PROJECT facts

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

Hydrogen & Syngas Technologies
Gasification Technologies

4/2009

DEVELOPMENT OF A HYDROGASIFICATION PROCESS FOR CO-PRODUCTION OF SUBSTITUTE NATURAL GAS (SNG) AND ELECTRIC POWER FROM WESTERN COALS

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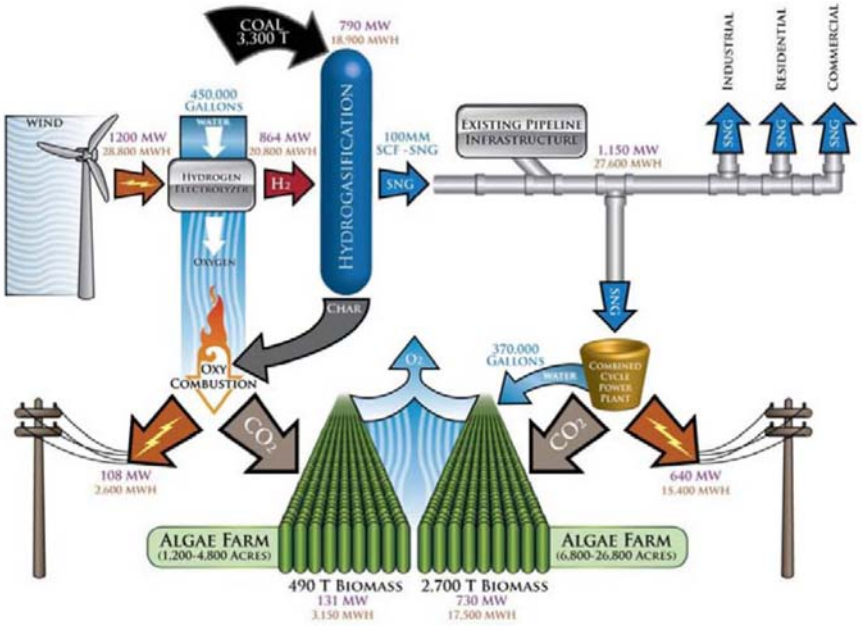
Description

In the next two decades, electric utilities serving the Western United States must install 60 gigawatts (GW) of new electric power generation to meet new loads, making the selection of technology for the next generation of electric power plants of the utmost importance. Future natural gas price increases and potential natural gas shortages create significant risk of high cost and unreliability for natural gas-fired power plants. Arizona Public Service (APS) is developing and evaluating a system for co-producing substitute natural gas (SNG) and electricity via a coal hydrogasification process. Their Advanced Hydrogasification Process (AHP) is currently envisioned as an integrated process for the co-production of SNG, biofuel, and electrical power from western coals. In the process, western coal is gasified using hydrogen as the reactant gas instead of oxygen (i.e., hydrogasification). By hydrogasifying the coal at high pressure and moderate temperatures (nominal 1,000 pounds per square inch absolute [psia] and 1,600 °F) a high methane-content syngas will be produced directly in the gasifier, perhaps eliminating the need for a downstream methanation process. SNG from the hydrogasifier will be cleaned, dried, compressed, and injected into the El Paso natural gas pipeline system. Unconverted coal from the gasifier will be withdrawn and sent to a low-pressure, oxy-combustion process to produce electricity. A portion of the carbon dioxide (CO_2)



Proposed APS Advanced Hydrogasification Process

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COST

Total Estimated Cost
$21,725,575

DOE/Non-DOE Share
$15,709,770 / $6,015,805

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stream from the combustion process will be compressed and recycled to convey the coal into the hydrogasifier. The remainder will be fed to an algae farm that consumes, or or reutilizes, the CO_2 from the process. Algae can be used as an additional fuel source or as a feedstock for biodiesel fuel production.

During Phase I, the concept was defined through laboratory testing of the individual technology components (hydrogasification, and CO_2 capture), as well as preliminary system engineering and economic analysis. During Phase II, now underway, the technology concept is being proven through bench-scale, coal gasification testing to evaluate the kinetics and product yield of western coal hydrogasification as a function of temperature, pressure, and coal-to-hydrogen feed rates. This activity will define the operating envelope to maximize methane concentration in the syngas. In the area of CO_2 capture and reutilization, APS is evaluating a prototype bioreactor for growing algae with power plant flue gas as a feedstock. The suitability of the algae for conversion to biofuels will be explored. If preceding phases indicate technological and economic merit, the project will proceed to Phase III where a field test system will be designed, built, and tested at an appropriate industrial host site.

Primary Project Goals

The primary project goal is to develop a commercially viable, advanced gasification process that will produce pipeline-quality SNG and electricity from western coals to meet the following performance targets: (1) Overall process efficiency greater than 50 percent; (2) SNG cost less than natural gas market price; (3) Capture and sequestration of CO_2 equivalent to 90 percent of power production emissions; and (4) Water usage to be at least 50 percent less than SNG from partial oxidation gasification followed by syngas methanation.

Accomplishments

Phase I

- Identified a Fruitland formation of Western subbituminous coal as the hydrogasifier fuel, completed chemical characterization of the coal, and conducted thermogravimetric analysis (TGA) reactivity tests
- Conducted thermodynamic equilibrium analyses for various temperatures, pressures, and feed gas makeup to identify the optimum conditions for methane production in the hydrogasifier
- Completed an overall process efficiency analysis and preliminary economics for a conceptual AHP facility, which concluded that the process design meets or exceeds the project goal

Phase II

- Designed and fabricated the high-pressure, high-temperature, bench-scale reactor system
- Developed a test matrix for the bench-scale testing to evaluate the effects of temperature, pressure, hydrogen, coal feed rate, and residence time on gasification efficiency and syngas composition
- Conducted a quarter-acre, engineering-scale field test of a carbon recycling concept at the APS Red Hawk Power Plant utilizing flue gas from the power plant to feed a closed-system algae farm. More than twice the growth rate documented in the literature for closed systems was achieved—indicating tremendous potential for this carbon management process

Benefits

Today's electric power generation infrastructure has grown highly dependent on natural gas. Given the vast coal resources of the United States, efficient production of SNG from coal offers supply and price stability. SNG has the advantages of being a hydrogen carrier, easily stored, a fuel source for existing Natural Gas Combined Cycle (NGCC) power production, and easily transported in an existing nationwide natural gas pipeline network.