Independent Study Environmental Engineering - 2021

Using Carbon Capture Sequestration and Recycling methods to Mitigate Climate Change

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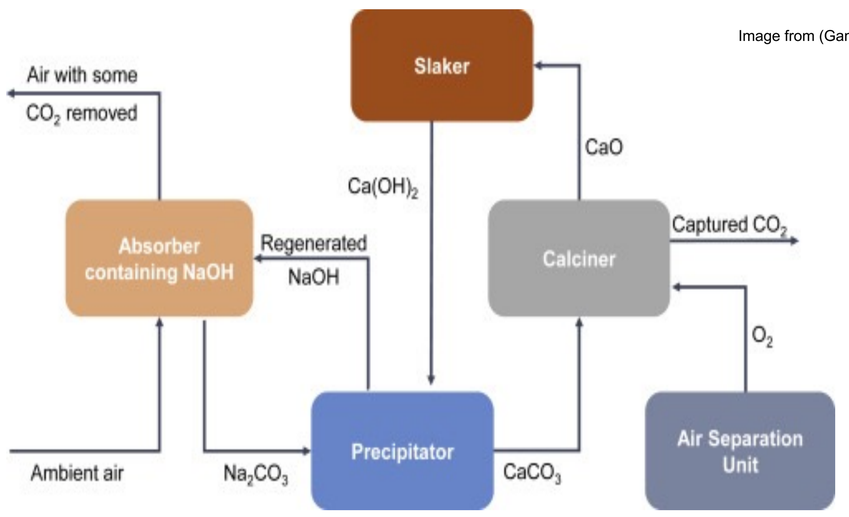
Abstract

Climate change is one of the most crucial issues in our society as atmospheric CO_2 levels continue to rise. Geoengineering techniques will serve a lead role in removing carbon from the atmosphere. This review of carbon capture and sequestration and recycling methods will outline where we currently stand with specific capture and burial methods with the goal of raising awareness for what can be done to help combat climate change. Direct air capture (DAC), pre-combustion carbon capture, and post-combustion carbon capture are the three main geoengineering methods that are used to capture carbon. DAC is the most promising method as it captures carbon from ambient air. Other methods reviewed include planting trees to capture carbon in urban settings, fertilizing the oceans, burning biochar, and bio-energy with carbon capture and storage (BECCS). Analysis of the cost and energy needed to capture carbon from the methods above is also investigated. Once the carbon is captured, it is important to convert it or safely sequester of it and store it in geologic settings. Burying carbon deep in the ocean and in geologic formations on land will be reviewed as well. Moving forward, the goal is that between implementing a wide array of geoengineering methods powered with renewable energy sources, the United States and the rest of the world will be able to reduce atmospheric CO_2 levels and mitigate the effects of climate change.

Direct Air Capture (DAC)

DAC is the process of capturing CO_2 from ambient air. According to (Gambhir, 2019), the two main methods are through the absorption and adsorption process. In the adsorption process the ambient air reacts with a sorbent like potassium hydroxide or sodium hydroxide (Gambhir, 2019). The adsorption method uses a solid amine material to adsorb the CO_2 (Gambhir, 2019).

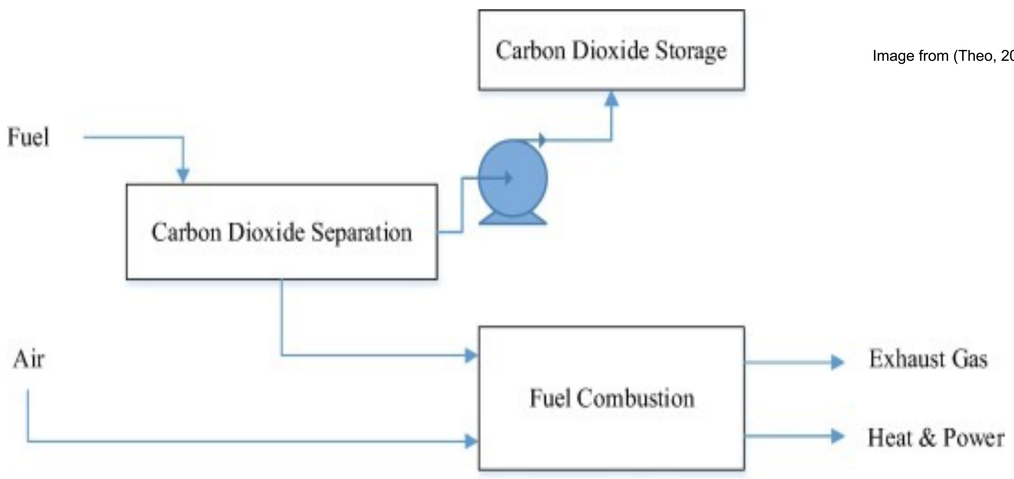
Image from (Gambhir, 2019)



Pre-Combustion Carbon Capture

Pre-combustion carbon capture focuses on separating the CO_2 from the source before the combustion process is completed. This process is implemented in fossil fuel plants as it relies on the combustion of fossil fuels to run. According to (Theo, 2016), the adsorption and absorption methods are implemented to separate the CO_2. For the more popular adsorption method, novel and modified materials like amine-modified titanium oxide are mixed with sustainable ingredients like rice straw (Theo, 2016). For the absorption method, research to improve its efficiency is in developing the formation of a pure ionic liquid to be used as the solvent (Theo, 2016).

Image from (Theo, 2016)



Cost Analysis and Future Work

Between the three main geoengineering methods (DAC, pre-combustion, and post-combustion), pre- and post-combustion are currently relatively cheap and operate on lower energy than DAC. DAC is still expensive and requires much more energy but is lacking the research and attention these other methods have had. DAC will be much more reliable in the future as we transition to renewable energy given it uses ambient air and not a fossil fuel power plant. It is important that ongoing research is competed to improve the sorbents and solid amine materials in the reaction which will eventually bring the price and energy usage significantly down.

Post-Combustion Carbon Capture

Post-combustion capture implies capturing the CO_2 after combustion but before it leaves the plant. This process is implemented in fossil fuel power plants. The most efficient way to capture CO_2 using this method is through using select solvents to absorb CO_2 from a flue gas (Liang, 2015). Examples of good solvents to use could be chilled ammonia, and ionic liquids (Liang, 2015).

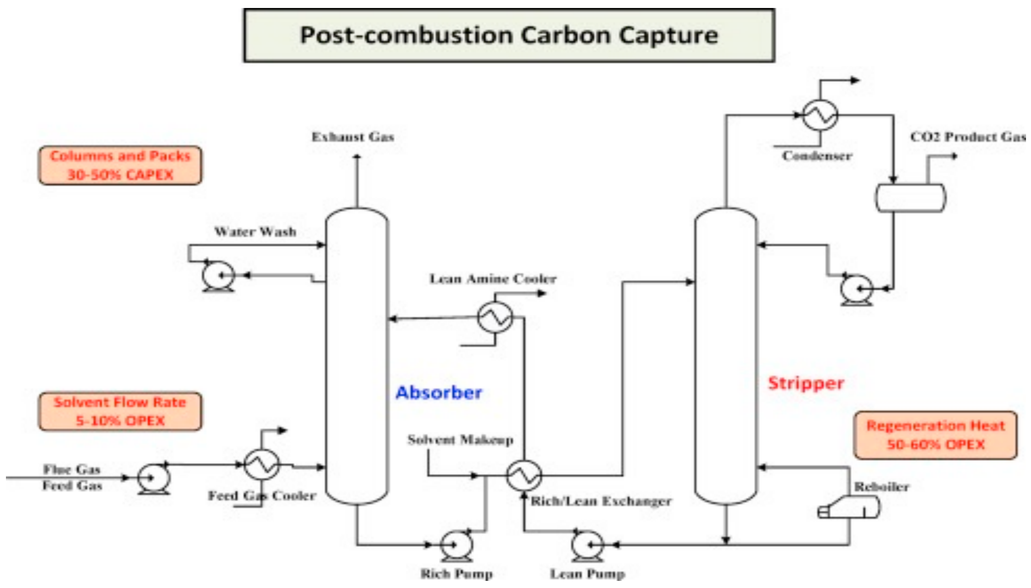


Image from (Liang, 2015)

Other Methods

- **Ocean Fertilization:** Methods are used to increase the oceans Alkalinity which allows for a greater storage capacity of CO_2. The addition of carbonates to the ocean can also increase weathering and alkalinity thus drawing down atmospheric CO_2 levels. One proposition is to add volcanic ash to fertilize the oceans surface. Once the tephra is added to the ocean, photosynthesis and production increase (Longman, 2020). This cycle buries CO_2 as the organisms die and decompose in the bottom of the ocean.
- **Burning Biochar:** Biomass is taken and through pyrolysis, is formed into CO_2 substances that can be recycled and stored or used for other processes. Pyrolysis is an irreversible process that involves thermal degradation of biomass in an inert environment at elevated temperatures under limited or complete lack of oxygen (Singh, 2019). The process of Biochar leads into the method of BECCS. BECCS is a combination of using biomass to fuel carbon capture systems.
- **Planting Trees:** if the United States can increase urban tree cover from 28%-33% over the next 50 years, we could store an additional 150 million tons of CO_2 (Rowntree, 1991).

What to do with Captured Carbon?

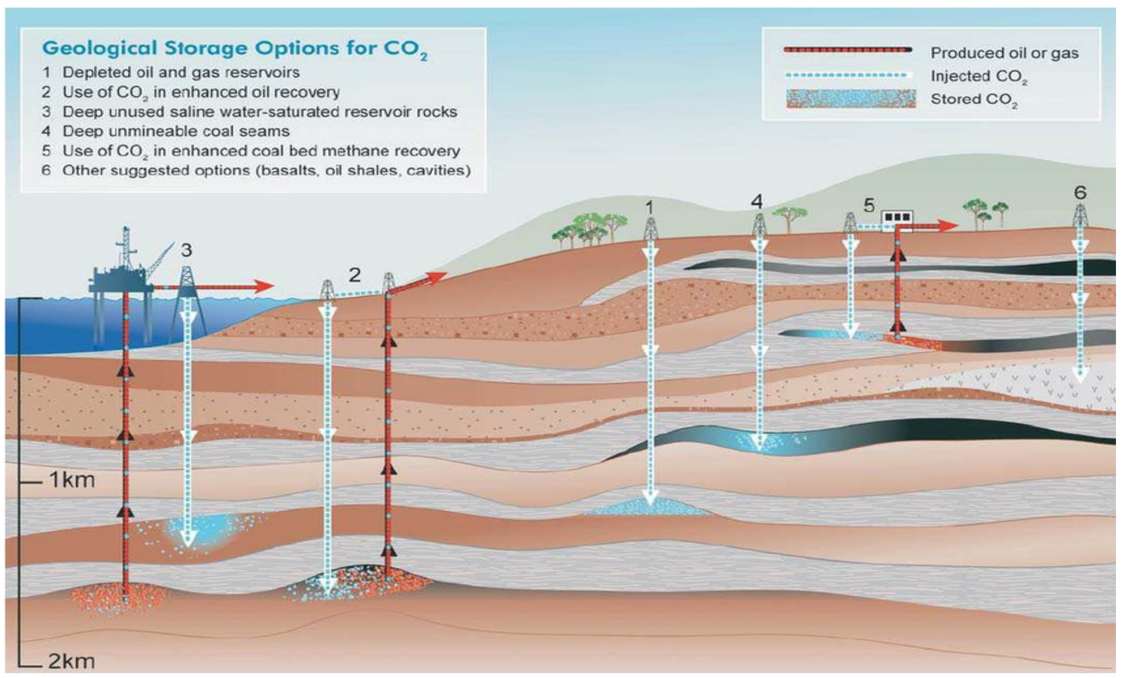


Image from (Benson, 2008)

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