Project Title	Primary Contractor	Project End Date	Fact Sheet Listing
A Collaborative Project to Develop Technology for Capture and Storage of CO_2 from Large Combustion Sources	BP Corporation	4/15/2005	PAC-3
CO_2 Selective Ceramic Membrane for Water-Gas-Shift Reaction with Simultaneous Recovery of CO_2	Media and Process Technology Inc.	3/31/2005	PAC-7
Greenhouse Gas Emissions Control by Oxygen Firing in Circulating Fluidized Bed Boilers	ALSTOM Power, Inc.	10/30/2004	PAC-9
Conceptual Design of Oxygen-based PC Boiler	Foster Wheeler Corporation	9/30/2005	PAC-11
Advanced Oxyfuel Boilers and Process Heaters for Cost Effective CO_2 Capture and Sequestration	Praxair, Inc.	3/31/2007	PAC-13
Combined Power Generation and Carbon Sequestration Using a Direct Fuel Cell	FuelCell Energy, Inc.	12/31/2005	PAC-15
Carbon Dioxide Capture from Flue Gas Using Dry Regenerable Sorbents	Research Triangle Institute	5/31/2007	PAC-17
Conceptual Design of Supercritical Oxygen-Based PC Boiler	Foster Wheeler Power Group, Inc.	9/30/2006	*

(UCR projects not included)

* Factsheet Not Available

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PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Sequestration

06/2003

CO_2 CAPTURE PROJECT: COLLABORATIVE TECHNOLOGY DEVELOPMENT PROJECT FOR NEXT GENERATION CO_2 SEPARATION, CAPTURE AND GEOLOGIC STORAGE

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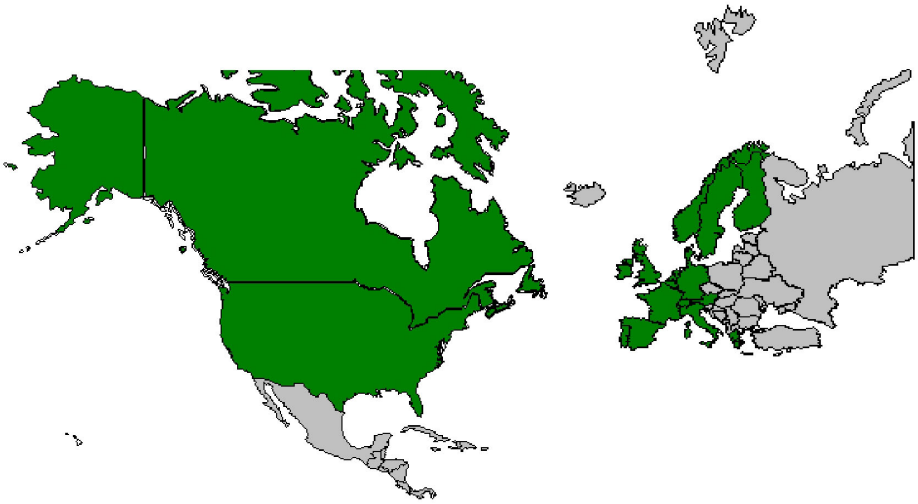
Background

DOE has joined with eight major international energy companies to sponsor the CO_2 Capture Project (CCP) with the goal of developing breakthrough technologies aimed at substantially reducing the cost of CO_2 capture and geologic storage. The CCP consortium is operated by BP and its members include ChevronTexaco, ENI, Norsk Hydro, PanCanadian, Shell, Statoil, and Suncor. In addition to the U.S. program, the CCP is comprised of separate, but complimentary projects which are also being sponsored by the European Union, and Norway. The total value of the CO_2 Capture Project, including international components, is $25 million.



Global participation of International Leading Energy Companies

Participating Phase I Technology Providers

Air Products & Chemicals, Inc.

Colorado School of Mines

Eltron Research Corporation

Energy Resource Centre of the Netherlands (ECN)

Fluor Daniel, Inc.

Idaho National Engineering & Environmental Laboratory

Lawrence Berkeley National Laboratory

Lawrence Livermore National Laboratory

McDermott Technology, Inc.

Netherlands Institute of Applied Geosciences

Oakridge National Laboratory

Scientific Monitor

SINTEF

Stanford University

Stanford Research Institute

TDA Research, Inc.

Texas Tech University

Tie-Line Technology

University of Cincinnati

Utah State University

The project schedule spans a 3-year period and is divided into two phases. Phase 1 represents the initial technology development period in which various promising avenues of R&D are pursued. Phase 2 will involve reprioritizing the R&D activities based on Phase 1 findings and then continuing with development of the most promising technologies.

Objectives

The strategic objective of the proposed project is to work with selected technology providers to develop new, breakthrough technologies, to the proof-of-feasibility stage, to reduce the cost of CO_2 separation, capture, transportation and sequestration from flue gases by one-half over today's best available technology for existing facilities, and by three-quarters for new facilities, by the end of 2003. The tactical objectives of the project are to:

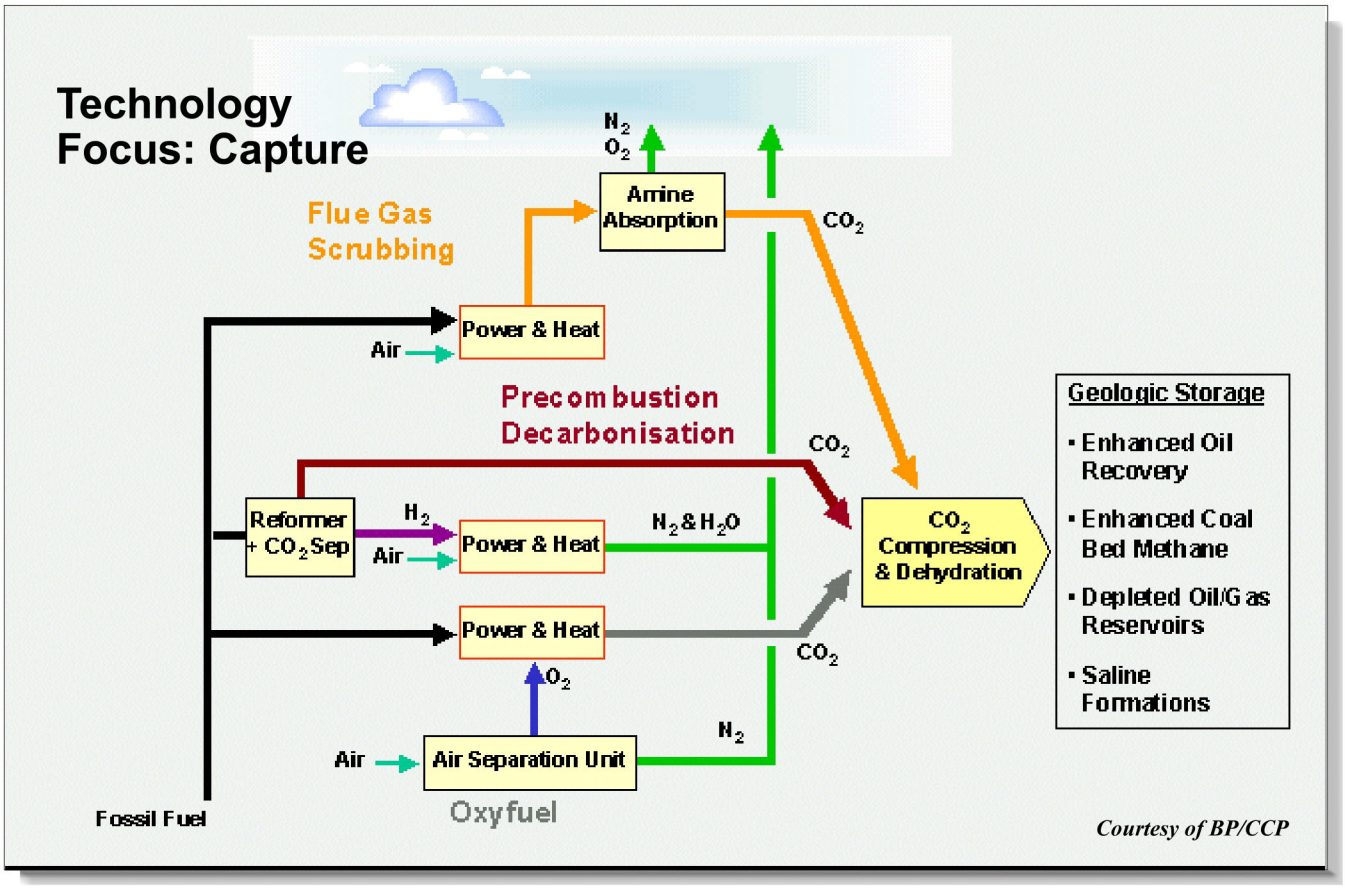
- Perform "benchtop" R&D (engineering studies, computer modeling, laboratory experiments) to prove the feasibility of advanced CO_2 separation and capture technologies, specifically targeting post-combustion methods, pre-combustion decarbonization, and oxyfuel.
- Develop guidelines for maximizing safe geologic sequestration, for measuring/verifying sequestration volumes, and for assessing and mitigating sequestration risks.
- Demonstrate to external stakeholder that CO_2 storage is safe, measurable, and verifiable.
- Develop technologies to the "proof of concept" stage by 2003/2004 and achieve at least one large-scale application by 2010

Benefits

The CCP team collectively accounts for approximately 32% of all oil and 17% of all gas production in the U.S., and 28% and 17% of oil and gas production respectively from OECD countries,. This team not only represents a significant market for the technologies to be developed, it is in the unique position of also operating and utilizing many of the geologic sinks needed to sequester the CO_2. These existing commercialization pathways will facilitate rapid industrial deployment of the new technologies developed under this project. Using conservative assumptions, the technology developed in the project could reduce the emissions of the CCP participants by 10 million tonnes of carbon per year (11 million tons per year). When applied more broadly in industry, the technology could reduce emissions by up to 140 million tonnes of carbon per year.

The potential scientific breakthroughs that could result from this project include:

- New solvents to reduce CO_2 separation costs.
- Improved CO_2 /H_2 absorption membranes.
- Integrated H_2 generation processes.
- Advanced oxyfuel boiler designs.
- An enhanced understanding of controls and requirements for geologically sequestering CO_2.



Flow diagram of various CO_2 capture and storage technologies

CO_2 Capture Project: Collaborative Technology Development Project for Next Generation CO_2 Separation, Capture and Geologic Storage

In addition to reducing technology costs, domestic energy security will also benefit. The proposed project develops lower cost separation and capture technology, which when combined with value-added geologic sequestration opportunities (EOR and ECBM) provides industry with a market-driven mid-term option for reducing CO_2 emissions while continuing to use fossil fuels. Additional benefits include a significant increase in the production of domestic oil and natural gas which improves U.S. energy security. It is estimated that 12 billion barrels (1.9 billion m 3) of incremental oil and 31 Tcf (0.9 Tm 3) of incremental gas is technically recoverable via these processes. Although the technology will enhance viability of CO_2 EOR, the focus of the R&D will be on new technologies to maximize the amount of CO_2 stored and the assurance and verification of sequestered volumes.

PARTNERS

National Energy Technology Laboratory

BP Corporation

ChevronTexaco

Norsk Hydro

Shell

Statoil

Suncor Energy

Pan Canadian

ENI

COST

Total Project Value	$9,994,165
DOE	$4,995,000
Non-DOE Share	$4,999,165

CUSTOMER SERVICE

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WEBSITE

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Proj185.pmd

PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Sequestration

03/2006

CO_2 Selective Ceramic Membrane for Water-Gas-Shift Reaction with Simultaneous Recovery of CO_2

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Background

The water-gas-shift (WGS) reaction, $CO + H_2O \leftrightarrow H_2 + CO_2$, is used to increase the hydrogen content of synthesis gas. However, this reaction is equilibrium limited. One approach for overcoming this limitation is to carry out the reaction in a reactor with walls that are CO_2 permeable. This continuously removes CO_2 from the system and allows the reaction to continue.

This project involves the development of a technique for depositing hydrotalcite onto a ceramic membrane suitable for implementing the reactive separation concept with the WGS reaction in integrated gasification combined cycle (IGCC) systems. The membranes are being developed using available sol gel and chemical vapor deposition (CVD) preparation techniques. The hydrotalcite is permeable to CO_2 but plugs the pores, preventing passage of other gases. The hydrothermal and chemical stability in a simulated WGS reaction environment will be evaluated to confirm the inert material properties of the ceramic membrane. Then, a membrane reactor (MR) study will be conducted to demonstrate the benefit offered by this membrane. Finally, process feasibility will be demonstrated in a test module, and an economic evaluation will be performed to estimate the positive effect of using a WGS-MR in IGCC coalfired power plants.

Primary Project Goal

The primary objective of this program is to develop a defect-free hydrotalcite membrane for selective CO_2 removal that will be effective in the water-gas-shift reaction environment, i.e., 300 to 600°C and in the presence of steam.

Objectives

- Conduct a screening study to select an optimal material for developing a membrane and determine the optimum operating conditions in terms of temperature and steam content of the gas for selective CO_2 removal (good thermal, hydrothermal and chemical stability).
- Fabrication of the desired membrane in tubular geometry and verification of the feasibility of CO_2 separation along with the conversion enhancement.

PARTNERS

Media and Process Technology Inc.
University of Southern California

COST

Total Project Value
$900,000

DOE/Non-DOE Share
$720,000 / $180,000

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Accomplishments

Hydrotalcite was investigated as both an adsorbent and a membrane for CO_2 separation. The adsorption isotherm and intraparticle diffusivity for the hydrotalcite-based adsorbent were experimentally determined, and found to be suitable for low temperature shift (LTS) of the WGS reaction. The hydrotalcite-based membranes were synthesized using Media and Process Technonlogy's (MPT) commercial ceramic membranes as substrate. These experimental membranes were characterized comprehensively in terms of their morphology, and CO_2 permeance and selectivity to demonstrate the technical feasibility. In parallel, an alternative CO_2 affinity membrane (carbonaceous base) developed by MPT was characterized and also demonstrated enhanced CO_2 selectivity at the LTS-WGS condition. Each of these membranes requires additional optimization to reduce defects.

Based upon the unique CO_2 affinity of the hydrotalcite at the LTS/WGS environment, an innovative membrane reactor, Hybrid Adsorption and Membrane Reactor (HAMR) was developed. The HAMR combines the reaction and membrane separation steps with adsorption on the membrane feed or permeate side. A mathematical model was developed to simulate this one-step process. Finally, a bench-top reactor was employed to generate experimental data, which were consistent with the prediction from the HAMR mathematical model. Preliminary results indicate HAMR offers potential to achieve near 100% CO conversion, and produce both a high purity hydrogen product and a concentrated CO_2 stream.

Benefits

This combined shift reaction and CO_2 separation system project will produce a hydrogen rich gas which is at high pressure, high temperature and contains significant quantities of steam making it highly suitable for direct firing in a gas turbine with high efficiency. The use of an improved WGS-MR with CO_2 recovery capability is ideally suited to integration into the IGCC power generation system. Thus, the hydrogen (high pressure and CO_2-free) produced from the IGCC can be used either as a product for power generation via a turbine or a fuel cell, or as a reactant for fuels and chemicals production.

PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Sequestration

03/2006

GREENHOUSE GAS EMISSIONS CONTROL BY OXYGEN FIRING IN CIRCULATING FLUIDIZED BED BOILERS

CONTACTS

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Background

The object of oxygen-fired combustion is to burn the fuel in enriched air or pure oxygen to produce a concentrated stream of CO_2. Oxygen fired combustion presents significant challenges, but also provides a high potential for technology breakthroughs and a step-change reduction in CO_2 separation and capture costs. Barriers and issues include: 1) oxygen from cryogenic air separation is expensive, and oxygen combustion consumes several times more oxygen than gasification; 2) combustion of fuels in pure oxygen occurs at temperatures too high for existing boiler or turbine materials, while CO_2 recycle to control temperature increases the parasitic power load.

Primary Project Goal

The overall project goal is to conduct economic evaluations of the recovery of carbon dioxide using a newly constructed circulating fluidized bed (CFB) combustor while burning coal, petroleum coke, or biomass fuel with a mixture of oxygen and recycled flue gas, instead of air.

Objectives

- The Phase I objective is to determine which of the new concepts in a CFB are technically feasible and have the potential of reducing the target cost of carbon avoided.
- Petroleum coke and coal samples will be combustion tested in a 4-inch Fluidized Bed Combustion reactor to determine their gaseous (NO_x, SO_2,CO) and unburned carbon emissions and ash agglomeration/sintering potentials during combustion in oxygen-rich environments.
- The Phase II objective is to generate a refined technical and economic evaluation of the most promising concept for reducing CO_2 mitigation costs (based on recommendations from Phase I), based on data from proof-of-concept testing of the most promising concept.

PARTNERS

Alstom Power Inc.

ABB Lummus Global, Inc.

Praxair, Inc.

Parsons Energy and Chemical Group

COST

Total Project Value
$2,730,471

DOE/Non-DOE Share
$2,730,471 / $546,095

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Accomplishments

Phase I has been completed. The performance analysis of the base case (Air-Fired) CFB has been conducted. Key results included plant-efficiency, equipment costs, cost of electricity, and CO_2 mitigation costs. Work was completed on design/performance analyses of:

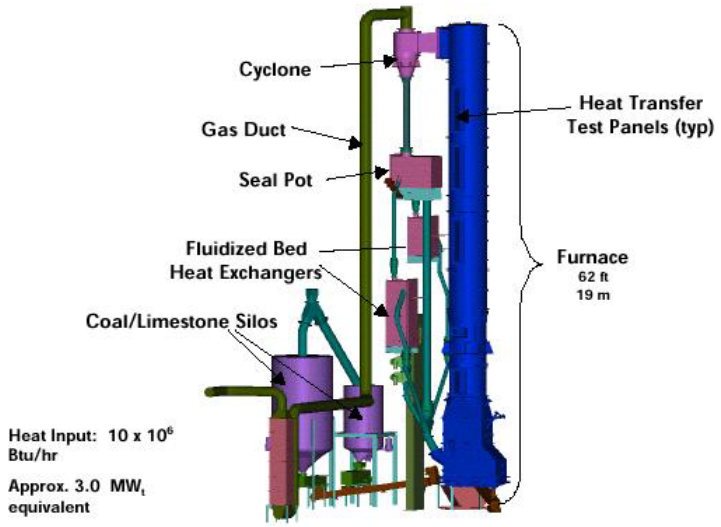
- Three advanced O_2-fired CFB concepts
- One high temperature carbonate regeneration process
- One chemical looping concept
- Two IGCC cases (one base case without CO_2 capture and one with a water-gas shift reactor to capture CO_2).

Phase II pilot testing has been completed. Two test runs were performed in March and June of 2004. Experiments were conducted using coal and petcoke. Oxygen levels examined include 21% (baseline) and various levels up to a local high of 70% oxygen. The rest of the stream was CO_2 to simulate a flue gas recycle. Key results include:

- Successful operation of the 2.9MW_{th} facility with bituminous coal and petcoke with no evidence of particle agglomeration or defluidization in the furnace
- Higher than normal sulfur emissions for bituminous coal than normal for the same limestone feed rate. Due to higher furnace temperature necessary to ensure calcination of limestone.
- Lower NO_x emissions under oxygen firing. Mainly due to reduction in prompt NO_x.
- Updated performance analyses based upon testing results.

Benefits

The results from this project will provide the power industry with concrete data concerning greenhouse gas emissions control by oxygen firing in circulating fluidized bed boilers. The comparison of the several different technologies will target the most economical gas clean-up configuration.



ALSTOM's Multi-Use Test Facility (MTF)

Project201.pmd

PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Sequestration

03/2006

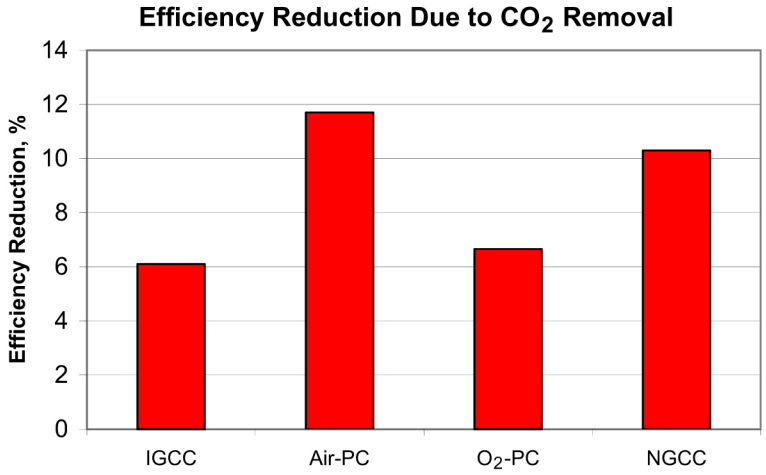
CONCEPTUAL DESIGN OF OXYGEN-BASED PC BOILER

Background

Because of growing concern that a link exists between global climatic change and emission of greenhouse gases, such as CO_2, it is prudent to develop new coal combustion technologies to meet future emissions standards, should it become necessary to limit CO_2 emissions to the atmosphere. New technology is needed to ensure that the U.S. can continue to generate power from its abundant domestic coal resources. This project will design an optimized combustion furnace to produce a low-cost, high-efficiency power plant that supports the U.S. Department of Energy's (DOE) goal of developing advanced combustion systems that have the potential to control CO_2 through an integrated power system that produces a concentrated CO_2 stream for subsequent use or sequestration. Specifically, this work will evaluate the technical viability and economic competitiveness of an oxygen-enriched, pulverized coal (PC) fired boiler system with CO_2 sequestration. When oxygen is used in place of air as the combustion medium, the flue gas has a high concentration of CO_2, making recovery of CO_2 for sequestration much more economic.

Primary Project Goal

The primary goal of this project is to develop a conceptual PC-fired powerplant, using oxygen as the combustion medium to facilitate the capture of CO_2 for subsequent sequestration.



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PARTNER

Foster Wheeler Development Corporation

COST

Total Project Value
$406,482

DOE/Non-DOE Share
$325,186 / $81,296

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WEBSITE

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Objectives

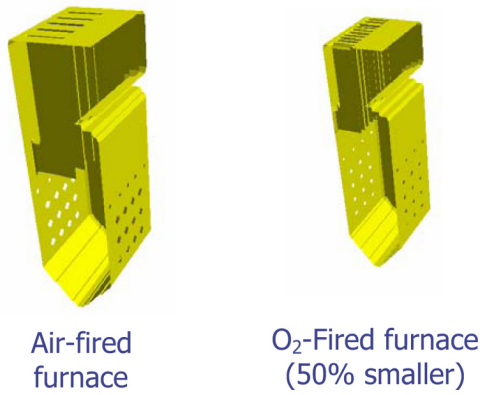
- Conduct a literature review to evaluate previous work in this area.
- Develop process modeling simulations for a conceptual design for an oxygen-enriched, PC-fired boiler with CO_2 capture.
- Develop a conceptual power plant design.
- Estimate costs for this conceptual power plant.
- Predict power plant performance and emissions and compare the overall cost of electricity of the conceptual power plant to a conventional PC-fired power plant (460 MW_e subcritical, natural circulation boiler firing high-volatile bituminous coal to produce 2,400 psig steam at 1,050 ºF and reheat steam at 1,050 ºF).

Accomplishments

All project objectives have been achieved. The entire cycle has been modeled in Aspen-Plus, including mills, air heater, furnace, heat recovery banks, feed water heaters, and steam turbines. Parametric runs have been made to evaluate the effect of operating variables on furnace performance. These studies have led to several conclusions. A higher flame temperature results in a more compact furnace and less gas recycle (limited by maximum furnace wall temperature) and to a higher cycle efficiency due to greater boiler efficiency. Estimates indicate that the parasitic power requirement for CO_2 capture is considerably lower than for a conventional plant and is comparable to that for an integrated gasification combined cycle (IGCC) system. Similarly, efficiency loss due to CO_2 capture is lower than for a conventional plant and comparable to an IGCC system.

Benefits

This project resulted in a conceptual design of a process that is competitive with IGCC in terms of cost of electricity and CO_2 mitigation cost when carbon dioxide is being captured. The best case is under higher capacity factors (around 85%). A substantially reduced furnace size leads to cost benefits, and a simple plant design means high reliability. The new plant uses proven steam plant technology. New air separation techniques could significantly improve economics.



Spatial comparison of an air-fired furnace versus an oxygen-fired furnace.

Project303.pmd

PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Sequestration

03/2006

ADVANCED OXYFUEL BOILERS AND PROCESS HEATERS FOR COST EFFIECTIVE CO_2 CAPTURE AND SEQUESTRATION

CONTACTS

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Background

Reducing CO_2 from large stationary combustion systems has been targeted as a cost efficient means of reducing the emission of greenhouse gases from fossil fuel combustion systems. A number of concepts exist or have been proposed to reduce emissions, including fuel switching, efficiency improvements, CO_2 capture from conventional flue gas streams, and oxy-fuel fired systems with CO_2 capture. Switching fuels from coal to lower carbon fuels such as natural gas can reduce emissions, but severely restricts the nation's fuel flexibility and underutilizes the most abundant natural resource in the United States. Enhancing site efficiency by building natural gas combined cycle plants or making efficiency improving plant modifications can also significantly reduce emissions of greenhouse gases. However, these options simply do not provide enough reduction in emissions to mitigate the growing problem of global warming.

One economical solution to overcome these problems is to switch to oxy-fuel combustion. The use of oxygen in place of air results in a much lower volume of flue gas, which enhances thermal efficiency, thereby lowering CO_2 emissions. This four-year project will advance the integration of oxygen transport membranes (OTM) into oxyfired boilers from the bench scale to the point-of-readiness for engineering scaleup. The development of this novel boiler will require both Praxir's expertise in OTM development and oxyfuel combustion and the experience of Alstom Power in boiler development and manufacturing. These highly efficient boilers, through incorporation of lower cost OTM oxygen generation technology, can economically provide a significant portion of the required reductions in greenhouse gases.

Primary Project Goal

The object of this project is to develop and demonstrate the integration of a novel ceramic oxygen transport membrane (OTM) with the combustion process to enhance boiler efficiency and carbon dioxide recovery.

PARTNERS

Praxair
Alstom Power

COST

Total Project Value
$5,564,765

DOE/Non-DOE Share
$3,895,335 / $1,669,430

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Objective

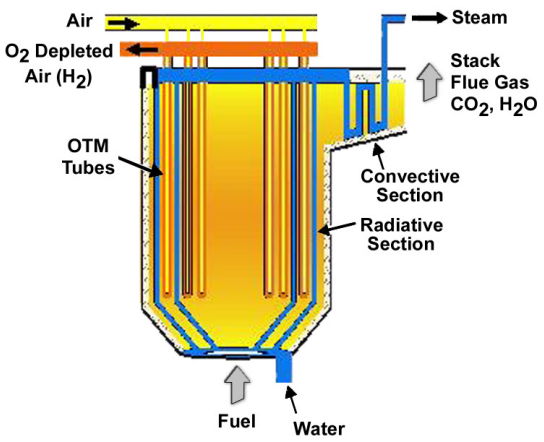
- Identify the optimal design based on technical performance; identify and demonstrate the most promising OTM materials for the integrated system; and develop a conceptual design for a laboratory scale boiler simulator.
- Perform economic analyses throughout the program to ensure the novel boiler will bring economic value to both the industrial customers and to the participating companies.
- Complete project by June 2006.

Accomplishments

A ceramic membrane and seal assembly have been developed for thermal integration between the high temperature membrane and the combustion process. Alstom Power has initiated modeling studies to understand and predict the combustion characteristics of oxy-fuel technology. Current efforts are focusing on laboratory scale evaluations for integration of OTM with the combustion process. Multi- and single- tube reactors have been built and operated with early prototype OTM tubes. Throughout all operation, no membrane failures have been observed.

Benefits

The development of a novel oxy-fuel boiler will significantly reduce the complexity of CO_2 capture, drastically reduce the cost of carbon sequestration, and offer increased thermal efficiency and reduced pollution emissions. This highly efficient boiler will economically provide a significant portion of the required reductions in greenhouse gases. Gasification plants which integrate OTM technology will have higher efficiency, lower cost of electricity, and lower emissions of pollutants compared to using a conventional cryogenic air separation unit.



Praxair Advanced Boiler

Project197.pmd

PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Sequestration

12/2004

COMBINED POWER GENERATION AND CARBON SEQUESTRATION USING A DIRECT FUELCELL®

Background

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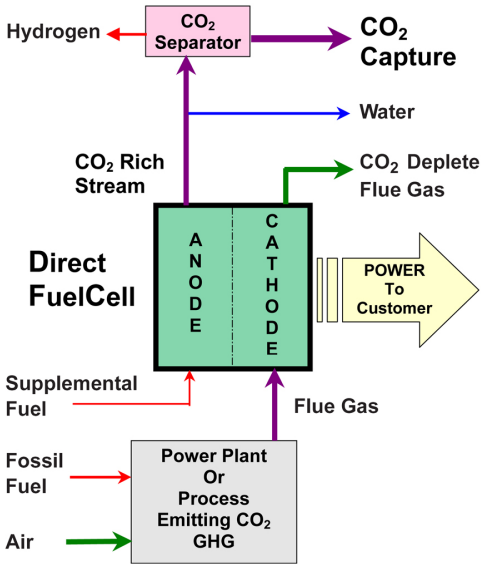
This project is responsive to the growing concern over global warming as a result of carbon dioxide emissions into the atmosphere from fossil fuel burning power plants and other industrial sources. FuelCell Energy (FCE) has developed a novel concept for the separation, capture, and potential sequestration of CO_2 emissions through the use of Direct FuelCell (DFC®) technology while concurrently generating power at high efficiency. The mitigation of the greenhouse effect through CO_2 sequestration is a new and unique application for DFC.

In the DFC, CO_2 is transferred from the cathode to the anode of the fuel cell resulting in a CO_2 rich exhaust stream, which can be sequestered. Key reactions are:

Anode: $H_2 + CO_3^{-2} \rightarrow H_2O + CO_2 + 2e^-$

Cathode: $\frac{1}{2} O_2 + CO_2 + 2e^- \rightarrow CO_3^{-2}$

Internal reforming of a hydrocarbon, such as natural gas, provides the hydrogen for the anode reaction. During normal fuel cell operation, some of the CO_2 from the anode exhaust is recycled to the cathode to form CO_3^{-2} ions that carry the current through the cell. In the concept of this project, the CO_2 is provided by passing flue gas over the cathode; and, as the fuel cell operates, the CO_2 in the flue gas is transferred from the cathode to the anode. The system will be studied to determine its effectiveness in capturing more than 90% of the carbon dioxide from the flue gas. The gain in electric power generated by the fuel cell is anticipated to result in a low net cost for carbon dioxide capture. Additionally, hydrogen from the anode exhaust may be recovered for sale or burned onsite to raise steam for a steam turbine generator.



CO_2 capturing system concept utilizing Direct FuelCell

CUSTOMER SERVICE

1-800-553-7681

WEBSITE

www.netl.doe.gov

PARTNERS

FuelCell Energy, Inc.

COST

Total Project Value
$171,222

DOE/Non-DOE Share
$136,978/$34,244

Benefits

One of the major problems in reducing CO_2 emissions from power plants is the high cost of recovering CO_2 from flue gas. This project is anticipated to result in a CO_2 separation and capture system based on an internally reformed DFC with potential for capturing at least 90% of GHG emissions generated by power plants and other industrial processes. The proposed system is targeted at no more than a 10% increase in the cost of electric power. If an inexpensive CO_2 capture system can be developed, then CO_2 sequestration could be practiced with minimal impact on the nation's economy.

This project will conduct the research and development essential for process optimization and cost estimation to ensure the successful implementation of the system. The design activities will be focused on integration of DFC-based CO_2 capture systems with coal-based power plants, which emit large amounts of greenhouse gases. The types of coal-fired power plants to be studied include pulverized coal (PC) fired, fluidized bed combustion, and integrated gasification combined cycle (IGCC). In parallel to the design activities, operation of a laboratory scale DFC will verify the benefits of the concept and provide input to the design activity. The anticipated result of this project is the development of a DFC-based CO_2 capture system that will increase the cost of electricity by less than ten percent.

FCE is a leading developer of DFC technology deployed for commercial power production applications. High volume manufacturing of fuel cells for power applications is projected to lower the cost of DFC based CO_2 sequestration systems. Considering that alternative technologies are energy intensive, expensive and/or complex, the efficient energy producing DFC carbon capture system is seen as a viable option for mitigating greenhouse gases from large point sources.

Primary Project Goal

The overall goal of this project is the development of a cost effective carbon separation and capture system utilizing a novel concept based on DFC technology.

Objectives

The objectives of this project are:

- To develop process design options for the integrated DFC-based CO_2 capture system to reduce GHG emissions from traditional coal-based plants, such as pulverized coal fired power plants, as well as advanced technologies, such as IGCC.
- To develop a database for various GHGs derived from coal fired power plants.
- To evaluate options for desulphurization of GHGs.
- To investigate techniques for the separation of CO_2 from the fuel cell anode exhaust.
- To perform detailed analysis using computer simulation of the DFC-based carbon capture system to verify the added benefits of simultaneous power generation and hydrogen by-product production.
- To determine the net cost of energy production after retrofitting a conventional power plant with DFC carbon capture.
- To experimentally validate simulation results and to refine equipment and cost models by conducting DFC tests in a lab-scale fuel cell using state-of-the-art fuel cell components.

Proj319.pmd

PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Carbon Sequestration

4/2008

CARBON DIOXIDE CAPTURE FROM FLUE GAS USING DRY REGENERABLE SORBENTS

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Background

Currently available commercial processes to remove CO_2 from flue gas streams are costly and energy intensive. RTI International is heading a research team to develop an innovative process for CO_2 capture that employs a dry, regenerable sorbent. The process is cyclic in that the sorbent captures CO_2, is regenerated to yield a concentrated stream of CO_2, and is then recycled to capture additional CO_2. The proposed process can be used to remove CO_2 from the flue gases of coal- and natural gas-fired power plants.

RTI's CO_2 removal process uses a sodium carbonate-based sorbent. Sodium carbonate is converted to sodium bicarbonate through reaction with CO_2 and water vapor. The sorbent is regenerated using a thermal swing and produces a gas stream containing only CO_2 and water. The water is then removed by condensation to produce a pure CO_2 stream for subsequent use or sequestration.

Primary Project Goal

The goal of this project is to develop a simple, inexpensive process to separate CO_2 as an essentially pure stream from a fossil-fuel combustion system using a regenerable, carbonate-based sorbent process.

Objectives

To develop a technology that is:

- Applicable to both coal- and natural gas-fired power plants.

([1]RTI International is a trade name of Research Triangle Institute)

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PERFORMANCE PERIOD

08/31/2000 to 06/30/2007

COST

Total Project Value
$2,533,406

DOE/Non-DOE Share
$2,026,724 / $506,682

- Applicable as a retrofit to existing plants.
- Compatible with the operating conditions in current power plant configurations.
- Relatively simple to operate.
- Less energy intensive than currently available technologies.
- Less expensive than currently available technologies.

Benefits

This technology will provide conventional coal-fired power plants, natural gas-fired plants, and advanced power generation systems with a less costly and less energy intensive process to remove CO_2 from flue gas.

Accomplishments

RTI has achieved the following accomplishments over the entirety of this project:

- A relatively low-cost, novel, solid absorbent material for CO_2 capture has been identified and prepared by a catalyst manufacturer utilizing its production processes. The manufacturer-grade sorbent, developed first in RTI's laboratory, has been well characterized, analyzed, and tested throughout various phases of this project.
- The sorbent's capacity for 90 percent CO_2 capture has remained stable and consistent over 1000 hours of testing.
- The sorbent has shown little to no physical degradation over 1000 hours of fluidization and cycling in various reactor systems.
- RTI's novel sorbent was able to capture greater than 90 percent of the CO_2 present in both simulated flue gas in the laboratory and actual, fossil-fuel (coal and natural gas) combusted flue gas at a field test site.
- A novel process configuration (RTI's Dry Carbonate Process) has been developed for CO_2 capture based on RTI's novel sorbent material.
- A lab-scale version of RTI's Dry Carbonate Process was designed and constructed for small-scale demonstration testing. This test unit is capable of treating 300 to 450 standard cubic feet per hour of flue gas and can circulate sorbent material between a range of 25 to 250 pounds per hour.

- The lab-scale Dry Carbonate Process was fully integrated within a fossil-fuel combustion facility and tested for nearly 250 hours in order to test the process under actual flue gas conditions. With the assistance of ARCADIS, Inc., RTI was able to install the test unit at the Multi-Pollutant Control Research Facility at the U.S. Environmental Protection Agency's site in Research Triangle Park, NC. EPA's MPCRF is a 4M Btu per hour multi-fuel fired facility capable of firing coal, lignite, and natural gas.

- RTI observed little or no negative effects to the sorbent-capture performance due to the presence of contaminants in the flue gases.

- RTI performed various "trip" tests of the test unit (e.g., the flue gas was stopped, the sorbent circulation was stopped, etc.) to prove that the system was robust and reliable. RTI was able to get the unit "on line" with minimal effort after these trip tests.

- Preliminary economic analyses show that a commercial embodiment of the Dry Carbonate Process has potential to be significantly less costly and less energy intensive than conventional CO_2 capture technologies (i.e. amine-based technologies).

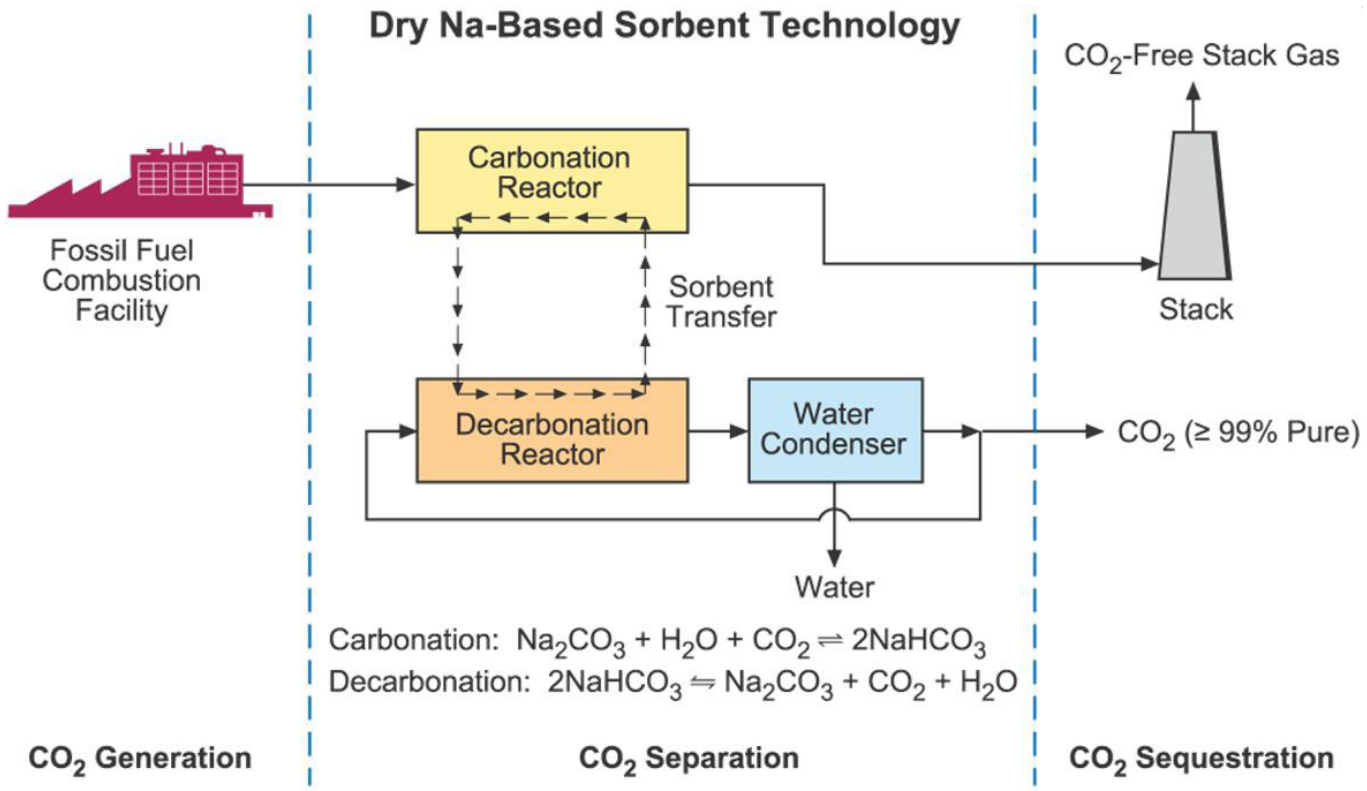

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Figure 2. The lab-scale demonstration unit of RTI's dry-carbonate process