CHAPTER 1

# CARBON CAPTURE & STORAGE

**Expected Outcomes**

Able to learn storage and carbon capture technique and environmental safety issue regarding carbon sequestration

# “CARBON CAPTURE & STORAGE”

# Content

- About CCS
- Basic Knowledge of System
- Capture system of CO2
- Transport of CO2
- Carbon Sequestration
- Current Project of CCS
- Environmental effect of CCS
- Challenges CCS
- Conclusion

# Carbon Capture & Storage

- CCS is a technology implied to prevent the release of large quantities of carbon dioxide ($CO_2$) into the atmosphere by capturing and storing it.

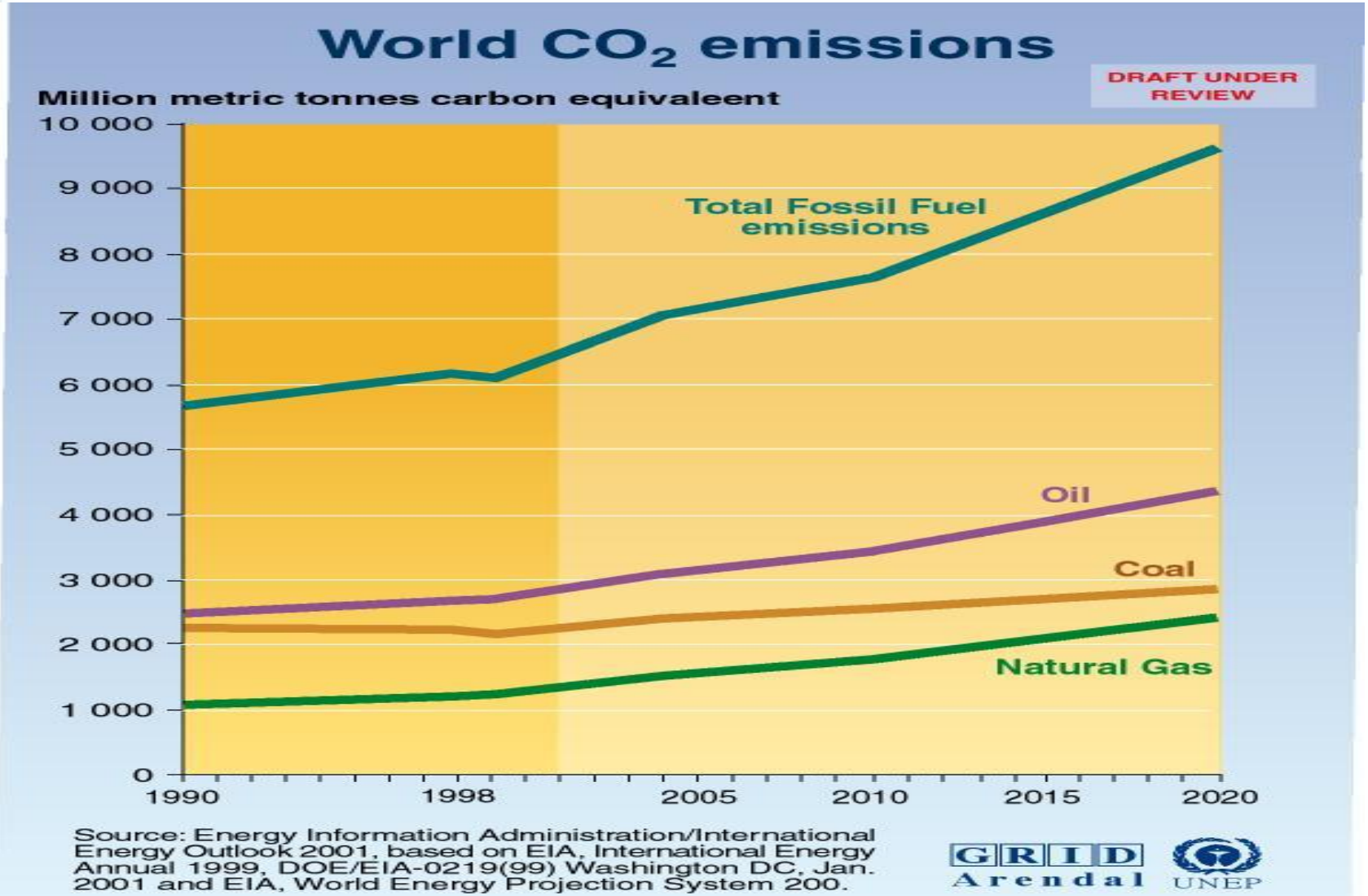
# CARBON CAPTURING AND STORAGE

Carbon capture and storage methods are used for limiting the emissions of $CO_2$ from large stationary sources (many industrial processes and electricity generation etc.) and storing it away from the atmosphere.

# How CCS limits the amount of $CO_2$ release into the atmosphere

- $CO_2$ is a greenhouse gas. Currently its concentration in atmosphere is approximately 400 ppm. But, its concentration is increasing rapidly in atmosphere mainly due to anthropogenic activities, e.g., burning of fossil fuels and industries. The increasing $CO_2$ concentration is one of the main factor contributing to the global warming.
- Carbon dioxide Capture and Storage (CCS) is an evolving technique that could limit the emissions of $CO_2$ into the environment. This technique involves the capturing of $CO_2$ from its emission source (power plants or industrial facilities) and its storage in underground layers away from atmosphere. It is different from carbon sequestration, which involves the removal of $CO_2$ from the atmosphere by using natural practices such as forest growth etc.
- One 900 MW CCS coal-fired power plant could abate around 5 million tones of $CO_2$ a year. 80-120 commercial CCS projects are projected to operate in Europe by 2030. They would be able to decrease the emission of some 400-600 million tones of carbon dioxide into the atmosphere per year.

# …why we need CCS



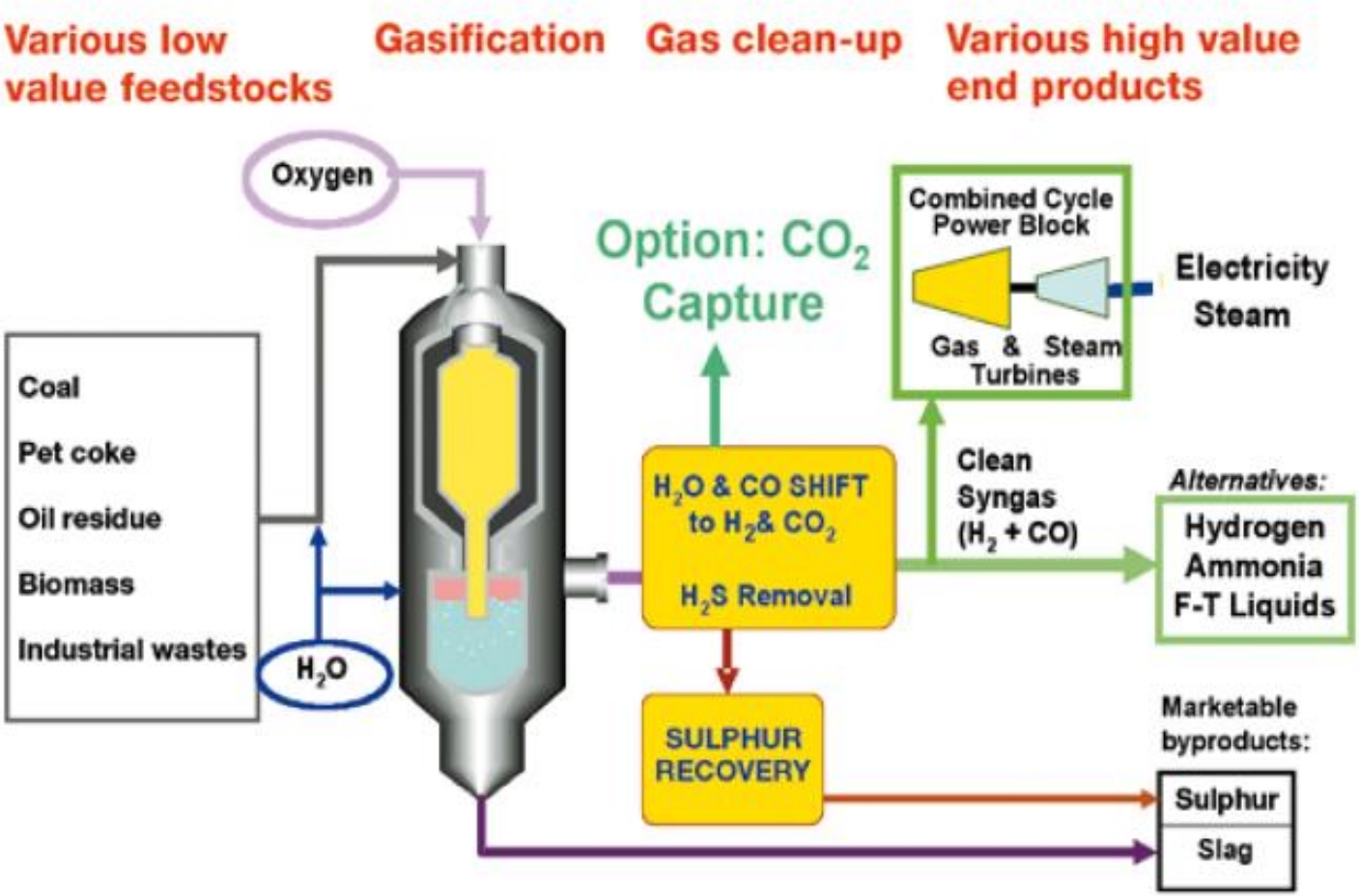
# Capture Of CO2

1. Pre-combustion capture system
2. Post-combustion capture system
3. Oxy-fuel combustion capture system

# Pre-combustion capture System

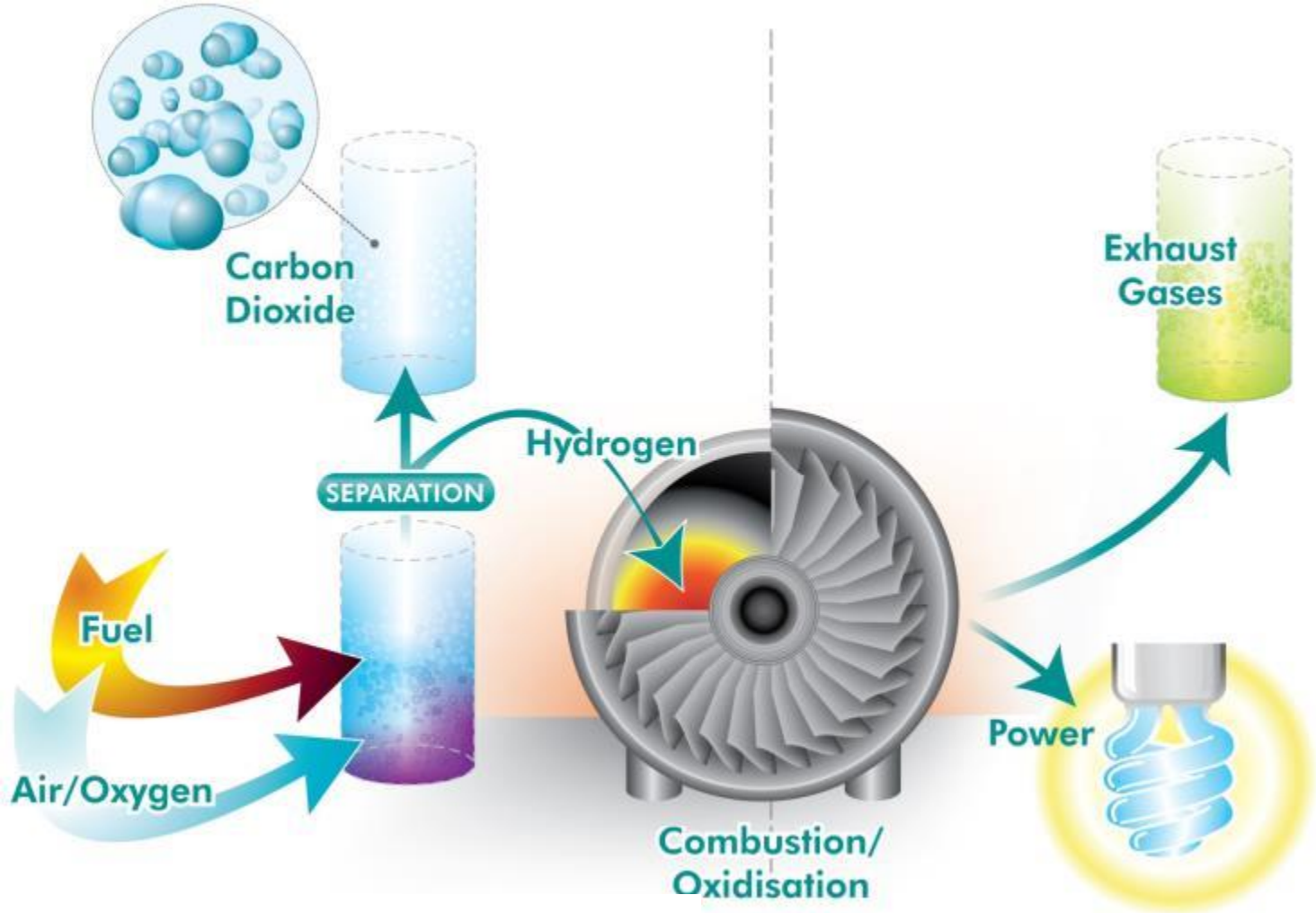
- In this process the $CO_2$ is removed before the combustion.
- The fossil fuel is only partially oxidized e.g., in gasifier.
- The syngas (CO and $H_2O$) produced by this is shifted into $CO_2$ and $H_2$.
- The $CO_2$ is captured from a relatively pure exhaust stream and the the $H_2$ can be used as fuel.
- This technology is widely applied in chemicals, fertilizers, gaseous fuels ($H_2$, $CH_4$) and power production.

# Pre combustion system




Source: www.energy.siemens.com

# Carbon Capture Options
## *Pre-Combustion*

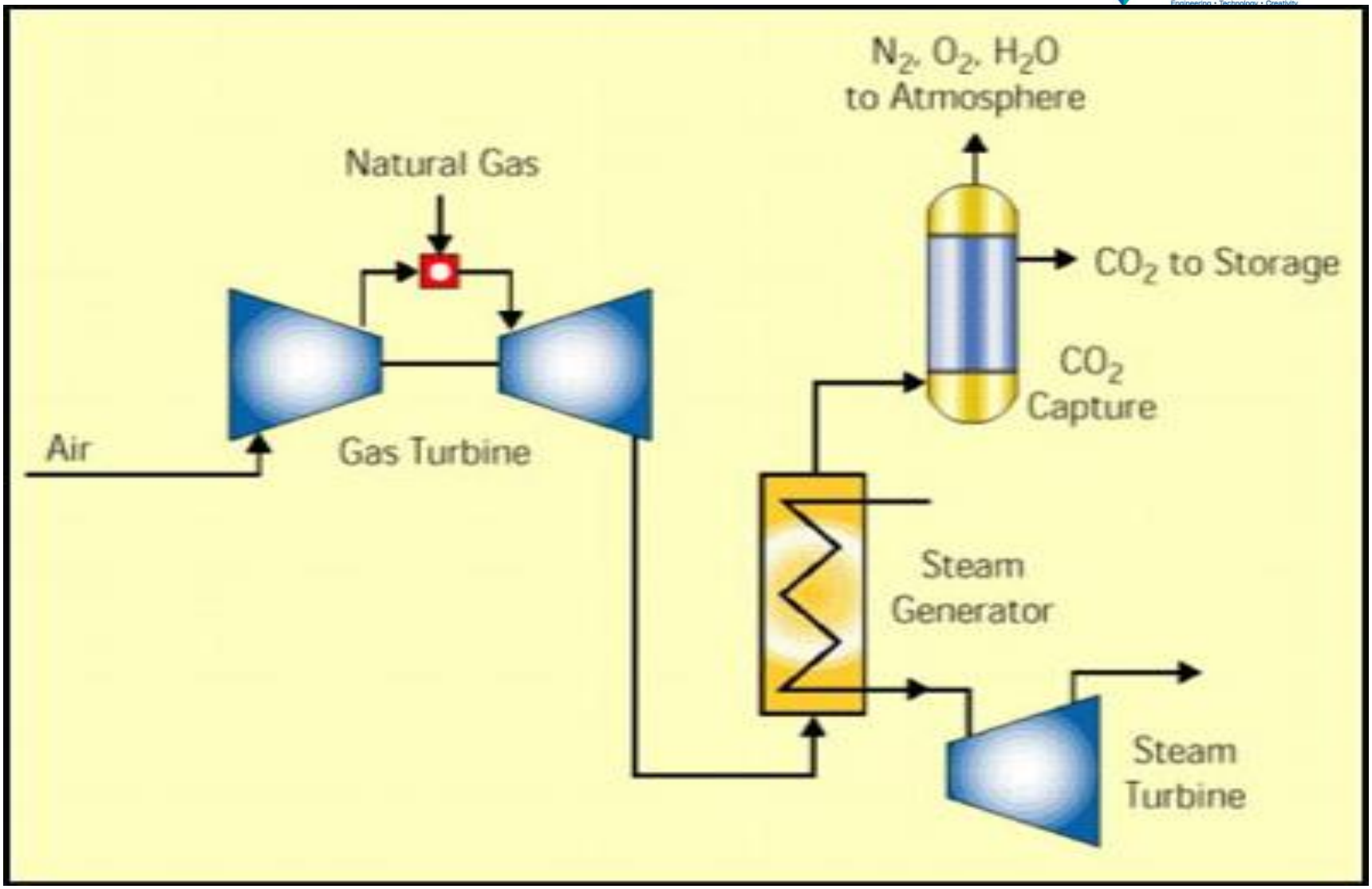



Source: http://www.co2crc.com.au/ 12/19/2015

# Post combustion capture System

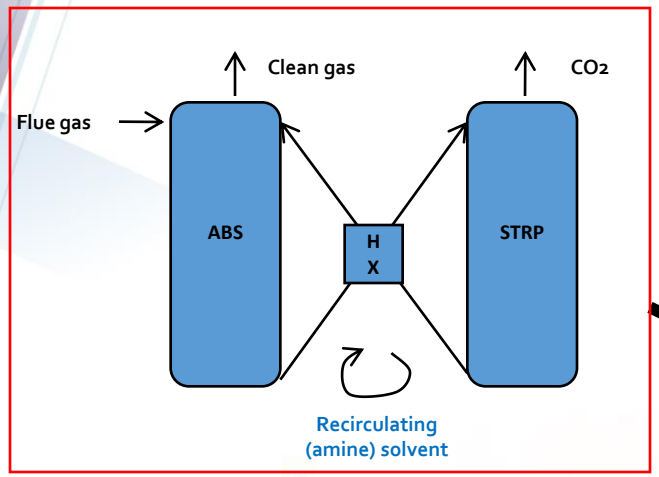
- In this process the $CO_2$ is removed after the combustion of fossil fuels. A chemical solvent is used to remove the $CO_2$ from the gaseous exhaust of a traditional power plant (gas or coal) or any other industrial facilities, e.g., cement kilns, refineries etc. A typical amine solution is used as solvent which binds with the $CO_2$. The solvent-$CO_2$ combination is heated after separation from the rest of the exhaust gas. A relatively pure $CO_2$ drives off by heating which is then compressed and sequestered. The solvent can be reused after cooling. Post-combustion technology can be used in iron and steel plants .

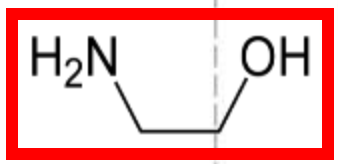
# Post combustion system




Source: www.energy.siemens.com

# Carbon Capture Options
## *Post-Combustion*





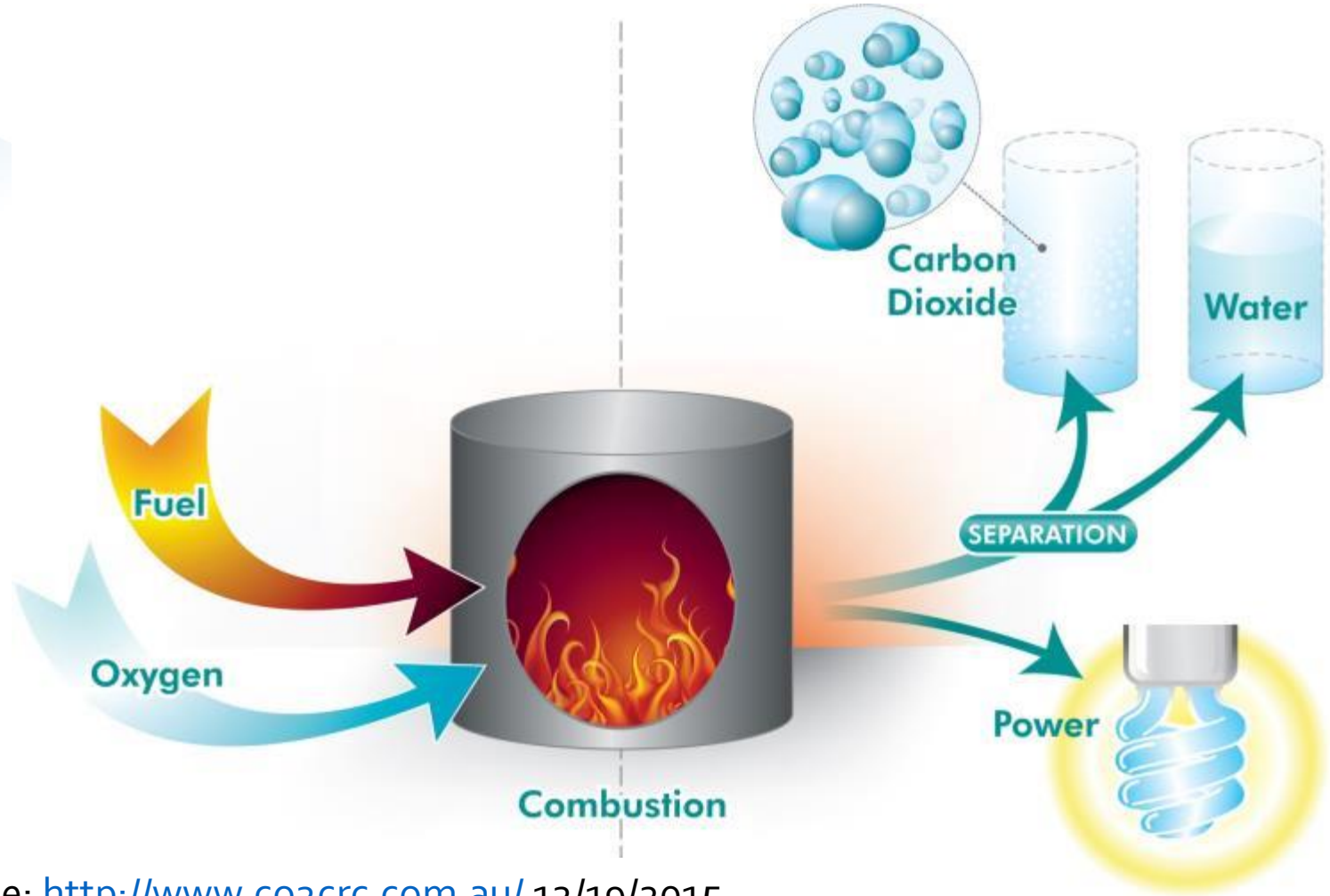


Source: http://www.co2crc.com.au/ 12/19/2015

# Oxy fuel Combustion system

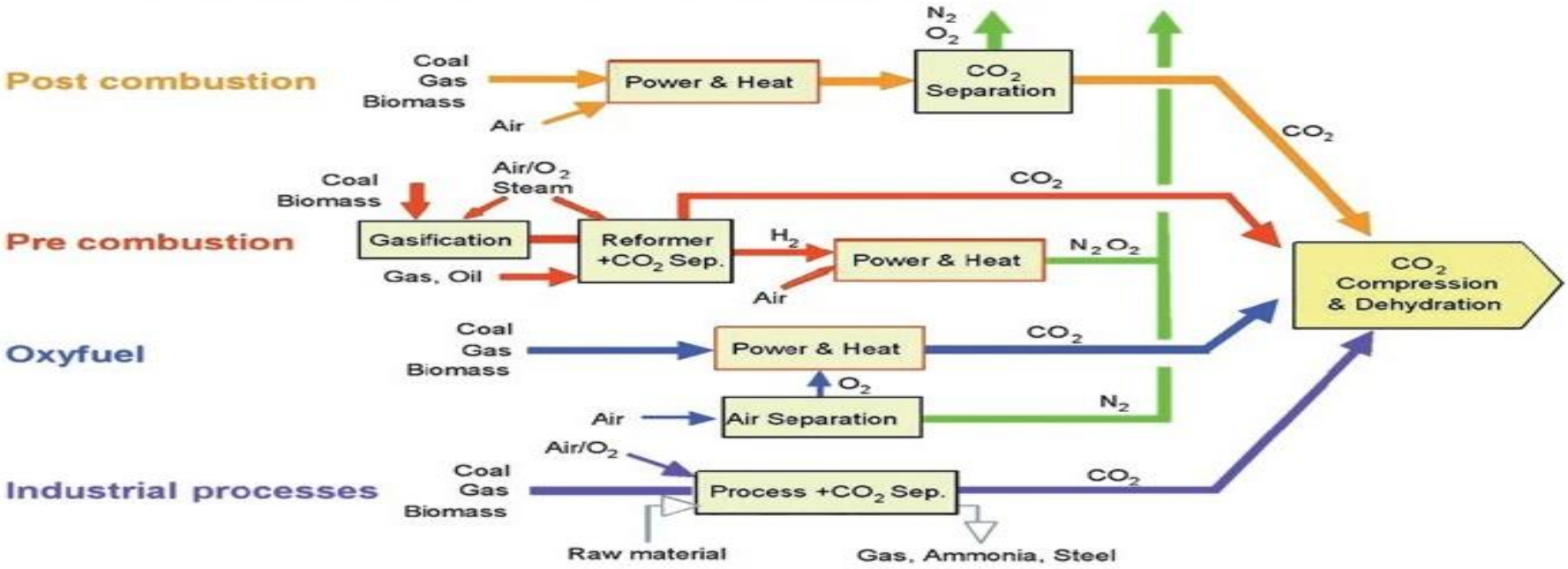
- Fuel is burned in the presence of oxygen.
- Than it eliminates the nitrogen from the flue gases.
- Combustion temperature of about $3500^0$C.
- The net flue gas have 80-90% $CO_2$.
- The efficiency of Oxy-fuel combustion capture system is near about 100%

# Carbon Capture Options
## *Oxy-Fuel Process*




Source: http://www.co2crc.com.au/ 12/19/2015

# How does $CO_2$ capture technologies work?




Source: www.slideshare.net 12/19/2015

# Emerging Technology

(Post Combustion Capture System)

- Membrane Based
  - Amine Membrane
  - Pot. Carbonate Poly. Gel Membrane
  - Poly electrolyte membrane

- Solid Sorbents
  - Li based Sorbent
  - CaO based Sorbent

# Transport of CO2

- $CO_2$ is transported in three states:

  - Gas
  - Liquid
  - Solid

- Transportation system used:

  - Pipeline transportation system
  - Marine Transportation system

# Specifications for transportation of CO2 in pipeline

- Carbon Dioxide: Minimal of 95% of CO2 should be present.
- Water: No free water should be present.
- Sulphur: less than 1450 ppm
- Temperature: not more than 48.9 ° C.
- Nitrogen: not exceed more than 4%.
- Oxygen: less than 10 ppm by weight.

# Carbon Sequestration

• Carbon sequestration is the process which involves the long-term storage of carbon dioxide or any other form of carbon to mitigate the detrimental effects of global warming.

• Carbon sequestration is the process of storing carbon underground to curb the accumulation of carbon dioxide in the atmosphere.

# Storage of CO2

**Geological Storage**:-

The subsurface of the earth is the largest carbon reservoirs where the vast majority of carbon  is held in the form of coal ,oil, gas organic rich shells and carbonate rocks.

There is two types of storage:

1. Underground Storage
2. Ocean storage

# Underground Storage

- Geological storage : The compressed $CO_2$ can be stored below the Earth's surface by injecting into the porous rock formations. The main types of geological storages are deep saline formation, oil and gas reservoirs and un-minable coal beds. In theses processes the $CO_2$ is physically trapped under a well-sealed rock layers or in the pore spaces within the rock. It can trapped chemically also by dissolving the $CO_2$ in water and reacting it with the surrounding rocks. The risk of leakage from these reservoirs is rather small.

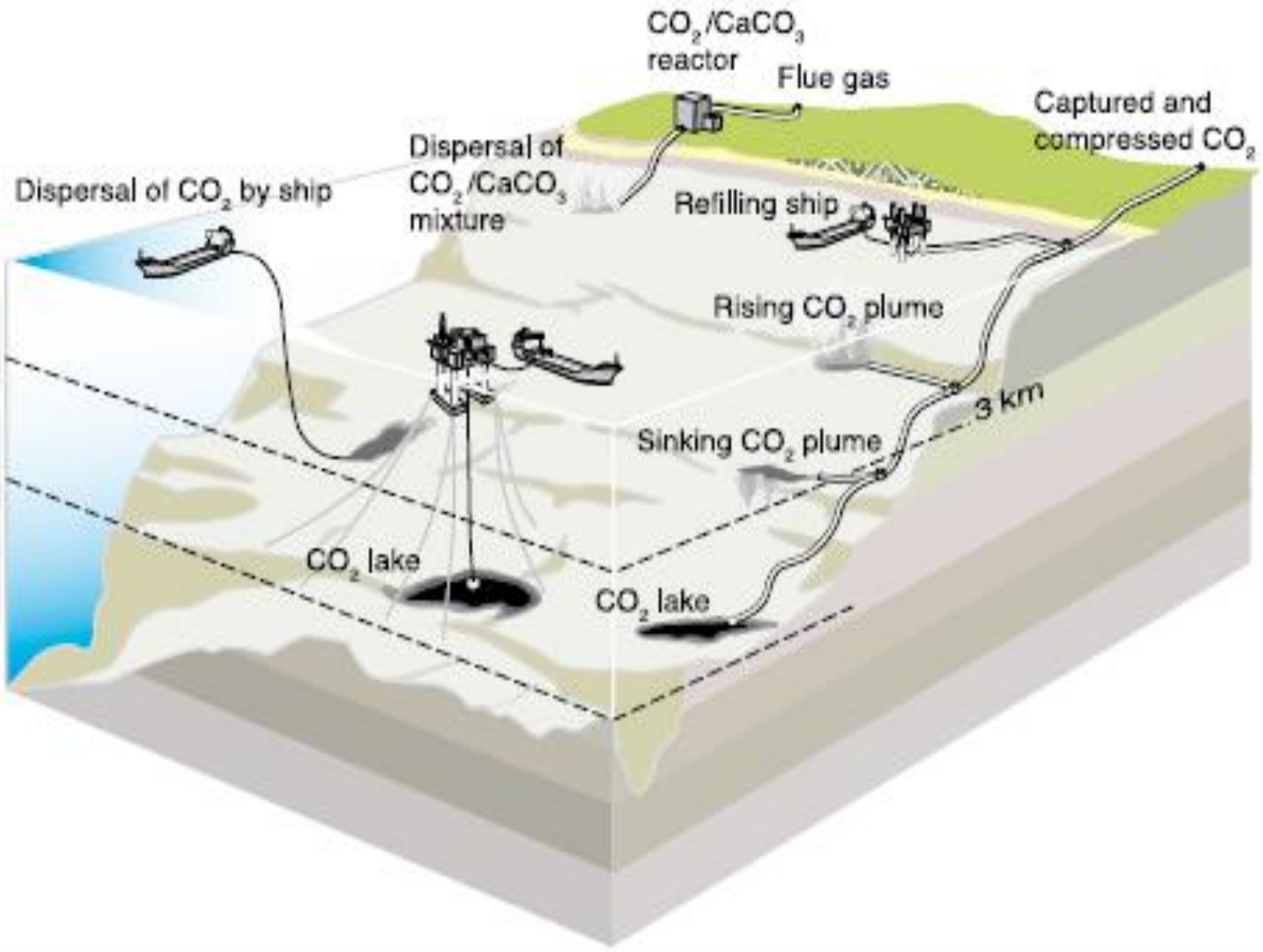
- Coal seams- $CO_2$ adsorbs to the surface of coal
- Deep saline formations-Deep saline formations (sub-terranean and sub-seabed) have the greatest $CO_2$ storage potential because of their large potential storage volume and common occurrence .

# Ocean storage

Two main concepts exist

- The dissolution type: this involves the injection of $CO_2$ into the water column by ship or pipeline at depths of ≥1000 m, where the $CO_2$ dissolves subsequently.
- The lake type: this process involves the deposition of $CO_2$ directly on the sea floor at depths greater than 3000 m, where $CO_2$ form a lake type structure as there it is denser than water. This is expected to delay the dissolution of $CO_2$ into the environment.

# Ocean storage system



# Current project - Sleipner

- Sleipner – Norway
- Motivation for injection/storage
- Storage in saline formation (200 m thick, at 800-1000 m depth)
- 3000 t $CO_2$ /day (1 Mt annually)
- Total storage planned : 20,000,000 t $CO_2$

# Current project - Salah

- In Salah – Algeria
- Separation of $CO_2$ from natural gas in amine contactor towers
- Storage in gas field
- 3-4000 t $CO_2$ /day
- Total planned storage: 17,000,000 t $CO_2$

Source: www.telegraph.co.uk 12/19/2015

# CCS Challenges

- Leakages

  Uncertainty about magnitude ..... but likely to be very small (0.1% - 1% in different studies)

- Monitoring

- Infrastructure needs: Large and long-term investments required for transportation and separation.

# Cost of CCS

- Capturing and compressing of $CO_2$ is an energy requiring process due to which the cost of CCS-equipped power plants increases significantly. The energy needs of a CCS equipped plant is about 10-40% higher.
- The transport of $CO_2$ largely done by pipeline. This cost is about 0.5USD/metric tonne/100km
- The overall cost of CCS is about 100USD/tonne of $CO_2$

# Compensation:

- **Compliance** – Government regulations require $CO_2$ emission reductions and the cost of compliance that a corporation avoids by undertaking CCS is a core financial driver.
- **Enhanced Oil Recovery** – $CO_2$ can be used in old oil fields and the companies to enhance the production for which they will pay. This would be a revenue source for $CO_2$ capture companies.
- **Tax Savings** – Corporate financial tax savings resulting from the economic expenditure on CCS.

# Conclusion

- CCS really plays a main role in reduction of Greenhouse gases ,but this is not enough .There is a need of more research which help in securing the storage and other protection technique.

- The challenges against the CCS is about the cost, it really need to reduce it.

- There are many gaps in knowledge which really need to clear it out.

# ……THANK YOU……