the ENERGY lab

PROJECT FACTS

Existing Plants, Emissions & Capture

Application of a Heat-Integrated Post-combustion CO_2 Capture System with Hitachi Advanced Solvent into Existing Coal-Fired Power Plant

Background

The mission of the U.S. Department of Energy/National Energy Technology Laboratory (DOE/NETL) Existing Plants, Emissions, & Capture (EPEC) Research & Development (R&D) Program is to develop innovative environmental control technologies to enable full use of the nation's vast coal reserves, while at the same time allowing the current fleet of coal-fired power plants to comply with existing and emerging environmental regulations. The EPEC R&D Program portfolio of carbon dioxide (CO_2) emissions control technologies and CO_2 compression is focused on advancing technological options for the existing fleet of coal-fired power plants in the event of carbon constraints.

Pulverized coal (PC) plants burn coal in air to produce steam and comprise 99 percent of all coal-fired power plants in the United States. Carbon dioxide is exhausted in the flue gas at atmospheric pressure and a concentration of 10–15 percent by volume. Post-combustion separation and capture of CO_2 is a challenging application due to the low pressure and dilute concentration of CO_2 in the waste stream, trace impurities in the flue gas that affect removal processes, and the parasitic energy cost associated with the capture and compression of CO_2. Solvent-based CO_2 capture involves chemical or physical sorption of CO_2 from flue gas into a liquid carrier. Although solvent-based systems are used commercially to remove CO_2 from industrial gases, they have not been applied to the removal of large volumes of gas, as in coal-fired power plant flue gas, due to significant cost and efficiency penalties.

Project Description

The University of Kentucky Center for Applied Energy Research (UK CAER) Team will develop a two megawatt thermal (0.7 megawatt electrical [MWe] equivalent) slipstream post-combustion CO_2 capture system for a coal-fired power plant using novel concepts coupled with Hitachi's proprietary solvent (H3-1). An innovative heat integration method will utilize waste heat from the carbon capture system while improving steam turbine efficiency. A two-stage stripping concept will be combined with the heat integration method to increase solvent capacity and capture rate in the CO_2 scrubber. The advanced solvent utilized by the process has several advantages over conventional amine solvents such as 30 weight percent (wt%) monoethanolamine (MEA), including exhibiting lower heat of regeneration, higher capacity, and less solvent degradation. Previous laboratory and pilot-scale tests of the H3-1 solvent, as well as results from an initial techno-economic analysis of the capture process, illustrate the potential of this CO_2 capture system. Key features of the project are a two-

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PROJECT DURATION

Start Date	End Date
10/01/2011	09/30/2015

COST

Total Project Value
$19,351,780

DOE/Non-DOE Share
$14,502,144/$4,849,636

AWARD NUMBER

DE-FE0007395

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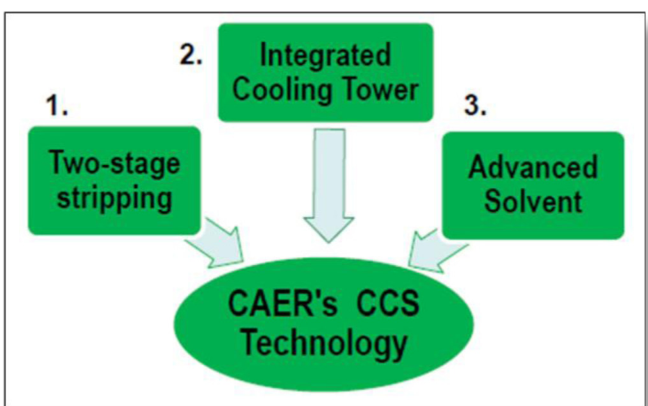
stage stripping process for solvent regeneration and a heat-integrated cooling tower system that recovers waste energy from the carbon capture platform. The two-stage stripping process will increase solvent working capacity by providing a secondary air stripping column following the conventional steam stripping column. The air stripping stream will be sent to the boiler as combustion air to increase the CO_2 content in the flue gas exiting the boiler. The integrated cooling tower system will use a liquid desiccant to dry the cooling tower air and waste heat to dry the liquid desiccant. The overall effect will be improved power plant cooling tower and steam turbine efficiency.

The project will be located at LG&E and KU Services Company's E.W. Brown Generating Station, located near Harrodsburg, Kentucky. The design, start-up, and commissioning of the test facility will be performed with a generic 30 wt% MEA solvent to obtain baseline data for comparison with other proprietary solvents to be tested in the program. Testing will be conducted on two proprietary solvents: Hitachi's advance amine solvent (H3-1), and a proprietary solvent developed by the CAER as an alternative solvent. Parametric testing and long-term verification campaigns will be conducted for each of the solvents. Corrosion evaluation and solvent degradation studies will be conducted concurrently with the verification runs. The potential heat integration, solvent and water management, and CO_2 capture system stability and operability will be the main focal points. Process modeling will be performed to optimize the post-combustion CO_2 capture system, determine power plant integration strategies, and conduct sensitivity analyses. The results of the modeling studies will be used to complete an economic analysis of the process to determine its capital and operating costs as well as to estimate the cost of electricity (COE) as compared to the reference MEA process.



CAER's three-process CO_2 capture technology.

Primary Project Goal

The project goal is to design, fabricate, install, and test a modular 0.7 MWe CO_2 capture system utilizing the advanced solvent process with heat integration on a slipstream of flue gas from a coal-fired power plant to show the potential to meet DOE's target of no more than a 35 percent increase in the COE while capturing at least 90 percent of the CO_2 released during the combustion of fossil fuels in existing coal-fired power plants.

Objectives

The objectives of the project are to (1) develop and deploy a novel heat integration scheme demonstrating the capability to integrate waste heat from the carbon capture platform to limit the reduction in overall power plant efficiency, (2) determine the performance of the H3-1 advanced solvent, and (3) collect the necessary information on mass and energy balances, solvent degradation (rate and products), and corrosion to provide a full techno-economic and environmental, health, and safety (EH&S) analysis at a 550 MWe commercial-scale level.

Planned Activities

- Perform an updated techno-economic analysis of the final process design, based on a 550 MWe power plant.
- Design, fabricate, and install the 0.7 MWe modular slipstream facility.
- Commission and shakedown the facility with a baseline 30 wt% MEA solvent.
- Conduct parametric and verification investigations using two proprietary solvents.
- Conduct a system dynamics load-following study, a solvent degradation study, and a materials corrosion study.
- Perform system and economic analyses of the proposed technology using various steam extraction and heat recovery configurations, and compression technologies.
- Conduct transient tests to quantify the ability of the system to follow the load demand of the power station.
- Perform an EH&S assessment of the process

Accomplishments

- Kick-off meeting conducted in October 2011.

Benefits

The novel concepts and advanced solvent used in this project show promise of improving the overall plant efficiency when integrated with a CO_2 capture system, and can be utilized to retrofit existing coal-fired power plants. The knowledge gained from this project on various aspects such as material coatings, process simplification/optimization, system compatibility and operability, solvent degradation and secondary environmental impact, water management and potential heat integration can potentially be applied to future commercial applications directed toward achieving DOE's current goals for post-combustion CO_2 capture.