Carbon dioxide (CO_2) levels has been rising every year due to human activities. Electricity generation and heavy industries which provide for our routine daily enjoyments such as television, strong and sturdy houses as well as heating during winter (and air-conditioning during summer) are major contributors of CO_2. This leaflet provides an overview of a system which strives to lessen the amount of CO_2 emitted into the atmosphere with the ultimate goal of reducing global warming. In a circular flow manner, four main aspects of the system will be presented. They are **capturing** of the CO_2, **transporting** the CO_2 to the vicinity of the storage site and the eventual **storage** site with a meticulous **monitoring** plan.

What is CCS?

Carbon Capture and Storage (CCS) is a method which can be used to capture, transport and store carbon dioxide for large periods of time to prevent additional changes to the atmosphere. Once it is captured, the carbon dioxide must be transported to a location where it can be stored safely for a long time (a thousand years or more).

Why is CCS needed?

The technology behind renewable energy is still developing and is not ready to be the primary source of power in most countries. Until renewable energy catches up, coal power generation will continue to be primary sources of energy for many countries, especially China and India where energy demand is skyrocketing. CCS is seen as a way to buy time for better technology while reducing the impact of human activities on the environment.

Where will the carbon dioxide go?

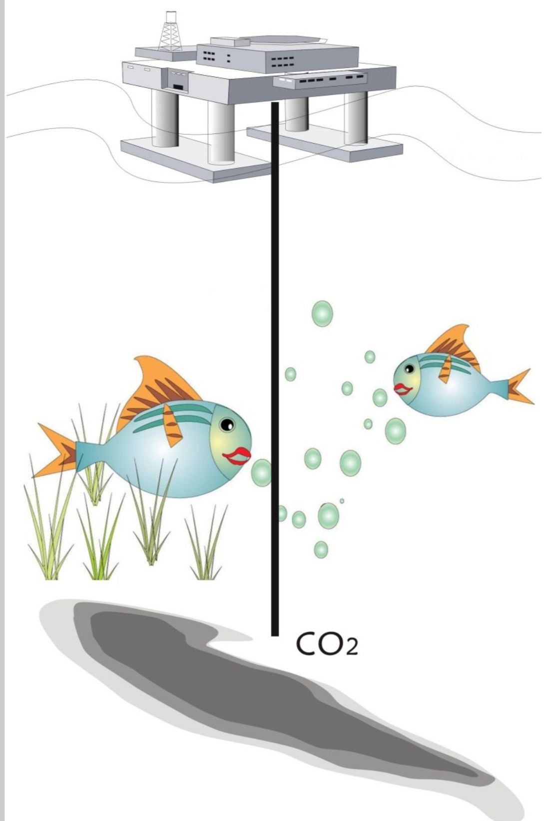
Carbon dioxide can exist in three forms: gaseous, liquid or solid. Therefore, a wide range of storage options can be considered for the captured CO_2. The locations can include empty oil and gas fields, underground saline aquifers (undrinkable water sources) and the deep ocean. Current research focuses on onshore or offshore underground storage of CO_2. At times suitable sites for storage are located near or directly underneath populated areas, in which case, offshore storage, in particular direct injection of the CO_2, offers a innovative alternative as it is far from densely inhabited areas for both humans and living creatures. The process whereby oceans take in CO_2 has been occurring naturally for thousands of years and it is a widely acknowledged fact that the oceans are one of the largest carbon sinks on the earth, along with the rainforests.

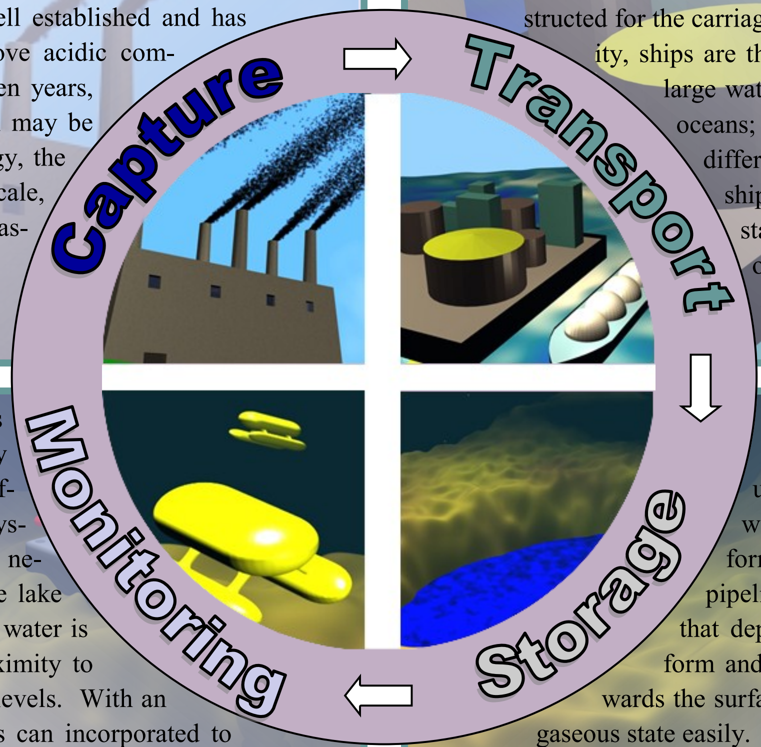
Where will CCS be used?

Countries which rely heavily on gas and coal power and have a vested interest in clean energy such as the United States, most countries in the European Union, and China are likely to be the largest adopters of CCS technology. However, most areas of the world rely on fossil fuel to meet a portion of their energy needs and may become potential users of CCS. In addition to power plants, heavy industries such as cement, iron, glass aluminium also produces a large amount of carbon dioxide, and can also be equipped with CCS.

Benefits

1. CCS provides time to develop better methods for eliminating CO_2 emission through the use of green technology (renewable energy).
2. CCS allows the continued use of existing power plants, while reducing their environmental impact, minimizing the cost of transitioning to clean energy.
3. CCS creates additional jobs primarily in the construction and shipping industries, and allows continued employment in coal related industries.
4. CCS minimizes the impacts of ocean acidification in the upper ocean protecting the fish stocks of the worlds oceans.





The capture of CO_2 begins at point sources where large amounts of CO_2 can be collected with relative ease. When dealing with the capture of CO_2 the first issue is what stage will the CO_2 be separated from the fossil fuel. It can be done either before or after the combustion process. The system utilized focuses on separating the CO_2 with post-combustion. The capture of CO_2 gas involves separating it from the other components of the exhaust from the furnace such as nitrous oxide and sulphur dioxide.

For immediate retrofit of existing power plants, the use of a chemical solvent that absorbs CO2 which is released when the solvent is regenerated through a change in pressure is recommended. This system is well established and has been used for gas refinery processing to remove acidic compounds from natural gas. For retrofits in the ten years, new technologies such as membrane separation may be more applicable. By introducing new technology, the costs will steadily decline due to economies of scale, rising knowledge regarding installation and increasing demand.

Transporting CO_2 to the storage location consists of two stages. The first stage is to construct an onshore pipeline system which will carry the CO_2 from the power stations and heavy industrial plants towards a central location for temporary storage. This can collocated with a sea port. Pipeline transportation of CO_2 is a well-developed technology present in the U.S. and it can guarantee the transport of CO_2 in a relatively safe and economical manner.

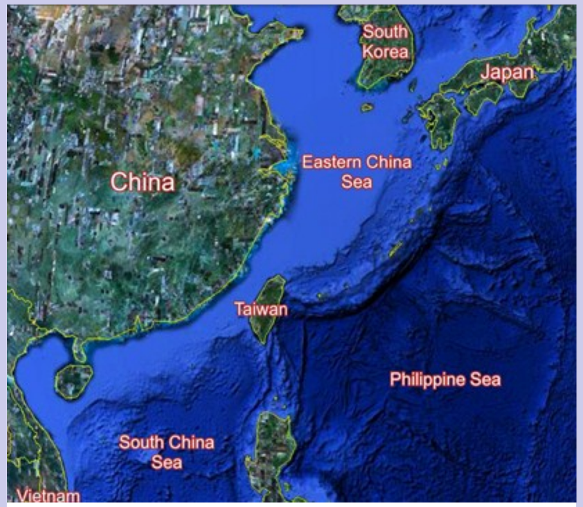
The second stage involves transferring the CO_2 from land to its final storage site in the deep depths of the oceans. Piping can still be considered for this stage. However, the additional benefits provided by ships, which are specifically constructed for the carriage of CO_2, such as flexibility and economic viability, ships are the ideal choice for transportation of CO_2 across a large water body. Many countries have access to seas and oceans; hence, this system will be easily applied to many different situations. The pollution generated through shipping must be compared with the harmful substances emitted during construction and installation of pipelines to ensure a balanced transportation approach.

Once CO_2 is delivered by ships to the waters above the storage location, a long pipeline can be used to inject the CO_2 (in its liquid form) downwards to depths of 3000m. The injected CO_2 will form a lake around the injection point (end of the pipeline) as the high pressure and low temperature at that depth would force the CO_2 to remain in its liquid form and location. Therefore, the CO_2 will not move towards the surface of the oceans or convert back into its original gaseous state easily.

The stored CO_2 will dissolve slowly into the surrounding water as a natural process and it will continue to do so until all of the CO_2 dissolves entirely. This reaction will span 400 to 500 years depending on the actual conditions of the location and the behaviour of the CO_2 lake itself. Hence, there are to be strict regulations on the level of purity of the CO_2 allowed to be stored in the oceans. More trials and experiments should be performed to gather more information with regards to the behaviour and impacts of CO_2 storage at full scale at those depths of the oceans.

Implementation of the described system requires a comprehensive monitoring system to detect any abrupt changes in the ocean chemistry and its effects on the local ecosystem. This provides the system administrators enough time to respond and negate any potentially unwanted effects which the lake may cause. As CO_2 dissolves, the surrounding water is acidified and most life forms within close proximity to the lake will migrate to waters with lower CO_2 levels. With an adaptive management system, new technologies can incorporated to assist in monitoring and mitigating any unwanted effects. The integrated monitoring suite will also provide information to further our understanding of the deep ocean.

A combination of chemical, biological and current sensors should be used. Current monitoring techniques include: bottom-mounted sensors , ship-based cruises, gliders, automated underwater vehicles (AUVs), and remotely operated vehicles (ROVs).



Why China?

China has one of the fastest growing economies in the world, which is accompanied by a rising demand for energy. China is currently expanding its number of coal power plants to meet the growing power demands of its people and has some of the largest coal reserves in the world. In addition As China is the largest emitter of carbon dioxide in the world, CCS is likely the only solution which is able to reduce the total emissions into the atmosphere. However, China has also taken responsibility and is actively researching into various options to handle the excess emissions. Any CCS implemented in China should meet the following requirements:

- Social acceptance,
- Economically Feasible,
- Technically Innovative,
- Minimize Public Risk,
- Fits within probable Legal Framework,
- Zero Carbon Footprint

Carbon Capture and Storage in Deep Ocean Space for the 21st Century: Guidelines for Implementation in China

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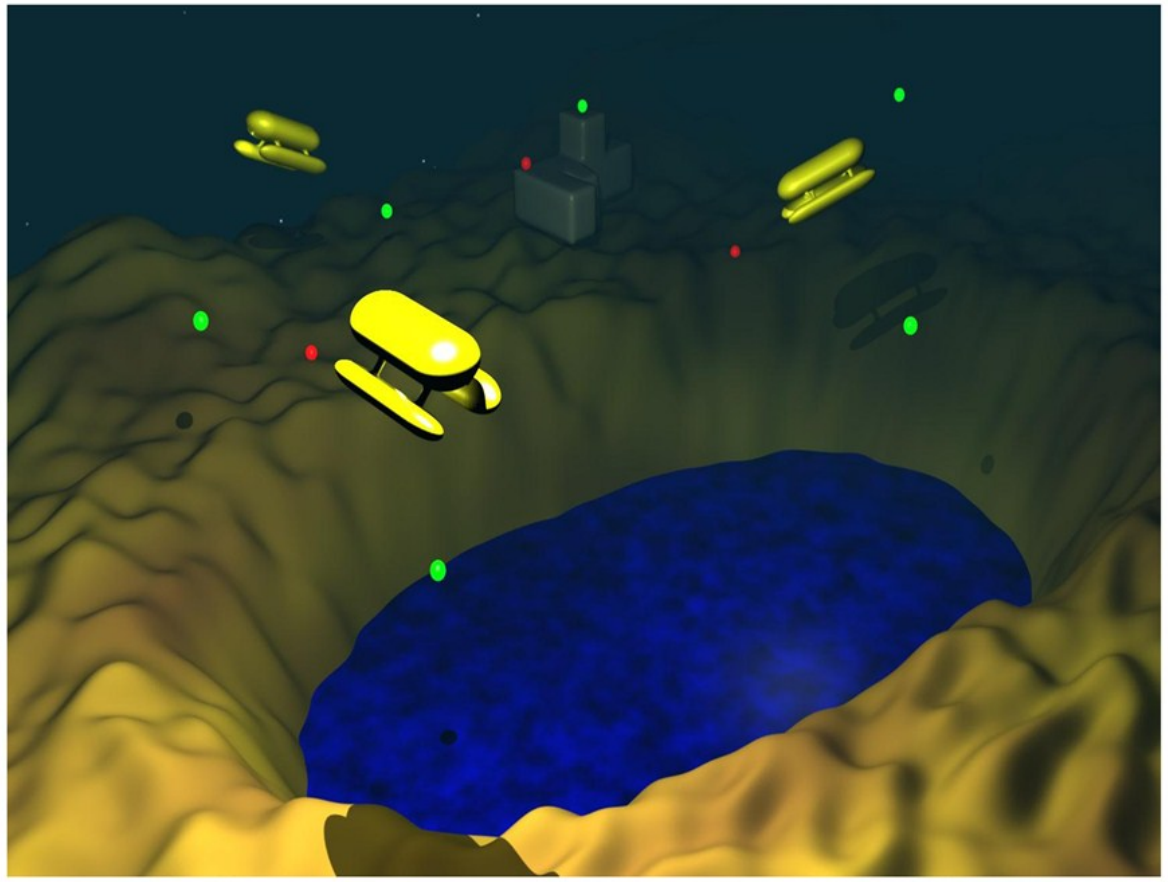

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