P178 QUICK INSIGHTS

RESOURCE PLANNING FOR ELECTRIC POWER SYSTEMS

Carbon Capture and Storage in Energy System Resource Planning

by Romey James

KEY INSIGHTS

- CCS has been demonstrated at power plants. Cost reductions will likely occur after additional deployment allows for greater industry experience.
- CCS consists of three major components: capture, transportation, and storage.
- There are several approaches to capturing CO_2, including post-combustion, pre-combustion, oxy-combustion, and direct air capture.
- Transportation and storage represent smaller portions of the overall costs than capture but can vary significantly and present uncertainties and potential challenges.
- Utilization of CO_2 offers an alternative to geologic storage though the market is much smaller than the potential supply of captured CO_2.

Carbon Capture and Storage (CCS) is the process of capturing CO_2 before it is released into the atmosphere and sequestering it underground. Applied to power plants, it could enable low-carbon, firm, baseload electricity.

CCS has been used since the 1970's for enhanced oil recovery (EOR), but in recent years the US Department of Energy and public agencies around the world have funded research into its potential as a climate solution. Two coal plants (Boundary Dam and Petra Nova) have demonstrated at-scale CCS on power generating facilities. The findings from these projects indicate that the technology is feasible, but that the power industry's experience is nascent and additional deployment and learning is required to achieve n^{th}-of-a-kind costs.

<u>Recent Legislation in the United States</u>

In 2022, the Unites States passed the Inflation Reduction Act which increased existing 45Q tax credits for carbon captured from point sources to $85/$tCO_2$ for storage and $60/$tCO_2$ for utilization if labor criteria are met. For direct air capture, the values are $180/$tCO_2$ and $130/$tCO_2$, respectively.

In May of 2023, the Environmental Protection Agency released proposed rules under section 111 of the Clean Air Act to regulate CO_2 emissions from new and existing power plants, declaring CCS as a best system of emissions reduction (BSER). The rule would require coal plants without a retirement scheduled before 2040 to implement 90% CCS by 2030, and baseload natural gas turbine plants would need to co-fire hydrogen or implement 90% CCS by 2035.

CCS consists of three major components: capture, transportation, and storage.

Capture

Post-combustion carbon capture can be achieved through a variety of mechanisms, including absorption, adsorption, membranes, and cryogenic processes. Of these pathways, only chemical absorption is technologically mature. The absorption process consists of contacting the flue gas with an amine-based solvent which absorbs the CO_2, then heating the solvent to release the CO_2 as a relatively pure stream.

Pre-combustion formula
Fossil fuel $\rightarrow CO + H_2^*$
$CO + H_2O \rightarrow CO_2^{\dagger} + H_2^*$
†captured *combusted

Carbon can also be captured **pre-combustion** by creating synthesis gas from fossil fuels, reacting the carbon monoxide with water to produce hydrogen and carbon dioxide via water-gas shift, and capturing the CO_2 prior to combusting the hydrogen for power generation.

Oxy-combustion presents a third category of carbon capture for power generation. In this process, a turbine combusts natural gas mixed with pure oxygen (and some recirculated flue gas) rather than ambient air, resulting in a flue gas stream of relatively pure CO_2 and water vapor. Engineering studies have found this could be one of the most cost-effective methods of producing low-carbon electricity from fossil fuels.

Direct air capture (DAC) refers to removing carbon dioxide directly from ambient air. Several technological approaches are under development, but most are early stage and very expensive. DAC is relevant to utility resource planning because it uses large amounts of energy and provides an upper bound on CO_2 mitigation costs.

Transportation

After the carbon is captured, it must be transported to where it will be stored underground. **Pipelines** are likely the only economically feasible method for transporting large quantities of CO_2, but pipeline infrastructure can be challenging to build. Though capture represents the largest portion of the CCS costs, transportation costs are not insignificant and vary substantially depending on how far the CO_2 must travel and how many other facilities are sharing the infrastructure (higher utilization lowers specific costs).

Storage

The final step in the CCS process is the injection of the CO_2 into deep underground formations for long-term storage. In the US, geologic storage of CO_2 requires **Class VI wells**, which carry stringent requirements to protect drinking water resources. The timelines for permitting, authorization, and construction of the few Class VI wells approved so far have proven lengthy, creating uncertainty for resource planning. Favorable geology for storage varies regionally, and greater distance from storage wells yields greater transportation costs.

Utilization

As an alternative to geologic storage, the CO_2 can be utilized in a variety of industrial applications. Sectors currently utilizing CO_2 include oil and gas for enhanced oil recovery, food and beverage for freezing and drink carbonation, and other industries as a chemical feedstock or fire suppressant. The current demand is small compared to the potential supply of CO_2 captured from large emission sources such as power plants, and the market could be easily flooded. New demand may develop, for example using captured CO_2 in the synthesis of fuels or building materials, but utilization is expected to play a relatively small role in CO_2 management overall.

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