tonne of CO₂.

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