PROJECT facts

U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Sequestration

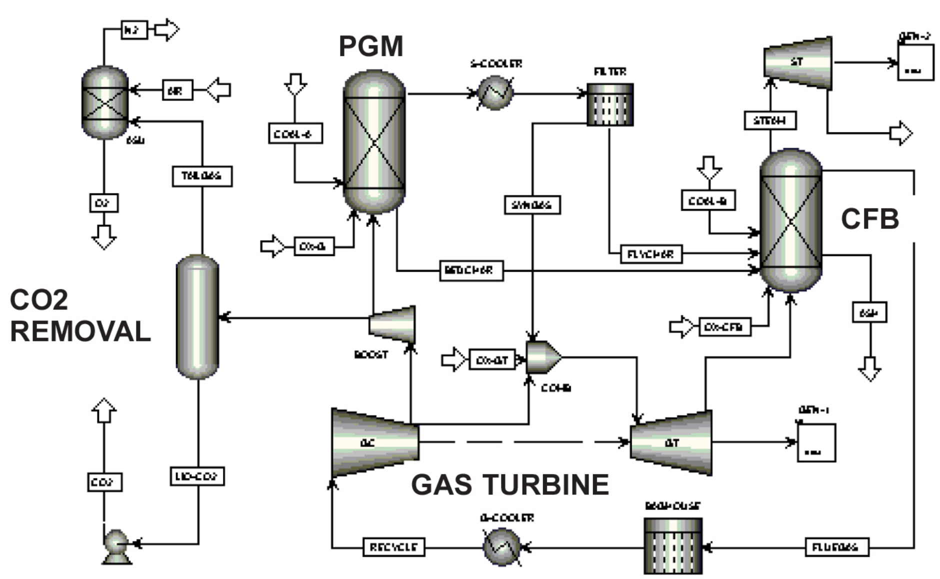
03/2006

Advanced CO_2 Cycle Power Generation

Background

This project will develop a conceptual power plant design based on hybrid fluidized bed technology that can achieve 100% CO_2 capture while avoiding the cost and technical limitations of CO_2 separation from syngas. The plant utilizes the novel concept of using CO_2 as a working fluid within a coal gasification-based powerplant, which efficiently generates power while concentrating CO_2 for sequestration. The first step of the process is air separation, where oxygen is extracted from air for use in both the gasification and combustion processes. Oxygen reacts with coal and steam in a partial gasification module (PGM) to generate syngas and char residue. Both of these fuel streams are then burned with oxygen: The syngas is burned in the combustion turbine to drive a gas turbine generator, and the char is burned in a circulating fluidized bed (CFB) steam generator to make steam for the steam cycle.

The CO_2 is concentrated in the process by recycling the exhaust gas flow, consisting primarily of CO_2, between the CFB combustor and the combustion turbine. As the final step to balance the process, a portion of the pressurized CO_2 rich gas is diverted from the process for sequestration. There is no plant stack and all waste streams including CO_2 from the process are in their most concentrated and manageable form.



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COST

Total Project Value
$300,000

DOE/Non-DOE Share
$240,000 / $60,000

ADDRESS

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Primary Project Goal

The main goal is to develop an advanced, gasification-based power cycle that produces a concentrated CO_2 stream for sequestration while achieving high plant efficiency and reliability at a competitive cost.

Objectives

The objectives are to optimize the plant process, complete a conceptual design of the plant, and estimate plant capital and operating cost to assess the feasibility of this advanced power technology.

Accomplishments

The Foster Wheeler CO_2 hybrid cycle project has been completed. The key components of the plant are a cryogenic air separation unit (ASU), a pressurized circulating fluidized bed gasifier, a CO_2 powered gas turbine, a circulating fluidized bed boiler, and a super-critical pressure steam turbine.

The process as designed yields an overall plant efficiency of almost 36% while sequestering CO_2. Two of the key project targets were achieved. The process developed had the lowest efficiency penalty for carbon sequestration when compared to alternative methods along with the lowest CO_2 mitigation cost. However, the process failed to achieve the lowest cost of electricity among coal fired alternatives. This was mainly due to the basis of the plant on the pressurized circulating fluidized bed gasifier which is still in developmental stages. The cost of the developmental gasifier is estimated to be greater than IGCC, but there still is a lot of uncertainty in the estimates. Another issue is that the currently available turbines would not be able to handle the CO_2 stream. Current turbines operate on mainly nitrogen streams (from air combustion) and therefore were designed with different thermodynamic limits.

Benefits

This technology offers the following key benefits:

- A completely zero emissions stackless plant that can produce power and a high pressure CO_2 exhaust stream more efficiently than conventional gasification technologies.
- CO_2 sequestration is achieved while avoiding the costly, energy-intensive CO shifting, CO_2 chemical/physical absorption, and CO_2 stripping processes used in conventional gasification technology.
- A wide range of inexpensive coals can be used as fuel because fluidized bed technology is used for both the gasification and combustion processes.
- Minimal water is used in the process because water scrubbing and water gas shift processes are avoided.
- All effluent streams from the process (SO_2, CO_2, NO_x, N_2, H_2O, metals, ash) are concentrated for efficient reuse or disposal.
- The CO_2 exhaust stream is provided inherently at pressure from the process.