PROJECT facts

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

Gasification Technologies

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# FUEL-FLEXIBLE GASIFICATION-COMBUSTION TECHNOLOGY FOR PRODUCTION OF HYDROGEN AND SEQUESTRATION-READY CARBON DIOXIDE

## CONTACTS


**Gary J. Stiegel**
Gasification Technology Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236
412-386-4499
gary.stiegel@netl.doe.gov

**Kamalendu Das**
Project Manager
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507
304-285-4065
kamalendu.das@netl.doe.gov

**George Rizeq**
Principal Investigator
GE Global Research
18A Mason
Irvine, CA 92618
949-330-8973
rizeq@research.ge.com

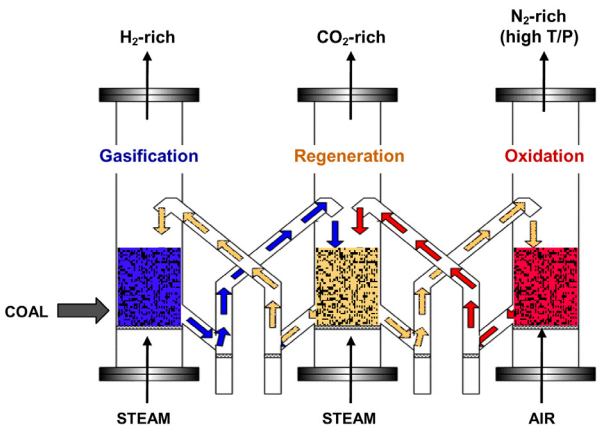

## Description

Projections of increased demands for energy worldwide, coupled with increasing environmental concerns have given rise to the need for new and innovative technologies for coal-based energy plants. Incremental improvements in existing plants will likely fall short of meeting future capacity and environmental needs economically. Thus, the implementation of new technologies at large scale is vital. In order to prepare for this inevitable paradigm shift, it is necessary to have viable alternatives that have been proven both theoretically and experimentally at significant scales. The U.S. DOE's Gasification Technologies program aims to support these development needs through funding the development of enabling technologies such as the GE Global Research Unmixed Fuel Processor (UFP).

GE Global Research is developing the innovative UFP technology for conversion of coal to hydrogen and electricity with inherent $CO_2$ separation. It is expected to meet or exceed all environmental requirements economically. The technology utilizes three circulating fluidized beds to convert coal, steam and air into separate streams of (1) hydrogen-rich gas that can be utilized in fuel cells or turbines, (2) sequestration-ready $CO_2$, and (3) high temperature and pressure vitiated air to produce electricity in a gas turbine. The process produces near-zero emissions and is projected to have higher process efficiency than conventional technologies with $CO_2$ separation. This project integrates experimental testing, modeling and economic studies to demonstrate the UFP technology.

Early in the project, UFP feasibility was demonstrated at bench scale. A pilot-scale system was designed, fabricated and tested. Additional bench-scale testing will characterize bed material attrition and lifetime, while pilot plant testing will identify final disposition of pollutants and optimized pilot plant operating performance.

The UFP technology makes use of three circulating fluidized bed reactors containing a $CO_2$ sorbent and an oxygen transfer material (OTM). Coal is partially gasified with steam in the first




*Conceptual design of the UFP technology*

reactor, producing $H_2$, CO and $CO_2$. As $CO_2$ is absorbed by the $CO_2$ sorbent, CO is also depleted from the gas phase via the water-gas shift reaction. Thus, the first reactor produces a $H_2$-rich product stream suitable for use in fuel cells or turbines. Gasification of the char, transferred from the first reactor, occurs with steam fluidization in the second reactor. The OTM is reduced as it provides the oxygen needed to oxidize CO to $CO_2$ and $H_2$ to $H_2O$. The $CO_2$ sorbent is regenerated as the hot moving material from the third reactor enters the second reactor. This increases the bed temperature forcing the release of $CO_2$ from the sorbent, generating a $CO_2$-rich product stream suitable for sequestration. Air fed to the third reactor re-oxidizes the oxygen transfer material via a highly exothermic reaction that consumes the oxygen from the air fed. Thus, reactor 3 produces oxygen-depleted air at high temperature/pressure for a gas turbine, as well as generates heat that is transferred to the first and second reactors via solids transfer. Solids transfer occurs between all three reactors, allowing for the regeneration and recirculation of both the $CO_2$ sorbent and the oxygen transfer material. Periodically, ash and bed materials will be removed from the system and replaced with fresh bed materials to reduce the amount of ash in the reactor and increase the effectiveness of the bed materials.

## Primary Project Goal

The primary goal of this project is the development of a novel technology for conversion of coal to $H_2$ and electricity with inherent $CO_2$ separation meeting the technical, environmental and economic performance targets of the DOE and the utility industry. The current R&D program focus is to assess the technical and economic feasibility of the integrated UFP technology through bench and pilot-scale testing, and to reduce the technical risk associated with key aspects of the technology.

## Accomplishments

- Constructed bench-scale high pressure, high temperature fluid bed system
- Successfully completed pilot plant construction
- Demonstrated operation of pilot plant with coal
- Completed preliminary cost and performance analysis

## Benefits

The UFP technology represents a significant advancement in clean and efficient utilization of coal for energy and hydrogen production. The UFP module offers the potential for reduced cost and increased process efficiency relative to conventional gasification and combustion systems, and near-zero emissions of pollutants such as $NO_X$ and $SO_X$ while providing inherent separation of $CO_2$ for sequestration. Preliminary economics for the UFP technology show a 6 percent increase in $CO_2$ capture, a 21 percent increase in efficiency (LHV), and a 15 percent decrease in the cost of electricity compared to the current IGCC with $CO_2$ capture technologies.

*UFP pilot plant & auxiliary systems (left) & bench-scale system (right)*

## PARTNERS

GE Global Research

Southern Illinois University

California Energy Commission

## COST

**Total Project Value**
$6,612,559

**DOE/Non-DOE Share**
$4,688,166 / $1,924,393

## CUSTOMER SERVICE

**1-800-553-7681**

## WEBSITE

**www.netl.doe.gov**