Decarbonization

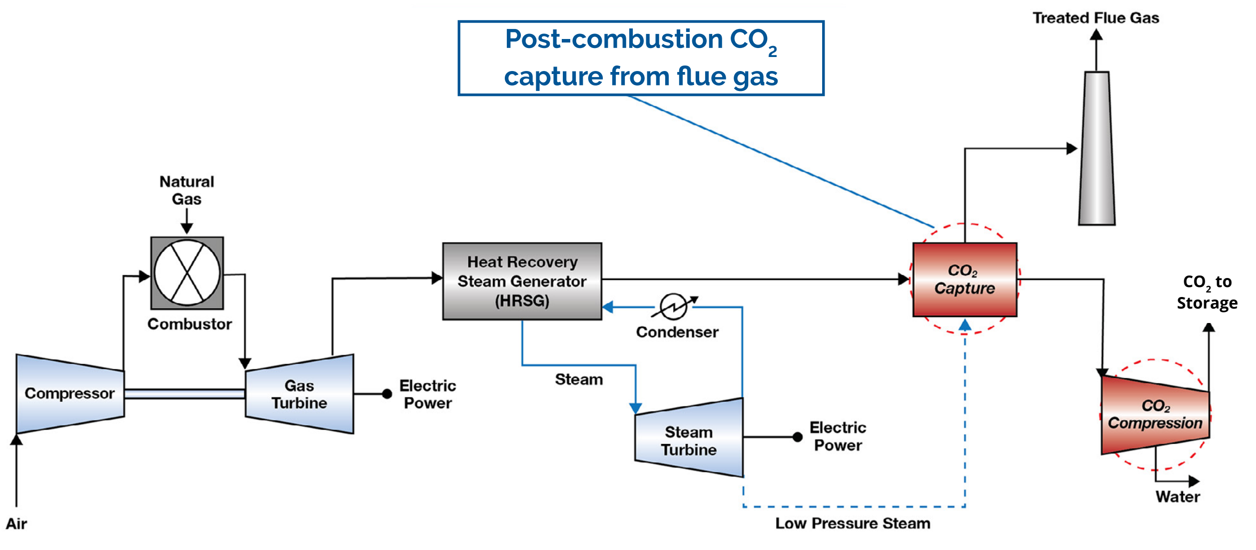
Carbon Capture And Storage (CCS)

As the topic of climate change continues to increase in profile, solutions to reducing the world's greenhouse gases are gaining importance. Of the many greenhouse gases, carbon dioxide (CO2) is the most prominent due to the significant amounts of CO2 that are produced from human activity (e.g., burning fossil fuels, concrete production, agriculture, etc.).

To combat rising CO2 levels, the power industry has investigated ways to capture CO2 from the flue gas emissions of power plants. The most developed and commercially available carbon capture systems use an amine-based solvent to absorb CO2. Figure 1 shows a process diagram for a carbon capture system on a combined cycle power plant.

Figure 1

Process Diagram of Carbon Capture and Compression on a Combined Cycle Power Plant



Source: NETL, DOE, Post-Combustion CO2 Capture, https://netl.doe.gov/coal/carbon-capture/post-combustion

Post Combustion Carbon Capture

- CO_2 capture from facilities that burn fossil fuels (e.g., coal and natural gas) can be accomplished by using chemical and physical solvents, sorbent materials, membrane, cryogenic processes and technologies
- The most developed post-combustion technologies use an amine (chemical) solvent to absorb CO_2 from flue gas, and heat is applied to release the CO_2 from the solvent prior to it being dehydrated and compressed
- 90-95 percent CO_2 capture rate is generally achieved
- There are various generic and proprietary amine solvents commercially available in the market, sometimes dependent on technology providers
- Solvents can degrade and lose ability to absorb CO_2 overtime, due to flue gas impurities, and annual replenishment is necessary
- Fluor, MHI, and Shell offer proprietary amine-based solvent technology and systems, currently the most proven in commercial applications

Carbon Capture Emerging Technologies

- VeloxoTherm (Svante) uses a framework of solid adsorbents and has a demonstration facility in Saskatchewan, Canada
- CDRMax (Carbon Clean) uses a proprietary formula of amines and salts and has been demonstrated in several facilities across Europe
- ICE-31 (Ion Clean Energy) uses solvents and a proprietary packing and has completed a demonstration in Wilsonville, AL

Direct Air Capture (DAC)

- DAC systems absorb CO_2 directly from the atmosphere, where CO_2 concentrations are much lower than flue gas streams
- DAC technologies differ in how they capture CO_2 (e.g., solutions of potassium and calcium hydroxides, solid absorbents, etc.), and they are still in various stages of research and development, with limited demonstration
- Most DAC systems are generally modular, allowing installation near CO_2 utilization or storage sites

Storage Options

- Permitting and environmental considerations are key to developing CO_2 storage opportunities and alternatives
- Initiatives are underway in the U.S to develop CO_2 pipelines to transport CO_2 to storage locations
- Storage sites need to be sufficiently deep and surrounded by suitable rock formations (e.g., caprock or shale) to prevent CO_2 from escaping and reentering the atmosphere (e.g., some sandstone formations are sufficiently solid and porous to store CO_2)
- Storage reservoirs must be isolated from water sources (e.g., water aquifers)
- On-site monitoring of CO_2 is required to ensure CO_2 is not escaping the storage sites, but requirements for monitoring differ between states

Safety

- CO_2 capture systems are relatively safe, due to the inert nature of CO_2. However, the amines used to capture CO_2 should be handled with care and in accordance with industry safety codes and standards.

Opportunities, Challenges, and Risks

- The capital and O&M costs of carbon capture systems remain relatively high and technology optimization through scaled deployment is needed to lower costs
- Emerging and developing technologies must be able to scale-up their systems to industrial sizes
- Additional CO_2 pipeline and storage infrastructure need to be developed to facilitate more CCS projects and support their economic viability moving forward
- Private and government funding must continue to support research and development (R&D) of CO_2 capture technologies to achieve commercial scale deployment. R&D is necessary to optimize processes and lower capital and operating costs of CO_2 capture systems.
- CO_2 emission focused policies and regulations need to be better defined and aligned with state and federal decarbonization goals and commitments

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