Carbon Dioxide, Capturing & Purification

Carbon Dioxide (CO_2)

Carbon Dioxide is natural gas. It is present in air at very low level 0.03% by volume. It vital substance to plant kingdom for the process of photosynthesis. In which it's converted, using water and sunlight energy, into carbohydrates. These, in turn, serve as nutrients for growing plants and help to build its main cellular structural component, cellulose. Carbon Dioxide can exist in three forms:

- Gas
- Solid (dry ice)
- Liquid (under certain pressure level)

It has physical and chemical properties that render it ideal for the role it plays in carbonated beverages.

Properties

- It is a nontoxic, colorless, and odorless gas that don't impart any flavor to the beverages.
- It is nonflammable and presents no fire hazards when handled.
- It is soluble in water and dissolves easily in beverage.
- Its solubility can be controlled by regulating the temperature and pressure relationship.
- In water it makes weak carbonic acid that give the beverage typically tart taste note.
- The carbonic acid can retard the growth of many common microorganisms.
- Carbonic acid easily releases the Co_2 gas to create effervescence when the beverage is consumed

Carbon dioxide is produced in various industrial chemical processes, where its often a by-product of sufficient volumes to warrant further processing into the purified product used in soft drinks industry. This is most commonly supplied to the bottler in the pasteurized liquid CO_2 form by specialist industrial gas producing companies. This liquid co_2 can be supplied in cylinders. However in most reasonably sized soft drinks operations, the liquid CO_2 is normally transported to bottlers site and transferred into refrigerated bulk storage pressure vessels owned and maintained by the supplier. These liquid CO_2 plants on bottler's site to designed to deliver Co_2 in its gaseous form when drawn off for production purposes.

Soft drink companies have strict specifications regarding purity and general quality of liquid CO_2 It is recommended to only deal with suppliers that can meet these specifications. A bottler doesn't normally have the equipment or to expertise for testing the specification details. However some basic routine testing of CO_2 for taste, odor, and appearance can be performed. This is done by gently bubbling some CO_2 gas that is drawn from an on-line sampling source through a sweetened dispersing the CO_2 in the solution, it is tested for taste, odor, and appearance against a control solution. There should be no off-tastes or off-odors the test sample in the test sample which should be clear of any turbidity or foreign matter.

Sources of Co_2

- By burning of carbonaceous materials
- In the production of H_2 by steam reforming of methane or other hydrocarbons, 16% pure CO_2 is obtain
- In manufacture of alcohol (ethanol) by the fermentation process 99.9 % pure CO_2 is obtained
- In calcinations of $CaCO_3$ at 1000°C ,40% CO_2 is obtained

Carbon Capture & Storage Technology
"A Technology that can capture 90% of the Carbon Dioxide Emission and Prevent CO_2 from entering the Atmosphere" The CCS chain consist of three parts

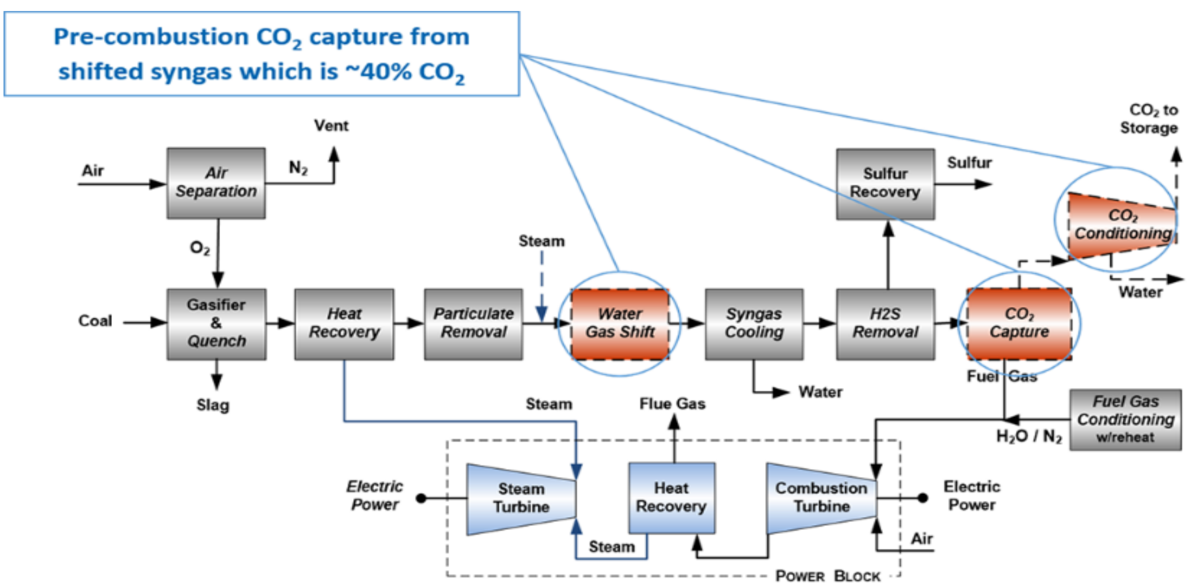
- Capturing
- Transportation
- Storage

Capturing Carbon Dioxide
Capturing of CO_2 by

1. Pre combustion Technology
2. Post combustion Technology
3. Oxy fuel process

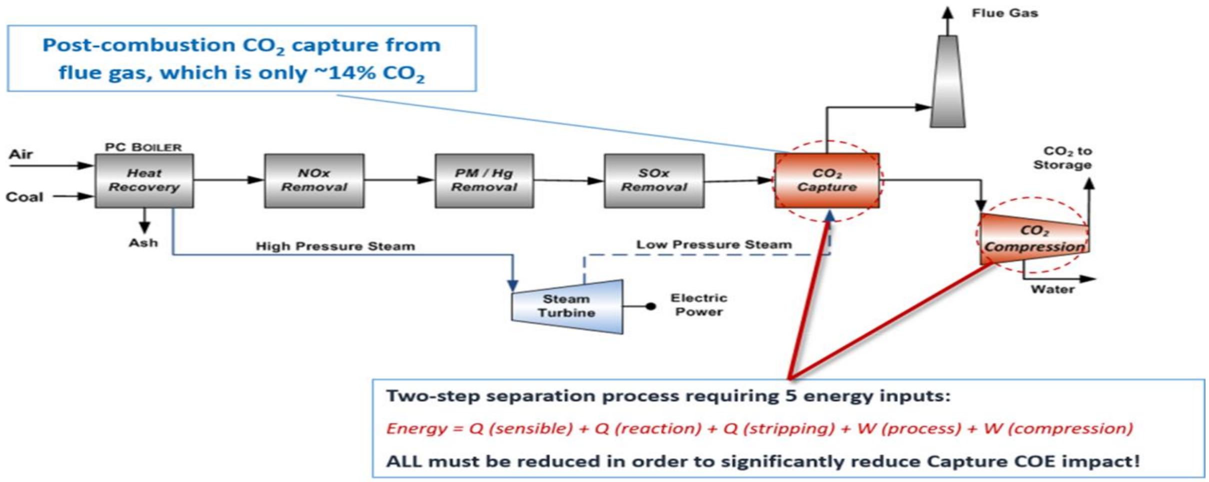
Pre combustion Technology

Pre-combustion Capture is applicable to gasification including integrated gasification combined cycle power plants, where solid fuel (i.e., coal) is converted into gaseous fuel (hydrogen and carbon monoxide, or "syngas") by applying heat under pressure in the presence of steam and oxygen. The syngas is used to fuel a gas turbine generator to produce electricity. The recovered heat is used to produce steam that also drives a turbine generator designed to generate electricity. The carbon is captured from the syngas *before it is combusted* in the gas turbine.



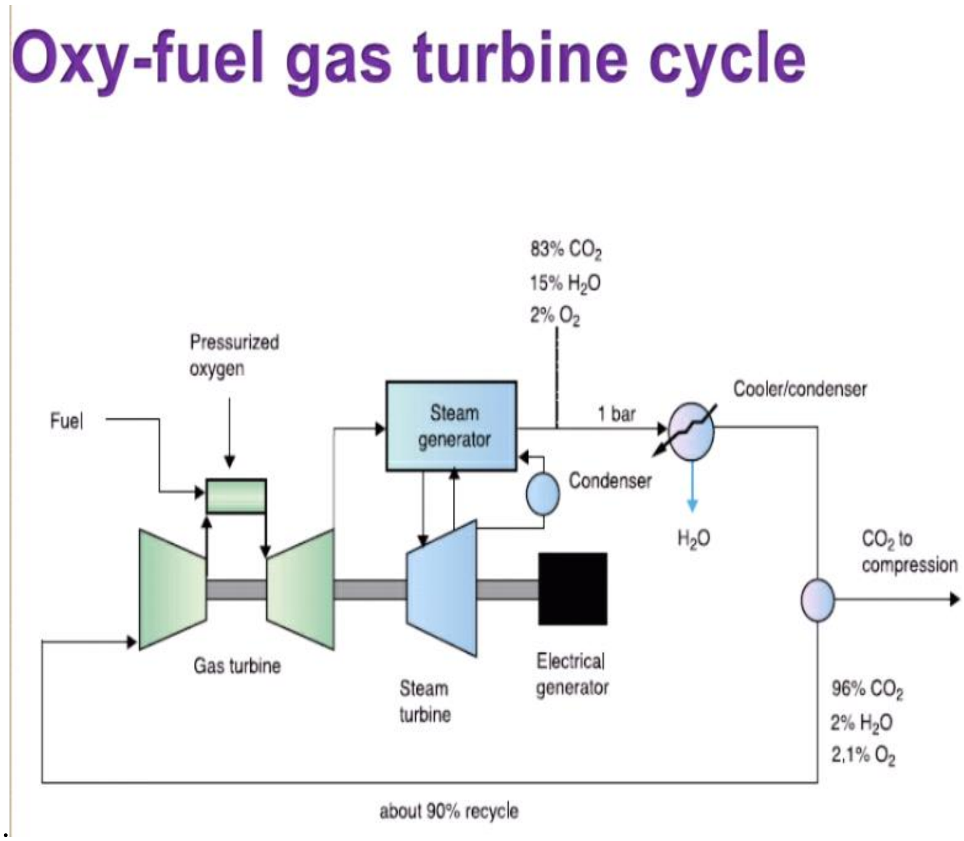
Post Combustion Technology

Post-combustion Capture refers to capturing carbon dioxide from flue gas after the fossil fuel (e.g., coal, natural gas, or oil) has been burned. Of the 4 trillion kilowatt hours of electricity generated, about 33% was from coal. In conventional coal-fired power plants, coal is burned with air in a boiler producing steam to rotate a turbine generator and produce electricity.



Oxy-fuel combustion systems

In the process of oxy-fuel combustion the oxygen required is separated from air prior to combustion and the fuel is combusted in oxygen diluted with recycled flue-gas rather than by air. This oxygen-rich, nitrogen-free atmosphere results in final flue-gases consisting mainly of CO_2 and H_2O (water), so producing a more concentrated CO_2 stream for easier purification



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Transportation of CO_2

Once captured, carbon dioxide (CO_2) must then be transported by pipeline or ship for storage at a suitable site. The technologies involved in pipeline transportation are the same as those used extensively for transporting natural gas, oil and many other fluids around the world. In some cases it may be possible to re-use existing but redundant pipelines. Carbon dioxide is currently transported for commercial purposes by road tanker, ship and pipeline. Each CCS project would choose the most appropriate method for transporting carbon dioxide and be subject to planning and health and safety regulation. Large commercial networks of carbon dioxide pipelines have been in operation for more than 30 years with excellent safety and reliability records. There is significant potential for the development of local and regional CCS pipeline infrastructure, leading to CCS "clusters" where CO2-intensive industries could locate. Developing clusters, where infrastructure can be shared by a number of industrial sources of carbon dioxide emissions, will result in the most cost-effective way to deliver CCS infrastructure development and ultimately lower costs to consumers.

Storage

Once the carbon dioxide ($CO_{2)}$ has been transported, it is stored in porous geological formations that are typically located several kilometers under the earth's surface, with pressure and temperatures such that carbon dioxide will be in the liquid or 'supercritical phase'. Suitable storage sites include former gas and oil fields, deep saline formations (porous rocks filled with very salty water), or depleting oil fields where the injected carbon dioxide may increases the amount of oil recovered. Depleted oil and gas reservoirs are more likely to be used for early projects as extensive information from geological and hydrodynamic assessments is already available. Deep saline aquifers represent the largest potential carbon dioxide storage capacity in the long term, but are currently less well understood.

At the storage site the carbon dioxide is injected under pressure into the geological formation. Once injected, the carbon dioxide moves up through the storage site until it reaches an impermeable layer of rock (which cannot be penetrated by carbon dioxide) overlaying the storage site; this layer is known as the cap rock and traps the carbon dioxide in the storage formation. This storage mechanism is called **"structural storage"**.

Structural storage is the primary storage mechanism in CCS and is the same process that has kept oil and natural gas securely trapped under the ground for millions of years providing confidence that carbon dioxide can be safely stored indefinitely. As the injected carbon dioxide moves up through the geological storage site towards the cap rock some of it is left behind in the microscopic pore spaces of the rock. This carbon dioxide is tightly trapped in the pore spaces by a mechanism known as **"residual storage".**

Over time the carbon dioxide stored in a geological formation will begin to dissolve into the surrounding salty water. This makes the salty water denser and it begins to sink down to the bottom of the storage site. This is known as "dissolution storage". Finally "mineral storage" occurs when the carbon dioxide held within the storage site binds chemically and irreversibly to the surrounding rock.

As the storage mechanisms change over time from structural to residual, dissolution and then mineral storage the carbon dioxide becomes less and less mobile. Therefore the longer carbon dioxide is stored the lower the risk of any leakage.

Uses of CO_2

Food

Carbon dioxide is a food additive used as a propellant and acidity regulator in the food industry It is approved for usage in the EU, USA, Australia and New Zealand

Baking

Leavening agents cause dough to rise by producing carbon dioxide. Yeast produces carbon dioxide by fermentation of sugars within the dough, while chemical leaveners such as baking powder and baking soda release carbon dioxide when heated or if exposed to acids.

Beverages Carbonation

Carbon dioxide is used to produce carbonated soft drinks and soda water. Traditionally, the carbonation in beer and sparkling wine came about through natural fermentation, but many manufacturers carbonate these drinks with carbon dioxide recovered from the fermentation process. In the case of bottled and kegged beer, the most common method used is carbonation with recycled carbon dioxide

Purification of CO_2

Various different process arrangements are possible depending on the purity and recovery of CO_2 required. Gas purification is a specialist area, and the sub-system will probably be supplied as a separate package and designed by the supplier, including material selection.

In the present design cases, the only inlet to the system, stream RCO7, has been dried in the previous molecular sieve dryer and contains only 5 ppm of water. Therefore, the entire purification process can be regarded as dry and corrosion free. Some of the streams are at temperatures suitable for low temperature carbon steel (LTCS), for example to ASTM A333 with a specified Charpy impact transition temperature of -46°C. For operating temperatures below this range, austenitic stainless steels, such as 316L or 304L are suitable. Carbon steel is suitable for exit streams at near ambient temperature.

Pressurized Co_2 purification processes

The oxy-fuel flow sheet thus should consider both the combustion process as well as gas cleaning/purification process, For the power plant, the acid dew point and sulfur corrosion determines the necessity of recycled flue gas cleaning and the need for special materials used for ducts, heat exchangers and other Equipments as SO_2 concentration in oxy-fuel firing may be 2-4 times higher compared to air-firing mode. For coals with about 1% sulfur by weight or less, no sulfur removal may be required; for coals with higher than 1% sulfur by weight; the secondary recycle flue gas may be cleaned with a SO_2 scrubber. Either dry or wet scrubbers can be considered.

The flue gas cleaning must also meet the requirement for CO_2 transportation and regulations for CO_2 storage. The integration of gas quality control for both recycled flue gas as well as CO_2 effluent stream leads to various oxy-fuel flow sheets.

Expertise in the field of pressurized gas cleaning belongs to the international gas vendors (for ox fuel these are Air Products, Air Liquid, Linde and Praxair), but some research has been established in research laboratories. the flue gas is fed into a separator, and further compressed by the fan to around 1.25 bar to overcome the pressure drop in the activated carbon filtration unit for mercury control. After filtration, the gas is compressed by a two-stage compressor with inter-stage cooling at 22 bar. The moisture is condensed and recovered as condensate in the separator. Then the CO_2 stream is sent to the de-hydration unit to remove the moisture. The dried flue gas is then liquefied and purified through a cold box and a rectification column. The vent gas containing mainly non-condensable gases and CO_2 is sent to atmosphere.