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CO_2-capture

CO_2 emissions can be reduced by capturing CO_2 from large point sources and storing it at a safe underground location. CO_2-capture means separating the CO_2 from flue gas emitted from large point sources, such as fossil fuelled power plants or industrial installations.

Production of energy is responsible for nearly 50 percent of global CO_2-emissions, while transportation accounts for about 20 percent (IEA, 2005). The remaining emissions arise from industry and other sources. It is practical to capture CO_2 from large point sources, such as power plants and major industrial installations. Because it is difficult to capture CO_2 from vehicles, it is necessary to implement use of alternative fuels which does not produce CO_2-emissions. Important future energy carriers in the transportation sector are electricity and hydrogen. The CO_2 can then be captured at sites where hydrogen and electricity is produced.

Technologies for CO_2- capture

There are multiple technologies for CO_2-capture available; most of them can be classified into three main groups:

- *Post-combustion*: CO_2 capture from the flue gas after combustion of the fossil fuel.
- *Pre-combustion*: Removal of CO_2 from the fossil fuel prior to combustion.
- *Oxy-fuel:* Combustion of fossil fuel with pure oxygen rather than air.

Post-combustion

To rinse existing emissions, post-combustion CO_2-capture can be used. The process is based on chemical absorption, where the flue gas is brought into contact with a chemical absorbent with an ability to attach the CO_2. This process continues inside a scrubber column, where the flue gas and absorbent dissolved in water flow inside, see figure 1. Typical absorbents used are amines and carbonates.

The scrubber column is designed to ensure that the exhaust gas and the absorbent are brought into close contact with each other. The CO_2 is then transferred from the flue gas to the absorbent, and there are two out-going flows from the scrubber column; a cleaned gas-stream with low CO_2 content and a liquid-stream containing water, absorbent and CO_2.

After the absorption process, the absorbent and the CO_2 are separated in a regeneration column. When heated, the absorbents ability to retain CO_2 is reduced, resulting in regeneration of the absorbent, which can then be re-used. The CO_2 leaves the regeneration column as a gas stream of high CO_2 purity. This gas can be transported to a CO_2 storage site.

80 to 90 percent of the CO_2 from a power plant can typically be removed by post-combustion CO_2 capture.

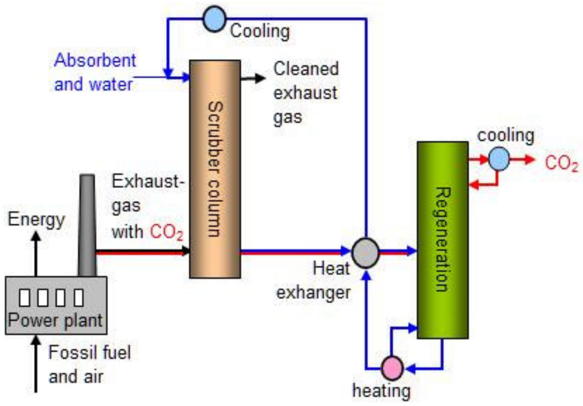


FIGURE 1. POST COMBUSTION CO_2 CAPTURE.

An advantage of post-combustion technology is that it can be added to an existing power plants without modifying the original power plant. The largest providers of processing equipment for CO_2-capture are Fluor Daniel (USA), ABB Lummus (USA) and Mitsubishi Heavy Industries (Japan).

There are currently no large scale CO_2 capture plants. Smaller plants exist, but it is still a large technical challenge to build a capture plant at the size required for a coal power plant.

Several other actors are interested in projecting and constructing CO_2 capture plants. The Norwegian company Aker Kværner launched a new project called "Just Catch" in 2005. This project is based on optimising known post-combustion technology by using amine absorption. A full scale capture plant can be in operation in 2014, and the cost of CO_2 capture is estimated to approximately 25 Euro per tonne CO_2, which would imply a 50 percent reduction of current capture cost.

The Norwegian company Sargas is also developing CO_2 capture technology. Their concept is based on combustion of fossil fuel in a boiler; CO_2-capture from the flue gas; and then a gas turbine running on purified flue gas. The capture cost is estimated to be lower than at the "Just Catch" project.

Another example of companies developing CO_2 capture technology is Alstom. Their concept is called “Chilled ammonia” and is based on post-combustion CO_2 capture with ammonium carbonate as absorbent.

There are several other companies developing new post-combustion CO_2 capture technology.

Pre-combustion

CO_2 can be separated from the fossil fuel before combustion, the so-called pre-combustion CO_2 capture method.

The principle of this process is first to convert the fossil fuel into CO_2 and Hydrogen gas (H_2). Then, the H_2 and the CO_2 is separated in the same way as under post-combustion, however a smaller installation can be used. This results in a Hydrogen-rich gas which can be used in power plants or as fuel in vehicles. The combustion of Hydrogen does not lead to any creation of CO_2. The process is described in figure 2.

When using natural gas for power production, the natural gas and steam is converted into synthesis gas in a traditional steam reformer. Synthesis gas is a common industrial gas consisting of carbon mono-oxide (CO) and hydrogen gas. The CO subsequently reacts with steam to form CO_2.

The pre-combustion CO_2 capture is applicable to coal power plants and there is a lot of focus on the IGCC technology (Integrated coal Gasification Combined Cycle), where coal is converted into CO_2 and H_2 before combustion.

By pre-combustion CO_2 capture about 90 percent of the CO_2 from a power plant can be removed. As the technology requires significant modifications of the power plant, it is only viable for new power plants, not for existing plants.

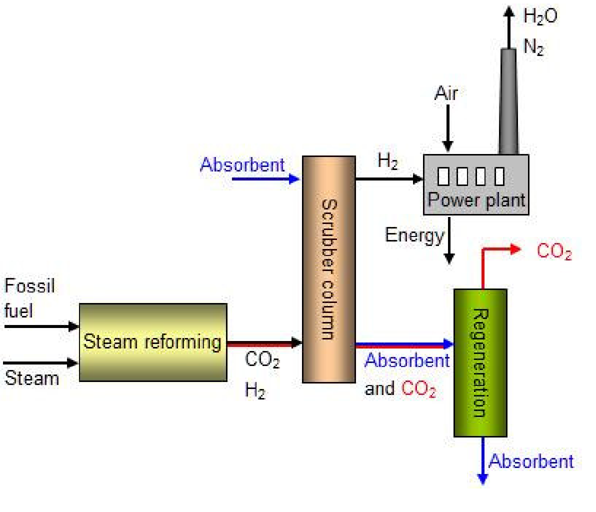
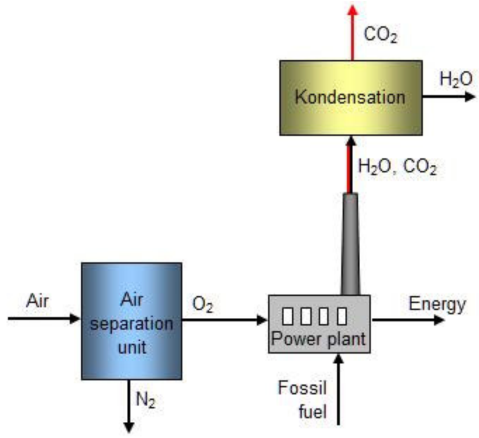


FIGURE 2. PRE-COMBUSTION CO_2 CAPTURE.

Using today’s technologies, the investment costs for a gas power plant with pre-combustion CO_2 capture will be twice as high as for a similar plant using post combustion of flue gas (Thomas, 2005). The separation of CO_2 from fossil fuel prior to combustion will become far more interesting as technological development will bring down investment- and operating costs.

Oxyfuel

In traditional fossil fuelled power plants, combustion is carried out using air, where the nitrogen (N_2) in the air follows the flue gas. An alternative is to use pure oxygen (O2) instead of air in the combustion. The advantage this so-called oxyfuel technique is that the flue gas only contains steam and CO_2. These two components are easily separated through cooling. The water then condenses, and a CO_2 rich gas-stream is formed. Up to 100 percent CO_2 can be captured in this process which is illustrated in Figure 3.



FIGUR 3. CO_2 CAPTURE USING OXYFUEL COMBUSTION.

The combustion of natural gas and pure oxygen gives high material stress in the gas turbine, hence the development of new materials is a prerequisite for deployment of this technology. In coal powered plants, this obstacle is avoided, as combustion is done in a boiler.

The currently available technologies for pure oxygen-production is based primarily on cryogenic separation of air, where the air is cooled down below the boiling point before the liquefied oxygen, nitrogen and the argon are separated. However, this is a very expensive process, due to major energy costs. Consequently, much research is carried out to develop membranes that more efficiently separate oxygen from air.

Current status of CO_2-capture

As of today, no power plants with CO_2-capture have been realized. The reasons being the lack of infrastructure for capture, transportation and storage, in addition to the significant financial risk associated with necessary infrastructural and technological investments.

There is not expected any paradigm shift in CO_2 capture technology in the near future, and the short-

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term development is thus expected to be simply a further development of existing technologies.

Optimising current technology will lower the capture costs; raise the efficiency in power plants with CO_2-capture; and give greater flexibility in terms of fuel quality.

CO_2-capture is receiving an increasing amount of attention and is continuously advancing on the list of political and corporate priorities. The Norwegian government has stated that that the gas power plant at Kårstø should be extended with a capture plant for CO_2. In addition, the Norwegian government and Statoil has agreed on building a full-scale CO_2 capture plant for the new power plant at Mongstad. Several initiatives is launched in the EU, and the European Parliament is planning to build 10 to 12 demonstration plants for CO_2 capture and storage and thereby commercialize the technology by 2020. A promising initiative is also launced in the USA where the FutureGen project will build a pre-combustion CO_2 capture demonstration plant. If all these projects are successfully carried out, CO_2 capture technology can be commercially available within few years.

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External links:

Bellona Web on CO_2 capture and storage, http://www.bellona.no/subjects/1138831369.22/section_5min_view

Bellona, "CO_2 for EOR on the Norwegian Shelf", http://www.bellona.no/filearchive/fil_CO2_report_English_Ver_1B-06022006.pdf

The European Technology Platform for Zero Emission Fossil Fuel Power Plants, http://www.zero-emissionplatform.eu/

CO_2 Capture Project (CCP), http://www.co2captureproject.com/index.htm

FutureGen, http://www.fossil.energy.gov/programs/powersystems/futuregen/

Sargas' plans for CO_2 capture www.sargas.no

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