Front-End Engineering Design Study for Retrofit Post-Combustion Carbon Capture on a Natural Gas Combined Cycle Power Plant

primary project goal

Electric Power Research Institute (EPRI) and its partners Fluor Corporation and California Resources Corporation (CRC) are conducting a front-end engineering design (FEED) study to determine the technical and economic feasibility of a retrofit, post-combustion carbon capture technology on a commercially operating, natural gas-fired combined cycle (NGCC) power plant.

technical goals

Conduct a FEED study for 75% overall capture (90% capture on 83% slipstream) at CRC's 550-megawatt-electric (MWe) NGCC Elk Hills Power Plant (EHPP) using Fluor's proprietary Econamine FG Plus^{SM} (EFG+) aqueous amine technology. The captured 4,000 tonnes of carbon dioxide (CO_2) per day will be used by CRC for enhanced oil recovery (EOR) in fields adjacent to the power plant.

technical content

The FEED study will examine the cost and engineering requirements for installing a plant to capture CO_2 produced by the 550-MWe NGCC unit located in the Elk Hills Oil Field in Kern County, California. Fluor is the design engineering contractor and Fluor's EFG+ technology is used for the carbon capture system design. CRC is the owner and operator of the host site, EHPP. Fluor's EFG+ technology is a post-combustion CO_2 capture technology with proven process for removal of CO_2 from flue gases, with the CO_2 product used for EOR and other applications.

The FEED study deliverables will include a design basis, process flow diagrams, piping and instrument diagrams, equipment datasheets, a plot plan, bulk material takeoffs, and a capital cost estimate. For the design basis of the FEED study, the completed and ongoing details include: consolidated historic performance and run history of the power plant, evaluating various operating scenarios and conditions; results from flue gas testing review and validation of solvent performance through FEED; historic construction details from surrounding facilities to incorporate site requirements; ongoing review and optimization of energy use and waste streams; and ongoing evaluation of construction practices and contracting strategies to optimize cost, schedule, and risk.

program area:
Point Source Carbon Capture

ending scale:
FEED

application:
Post-Combustion Power Generation PSC

key technology:
Solvents

project focus:
Econamine FG Plus^{SM} Retrofit to NGCC

participant:
Electric Power Research Institute, Inc.

project number:
FE0031842

NETL project manager:
Carl Laird
carl.laird@netl.doe.gov

principal investigator:
Abhoyjit Bhown
EPRI
abhown@epri.com

partners:
Fluor Corporation; California Resources Corporation

start date:
10.01.2019

percent complete:
100%

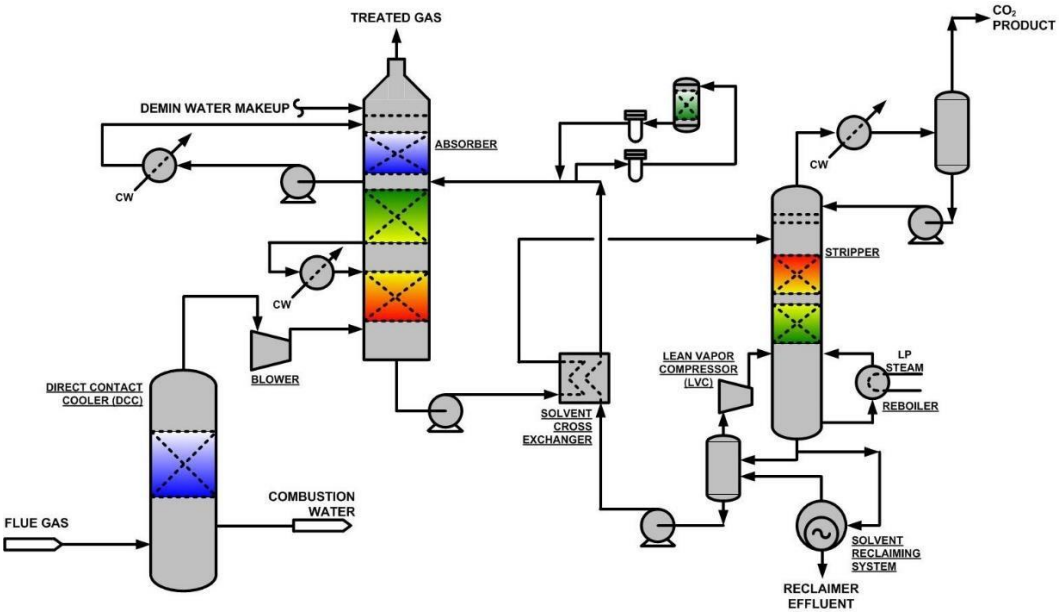

Figure 1: Simplified schematic of Fluor Corporation's Econamine FG Plus℠ CO_2 capture process.

Flue Gas Assumptions – Unless noted, flue gas pressure, temperature, and composition leaving the NGCC unit (wet basis) should be assumed as:

Pressure	Temperature	Composition						
		vol%					ppmv	
psia	°F	CO_2	H_2O	N_2	O_2	Ar	SO_x	NO_x
14.5	205	4.54	9.30	72.95	12.34	0.88	0.7	1.7

Parameter Descriptions:

Chemical/Physical Solvent Mechanism – The absorption of CO_2 is by chemical reaction.

Solvent Contaminant Resistance – The solvent has high resistance to contaminants in the flue gas due to the solvent maintenance system's ability to maintain the solvent in pristine condition.

Solvent Foaming Tendency – None.

Flue Gas Pretreatment Requirements – None.

Solvent Makeup Requirements – 0.42 kg/tonne CO_2.

Waste Streams Generated – Solvent maintenance system waste.

Process Design Concept – Flowsheet/block flow diagram shown above in Figure 1.

Proposed Module Design – To be prepared after logistics/route study.

technology advantages

- FEED studies for carbon capture systems at actual sites such as this will provide the U.S. Department of Energy (DOE) with a more detailed understanding of carbon capture costs in a commercial application, thereby enabling DOE to better design its research and development (R&D) program to reduce those costs for similar carbon capture technologies being developed in its R&D portfolio.
- This FEED study could lead to the world's first commercial deployment of carbon capture on a natural gas-fired power plant and could be duplicated at other power plants across the world.

- Fluor's latest version of its EFG+ technology has several key features, including enhanced solvent formulation that has a high resistance to degradation, reduced amine circulation rate, a solvent maintenance system that keeps the solvent in pristine condition, low waste production, very low absorber vent emissions, and load-following capability. These features are proven on both gas turbine exhaust and coal flue gas. The enhanced dual-cell column and absorber design enables a large flue gas throughput, which reduces capital costs.

R&D challenges

- Targeting not just operating expenses, but also capital expenses in this FEED study to minimize the overall cost of CO_2 capture via utilization of various technology and process synergies.
- Optimizing cooling water usage as California and the Bakersfield area's ongoing challenge of water availability for power production.

status

The final FEED study package was completed and submitted to the National Energy Technology Laboratory (NETL). Design activities completed include process modeling, heat and material balances, process and utility flow diagrams, piping and instrumentation diagrams, equipment sizing and selection, process hazard analysis, cause and effect diagrams, plot plan, electrical load list, 3D model development, and capital and operating cost estimates. Value engineering studies were conducted to reduce the column heights of the direct contact cooler and absorber designs, reduce flue gas ducting costs using alternate geometry and metallurgy, and optimize the plot layout by reducing the size of the plate and frame exchanger support structure and minimizing the higher cost alloy piping. A study was also conducted to modify integration with the host power plant, allowing the existing steam turbine to supply the full regeneration steam requirement to the capture plant, thus eliminating the need for new natural gas-fired boilers dedicated to the capture plant, increasing CO_2 captured from the plant and reducing cooling tower load and water consumption. The final report is under development.

available reports/technical papers/presentations

"Front-End Engineering Design Study for Retrofit Post-Combustion Carbon Capture on a Natural Gas Combined Cycle Power Plant," DOE Project Kickoff Meeting, October 30, 2019. *https://www.netl.doe.gov/projects/plp-download.aspx?id=10875&filename=Front-End+Engineering+Design+Study+for+Retrofit+Post-Combustion+Carbon+Capture+on+a+Natural+Gas+Combined+Cycle+Power+Plant.pdf.*

"Front-End Engineering Design Study for Retrofit Post-Combustion Carbon Capture on a Natural Gas Combined Cycle Power Plant," 2020 NETL Project Review Meeting - CCUS Integrated Projects, August 18, 2020. *https://netl.doe.gov/sites/default/files/netl-file/20CCUS_Bhown.pdf.*

"Front-End Engineering Design Study for Retrofit Post-Combustion Carbon Capture on a Natural Gas Combined Cycle Power Plant," 2021 NETL Carbon Management and Oil and Gas Research Project Review Meeting - Integrated CCUS Projects and FEED Studies, August 3, 2021. *https://netl.doe.gov/sites/default/files/netl-file/21CMOG_CCUS_Bhown.pdf*.