Carbon Capture and Storage in View of EU Climate Policy and Directive 2009/31/EC

Paper presented at SET@W Project Matchmaking Event New Delhi, India, 15-16 March 2010

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Carbon capture and storage (CCS)…

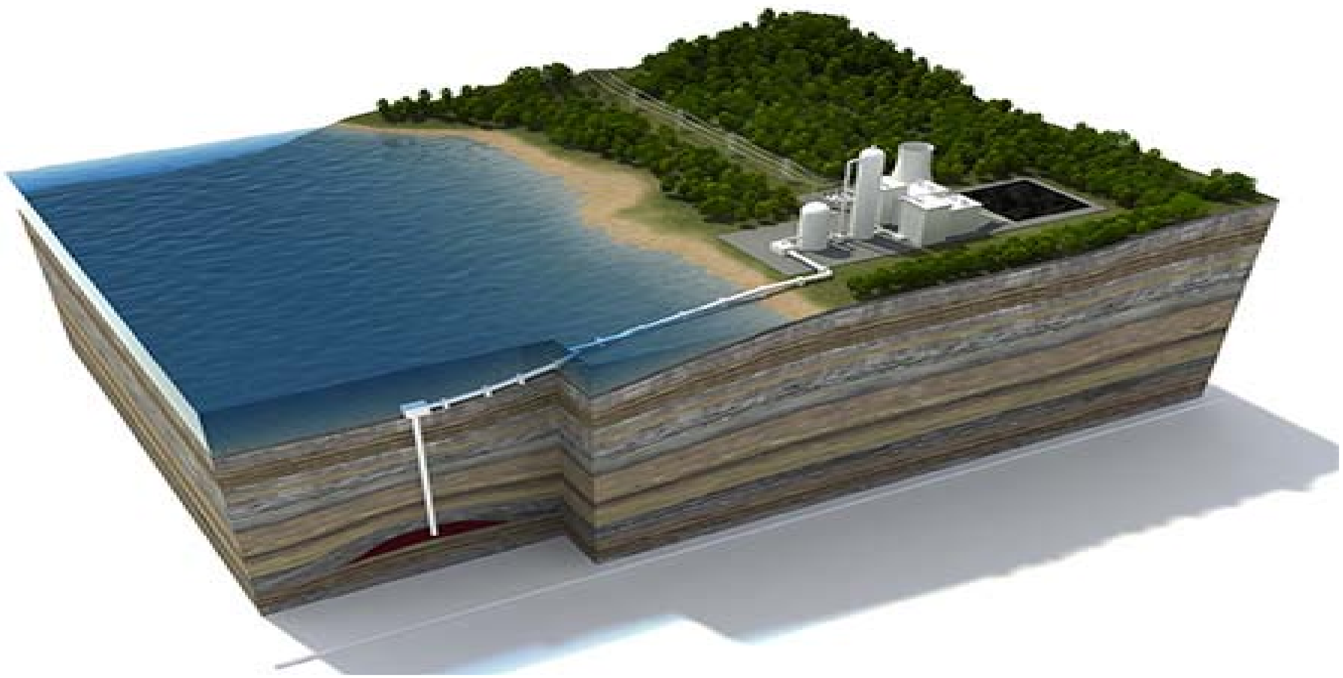
EU being a global leader in climate change abatement considers CCS technologies as one of the crucial areas in its climate policy.

An integral part of EU's efforts in CCS is the planned European CCS demonstration programme of 10-12 large scale demonstration projects.

In cooperation with the US, Australia and Canada, EU has set up a target of 20 large CCS demonstration plants in to be commissioned globally operation by 2015.

Carbon Capture & Storage (CCS)

is a process that captures Carbon Dioxide (CO_2) emissions and stores them deep inside the earth.



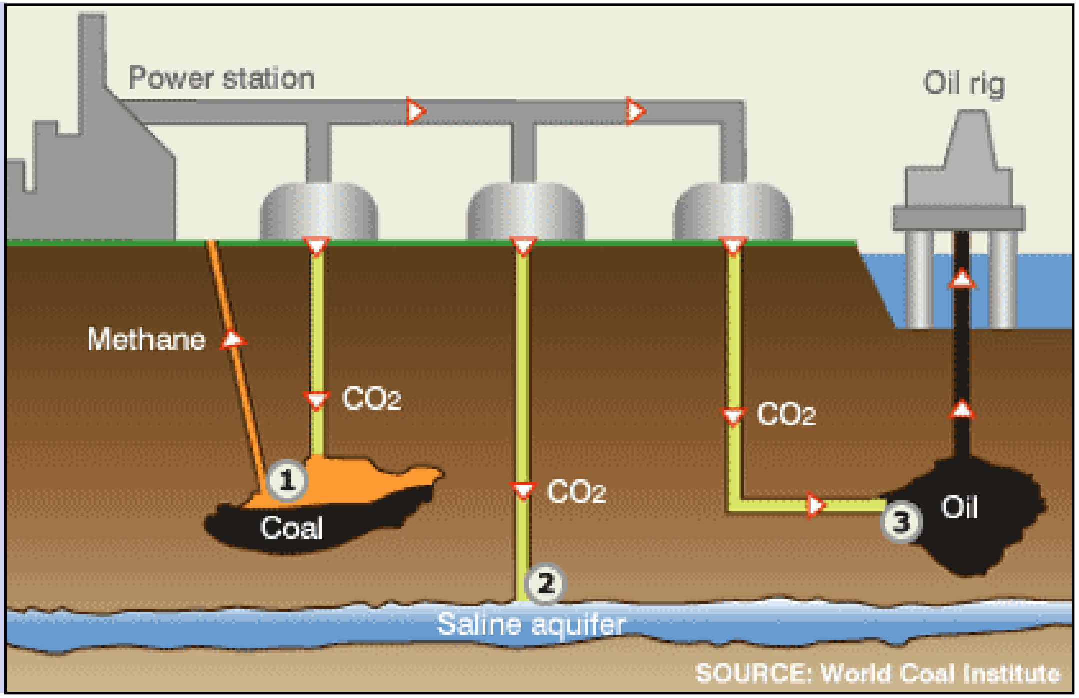
CCS *(also called "Carbon Capture & Sequestration)*
has been used in Oil & Gas & Coal mining industries before.
Recently, it's use has been dedicated to CO_2 removal from atmosphere.

How it works:

CO_2 is compressed and pumped in appropriate geological formations,

for example:

- Coal bed seams (1),
- Deep saline aquifers(2),
- Oil or gas reservoirs (3).



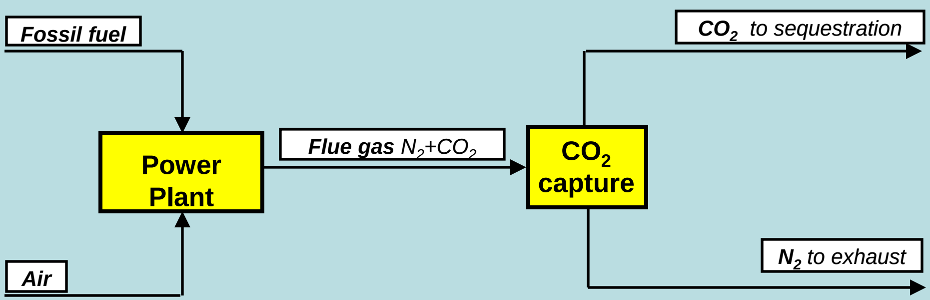
Sustainable Energy Technology at Work

SEVENTH FRAMEWORK PROGRAMME

Carbon Capture

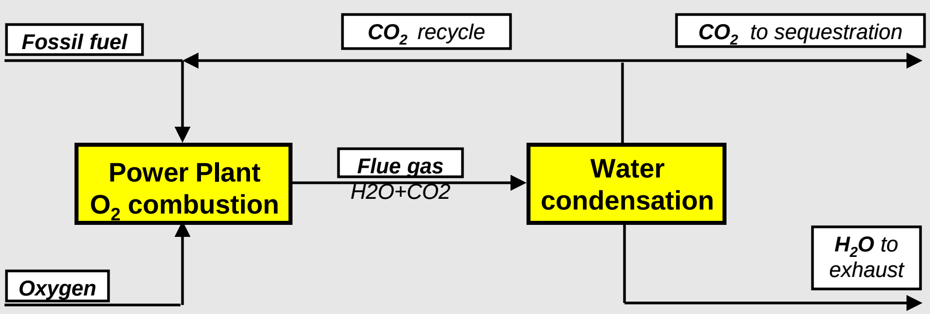
CO_2 has first to be captured from flue gas by either of following three principles:

1. Post-combustion principle



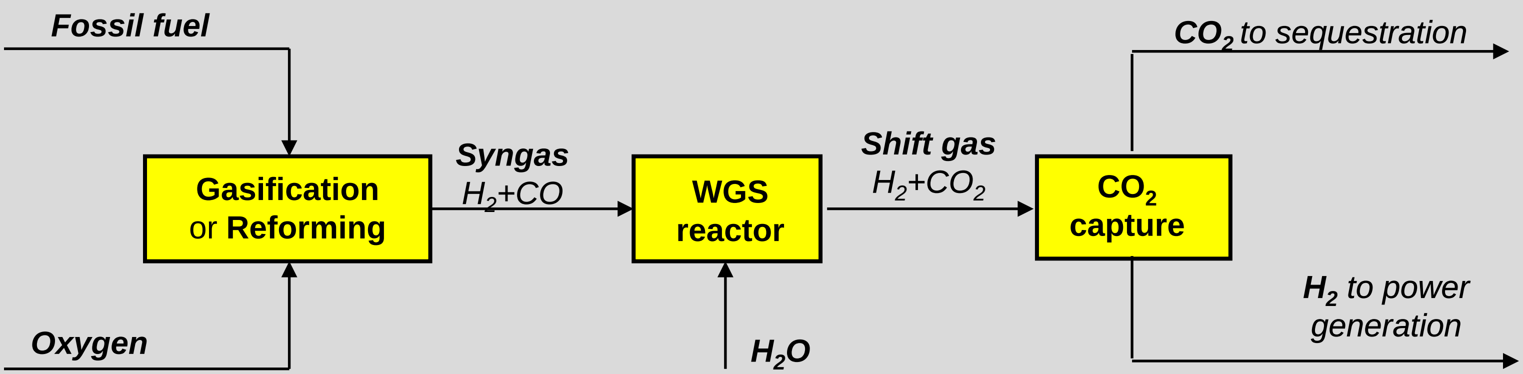
CO2 is separated out from flue gas by means of Amine Absorbtion technology. Then it is compressed and transported to site where it is injected under the earth.

2. Oxy-fuel combustion principle



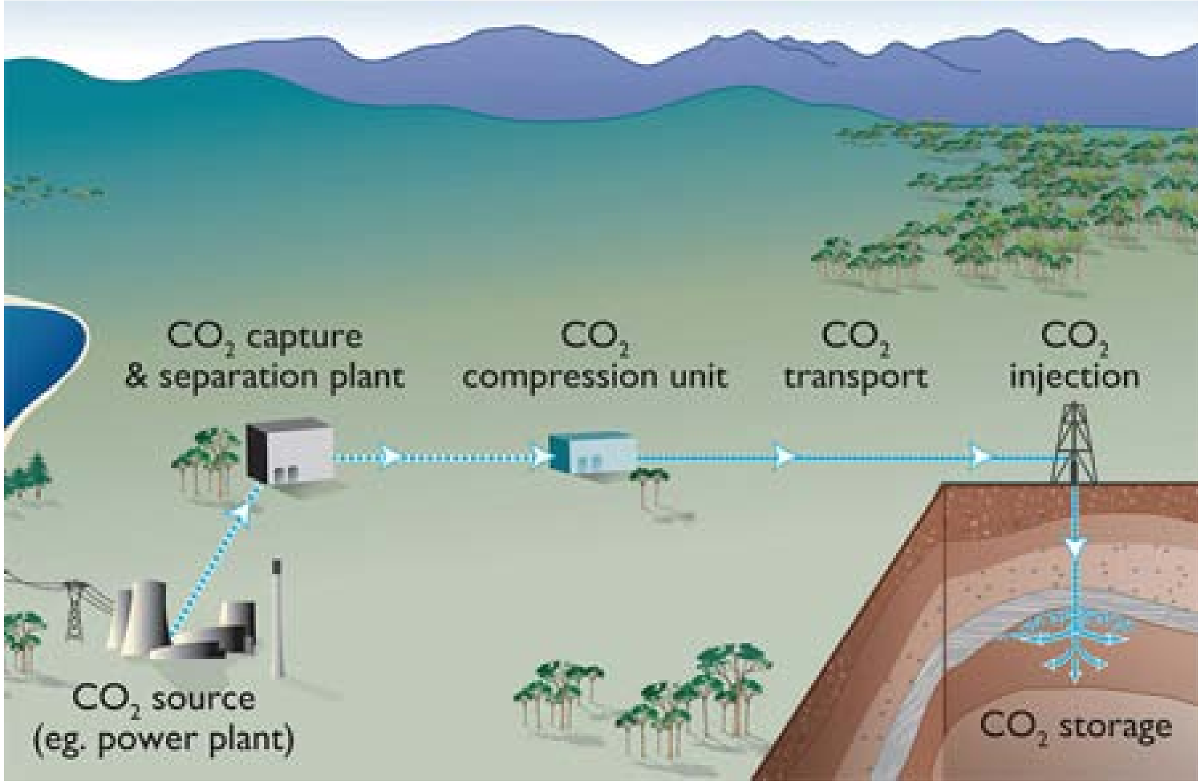
Fuel in Power Plant is burned with pure Oxygene instead of air. Flue gas from oxy-burning has no nitrogen and its CO2 concentration is very high. Separation of CO2 from flue gas is very easy.

3. Pre-combustion principle



Fossile fuel is gasified or reformed to produce Synthetic Gas (syngas).
Syngas is transformed to mixture of CO2 + Hydrogen.
CO2 is then captured, compressed and transported to Injection Site.

CCS Process in 3 or 4 steps



1… CO2 Capture (*can be with compression)*

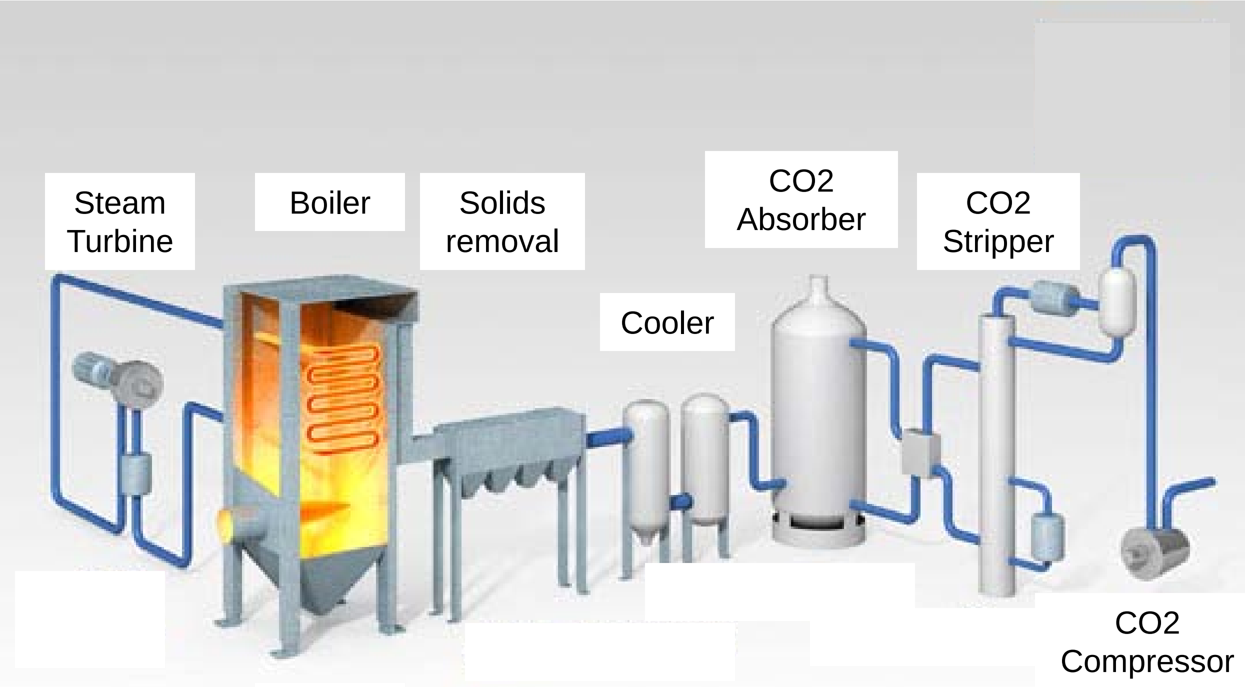
2. CO2 Compression

3. .. Transportation to site *(can be 100's km) via pipeline or track*

4……… Storage (Sequestration) (CO2 is injected in the earth)

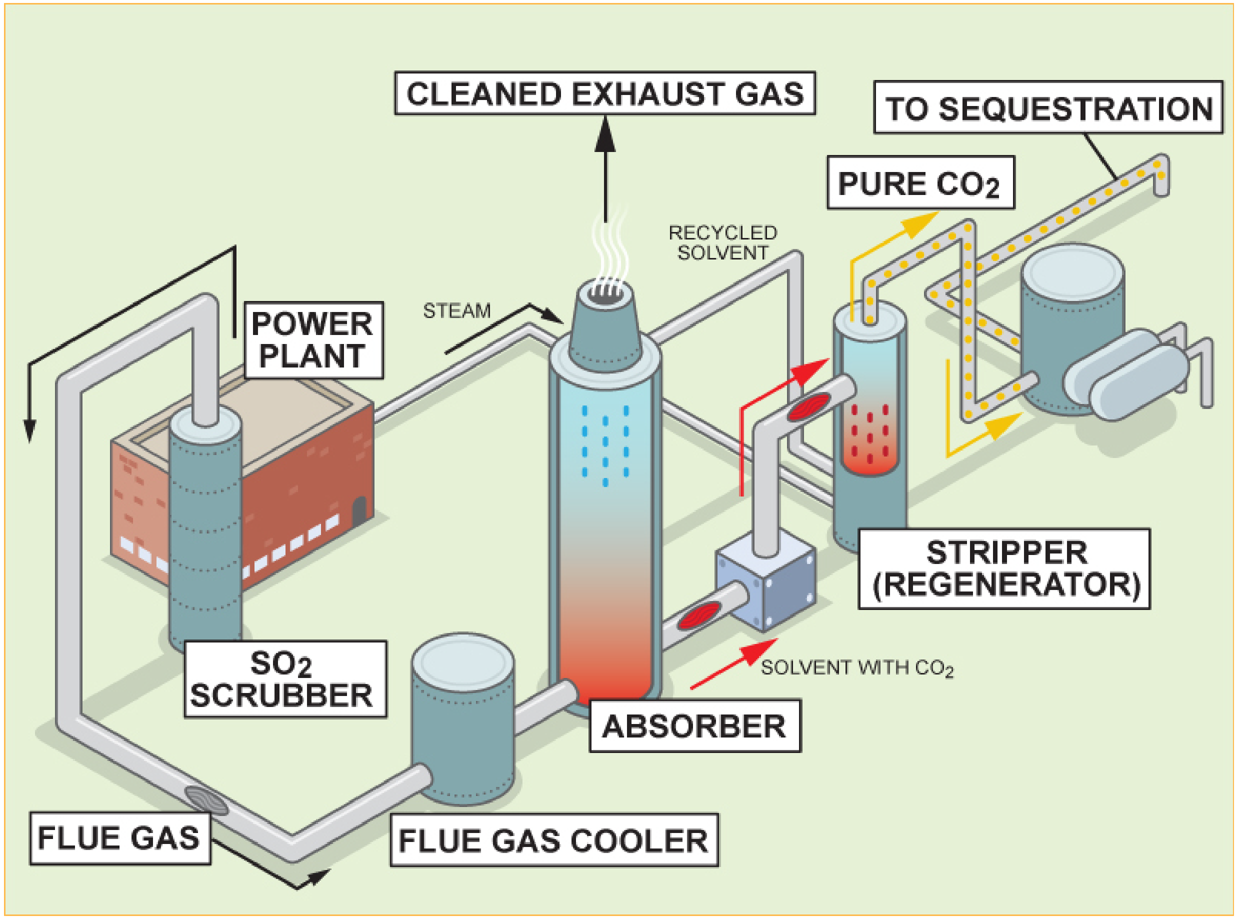
How CO_2 Capture Systems Work

1. Post-Combustion CO_2 Capture Systems



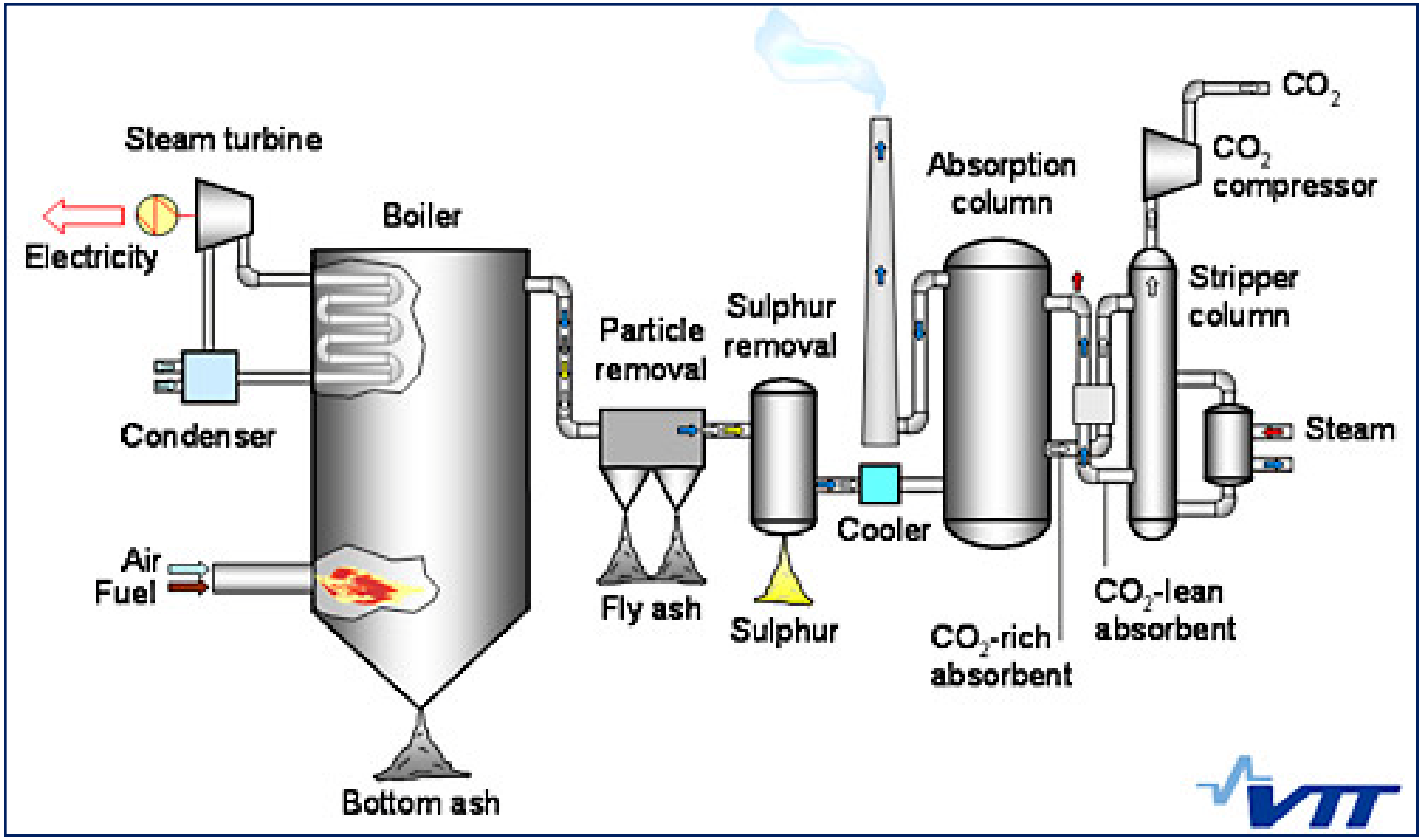
Post Combustion Capture technology involves capturing the CO_2 directly from the flue gas of fossil fuel fired power facilities. It is the simplest way of all capturing processes. Being end-of-pipe component, it can be applied to existing power plants, which is not possible with other CCS systems. Its disadvantage is high volume of flue gas to be processed, with low CO_2 concentration. High energy consumption is therefore necessary.

Post-combustion Carbon Capture System in 3D Outline



Post-combustion capture

can be applied to majority of conventional fossil-fuelled power plants.



The flue gas is directed to a CO2 Absorbtion column that removes the CO2 from the flue gas stream with the aid of suitable solvent. In Strpper Column CO2 is desorbed and solvent regenerated.

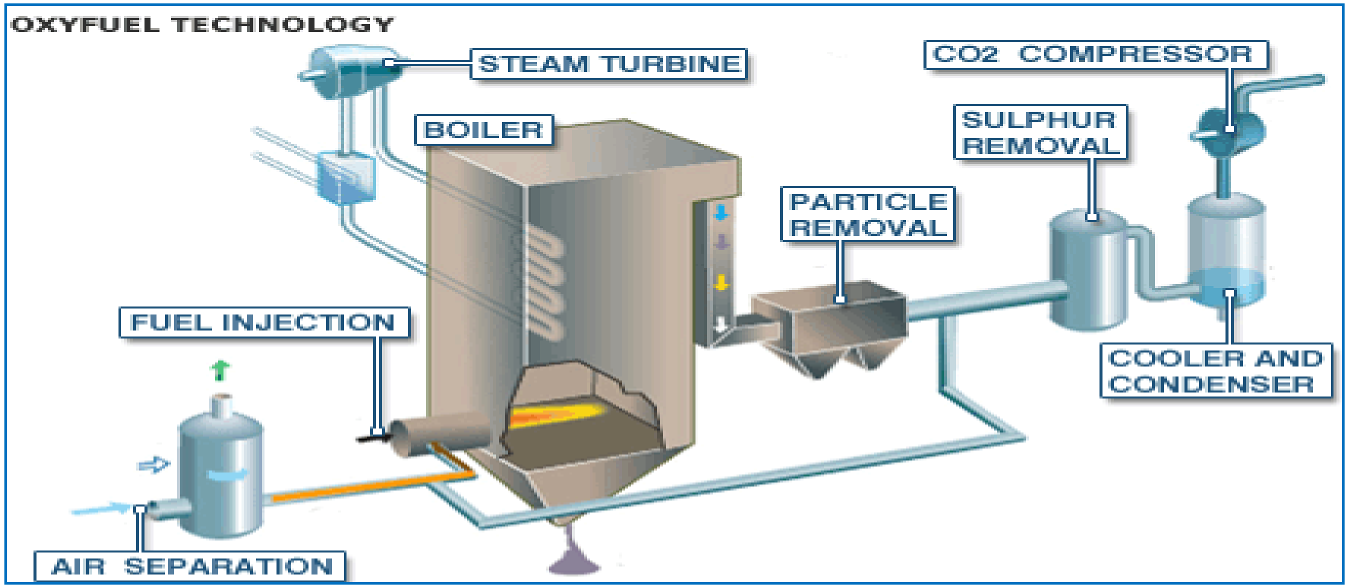
Post-combustion capture systems typically reach a capture rate of approximately 90%.

2. Oxy-Fuel Combustion Carbon Capture Systems

Using Oxygen instead of air substantially increases the concentration of carbon dioxide (CO2) in the flue gases. Oxygen combustion combined with flue gas recycle increases the CO2 concentration of the off-gases from around 15% for Pulverised Coal up to 95%.

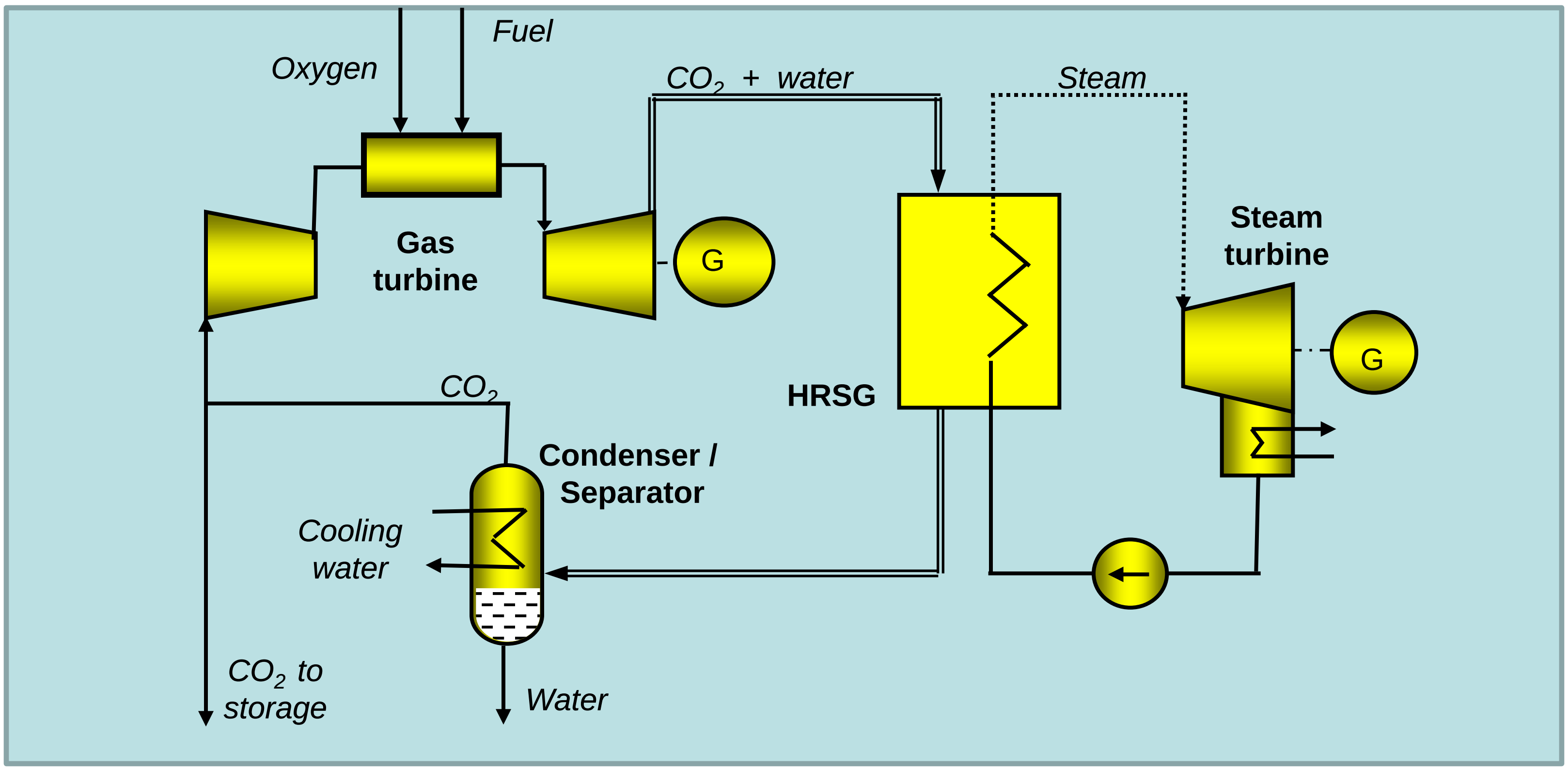
Oxyfuel Combustion with Coal-fired Plant

is based on the idea that the fuel is burned together with pure oxygen and recycled CO2 instead of air. This can be achieved by separating nitrogen from air in an Air Separation Unit (ASU). This way the flue gas from the boiler consists mainly of CO2 and some water. The water can then be easily separated from CO2 with a condenser resulting in a stream of CO2 ready for underground storage.

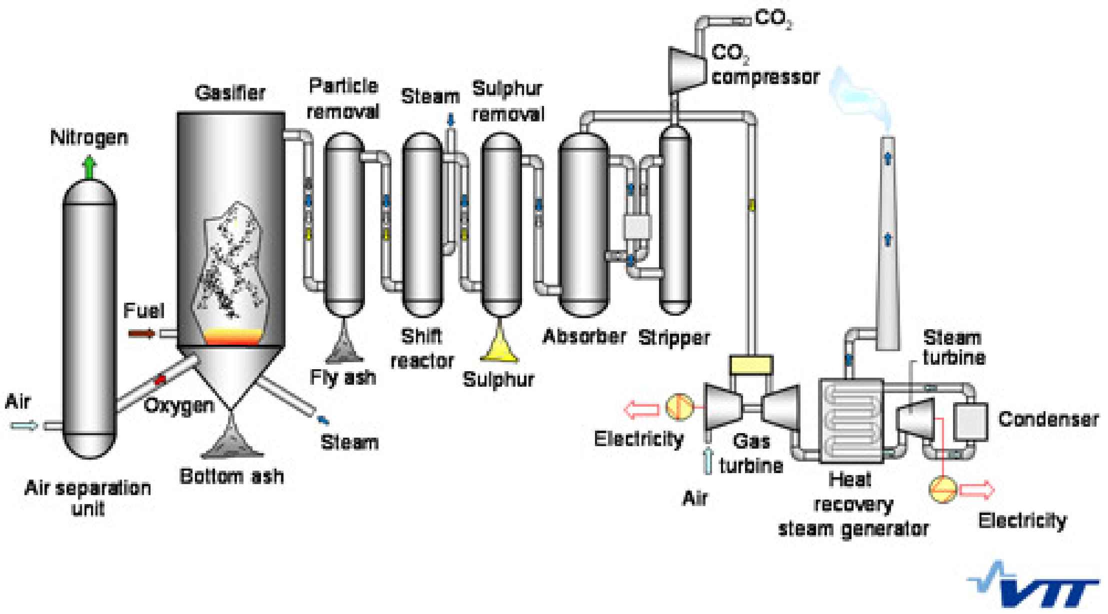


Oxyfuel Combustion with Combined-cycle Plant

Pure oxygen is used for firing the Gas Turbine instead of air. Flue gas from HRSG (Heat Recovery Steam Generator) discharge is separated to Water + CO_2. Finally, CO_2 is injected back into the Gas Turbine.

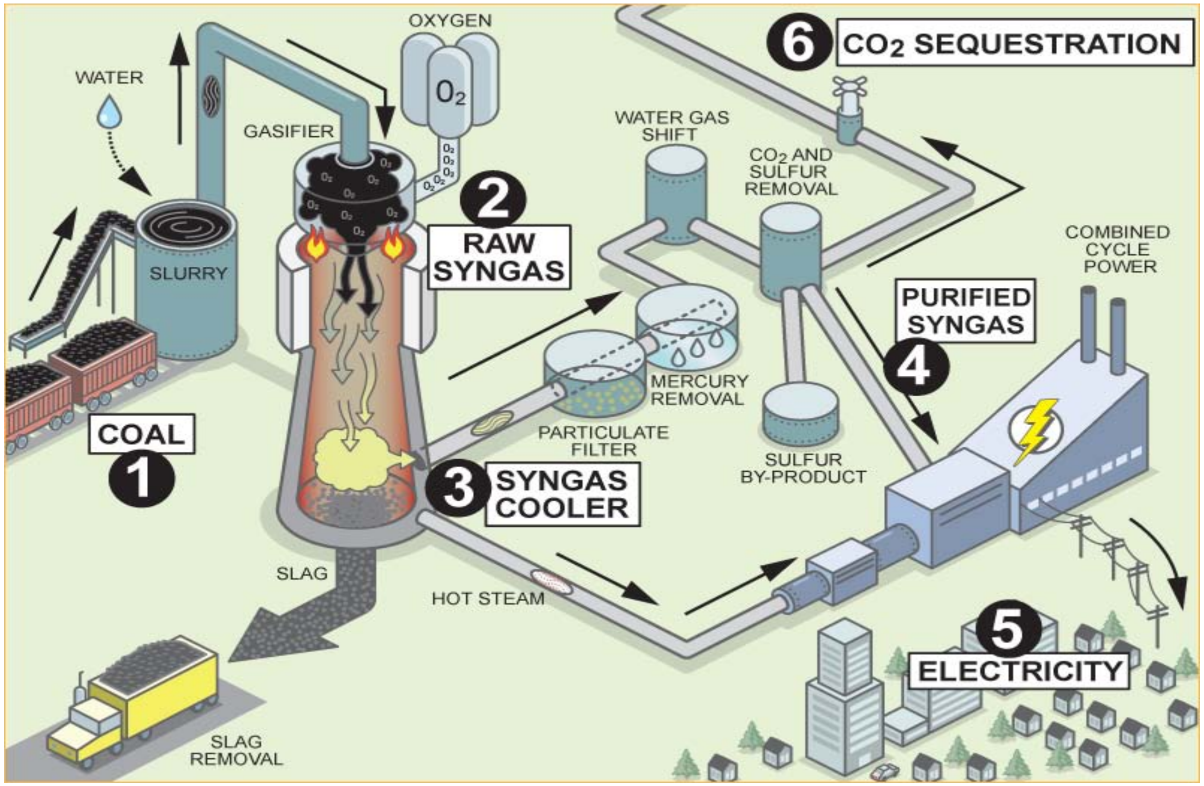


3. Pre-Combustion CO_2 Capture Systems



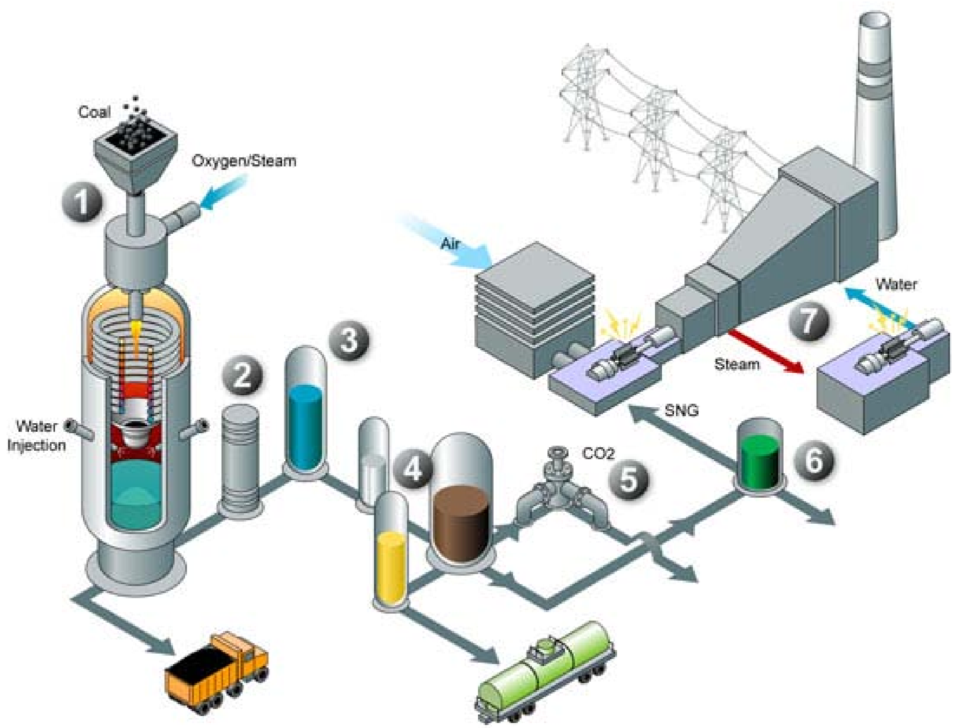
Pre-combustion systems

are based on Gasification Process. It was invented in 1794 and was used to make the “town-gas” (syngas).



Town gas was used to light cities before natural gas was discovered and electricity became preferred.

The resulting hydrogen can then become the energy source used to generate CO2-free electricity because when burnt, it produces only heat and water vapor. Pre-combustion capture technology is well established in the fertilizer industry and natural gas reforming, which uses similar technology, has been widely applied in the refining and chemicals industries.



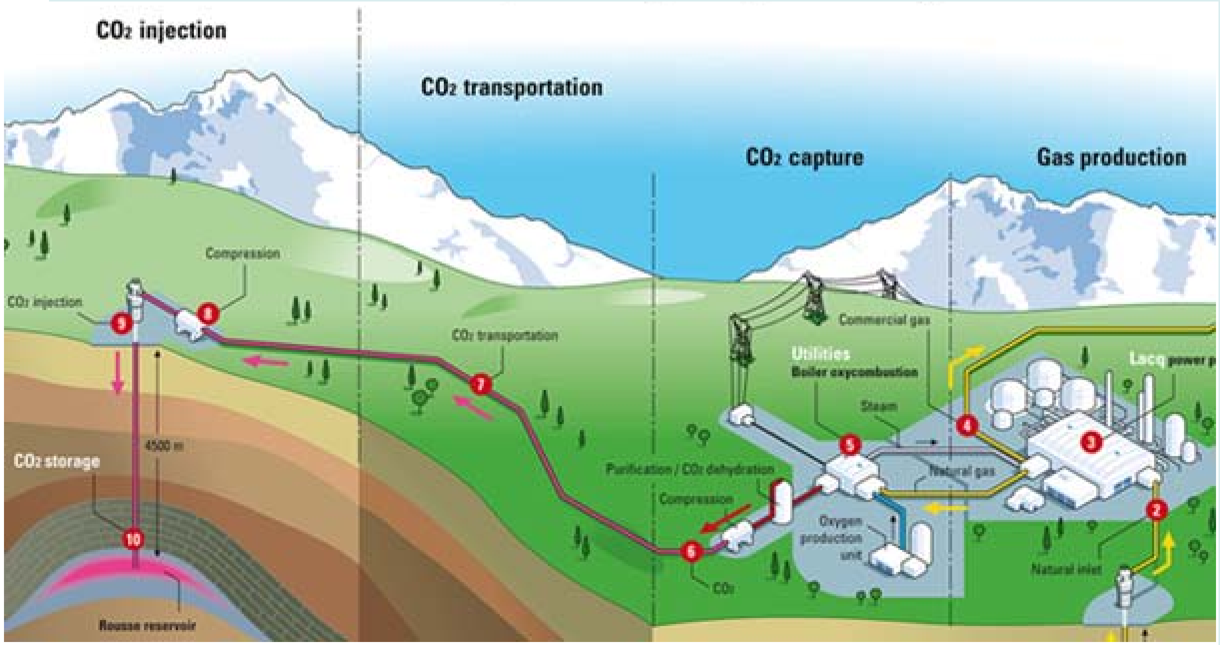
This approach, while more complex and consequently more expensive than those involved in post-combustion, are cost-effectively used to make large amounts of clean hydrogen for the power industry as well as in refineries and other chemical plants.

CO_2 Transportation to Injection Site

After capture, the CO2 has to be transported from the capture plant to suitable storage sites with either pipelines, ships, trucks or railway transportation.

Pipeline transportation

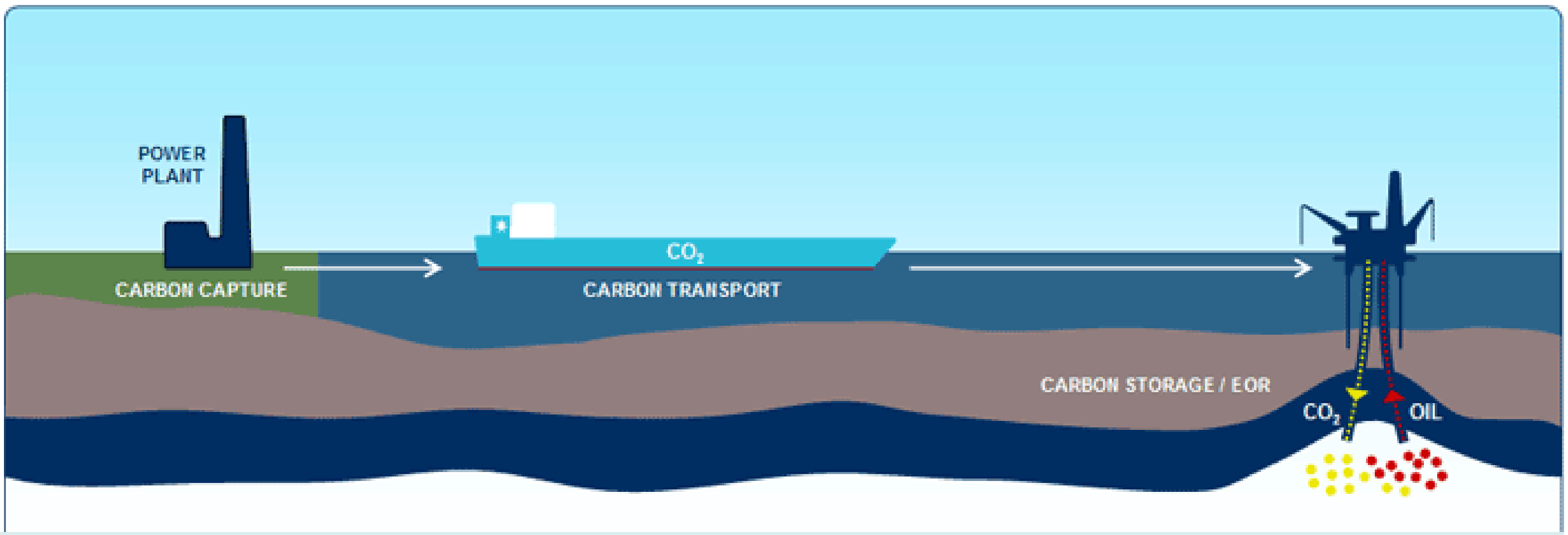
is generally the cheapest form of transport. In 2008, there were approximately 5,800 km of CO2 pipelines in the United States, used to transport CO2 to oil production fields where the CO2 is injected in older fields to extract oil. The injection of CO2 to produce oil is generally called "Enhanced Oil Recovery" or EOR. In pipeline transportation, CO2 is usually compressed to the pressure of approximately 200 bars.



The high pressure drives the CO2 from the power plant towards the storage site. The pressure needs to be maintained sufficiently high (above 74 bars) to keep the CO2 in supercritical state and to avoid gas formation. A compressor station is needed along the pipeline route usually for distances that exceed 300 km. Pipelines are considered as the primary means for transportation especially if several emission sources can be connected to a joint pipeline solution.

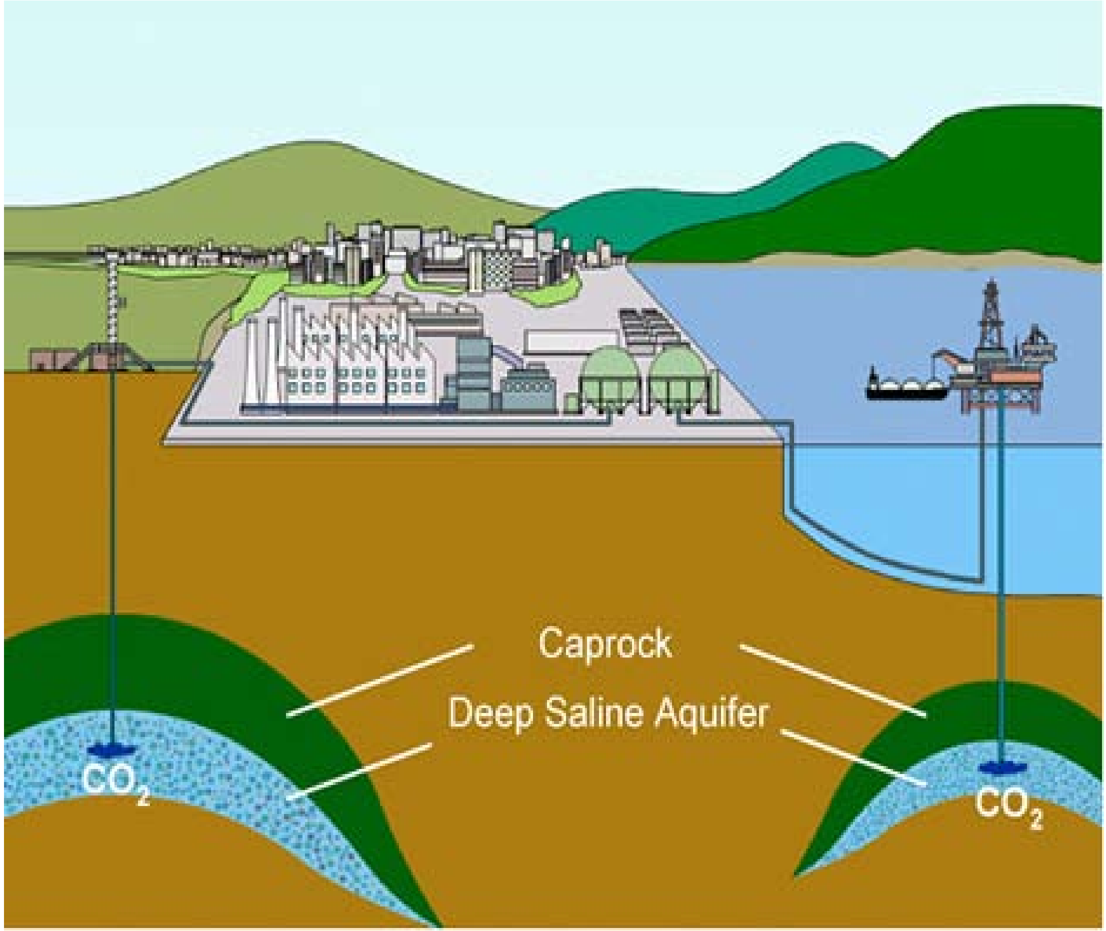
Ship transportation

of CO2 is considered suitable for longer distances, difficult terrains and isolated CO2 emission sources. Ship transportation also allows for flexibility to alter storage sites and to utilize the CO2 in for example enhanced oil recovery. CO2 is usually transported as a cold liquid (-50 ˚C, 7 bar) in order to maximize the density and minimize the required shipping volume. Ship transportation also requires an intermediate storage to be constructed at the power plant because. Ship transportation of CO2 from a 500 MW power plant would require 1-2 ships for a 1 000 km transportation distance.



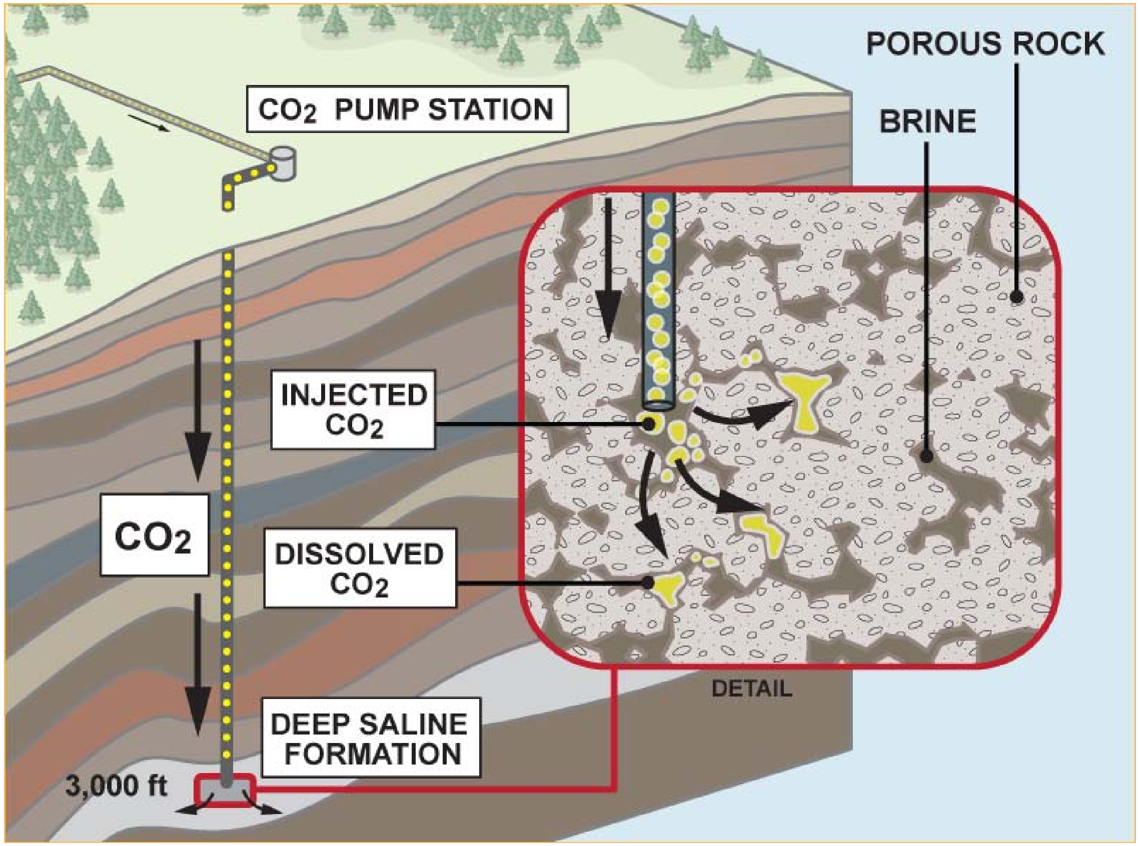
Ground transportation by trucks or railroad can be considered for smaller scale applications.

How CO_2 Is Stored in the Earth



Storage in Deep Saline Aquifers

CO_2 can be stored beneath the soil but also under the sea-bed



Storage in Deep Saline Aquifers

CO_2 is pumped in thousands meeters depth.

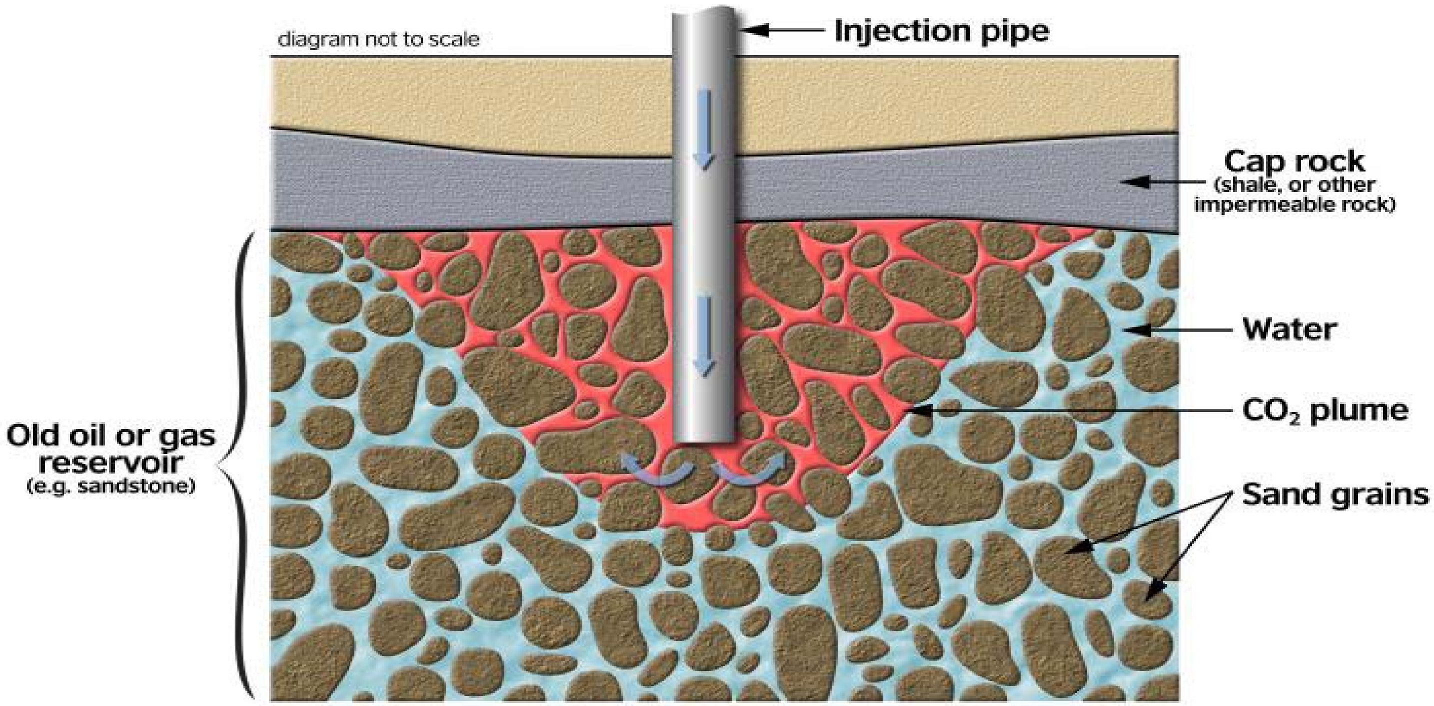
It dissolves in brine inside porous rock of saline aquifer where it remains trapped for ages of geological periods.

Enhanced oil recovery (EOR)

involves capturing CO2 and injecting it into depleting oil reserves under the sea-bed..

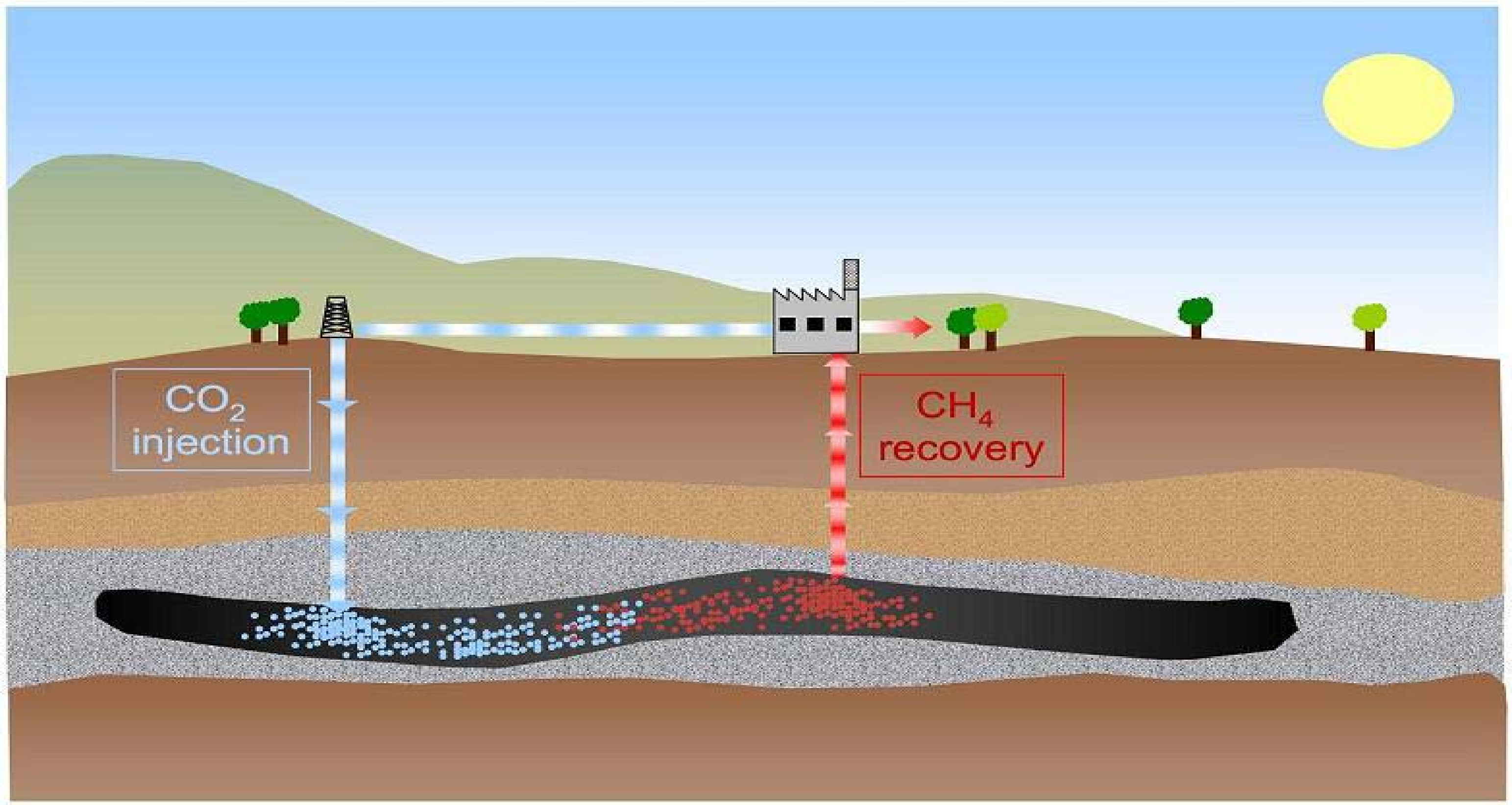
Enhanced oil recovery (EOR)

The CO2 provides the pressure needed to enhance the flow of the oil, which makes it easier to pump to the surface.



Enhanced Coal Bed Methane Recovery (ECBM)

CO_2 is pumped into the coal seam to displace methane thanks to higher CO_2 adsorptivity.



Storage capacity

Geological formations that can be used for CO_2 storage are estimated to have storage capacity from 2 000 to 10 000 Gt CO_2.

Current anthropogenic CO_2 emissions globally are in the region of 26 Gt. Thus there is enough storage capacity to store all human CO_2 emissions for hundreds of years globally.

In Europe, the storage capacity is estimated at 120-360 Gt (VTT, 2009). This would mean a storage capacity from 60 to 180 years for all European CO_2 emissions. For energy production related emissions, the storage capacity would be enough for 150-900 years.

Costs of CCS

The avoidance cost of CCS demonstration plants would be approximately 60-90 €/tCO_2. This cost includes capture, transportation with a pipeline for 100-200 km in a pipeline and geological storage.

The cost for first commercial plants in the 2020's would be 35-50 €/tCO_2 and the cost in large scale installations in fully commercial market would be 30-45 €/tCO_2. Thus CCS would reduce the overall cost of needed CO_2 emission reductions significantly.

Most of the costs in the CCS chain derive from CO_2 capture. Capture plant requires large investments and lowers the efficiency of the base plant significantly. Usually capture costs are estimated to have a share of 50-80 % of the total costs of the CCS chain.

Transportation and storage costs are highly dependant on site specific features, such as transportation distance, opportunity to achieve economies of scale by combining several emission sources and the final storage solution. Usually costs of transporting and storing CO_2 have been assessed at 20-50 % of the total costs of the CCS chain.

Particularly demonstration plants will face relatively high transportation and storage costs. This is mainly because projects are located far away from each other and the projects need to make large investments to transportation and storage for CO_2 amounts that are in the region of 1-2 Mt annually. Lower investment costs compared to pipelines are estimated to make ship transportation an especially interesting option during the demonstration period.

EU Climate Policy in View of Directive 2009/31/EC regarding CCS

New Delhi, India, 15-16 March, 2010

Directive 2009/31/EC

of the European Parliament
and of the Council of 23 April 2009
on the geological storage of carbon dioxide
and
its implications in European activities in CCS

The Commission Communication of 10 January 2007 entitled
'Limiting global climate change to two degrees Celsius:
The way ahead for 2020 and beyond' envisaged
global reduction of greenhouse gas (GHG) emissions
of 50 % by 2050,
a reduction in GHG emissions
of 30 % in the developed world by 2020,
rising to 60 %-80 % by 2050

Possible CCS Contribution

Directive 2009/31/EC states that 7 Million tons of CO_2 could be stored by 2020, and up to Million tons by 2030, assuming a 20 % reduction in greenhouse gas emissions by 2020.

Provided that CCS obtains private, national and Community support and proves to be an environmentally safe technology, the CO2 emissions avoided in 2030 could account for some 15 % of the reductions required in the Union.

Working Group on CCS

Working Group on CCS has been set up.
Working Group published a detailed report which was adopted regarding development of both policy and regulatory frameworks for CCS aiming at near-zero emissions from coal after 2020

Demonstration plants

Construction and operation
of up to 12 CCS demonstration plants
is supposed to be accomplished by 2015.

This Directive should apply to big plants
with a total intended storage above
100 kilotonnes per year.

Follow up

In the early phase of the implementation of this Directive, ... all storage permit applications should be made available to the Commission after receipt.

Member States should submit reports on the implementation of this Directive on the basis of questionnaires drawn up by the Commission pursuant to Council Directive 91/692/EEC

Biggest CCS Projects in the World

SET@W Matchmaking, New Delhi, March 2010

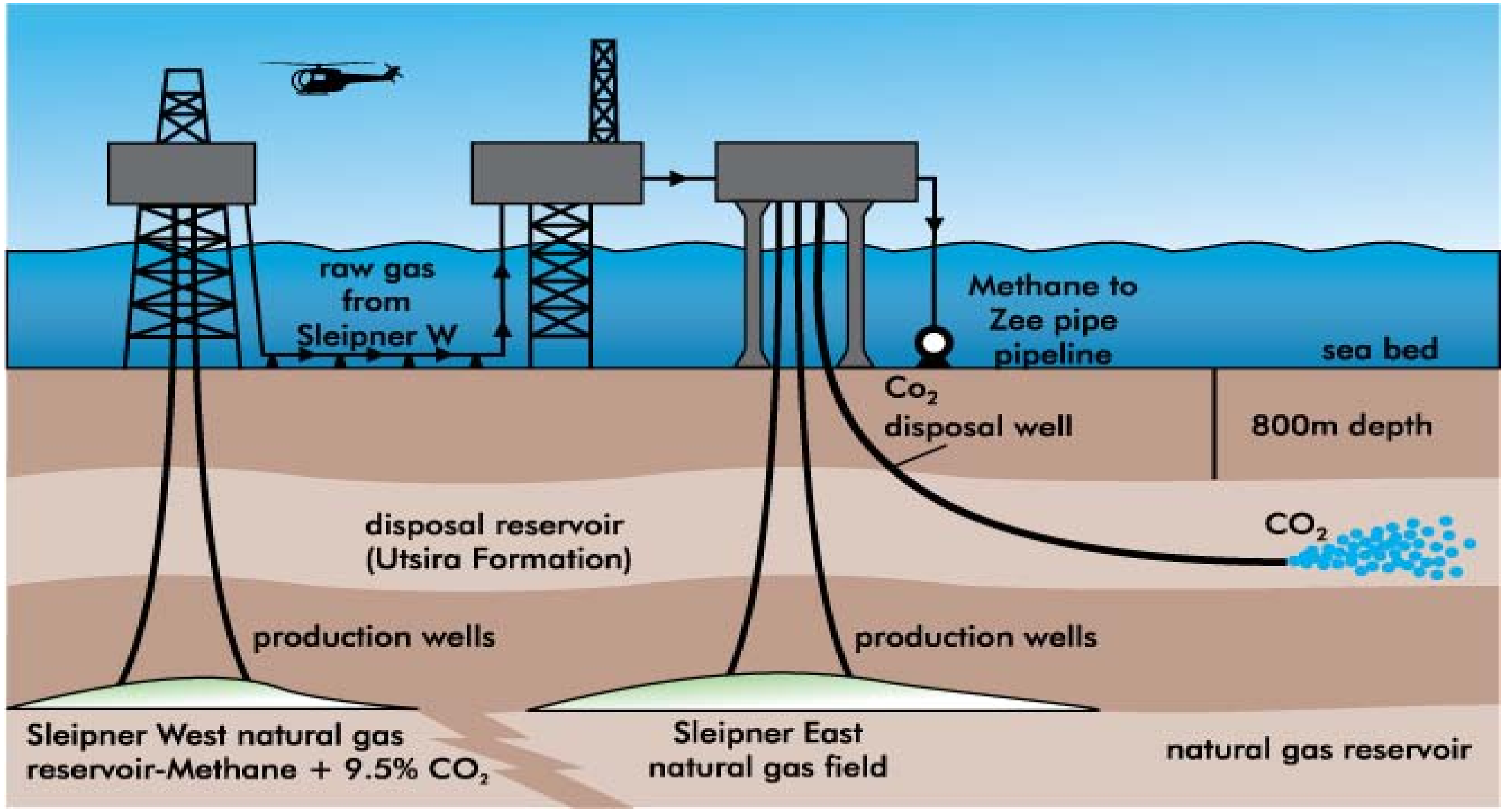
CCS technology has been developed as strong industry in North America. Thousands miles of CO_2 pipeline infrastructure are in the USA and Canada

Sleipner CO2 Storage Project, Norway, biggest in Europe

Company:	StatoilHyrdo
Location:.	Norway, North Sea.
Start Date:	1996
Size:	1 Million ton CO2 / Year
CO2 Source:	Gas Processing. (Produced hydrocarbons have 9% CO2 which is removed before shipment to onshore).
Storage:	Deep Saline Reservoir 1000m Below sea floor.
Economics:	Sleipner was built in order to evade the 1991 Norwegian CO2 tax. Sleipner obtains CO2 credit and does not pay the tax.

Sleipner was the world's first commercial CO2 storage project. It has so far stored 8-9MT of CO2. There is no evidence of CO2 leakage and the CO2 remains insitu. CO2 capture is done using Amine techonolgy. Injection currently costs $17 US / Tonne CO2.

Sleipner CO2 Storage Project – how it works



Thank you for your attention