CARBON CAPTURE AND STORAGE: A PROMISING SOLUTION FOR MITIGATING CLIMATE CHANGE

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Abstract

The rapid increase in greenhouse gas emissions, primarily carbon dioxide (CO2), has led to a pressing need for effective strategies to combat climate change. Carbon capture and storage (CCS) has emerged as a promising technology that aims to capture CO2 emissions from various sources and store them underground, thereby preventing their release into the atmosphere. This paper provides an in-depth analysis of CCS, including its underlying principles, different capture technologies, storage methods, challenges, and potential benefits. The paper also examines the current state of CCS implementation worldwide and discusses its role in achieving global climate goals. By presenting a comprehensive overview, this paper highlights the importance of CCS as a viable option for mitigating climate change.

Introduction

Carbon capture and storage (CCS), also known as carbon capture, utilization, and storage (CCUS), is a process that involves capturing carbon dioxide (CO2) emissions from various sources, such as power plants, industrial facilities, and other large-scale emitters, and permanently storing or utilizing the captured CO2 to prevent its release into the atmosphere.

The CCS process (Fig 1) can be divided into three main steps: capture, transportation, and storage/utilization.

1. Capture: The capture stage involves separating CO2 from the flue gases emitted during combustion or industrial processes. Various capture technologies are employed depending on the emission source. These technologies include pre-combustion capture, post-combustion capture, and oxy-fuel combustion capture.

2. Transportation: Once captured, the CO2 needs to be transported from the capture site to the storage or utilization site. This transportation is usually done through pipelines or, in some cases, by using ships or trucks. The transportation infrastructure should be designed to ensure safe and efficient delivery of the Transportation: Once captured, the CO2 needs to be transported from the capture site to the storage or utilization site. This transportation is usually done through pipelines or, in some cases, by using ships or trucks. The transportation infrastructure should be designed to ensure safe and efficient delivery of the captured CO2

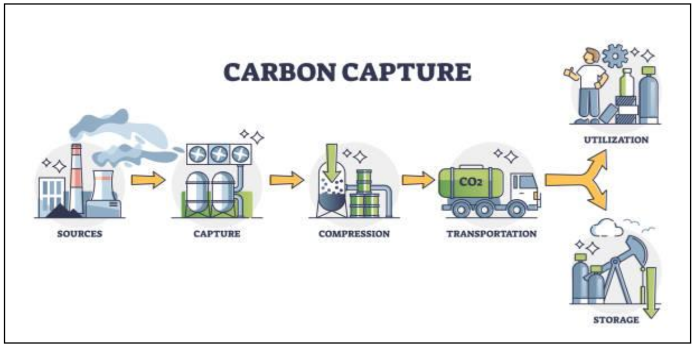

Fig 1. Carbon capture illustration

3. Storage/Utilization: The final stage involves storing the captured CO2 deep underground in geological formations or utilizing it for other purposes. Geological storage is the most common method, where the CO2 is injected into deep underground rock formations, such as depleted oil and gas reservoirs, saline aquifers, or coal seams. The CO2 is stored securely and permanently, preventing its release into the

Atmosphere Alternatively, the captured CO2 can be utilized in industrial processes, such as enhanced oil recovery (EOR), where the CO2 is injected into oil fields to enhance oil production while simultaneously storing the CO2 underground.

Carbon capture and storage (CCS) holds great promise as a critical technology for mitigating CO2 emissions and combating climate change. It offers a pathway to decarbonizes energy-intensive industries and power generation while minimizing the environmental impact

Overview of CCS Technology for Fossil-fuel Fired EGUs

The majority of new fossil-fuel fired electric generating units are projected to use natural-gas combined cycle technology which results in lower CO2 emissions per MWh of electricity produced than steam generating units or IGCC systems burning solid fossil fuels such as coal. Use of CCS was analyzed as an option for reducing CO2 emissions from new steam generating units and new IGCC systems for purposes of the NSPS. Carbon capture and storage (CCS) involves the separation and capture of CO2 from flue gas, or syngas in the case of IGCC. CCS is a three-step process that includes: 1. Capture of CO2 from electric generating units (or other industrial processes); 2.Compression and transport of the captured CO2 (usually in pipelines); 3. Underground injection and geologic sequestration (also referred to as storage) of the CO2 into deep underground rock formations. These formations are often a mile or more beneath the surface and consist of porous rock that holds the CO2. Overlying these formations are impermeable, non-porous layers of rock that trap the CO2 and prevent it from migrating upward. Figure 1 illustrates the typical depth at which CO2 would be injected (literature survey of carbon capture technology 2015)

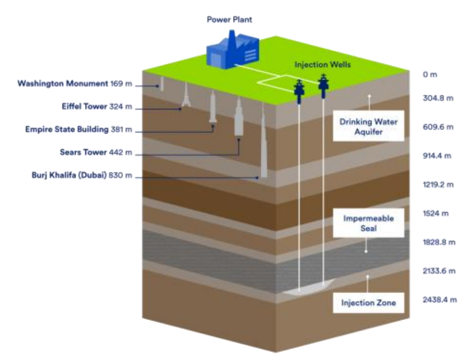

Fig 2. CCS Schematic (Subsurface depth to scale, 5,280 feet equals one mile) (EPA, 2013c)

Geologic sequestration is feasible in different types of geologic formations including deep saline formations (formations with high salinity formation fluids) or in oil and gas formations, such as where injected CO2 increases oil production efficiency through a process referred to as enhanced oil recovery (EOR). CO2 may also be used for other types of enhanced recovery, such as for natural gas production. Reservoirs such as unmineable coal seams also offer the potential for geologic storage.

Adapted Methodology

Carbon capture and storage (CCS) is a process that involves capturing carbon dioxide (CO2) emissions from industrial sources. There are several methods involved in CCS.

- .Post-combustion Capture
- .Pre-combustion Capture
- .Oxyfuel Combustion
- Carbon Capture from Direct Air

This paper aims to explain complete procedure for post combustion capture method which is used to capture CO2. Post-combustion carbon capture involves capturing CO2 from the flue gases that are produced after the combustion of fossil fuels. The post-combustion method is particularly valuable because it can be retrofitted onto existing power plants and industrial processes without significant modifications.

Post-combustion CO2 capture refers to removal of CO2 from combustion flue gas prior to discharge to the atmosphere. It is referred to as “post-combustion capture” because the CO2 is the product of the combustion of the primary fuel and the capture takes place after the combustion of that fuel. A simplified process schematic of post-combustion CO2 capture is shown in (Figure 3).

Fuel is burned with air in a boiler to produce steam that drives a turbine/generator to produce electricity. Flue gas from the boiler consists primarily of N2 and CO2 with other components in trace amounts (e.g., particulate matter (PM), sulfur oxides (SOx), nitrogen oxides (NOx), hydrochloric acid (HCl) etc.).

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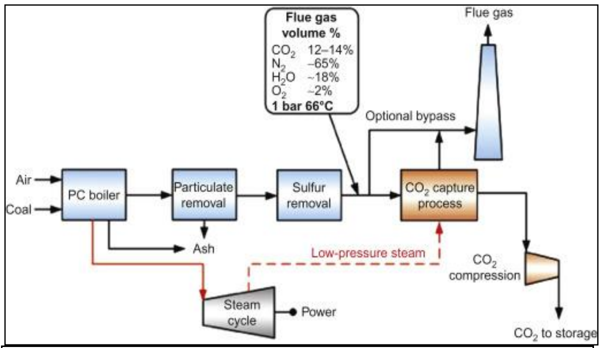

Fig 3. Diagram Illustrating a Pulverized Coal Boiler with Post-Combustion CO2 Capture

The CO2 capture process is located downstream of the conventional pollutant controls for removal of PM and acid gases so these components will not interfere with CO2 removal. In addition to the need to remove pollutants upstream of the CO2 capture system, challenges to separating CO2 from steam generating unit combustion flue gas include: • the high volume of gas to be treated because the CO2 is dilute (13–15 volume percent in coal-fired systems); • the low pressure [15–25 pounds per square inch (psi)] of the flue gas; • and the large auxiliary power load to compress captured CO2 from near atmospheric pressure to pipeline pressure (about 2,200 psi). The volume of flue gas to be treated (and the associated energy penalty) is reduced in partial CO2 capture systems, where a slipstream of the flue gas is treated as opposed to the entire flue gas stream. The CO2 capture process involves use of a chemical solvent, solid sorbent, or membrane to separate CO2 from the flue gas. Amine-based solvent systems are most commonly used for post combustion capture systems. When contacted with the combustion flue gas, then solvent participates in a chemical absorption (chemisorptions) separation process in which the CO2 is absorbed by the liquid solvent. Solid sorbents can be used to capture CO2 from flue gas through chemical adsorption, physical adsorption, or a combination of the two. Possible configurations for contacting the flue gas with solid sorbents include fixed, moving, and fluidized beds. Membrane-based capture uses permeable or semi-permeable materials that allow for the s elective transport/separation of CO2 from flue gas (NETL2013) the post-combustion method of carbon capture enables the reduction of CO2 emissions from existing power plants and industrial facilities. By capturing and storingCO2, this method contributes to the mitigation of climate change and the transition to a low-carbon economy

Case study

The Sleipner Field CCS project is a prominent example of carbon capture and storage (CCS) implemented in the oil and gas industry. Located in the North Sea, operated by Equinor (formerly Statoil), the Sleipner field has been producing natural gas since 1996. The project's objective was to reduce carbon emissions associated with natural gas production and prevent the release of significant amounts of carbon dioxide (CO2) into the atmosphere. The Sleipner Field CCS project faced several challenges during its implementation. One significant challenge was the high cost associated with capturing, transporting, and storing the CO2. However, the project demonstrated the technical feasibility and environmental benefits of CCS, providing valuable insights into the potential of CCS deployment in the oil and gas industry. The Sleipner Field CCS project serves as a successful case study in the implementation of CCS in the oil and gas sector. It demonstrates that CCS can be a viable solution for reducing carbon emissions and mitigating climate changes. (Ak Furre 2017).

Future advances in CO2 capture technology

The field of CO2 capture technology is continually evolving, and future advances hold the potential to further improve the efficiency, cost-effectiveness, and scalability of carbon capture processes. Here one of the potential future advancements in CO2 capture technology: Novel Solvents and Sorbents: Researchers are exploring new solvents and sorbents that can enhance the CO2 capture efficiency and reduce energy requirements. The development of advanced solvents with improved selectivity for CO2 and reduced regeneration energy demand could significantly enhance the performance of post-combustion capture processes. Additionally, the discovery and optimization of new adsorbents with higher CO2 adsorption capacities and improved regeneration properties could enhance the viability of adsorption-based capture technologies.

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Conclusions:

CCS holds great potential for reducing CO2 emissions from large-scale industrial sources that are difficult to decarbonize. It can enable the continued use of fossil fuels while minimizing their environmental impact. Moreover, the integration of CCS with bioenergy production (BECCS) presents an opportunity for achieving negative emissions by removing CO2 from the atmosphere**.**

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