Advanced Coal Conversion Process Demonstration

Demonstration Operations Completed

Participant

Western SynCoal LLC (formerly Rosebud SynCoal Partnership; a subsidiary of Montana Power Company's Energy Supply Division)

Additional Team Members

None

Location

Colstrip, Rosebud County, MT (adjacent to Western Energy Company's Rosebud Mine)

Technology

Western SynCoal LLC's Advanced Coal Conversion Process for upgrading low-rank subbituminous and lignite coals

Plant Capacity/Production

45 tons/hr of SynCoal® product

Coal

Powder River Basin subbituminous (Rosebud Mine), 0.5–1.5% sulfur, plus tests of other subbituminous coals and lignites

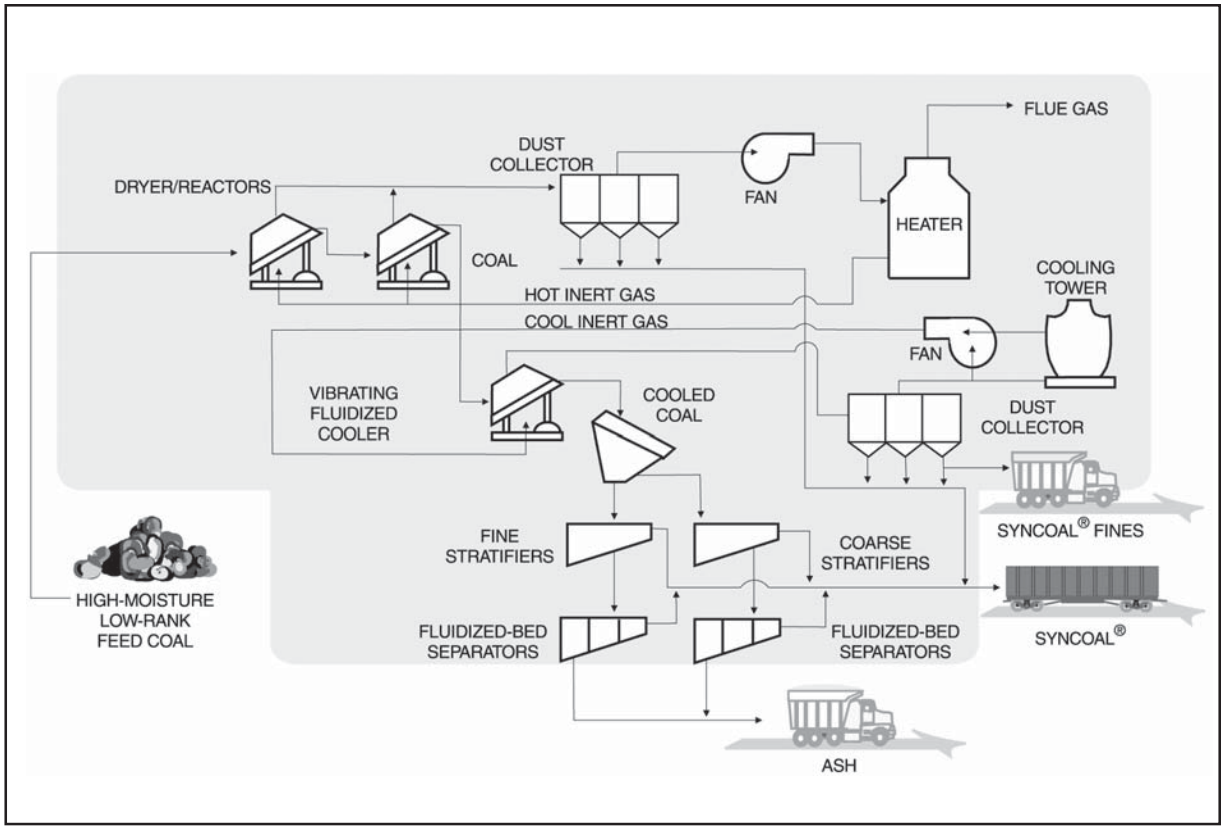
Project Funding

Total	$105,700,000	100%
DOE	43,125,000	41
Participant	62,575,000	59

Project Objective

To demonstrate Western SynCoal LLC's Advanced Coal Conversion Process (ACCP) to produce SynCoal®, a stable coal product having a moisture content as low as 1%, sulfur content as low as 0.3%, and heating value up to 12,000 Btu/lb.

SynCoal is a registered trademark of the Rosebud SynCoal Partnership.

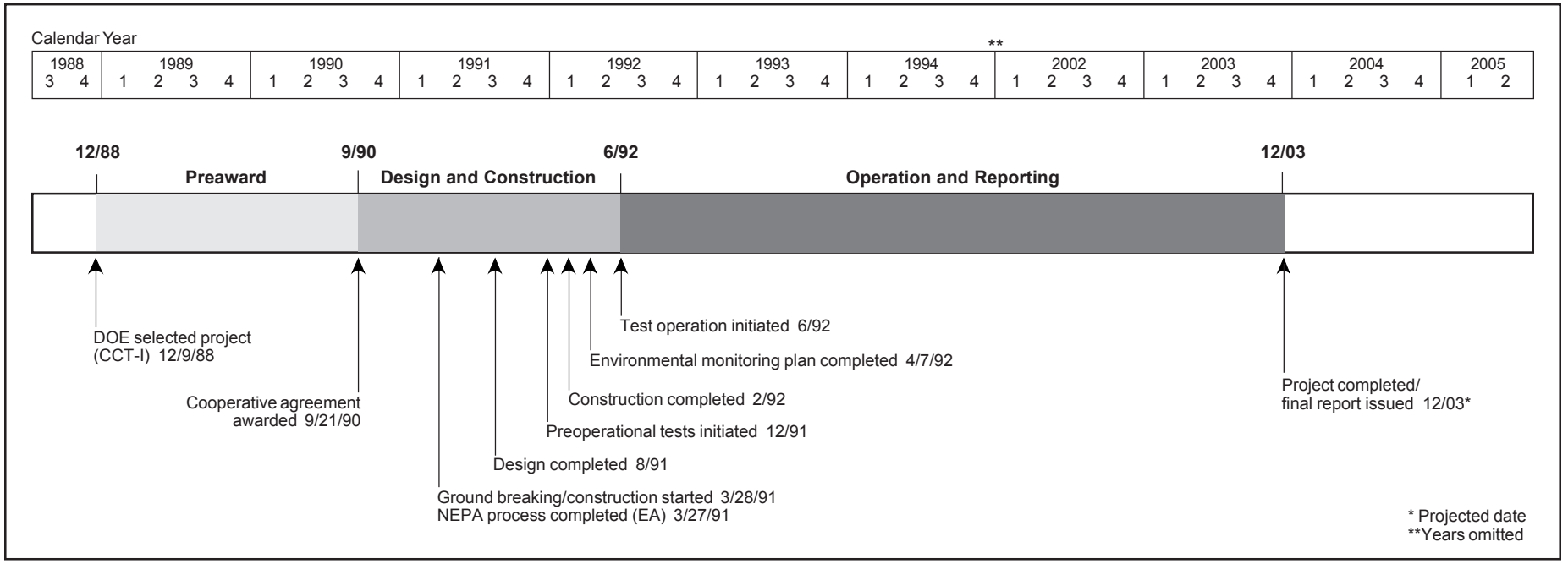


Technology/Project Description

The process demonstrated is an advanced thermal coal conversion process coupled with physical cleaning techniques to upgrade high-moisture, low-rank coals to produce a high-quality, low-sulfur fuel. The raw coal is screened and fed to a vibratory fluidized-bed reactor where surface moisture is removed by heating with hot combustion gas. Coal exits this reactor at a temperature slightly higher than that required to evaporate water and flows to a second vibratory reactor where the coal is heated to nearly 600 °F. This temperature is sufficient to remove chemically bound water, carboxyl groups, and volatile sulfur compounds. In addition, a small amount of tar is released, partially sealing the dried product. Particle shrinkage causes fracturing, destroys moisture reaction sites, and liberates the ash-forming mineral matter.

The coal is then cooled to less than 150 °F by contact with an inert gas in a vibrating fluidized-bed cooler. The cooled coal is sized and fed to deep-bed stratifiers where air pressure and vibration separate mineral matter, including much of the pyrite, from the coal, thereby reducing the sulfur content of the product. The low specific gravity fractions are sent to a product conveyor while heavier fractions go to fluidized-bed separators for additional ash removal.

The fines handling system consolidates the coal fines that are produced throughout the ACCP facility. The fines are gathered by screw conveyors and transported by drag conveyors to a bulk cooling system. The cooled fines are blended with the coarse product, stored in a 250-ton capacity bin until loaded into pneumatic trucks for off-site sales, or returned to the mine pit.



Results Summary

Operational

- During the life of the ACCP project, over 2.8 million tons of raw coal was processed to produce almost 1.9 million tons of SynCoal® products, which included regular, fines, blends, DSE treated, and special characteristic SynCoal® shipped to various customers.
- The product produced was exceptionally close to the design basis product from a chemical standpoint, but did not allow for conventional bulk handling from a physical standpoint due to instability (spontaneous heating) and dustiness.

Environmental

- The measured emissions of PM from the process stack were 0.0259 gr/dscf (2.563 lb/hr) with a limit of 0.031 gr/dscf.
- The measured emissions of NO_x were 4.50 lb/hr (54.5 ppm) compared with a vendor estimated limit of 7.95 lb/hr for controlled emissions and 11.55 lb/hr for uncontrolled emissions.
- The measured emissions of CO were 9.61 lb/hr (191.5 ppm) compared with a vendor estimated limit of 6.46 lb/hr for controlled emissions and 27.19 lb/hr for uncontrolled emissions.
- The measured emissions of SO_2 were 0.227 lb/hr (2.0 ppm) compared with a vendor estimated limit of 7.95 lb/hr for controlled emissions and 20.27 lb/hr for uncontrolled emissions.
- The measured emissions of total hydrocarbons were 2.93 lb/hr (37.1 parts per million).
- The measured emissions of hydrogen sulfide were 0.007 lb/hr (0.12 parts per million).

Economic

- Economic data are not available.

Project Summary

This project demonstrated an advanced, thermal, coal upgrading process, coupled with physical cleaning techniques, that was designed to upgrade high-moisture, low-rank coals to a high-quality, low-sulfur fuel, registered as the SynCoal® process. The coal was processed through three stages (two heating stages followed by an inert cooling stage) of vibrating fluidized-bed reactors that remove chemically bound water, carboxyl groups, and volatile sulfur compounds. After thermal upgrading, the coal is processed in vibrating pneumatic stratifiers to separate the pyrite-rich coal refuse from the SynCoal® product.

The 45-ton-per-hour unit is located adjacent to a unit train load-out facility at Western Energy Company's Rosebud coal mine near Colstrip, Montana. The demonstration plant was sized at about one-tenth the projected throughput of a projected commercial facility.

Operational Performance

During the life of the ACCP project, over 2.9 million tons of raw coal was processed to produce almost 2.0 million tons of SynCoal® products, which include regular, fines, blends, dust stabilization enhancement (DSE) treated, and special characteristic SynCoal® shipped to various customers. See Exhibit 2-4 for annual statistics from the ACCP plant. The plant posted a perfect worker safety record with no lost time accidents during the entire nine years of operation. When operation ended in 2001, the ACCP had been supplying six commercial customers with SynCoal®.

The product produced has been exceptionally close to the design basis product from a chemical standpoint, but was not acceptable for conventional bulk handling and storage due to instability (spontaneous heating) and dustiness. Due to the instability, SynCoal® had to be stored with an inert gas or in tightly sealed vessels to prevent air infiltration. A CO_2 inert storage system was developed and installed for silo storage of SynCoal®. A significant amount of work has gone into addressing the instability issue. In conjunction with ENCOAL LLC and Amax Coal Company, Western SynCoal researched the effects of different environments and treatments on low-rank coal composition. Specific objectives were to study the explosivity and flammability limits of dust from the conversion process and to identify the causes of spontaneous heating of upgraded coal products. At the time activities were suspended, the development efforts were focused on the use of the Aeroglide Tower Reactor design.

The Aeroglide reactor represents a novel method of allowing process gases to contact the solids in a mechanically gentle environment. Solids are fed to the unit and flow, assisted only by gravity, downward through a system of baffles that gently mix the solids during the migration of the solids from the inlet to the outlet. The flow is controlled using a mass flow discharge valve. Rows of baffles are configured perpendicular to each successive row. Process gases are introduced using alternate horizontally configured baffles and distributed into the solids uniformly. Process gases migrate to adjacent baffles and exit the process bed of solids. The Aeroglide reactor was configured to rehydrate processed SynCoal®, remove the heat of reaction, and partially oxidize the product in an effort to promote product stability. This process scheme was intended to modify the characteristics of the final SynCoal® product allowing traditional transportation techniques to be employed. Results of the testing were promising, but not conclusive.

With regard to the operational performance of the SynCoal® product, three different feedstocks were tested at the ACCP facility—North Dakota lignite, Knife River lignite, and Amax subbituminous coal. Approximately 190 tons of the SynCoal® product produced with the North Dakota lignite was burned at the 250-MWe cyclone-fired Milton R. Young Power Plant Unit No. 1. Testing showed dramatic improvement in cyclone com-

Exhibit 2-4
ACCP Annual Production Rates

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Total
Raw Coal Processed (tons)	28,686	157,421	371,447	479,621	369,652	395,450	163,272	419,296	441,379	112,931	2,939,235
Availability (%)	18	50	65	78	65	66	28	70	73	54	58
Forced Outage Rate (%)	68	24	26	13	21	26	8	15	14	36	23
Avg. Feed Rate (ton/hr)	21.1	35.8	64.8	70.1	64.3	68.0	66.0	68.4	69.0	73.0	63.3
SynCoal® Shipped (tons)	5,566	57,927	208,428	315,688	238,766	250,070	97,575	288,650	291,604	76,649	1,811,124

Note: 163,106 tons of fines sold in July 1997.

bustion, improved slag tapping, and a 13% reduction in boiler air flow requirements. In addition, boiler efficiency increased from 82% to over 86%, and the total gross heat rate improved by 123 Btu/kWh.

At the Colstrip plant with two coal-fired power plants, baseline testing at the start of the demonstration indicated that the 330-MWe Unit No. 2 was typically producing 2.9 MWe (net) less than Unit No. 1, a sister unit of comparable capacity. In late Spring 1999, Unit No. 1 was overhauled, resulting in an increase in its average output of 7 MWe (net). With this increase in output, the overhauled Unit No. 1 would have produced 5.4 MWe more than Unit No. 2. However, for the days that SynCoal® was used, Unit No. 2 out-produced the overhauled Unit No. 1 by an average of 7.3 MWe—285.7 MWe versus 278.4 MWe (net)—with 15.0% of the total heat input coming from SynCoal. Furthermore, SynCoal® can be credited for actual 1999 SO_2 emissions reductions for Unit No. 2 of approximately 430 tons, or an 8% reduction, and NO_x emissions reductions of approximately 826 tons, or a 19% reduction, when compared with Unit No. 1 emissions.

Environmental Performance

Western SynCoal originally assumed that SO_2 emissions would have to be controlled by injecting chemical sorbents into the ductwork. Preliminary data indicated that the addition of chemical injection sorbent was not necessary to control SO_2 emissions under the operating conditions.

The coal-cleaning area's fugitive dust was controlled by placing hoods over the fugitive dust sources conveying the dust-laden air to fabric filters. The bag filters effectively removed coal dust from the air before discharge. The Montana Department of Health and Environmental Sciences completed stack tests on the east and west baghouse outlet ducts and the first-stage drying gas baghouse stack in 1993.

A stack emissions survey was conducted in May 1994. The survey determined the emissions of particulates, sulfur dioxide, oxides of nitrogen, carbon monoxide, total hydrocarbons, and hydrogen sulfide from the process stack. The results are shown in Exhibit 2-5.

Economic Performance

Economic data are not available.

Commercial Applications

ACCP has the potential to enhance the use of low-rank western subbituminous and lignite coals. SynCoal® is a viable compliance option for meeting SO_2 emission reduction requirements. SynCoal® is an ideal supplemental fuel for plants seeking to burn western low-rank coals, because the ACCP allows a wider range of low-sulfur raw coals without derating the units.

The project was able to prove the value of SynCoal® through the seven commercial customers serviced during the last few years of operation. The customers represented utility, industrial, and metallurgical applications.

The ACCP has the potential to convert inexpensive, low-sulfur, low-rank coals into valuable carbon-based reducing agents for many metallurgical applications. Furthermore, SynCoal® enhances cement and lime production and provides a value-added bentonite product.

Contacts

Harry Bonner, General Manager
(406) 494-5119
Western SynCoal LLC
120 North Parkmont
Butte, MT 59701
(406) 494-3317 (fax)

Douglas Archer, DOE/HQ, (301) 903-9443
douglas.archer@hq.doe.gov

Joseph B. Renk III, NETL, (412) 386-6406
joseph.renk@netl.doe.gov

References

Technical Progress Reports (1991–2000). Western SynCoal LLC. April 2001, January 2001, November 1999, February 1999, August 1998, May 1997, February 1995, December 1993, and February 1992.

Exhibit 2-5
ACCP Stack Emissions Survey Results

	Limit	Measured
Particulate Matter	0.031 gr/dscf	0.0259 gr/dscf 2.563 lb/hr
Nitrogen Oxides	7.95 lb/hr[a] 11.55 lb/hr[b]	4.50 lb/hr 54.5 ppm
Carbon Monoxide	6.46 lb/hr[a] 27.19 lb/hr[b]	9.61 lb/hr 191.5 ppm
Sulfur Dioxide	7.95 lb/hr[a] 20.27 lb/hr[b]	0.227 lb/hr 2.0 ppm
Total Hydrocarbons as Propane (Less Methane and Ethane)	NA	2.93 lb/hr 37.1 ppm
Hydrogen Sulfide	NA	0.007 lb/hr 0.12 ppm

[a] Estimated controlled emissions based on vendor information.
[b] Estimated uncontrolled emissions based on vendor information.