Carbon dioxide Capture and Storage (CCS)

What is CCS?

- CCS is a method used to capture CO2 that is produced via the combustion of fossil fuels and then store it away from the atmosphere for a long time.
- The focus of CCS is on power generation and industry sectors, mainly because they emit such a large volume of carbon dioxide that the capture and storage there will be the most beneficial.
- The most researched/developed ways to capture CO2 are by pre-combustion capture, post-combustion capture, and oxy-fuel combustion capture.
- Once the carbon dioxide is captured, it can either be stored underground or stored in the ocean.

Why do we care about CCS?

- Global warming is real and is seriously affecting our planet.
- The major factor in increased global warming comes from carbon dioxide emission.
- Coal fire power plants, cement/brick factories, oil refineries, natural gas wells, and transportation all emit CO2 from the burning of fossil fuels.
- The government is planning to set mandatory caps on CO2 emissions, causing companies to develop and test methods to mitigate their carbon footprint.
- One possible way to accomplish this is by Carbon dioxide Capture and Storage.

Where is the CO2 coming from?

- The overwhelming majority of carbon dioxide emissions come from the industry. Industry and power sectors account for 60% of the global CO2 emissions.
- Coal is the major energy source for industrial processes. It is very dirty when burned and emits a lot of carbon dioxide.
- A coal fire power plant is an ideal spot for CCS because of the large amount of CO2 it emits and the fact it is stationary.
- Currently there are multiple areas around the world that emit large enough amounts of carbon dioxide that makes CCS relevant. The four main areas are North America, Western Europe, South East Asia and Southern Asia.
- Transportation emissions not included; mobile source difficult for CCS to work.

Where is the CO2 coming from?

Source: http://www.ipcc.ch/pdf/special-reports/srccs/srccs_wholereport.pdf

The correlation is that the more developed and more populated an area is the more carbon dioxide is emitted.

Where is the CO2 coming from?

- Carbon dioxide emissions are projected to increase until at least year 2050.
- New areas of large-volume emissions can arise, but it depends on many factors, including economic development, increased population, and technological changes.
- By knowing where the areas of stationary and high-volume CO2 emissions come from, we can pinpoint the major sources and implement an efficient CCS system on them.

How is the CO2 captured?

- Three main capturing systems:
- Pre-combustion capture
- Post-combustion capture
- Oxy-fuel combustion capture

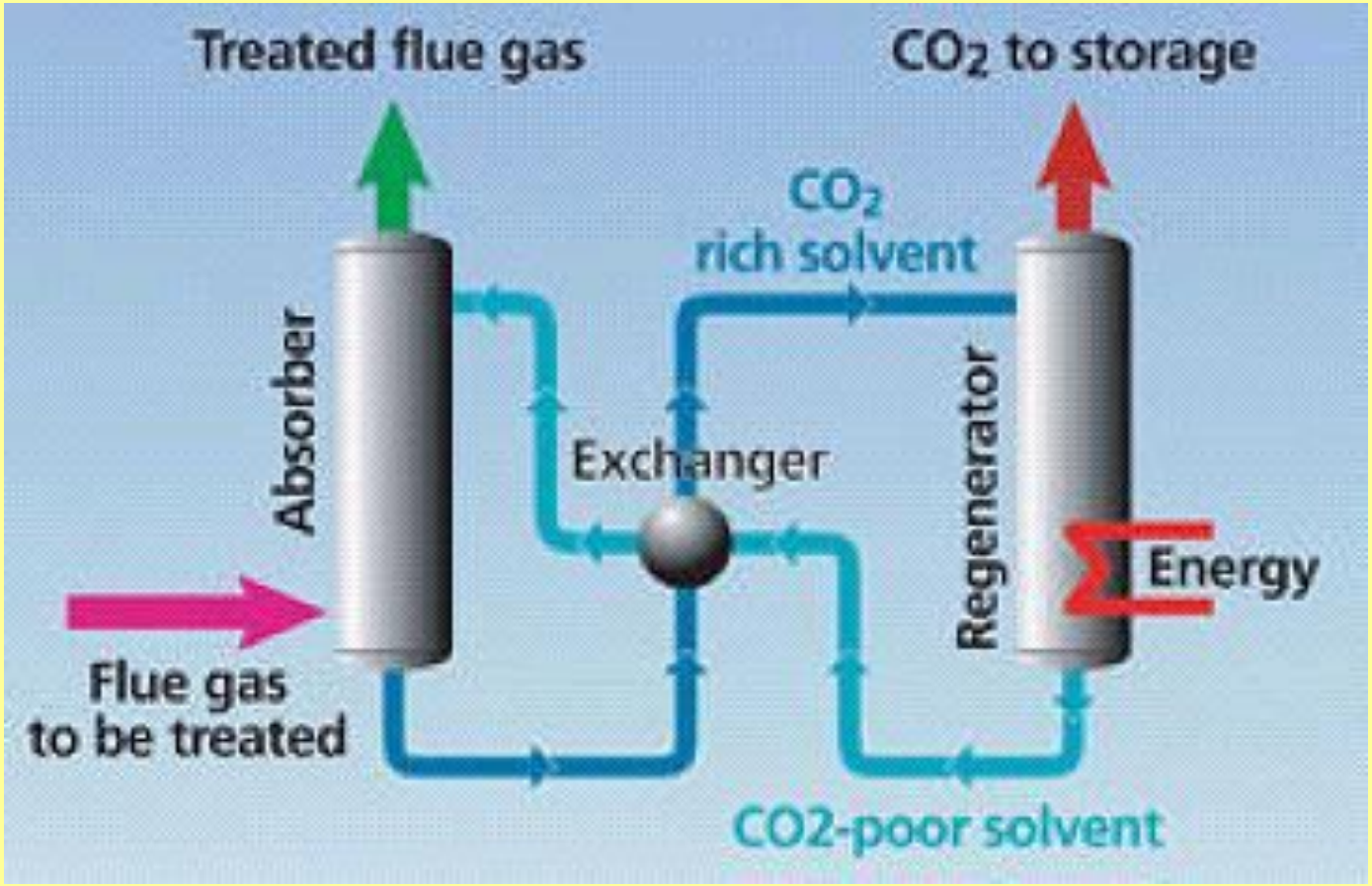
Pre-combustion capture

- The fossil fuel is oxidized to produce a “syngas” composed of CO and H2.
- The CO is then shifted in a converter, producing CO2 and more H2.
- Then the carbon dioxide is separated from the hydrogen before combustion even takes place.
- Most common form of separation is by solvent absorption process (amines).

Post-combustion capture systems

- The flue gas from the combustion is cooled and then fed into an absorber where it comes into contact with the solvent (MEA).
- The carbon dioxide/amine solvent solution passes through a heat exchanger into a hot stripper.
- Continual heat is supplied causing the carbon dioxide to detach from what is now steam.
- The steam is collected in the condenser, whereas the CO2 gas leaves the stripper and comes out as a product gas.

Post-combustion capture systems



Source: http://www.claverton-energy.com/download/137/

Process the flue gas goes through to remove the carbon dioxide.

Post-combustion capture systems

- Percentage of carbon dioxide removed in this process is between 80% and 95%, making it very efficient.
- High recovery rate comes from tall absorption columns and expensive amine solvents, making it a pricy process.
- Contaminants in the combusted flue gas such as NOx and SOx take up absorption capacity, form solids in the solution, and create unwanted waste.

Oxy-fuel combustion capture systems

- Takes the hydrocarbon and combusts it in pure oxygen at high temperatures which eliminates nitrogen from the flue gas stream.
- The product of the combustion consists mainly of CO2 and water vapor.
- The water vapor is condensed out via cooling, leaving a concentrated carbon dioxide stream.

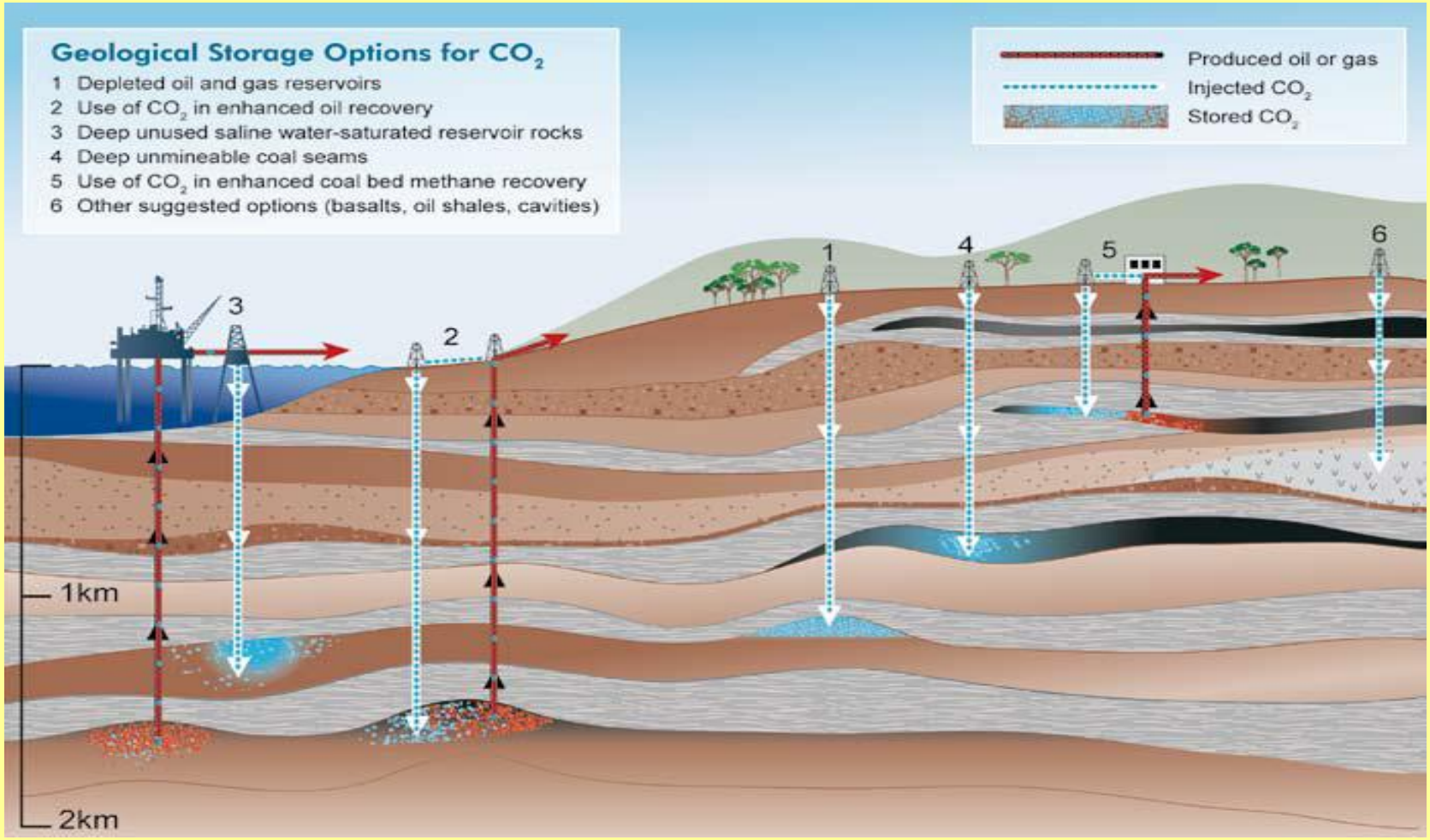
What is done with the captured CO2?

- Choices are:
- Underground geological storage.
- Ocean storage.

Underground geological storage.

- Storage is possible in many different geological settings.
- Best areas to store CO2 is below caprocks, low-permeability shale, or salt beds since they physically trap the carbon dioxide.
- Stored in oil fields, gas fields, coal seams or saline formations.
- Also used for enhanced oil recovery (EOR).

Underground geological storage.



Source: http://www.ipcc.ch/pdf/special-reports/srccs/srccs_wholereport.pdf

The figure shows all the possible ways carbon dioxide can be stored underground.

Underground geological storage.

- The potential problem in geological storage systems is the ability for the injected CO2 to leak back out into the atmosphere.
- The carbon dioxide can escape through pores in caprocks or shale, through openings in faults, fractures, or caprocks, or though pathways made from old or poorly build abandoned gas or oil wells.
- Future research and development is currently in progress to see how to prevent this leakage in the numerous types of storage areas.

Ocean storage

- CO_2 stored in the ocean by:
- Direct injection.
- Dissolution of carbonate materials.
- Production of a CO_2 lake.

Direct injection

- The captured CO2 is compressed and injected deep in the ocean so it can dissolve in the surrounding water and become part of the ocean carbon cycle.
- Eventually the ocean and atmosphere will equilibrate causing the CO2 to be dispersed back into the air, but that occurs on a very large time scale and therefore is not a serious drawback for CO2 ocean storage.

Dissolution of carbonate materials

- When ocean water receives an addition of CO2, the acidity goes up.
- To neutralize this rise, natural dissolution of carbonate materials in the sea-floor occurs creating a balance.
- Methods are being researched to accelerate this carbonate neutralization.
- One proposed way is by adding alkaline minerals to the ocean; would increase the ocean carbon storage in both long and short term time scales.

Production of a CO2 lake

- A CO2 lake is formed by taking the carbon dioxide so deep that it becomes a liquid form that is denser than the sea water and settles near the ocean floor.
- The CO2 must be taken down to around 3000 meters below the ocean surface for process to be possible.
- No large scale experiments have been conducted. Relatively new and untested idea.

Conclusions

- Using the Carbon dioxide Capture and Storage method to mitigate our climate change is a realistic and possible method.
- Drawbacks in capture are cost and inefficiency to plant.
- Drawbacks in storage are possible leakage and environmental effects.

References

- Scully, Vaughan . "Capturing Carbon Dioxide Eases Environmental Impact of Coal-Fired Power." Standard and Poor's Morning Briefing (2008): 4-6.
- "Carbon Dioxide Capture and Storage." Intergovernmental Panel on Climate Change (IPCC) (2005)
- Gielen, Dolf. Prospects for CO2 Capture and Storage. Paris, France: 2004.
- Hodrien, Chris . "Squaring the Circle on Coal-Carbon Capture and Storage." 26 Oct 2008. CCSA. 22 Nov 2008 <http://www.claverton-energy.com/download/137/>.
- Starr , F.. "Integrated Gasification Combined Cycle for Carbon Capture & Storage." Claverton Energy Research Group. 11 Oct 2008 . 22 Nov 2008 <http://www.claverton-energy.com/integrated-gasification-combined-cycle-for-carbon-capture-storage.html>.