Post-combustion capture of carbon dioxide

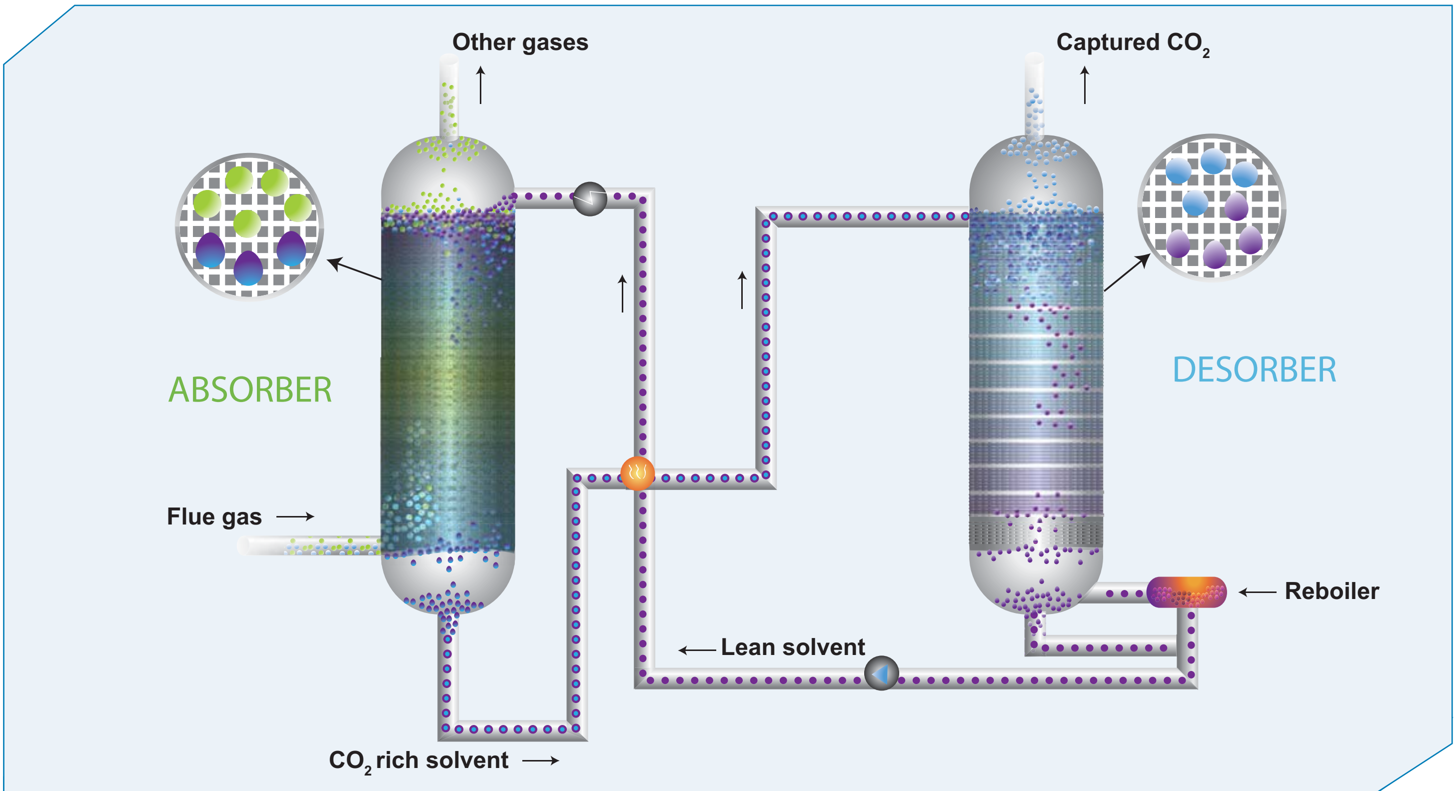
Solvent absorption

Solvent absorption is currently the preferred option for removing carbon dioxide (CO_2) from industrial waste gas and for purifying natural gas. It is the method used by the International Power Capture Plant at Hazelwood power station and involves passing the flue gas through liquid chemicals that absorb CO_2 and then release it at an elevated temperature in another vessel. The same chemical can be used over and over again to separate CO_2.

In post-combustion capture from power stations, the flue gas is at atmospheric pressure and contains mainly nitrogen, CO_2, oxygen and water. At Hazelwood Power Station the CO_2 makes up about 11 per cent of the flue gas.

The cooled flue gas comes into contact with the solvent in the *absorber* and the CO_2 is absorbed into the solvent at a temperature of between 40-60°C. The other gases leave the absorber column and the "rich" solvent containing the CO_2 is then pumped to another column (called a stripper or *desorber*) via a heat exchanger. The "rich" solvent is then heated to about 120°C, causing the CO_2 to be released from the solvent.

The CO_2 emerges at the top of the desorber where it is cooled to remove water. The water is returned to the desorber and the "lean" solvent pumped back to the absorber. On the way, the hot, lean solvent passes through a heat exchanger, where it exchanges heat with the rich solvent leaving the absorber column.



Solvent-based absorption CO_2 capture.

Post-combustion capture of carbon dioxide

The CO2CRC H3 Capture Project is conducting research into solvent absorption for CO_2 capture using the International Power Capture Plant at Hazelwood power station.

The project aims to:

- trial a number of solvents including a hot potassium carbonate-promoted solvent;
- reduce the energy consumption for solvent regeneration;
- assess the energy integration options for the power plant and capture processes;
- control or avoid solvent degradation and corrosion;
- understand the interaction between the solvent system and impurities present in the flue gas, including SOx and NOx; and
- review the technical and economic issues for commercial use of post combustion capture in existing and new Victorian brown coal power stations.

The International Power Capture Plant has been constructed by The Process Group and in the first phase is designed to capture 25 tonnes per day of CO_2 from flue gas.

The H3 project is part of the Latrobe Valley Post-combustion Capture Project and is supported by the Victorian Government, through their Energy Technology Innovation Strategy (ETIS) Brown Coal R&D funding.

CO2CRC is supported through the Australian Government's Cooperative Research Centre Program.

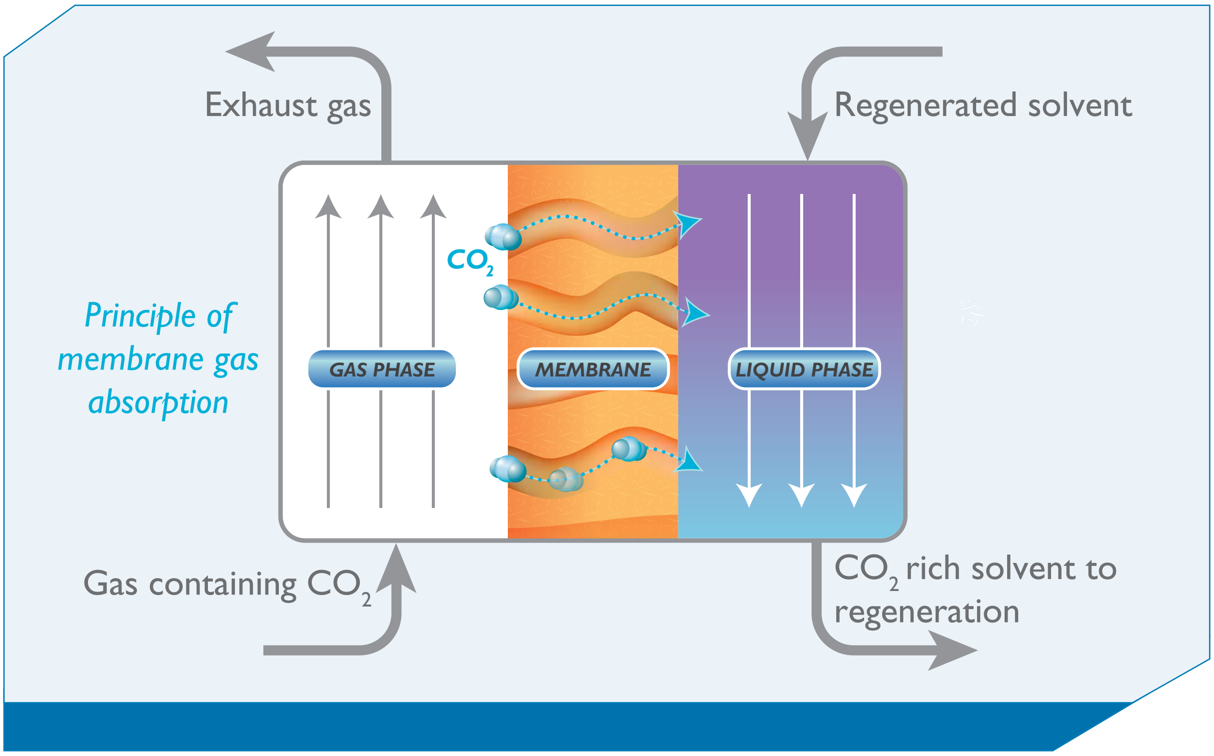
Membrane technologies

Membranes, generally made of polymers or ceramics, can be used to effectively sieve out carbon dioxide (CO_2) from gas streams. The membrane material is specifically designed to preferentially separate the molecules in the mixture. The process has not yet been applied on a large scale and there are challenges related to the composition and temperature of the flue gases.

Membranes are used to separate CO_2 from other gases (gas separation membranes) and to allow CO_2 to be absorbed from a gas stream into a solvent (membrane gas absorption). There are a range of membrane types for these processes.

Membrane Gas Absorption

A membrane can be used with a solvent to capture the CO_2. The CO_2 diffuses between the pores in the membrane and is then absorbed by the solvent. The membrane maintains the surface area between gas and liquid phases. This type of membrane is useful when the CO_2 has a low partial pressure, such as in flue gases, because the driving force for gas separation is small.



In the diagram above, the porous membrane allows gases to come into contact with the solvent. Only CO_2 is absorbed because of the selectivity of the solvent. The membrane itself does not separate the CO_2 from other gases, but rather maintains a barrier between the liquid and gas with permeability through the pores.

In a traditional solvent absorption process, the liquid and the gas are together, which leads to flow problems such as foaming and channelling. The physical separation of the gas flow from the liquid flow in a membrane absorber eliminates these problems.

Using a compact membrane can reduce the size of the equipment required to absorb the CO_2. Research is focused on developing appropriate materials that ensure that solvent does not penetrate the membrane pores.

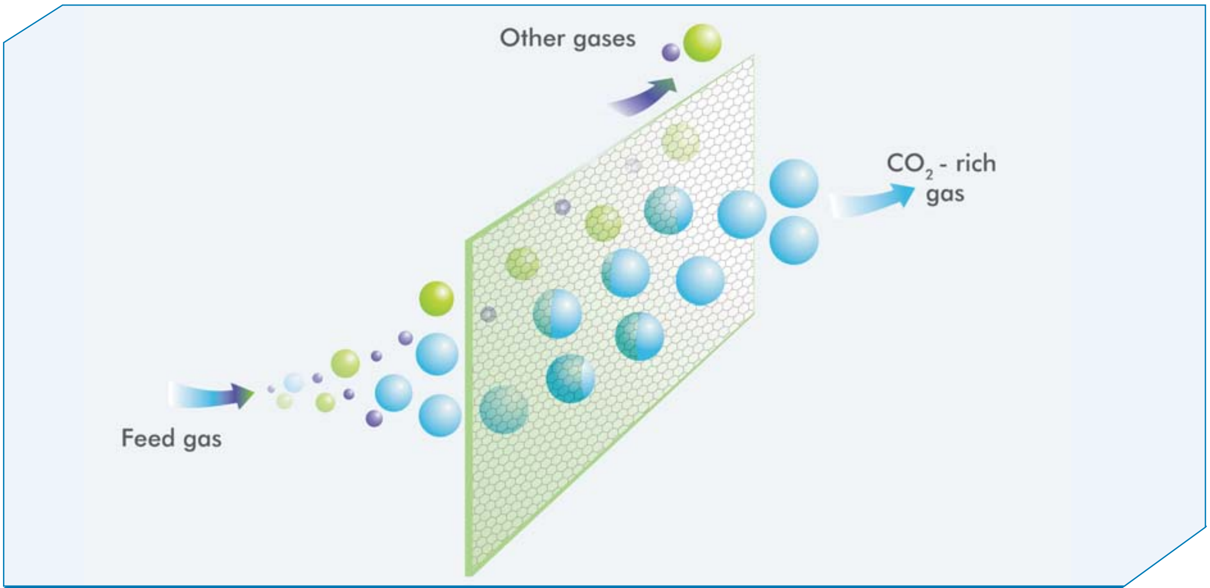
The CO2CRC H3 Capture Project at International Power's Hazelwood Power Station is conducting research into membrane gas absorption for CO_2 capture. The project aims to:

- test a range of membrane materials with a range of solvents; and
- evaluate the performance of each configuration.

Gas separation membranes

The advantage of using gas separation membranes is that the equipment is much smaller and there is no solvent involved. At the current stage of development, the main cost is the energy required to create a large enough pressure difference across the membrane to drive separation.

A membrane acts as a semi-permeable barrier. The CO_2 passes through this barrier more easily than other gases. In general, the rate at which a particular gas will move through the membrane can be determined by the size of the molecule, the concentration of gas, the pressure difference across the membrane and the affinity of the gas for the membrane material.



While the equipment is smaller, gas separation membranes require a large pressure difference to drive separation.

The CO2CRC H3 Capture Project at International Power's Hazelwood Power Station is conducting research into gas separation membranes for CO_2 capture. The project aims to:

- test a range of gas separation membranes;
- investigate the separation performance of these membranes under real flue gas conditions; and
- monitor the effects of minor gas components in the flue gas.

The project is part of the Latrobe Valley Post-combustion Capture Project and is supported by the Victorian Government, through their Energy Technology Innovation Strategy (ETIS) Brown Coal R&D funding.

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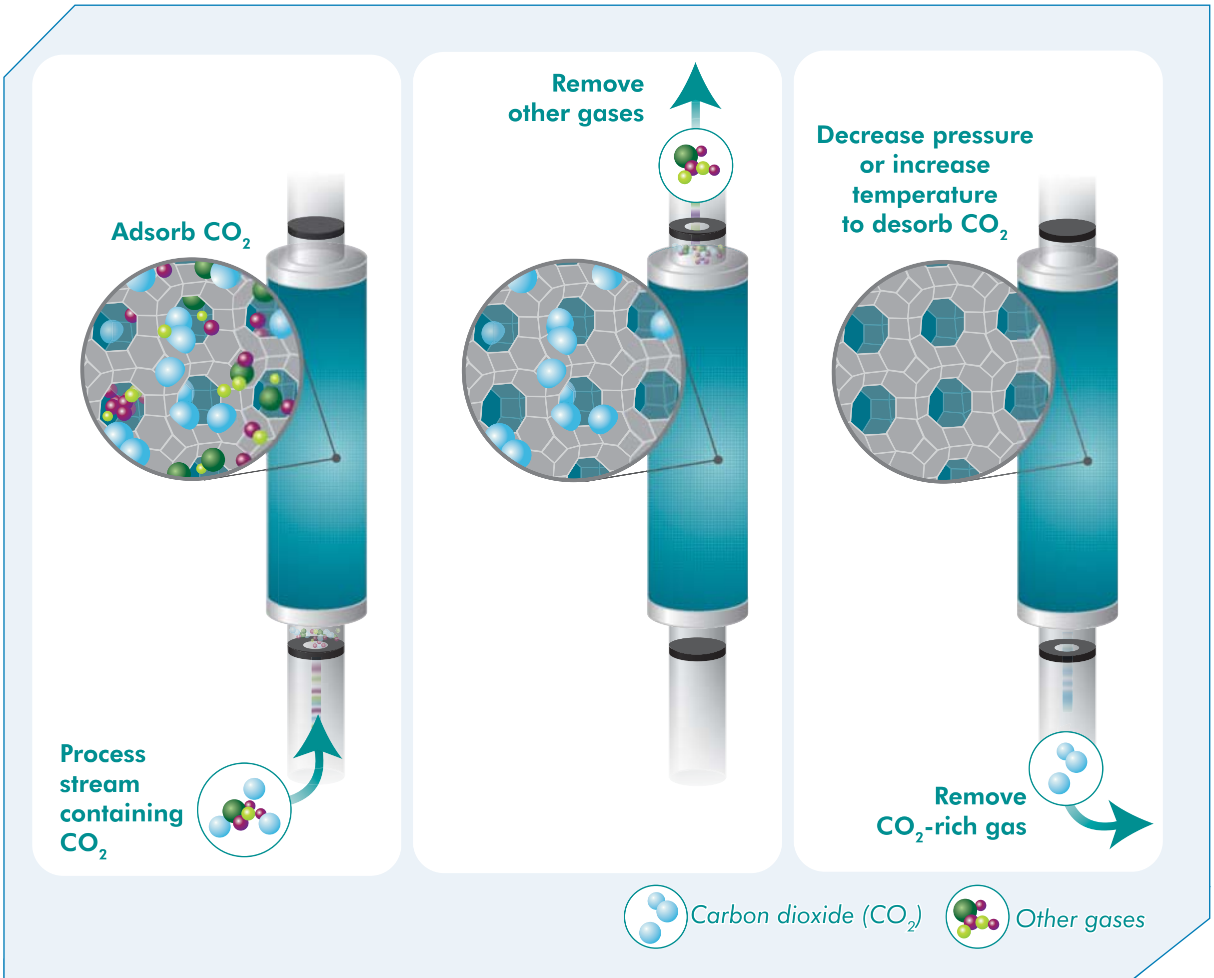
Adsorption technologies

Adsorbent capture technologies for separating carbon dioxide (CO_2) from industrial gas streams have the potential to be highly cost-effective, as they require less energy and could have less impact on the environment.

Adsorbents are solids, typically minerals called zeolites, that can capture CO_2 on their surface, release the CO_2 following a change in temperature or pressure and be reused in a cyclical process.

In current CO2CRC trials, the CO_2 is released from the adsorption material by reducing the pressure. This is known as Pressure Swing Adsorption (PSA) or, where the pressure is reduced to very low pressure, Vacuum Swing Adsorption (VSA). This process is widely used in air separation, natural gas purification and hydrogen gas generation.



Principles of adsorption.

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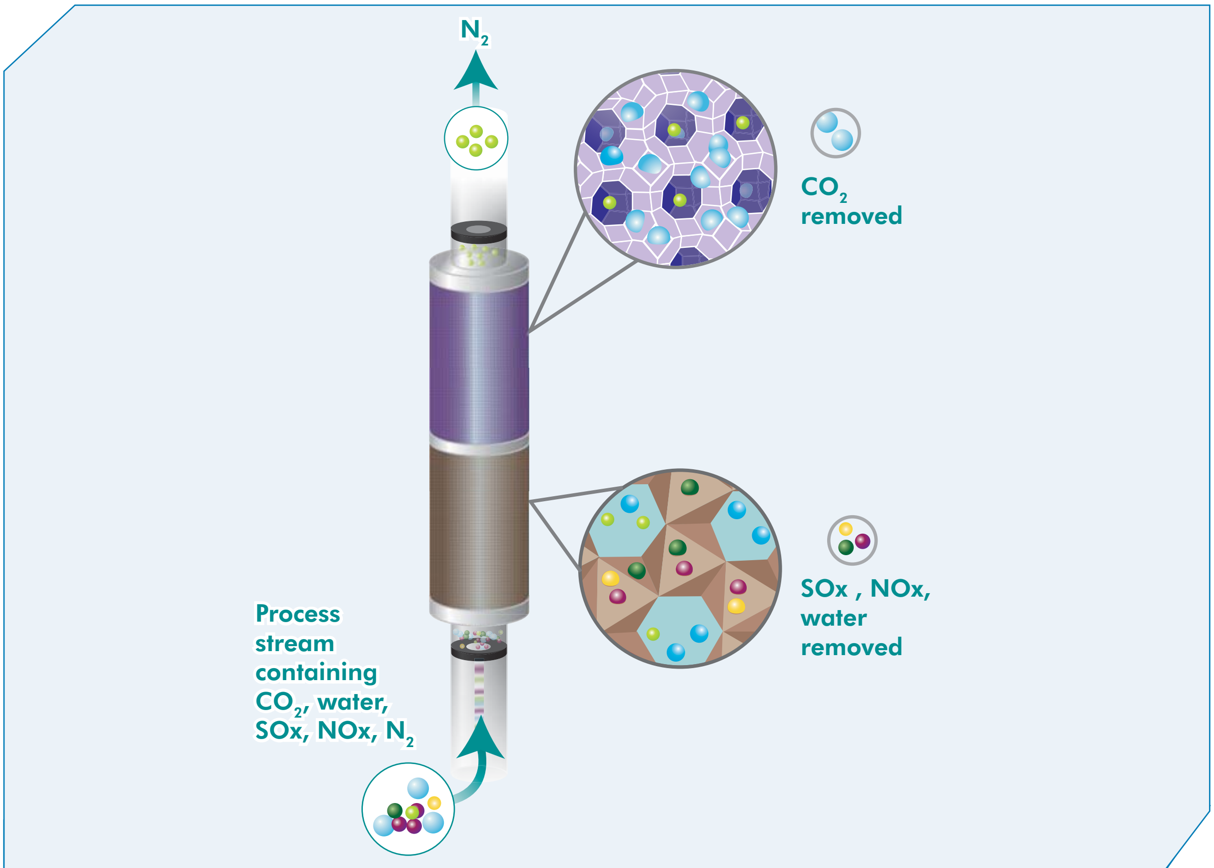
In current CO2CRC trials, the adsorber column contains multiple layers to deal with the complex composition of the flue gas.



A water-selective and acidic gas-resistant adsorbent is used to remove the water and the SOx and NOx in the flue gas.

The CO2CRC H3 Capture Project at International Power's Hazelwood Power Station is conducting research into adsorption technologies for CO_2 capture. The project aims to:

- demonstrate adsorption for CO_2 capture from flue gas;
- assess adsorption process, equipment and different adsorbents under various working conditions and equipment configurations;
- assess effect of impurities, temperature and load on the vacuum swing adsorption process; and
- assess economic and engineering issues for scale-up.

The project is part of the Latrobe Valley Post-combustion Capture Project and is supported by the Victorian Government, through their Energy Technology Innovation Strategy (ETIS) Brown Coal R&D funding.

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