2012

ADVANCED ENERGY SYSTEMS—GASIFICATION SYSTEMS

PROJECT PORTFOLIO

Accompanying CD links to the latest information on DOE's Gasification website

U.S. DEPARTMENT OF ENERGY | National Energy Technology Laboratory

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Table of Contents

For updates visit the Gasification Systems Project Portfolio page online:

www.netl.doe.gov/technologies/coalpower/gasification/portfolio.html

For more information visit the NETL Gasification Systems Website:

www.netl.doe.gov/technologies/coalpower/gasification/index.html

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Introduction

Gasification *is a clean way to produce electricity from coal or other solid feedstocks. By first converting the solid feedstock to a gaseous form (syngas), potential pollutants can be captured and reduced to essentially any desired level and then converted to useful by-products or disposed of safely. The Gasification Systems Program is developing advanced technologies to reduce the cost and increase the efficiency of producing syngas.*

The Gasification Systems Project Portfolio provides an overview of the program, a description of the Gasification Systems Structure and Project Fact Sheets and Summaries:

The Gasification Systems Structure section describes the Gasification Systems Research and Development (R&D) approach in the three key areas: i) *Gasifier Optimization* -- focuses on the development of technologies and models to improve the performance of advanced gasifiers, including high-pressure coal-feed pumps; low-rank coal utilization; new process instrumentation; improved reliability, availability, and maintainability (RAM); and advanced materials; ii) *Gas Cleaning* -- focuses on the development of high-efficiency processes that operate at moderate to high temperatures and provide multi-contaminant control to extremely low levels, and iii) *Gas Separation* -- focuses on the development of systems to reduce the parasitic energy penalty associated with these technologies.

Project fact sheets and project summaries for the Gasification Systems R&D Projects and a description of the Gasification Systems Resources that are available on the DOE/NETL Gasification Systems web page are included in the portfolio appendices.

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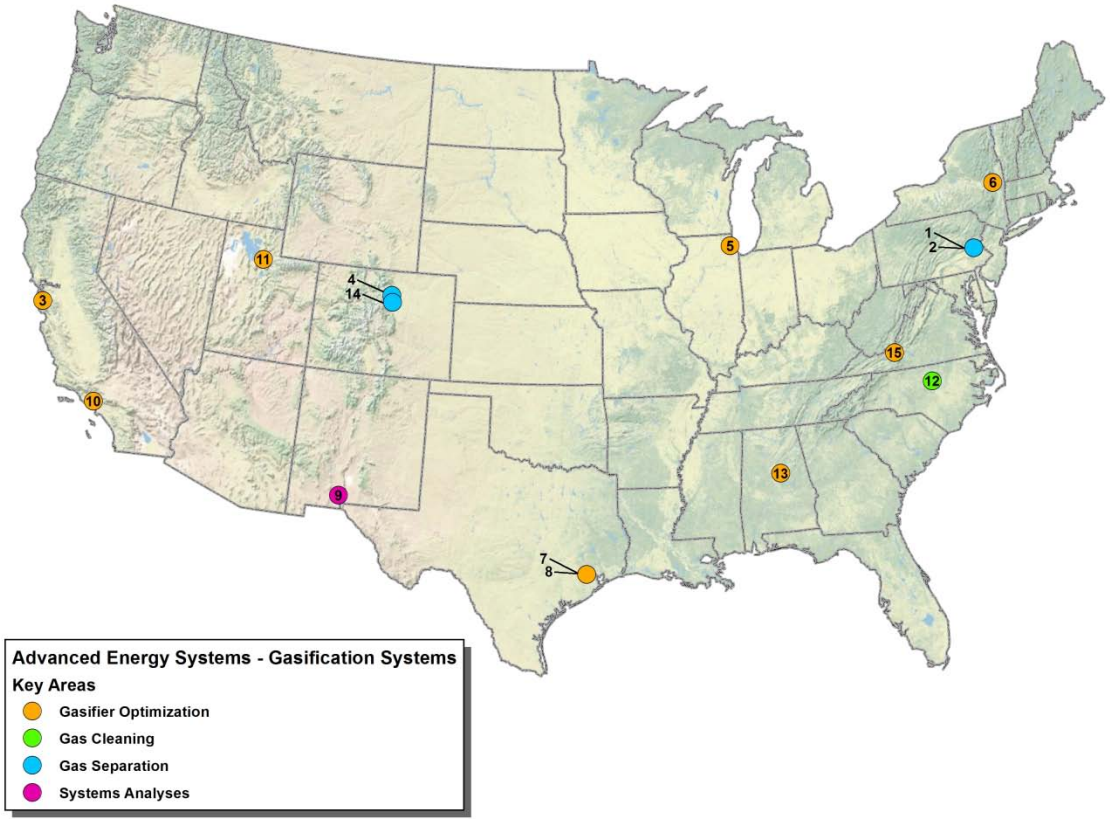
Gasification Systems Projects National Map



	Major Participant	Gasification Systems Project
1	Air Products and Chemicals, Inc.	Advanced Acid Gas Separation Technology for the Utilization of Low Rank Coals
2	Air Products and Chemicals, Inc.	ITM Oxygen Technology for Integration in IGCC and Other Advanced Power Generation Systems
3	Electric Power Research Institute, Inc.	Carbon Dioxide Coal Slurry for Feeding Low-Rank Coal to Gasifiers
4	Eltron Research, Inc.	Scaleup of Hydrogen Transport Membranes
5	Gas Technology Institute	Real Time Flame Monitoring of Gasifier Burner and Injectors
6	GE Global Research	Model-Based Optimal Sensor Network Design for Condition Monitoring in an IGCC Plant
7	General Electric Company	Studies to Improve Plant Availability and Reduce Total Installed Cost
8	General Electric Company	Evaluation of the Benefits of Advanced Dry Feed System for Low Rank Coal
9	New Mexico State University	Arrowhead Center to Promote Prosperity and Public Welfare in New Mexico
10	Pratt and Whitney Rocketdyne, Inc.	Advanced Gasification Systems Development
11	Reaction Engineering International	Mitigation of Syngas Cooler Plugging and Fouling
12	Research Triangle Institute	High Temperature Syngas Cleanup Technology Scaleup and Demonstration Project
13	Southern Company Services, Inc.	National Carbon Capture Center at the Power Systems Development Facility
14	TDA Research, Inc.	Advanced CO_2 Capture Technology for Low-Rank Coal IGCC Systems
15	Virginia Polytechnic Institute & State University	Single-Crystal Sapphire Optical Fiber Sensor Instrumentation Virginia Polytechnic Institute

Projects by State with Congressional District

Alabama

National Carbon Capture Center at the Power Systems Development Facility	Southern Company Services, Inc.	AL06

California

Liquid CO_2 Slurry for Feeding Low Rank Coal Gasifiers	Electric Power Research Institute, Inc.	CA14
Development of Technologies and Capabilities for Coal Energy Resources	Pratt and Whitney Rocketdyne, Inc.	CA30

Colorado

Scaleup of Hydrogen Transport Membranes for IGCC and FutureGen Plants	Eltron Research, Inc.	CO02
Advanced CO_2 Capture Technology for Low-Rank Coal IGCC Systems	TDA Research, Inc.	CO07

Illinois

Real Time Flame Monitoring of Gasifier Burner and Injectors	Gas Technology Institute	IL06

North Carolina

High Temperature Syngas Cleanup Technology Scaleup and Demonstration Project	Research Triangle Institute	NC04

New Mexico

Arrowhead Center to Promote Prosperity and Public Welfare in New Mexico	New Mexico State University	NM02

New York

Model-Based Optimal Sensor Network Design for Condition Monitoring in an IGCC Plant	GE Global Research	NY21

Pennsylvania

ITM Oxygen Technology for Integration in IGCC and Other Advanced Power Generation Systems	Air Products and Chemicals, Inc.	PA15
Three-step Process to Recover Syngas, H_2S, and CO_2 from Gasifier Off-Gas	Air Products and Chemicals, Inc.	PA15

Texas

Studies to Evaluate the Benefits of an Advanced Dry Feed System on the Use of Low Rank Coal	General Electric Company	TX07
Feasibility Studies to Improve Plant Availability and Reduce Total Installed Cost in IGCC Plants	General Electric Company	TX07

Utah

Mitigation of Syngas Cooler Plugging and Fouling	Reaction Engineering International	UT01

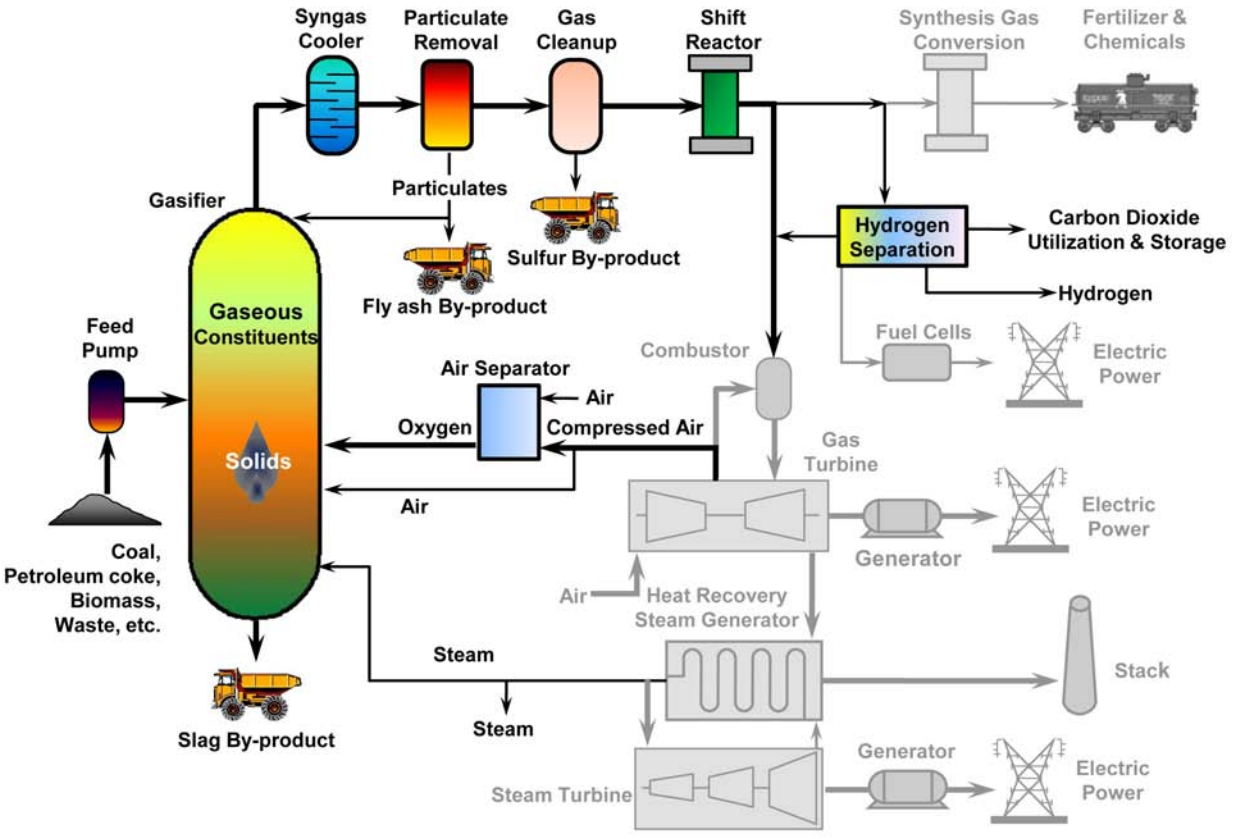
Virginia

Single-Crystal Sapphire Optical Fiber Sensor Instrumentation Virginia Polytechnic Institute	Virginia Polytechnic Institute & State University	VA09

GASIFICATION SYSTEMS PROGRAM

- Reduce gasification costs so coal can support U.S. economic growth
- Ensure excellent environmental performance for coal gasification

Gasification is used to convert a solid feedstock, such as coal, petcoke, or biomass, into a gaseous form, referred to as synthesis gas or syngas, which is primarily hydrogen and carbon monoxide. With gasification-based technologies, potential pollutants can be captured and then disposed of or converted to useful by-products. To capture CO_2 and make clean power using gasification, steam is added to the syngas in a water-gas shift (WGS) reactor to convert the carbon monoxide to carbon dioxide (CO_2) and to produce additional hydrogen. The hydrogen and CO_2 are separated—the hydrogen is used to make power and the CO_2 is sent to storage or converted to useful product. For example, CO_2 can be used for enhanced oil recovery (EOR) or as a feedstock to make value-added products. In addition to efficiently producing electric power, a wide range of transportation fuels and chemicals can be co-produced from the cleaned syngas (as shown in the figure, below), thereby providing the flexibility needed to capitalize on the changing economic market. As a result, gasification provides a flexible technology option for using domestically available resources while meeting future environmental emission standards.



Gasification Systems Program Research and Development Areas are in Color.
Grey sections are part of other closely aligned DOE/NETL Research Technology Programs.

The Gasification Systems Program is developing advanced technologies to reduce the cost and increase the efficiency of producing syngas, with carbon capture, in three key research and development (R&D) areas:

Gasifier Optimization, *Gas Cleaning*, and *Gas Separation*.

Gasifier Optimization R&D

Focuses on the development of technologies and models to improve the performance of advanced gasifiers, including high-pressure coal-feed pumps; low-rank coal utilization; new process instrumentation; improved reliability, availability, and maintainability (RAM); and advanced materials. A recent NETL systems analysis, "Current and Future Technologies for Gasification-Based Power Generation Volume 2: A Pathway Study Focused on Carbon Capture Advanced Power Systems R&D Using Bituminous Coal" shows that the primary benefit of Gasifier Optimization R&D is decreased capital cost and improved RAM.

Gas Cleaning R&D

Conventional methods for removing sulfur and other contaminants from syngas typically rely on chemical or physical absorption processes operating at temperatures of 100 °F or less. After contaminant removal, the gas has to be reheated and additional steam often needs to be added for downstream hydrogen production. These process swings adversely impact the plant's thermal efficiency and cost. The Gas Cleaning R&D approach focuses on the development of high-efficiency processes that operate at moderate to high temperatures and provide multi-contaminant control to extremely low levels.

Gas Separation R&D

Gas separation unit operations represent major cost elements in gasification plants. Gasification-based energy conversion systems rely on two gas separation processes: (1) separation of oxygen from air for feed to oxygen-blown gasifiers; and (2) post-gasification separation of hydrogen from CO_2 following (or along with) the shifting of gas composition when CO_2 capture is required, or hydrogen is the desired product. The advanced gas separation systems being developed operate at elevated temperatures, thereby reducing the parasitic energy penalty associated with conventional technologies.

More information on Gasification Systems Program R&D, on how systems analysis supports the program, on the benefits of gasification, and on individual projects can be found at at the NETL website:

http://www.netl.doe.gov/technologies/coalpower/gasification/index.html

Or **Google "Gasifipedia"**

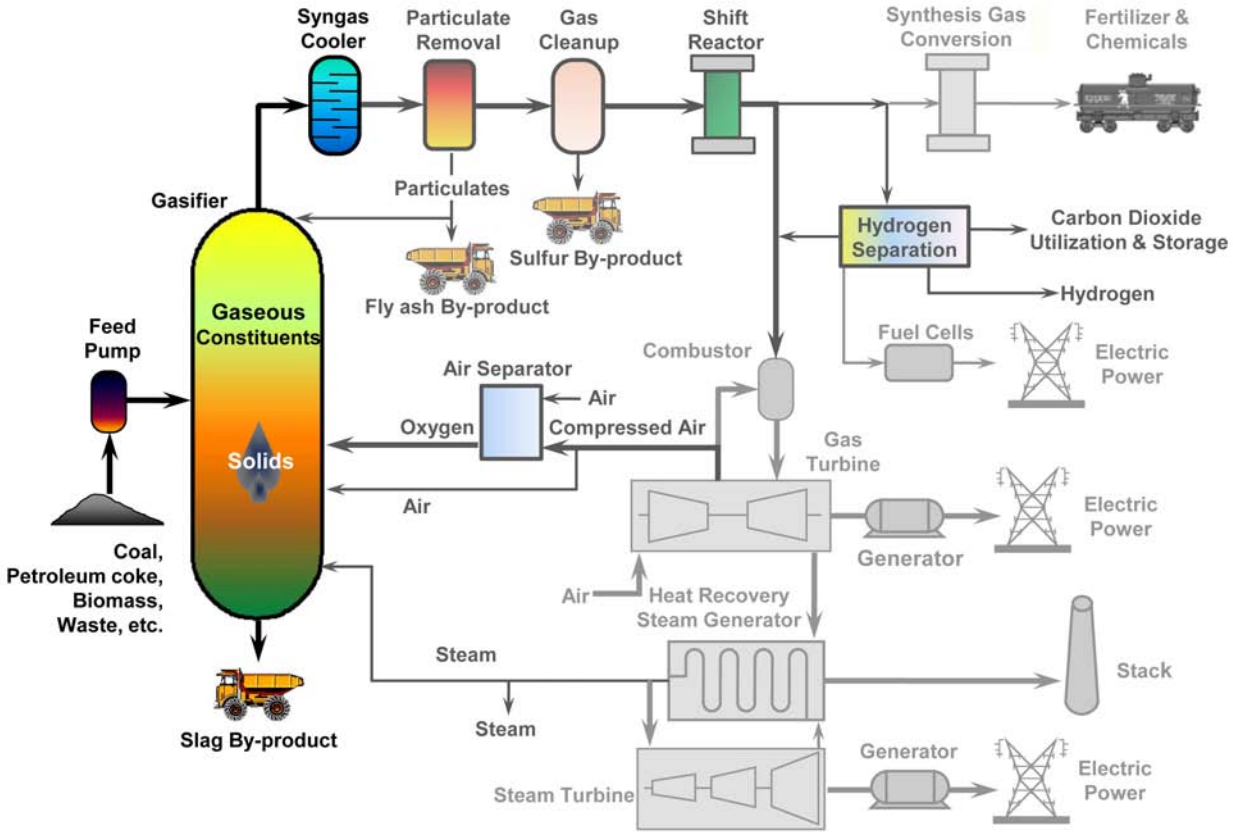
December 2011

GASIFIER OPTIMIZATION

Part of the DOE Gasification Systems Program to

- Reduce gasification costs so coal can support U.S. economic growth
- Ensure excellent environmental performance for coal gasification

The Gasifier Optimization research and development (R&D) area focuses on the development of technologies and models to improve the performance of advanced gasifiers, including high-pressure coal-feed pumps; low-rank coal utilization; new process instrumentation; improved reliability, availability, and maintainability (RAM); and advanced materials. A recent NETL systems analysis, "Current and Future Technologies for Gasification-Based Power Generation Volume 2: A Pathway Study Focused on Carbon Capture Advanced Power Systems R&D Using Bituminous Coal" (Pathways Study) shows that the primary benefit of Gasifier Optimization R&D is decreased capital cost and improved RAM. The resulting benefit includes 0.8 percentage points of efficiency gain; $7/kW reduction in total plant cost; and more than $7.5/MWh reduction in cost of electricity. Subsequent to this study, recently awarded projects were selected to further reduce the cost of gasification with carbon capture. Both ongoing and new projects aim to improve gasifier performance and reduce costs by: improving RAM, expanding flexibility (especially low-rank coal), and increasing plant efficiency.



Gasification Systems Program Research and Development Areas are in Color. Gasification Optimization R&D Areas are Brighter. Grey sections are part of other closely aligned DOE/NETL Research Technology Programs.

Improve Reliability

Several projects are actively seeking to improve gasifier refractory and to reduce syngas cooler fouling because their reliability is generally lower than other process equipment in the gasification island. Furthermore, recent gasification construction lessons learned are being leveraged to study how improvements can be made to reduce construction costs while maintaining or improving plant availability.

Expand Fuel Flexibility

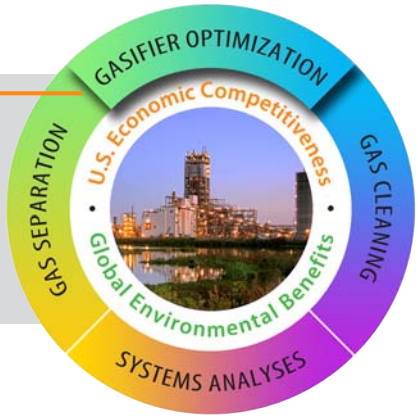
Utilizing the Nation's large reserves of low-cost, low-rank coals in IGCC systems is currently limited because the most efficient advanced gasifiers tend to perform better on bituminous coal, and available coal feed systems have limited flexibility. Advancements in low-rank coal gasifier technologies have the potential to boost the economies of U.S. regions with low-rank coal reserves and to support industry growth across the U.S. Several projects were recently launched to reduce the cost of low-rank coal gasification, and ongoing work seeks to improve the effectiveness of mixing up to 15% woody biomass (mixed with coal) gasification.

Increase Efficiency

Increasing the efficiency of gasification results in more syngas, or power, produced per ton of coal, reducing the impact of coal contaminants, reducing costs and conserving U.S. coal reserves. Projects designed to increase efficiency include those that will improve control and uniformity of feed to gasifier systems, improve gasifier monitoring and control, and increase the understanding of gasifier operations through modeling. Several projects span the R&D areas described, but also include efficiency gains. For instance, projects aimed at improving syngas cooler reliability will also result in increased efficiency, and the two projects on high pressure dry feeding of coal to enable more efficient low-rank coal use are also expected to improve gasifier plant efficiency and reliability.

For more information on this R&D Area, including project fact sheets, visit this section of our website:

http://www.netl.doe.gov/technologies/coalpower/gasification/adv-gas/index.html



Other Key R&D areas in the Gasification Systems Program are Gas Cleaning and Gas Separation. More information on Gasification Systems Program R&D, on how systems analysis supports the program, on the benefits of gasification, and on individual projects can be found at the NETL website:

http://www.netl.doe.gov/technologies/coalpower/gasification/index.html

Or **Google "Gasifipedia"**

December 2011

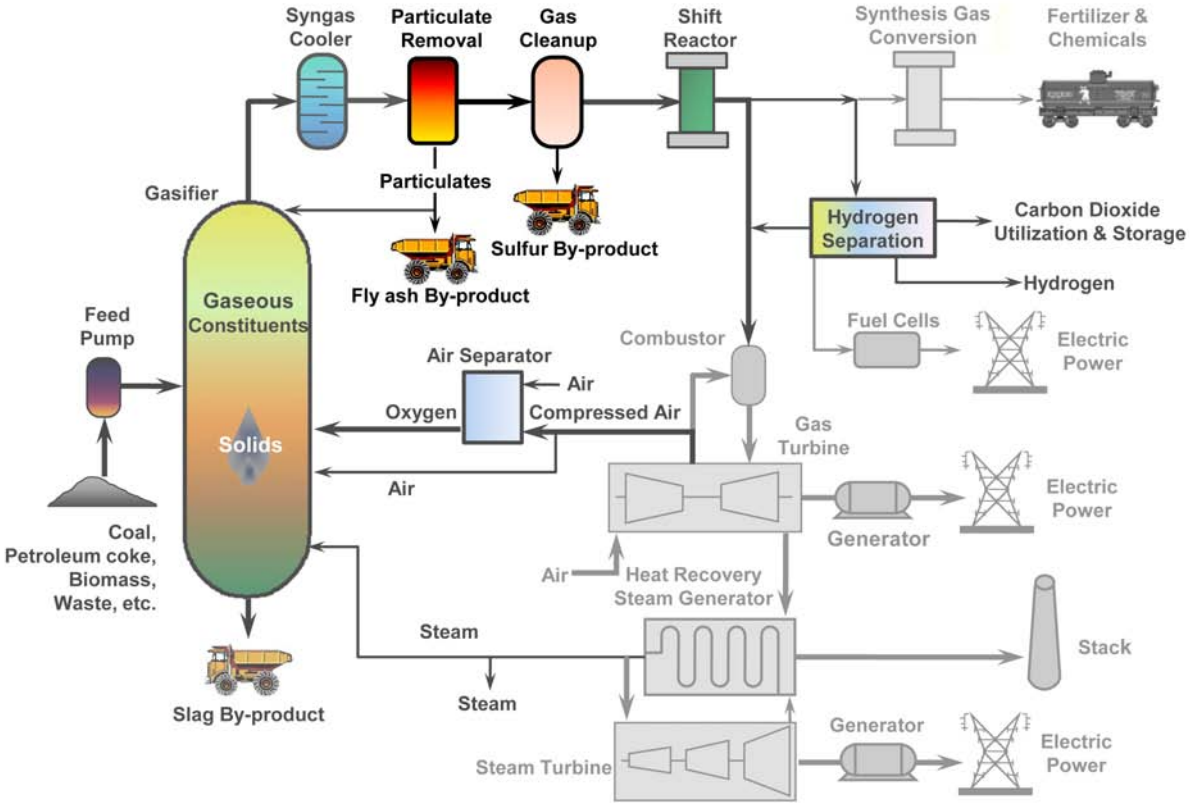
GAS CLEANING

Part of the DOE Gasification Systems Program to

- Reduce gasification costs so coal can support U.S. economic growth
- Ensure excellent environmental performance for coal gasification

The Gas Cleaning research and development (R&D) area focuses on reducing the cost of cleaning syngas, while simultaneously cleaning syngas to extremely clean levels—including particulates, sulfur, ammonia and mercury removal.

Conventional methods for removing sulfur and other contaminants from syngas typically rely on chemical or physical absorption processes operating at temperatures of 100 °F or less. When cooled to this level, nearly all of the steam present in the syngas condenses. After contaminant removal, the gas has to be reheated and additional steam often needs to be added for downstream hydrogen production. These process swings adversely impact the plant's thermal efficiency and cost. Economic analysis shows that gas-cleaning processes that are amenable to higher operating temperatures could significantly reduce this efficiency loss and improve the gasification plant's commercial viability. It is also critical that, while improving efficiency and reducing cost, the gas cleaning removes a wide variety of coal contaminants (including ammonia, hydrogen chloride, hydrogen sulfide, and carbonyl sulfide, as well as various forms of trace metals, including arsenic, mercury, selenium, and cadmium) to extremely low levels.



Gasification Systems Program Research and Development Areas are in Color. Gas Cleaning R&D Areas are Brighter. Grey sections are part of other closely aligned DOE/NETL Research Technology Programs.

The Gas Cleaning R&D approach focuses on the development of high-efficiency processes that operate at moderate to high temperatures and provide multi-contaminant control to meet the highest environmental standards. A recent NETL systems analysis, "Current and Future Technologies for Gasification-Based Power Generation Volume 2: A Pathway Study Focused on Carbon Capture Advanced Power Systems R&D Using Bituminous Coal" (Pathways Study) shows that the primary benefit of warm gas cleanup is achieved when it is coupled with a hydrogen-CO_2 separation process that operates at a similar temperature. The resulting benefit includes 2.9 percentage points of efficiency gain, $378/kW reduction in total plant cost, and $12/MWh reduction in cost of electricity. The Gas Cleaning R&D area includes a 30–50 MWe scale project to test sulfur removal integrated with optimized water-gas-shift, carbon capture, and CO_2 sequestration; in-house research to monitor and remove mercury and other trace contaminants to extremely low levels; work at small pilot scale using industrially produced coal syngas; and a new project focused on the removal of contaminants from low-rank coal.

For more information on this R&D Area, including project fact sheets, visit this section of our website:

http://www.netl.doe.gov/technologies/coalpower/gasification/gas-clean/index.html

Other Key R&D areas in the Gasification Systems Program are Gasifier Optimization and Gas Separation. More information on Gasification Systems Program R&D, on how systems analysis supports the program, on the benefits of gasification, and on individual projects can be found at the NETL website:

http://www.netl.doe.gov/technologies/coalpower/gasification/index.html

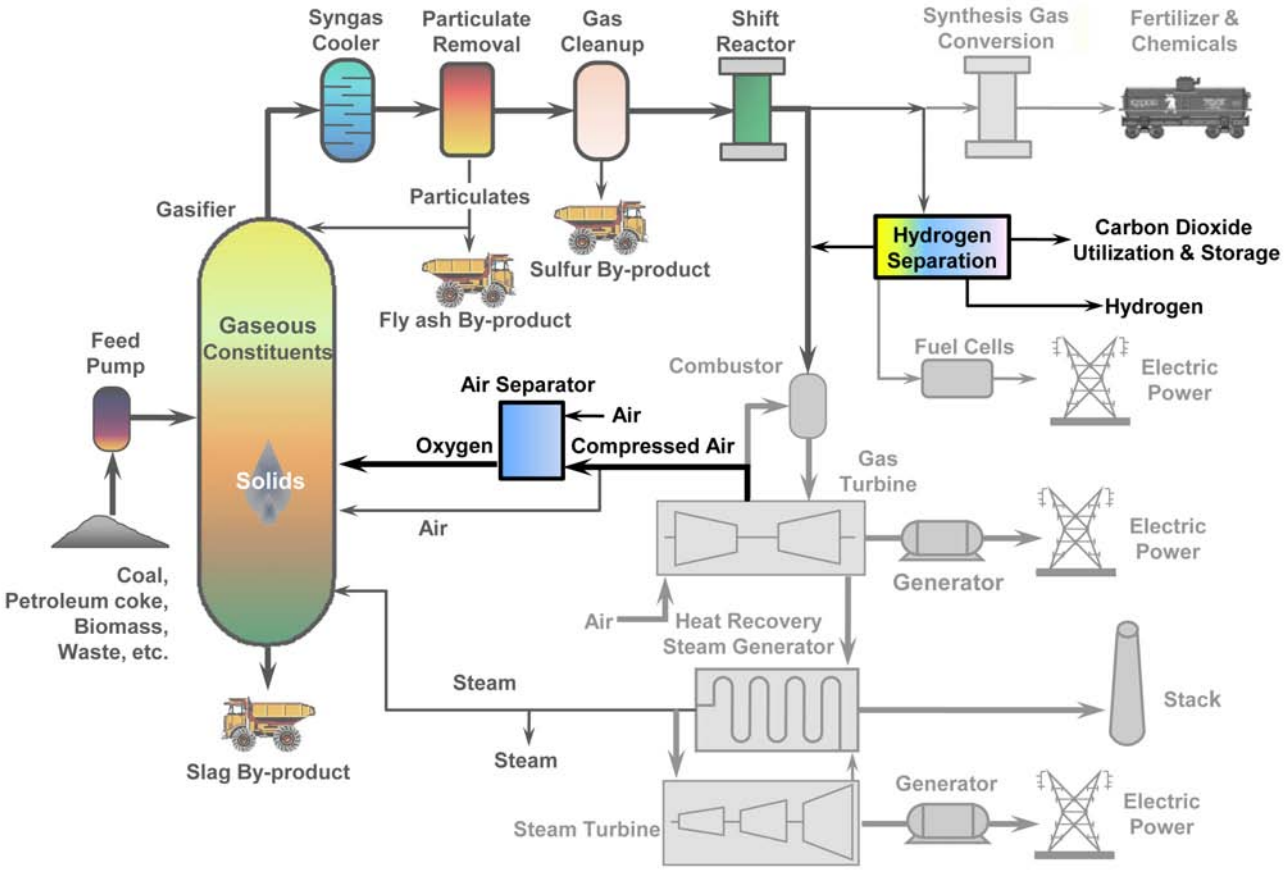
Or **Google "Gasifipedia"**

GAS SEPARATION

Part of the DOE Gasification Systems Program to

- Reduce gasification costs so coal can support U.S. economic growth
- Ensure excellent environmental performance for coal gasification

The Gas Separation research and development (R&D) area focuses on reducing the cost of two gas separation processes: (1) separation of oxygen from air for feed to oxygen-blown gasifiers; and (2) post-gasification separation of hydrogen from CO_2 following (or along with) the shifting of gas composition when CO_2 capture is required, or hydrogen is the desired product. Gas separation unit operations represent major cost elements in gasification plants.



Gasification Systems Program Research and Development Areas are in Color. Gas Separation R&D Areas are Brighter. Grey sections are part of other closely aligned DOE/NETL Research Technology Programs.

Oxygen Separation

An advanced air separation technology is being developed that can produce commercial-scale quantities of oxygen at lower cost than conventional cryogenic systems. The cryogenic air separation unit (ASU) in a conventional IGCC plant typically accounts for 12 to 15 percent of the overall capital cost of the plant; the technology being developed (Ion Transport Membrane or ITM) is projected to cost 25–33 percent less than an equivalent-sized state-of-the-art cryogenic ASU. In addition, ITM systems operate at elevated temperatures, thereby reducing the parasitic energy penalty associated with cryogenic oxygen production.

Hydrogen and CO_2 Separation

For effective integration with advanced gasification technologies, and to be able to realize the full advantages of high-temperature gas cleaning technologies, hydrogen and CO_2 separation must be accomplished at temperatures higher than conventional separation processes. Operation at higher process temperatures also offers the possibility of enhancing the water-gas-shift process through integration with advanced membranes, since both processes operate at similar temperatures. Technologies that are capable of producing both hydrogen and CO_2 at high pressure can avoid significant recompression costs that would further enhance the economics of these plants. The hydrogen transport membrane, which uses metal or metal alloy materials with surface exchange catalysts to separate hydrogen from CO_2, is being aggressively developed. Smaller scale work, more exploratory in nature, is being performed on two other non-membrane technologies integrated with the WGS.

For more information on this R&D Area, including project fact sheets, visit this section of our website:

http://www.netl.doe.gov/technologies/coalpower/gasification/gas-sep/index.html

Other Key R&D areas in the Gasification Systems Program are Gasifier Optimization and Gas Cleaning. More information on Gasification Systems Program R&D, on how systems analysis supports the program, on the benefits of gasification, and on individual projects can be found at the NETL website:

http://www.netl.doe.gov/technologies/coalpower/gasification/index.html

Or **Google "Gasifipedia"**

December 2011

Appendix A – Project Summaries and Fact Sheets

Gasifier Optimization

Gas Cleaning

Gas Separation

Systems and Industry Analyses

All NETL Fact Sheets - www.netl.doe.gov/publications/factsheets/fact_toc.html

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Advanced Gasification Systems Development

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Description

The Advanced Gasification Systems Development (AGSD) Program was initiated in October 2004 to demonstrate technologies that improve the availability and efficiency of gasification-based power plants and to reduce plant capital and operational costs. This project was the first step in realizing Pratt & Whitney Rocketdyne's (PWR) vision of improving gasification economics, through a paradigm shift in gasifier technology, to enable widespread commercial deployment of coal-based gasification systems. PWR has released a final interim report describing the results of this project through the summer of 2008, including:

- Pilot plant design for the novel PWR gasifier
- Mechanically cool liner tests
- Economic analysis of the PWR gasification system
- Dynamic modeling of the PWR gasifier

The second phase of this project will focus on the continued development of a high pressure solids feed pump for use in high pressure gasifiers and conclude with tests using coal, petcoke, and a biomass-coal mixture in a 600-ton per day (tpd) prototype at over 1,000 pounds per square inch (psi). The PWR feed pump will be able to transport fuel into a high pressure gasifier without first creating a slurry, so it will result in greater gasifier efficiency than a slurry feed pump. The PWR feed pump will also be able to operate across much greater pressure differentials at lower cost and higher reliability than a conventional lock hopper system. No extraordinary coal processing (drying, grinding, etc.) is expected to be required for use with the PWR feed pump. PWR has agreed to make their feed pump technology readily available to industry once it is commercially ready.

Primary Project Goal

The primary project goal is to successfully test a 600 tpd prototype of the PWR feed pump on a variety of coals and on at least one coal-biomass mixture.

PARTNERS

Pratt & Whitney Rocketdyne

Natural Resources Canada
CANMET Energy Technology Centre

Oak Ridge National Laboratory

University of North Dakota
Energy & Environmental Research Center

COST

Total Project Value
$22,153,282

DOE/Non-DOE Share
$13,816,231 / $8,337,051

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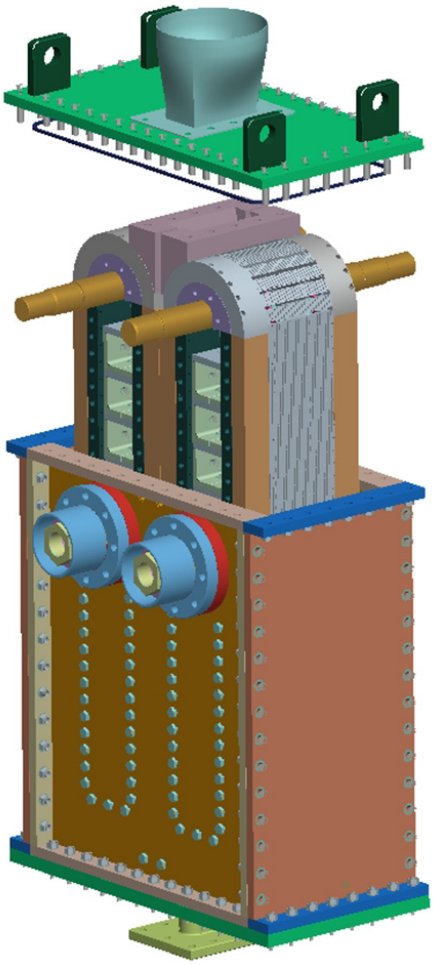
Accomplishments

- Obtained a peer review of the gasifier and feed system. The peer reviewers believed that the PWR high pressure feed pump, uniform flow splitting, and mechanically cooled liner are concepts that, if successfully developed, are likely to have a beneficial impact on the gasifier industry because they could be adapted for use with other gasifiers.
- Completed several test runs of 6-way and 18-way flow splitting of the feed system, showing excellent potential for uniform and consistent flow splitting.
- Completed construction of the high pressure feed system (less the feed pump) at the University of North Dakota Energy & Environmental Research Center.
- Completed a pressure sensitivity study showing that 1,000 psi operation is the most efficient operating pressure analyzed.
- Completed preliminary design of the high pressure feed pump prototype.



PWR High Pressure Solids Pump

Benefits

The PWR feed pump has the potential to significantly improve the availability and efficiency of feeding coal, petcoke, and/or biomass into high pressure gasifiers, thereby increasing the efficiency of the gasifier and reducing plant capital, maintenance, and operating costs. These benefits have far-reaching implications for the gasification industry as PWR has agreed to make this technology available, as per typical industry licensing practices. Also, being able to feed high moisture coal into high pressure gasifiers, without added water to form a slurry or the use of lock hoppers, is expected to make these coals more commercially competitive.

Project328.indd

Advanced Virtual Energy Simulation Training and Research (AVESTAR™) Center

Description

The National Energy Technology Laboratory (NETL) has collaborated with software, industry, and university partners to establish the world-class Advanced Virtual Energy Simulation Training and Research (AVESTAR™) Center dedicated to the operation and control of advanced energy plants with carbon capture. The AVESTAR™ Center offers a collaborative research and development (R&D) program and comprehensive hands-on training built around a portfolio of non-proprietary, high-fidelity, real-time dynamic simulators. The simulators provide full-scope operator training system (OTS) capabilities for normal and faulted operations, as well as plant start-up, shutdown, and load following. Immersive three-dimensional (3-D) virtual reality adds another dimension of realism to the dynamic OTSs and extends the training scope to both control room and outside operators, allowing them to work as a team. The benefits of high-fidelity immersive training systems (ITSs) include more realistic training scenarios, improved communication and collaboration among work crews, off-line evaluations of procedures, and training for safety-critical tasks and rare abnormal situations.

Immersive 3-D virtual reality adds a dimension of realism to training scenarios

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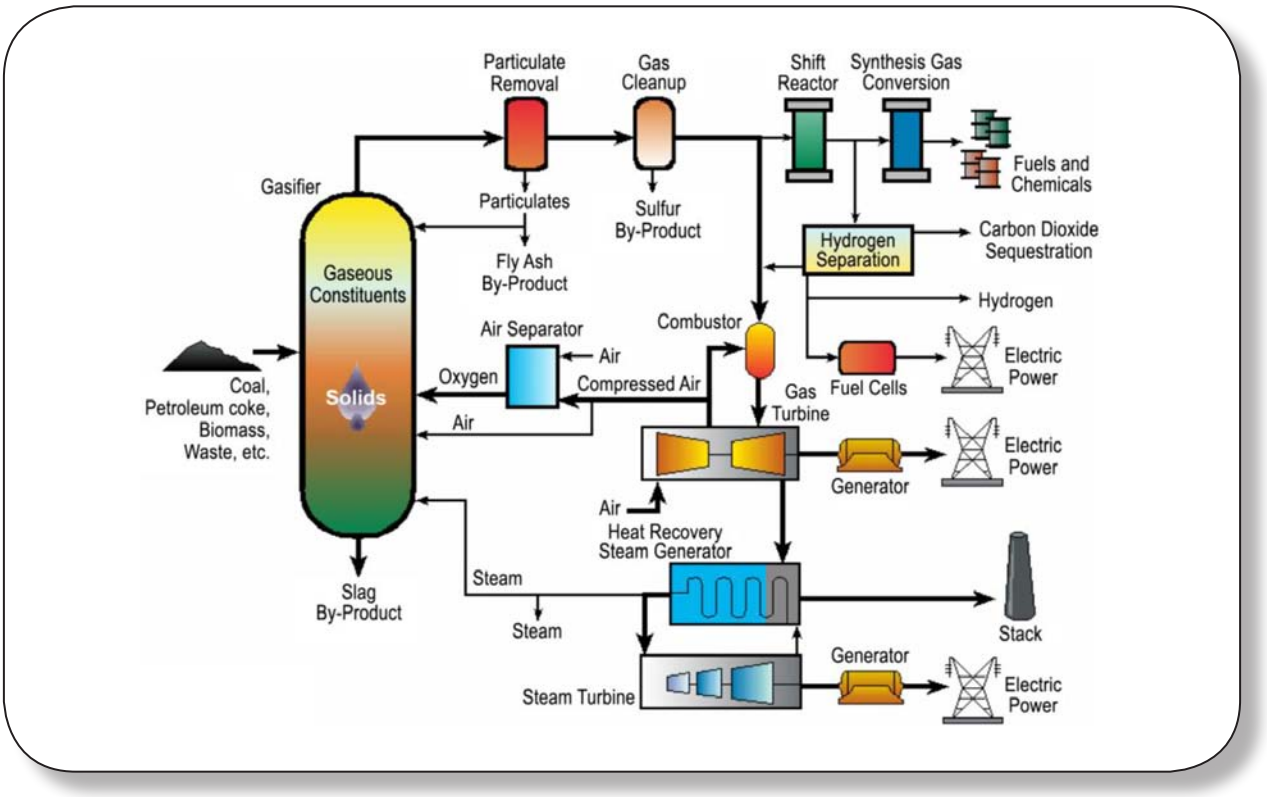
Dynamic Simulator / Operator Training System

By providing comprehensive virtual energy plant OTS and ITS solutions, the AVESTAR™ Center will develop a workforce well-prepared to operate and control commercial-scale power plants with carbon capture. Users include engineers, managers, and trainers from electric utilities, engineering and construction firms, equipment vendors, and research, consulting, and training entities. With support from the NETL-Regional University Alliance (NETL-RUA), the AVESTAR™ Center is also used to educate and train engineering students and researchers on plant operations and control. The real-time dynamic simulators and ITSs provide a practical, hands-on "learning by operating" experience. The AVESTAR™ Center is operated with support from the URS Corporation and the NETL-RUA with locations at NETL in Morgantown, West Virginia, and West Virginia University's (WVU) National Research Center for Coal and Energy.

IGCC Dynamic Simulator and Immersive Training System

The first dynamic simulator and ITS deployed at the AVESTAR™ Center is a next-generation, integrated gasification combined cycle (IGCC) plant with carbon capture. The IGCC reference plant is a modified version of an IGCC system presented in NETL's report, titled "Cost and Performance Comparison of Fossil Energy Power Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity Final Report (DOE/NETL-2010/1397), Rev. 2 November 2010." The coal, biomass, and/or petroleum coke-fired IGCC plant consists of two entrained down-flow gasifiers with radiant syngas coolers; a two-stage water gas shift; a dual-stage acid gas removal process where the second stage captures carbon dioxide; and a combined cycle including two F-class gas turbines, heat recovery steam generator, and steam turbine cycle with three pressure levels. The highly flexible OTS software and hardware configuration allows concurrent training on separate gasification and combined cycle simulators, or up to two IGCC simulation sessions at the same time. The dynamic simulator will be combined with a plant-wide ITS to create an accurate, 3-D virtual experience of the IGCC system using stereoscopic goggles and gesture-sensitive handheld devices.



Integrated Gasification Combined Cycle Plant

The multi-year R&D project to develop the combined IGCC OTS/ITS solution consists of the following overlapping phases:

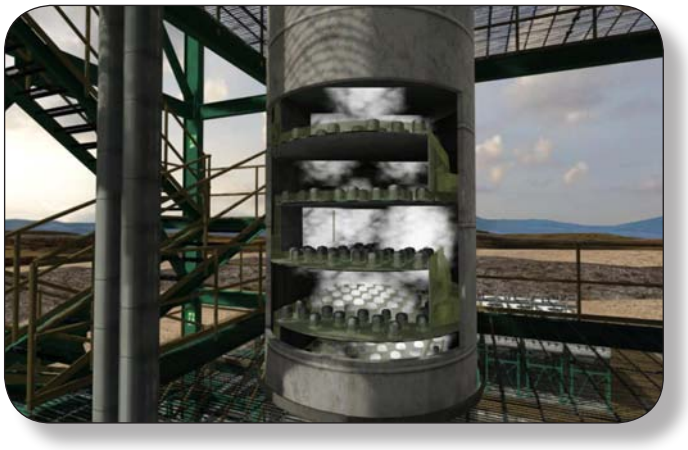
- **Phase I** – IGCC dynamic simulator/OTS scoping study (Complete)
- **Phase II** – IGCC dynamic simulator/OTS detailed planning/ functional design specification (Complete)
- **Phase III** – Development/acceptance testing of IGCC dynamic simulator/OTS (Complete)
- **Phase IV** – Deployment of IGCC dynamic simulator/OTS at the NETL AVESTAR™ Center (Complete)
- **Phase V** – Establishment of the NETL AVESTAR™ Center (Complete)
- **Phase VI** – IGCC ITS planning/functional design specification (Complete)
- **Phase VII** – Development of IGCC ITS (In Progress)
- **Phase VIII** – Deployment of IGCC ITS at the NETL AVESTAR™ Center (November 2011)
- **Phase IX** – Ongoing support and development of the NETL AVESTAR™ Center (In Progress)

Primary Project Goals

- Establish a world-class AVESTAR™ Center to provide research, education, demonstration, and training capabilities for the operation and control of advanced near-zero emission energy systems.
- Develop and deploy a portfolio of non-proprietary, full-scope, high-fidelity, real-time dynamic simulators with ITSs for a wide variety of advanced energy plants, starting with an IGCC system with carbon capture.
- Implement strategic R&D collaborations with the process and energy industries, engineering and construction firms, technology suppliers, government labs, universities, and simulator software and service providers.
- Conduct leading-edge R&D in the areas of high-fidelity, real-time dynamic simulation, reduced order modeling, model predictive control, sensor placement, risk and safety analysis, and virtual engineering.

Key IGCC Dynamic Simulator Features

- High-fidelity, real-time dynamic model of process-side (gasification) and power-side (combined cycle) for a generic, commercial-scale IGCC plant with carbon capture.
- Full-scope dynamic simulator capabilities, including complete cold, warm, and hot start-ups; shutdowns; load changes; normal, abnormal, and emergency operating conditions; control strategy analysis; malfunctions/trips and alarms; scenarios, trending, and snapshots; data historian; and trainee performance monitoring.
- Extendable to incorporate additional gasification, gas turbine, and carbon capture technologies, as well as new, advanced technologies, such as fuel cells and membrane separation systems.



3-D Virtual Immersive Training System

Benefits

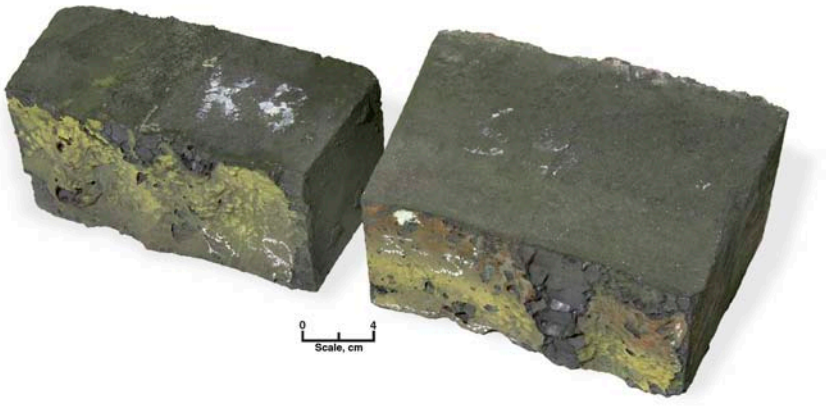
The AVESTAR™ Center provides the following impact and benefits:

- Provides users with world-class simulation tools for research, training, and education.
- Demonstrates key IGCC technologies including gasification, carbon capture, and power generation.
- Enables combined control room and plant crew training in an immersive 3-D plant walkthrough environment.
- Develops and trains the existing workforce and a new generation of engineers, thereby satisfying the growing industry demand for expertise and experience with the analysis, operation, and control of commercial-scale energy plants with carbon capture.
- Serves as a focal point for collaborative R&D with universities, research organizations, government labs, software and service providers, and the power and energy industries.
- Accelerates the application of advanced dynamic simulation technology to better achieve the aggressive design, operability, and controllability goals for high-efficiency, zero-emission power plants.

Improved Refractory Materials for Slagging Gasification Systems

Advances in technology are often directly linked to materials development. For gasification, the reliability and affordability of slagging gasifier operation depend directly on the service life and performance of the refractory materials used to contain the high-temperature gasification reaction. The National Energy Technology Laboratory (NETL) is working with industry to develop high-performance, affordable materials for this application.

In the most severe areas of a slagging gasifier, where tons of molten slag each day flow by at temperatures in excess of 1350 °C, refractory service life can be as short as 90 days, requiring complete shutdown of the gasifier island every 3 months for material replacement. Unless there is a second gasifier available, these shutdowns result in no syngas production, and therefore no product for up to 14 days. The costs of these shutdowns, including lost opportunity costs, reach into the millions. To help address this issue, scientists at NETL developed and patented a new refractory designed specifically for longer service life in this application. Field tests of this new refractory at several commercial gasifier sites in the United States showed significantly improved performance relative to other commercially-available materials. Based on field test results, Harbison-Walker Refractory Company licensed this technology and now markets this material to the gasifier industry as Aurex® 95P.



Refractories removed from adjacent positions in the gasifier. The NETL refractory has approximately 50 percent more material remaining after the test.

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Harbison-Walker Refractories Company

Materials development work continues at NETL to design new materials and systems that can match or beat current refractory performance at a lower cost and with less environmental impact. The target is an affordable refractory material that will provide superior service life regardless of the feedstock used, offering the gasifier operator true fuel flexibility and the opportunity to achieve the industry's goal of 90 percent + on-line availability.

In addition to the improved refractory, an NETL-designed thermocouple assembly is also being developed with the goal of providing longer and more consistent temperature measurement to the gasifier operator, leading to better operational control of the system.

Test thermocouples being installed in a commercial gasifier.

Current generation thermocouples are very susceptible to the harsh operating environment inside the slagging gasifier and often fail within hours of gasifier start-up, leaving the operator with no real-time means of temperature measurement. NETL's newly designed thermocouple incorporates improved fabrication and installation methodologies with an enhanced ceramic protection system that can better shield the thermocouple from the corrosive components of the molten slag. Field tests in commercial gasifiers continue to optimize the concept.

Improvement in materials service life translates directly to improved gasifier reliability and reduced operational costs, both of which are necessary to make gasification a viable means of generating energy from fossil fuel sources.

Field tests to date have been run at the Eastman Chemical Company's Kingsport, TN, site; at Tampa Electric Company's Polk Power Station in Lakeland, FL; and at the Wabash River Power Station in Terre Haute, IN. Funding for this project comes via the Department of Energy, Fossil Energy's Advanced Gasification Technologies and Advanced Research—Materials technology lines.

Test panel inside the gasifier just prior to removal. The circled area is the origin of the two bricks illustrated on page one.

Model-Based Optimal Sensor Network Design for Condition Monitoring in an IGCC Plant

Background

The U.S. Department of Energy's National Energy Technology Laboratory (NETL) develops affordable and clean energy from coal and other fossil fuels to secure a sustainable energy economy. To further this mission, NETL funds research and development of advanced sensor and control technologies that can function under the extreme operating conditions often found in advanced power systems, particularly those that are gasification-based. Reliable and robust sensors and controls are essential to the development of high-efficiency, clean energy technologies, such as low-emission power systems that use coal or other fossil fuels.

Gasification offers a viable pathway for the clean generation of power and fuels and a cost-effective option for the sequestration of carbon dioxide. Select areas of an integrated gasification combined cycle (IGCC) plant require innovative solutions to enable the system to perform as intended. One area of innovation is the use of advanced predictive controls that couple modeling, use of sensors, and model-based online estimation to enable real-time optimization of the gasifier and radiant synthesis gas cooler (RSC).

Project Description

NETL will partner with General Electric (GE) Global Research to develop an advanced model-based optimal sensor network to monitor the condition of the gasification section in an IGCC plant. The work will build on model-based controls aimed at enhancing efficiency and operational flexibility through increased automation.

Within an overall strategy of employing model-based online monitoring and predictive controls, GE Global Research will extend existing models for gasifier and RSC to include the effects of degradation and fouling and will implement an estimation algorithm to assess the extent of gasifier refractory degradation and RSC fouling. An optimization-based solution for sensor placement to achieve the monitoring requirements will also be developed. The performance of the sensor placement algorithm and resulting monitoring solution will be demonstrated through simulations using representative test cases. The overall approach is one of the first to be applicable to condition monitoring of critical components in IGCC plants.

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PROJECT DURATION

Start Date
08/20/2010

End Date
12/31/2012

COST

Total Project Value
$1,195,894

DOE/Non-DOE Share
$956,714 / $239,180

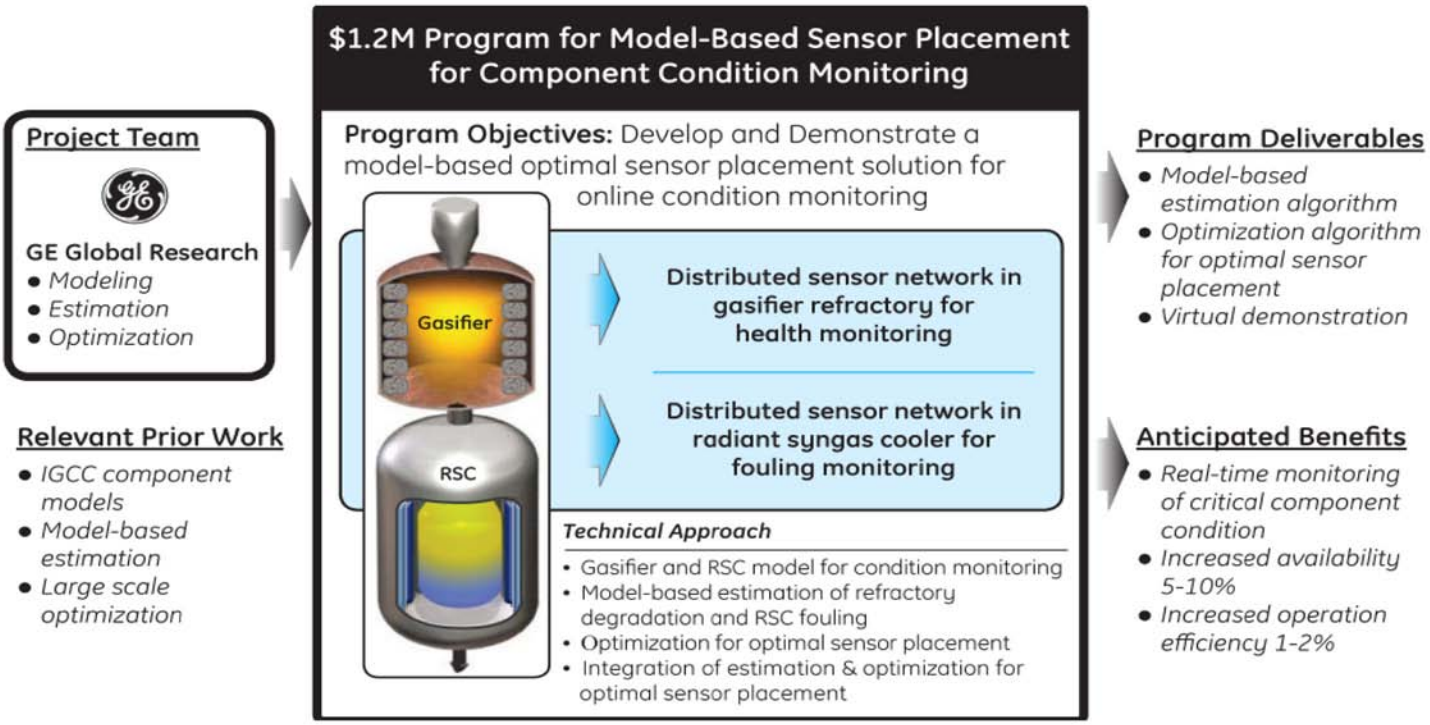
Goals and Objectives

The goal of this project is to develop a sensor network design based on models of an IGCC plant that support the development of an online condition monitoring system. To achieve this goal, the project will (1) develop a set of computational tools to address the problem of optimal sensor placement through a combination of model-based estimation and non-linear optimization; and (2) demonstrate the developed solution through extensive computer simulations, focusing on optimal sensor placement to infer and monitor the condition of the gasifier refractory and fouling of the RSC.

Benefits

The program will develop a general computational tool for solving the problem of optimal sensor placement, and demonstrate the application for condition monitoring of key equipment in the gasification section of an IGCC plant. Key benefits of the project include—

- Capability for real-time online monitoring of gasifier refractory degradation and RSC fouling.
- Improved online monitoring integrated with advanced controls to improve availability and operation efficiency.
- A general modular tool that can be applied to other process units for optimal sensor placement for online performance and condition monitoring.



Program overview and scope for model-based optimal sensor placement for component condition monitoring.

Real Time Flame Monitoring of Gasifier Burner and Injectors

Background

The Gasification Technologies Program at the National Energy Technology Laboratory (NETL) supports research and development (R&D) in the area of gasification—a process whereby carbon-based materials (feedstocks) such as coal are converted into synthesis gas (syngas), which is separated into hydrogen (H_2) and carbon dioxide (CO_2) gas streams in a combustion turbine-generator as a way to generate clean electricity while preventing the release of CO_2.

The R&D efforts of the Gasification Technologies Program for instrumentation materials as well as other areas focus on enhancing the performance of gasification systems, thus enabling U.S. industry to improve the competitiveness of gasification-based processes. One area in need of performance enhancement is that of scheduling gasifier coal injector replacement. Gas Technology Institute (GTI) has discovered that coal gasifier feed injectors tend to be replaced on a conservative schedule to limit unexpected gasifier failures. GTI realized that replacing injectors only when needed would result in less gasifier down time, resulting in more economical operation.

In an effort to advance this technology, NETL will collaborate with GTI, North Carolina State University, and ConocoPhillips Company (CP) to increase the life of coal gasifier feed through advanced condition monitoring.

Project Description

This project focuses on the development of a sensor that expands the capabilities of existing and emerging combustion sensors to produce a flame monitor to help minimize the maintenance costs of gasifier operation. The primary goal is to develop a reliable, practical, and cost-effective means of monitoring coal-gasifier feed-injector flame characteristics using a modified version of an optical flame sensor. The flame characteristics monitored by this sensor are flame shape, flame mixing patterns, flame rich/lean zones distribution, hydrocarbon oxidation dynamics, flame stability, and flame temperature. The sensor will be tested at lab-scale on a natural gas flame, at bench-scale in the vertical coal-slurry oxygen (O_2)-enriched air combustor, and at pilot-scale in an O_2-fired, high-pressure slagging gasifier. This project will result in a simplified, industrially robust flame-characteristics sensor able to provide reliable information on the wear of coal-gasifier feed injectors, thereby improving injector life in coal gasification systems.

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North Carolina State

PROJECT DURATION

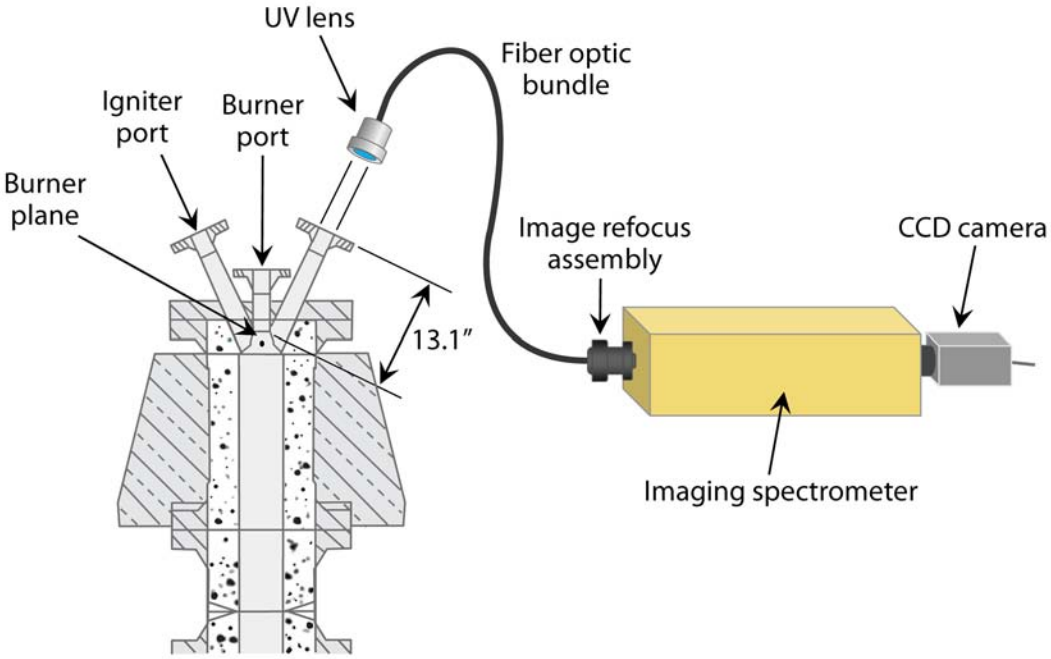
Start Date
10/01/2002

End Date
12/31/2012

COST

Total Project Value
$ 1,683,394

DOE/Non-DOE Share
$ 1,247,896 / $ 435,498



Conceptual Schematic of Sensor Installation on a Coal Gasifier

The bench- and pilot-scale work will be performed at CANMET Energy Technology Centre (CETC) in Ottawa, Canada. Then GTI will perform field demonstration tests in an O_2-fired commercial scale gasifier at Global Energy, Inc's Wabash facility, with CP as the industrial partner.

Goals and Objectives

The primary goal of this project is to develop a reliable, practical, and cost-effective means of monitoring coal gasifier feed injector flame characteristics using a modified version of an optical flame sensor already under development. Specific objectives include (1) testing the flame sensors at lab scale, (2) testing at bench and pilot scale at CETC, and (3) performing a field demonstration on an O_2-fired commercial scale gasifier.

Accomplishments

GTI was able to complete existing sensor modification to detect ultraviolet (UV), visible, and/or near infrared (NIR) wavelengths for optimum flame monitoring and laboratory testing equipment set-up., the sensor was modified following lab-scale testing on natural gas flames for pilot-scale testing at the CETC O_2-fired, high pressure, pilot-scale slagging gasifier, and was successfully tested on a natural gas mockup of this gasifier. Flame parameters, including swirl intensity, coal feed rate, coal feed velocity, and O_2 content in the oxidizer were varied during the tests. After pilot-scale tests were completed using the CETC pressurized entrained flow gasifier, researchers designed and built test equipment to evaluate spectroscopic and imaging properties of the fibers as well as to assess the capability of the fiber optic probe (FOP) enclosure to withstand high pressures. Tests showed that the video fiber capacity to transmit UV light is low; therefore, the spectroscopic fiber bundle was used in the prototype flame monitor. An eight hour test of the modified FOP lab-scale prototype at the GTI Combustion Laboratory demonstrated that it could survive long-term exposure to high temperatures and was able to collect images with sufficient resolution, viewing angle, focal depth, sensitivity, and contrast. The project also successfully tested the sensor at the Wabash facility and collected images of the gasifier for several hours including data that was used to estimate temperature.

Benefits

A reliable real-time flame monitor for gasifier injectors would allow gasifier operators to more accurately plan for injector replacement, thereby reducing maintenance costs and increasing gasifier reliability. The sensor data on flame characteristics may also assist in the development of better, longer-lasting injectors, which would also lead to gasifier operation savings. These sensors will allow furnace operators to manually adjust appropriate burner controls (e.g., flame length or firing rate) as well as maintain safe and stable combustion.

Single-Crystal Sapphire Optical Fiber Sensor Instrumentation for Coal Gasifiers

Description

Accurate temperature measurement inside a coal gasifier is essential for safe, efficient, and cost-effective operation. However, current sensors are prone to inaccurate readings and premature failure due to harsh operating conditions like high temperature (1,200–1,600 °C), high pressure (up to 500 pounds per square inch gauge [psig]), chemical corrosiveness, and high flow rates, all of which lead to the corrosion, erosion, embrittlement, and cracking of the gasifier components. Temperature measurement is a critical gasifier control parameter, because premature failure of temperature sensors impacts the efficiency and reliability of the entire system.

Sponsored by the U.S. Department of Energy's Office of Fossil Energy (DOE/FE) through the National Energy Technology Laboratory (NETL), the Center for Photoics Technology at the Virginia Polytechnic Institute and State University (Virginia Tech) has developed a new, robust, accurate temperature measurement system that can withstand the extreme conditions found in commercial gasifiers for an extended period, allowing for improved reliability and advanced process control. This system utilizes a sapphire-based fiber and sapphire wafer to form a point sensor (Figure 1), also referred to as an extrinsic Fabry-Perot interferometric (EFPI) sensor, which provides temperature data from inside the gasifier at temperatures up to 1,600 °C.

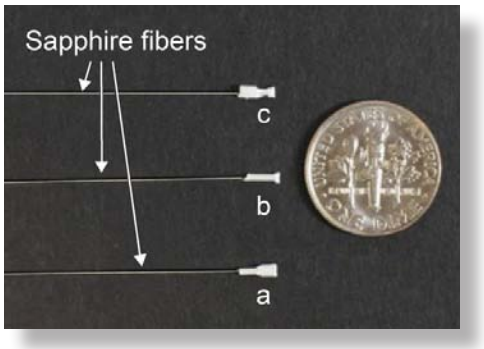


Figure 1. Single-crystal sapphire sensor heads with sapphire fiber waveguides achieve greater precision through miniaturization.

The approach is based on the measurement of the optical path difference (OPD) between two light beams reflected from sapphire wafer surfaces. Reflections from the two surfaces will interfere with each other, producing a modulated spectrum, whose pattern is determined by the optical thickness (OT) of the wafer. The OT is the product of the refractive index and the thickness of the wafer, both of which have thermal dependence, resulting in a temperature-sensitive OT and spectrum. Therefore, the temperature can be determined from the change in the reflected spectrum.

Primary Project Goal

The primary goal of this project is to develop an accurate temperature measuring system that is capable of withstanding extreme conditions for use in commercial full-scale gasification systems.

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Virginia Polytechnic Institute and State University

PROJECT COST

Total Project Value:
$1,711,221

DOE/Non-DOE Share:
$1,363,507 / $347,714

Accomplishments

This effort succeeded in developing and testing a prototype temperature measurement system under full-scale operating conditions, resulting in the potential for process improvement, cost reduction, and greater efficiency. Specific accomplishments include:

- Evaluated various sensor designs and selected a Fabry-Perot interferometry-based design for its self-calibrating capability, simplicity, and accuracy. This design was used in the development of sensor prototype for full scale testing.
- Demonstrated in a laboratory setting that the sensor was capable of accurately measuring temperature from room temperature up to 1,600 °C with a close resolution of approximately 0.26 °C. Sensor consistency was also demonstrated in multiple laboratory tests, which conformed closely to B-type thermocouple data.
- Demonstrated improved sapphire corrosion resistance compared to other ceramic materials, such as polycrystalline alumina.
- Tested the prototype sensor at Tampa Electric Company's Polk Power Station under actual operating conditions; sensor was evaluated and optimized at temperatures up to 1,400 °C.
- The prototype sensor survived and measured temperature seven months in the gasifier (Figure 2). This surpassed the performance of resistance based temperature sensors which survive on average of only 45 days. Continuous operation for one year of the sensor is a goal now that basic performance and survivability have been shown to be improvements over current technology.
- Examined the sensor after an additional full-scale test failure revealed that the protective housing had broken and a crack allowed slag to reach the fiber; however, the sensor itself remained intact, proving that the sensor design and sensor are robust.

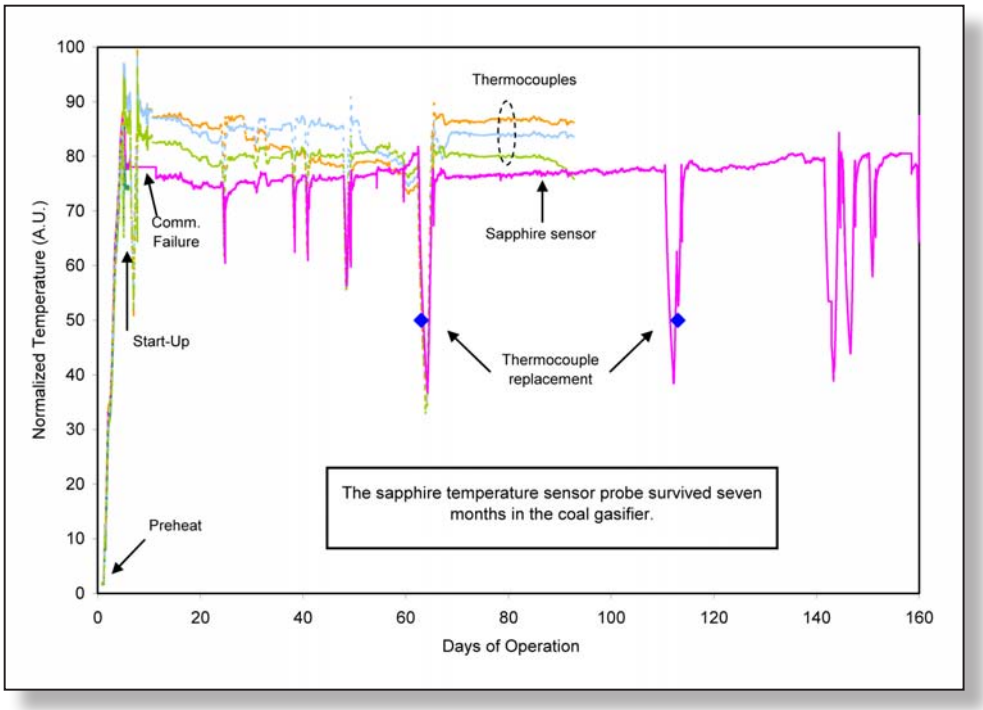

Figure 2. Comparison of sapphire fiber sensor temperature data to conventional thermocouple data. Both sets of thermocouples have now been replaced, as indicated by the blue diamonds on the graph. Differences in port sizes and sensor positions resulted in lower temperature readings from the fiber sensors.

Benefits

The development of a single-crystal sapphire temperature sensor that can accurately measure gasification conditions in extreme conditions will increase the reliability and efficiency of gasifier systems. Since gasifiers are central to many advanced high-temperature power systems, tomorrow's advanced power generation systems, such as Integrated Gasification Combined Cycle (IGCC), will benefit from this development. Other high-temperature applications, such as a combustion turbine, may benefit as well.

The U.S. Department of Energy National Carbon Capture Center at the Power Systems Development Facility

Background

In cooperation with Southern Company Services, the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) established the National Carbon Capture Center (NCCC) at the Power Systems Development Facility (PSDF) in Wilsonville, Alabama. The center will bolster national efforts to reduce greenhouse gas emissions by developing cost-effective technologies to capture the carbon dioxide (CO_2) produced by fossil-fueled power plants.

The PSDF is a unique test facility. It is large enough to provide commercially relevant data, yet small enough to be cost-effective and adaptable to testing a variety of emerging technology developments. The facility is a test-bed capable of evaluating advanced technologies at multiple scales, thus allowing results to be scaled directly to commercial application. This capability gives the PSDF the flexibility to develop and demonstrate a wide range of advanced power generation technologies that are critical to developing highly efficient power plants that capture CO_2.

The PSDF was launched in late 1990 with the signing of an agreement between DOE and Southern Company Services. Since completion of the facility in 1996, it has been a center of national efforts to develop coal-based power generation technologies that are reliable, environmentally acceptable, and cost effective. Many of the technologies developed at the facility are now commercially available or are ready for commercialization, including a design for an integrated gasification combined cycle power plant to be built in Kemper County, Mississippi, that will showcase a transport gasifier technology that was developed at the PSDF. Building on this success, the PSDF is now narrowing its focus. The new NCCC at the PSDF will concentrate on developing cost-effective, commercially viable carbon capture

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Luminant
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Peabody Energy
Rio Tinto

PERFORMANCE PERIOD

10/01/2008 to 09/30/2013

COST

Total Project Value
$251,454,148

DOE/Non-DOE Share
$201,163,318 / $50,290,830

AWARD NUMBER

DE-NT0000749

technology for coal-fueled power plants through scale-up and continued technology development by DOE and/or third party technology developers.

Project Description

DOE/NETL and Southern Company Services have entered into a five-year cooperative agreement to establish and manage the NCCC at the PSDF. During this period, the NCCC and supporting industrial participants will:

- Modify the PSDF to increase the facility's ability to test, evaluate, and develop emerging CO_2 capture systems for fossil-fueled power plants. The NCCC will include multiple slip-stream capabilities of variable throughput to accommodate the evaluation of a wide-range of capture technologies, including evaluation of pre-combustion CO_2 capture, post-combustion CO_2 capture, and oxy-combustion processes.

- Test and develop CO_2 capture technologies that provide improved efficiency and cost effectiveness over those currently deemed commercially available. In addition to individual component testing, components of the CO_2 capture process will be integrated and optimized to provide data needed for scale-up.

- Test, develop, and optimize components to enable the deployment of carbon capture with minimal increase in the cost of electricity. These components include gas contaminant cleanup, gas separations, coal/biomass gasification or combustion technologies, fuel cell technology, materials, sensor technology, and others.

- Test and evaluate the transport gasifier with CO_2 capture using a variety of fuels including coal/biomass mixtures to characterize the performance of the different technology units, their integration, and balance-of-plant processes.

Scope

The NCCC will support national efforts to reduce greenhouse gas emissions by collaborating with technology developers in accelerating their CO_2 capture technology development for application to coal-fueled power plants. The NCCC offers a flexible test facility which provides commercially representative flue gas and syngas, and the necessary infrastructure in which developers' technologies are installed and tested to generate data for performance verification under industrially realistic operating conditions. Testing and developing new CO_2 capture technologies in commercially representative conditions is critical before the technologies can be deployed at full scale. The NCCC can provide such a setting by delivering coal-derived flue gas and syngas over a wide range of process conditions. The NCCC at the PSDF will provide the necessary personnel, materials, and facilities needed to conduct this research. The applied Research and Development (R&D) carried out at the NCCC on components or small pilot-scale systems can help bridge the gaps between fundamental R&D and large-scale commercial demonstration and provides for a seamless transition for promising technologies to migrate from laboratory to commercial applications.

Goals

- The NCCC will become a cornerstone for U.S. leadership in advanced CO_2 capture technology development.
- The NCCC will demonstrate integrated coal-based energy technology for plants that offer clean coal technology, including carbon capture.
- Technologies developed at the NCCC will be scaled directly to commercial-sized equipment and integrated with commercial projects, including those under DOE's Clean Coal Power Initiative.
- The NCCC will lead the way to lower-cost CO_2 capture technologies and enable affordable, reliable, and clean coal-based power generation for years to come.

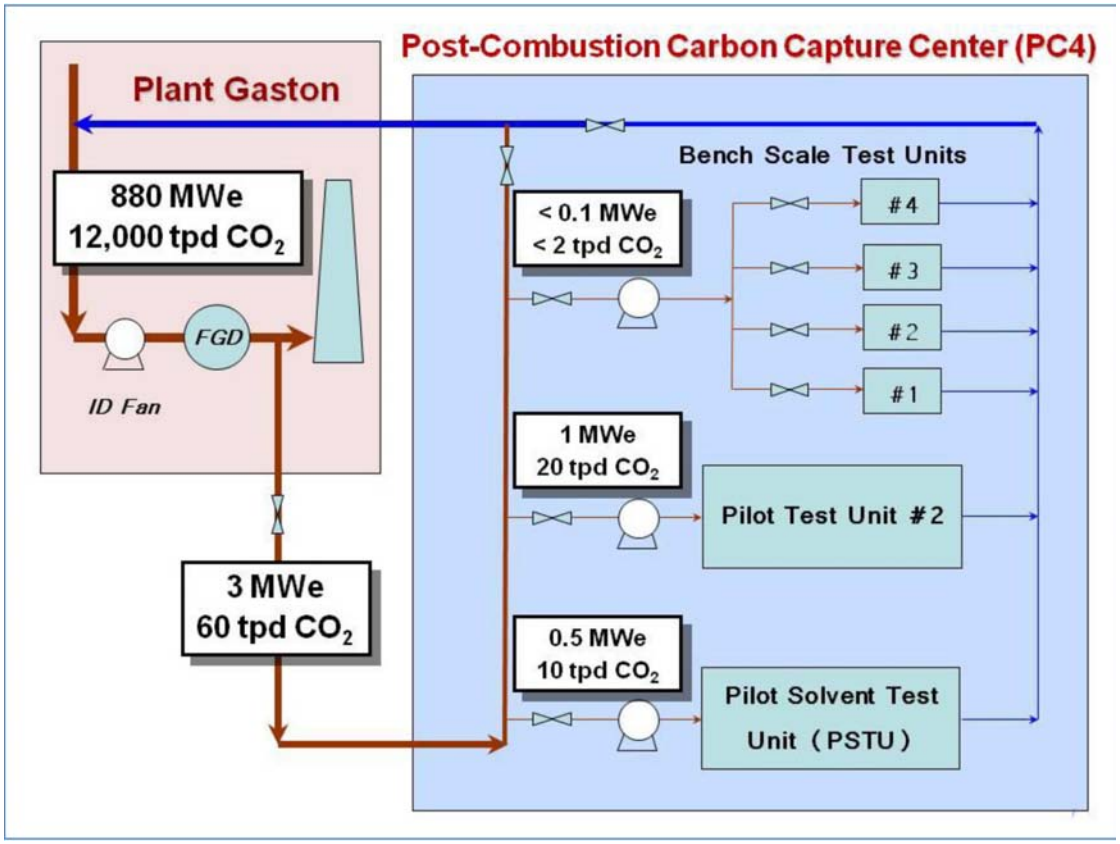

Figure 1. Diagram of the Post-Combustion Carbon Capture Center Test Facility.

Accomplishments

- DOE and NCCC jointly developed and instituted a Technology Screening Process (TSP) as an evaluation tool to assess and prioritize technologies for testing. The current TSP inventory contains more than 300 candidate technologies and is updated annually to ensure inclusiveness of the list.
- A preliminary screening study was conducted with favorable results for oxy-combustion CO_2 capture using the pressurized transport reactor. Detailed system studies, modeling, and additional economic analysis are in progress to further evaluate commercial feasibility of this technology.

- A pilot solvent test unit (PSTU) for testing developers' next generation of CO_2 absorption solvents has been designed, constructed, and commissioned. This is one of three major areas included in the Post-Combustion Carbon Capture Center (PC4) test facility, Figure 1, which is being built to accommodate tests of a wide-range of capture technologies from flue gas. Testing of advanced solvents in the PSTU, CO_2-selective membranes, and CO_2 sorbents will begin in late 2011.

- The Syngas Conditioning Unit (SCU) in the pre-combustion CO_2 capture area has been modified to improve the gas analyzer capability, increase the electrical and instrumentation infrastructure, upgrade the temperature control systems, and increase the syngas flow for membrane testing.

- Five test campaign runs have been carried out in support of CO_2 capture technology testing. Reliable syngas produced with either Powder River Basin (PRB) sub-bituminous coal, lignite coal, or coal/biomass co-feed was delivered to the SCU at various quality and conditions. A number of advanced CO_2 absorbing chemical and physical solvents, various hydrogen- and CO_2-selective membranes, Water Gas Shift (WGS) catalysts, high temperature mercury capture sorbents, and solid oxide fuel cells were tested. Performance data generated have been used to validate laboratory data under ideal conditions and allow for engineering design for scale up.

- WGS catalyst tests have been conducted which reveal that steam-to-carbon monoxide (CO) ratios can be reduced, which in turn increases the net power output of an Integrated Gasification Combined Cycle (IGCC) plant and reduces the cost of electricity with CO_2 capture. Results have been supplied to catalyst suppliers and findings are being implemented at a commercial IGCC plant now under construction. The impact at one plant translates to an operational savings of over $200 million over the life of the plant.

Studies to Improve Plant Availability and Reduce Total Installed Cost

Performer: GE Energy
Date: 9/29/2011-9/30/2014
Cost: $4,937,219

General Electric (GE) Energy has partnered with NETL to study the feasibility of improving plant availability and reducing total installed costs in IGCC plants. The project will complete eight techno-economic studies each focused on the cost, availability criterion, or both where applicable. The scope of work will include the identification of system and component level requirements for each task and subtask; the development of designs and materials as required for technical evaluation of concepts; validation and testing of components/sub-systems; and the development of appropriate operating methodologies, simulations, and controls philosophies where applicable.

The objective of this project is to evaluate the effects to total installed cost and availability through deployment of a multi-faceted approach in (1) technology evaluation, (2) constructability, and (3) design methodology. The technologies may individually improve just availability, just cost or, in some cases, both; when grouped together, the probability of successfully meeting the objectives of increased availability with decreased costs are significantly higher. The project will also benefit a large portion of the gasification industry from IGCC to chemical applications.

Mitigation of Syngas Cooler Plugging and Fouling

Performer: Reaction Engineering International
Date: 9/30/2011–9/30/2014
Cost: $1,441,250

Reaction Engineering International (REI) has partnered with NETL to explore the mitigation of syngas cooler plugging and fouling. The project will use a combination of impinging-jet laboratory scale experiments to evaluate deposit strength for a range of temperatures, surface materials, and fuel properties, modeling to assist in test design and data interpretation, and Computational Fluid Dynamic (CFD) modeling to investigate deposition, plugging, and fouling in the syngas cooler (SC) as well as to evaluate alternative process conditions and equipment designs to mitigate fouling and plugging.

The project objectives are to (1) develop a better understanding of ash deposition onto refractory and metal surfaces associated with the SC used in IGCC plants that incorporate a 2-stage gasifier, (2) evaluate plugging and fouling of SC designs, (3) develop methods to mitigate syngas cooler plugging and fouling, and (4) define and begin to validate specific means to implement mitigation methods. The successful completion of these objectives will result in improved availability and reliability of the SC and thereby improve the availability of the overall IGCC plant. Improving the performance of the SC through reduced plugging and fouling will improve the reliability, availability, and maintainability of IGCC plants, thereby making IGCC plants more competitive with conventional plants.

Carbon Dioxide Coal Slurry for Feeding of Low Rank Coal to Gasifier

Performer: Electric Power Research Institute
Date: 9/29/2011-9/30/2012
Cost: $995,603

Electric Power Research Institute (EPRI) has partnered with NETL to research CO_2 coal slurry for feeding low rank coal to gasifiers. This project will conduct an engineering study supported by computer simulations, laboratory work, and mechanical engineering design evaluations. The project aims to help reduce the cost and improve the efficiency of integrated gasification combined cycle (IGCC) with carbon capture and storage (CCS) by using a portion of the existing high CO_2 purity product stream as the carrier fluid to feed low rank coal (LRC) into the gasifier.

The outcome of the design effort will help lead the way to integrating LRC/ liquid CO_2 (LCO_2) slurry feed systems into future systems for prototype testing at an IGCC with CCS power plant. The successful completion of the project will also lead to confirmation of plant-wide performance and cost advantages for IGCC with CCS applications; acquisition of first-of-a-kind rheology data including viscosity and solids loading measurements, which are required to determine pressure drops, onset of turbulence, and agglomerate breakup of coal particles in LRC/LCO_2 slurries for designing and sizing equipment for large-scale industrial applications

Evaluation of the Benefits of Advanced Dry Feed System for Low Rank Coal

Performer: General Electric Company
Date: 9/30/2011 – 9/30/2012
Cost: $868,992

General Electric (GE) Energy has partnered with NETL to evaluate the benefits of an advanced dry feed system on the use of low rank coal in IGCC technologies. This project will complete comparative techno-economic studies of two IGCC power plant cases, one without and one with advanced dry feed technologies. A common basis of design will be developed so that overall assumptions and methodologies are common to the two cases for both technical and economic areas. The baseline case, without advanced dry feed technologies, will use operational data from the Eastman Chemical Company Kingsport gasification facility in combination with the DOE case study for IGCC using a low-rank coal with 90 percent carbon capture for both cost and performance comparisons.

The overall objective of this project is to evaluate and demonstrate the benefits of novel dry feed technologies to effectively, reliably, and economically provide feeding of low-cost low-rank coals into commercial IGCC systems. This study will focus on IGCC systems with 90 percent CCS, but the dry feed system will be applicable to all IGCC power generating plants and other industries that require pressurized syngas. A feed system based around the Posimetric® pump has the potential to provide a simpler, lower cost system with improved control and reliability. Successful demonstration of this advanced dry feed technology will allow utilization of vast reserves of low rank coal in the United States for power production and other applications.

RECOVERY ACT: Scale-Up of High-Temperature Syngas Cleanup Technology

Background

Coal gasification generates a synthesis gas (syngas)—predominantly a mixture of carbon monoxide (CO) and hydrogen (H_2)—that can be used for chemical production of hydrogen, methanol, substitute natural gas (SNG), and many other industrial chemicals, or for electric power generation. Conventional integrated gasification combined cycle (IGCC) power plants use this syngas as a fuel for a combustion turbine to produce power.

In an effort to advance these technologies, the Department of Energy (DOE) has awarded funds from the American Recovery and Reinvestment Act (ARRA) for expanding advanced projects to accelerate the development of technology. Specifically, the DOE's National Energy Technology Laboratory (NETL) is partnering with RTI International (RTI) to develop and scale up a high-temperature syngas cleanup technology for commercial deployment enabling improved thermal and environmental performance with lower costs in IGCC power and chemical production plants.

This project also includes Carbon Capture and Sequestration (CCS) supporting the DOE's vision of coal plants with near-zero emissions by reducing the cost and improving the efficiency of capturing and sequestering carbon dioxide (CO_2) and removing impurities from syngas derived from coal. This project will be the first to accomplish large-scale testing of high-temperature syngas cleanup technology enabling subsequent commercial deployment.

Description

RTI and its project partners will mitigate the technical risk associated with scale-up of high-temperature syngas cleanup and CCS technologies for coal gasification by designing, constructing, and operating a pre-commercial scale high-temperature syngas cleanup unit with integrated CCS technology. This pre-commercial high-temperature syngas cleanup system will clean part of the syngas from a 250 megawatt (MW) commercial IGCC power plant. The RTI cleanup unit will

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PERIOD OF PERFORMANCE

7/20/2009 to 9/30/2015

COST

Total Project Value
$177,756,400

DOE/Non-DOE Share
$171,792,957 / $5,963,443

Government funding for this project is provided in whole or in part through the American Recovery and Reinvestment Act.

clean about 20% of the total plant syngas, qualifying operation under actual commercial conditions. CCS technology scale-up will encompass CO_2 capture from the syngas, and injection into a deep saline aquifer for long-term geologic storage. The syngas cleanup system produces a syngas product that is suitable for chemical production and a CO_2 by-product that may be easily sequestered or used for enhanced oil recovery.

The high-temperature syngas cleanup system will consist of the High Temperature Desulfurization Process (HTDP). The high-temperature syngas cleanup system will remove more than 99.9 percent of the sulfur (S) from coal-derived syngas. A smaller scale Trace Contaminant Removal Process (TCRP) unit to remove multiple trace impurities will also be tested at temperature and pressure to seamlessly integrate with the HTDP. Separation of CO_2 from the clean syngas will be accomplished using activated methyl-diethanolamine (MDEA) solvent technology. Integration of an activated MDEA process with high-temperature syngas cleanup provides both economic and performance benefits.

The site for this project is the Tampa Electric Company (TECO) IGCC facility at Polk Power Station located near Tampa, Florida, which is fueled by a blend of petroleum coke and coal. Data on thermal efficiency, emissions, and cost benefits will be gathered during 8,000 hours of testing the high-temperature syngas cleanup system. Operation of the CCS system will entail capture of 90% of the CO_2 present in syngas and subsequent sequestering of 210,000 tons of CO_2 per year in a deep saline aquifer present at the Polk Power Station site for long-term geologic storage.

Tampa Electric Company's IGCC Plant, Polk Power Station

Goals and Objectives

The primary goal of this project is to mitigate the technical risk associated with scale-up of high-temperature syngas cleanup and CCS technologies for coal gasification to facilitate subsequent commercial deployment. The project team will commission the syngas cleanup system and operate the system for at least 5,000 hours. During operation, at least 300,000 tons of CO_2 will be captured by the syngas cleanup system and sequestered into a deep saline aquifer. In addition, operation of the syngas cleanup system will be used to establish reliability, availability, and maintenance targets for a full-scale commercial system; establish commercial operating experience; provide operator training for a commercial system; and develop process designs to meet the DOE contaminant removal performance goals for chemical production from syngas for impurities listed in the table below.

DOE Performance Goals	
Impurity	**Maximum After Cleanup**
Total Sulfur	50 parts per billion (ppb)*
Mercury	5 ppb by weight *
Selenium	200 ppb*
Arsenic	5 ppb*
CO_2	>90 percent removed**

*At pressure ≥ 600 pounds per square inch; temperature ≥ 400° Fahrenheit

** With <10 percent contribution to increase in Cost of Electricity

Accomplishments

A pre-FEED, or process design package, has been developed for the high-temperature syngas cleanup units utilizing the experimental information available from bench-scale testing and the Eastman pilot plant test with real coal-derived syngas. The design basis for the Front End Engineering Design (FEED) package was finalized and the FEED design has been completed.

A Final Environmental Assessment (EA) document has been issued for this project in compliance with DOE's National Environmental Policy Act (NEPA) implementation procedures. In conjunction with this Final EA document, DOE has issued a Finding of No Significant Impact (FONSI) for this project.

Benefits

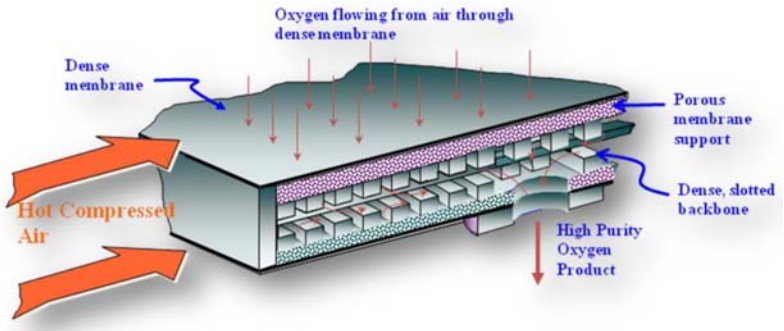
A DOE-funded and an independent system study predict that the RTI high-temperature syngas cleanup process for an IGCC plant will increase overall IGCC thermal efficiency by two to three percentage points and reduce the cost of electricity by six percent. Integrating this technology with activated MDEA solvent technology for CO_2 separation has the potential to minimize the impact of carbon capture on consumer electricity costs and accelerate CCS deployment. By using domestic coal resources, this system also has the potential to reduce the cost of producing chemicals, transportation fuels, and substitute natural gas, thereby enhancing America's energy security and economic prosperity.

Development of Ion Transport Membrane (ITM) Oxygen Technology for Integration in IGCC and Other Advanced Power Generation Systems

Background

The Gasification Technologies Program at the National Energy Technology Laboratory (NETL) supports research and development (R&D) in the area of gasification — a process whereby carbon-based materials (feedstocks) such as coal are converted into synthesis gas (syngas), which is shifted and separated into hydrogen (H_2) and carbon dioxide (CO_2) gas streams and uses a combustion turbine-generator as a way to generate clean electricity while preventing the release of CO_2. The focus of the Gasification Technologies Program is to support R&D that offers the potential to substantially improve the cost, efficiency and environmental performance of gasification systems. Within this R&D portfolio, novel approaches are being investigated for oxygen (O_2), H_2, and CO_2 separation under varying operating conditions.

To accelerate the advancement of these technologies, the Department of Energy (DOE) has awarded funds from the American Recovery and Reinvestment Act (ARRA) to expand advanced projects that would contribute to the development of industrial carbon capture and storage (ICCS) technologies at large scale. Specifically, this project will accelerate technology development by supporting domestic manufacturing capabilities for the membrane technology while concurrently pursuing a pilot scale demonstration of the membrane-based separation process. Novel membrane processes offer the potential to lower costs for separating gases and enabling CO_2 management more efficiently with a fully integrated advanced power carbon capture system. Following successful completion, this advanced technology will be ready for scale-up to large-scale systems for clean power, including industrial energy applications.



Ion transport Membrane Wafer Architecture to enable separation of Oxygen from Air

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PROJECT DURATION

Start Date
10/01/1998

End Date
06/30/2014

Project Description

Air Products and Chemicals, Inc., is currently developing ion-transport membrane (ITM) oxygen separation technology for large-scale oxygen production and for integration with advanced power production facilities, including gasification. The ITM Oxygen process uses dense, mixed ion and electron conducting materials that can operate as hot as 900 degrees Celsius (°C). The driving forces for the membrane oxygen separation are determined by the oxygen partial pressure gradient across the membrane. The energy of the hot, pressurized, non-permeate stream is typically recovered by a gas turbine power generation system. The development of the ITM process will support reduced capital cost and parasitic load of air separation systems compared to that of currently available cryogenic air separation technology. Because air separation is a critical component of the gasification process for power production, any reduction in the cost of this component will in turn reduce the overall costs of gasification, thereby making the process more competitive.

Goals and Objectives

The ITM Oxygen project will develop and scale up a novel, non-cryogenic air separation technology with lower capital cost and energy requirements than conventional cryogenic processes to produce high-temperature/high purity oxygen synergistically with IGCC and other advanced power generation technologies.

This project has been funded through several phase, with some objectives from previous phases already completed. The initial activities focused on materials and process R&D, and the design, construction, and operation of an approximately 0.1 ton per day (TPD) Technology Development Unit (TDU). The TDU test data allowed the establishment of cost and performance targets for stand-alone, tonnage-quantity, commercial ITM Oxygen plants, and integration schemes of ITM Oxygen with IGCC and other advanced power generation systems.

Subsequent activities were focused on testing the performance of full-size ITM Oxygen modules in a 5 TPD Sub-scale Engineering Prototype (SEP) facility specially designed for this purpose. The team fabricated thin, cost-optimized, multi-layer ITM devices that achieved oxygen production rates exceeding commercial performance targets at anticipated commercial operating conditions with significant operating lifetime. ITM Oxygen modules were scaled up to commercial size, built, and tested. Tests conducted in the SEP generated process information for the current activity.

The current objectives are to increase the scale of the engineering test facility from 5 TPD to approximately 100 TPD of oxygen in an intermediate-scale test unit (ISTU). The ISTU features oxygen production from an ITM coupled with turbo machinery for power co-production, and will provide data for further scale-up and development. In addition, and to support a larger test facility, expanded efforts in the areas of materials development, engineering development, ceramic processing development, and component testing are being undertaken. The project will also assess the overall reliability of the process relative to the industry standard.

Also, the project has additional concurrent planned objectives which include (1) the development of the manufacturing capability needed to support ITM technology commercialization and (2) preliminary design concepts for a 2,000 TPD ITM Oxygen gas production plant.

Accomplishments

Air Products and Chemicals, Inc., has achieved the following accomplishments over the entirety of this project:

- Developed a stable, high-flux material; demonstrated stable operation in the 0.1 TPD TDU.
- Demonstrated the commercial flux target under anticipated commercial operating conditions.
- Devised a planar ITM architecture.
- Scaled-up and produced commercial-size wafers in large quantities.
- Reconfirmed the economic benefits of the technology.
- Built first commercial-scale ITM Oxygen modules.
- Completed detailed design of SEP vessel capable of housing full-size ITM Oxygen modules to produce an estimated 5 TPD of O_2 at full commercial conditions of 200–300 psig and 800–900 °C.
- Completed construction of major equipment items for the 5 TPD SEP facility for testing full-size ITM modules for producing 1 to 5 TPD of O_2 at near 95 percent purity.
- Tested full-size ITM Oxygen modules in the SEP facility and produced O_2 near 95 percent purity and generated process information for further scale up to the ISTU.
- Completed reassessment of the status of ITM Oxygen economic evaluations and updated process economics.
- Completed subscale wafer flux evaluation studies with feed air impurities and determined the effect of potential impurities on the cost and engineering performance of ITM systems.
- Confirmed machinery integration pathways.
- The 5 TPD SEP was operated for over 18,000 hours; commercial flux targets were achieved or surpassed, and product purity exceeded 99 percent.
- Implemented patented advanced process control techniques during heating and cooling at SEP to improve module reliability.
- Two 0.5 TPD ITM modules were successfully tested in the SEP utilizing a prototype flow duct design. The flow duct design will be scaled up to support 1-TPD ITM module operation and fabrication techniques are transferable to the ISTU.
- Successfully tested 1-TPD modules in the SEP.
- Determined the 100 TPD ISTU vessel design and scalability criteria and completed the conceptual 100 TPD ITM Oxygen pressure vessel design.
- Completed the 100 TPD facility conceptual design by including major elements of a commercial ITM Oxygen facility.
- Completed economic assessment of carbon capture power plant cases with ITM Oxygen that feature carbon capture and sequestration technology options.
- Developed and selected a supported getter material that will remove gas phase chromium species upstream of the ITM modules.

COST

DOE/ARRA Funded

Total Project Value
$288,009,889

DOE/Non-DOE Share
$195,956,463 / $92,053,426

Government funding for this project is provided in whole or in part through the American Recovery and Reinvestment Act.

Benefits

The project will accelerate commercial manufacture of ion transport membrane modules and initiate the development of a 2,000 TPD pre-commercial scale facility ahead of schedule, enabling this technology to enter the marketplace at least two years earlier than previously projected. The ITM technology will produce O_2 at higher efficiencies and at lower capital and operating costs than state-of-the-art cryogenic O_2 production systems, benefitting domestic O_2-intensive industrial processes in terms of cost, efficiency, and productivity improvements, such as those involved in the making of aluminum, glass, and steel. Successful development of ITM will also lower the cost of oxy-combustion configurations, enabling lower-cost CO_2 capture.

Scale-Up of Hydrogen Transport Membranes

Background

In the gasification process, carbon-based feedstocks, such as coal, are converted into a gaseous mixture of hydrogen (H_2), carbon monoxide (CO), carbon dioxide (CO_2), and steam called synthesis gas (syngas). The syngas is processed in a water-gas shift reactor, which converts CO into CO_2 while producing additional H_2, thus increasing the CO_2 and H_2 concentrations. Carbon dioxide is present at a higher temperature and at much higher concentrations in shifted syngas than in flue gas, which enables shifted syngas to be more efficiently separated into H_2 and CO_2 gas streams. The H_2 is used in a combustion turbine to generate clean electricity, while the CO_2 gas stream may be captured for reuse or storage.

The Gasification Technologies Program at the National Energy Technology Laboratory (NETL) supports research and development in the area of advanced gas separation. NETL's advanced gas separation research focuses on the potential for substantial improvements in process efficiency and environmental and cost performance of gasification systems. Several novel approaches are being investigated for H_2 and CO_2 separation under varying operating conditions.

Eltron Research & Development Inc. (Eltron) has been developing a hydrogen transport membrane (HTM), a reaction-separation system, for energy-efficient hydrogen production and carbon capture. This project is funded in part by monies from the American Recovery and Reinvestment Act (ARRA) intended to accelerate the scale-up of an HTM technology system for energy-efficient hydrogen production and carbon capture, and to enable early technology commercialization by reducing time, technology risk, and cost.

Project Description

Eltron's HTM technology uses composite metal alloy materials for separating H_2 at practical rates from coal-derived syngas. Carbon dioxide on the feed side of the membrane remains at high pressure and in a concentrated form suitable for capture and re-use or storage. The Eltron HTM system is an enabling module for the production of high-purity H_2 and the capture of CO_2 at high pressure, which is applicable to future integrated gasification combined cycle (IGCC) power plants and central station H_2-production plants. These novel membranes have an operating temperature of 280–440 degrees Celsius, which is well matched with emerging coal gas–cleaning technologies and can significantly improve the overall efficiency and

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PROJECT DURATION

Start Date
08/16/2005

End Date
09/30/2015

COST

Total Project Value
$87,662,900

DOE/Non-DOE Share
$82,547,725 / $5,115,175

Government funding for this project is provided in whole or in part through the American Recovery and Reinvestment Act.

process economics for future gasification-based power, fuels, and chemical production plants. Eltron's membranes can withstand high differential pressures of up to 1,000 pounds per square inch gauge (psig) without structural failure, allowing for successful integration into advanced, high-pressure coal gasification plants.

Eltron is currently executing the project in two distinct parts:

- Part 1, titled "Scale-up of Hydrogen Transport Membranes for IGCC and Coal-to-Hydrogen Production Plants," is the base project.

- Part 2, titled "Scale-up of Hydrogen Transport Membranes (HTM)," is the ARRA-funded extension of the project.

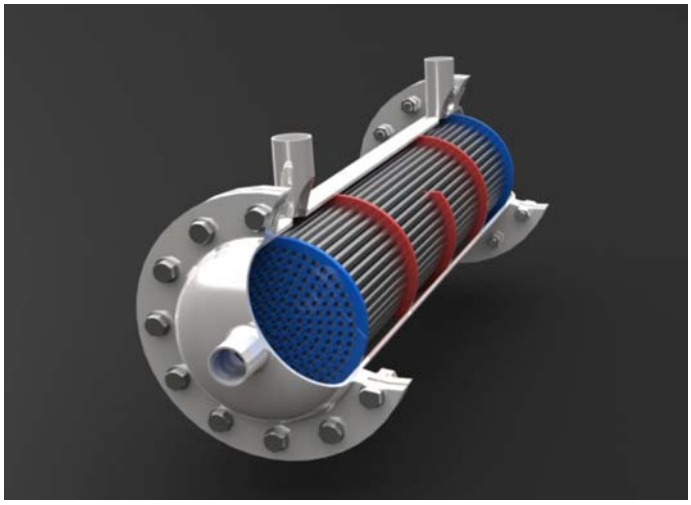
In Part 1, Eltron has sub-contracted Eastman Chemical Company as the site for scale-up and testing of its HTM technology. Eltron will design and construct a nominally 12-pound-per-day HTM module and operate it on coal-derived syngas from an Eastman gasifier. In Part 2, Eltron will accelerate the design, construction, and operation of a 250-pound-per-day module and further scale the technology up to a nominal 4- to 10-ton-per-day hydrogen production module. Eltron has sub-contracted URS as the engineering, procurement, and construction firm.

Goals and Objectives

The project will develop and scale up the HTM technology to cost-effectively separate H_2 from shifted coal-derived syngas at practical rates and retain CO_2 at high pressure, up to 1,000 psig, to minimize capital and compression costs for carbon capture, utilization, and storage (CCUS) applications. The HTMs are capable of producing pure H_2 at temperatures that approach commercial water-gas shift reaction conditions, thus allowing process intensification via an integrated reaction-separation system, with the potential to significantly improve the cost and efficiency of relevant industrial applications. The project will ready the HTM technology for early commercial deployment by accelerating the construction and test schedule of a 250-pound-per-day prototype H_2-separation module and, in parallel, continue activities for a 4- to10-ton-per-day pre-commercial module. The ARRA-funded efforts will significantly accelerate the design, construction, and operation of the prototype pre-commercial module; provide a head start on analyses of cost, performance, and engineering data for future integrated clean energy systems; and accelerate transfer of an enabling technology to the manufacturing sector.

Accomplishments

- Engineered novel HTM materials for producing pure H_2 from coal-derived synthesis gas. In bench-scale tests, the materials met the U.S. Department of Energy's 2010 targets for sulfur tolerance, economic life, and operating conditions, and they surpassed those for hydrogen production rate, product purity, and cost.
- Demonstrated the HTM hydrogen production technology at a 1.5-pound-per-day scale, meeting designed H_2 production rate and product purity.
- Demonstrated improved economics for scenarios utilizing HTM technology in coal-based IGCC plants with a refined process flow sheet.
- Successfully scaled manufacturing and catalyst deposition to 5-foot-long HTM tubes. Designed, constructed, and operated a 12-pound-per-day reactor to test the hydrogen membrane tubes under 16 different sets of pressure, temperature, and flow rate conditions, using a slipstream of coal-derived syngas at Eastman Chemical's gasifier in Kingsport, Tenn.



Conceptual design of a commercial membrane unit

Benefits

An HTM device separates H_2 from coal-derived shifted syngas, generates capture-ready CO_2, and serves as an enabling CCUS module for future IGCC power plants integrated with CCUS. The Eltron HTM achieves H_2 recoveries approximating 90 percent at high pressures, with essentially pure H_2 as a product, and it provides a viable step forward for a future H_2-fueled energy economy by using abundant domestic coal feedstocks. In addition, the Eltron HTM system separates and maintains CO_2 at high pressure, thereby minimizing compression costs for pipeline transportation to storage sites.

Advanced Acid Gas Separation Technology for the Utilization of Low Rank Coals

Performer: Air Products and Chemicals, Inc.
Date: 9/30/2011 – 12/31/2012
Cost: $999,930

Air Products and Chemicals, Inc., is partnered with NETL to test advanced acid gas separation technology for the utilization of low rank coals. Air Products will conduct extensive testing using a mobile, two-bed Sour PSA unit fed with North Dakota lignite coal-based syngas streams. This testing will be conducted in collaboration with the Energy and Environmental Research Center (EERC) at the University of North Dakota, utilizing their fluidized bed gasifier. Measurements of adsorbent and PSA unit performance over time will be collected and analyzed. In addition to pressure swing, the adsorbent system will be operated in thermal swing adsorption (TSA) mode to determine performance when exposed to syngas derived from lower rank coal.

The objective of this project is to test the performance of Air Products Sour PSA on a gaseous mixture generated from the gasification of lower rank, lignite coal and to perform a techno-economic analysis to predict the change in COE from incorporation of Sour PSA into a base 90 percent CO_2 capture IGCC power plant design utilizing low rank coal. The results from PSA and TSA testing will help determine if a PSA alone, or a combination of TSA followed by PSA, will provide for more robust operation. The results of this testing will be used to generate a high-level pilot process design, and to prepare a techno-economic assessment to evaluate the applicability of the technology to plants utilizing these coals.

Advanced CO_2 Capture Technology for Low Rank Coal IGCC Systems

Performer: TDA Research, Inc.
Date: 9/30/2011 – 9/30/2012
Cost: $625,000

TDA Research, Inc (TDA), partnered with NETL, will demonstrate the technical and economic viability of a new IGCC power plant designed to efficiently process low rank coals. The plant uses an integrated CO_2 scrubber/Water Gas Shift (WGS) catalyst to capture over 90 percent capture of the CO_2 emissions, while increasing the COE by less than 10 percent compared to a plant with no carbon capture.

TDA's goal is to optimize the sorbent/catalyst and process design, and assess the efficacy of the integrated WGS/CO_2 capture system, first in bench-scale experiments and then in a slipstream field demonstration using actual coal-derived syngas (to date the sorbent and catalyst have only been tested separately). Project results will feed into a techno-economic analysis using Aspen Plus™ software to estimate the impact of the contaminant tolerant WGS catalyst/CO_2 capture system on the thermal efficiency of the plant and COE.

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PROJECT FACTS

Gasification

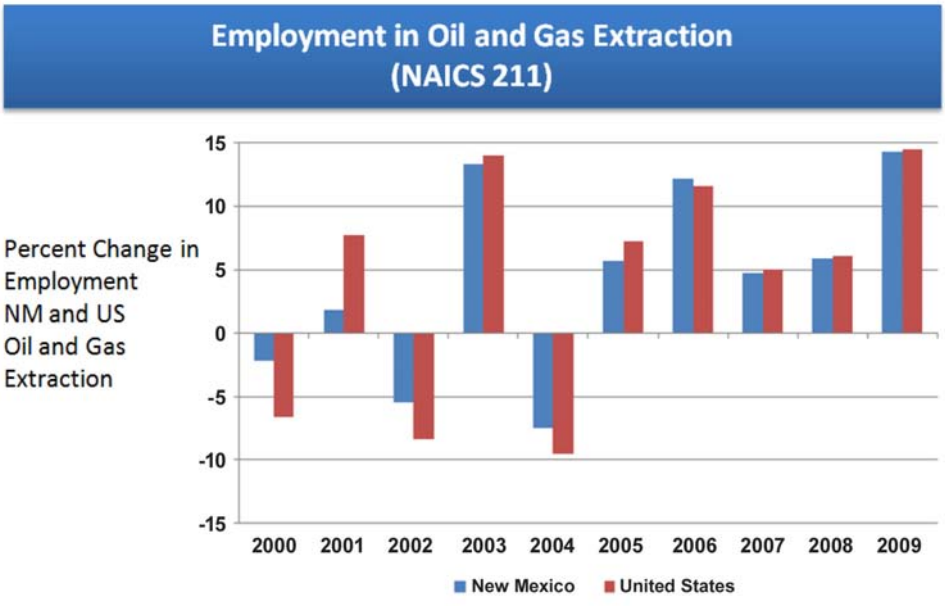
Arrowhead Center to Promote Prosperity and Public Welfare in New Mexico

Background

Domestic production of fossil fuels is becoming increasingly important as worldwide demand for energy rises. The natural abundance of fossil fuel resources in New Mexico and the lack of dense population in the areas where these resources occur provide significant potential for economic development in the state while supplying energy markets with vital supplies. Significant hurdles to the effective use of New Mexico's fossil fuels include limited water for agriculture, industry, and municipal uses and and low levels of economic development. A full analysis of the barriers to increased development and delivery of New Mexico's fossil fuels is lacking and is a priority of the project.

Project Description

The Arrowhead Center to Promote Prosperity and Public Welfare (PROSPER) of the New Mexico State University (NMSU) is conducting research analyzing the relationships between the fossil fuel energy sector and economic development issues in New Mexico. The project is a research and policy initiative to enhance fossil fuel energy production and use in New Mexico in an environmentally progressive manner that contributes to the economic development of the state and creates



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PROJECT DURATION

Start Date
10/01/2008

End Date
09/30/2011

COST

Total Project Value
$1,181,175

DOE/Non-DOE Share
$944,940 / $236,235

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a strong, vibrant economy that better serves the citizens of New Mexico. The project is engaging stakeholders in the research process and assessing (1) the impact of the fossil fuel industry on water resources in New Mexico, and (2) how the increasing worldwide demand for fossil fuels impacts energy production in New Mexico.

PROSPER is performing a full analysis of the barriers to increased development and delivery of New Mexico's fossil fuels over a three-year period utilizing faculty, staff, and graduate students in research, analysis, and outreach tasks. The project is being executed in phases, with the first year being devoted to stakeholder consultation on critical issues, identifying and prioritizing needs, and performing a comprehensive analysis of the fossil fuel energy sector. Research on critical issues identified during year one activities will be performed in years two and three. The PROSPER project provides analysis capabilities on economic issues related to fossil fuels and the project outcome is (1) policy briefs, (2) research articles, and (3) outreach and dissemination of results to stakeholders via website, print, and electronic media.

Goals/Objectives

The primary project goal is to enhance fossil fuel energy production and use in New Mexico in an environmentally responsible manner that contributes to the economic development of the state. PROSPER is assessing:

- The impact of the fossil fuel industry on water resources in New Mexico.
- The effects of changes in the fossil fuel industry on the New Mexico economy, with a special emphasis on the number and types of jobs created and the tax revenue generated by the fossil fuel industry.
- How increasing worldwide demand for fossil fuels impacts energy production in New Mexico.
- How to use New Mexico's fossil fuel resources to foster long term prosperity in New Mexico and the Southwest.

Accomplishments

A comprehensive and widely used dynamic simulation model for regional economies, developed by Regional Economic Models, Inc. (REMI), was acquired by NMSU and is now installed and fully operational. This version, customized for New Mexico, contains 169 sectors linked to the national model and is being used to simulate and forecast various energy price, production, and policy scenarios and their potential effects on the New Mexico economy, and to examine the implications of the peak oil hypothesis on the New Mexico economy and analysis of the effects of energy market volatility. These studies have been presented at professional conferences.

"The Fossil Fuel Industry in New Mexico: A Comprehensive Impact Analysis" was developed by the project team. The report details the comprehensive economic impacts of fossil fuel energy on a state economy. This report includes analysis results from previous reports on oil and gas extraction and coal mining in New Mexico and added fossil fuel related sectors: (1) petroleum refineries, (2) gasoline retailers, (3) electricity generation from fossil fuels, (4) natural gas pipeline transportation, and (5) natural gas distribution.

The PROSPER project has sponsored two conferences. In March 2009, the project sponsored a conference on "Enegy and Economic Development in New Mexico". A "Re-Energize America Conference" was sponsored by New Mexico State University in 2010. Details of the conference are available at http://energize.nmsu.edu/. The conference attendance was over 500 and allowed new contacts of energy stakeholders for the PROSPER project.

A project website, http://arrowhead.nmsu.edu/arrowheadcenter/prosper/presentations.html, is operational.

A technical report titled "Oil and Gas Production and Economic Growth in New Mexico" has been completed . A revised version of the report will be published in the Journal of Economic Issues in the near future.

A report entitled "The Economic Impact of the Coal Industry in New Mexico: An Update" has been developed. The analysis was conducted using a major update to the economic modeling software (IMPLAN Pro Version 3.0). The direct, indirect, and induced impacts of coal mining in New Mexico are presented in terms of output, value added, employment, and labor income for calendar year 2008. Tax, rental, and royalty income to the state are also presented. Historical coal production, reserves, and price data are also discussed. The economic impact analysis presented in this report suggests that coal mining is an important sector of the New Mexico economy.

Benefits

The PROSPER project seeks to find ways to improve the utilization of fossil fuel resources in New Mexico to create a strong, vibrant economy for the state. This project provides timely, in-depth, cutting-edge economic analysis of the issues that are identified as most critical to the development and utilization of New Mexico's fossil fuels and aid New Mexico in producing and delivering the energy the nation needs. The outreach activities provide public sector and industry policy-makers with the information and analysis needed to enhance New Mexico's energy economy.

NT04397, March 2011

Appendix B – Gasification Systems Resources

To ensure that the Gasification Systems Program continually addresses current and future needs, DOE/NETL relies on outreach activities, such as publications, workshops, a comprehensive website, and participation in open forums. These outreach efforts help foster wider awareness and understanding of the benefits of gasification technologies and products.

Gasification Systems webpage - A resource for information on the sub-program and its ongoing research, it was developed by NETL as part of its effort to educate the public about gasification.
http://www.netl.doe.gov/technologies/coalpower/gasification/index.html

Gasifipedia – A comprehensive online collection of resources to promote better understanding of gasification technology. It contains both introductory and in-depth information about gasification fundamentals, supporting technologies, gasification applications, environmental benefits, and the status of the latest RD&D.
http://www.netl.doe.gov/technologies/coalpower/gasification/gasifipedia/TOC.html

Worldwide Gasification Database – Includes information about syngas capacity, feedstock, product, gasifier technology, plant owner/operator, and location for all gasification plants worldwide, it describes the current world gasification industry and identifies near-term planned capacity additions.
http://www.netl.doe.gov/technologies/coalpower/gasification/worlddatabase/index.html

Gasification Systems Reference Shelf - NETL's Gasification Systems Reference Shelf provides numerous, valuable gasification resources, including: brochures, conferences and workshops, fact sheets, patents, presentations, and, technology and cost/performance studies.
http://www.netl.doe.gov/technologies/coalpower/gasification/ref-shelf.html

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January 2012