Initial Engineering Design Study for Advanced CO_2 Capture from Hydrogen Production Unit at Phillips 66 Rodeo Refinery

primary project goal

Phillips 66, with the assistance of Worley Group Inc., is performing an initial design of a commercial-scale, advanced carbon capture and storage (CCS) system that separates and stores approximately 190,000 tonnes per year net carbon dioxide (CO_2) with 90%+ carbon capture efficiency from an existing steam methane reforming (SMR) plant at the Phillips 66 Rodeo Refinery. The project goal is to analyze the technical results of three different carbon capture configurations and then select the one with the smallest predicted impact to the average levelized cost of hydrogen and produce an advanced engineering design for a commercial-scale unit based on the selected configuration.

technical goals

- Evaluate several proposed solvents for use in an absorption cycle and assess the performance of each, selecting one to utilize.
- Design and evaluate three different carbon capture configurations using a preliminary TEA. Select the best option for minimum cost of hydrogen production.
- Design and create an initial engineering package for the selected solvent and configuration.
- Perform a final TEA on the complete system.
- Perform an environmental health and safety (EH&S) analysis.

technical content

Phillips 66, in collaboration with the Worley Group Inc., is designing a commercial-scale carbon capture unit that could be installed onto the Phillips 66 Rodeo Refinery's SMR plant. The unit would capture 90% of the CO_2 produced by the plant. The first part of the project consists of a qualitative review of different commercially available technology providers' design packages. One licenser will then be chosen to proceed forward with the proposed three different carbon capture configurations.

The next phase of the project is focused on applying the selected technology to three separate CO_2 capture configurations: (1) capture from SMR flue gas and from the pressure-swing adsorption (PSA) tail gas; (2) capture from syngas before the PSA and from the SMR flue gas; and (3) capture from SMR flue gas only (post-combustion). By performing a TEA comparing these three options, the highest-ranked CCS system configuration with the lowest impact to the levelized cost of hydrogen will be selected. Consideration will also be given to the project's capital cost estimate, ease of integration into the existing refinery, solvent cost and stability, and the expected reliability of the new systems. The study team will

program area:
Point Source Carbon Capture

ending scale:
pre-FEED

application:
Post-Combustion Industrial PSC

key technology:
Solvents

project focus:
Solvent-Based Post-Combustion Carbon Capture System for NG Reforming

participant:
Phillips 66

project number:
FE0032109

predecessor projects:
N/A

NETL project manager:
Katharina Daniels
katharina.daniels@netl.doe.gov

principal investigator:
Robert Henderson
Phillips 66
rob.j.henderson@p66.com

partners:
Worley Group Inc.

start date:
03.01.2022

percent complete:
5%

further advance engineering efforts for completing the initial engineering design for the selected CCS configuration, such that the next phase of engineering can proceed.

After selecting the most viable option, engineering will proceed and an initial engineering design package of the chosen system will be created, including process flow diagrams (PFDs), piping and instrumentation diagrams (P&IDs), heat and mass balances, and equipment datasheets. Finally, a TEA will be completed as a part of this study.

TABLE 1: INDUSTRIAL PLANT CARBON CAPTURE

Economic Values	Units	Calculated Project Value
Cost of Carbon Captured	\$/tonne CO_2	TBD
Cost of Carbon Avoided	\$/tonne CO_2	TBD
Capital Expenditures	\$/tonne CO_2	TBD
Operating Expenditures	\$/tonne CO_2	TBD

Definitions:

Cost of Carbon Captured – Projected cost of capture per mass of CO_2 captured under expected operating conditions.

Cost of Carbon Avoided – Projected cost of capture per mass of CO_2 avoided under expected operating conditions.

Capital Expenditures – Projected capital expenditures in dollars per tonne of CO_2 captured.

Operating Expenditures – Projected operating expenditures in dollars per tonne of CO_2 captured.

Flue Gas Assumptions – Unless noted, flue gas pressure, temperature, and composition leaving the flue stack (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
14.7	425	18.0	18.3	61.4	1.5	0.7	5	10

technology advantages to be considered

- Fast kinetics, coupled with low water content, enhances the carrying capacity and reduces regeneration energy.
- Environmentally benign (i.e., low parasitic load, near-zero emissions, and negligible solvent makeup).
- Low thermal and oxidative degradation rates result in good solvent stability, reducing solvent makeup rates and associated operating costs (OPEX).
- Low specific reboiler duty and solvent stability result in smaller capture plant equipment, reducing capital expenditure (CAPEX).

R&D challenges

- Implementation of heat-integration strategies.
- Verification of long-term solvent performance in natural gas-fired flue gas environment.

status

Project has started. Technology provider contact has been initiated.

available reports/technical papers/presentations

N/A.