DOE/FE-0125

Clean Coal Technology Demonstration Program

Annual Report to Congress

U.S. Department of Energy
Assistant Secretary for Fossil Energy

February 1989

CCT-I Project Summaries

To prevent the release of project specific, proprietary information, the diagrams contained in this section of the report are presented only as illustrative of the concepts involved.

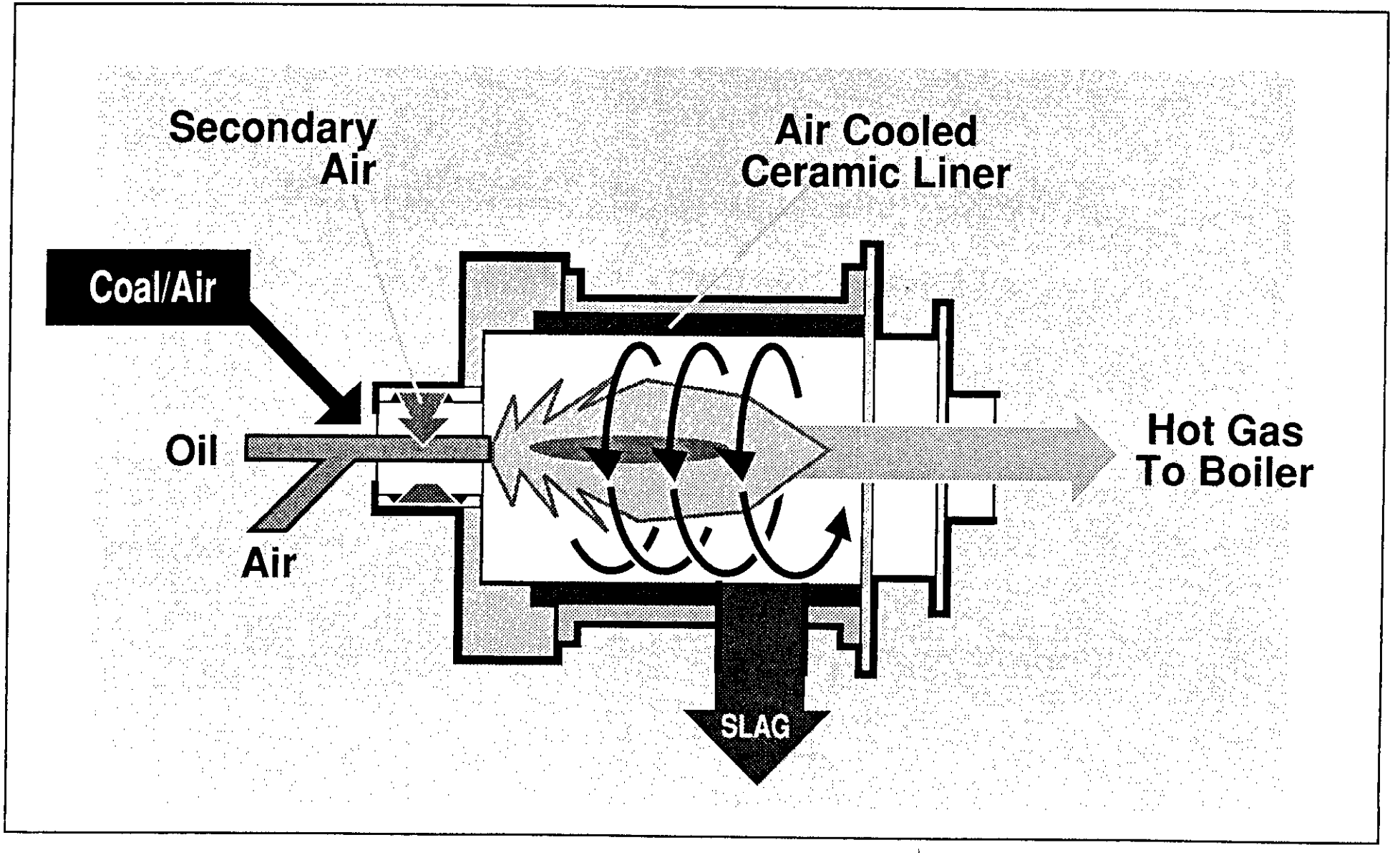
Advanced Cyclone Combustor Demonstration Project

Coal Tech Corporation

Advanced Cyclone Combustor Demonstration Project

COAL TECH CORPORATION

PROCESS FLOW DIAGRAM



Project: Advanced Cyclone Combustor Demonstration Project

Industrial Participant:
Coal Tech Corporation

Cofunders:
State of Pennsylvania Energy Development Authority
Pennsylvania Power and Light
Keeler Boiler Manufacturing Company

Process: Advanced air-cooled slagging cyclone combustor with limestone addition for SO_x control

Location:
Williamsport, Lycoming County, PA

Coal Feed Characteristics:
Pennsylvania bituminous--Freeport seam (2% to 4% sulfur)

Feed Rate: 24 tons of coal per day

Combustor Size: 30 MMBtu/hour

Production: Steam and/or electricity

Estimated Total Cost:	$785,984
DOE:	$392,992
Industrial Participants:	$392,992

Project Objectives:

To demonstrate an air-cooled cyclone, pulverized coal combustor of an advanced design to show that 90 percent of the coal ash can be retained and rejected, that NO_x emissions can be held to 100 parts per million and that SO_x emissions can be reduced by up to 90 percent. If successful and implemented, boiler slagging and acid rain precursor emissions would be reduced, and additional high-sulfur U.S. coal could be used in an environmentally acceptable manner.

Process Description:

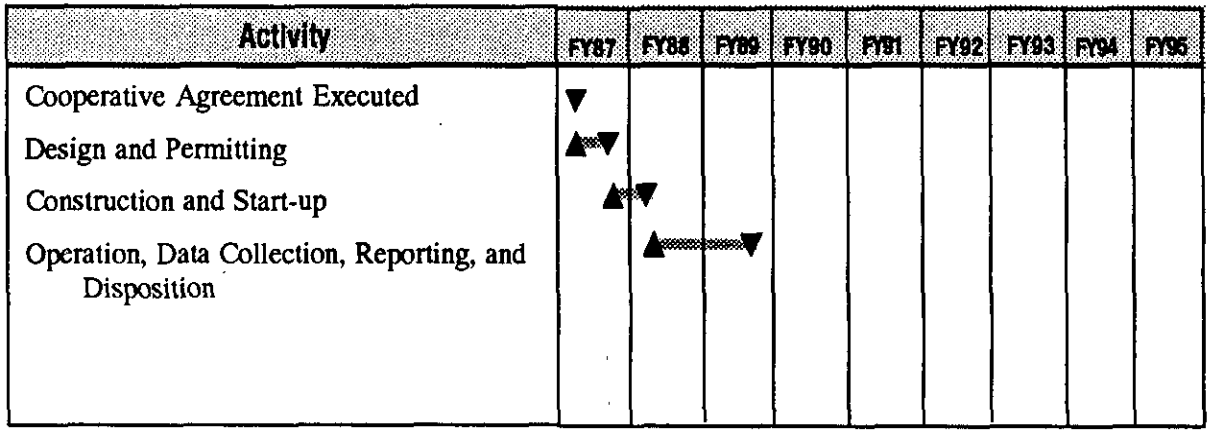
The project demonstrates an advanced horizontal cyclone combustor with integral sulfur, nitrogen, and ash control systems. Air is mixed with fuel in standard burners or combustors that are attached to the outside walls of boilers. The burning mixture is then discharged into the boiler, heating water in the tubes to produce steam. The Coal Tech combustor, which will replace a standard burner, also mounts on the outside wall of the boiler, mixes coal, sorbent (limestone) and air, provides ignition, and removes ash before discharging the hot combustion products to the boiler. The 30-MMBtu-per-hour combustor is approximately 5 feet in diameter and 8 feet long.

Sulfur oxide is controlled by means of limestone injection into the burner. Formation of NO_x is limited by operating the first combustion stage with an oxygen deficiency. Additional oxygen is added to complete combustion after the combustion products leave the combustor. The system is also designed to obtain very high ash removal by cyclonic action in the combustor, resulting in a unit that can be easily retrofitted to gas- and oil-fired units. The simultaneous reduction of three different pollutants makes the performance of this combustor unique.

Advanced Cyclone Combustor
Demonstration Project
(Coal Tech Corporation)

Key Milestone Dates:

DOE selected project	7/24/86
Issued comprehensive report to Congress	2/11/87
DOE signed cooperative agreement	3/20/87
Completed design and permitting	7/8/87
Completed construction and start-up	11/22/87
Started operation	11/23/87
Complete project	6/30/89



Project Status:

The combustor started operation in November 1987. Since then, the combustor has been operated approximately 18 times and in excess of 250 hours with over 90 parametric conditions and four Pennsylvania coals. The coals used were high and low ash-fusion temperature coals with sulfur and volatile content ranges of 1.1 - 2.5 percent and 20 - 25 percent, respectively. There are, however, concerns about (1) slag removal at the combustor, (2) schedule slippage, and (3) whether sufficient funds remain to meet all Cooperative Agreement deliverables.

Problems/Potential Problems:

Schedule and funding modifications are required if Coal Tech is to meet all of the Cooperative Agreement deliverables. Some equipment reliability problems developed during operations, thereby causing some delay to testing activities. These problems are being corrected. Overall technical feasibility in longer duration testing remains to be demonstrated.

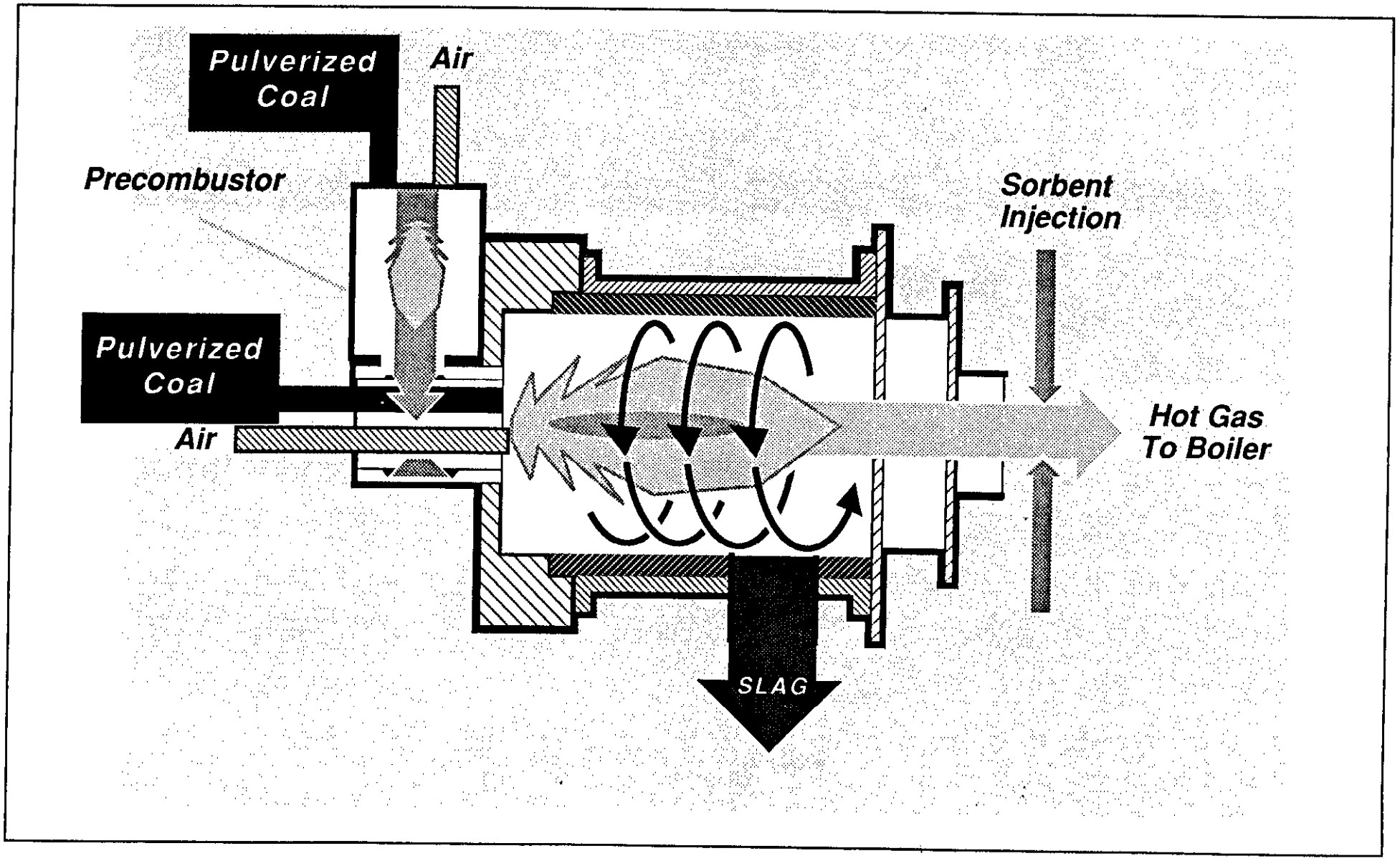
Advanced Slagging Coal Combustor Utility Demonstration Project

TRW, Inc.

Advanced Slagging Coal Combustor Utility Demonstration Project

TRW, INC.

PROCESS FLOW DIAGRAM



Project: Advanced Slagging Coal Combustor Utility Demonstration Project

Industrial Participant:
TRW, Inc.

Cofunders:
State of Ohio
State of New York
Orange and Rockland Utilities, Inc.
Empire State Energy Research and Development Authority
EPRI

Process: Advanced slagging coal combustor

Location:
Orange and Rockland Utilities' Lovett Station, Stony Point, NY
TRW Slagging Combustor Test Facility, Cleveland, OH

Coal Feed Characteristics:
Eastern U.S. bituminous coal of low- to medium-sulfur content (0.7% and 2.5%)

Plant Capacity: 69 MWe retrofit with four 160-MMBtu per hour combustors

Estimated Total Cost:	$49,000,000
DOE:	$23,520,000
Industrial Participants:	$25,480,000

Project Objectives:

To demonstrate an advanced slagging coal combustor at a scale suitable for utility application. The project will involve converting an existing utility boiler from oil to coal, while meeting environmental standards and without derating the unit.

Process Description:

The slagging combustor removes coal ash in the form of a molten slag and is similar to a unit currently being developed for industrial scale by TRW. A key distinction in the proposed demonstration effort is the addition of several techniques designed to remove potential sulfur pollutants. Limestone, which acts as a sulfur absorber, will be injected into the combustion gases before they are sent into the boiler. To enhance sulfur capture, a lime recycling system will be installed and tested. If successful it will economically control SO_x from low- to medium-sulfur coals to the NSPS level.

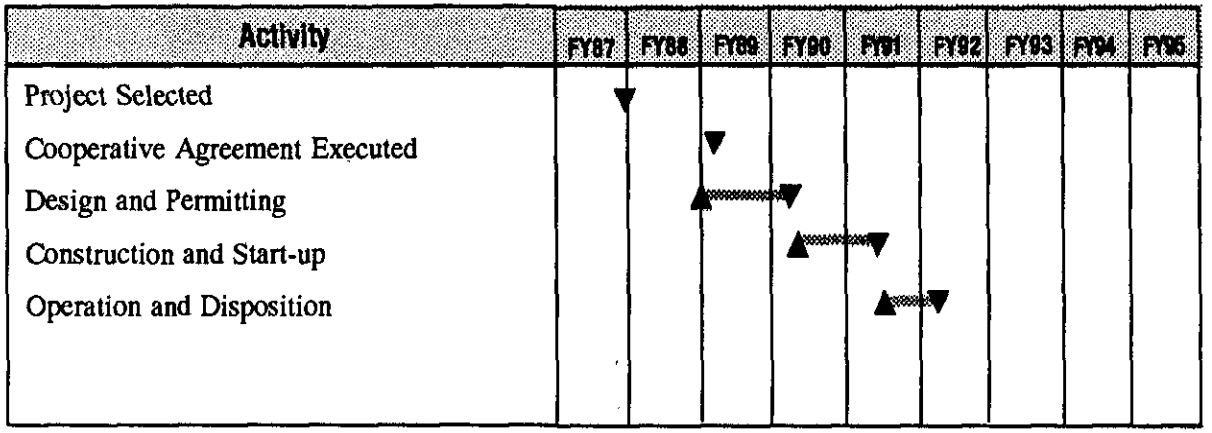
This project will extend TRW's demonstration of its slagging coal combustor from the small industrial boiler demonstration (40 MMBtu per hour) to a full-scale utility boiler retrofit demonstration, converting oil-firing to coal-firing using four 160-MMBtu-per-hour combustors and controlling NO_x, SO_x, and particulate emissions to meet environmental standards both economically and without derating the boiler.

A boiler in an Orange and Rockland Utilities power plant located at Stony Point, NY, will be retrofitted with four combustors, including pulverized coal and limestone feed systems, slag handling and particulate filter systems, and modification of heat exchange and gas flow systems. During the design phase of the Orange and Rockland project, coal-burning tests and calcined limestone recycle tests will be conducted at TRW's industrial-scale slagging combustor test facility located in Cleveland, OH.

Advanced Slagging Coal Combustor Utility Demonstration Project
(TRW, Inc.)

Key Milestone Dates:

DOE selected project	10/7/87
Issued comprehensive report to Congress	10/4/88
DOE signed cooperative agreement	11/4/88
Complete preliminary design	6/89
Long delivery ordering begins	5/89
Complete design and permitting	1/90
Begin construction	1/90
Complete construction and start-up	3/91
Begin operational testing	3/91
Complete project	12/91



Project Status:

The project is in its initial stage of post-award activities. Contracts are being negotiated between TRW, Inc., and subcontractors. An initial site inspection has been conducted by the architecture and engineering company working on the project. The first draft of the Environmental Information Volume has been received by DOE.

Problems/Potential Problems:

None.

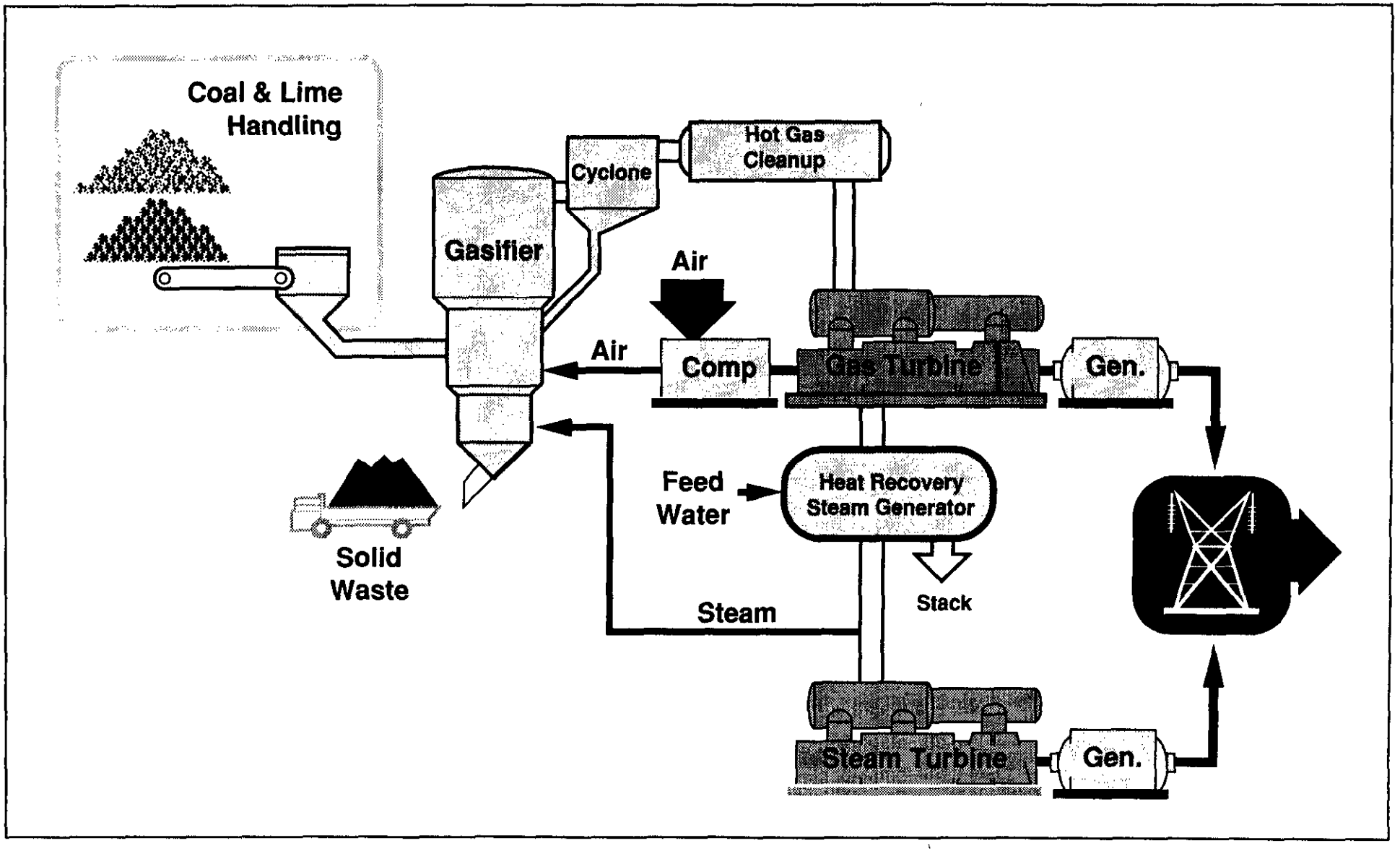
The Appalachian IGCC Demonstration Project

The M.W. Kellogg Company
Bechtel Development Company

The Appalachian IGCC Demonstration Project

THE M.W. KELLOGG COMPANY/BECHTEL DEVELOPMENT COMPANY

PROCESS FLOW DIAGRAM



Project: The Appalachian IGCC Demonstration Project

Industrial Participants:
The M.W. Kellogg Company
Bechtel Development Company

Cofunders: None

Process: Integrated coal gasification combined cycle

Location: New site in New York State under consideration

Coal Feed Characteristics:
Pennsylvania high-sulfur, bituminous coals from the Brookville, Upper Freeport, and Pittsburgh seams

Plant Capacity: 63.5 MWe (net)

Feed Rate: 551 tons of coal per day

Estimated Total Cost:	$243,837,000
DOE:	$87,528,500
Industrial Participants:	$156,308,500

Project Objectives:

To design, build, and operate a grass roots, advanced coal gasification combined-cycle, power generation plant that will utilize high-sulfur, Eastern U.S. bituminous coal to demonstrate an efficient, economical, and environmentally advantageous method of generating electric power.

Process Description:

Substantial effort already has been focused on the development of power generation systems utilizing coal gasification coupled with gas turbines in integrated gasification combined cycle (IGCC) configurations. From an economic standpoint, such systems show promise for significantly outperforming conventional coal-fired steam plants with FGD. They also have the potential to meet increasingly stringent environmental emission and siting requirements while taking full advantage of the Nation's vast coal resources.

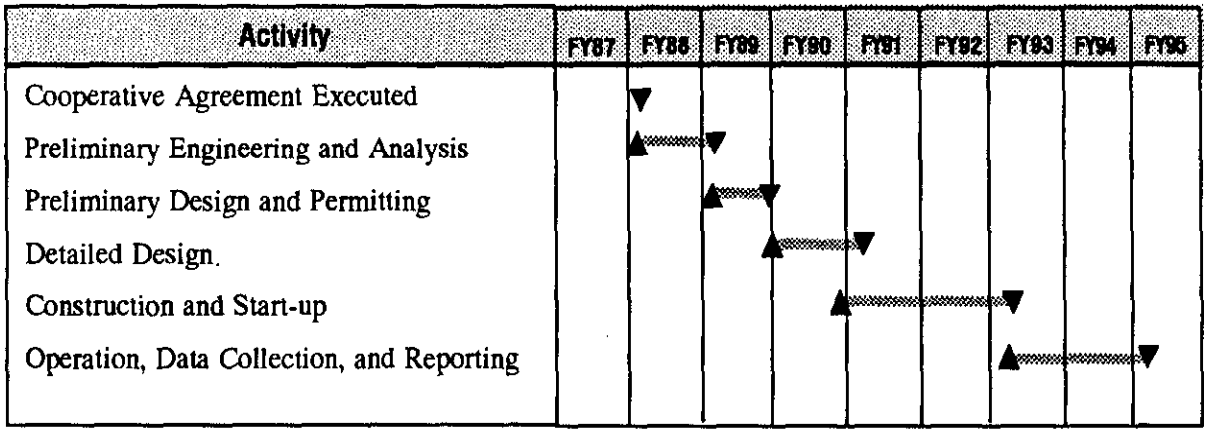
A major milestone in the development of IGCC technology in the U.S. was achieved with the successful operation of the Cool Water facility at Daggett, California. The Cool Water demonstration successfully integrated oxygen-blown, entrained-flow gasification; cold gas scrubbing technology for contaminant and sulfur removal; and a modern combined-cycle gas turbine system for power generation.

An advanced concept has been developed that improves upon this first-generation IGCC technology. By using a KRW air-blown gasifier (which consumes less auxiliary power than an oxygen-blown system), hot gas cleanup, and an innovative tail gas treatment processing scheme, the concept provides higher thermal efficiency and superior environmental performance when compared to first-generation systems. This advanced approach will offer an excellent option for meeting future and potentially more stringent environmental emission constraints. Its standardized modular design and simple process configuration are also expected to yield significantly lower engineering and equipment costs.

The Appalachian IGCC Demonstration Project
(The M.W. Kellogg Company/
Bechtel Development Company)

Key Milestone Dates:

DOE selected project	7/24/86
Issued comprehensive report to Congress	12/22/87
DOE signed cooperative agreement	1/22/88
Complete design and permitting	12/90
Complete construction and start-up	12/92
Begin operation	12/92
Complete project	12/94



Project Status:

The cooperative agreement was signed in January 1988. Phase I is proceeding and is subdivided into:

IA--Preliminary Engineering and Analysis (12 months)
IB--Preliminary Design and Permitting (9 months)
IC--Detailed Design (15 months)

Problems/Potential Problems:

A long-term sales agreement needs to be finalized on terms satisfactory to service the project debt and operating costs, otherwise the economic viability of the project could be in jeopardy. In order to mitigate sales problems an alternate site at Corning, NY, is under consideration. This has resulted in a project schedule increase for Phase IA of 6 months.

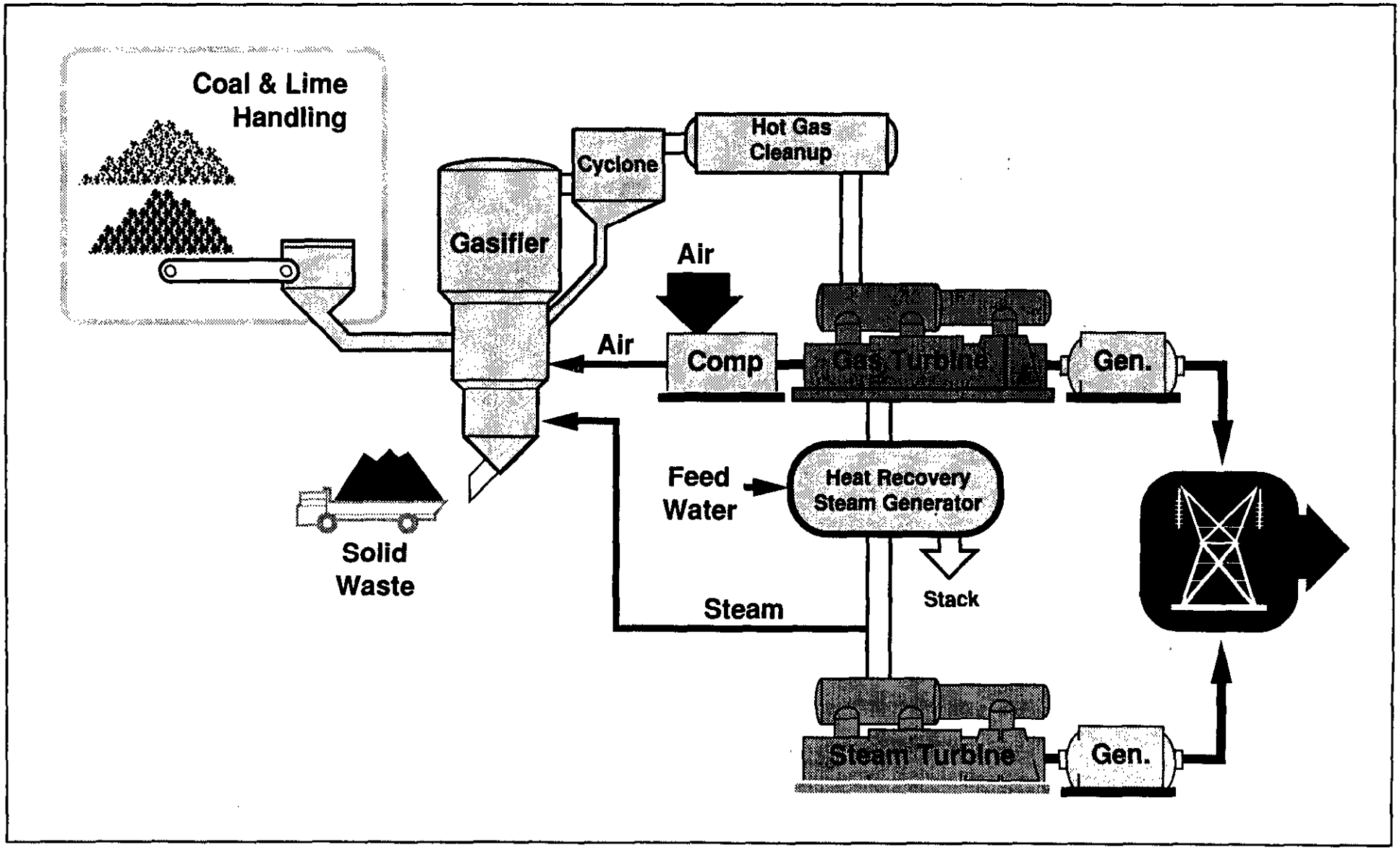
Clean Energy IGCC Demonstration Project

Foster Wheeler Power Systems, Inc.

Clean Energy IGCC Demonstration Project

FOSTER WHEELER POWER SYSTEMS, INC.

PROCESS FLOW DIAGRAM



Project: Clean Energy IGCC Demonstration Project

Industrial Participants:
Foster Wheeler Power Systems, Inc.
Others to be finalized

Cofunders:
Others to be finalized

Process: Integrated gasification combined cycle using IGT U-Gas process

Location: An alternate site in VA is under consideration.

Coal Feed Characteristics:
High-sulfur West Virginia coal

Production: 44 MWe and 200,000 pounds of steam per hour (59 MWt)

Feed Rate: 600 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participants:	TBD

TBD: To be determined

Project Objectives:

To demonstrate the technical, environmental, and economic performance of an advanced integrated gasification combined-cycle system in a repowering/cogeneration application at the integrated commercial scale. The system will utilize IGT's U-Gas process (fluidized bed gasifier) with hot gas cleanup.

Process Description:

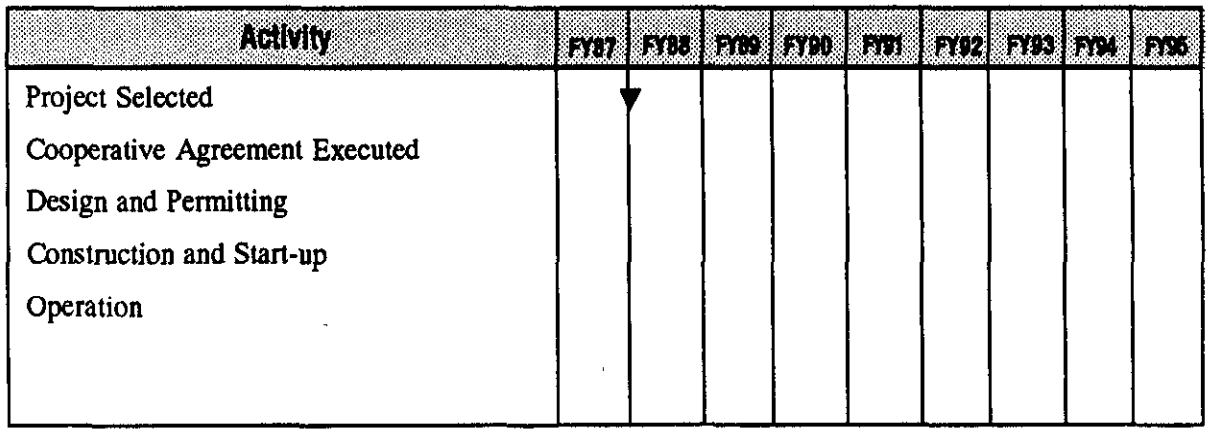
An integrated gasification combined-cycle powerplant will be designed to convert high-sulfur West Virginia coal into electric power and steam in an environmentally acceptable manner, while offering a significant reduction in capital and operating costs over conventional coal-based technologies with flue gas cleaning. The proposed project concept is based on the U-Gas coal-gasification process with limestone injection for sulfur removal. Hot particulate removal will be accomplished by a zinc-ferrite sulfur removal process. The product, low-Btu gas, will be combusted in a gas turbine with a steam generator to recover residual heat.

Clean Energy IGCC Demonstration Project
(Foster Wheeler Power Systems, Inc.)

Key Milestone Dates:

DOE selected project	10/7/87
Kick-off meeting for fact-finding process	11/5/87
Issued preagreement milestone schedule	12/15/88
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Complete design and permitting	TBD
Complete construction	TBD
Begin operation	TBD
Complete project	4/94*

* Preliminary: subject to negotiation



Project Status:

Fact-finding and negotiating activities are in progress. Execution of the cooperative agreement has been delayed due to project restructuring. It appears a new site in Virginia will be selected to supply power to VEPCO and steam to an adjacent industrial plant. A firm specializing in the development of cogeneration projects is considering becoming a principal participant.

Problems/Potential Problems:

None.

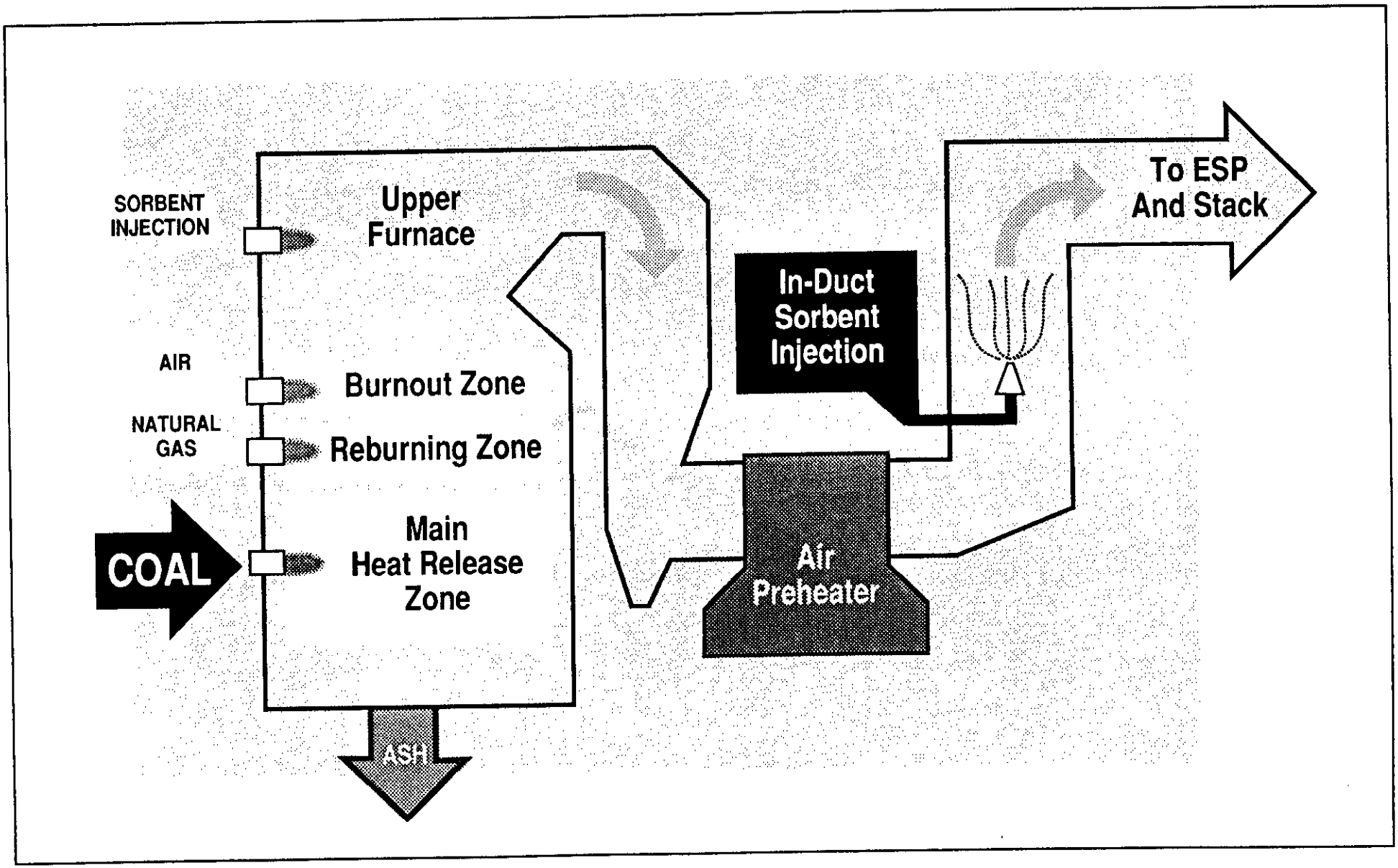
Gas Reburning/Sorbent Injection Demonstration Project

Energy and Environmental Research Corporation

Gas Reburning/Sorbent Injection Demonstration Project

ENERGY AND ENVIRONMENTAL RESEARCH CORPORATION

PROCESS FLOW DIAGRAM



Project: Gas Reburning/Sorbent Injection Demonstration Project

Industrial Participant:
Energy and Environmental Research Corporation

Cofunders:
State of Illinois
Gas Research Institute

Process: Flue gas clean-up by gas reburning for NO_x control and sorbent injection for SO_x control

Location:
Hennepin, Putnam County, IL
(Hennepin Station)
Bartonville, Peoria County, IL
(Edwards Station)
Springfield, Sangamon County, IL
(Lakeside Station)

Coal Feed Characteristics:
Illinois and Kentucky bituminous coals (1% to 3.8% sulfur)

Plant Capacity: 80 MWe, 117 MWe, 40 MWe

Estimated Total Cost:	$29,998,253
DOE:	$14,998,253
Industrial Participants:	$15,000,000

Project Objectives:

To conduct three full-scale utility demonstrations to show that the combination of gas reburning and sorbent injection can reduce NO_x emissions by 60 percent and SO_x emissions by 50 percent from pre-NSPS boilers. If successful, the project will demonstrate a process and equipment that could be easily retrofitted to about 900 U.S. utility boilers (tangentially fired, wall-fired, and cyclone-fired). This project would also make high-sulfur U.S. coals more usable and would reduce SO_x and NO_x emissions.

Process Description:

This project will demonstrate the gas reburning/sorbent injection process (GR/SI) on three different boilers representing three different combustion configurations.

The GR/SI process has been developed to interface with the existing coal combustion systems. The existing burners or combustors are retained when the GR/SI process is installed. Control of NO_x is achieved by burning less coal in the boiler at a carefully controlled air-to-fuel ratio. Natural gas injected downstream of the coal combustion zone compensates for the decreased coal input to the boiler. A portion of the NO_x formed by the coal combustion is converted to nitrogen by the reducing atmospheres caused by the partial combustion of natural gas. Air is then injected downstream of the natural gas injection point to complete this staged combustion process. This procedure reduces NO_x emissions by approximately 60 percent.

Emissions of SO_x are reduced in the GR/SI process by injecting a sorbent into the upper part of the boiler or into the flue gas duct downstream of the boiler. The sorbent (now contained in the fly ash) is removed from the flue gas in an existing ESP or baghouse. The need for flue gas humidification, which enhances both sorbent activity for SO_2 capture and ESP performance, is a site-specific determination. In this project, humidification will be used at two of the three sites, and sorbent injection into the flue gas duct will be tested at the cyclone boiler site. The process will reduce SO_x emissions by approximately 50 percent while burning a blend of high-sulfur coal. The GR/SI process provides an alternative technology to conventional wet FGD processes, while requiring less physical space.

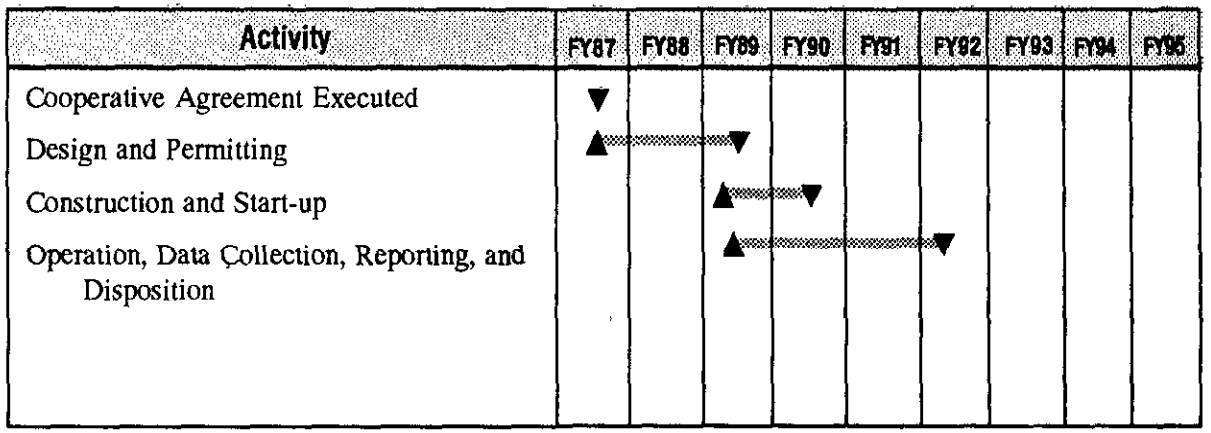
This project will use the following host sites:

- A tangentially fired 80-MWe boiler owned by Illinois Power Company and located near Hennepin, IL. This boiler has burners mounted at the corners and directs the burning coal and air toward points just off the center of the boiler.
- A wall-fired 117-MWe boiler owned by Central Illinois Light Company and located near Bartonville, IL. This boiler has burners that direct the burning air/coal into the furnace in a direction that is perpendicular to the wall in which the burners are mounted.
- A cyclone-fired 40-MWe boiler owned by City Water, Light and Power Company located in Springfield, IL. This boiler has a combustion system that is external to the boiler, and the hot combustion products enter the boiler after the combustion is complete.

Gas Reburning/Sorbent Injection Demonstration Project
(Energy and Environmental Research Corporation)

Key Milestone Dates:

DOE selected project	7/24/86
Issued comprehensive report to Congress	6/5/87
DOE signed cooperative agreement	7/14/87
NEPA clearance received for Hennepin Station	5/9/88
NEPA clearances expected for all sites	3/89
Complete design and permitting	3/89
Complete construction and start-up	3/90
Begin operation	3/89
Complete project	12/91



Project Status:

Phase I-Design and Permitting work, initiated in June 1987, continued throughout 1988. Host site characterizations, boiler design information requirements, architectural and engineering firm selections, and preparation of environmental information have resulted in a 6 month delay in completion of Phase I.

A Memo-to-File to complete the NEPA requirement was signed by DOE on June 13, 1988, for testing to be performed at the Hennepin Station of the Illinois Power Company. Completion of NEPA requirements for Edwards and Lakeside Stations is expected in early 1989.

Problems/Potential Problems:

Delay in completion of Phase I-Design and Permitting activities may adversely affect the total project schedule and cost.

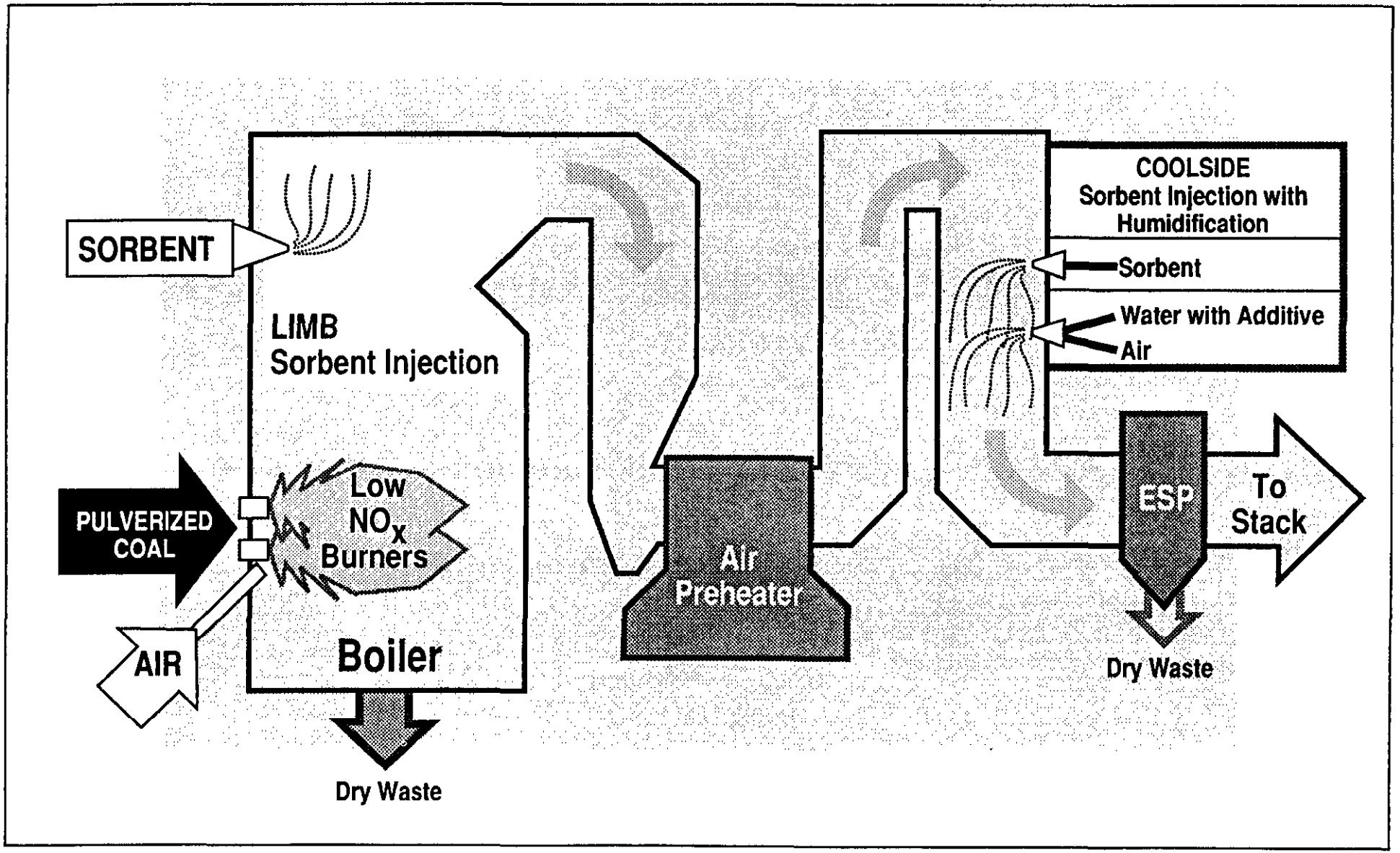
LIMB
Demonstration Project Extension

The Babcock & Wilcox Company

LIMB Demonstration Project Extension

THE BABCOCK & WILCOX COMPANY

PROCESS FLOW DIAGRAM



Project: LIMB Demonstration Project Extension

Industrial Participant:
The Babcock & Wilcox Company

Cofunders:
State of Ohio
Consolidation Coal Company

Process: Flue gas cleanup--LIMB and Coolside duct injection

Location: Lorain, Lorain County, OH (Ohio Edison's Edgewater Plant)

Coal Feed Characteristics:
Medium- and high-sulfur bituminous coal

Plant Capacity/Production: 105 MWe

Estimated Total Cost:	$19,404,940
DOE:	$7,597,026
Industrial Participants:	$11,807,914

Project Objectives:

To test a variety of coals and sorbents to demonstrate the limestone injection multistage burner (LIMB) process as a retrofit system for simultaneous control of sulfur and nitrogen oxides in the combustion process. Project goals for LIMB are to demonstrate up to 60-percent NO_x and SO_x reductions. Additionally, using the Coolside duct injection process, a base of sorbent and one coal will be tested to demonstrate in-duct sorbent injection, upstream of the humidifier and precipitator, to show SO_x removals of up to 80 percent.

This project will be conducted at Ohio Edison's Edgewater Plant in Lorain, OH, on a commercial, 105-MWe boiler. The present EPA-sponsored project will test only one coal and sorbent combination for the LIMB process. The DOE project will demonstrate the LIMB process with multiple coal and sorbent combinations to show the general applicability of the process using medium- and high-sulfur coal. The DOE project will also demonstrate the Coolside process using high-sulfur coal in a commercial scale plant. Until now, the Coolside process has been demonstrated only at the 0.1-MWe and 1-MWe scale.

Process Description:

The LIMB process is expected to reduce SO_x by 50 percent to 60 percent by injecting dry sorbent into the boiler at the point above the burners. The sorbent then travels through the boiler and is removed along with fly ash in the existing particulate removal equipment, either an electrostatic precipitator (ESP) or a baghouse.

In the Coolside process, dry sorbent is injected into the flue gas after the boiler and before the ESP. The gas is humidified in this process to enhance both ESP performance and SO_x absorption. Also, a chemical additive will be dissolved in the humidification water to improve SO_x absorption. Because of these benefits, it is expected that humidification equipment will be part of most, if not all, commercial Coolside applications. The spent sorbent is also collected with the fly ash as in the LIMB process. Reduction of SO_x by 50 percent to 80 percent is expected.

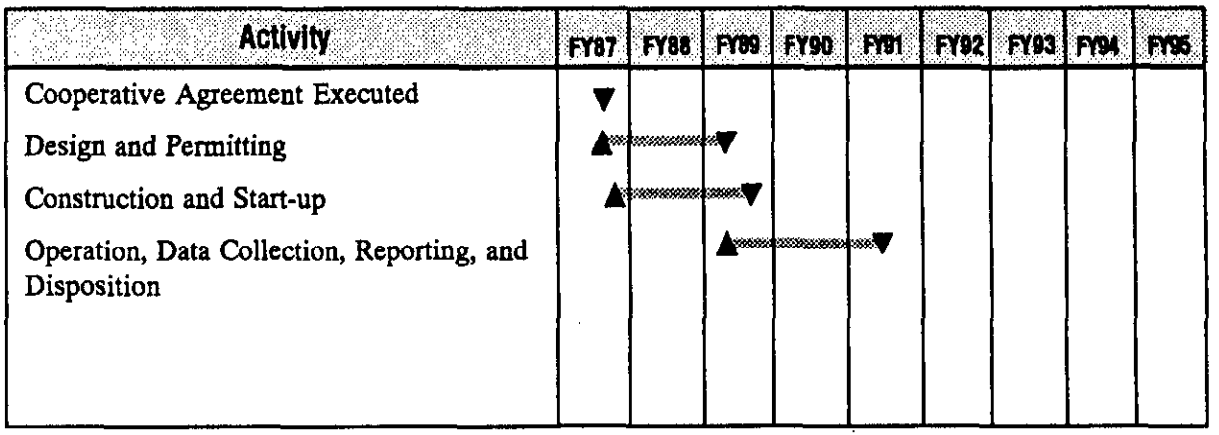
Both demonstrations will utilize the same low NO_x burners. These burners, which can replace conventional burners, control NO_x by injecting the coal and part of the combustion air simultaneously so that the first of the combustion reactions take place in an oxygen-deficient environment. The balance of the combustion air is introduced in a second stage to complete the combustion process. This staged combustion process has been found to reduce NO_x emissions by 50 percent to 60 percent.

The LIMB and Coolside processes both provide an alternative to conventional wet flue gas desulfurization (FGD) processes. Both are expected to be substantially less expensive than wet FGD, and their space requirements are also substantially less. These factors are very important in retrofit applications.

LIMB Demonstration Project Extension
(The Babcock & Wilcox Company)

Key Milestone Dates:

DOE selected project	7/24/86
Issued comprehensive report to Congress	5/11/87
Phase I (design and permitting) and IIA (long-lead procurement) began	5/11/87
Memo-to-File for NEPA requirement signed	6/2/87
DOE signed cooperative agreement	6/25/87
Started Coolside construction and LIMB/Coolside start-up	8/26/87
90% Phase I completion review held	11/16/88
Complete design and permitting	2/89
Begin Coolside/LIMB testing	3/89
Complete construction and start-up	7/89
Complete project	3/91



Project Status:

The overall Phase I design effort for the Coolside and LIMB extension demonstration is over 90 percent complete. The completion of Phase I has been extended by one month to February 1989. Selection of a Coolside waste disposal site remains to be completed.

Construction activities for Coolside are nearing completion and start-up of Coolside is anticipated in early 1989.

LIMB with humidification began continuous operation in September 1988 under the EPA test program. The system has operated at design rates and has achieved emissions goals for SO_2 and NO_x. The humidifier operation since September 1988 has enabled the precipitator to adequately control particulates.

The DOE LIMB extension test program is scheduled to begin in mid-1989 after completion of the Coolside testing. Four sorbents and three coals will be tested to develop a more extensive data base for the LIMB technology.

Problems/Potential Problems:

Efforts continue to resolve the disposal of LIMB and Coolside ash. Waste ash characterization studies have been completed.

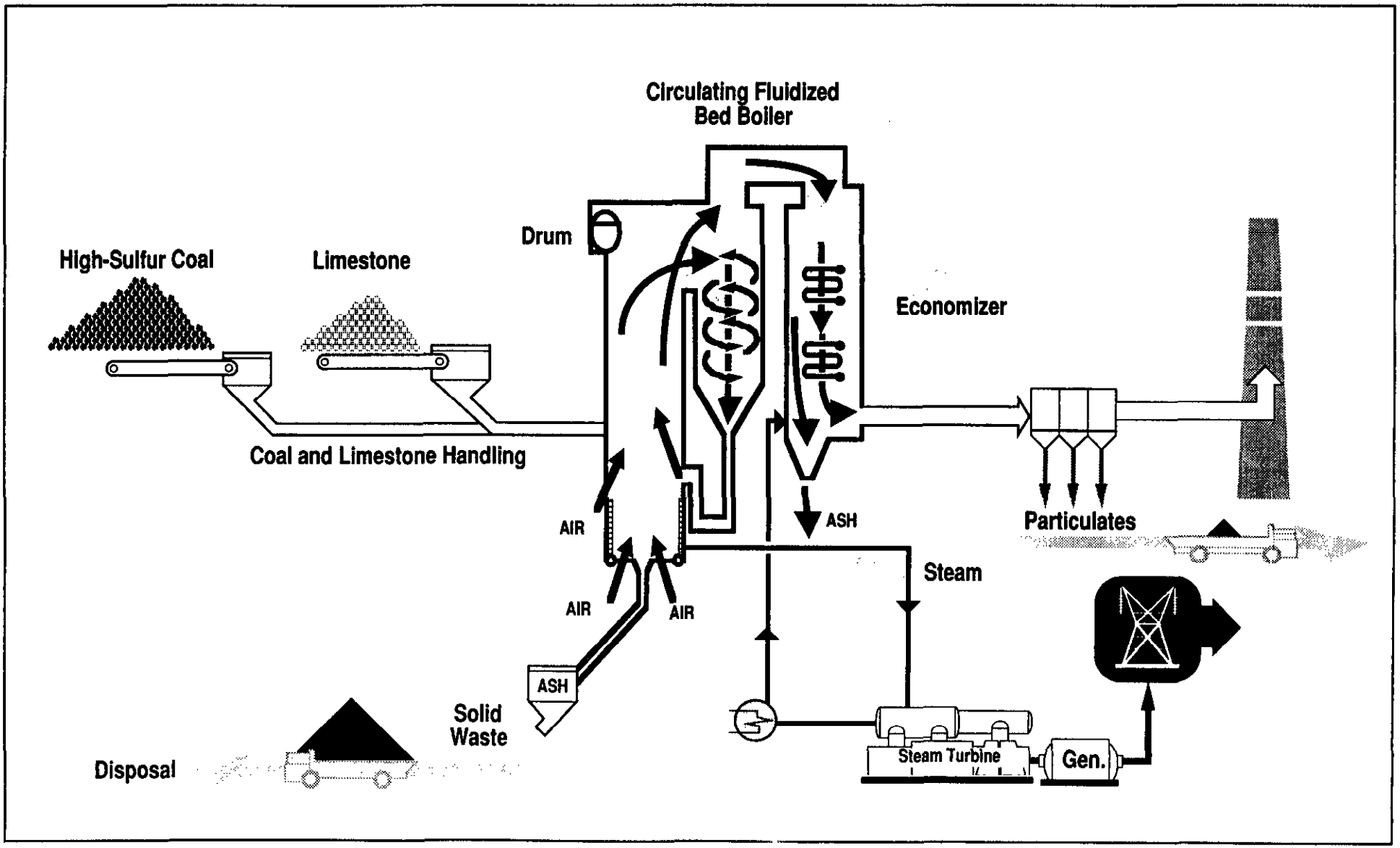
Nucla CFB
Demonstration Project

Colorado-Ute Electric Association, Inc.

Nucla CFB Demonstration Project

COLORADO-UTE ELECTRIC ASSOCIATION, INC.

PROCESS FLOW DIAGRAM



Project: Nucla CFB Demonstration Project

Industrial Participant:
Colorado-Ute Electric Association, Inc.

Cofunder: None

Process: Circulating fluidized-bed combustion

Location: Nucla, Montrose County, CO

Coal Feed Characteristics:
Bituminous and subbituminous coals

Plant Capacity: 110 MWe

Estimated Total Cost:	$54,087,000
DOE:	$19,920,000
Industrial Participant:	$34,167,000

Project Objectives:

To demonstrate the feasibility of circulating fluidized-bed (CFB) combustion technology and to evaluate the economical, environmental, and operational benefits of CFB steam generators on a utility scale.

Process Description:

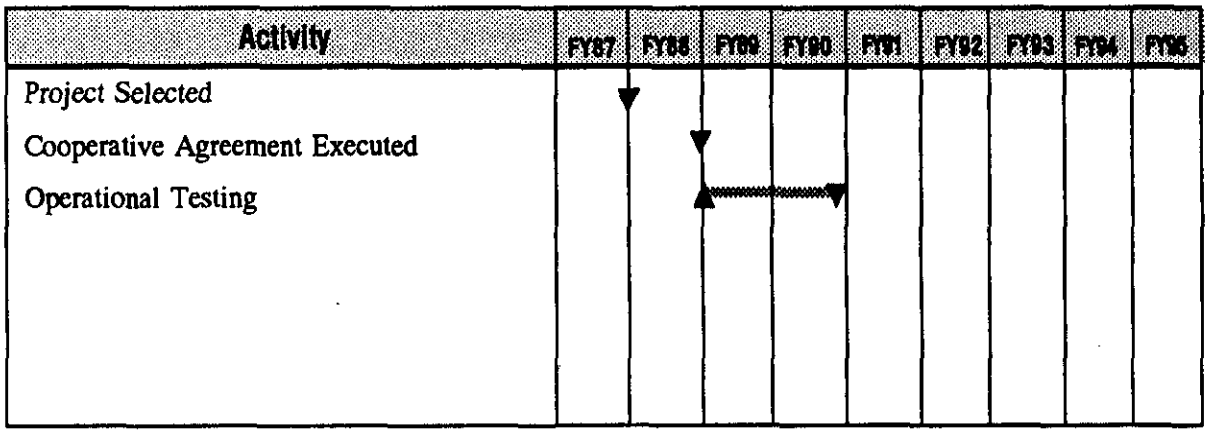
Circulating fluidized-bed combustion is a technology that offers several potential benefits. These include lower capital costs, reduced SO_x and NO_x emissions, and control of pollutants at lower costs than are offered by existing technologies. Emissions will be lower because NO_x is reduced by lower combustion temperature and SO_2 is reduced by reacting with limestone in the fluidized bed. The fluidized-bed combustor operates at atmospheric pressure, and the bed temperature usually ranges between 1,400 °F and 1,600 °F which helps prevent furnace slagging and NO_x emissions. The atmospheric circulating bed system was chosen for this project instead of an atmospheric bubbling bed system because of the potential for higher combustion efficiency and better utilization of limestone.

As part of this project, three small, coal-fired, stoker-type boilers at the Colorado-Ute Nucla Station are being replaced with a single CFB steam generator capable of driving a new 74-MWe turbine generator. Extraction steam from this turbine-generator will power the three existing turbine generators of 12 MWe each. The majority of other existing plant equipment is also being utilized to minimize costs and to demonstrate the suitability of CFB technology for retrofitting and extending the life of existing units.

Nucla CFB Demonstration Project
(Colorado-Ute Electric Association, Inc.)

Key Milestone Dates:

DOE selected project	10/7/87
Kick-off meeting for fact-finding process	11/10/87
Comprehensive report to Congress issued	8/4/88
DOE signed cooperative agreement	10/3/88
Complete first set of start-up and transient tests	2/89
Complete first set of steady state tests	6/89
Complete second set of start-up and transient tests	2/90
Complete second set of steady state tests	7/90
Complete project	8/90



Project Status:

The cooperative agreement was signed by DOE on October 3, 1988. DOE is participating in Phase III-Operation only. Construction of the new CFB boiler was completed prior to execution of the cooperative agreement by DOE. Cold mode shakedown tests are complete. Hot mode shakedown tests are awaiting the completion of boiler acceptance tests now in progress. Hot mode testing and alternate fuels testing are planned for 1989. More than 4,300 hours of operation have been logged during the acceptance test period. Tests using low-sulfur Colorado coal have been conducted. Alternate fuels proposed for future testing include Texas lignite and Illinois high-sulfur bituminous coal.

Problems/Potential Problems:

None.

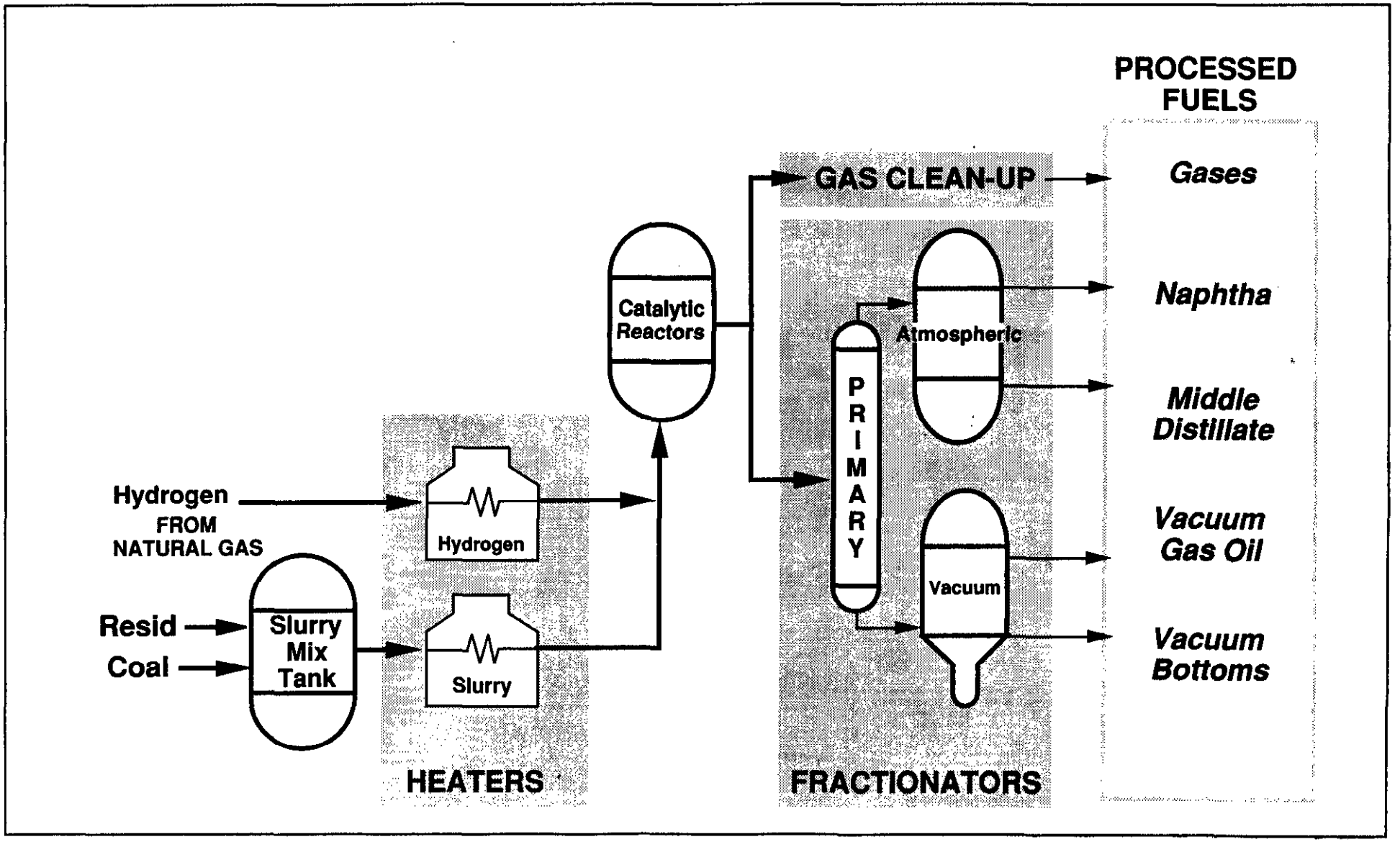
Prototype Commercial Coal/Oil Coprocessing Project

Ohio Ontario Clean Fuels, Inc.

Prototype Commercial Coal/Oil Coprocessing Project

OHIO ONTARIO CLEAN FUELS, INC.

PROCESS FLOW DIAGRAM



Project: Prototype Commercial Coal/Oil Coprocessing Project

Industrial Participant:
Ohio Ontario Clean Fuels, Inc.

Cofunders:
State of Ohio
Stone and Webster Engineering Corporation
Canadian Occidental Petroleum, Ltd.
EPRI (providing funding only for product combustion testing)
Equipment vendors
Ohio electric utility (potential)

Process: Coprocessing of coal and residual oil to produce clean liquid fuels

Location: Warren, Trumbull County, OH

Coal Feed Characteristics:
Ohio Nos. 5 and 6 (high-sulfur bituminous)

Production: 12,280 barrels per day of clean distillate products and 57 tons of sulfur

Feed Rate: 800 tons of coal and 8,675 barrels of oil per day

Estimated Total Cost:	$225,674,805
DOE:	$45,000,000
Industrial Participants:	$180,674,805

Project Objectives:

To build a grassroots prototype, commercial coal/oil coprocessing plant to convert high-sulfur, high-nitrogen, bituminous coal, and poor-quality petroleum residuum to clean liquid fuels, using ebullated-bed reactor technology.

Process Description:

Coal/oil coprocessing yields liquid fuels that are low in sulfur, nitrogen, and trace metals and high in heating value. These liquid products can be used directly as a clean-burning boiler fuel or further processed in a conventional petroleum refinery to produce transportation fuels. Nitrogen (in the form of ammonia) and sulfur are recovered as by-products, thereby avoiding their introduction into the atmosphere as SO_x and NO_x. Hydrocarbon gases are also collected as by-products in the form of liquefied petroleum gases (LPG).

Crushed and prepared coal, petroleum residuum, and a recycle solvent (oil) are mixed, pressurized, and heated and are introduced as a slurry along with pressurized hydrogen into the first of two process reactors.

In the reactor, hydrogen reacts with molecules of coal and heavy residual oil to produce lighter molecules. The hydrogen also reacts with the sulfur and nitrogen in the feed to form gaseous hydrogen sulfide (H_2S) and ammonia (NH_3) that are subsequently collected as waste products. Hydrogen consumption is reduced, and product yield is increased by using a second reactor. The liquid effluent from the second reactor is separated from the gases, and the light, clean liquids are then collected through a series of pressure reductions and cooling steps. The heavy liquid stream is cleaned and separated in several distillation steps. Both the lighter and heavier liquids are further distilled and blended to produce clean naphtha and clean distillate. The gases are cleaned and separated into butane, propane, and fuel gas.

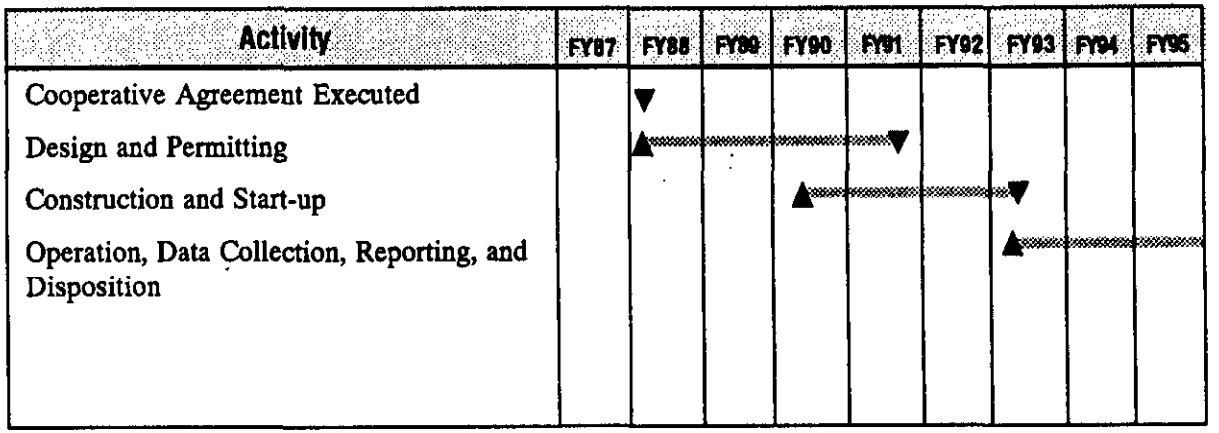
During the gas cleanup, the water soluble waste products are collected in a sour water stream. The sour water is treated by conventional refinery processes to recover elemental sulfur and ammonia as by-products. The wastewater is further treated to remove organic compounds before it is discharged from the plant.

The vacuum bottoms from the distillation process contain unreacted coal, ash, and residue, which forms a solid material at ambient temperature. These bottoms can be solidified, flaked, and burned to generate sufficient steam to meet the plant's requirements.

Prototype Commercial Coal/Oil Coprocessing Project
(Ohio Ontario Clean Fuels, Inc.)

Key Milestone Dates:

DOE selected project	7/24/86
Issued comprehensive report to Congress	10/30/87
DOE signed cooperative agreement	12/15/87
Complete design and permitting	6/91
Complete construction	12/92
Begin operation	1/93
Complete project	12/95



Project Status:

DOE signed the cooperative agreement on December 15, 1987, and the project is currently in Phase I (design).

Process development testing was initiated in September 1988. A preliminary market analysis and initial design and cost estimate have been completed. Studies of an alternate site are under way to improve marketing arrangements and project economics. Activities are currently being directed at a utility market venture with an Ohio-based utility.

Problems/Potential Problems:

The project schedule may be delayed if an environmental impact statement is required. A comprehensive environmental report is in preparation.

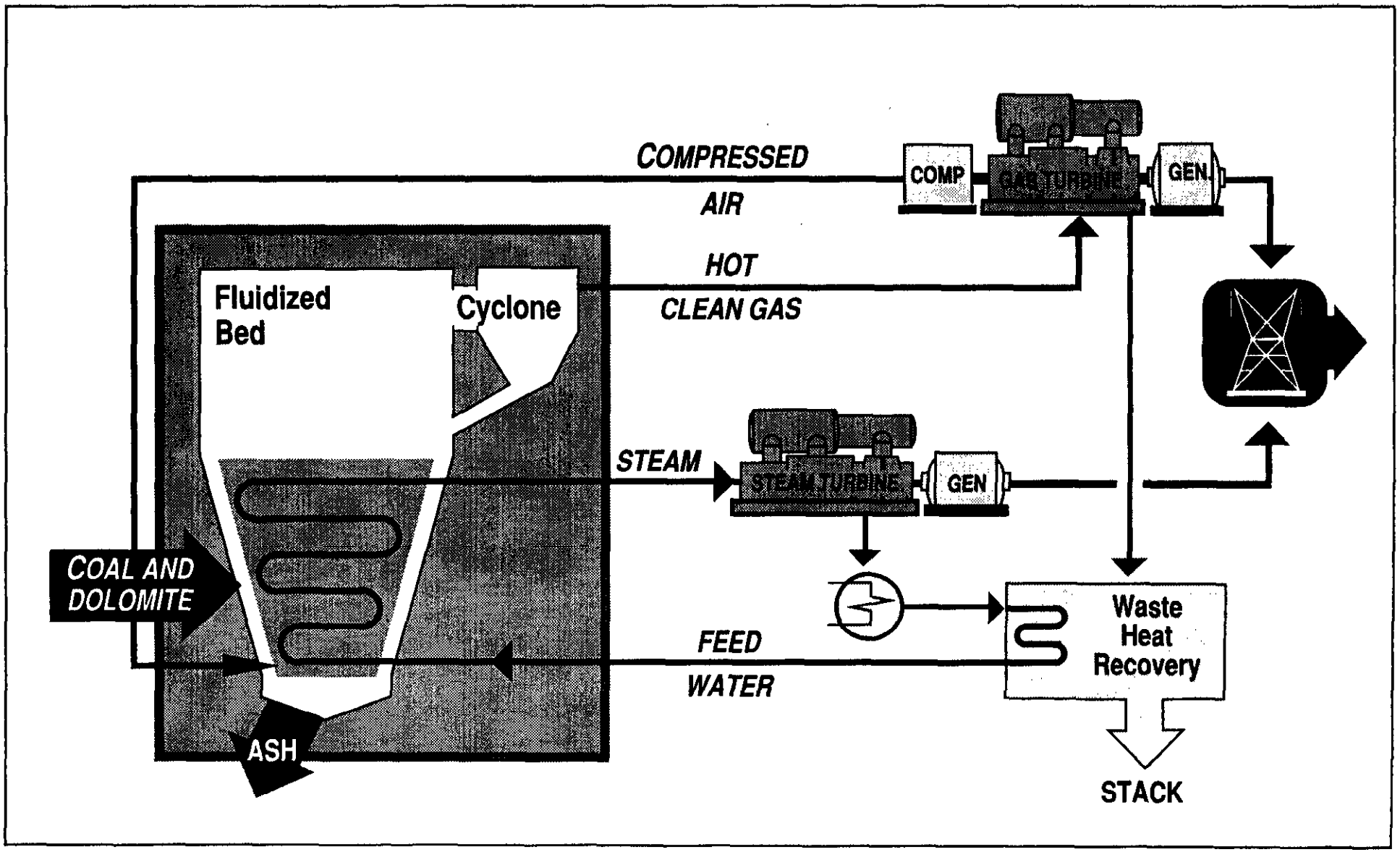
Tidd PFBC
Demonstration Project

Ohio Power Company

Tidd PFBC Demonstration Project

OHIO POWER COMPANY

PROCESS FLOW DIAGRAM



Project: Tidd PFBC Demonstration Project

Industrial Participant:
Ohio Power Company

Cofunder:
State of Ohio

Process: Pressurized fluidized-bed combustion

Location: Brilliant, Jefferson County, OH

Coal Feed Characteristics:
Ohio high-sulfur bituminous coal

Plant Capacity/Production: 70 MWe

Feed Rate: 660 tons of coal per day

Estimated Total Cost:	$167,500,000
DOE:	$60,200,000
Industrial Participants:	$107,300,000

Project Objectives:

To build and operate a 70-MWe PFBC combined-cycle power plant demonstrating that this new technology will permit the burning of high-sulfur coal to produce electricity in a more economical and efficient way than is commercially available, while meeting or exceeding stringent U.S. environmental standards.

Process Description:

Pressurized fluidized-bed combustion (PFBC) is a clean coal technology that can burn high-sulfur coal in an environmentally superior manner; that is, the emissions of SO_x and NO_x are held within current environmental limits. Unlike conventional technologies, combined-cycle PFBC provides for increased electric generation efficiency through a combined gas and steam cycle.

In the PFBC process, crushed coal and a sorbent (dolomite or limestone) are continuously fed into a pressurized vessel in which air, fed from the bottom, maintains the coal and sorbent in a highly turbulent suspended state, called fluidization. During the combustion process, the SO_2 formed is absorbed by the dolomite ($CaCO_3$ $MgCO_3$) to form an inert magnesium oxide calcium sulfate (MgO $CaSO_4$) complex.

The MgO $CaSO_4$ complex, a dry, granular by-product when removed from the fluidized bed, can be managed more easily than the sludge from a wet flue gas desulfurization system. The PFBC process has been demonstrated through extensive pilot plant testing to remove over 90 percent of the sulfur from 4-percent sulfur coal at a Ca/S molar ratio of 1.6. Similar reactions take place when limestone is used as the sorbent.

Combustion occurs in a fluidized bed at a relatively low temperature of 1,580 °F (860 °C). This temperature is below the ash fusion temperature of most coals, thus eliminating slag formation as well as reducing process sensitivity to coal type. Furthermore, the low combustion temperature restricts the formation of NO_x to less than that from a conventional pulverized coal-fired plant.

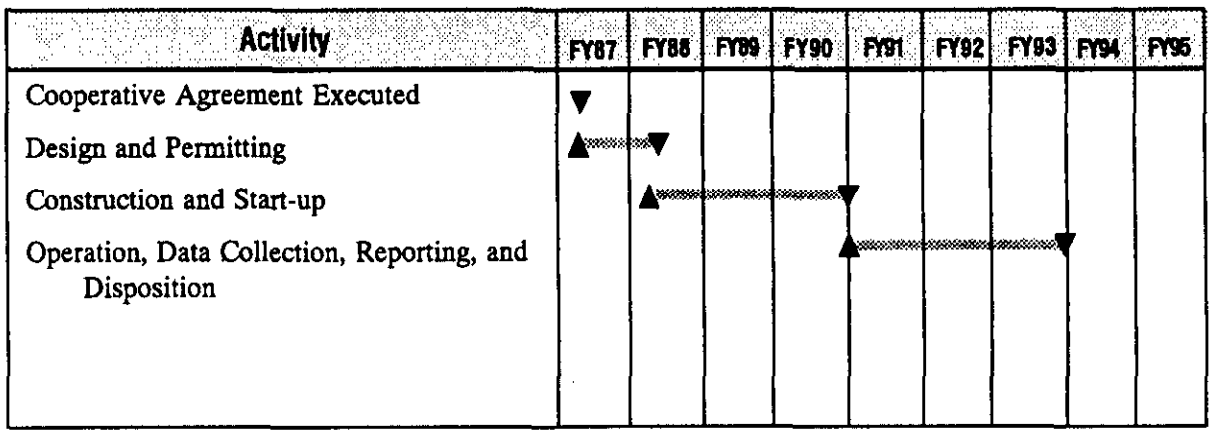
High pressure in the PFBC process permits a deep bed and allows high residence times, ensuring high combustion efficiency and good sorbent utilization. The deep bed also permits submerging all boiler tubes in the bed, thus taking maximum advantage of the high heat transfer coefficient, leading to a very compact boiler design. The overall heat-transfer rates in submerged boiler tubes are about 4 to 5 times higher than in a convective environment. The steam produced within these tubes drives a steam turbine generator to produce the bulk of the plant's electric power.

High pressure in the process also permits hot gases from the combustor, after cleaning, to operate a gas turbine-generator. Gases from the combustor pass through high efficiency cyclones to remove approximately 99 percent of the solids in the gas stream before entering the gas turbine. The flue gas from the gas turbine exhausts through an economizer, an electrostatic precipitator, and a stack.

Tidd PFBC Demonstration Project
(Ohio Power Company)

Key Milestone Dates:

DOE selected project	7/24/86
Issued comprehensive report to Congress	2/11/87
DOE signed cooperative agreement	3/20/87
Air Permit to Install received from Ohio EPA	5/28/87
Complete design and permitting	12/16/87
Continuation into Phase II approved	12/9/87
Ash Disposal Permit to use existing Cardinal fly-ash pond received	1/88
Complete construction	10/90
Begin operation	10/90
Complete project	10/93



Project Status:

This project is in Phase II-Procurement, Construction, and Start-up and remains on schedule and within budget. Formal ground breaking at the Tidd site took place in April 1988.

Overall construction is more than 20 percent complete. Notable accomplishments include completion of excavation and pile driving, pouring of the concrete basement and combustor support ring, removal of asbestos from the existing building, refurbishment of the coal and dolomite storage area, dredging of the cooling water intake and discharge channels, and refurbishment of the coal handling equipment.

Welding of the pressure vessel was completed at the Babcock & Wilcox fabrication shop in Mt. Vernon, Indiana. Radiographic testing of the final weld and stress relieving of the vessel was completed, and hydrostatic testing was completed in November 1988. Shipment of the pressure vessel to the Tidd plant site is scheduled for May 1989.

Fabrication of the GT-35P gas turbine has begun. The turbine is scheduled for a Spring 1989 shakedown on the test stand in Sweden.

Problems/Potential Problems:

None.

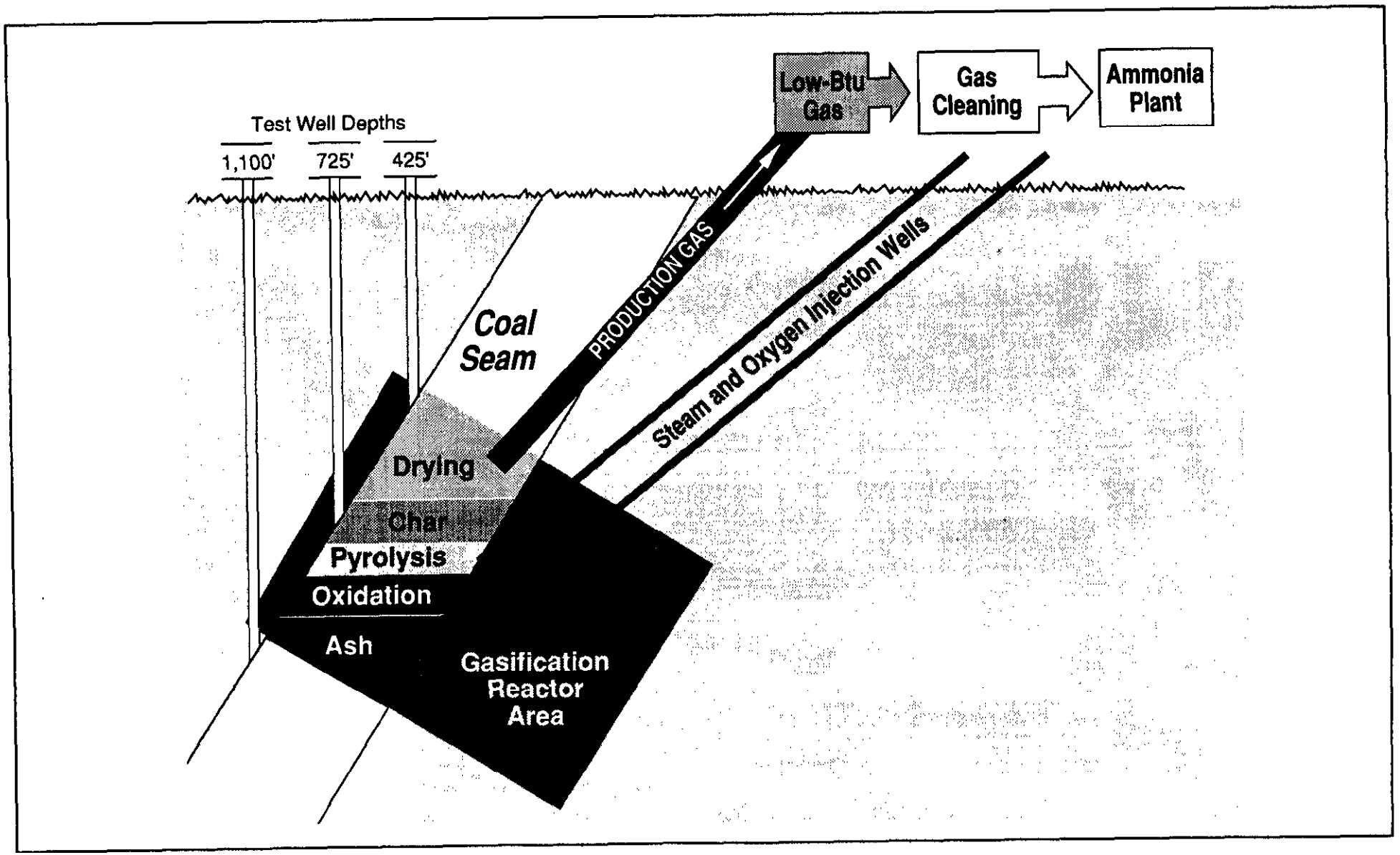
Underground Coal Gasification Demonstration Project

Energy International, Inc.

Underground Coal Gasification Demonstration Project

ENERGY INTERNATIONAL, INC.

PROCESS FLOW DIAGRAM



Project: Underground Coal Gasification Demonstration Project

Industrial Participant:
Energy International, Inc.

Cofunder:
Venture Pacific, Ltd.

Process: Underground coal gasification

Location: Rawlins, Carbon County, WY

Coal Feed Characteristics:
Wyoming subbituminous coal

Feed Rate: 500-1,000 tons of coal per day

Plant Production: 400 tons of ammonia per day

Estimated Total Cost:	$113,182,538
DOE:	$11,792,362
Industrial Participants:	$101,390,176

Project Objectives:

To demonstrate that underground gasification of steeply dipping subbituminous coal beds is a cost-effective, reliable, and environmentally acceptable alternative to conventional mining with subsequent surface gasification. The specific objective of this project is to conduct a commercial-scale demonstration of steeply dipping bed underground coal gasification to provide synthesis gas for a small, commercial ammonia plant.

Process Description:

Underground coal gasification (UCG) is the process by which coal is burned underground (*in situ*), and the heat generated by the oxidation pyrolytically decomposes and gasifies additional coal to produce combustible gases. As the coal is consumed, a cavity develops in the coal seam. The most straightforward type of UCG process requires drilling one well to inject oxygen-containing gases and another to remove the gaseous products.

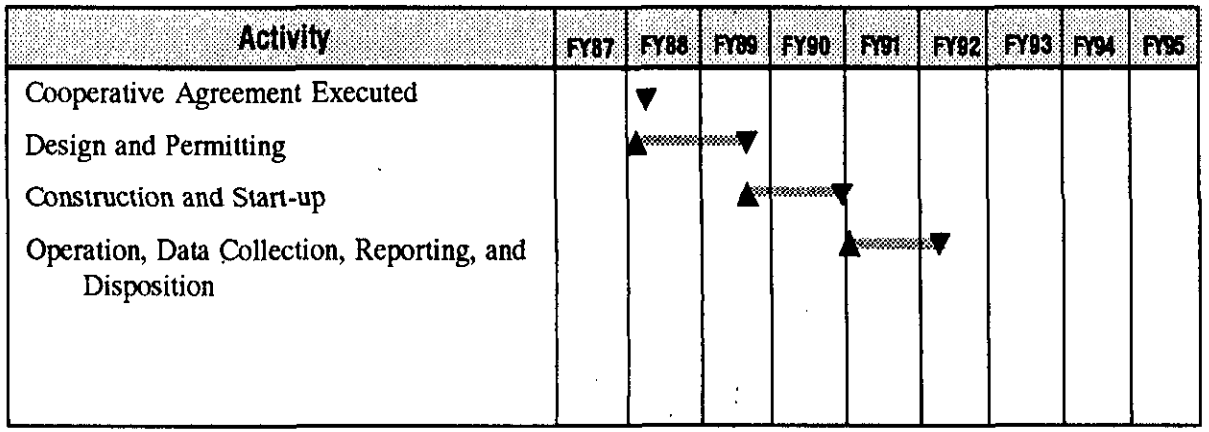
This project will demonstrate UCG technology in steeply dipping beds of subbituminous coal in Wyoming. The demonstration facility will operate for 12 months, gasifying 500 to 1,000 tons of coal per day to produce 24-48 million standard cubic feet per day of product gas. This gas will then be used to produce 400 tons of ammonia per day. The feedstock gas for the ammonia plant will be produced by using several UCG modules operating simultaneously.

In this application, a module is an area in the coal bed containing the gasification reaction zone and the necessary injection and production wells that would comprise a single process unit in a commercial plant. One coal gasifier in a surface coal gasification plant is the equivalent of one *in-situ* gasification module. Each UCG module consists of two steam/oxygen injection wells and one producer well located above the two injection wells. After combustion is initiated, gasification will continue until the coal in the module is exhausted. The gas produced will flow successively to heat exchange equipment, a gas/liquid separation unit, a sulfur removal unit, and then to a conventional ammonia synthesis unit.

Underground Coal Gasification
Demonstration Project
(Energy International, Inc.)

Key Milestone Dates:

DOE selected project	7/24/86
Comprehensive report to Congress issued	11/9/87
Began Phase I--design and permitting	11/9/87
DOE signed cooperative agreement	12/23/87
NEPA documentation completed	2/9/88
Complete design and permitting	7/89
Begin site construction	7/89
Complete construction	9/90
Begin test operations	10/90
Complete project	1/92



Project Status:

Phase I site characterization work has indicated that there is no major problem at the site. Energy International, Inc., has drilled 26 test holes at the site, 18 of which were for hydrological data. Over 95 percent of the process flow diagrams have been approved for design. Most long-lead items are out on inquiry. An ammonia plant will be installed at the site instead of the earlier planned ammonia/urea facility.

Problems/Potential Problems

Delays have been experienced in completing financing for Phases II and III. A financial package will need to be finalized before the project can proceed into construction.

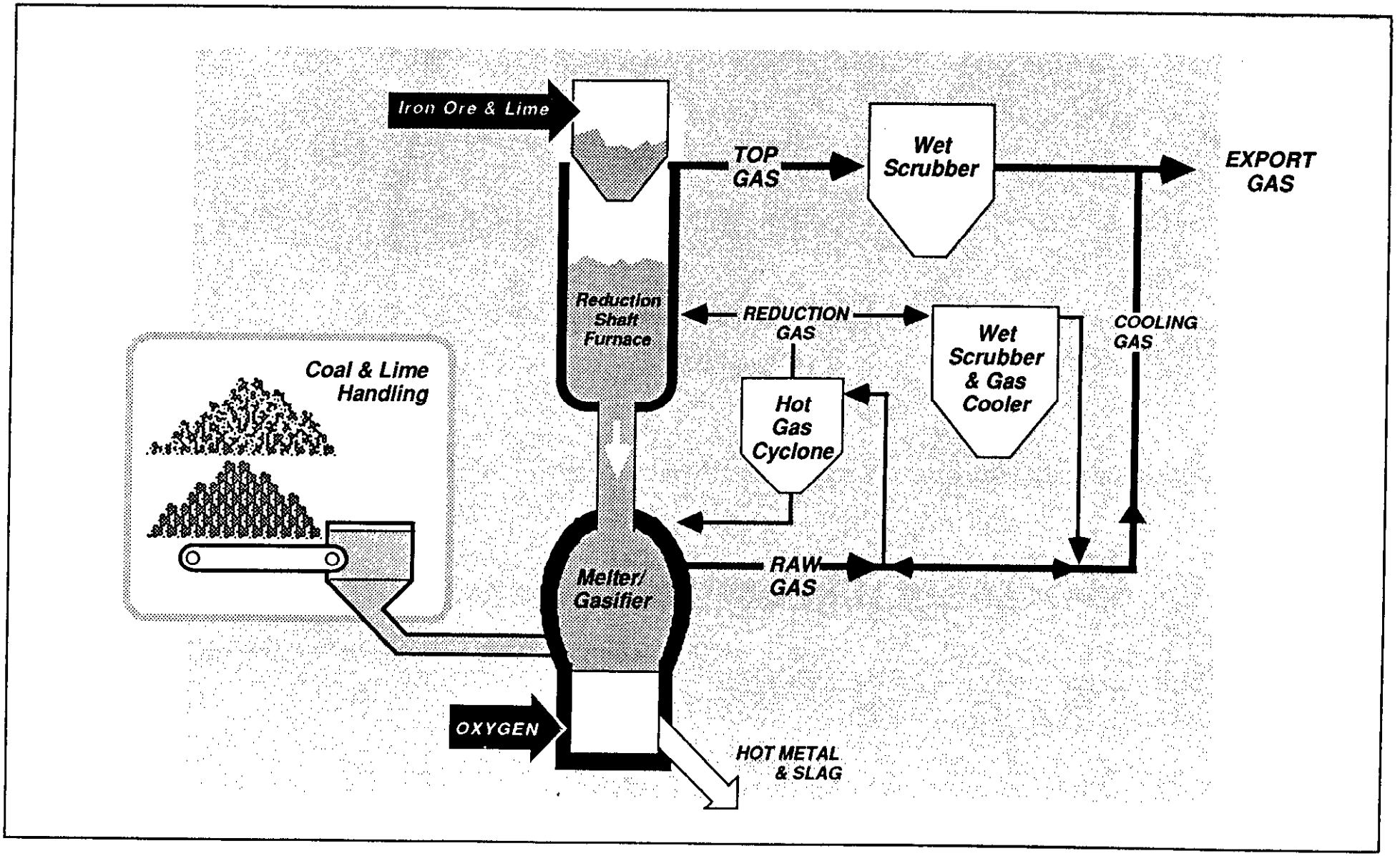
COREX Ironmaking Demonstration Project

Minnesota Department of Natural Resources

COREX Ironmaking Demonstration Project

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

PROCESS FLOW DIAGRAM



Project: COREX Ironmaking Demonstration Project

Industrial Participant:
Minnesota Department of Natural Resources

Cofunder: None

Process: COREX

Coal Feed Characteristics:
Low volatile coals and coal blends

Feed Rate: 240,000-400,000 tons of coal per year

Plant Capacity/Production:
300,000-600,000 tons of iron per year

Project Objectives:

To demonstrate at a commercial scale (300,000 metric tons per year of pig iron minimum) that the COREX process can be used to produce pig iron of blast furnace quality directly from U.S. coals and ores, thereby eliminating the coke plant and its environmental problems from the ironmaking process.

Process Description:

The COREX process, developed by Korf Engineering (a West German company), replaces the two-step coke oven/blast furnace approach to producing pig iron from iron ore and metallurgical coal with an integrated two-component system capable of operation on a variety of U.S. coals. The system consists of an upper "reduction shaft" and a lower "melter-gasifier" component. Iron ore, along with an appropriate flux (e.g., limestone), is fed into the top of the reduction shaft where it is reduced to sponge iron by the off-gas from the lower melter-gasifier section into which it is then introduced along with coal. This lower section is an oxygen-blown fluidized-bed gasifier. In this section, the sponge iron is melted and the resulting pig iron and slag are separated and tapped as in a blast furnace. The low- to medium-Btu, sulfur-free off-gas from the process (sulfur is captured by the limestone and remains in the slag) is scrubbed to remove particulates and is available for site use.

The practicality of ironmaking by the traditional method of reducing iron ore material in a coke-fed blast furnace has been severely impacted due to environmental problems. The problems lie principally with the coke-manufacturing operation which generates emissions and effluent that have proven to be exceedingly difficult to control to levels meeting environmental regulations. The COREX process, by eliminating the coking step, is environmentally superior to established ironmaking methods. The process offers other advantages as well, including attractive economics, the ability to operate on a wide range of coal and iron feedstocks, the capability for rapid start-up and shutdown, and flexibility in terms of product slate and plant scale up.

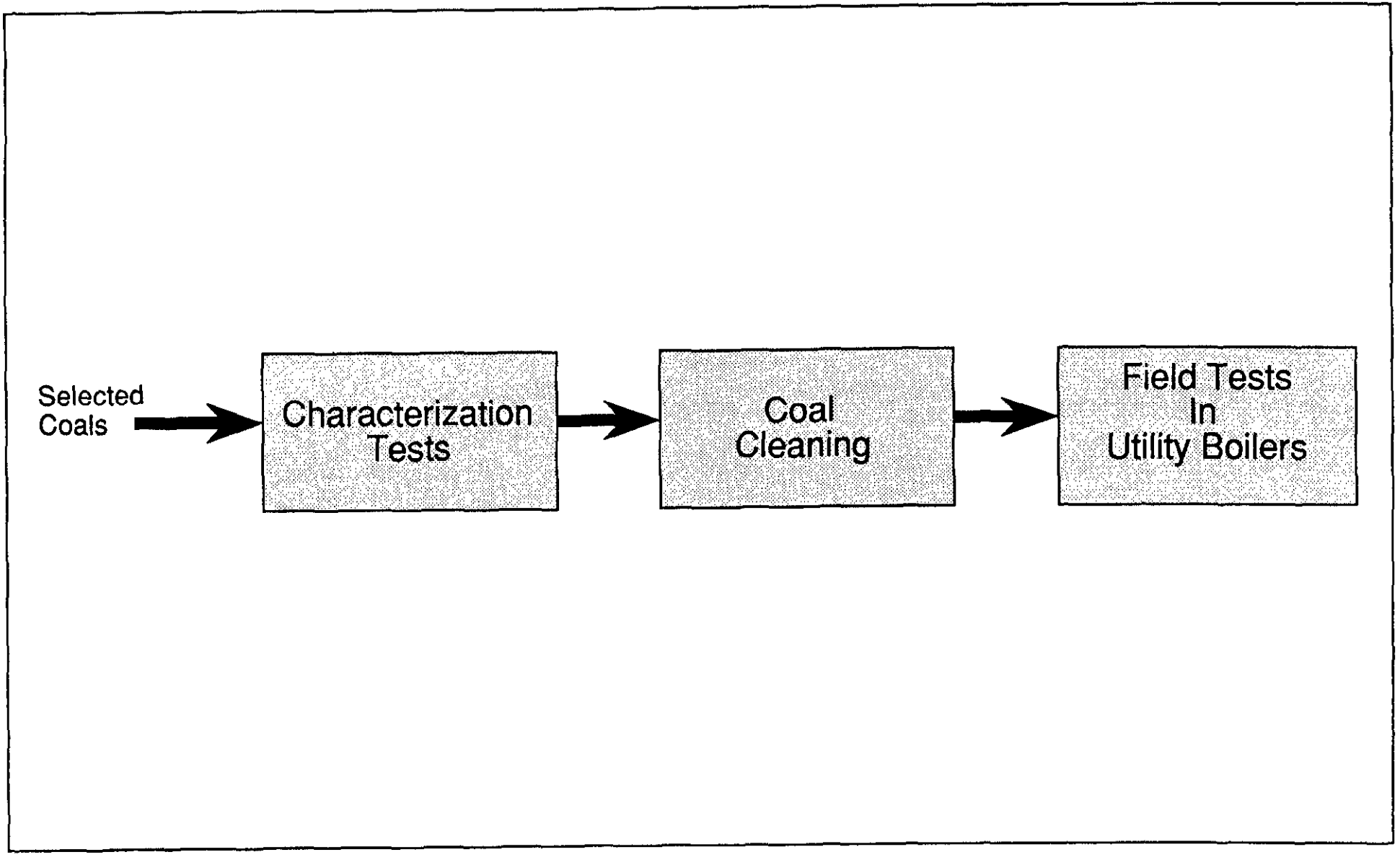
Clean Coal Combustion Testing Project

Combustion Engineering, Inc.

Clean Coal Combustion Testing Project

COMBUSTION ENGINEERING, INC.

PROCESS FLOW DIAGRAM



Project: Clean Coal Combustion Testing Project

Industrial Participant:
Combustion Engineering, Inc.

Cofunder:
EPRI

Process: Coal cleaning

Location: Windsor, Hartford County, CT

Coal Feed Characteristics:
Anthracite, bituminous, subbituminous, and lignite coals

Plant Production: 200-MWe test burns

Feed Rate: 20 tons per hour coal cleaning

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participant:	TBD

TBD: To be determined

Project Objectives:

To develop a comprehensive data base on the performance of cleaned coals to allow confident assessment of the effects of cleaning on specific boiler performance. To develop and validate a methodology that allows prediction of fuel impacts on total power plant operation and costs based upon inputs from bench-scale tests.

Process Description:

In this project, combustion tests will be conducted on coals cleaned to different levels at EPRI's existing coal cleaning test facility. An initial group of coals will be selected based on their commercial significance, rank, and mineral matter characteristics. Washability tests will be conducted on the coals to determine their potential for beneficiation. From the initial group, eight coals will be selected and beneficiated to two levels (one medium and one deep cleaned). Samples, as appropriate, will be tested in the laboratory and in small (4-5 MBtu/hr) test rigs. The work will be accomplished by two boiler companies to permit comparison between tangentially and wall-fired combustion systems. Subsequently, four coals would be selected for field testing in 200-MWe coal-fired utility boilers.

Clean Coal Combustion Testing Project
(Combustion Engineering, Inc.)

Key Milestone Dates:

DOE selected project	12/9/88
Kick-off meeting for fact-finding process	2/89
Issue preagreement milestone schedule	TBD
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Begin coal cleaning and combustion testing	TBD
Complete project	9/92*

* Preliminary; subject to negotiation

Activity	FY87	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95
Project Selected			▼						
Preagreement Milestone Schedule Issued									
Cooperative Agreement Executed									
Coal Cleaning and Combustion Testing									

Project Status:

Fact-finding and negotiating activities are in progress.

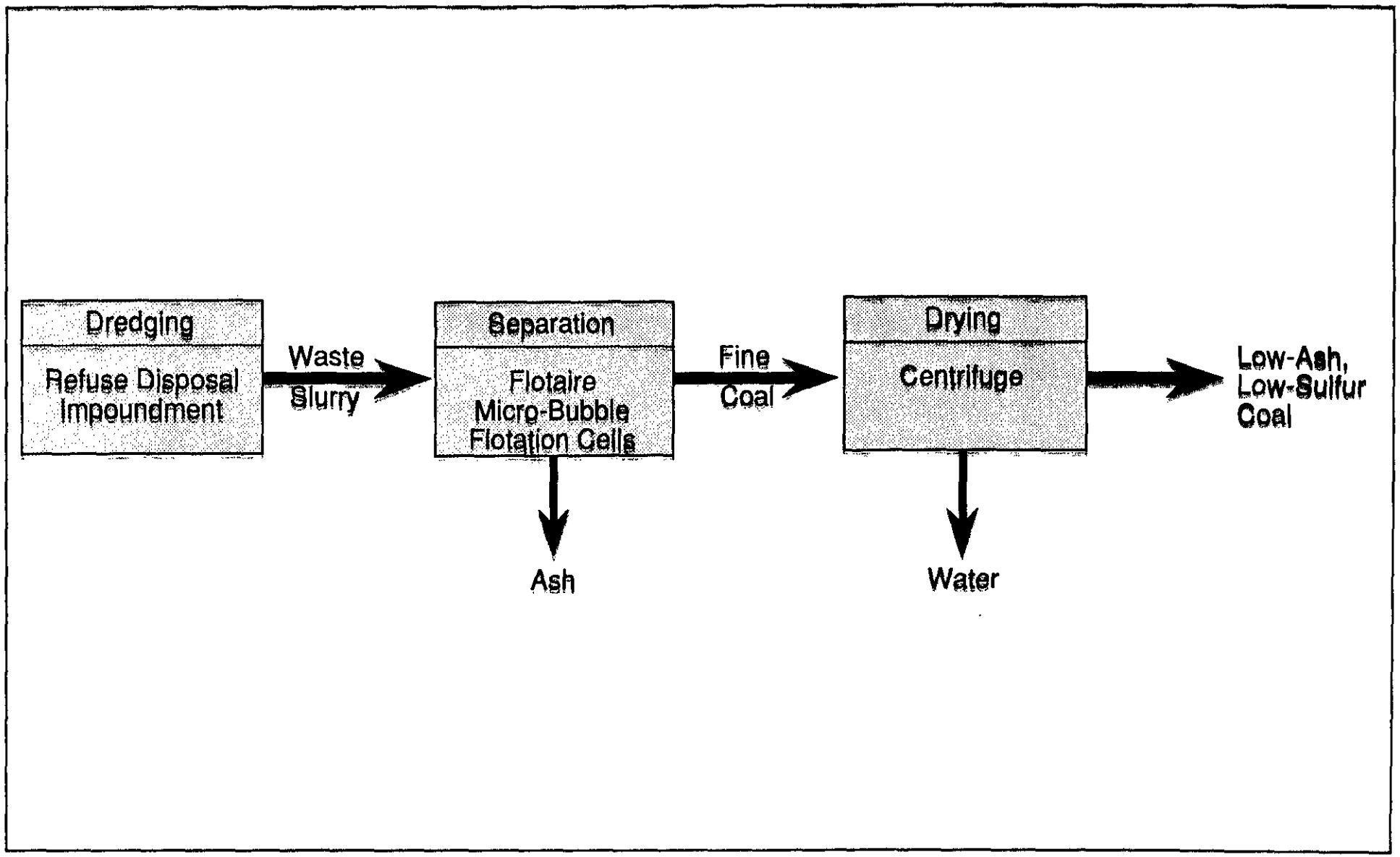
Coal Waste Recovery Demonstration Project

United Coal Company

Coal Waste Recovery Demonstration Project

UNITED COAL COMPANY

PROCESS FLOW DIAGRAM



Project: Coal Waste Recovery Demonstration Project

Project Industrial Participant:
United Coal Company

Cofunder: None

Process: Microbubble flotation and centrifugal drying of coal preparation wastes

Location: Sharples, Logan County, WV

Coal Feed Characteristics:
Low-sulfur coal fines

Plant Production: 385 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participant:	TBD

TBD: To be determined

Project Objectives:

To demonstrate the cost-competitive recovery of fine, low-sulfur coal from a coal refuse disposal impoundment.

Process Description:

This project will demonstrate the recovery of fine, low-sulfur coal from the Monclo refuse disposal impoundment. The waste material slurry in the impoundment will be removed using a Mudcat floating dredge. It will be pumped to Flotaire microbubble flotation cells where the fine coal will be efficiently separated from the ash. The recovered coal will then be dried to 7.7 percent moisture content using a Robert and Shaefer centrifuge. The final product is a low-ash, low-sulfur coal in a granular, non-dusty form. It is easy to handle and suitable for blending. The demonstration project will be conducted at the Sharples Coal Facility, Logan County, West Virginia.

Coal Waste Recovery Demonstration Project
(United Coal Company)

Key Milestone Dates:

DOE selected project	12/9/88
Kick-off meeting for fact-finding process	3/89
Issue preagreement milestone schedule	TBD
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Complete design and permitting	TBD
Complete construction	TBD
Begin operation	TBD
Complete project	9/91*

* Preliminary; subject to negotiation

Activity	FY87	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95
Project Selected			▼						
Preagreement Milestone Schedule Issued									
Cooperative Agreement Executed									
Design and Permitting									
Construction and Start-up									
Operation									

Project Status:

ICCT Project Summaries

To prevent the release of project specific, proprietary information, the diagrams contained in this section of the report are presented only as illustrative of the concepts involved.

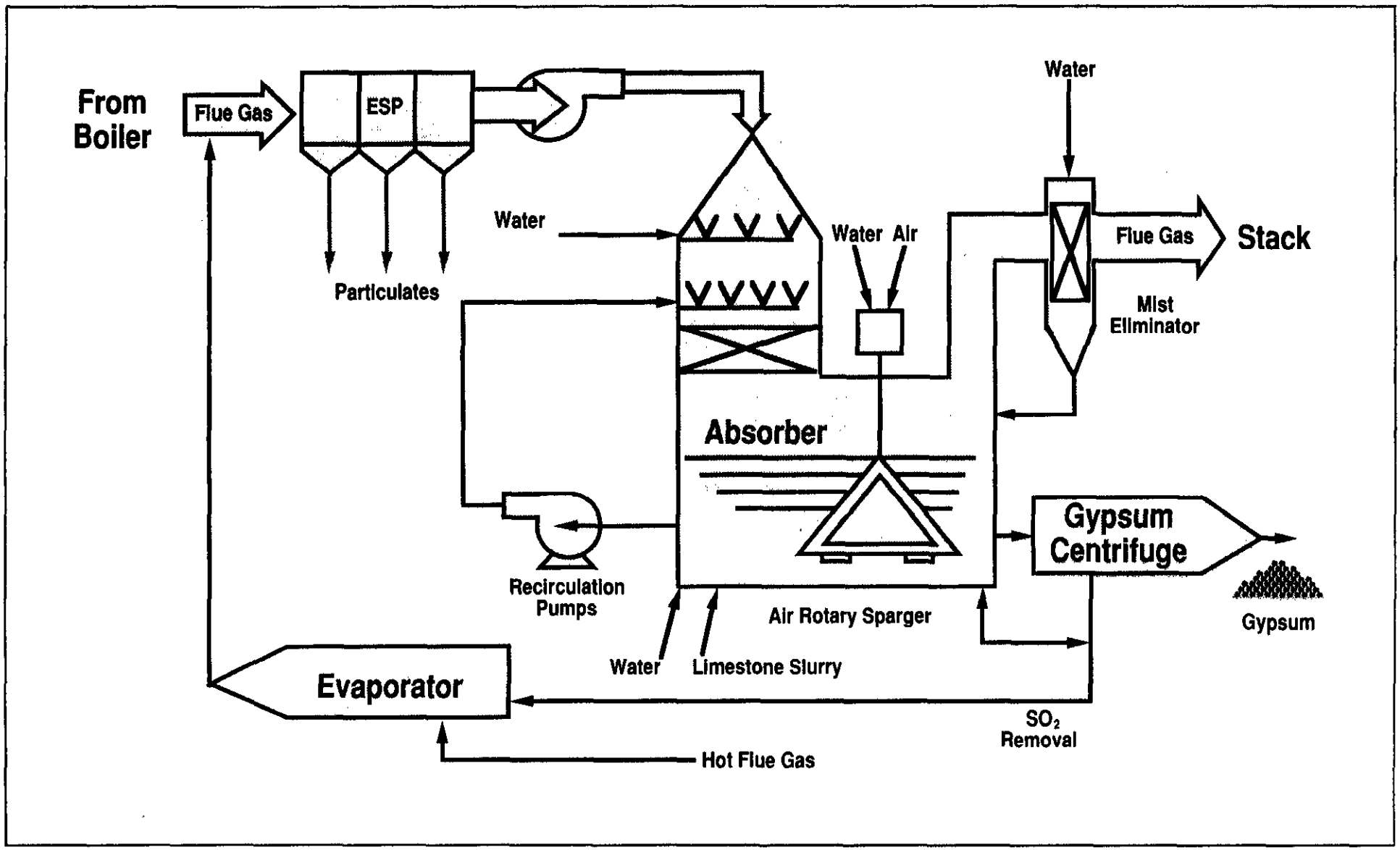
Advanced Limestone Scrubber FGD Demonstration Project

Pure Air

Advanced Limestone Scrubber FGD Demonstration Project

PURE AIR

PROCESS FLOW DIAGRAM



Project: Advanced Limestone Scrubber FGD Demonstration Project

Industrial Participant:
Pure Air

Cofunder:
Northern Indiana Public Service Company (host utility)

Process: Advanced flue gas scrubber

Location: Gary, Lake County, IN

Coal Feed Characteristics:
Bituminous coal (2.9% to 4.5% sulfur)

Plant Capacity: 529 MWe

Feed Rate: 4,800 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participant:	TBD

TBD: To be determined

Project Objectives:

To demonstrate the Mitsubishi wet limestone flue gas desulfurization (FGD) technology including advanced features at the 500-MWe scale using high-sulfur U.S. coals. The project will demonstrate 90 percent sulfur removal, efficient plant operations, and production of salable by-product gypsum, at a cost of approximately 50 percent of currently available FGD systems.

Process Description:

A single absorber module will treat the flue gas from existing boilers. The expected high reliability will permit operation without the use of spare absorber modules. The system design will use a high velocity, concurrent flow absorber with direct injection of pulverized limestone. The system design includes a new and innovative single-loop process which produces commercial gypsum, using in-situ forced oxidation accomplished by a rotary air sprayer. A novel wastewater evaporation system will be evaluated that potentially eliminates water disposal/treatment problems associated with the use of high chloride containing coals; the system results in essentially no water discharge. A cyclic reheater will be used to reduce the operating costs normally associated with steam reheat.

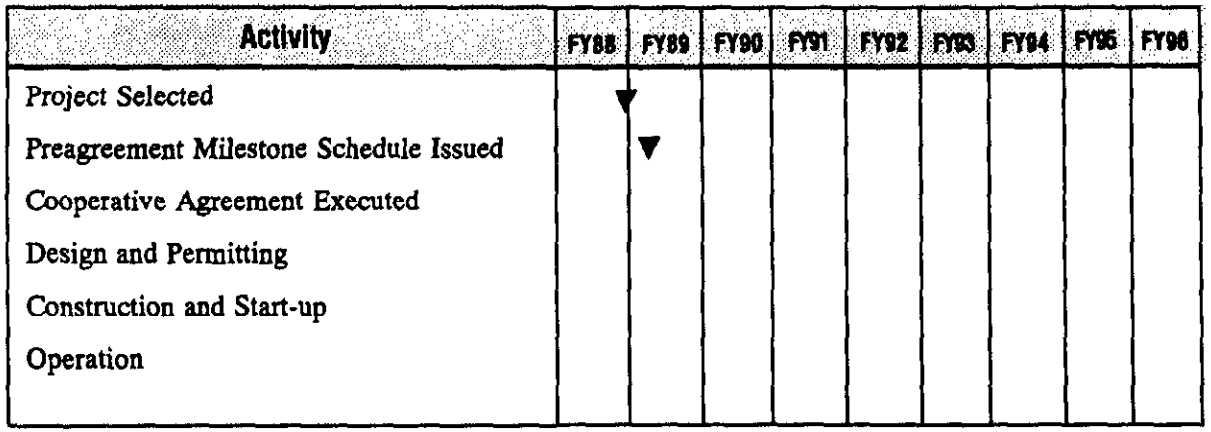
Unique technical features of the project include the first demonstration of a single, 100-percent capacity, scrubber module serving multiple boilers; the use of an innovative single-loop process, together with in-situ oxidation to produce industrial-grade gypsum; and a new wastewater evaporation system that eliminates effluent.

Advanced Limestone Scrubber FGD Demonstration Project
(Pure Air)

Key Milestone Dates:

DOE selected project	9/28/88
Kick-off meeting for fact-finding process	10/19/88
Issue preagreement milestone schedule	1/89
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Complete design and permitting	TBD
Complete construction	TBD
Begin operation	TBD
Complete project	6/95*

* Preliminary; subject to negotiation



Project Status:

Fact-finding and negotiating activities are in progress. Pure Air and the host utility are considering a site change which will not measurably change the demonstration project.

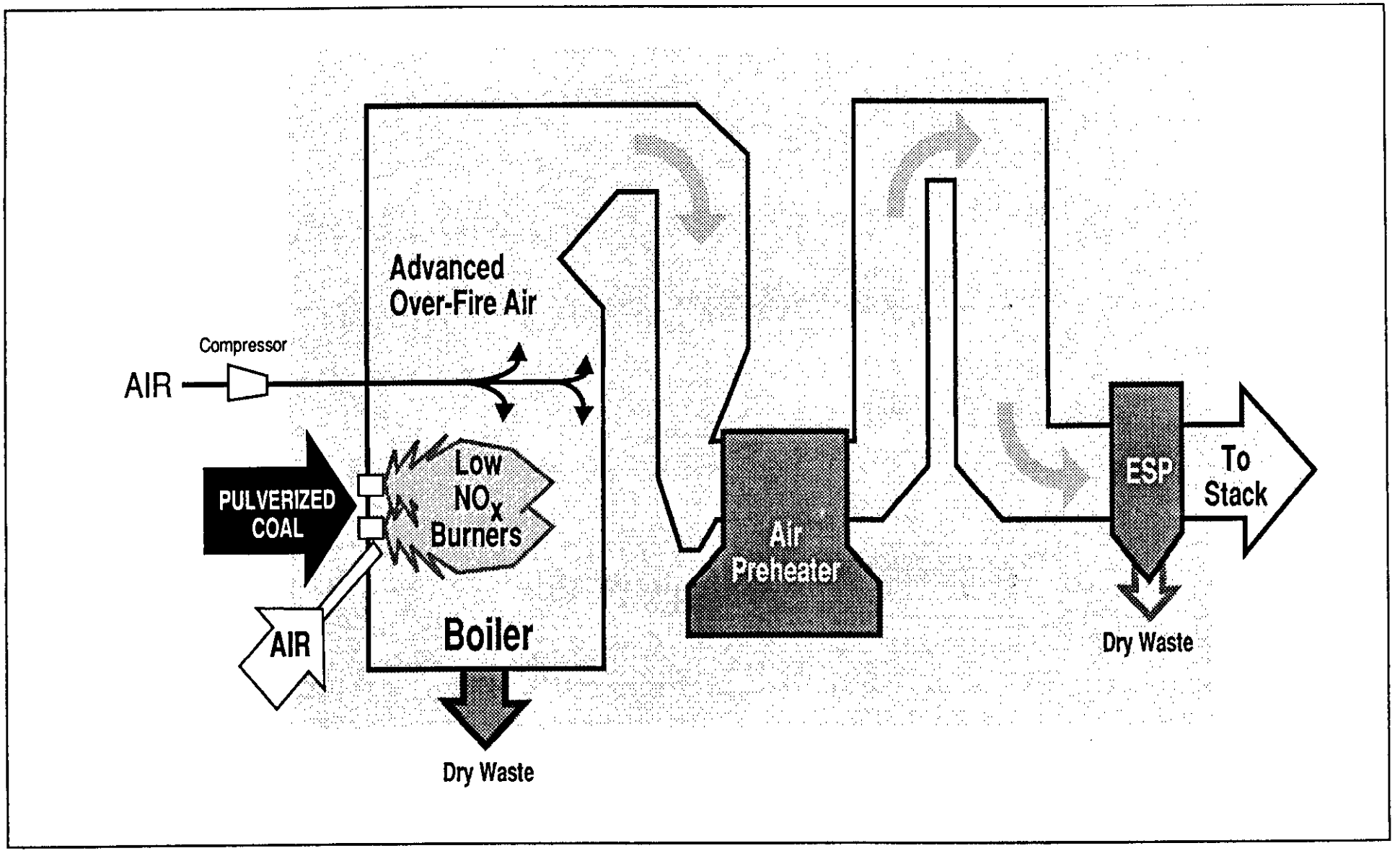
Advanced Tangentially Fired Combustion Demonstration Project

Southern Company Services, Inc.

Advanced Tangentially Fired Combustion Demonstration Project

SOUTHERN COMPANY SERVICES, INC.

PROCESS FLOW DIAGRAM



Project: Advanced Tangentially Fired Combustion Demonstration Project

Industrial Participant:
Southern Company Services, Inc.

Cofunders:
Gulf Power Company (host utility)
EPRI

Process: Advanced over-fire air (AOFA)
Low-NOx concentric-firing system (LNCFS)
Advanced tangential-firing system (ATFS)

Location: Lynn Haven, Bay County, FL (Plant Smith)

Coal Feed Characteristics:
Bituminous coals from IL, WV, AL, and KY (2.6% to 3.1% sulfur)

Plant Capacity: 180 MWe

Feed Rate: 1,711 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participants:	TBD

Project Objectives:

To demonstrate three NO_x control techniques on a 180-MWe tangentially fired utility boiler. The three techniques are: (1) advanced over-fire air (AOFA), (2) the low-NO_x concentric-firing system (LNCFS), and (3) the advanced tangential-firing system (ATFS).

Process Description:

The performance and NO_x and SO_x reduction capabilities of each of the three technologies will be evaluated separately and then in combination on a single demonstration boiler. Each technology will be tested under typical dynamic boiler operating conditions.

The over-fire air process removes some of the excess air from the burner flame zone and reintroduces it later in the combustion area, away from the high-temperature flames to reduce NO_x formation. AOFA improves upon this process by incorporating the deep staging, improved over-fire air mixing, and boundary air.

LNCFS was developed solely for applications in tangentially fired steam generators and employs a technique of separating the fuel and air streams in the tangential-firing arrangement. LNCFS has two significant advantages over the standard tangential arrangement: NO_x is reduced, and furnace wall slagging is decreased.

The ATFS combines several established NO_x reduction techniques that are applicable to all tangentially coal-fired boilers. It includes AOFA in combination with some aspects of LNCFS. The major element of this technique is the repositioning of the coal nozzles from their standard alternating coal-air configuration into elevations that are clustered together in groups of two nozzles throughout the windbox. This creates local fuel-rich zones in the furnace burner zone, which reduces NO_x formation. Subsequent combustion is completed in the air-rich zones created by the LNCFS deflection air buckets and by the complete air/combustion-product mixing afforded by the AOFA, which allows deep staging.

Advanced Tangentially Fired Combustion Demonstration Project
(Southern Company Services, Inc.)

Key Milestone Dates:

DOE selected project	9/28/88
Kick-off meeting for fact-finding process	11/7/88
Preagreement milestone schedule issued	1/89
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Complete design and permitting	TBD
Complete construction	TBD
Begin operation	TBD
Complete project	6/92*

* Preliminary; subject to negotiation

Activity	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96
Project Selected		▼							
Preagreement Milestone Schedule Issued		▼							
Cooperative Agreement Executed									
Design and Permitting									
Construction and Start-up									
Operation									

Project Status:

Fact-finding and negotiating activities are in progress.

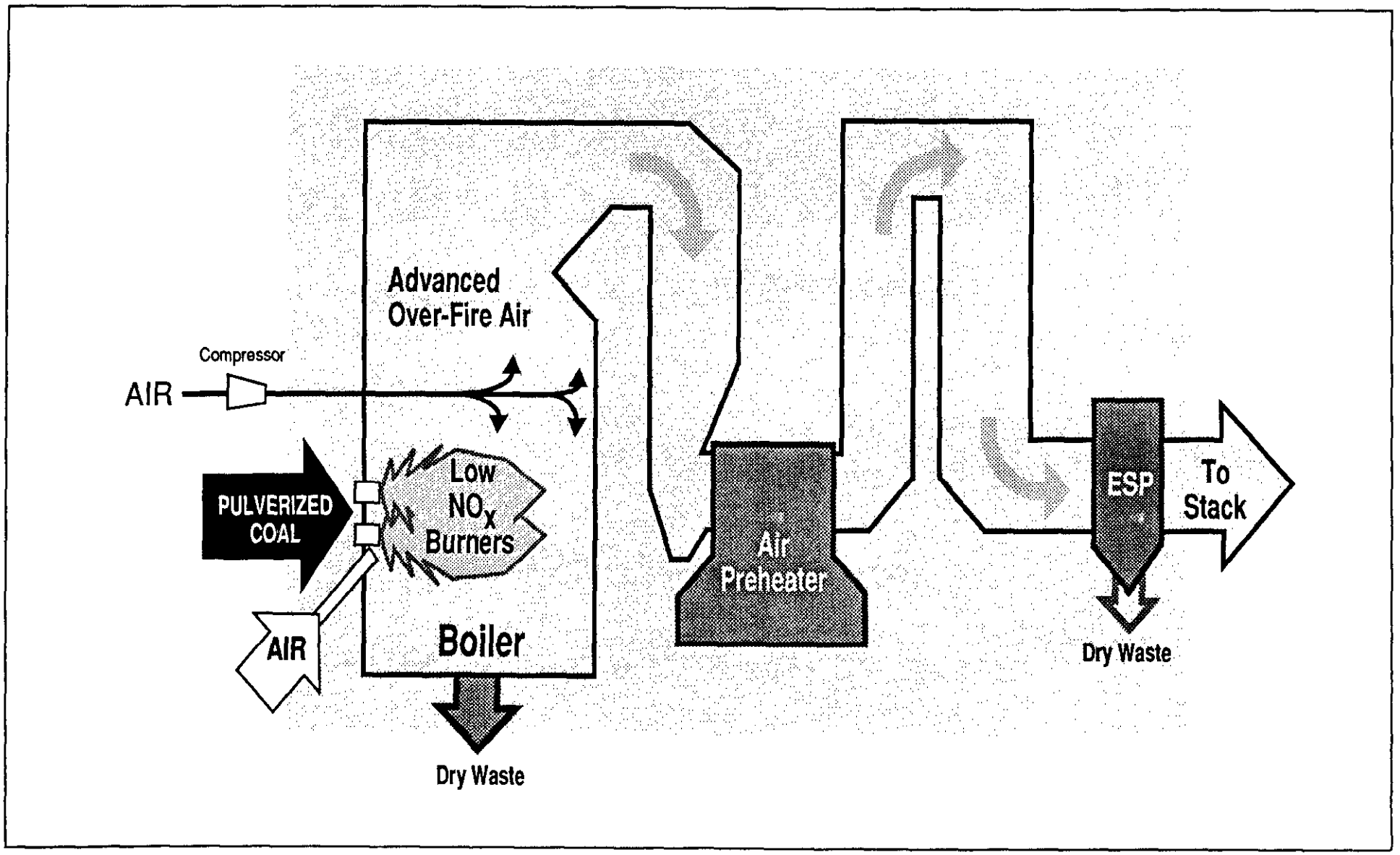
Advanced Wall-Fired Combustion Demonstration Project

Southern Company Services, Inc.

Advanced Wall-Fired Combustion Demonstration Project

SOUTHERN COMPANY SERVICES, INC.

PROCESS FLOW DIAGRAM



Project: Advanced Wall-Fired Combustion Demonstration Project

Industrial Participant:
Southern Company Services, Inc.

Cofunders:
Georgia Power Company (host utility)
EPRI

Process: Advanced over-fire air (AOFA)
Second generation low-NO_x burners (LNB)
LNB with AOFA combination

Location: Coosa, Floyd County, GA (Plant Hammond)

Coal Feed Characteristics:
Bituminous coals from WV, TN, KY, and VA (1.5% to 2.5% sulfur)

Plant Capacity: 500 MWe

Feed Rate: 4,668 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participants	TBD

TBD: To be determined

Project Objectives:

To demonstrate three NO_x control techniques for retrofitting wall-fired, pulverized coal-fired boilers. By demonstrating the performance of various advanced low-NO_x combustion technologies, the dynamic long-term NO_x emission characteristics can be determined using sophisticated statistical techniques, and the progressive cost-effectiveness can be determined.

Project Description:

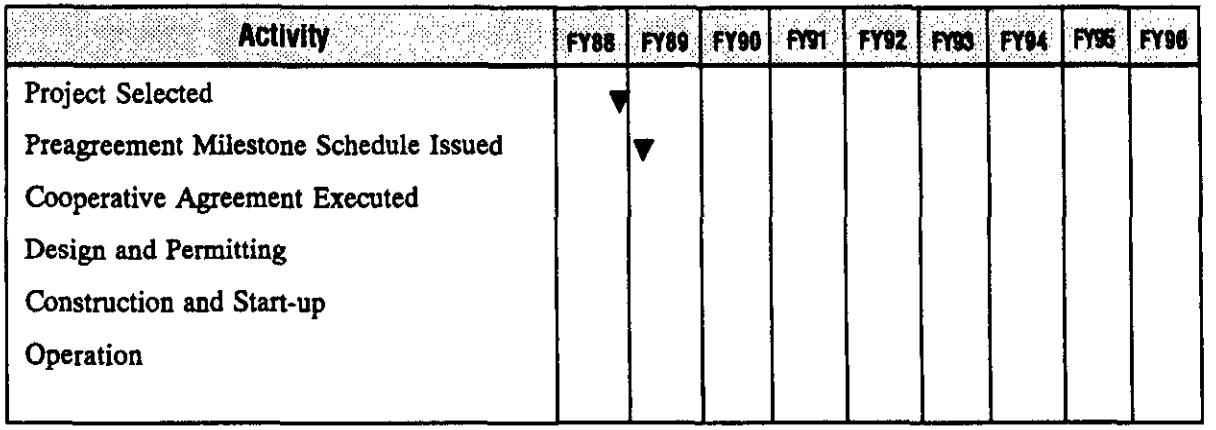
The three NO_x control techniques are (1) advanced over-fire air (AOFA), (2) second generation low-NO_x burners (LNB), and (3) LNB and AOFA combination. Over-fire air is a process that removes some of the excess air from the burner flame zone and reintroduces it later in the combustion area, away from the high temperature flames to reduce NO_x formation. AOFA improvements include the concepts of deep staging, improved over-fire air mixing, and boundary air. LNB provide an alternative to the use of over-fire air as a means to control NO_x production through controlled fuel/air mixing (staged combustion) for individual burner flames rather than for the entire furnace. Second generation low-NO_x burners include the Babcock & Wilcox dual register burner type XCL, the Foster Wheeler controlled flow split flame burner, and the Riley Stoker controlled venturi burner. The demonstration project will evaluate all potential retrofit burner candidates, and the best will be selected to accomplish project objectives. The selected LNB system coupled with AOFA is expected to have a NO_x reduction potential of 50-60 percent compared to the standard turbulent mixing burners.

Advanced Wall-Fired Combustion
Demonstration Project
(Southern Company Services, Inc.)

Key Milestone Dates:

DOE selected project	9/28/88
Kick-off meeting for fact-finding process	11/7/88
Issue preagreement milestone schedule	1/89
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Complete permitting and design	TBD
Complete construction	TBD
Begin operation	TBD
Complete project	12/91*

* Preliminary; subject to negotiation



Project Status:

Fact-finding and negotiating activities are in progress.

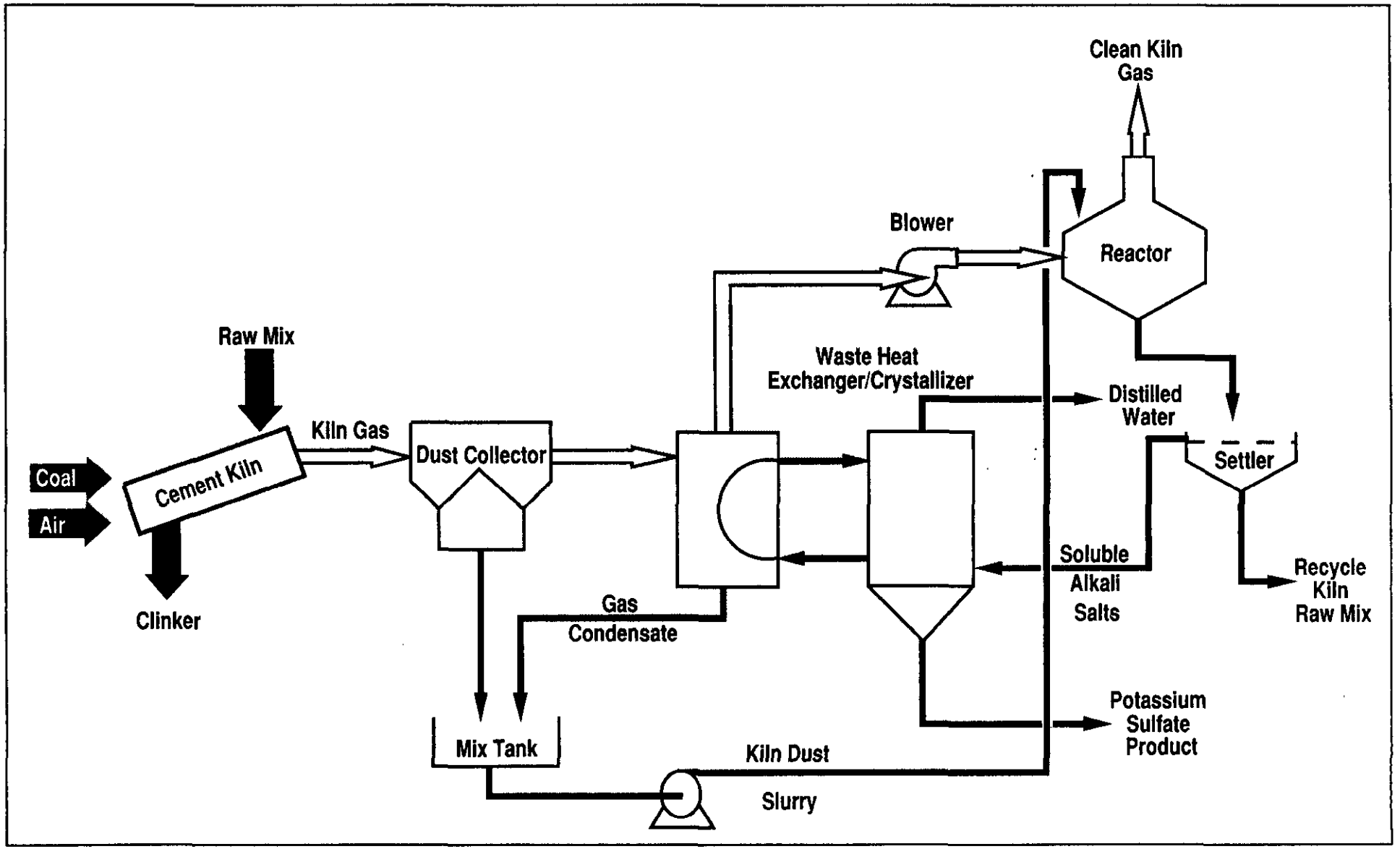
Cement Kiln Gas Cleaning Demonstration Project

Passamaquoddy Tribe

Cement Kiln Gas Cleaning Demonstration Project

PASSAMAQUODDY TRIBE

PROCESS FLOW DIAGRAM



Project: Cement Kiln Gas Cleaning Demonstration Project

Industrial Participant:
Passamaquoddy Tribe

Cofunders:
Others to be determined

Process: Desulfurization with by-product fertilizer production

Location: Thomaston, Knox County, ME

Coal Feed Characteristics:
Pennsylvania bituminous coal
(2.5% to 3.0% sulfur)

Plant Production: 1,425 tons of cement per day; 250,000 SCFM of kiln exhaust gas

Feed Rate: 274 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participant:	TBD

TBD: To be determined

Project Objectives:

To demonstrate the retrofitting of a coal-fired cement kiln with a reaction scrubber for removal of NO_x and SO_x from cement kiln exhaust gas, and a waste kiln-dust recovery system to produce a reusable kiln feedstock. The process also produces salable potassium (alkali) sulfate salts and distilled water. The project is directly applicable to other commercial cement plants. The project will process 250,000 SCFM of kiln gas, which represents a scale-up of the technology from the pilot level of 2,000 SCFM.

Process Description:

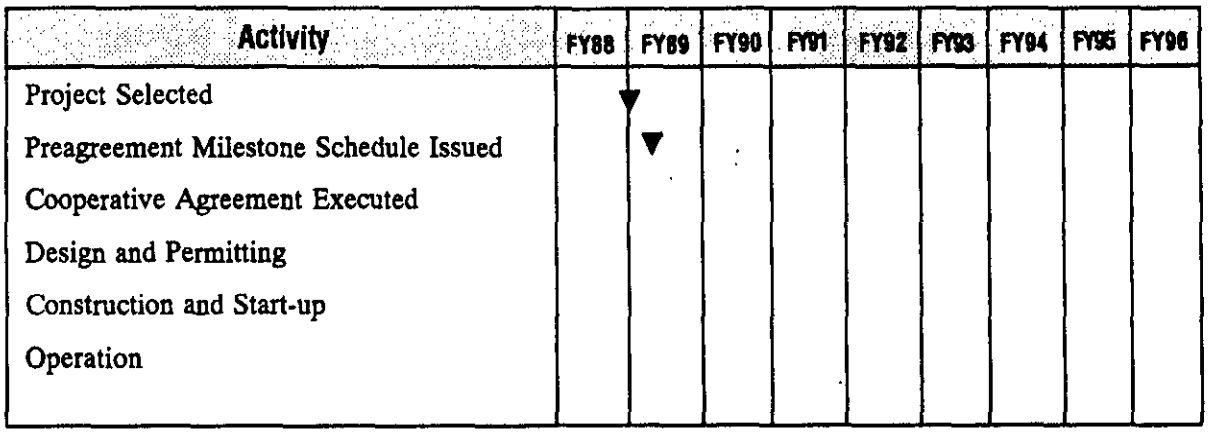
Exhaust kiln gas from a direct coal-fired cement kiln is first passed through a dust collector to recover kiln dust. The gas is then cooled from 300 °F to 130 °F in a combined waste heat exchanger and crystallizer. The gas is finally bubbled through a kiln dust slurry to remove about 95 percent of the SO_2 and some NO_x and then passed to the atmosphere. The kiln dust slurry is prepared from the dust recovered from the hot gas and condensate recovered by the cooling of the gas in the waste heat exchanger. The calcium oxide in the dust is hydrated to calcium hydroxide in the slurry and reacts with CO_2 in the exhaust gas during sulfur removal to produce calcium carbonate (limestone). The limestone is separated from the reactor effluent slurry and recycled to the cement kiln operation. The supernatant from the settler contains dissolved alkali salts, principally potassium sulfate produced by reaction of SO_2 with potassium hydroxide in the reactor. The potassium sulfate is concentrated and crystallized to produce a solid fertilizer product. The water evaporated from the alkali slurry is condensed and recovered as distilled water. Overall, the process removes 90 percent of the sulfur from the kiln gas and produces no solid or liquid waste.

Cement Kiln Gas Cleaning Demonstration Project
(Passamaquoddy Tribe)

Key Milestone Dates:

DOE selected project	9/28/88
Kick-off meeting for fact-finding process	10/19/88
Issue preagreement milestone schedule	12/14/88
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Complete design and permitting	TBD
Complete construction and start-up	TBD
Begin operation	TBD
Complete project	10/91*

* Preliminary; subject to negotiation



Project Status:

Fact-finding and negotiating activities are in progress.

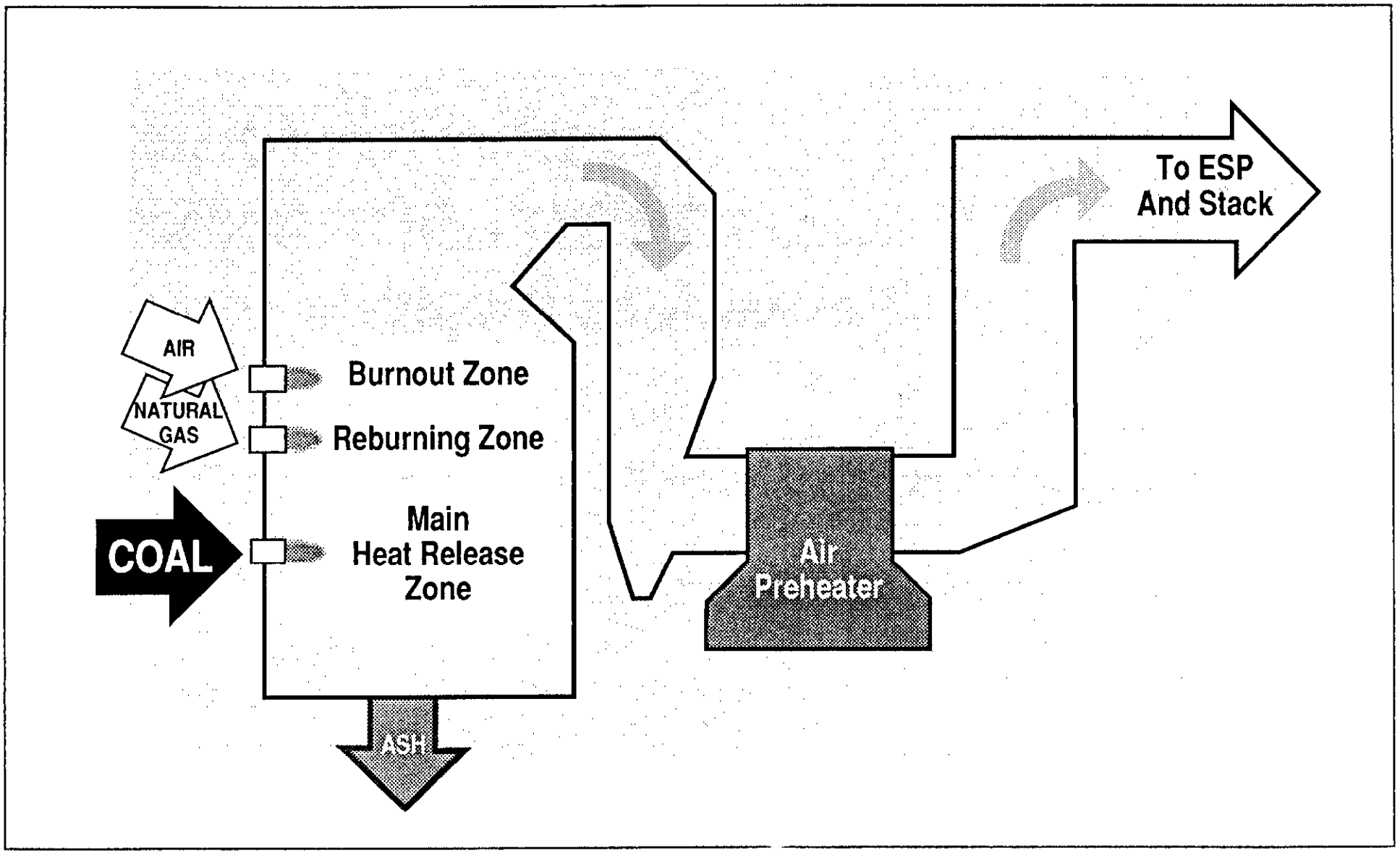
Coal Reburning in Cyclone-Fired Boilers Demonstration Project

The Babcock & Wilcox Company

Coal Reburning In Cyclone-Fired Boilers Demonstration Project

THE BABCOCK & WILCOX COMPANY

PROCESS FLOW DIAGRAM



Project: Coal Reburning in Cyclone-Fired Boilers Demonstration Project

Industrial Participant:
The Babcock & Wilcox Company

Cofunders:
Wisconsin Power & Light Company
(host utility)
EPRI
Illinois Department of Energy

Process: Coal reburning for NO_x control

Location: Cassville, Grant County, WI
(Nelson Dewey Plant)

Coal Feed Characteristics:
Bituminous coal from southern IN

Plant Capacity: 100 MWe

Feed Rate: 950 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participant	TBD

TBD: To be determined

Project Objectives:

To evaluate the applicability of reburning technology for reducing NO_x emissions in full-scale cyclone-fired boilers that use coal as a primary fuel. The project will demonstrate that (1) NO_x emissions can be reduced by more than 50 percent of those from uncontrolled (baseline) conditions at full load and (2) cyclone combustor operation, boiler efficiency, boiler fireside performance (corrosion and deposition), and boiler ash removal systems will not be seriously affected.

Process Description:

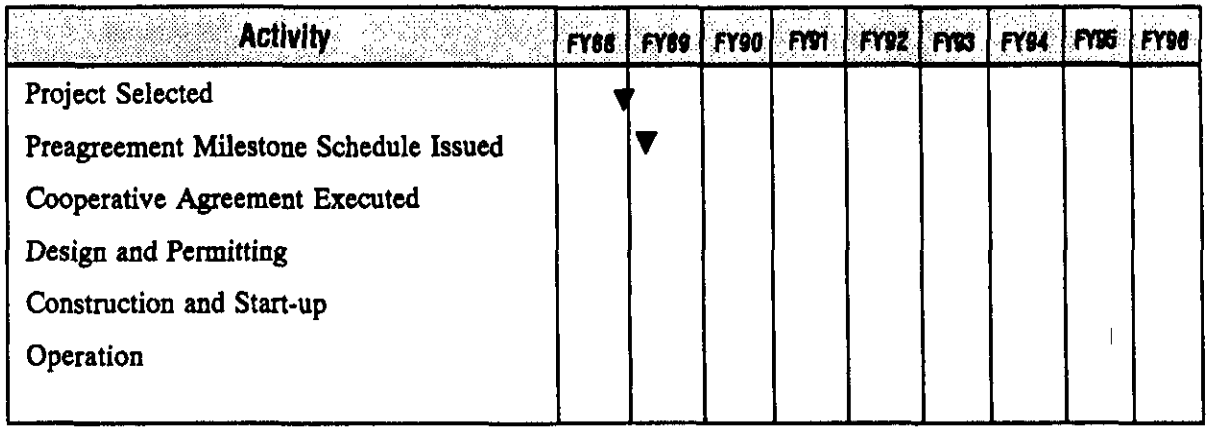
Reburning is a process by which NO_x produced in the cyclone is reduced (decomposed to molecular nitrogen) in the main furnace by injection of a secondary fuel. The secondary (or "reburning") fuel creates an oxygen deficient (reducing) region which accomplishes decomposition of the NO_x. Since reburning can be applied while the cyclone operates under its normal oxidizing condition, effects on cyclone performance can be minimized.

Coal Reburning in Cyclone-Fired Boilers
Demonstration Project
(The Babcock & Wilcox Company)

Key Milestone Dates:

DOE selected project	9/28/88
Kick-off meeting for fact-finding process	11/7/88
Issue preagreement milestone schedule	1/89
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Complete design and permitting	TBD
Complete construction	TBD
Begin operation	TBD
Complete project	10/92*

* Preliminary; subject to negotiation



Project Status:

Fact-finding and negotiating activities are in progress.

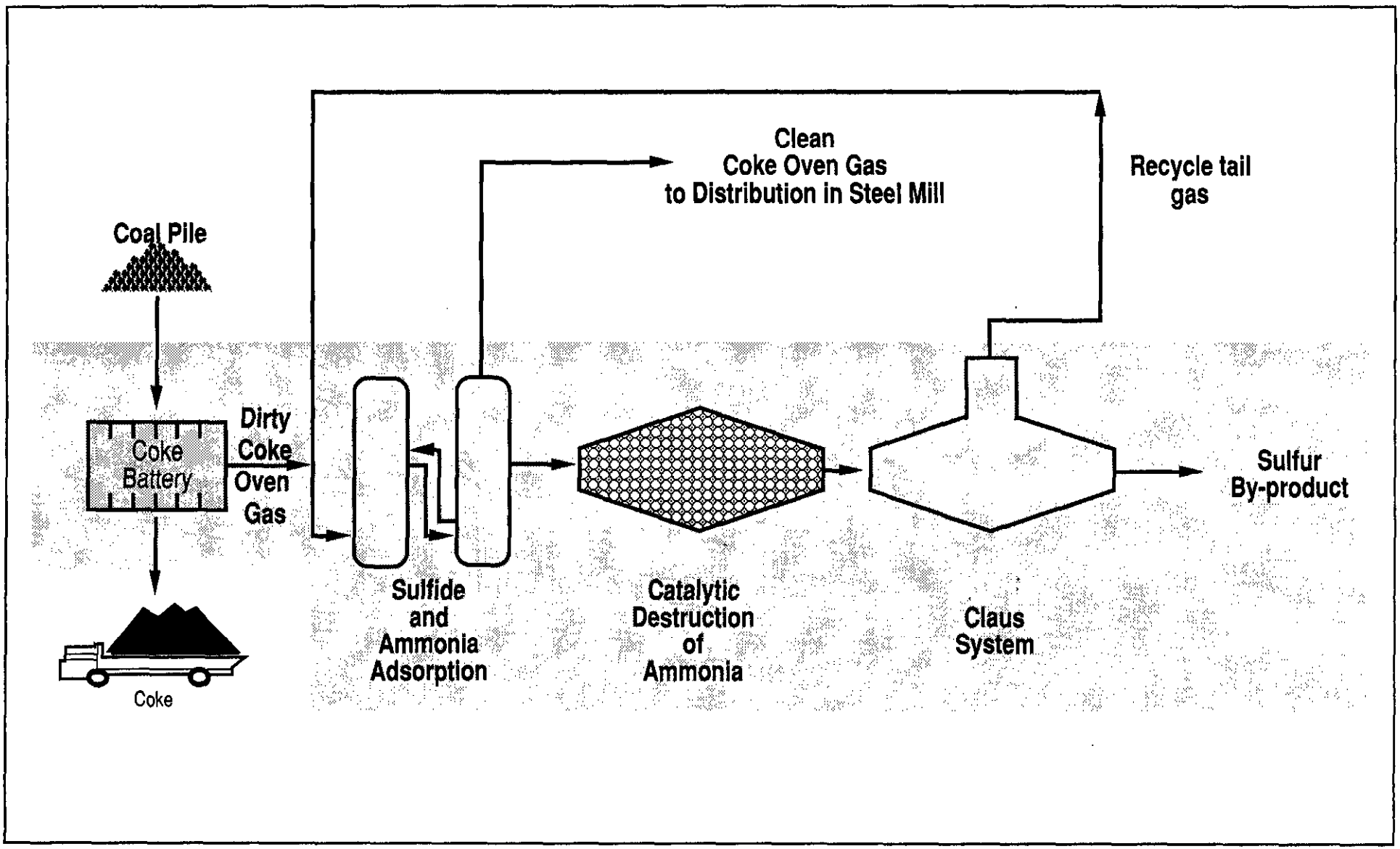
Coke Oven Gas Cleaning Demonstration Project

Bethlehem Steel Corporation

Coke Oven Gas Cleaning Demonstration Project

BETHLEHEM STEEL CORPORATION

PROCESS FLOW DIAGRAM



Project: Coke Oven Gas Cleaning Demonstration Project

Industrial Participant:
Bethlehem Steel Corporation

Cofunder: None

Process: Removal of sulfur, ammonia, and particulates from coke oven gas

Location: Sparrows Point, Baltimore County, MD (Sparrows Point Plant)

Coal Feed Characteristics:
Pittsburgh and Kittaning bituminous coals (0.9% to 1.4% sulfur)

Plant Production: 74 million SCFD of coke oven gas and 12 tons of sulfur per day

Feed Rate: 5,687 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participant:	TBD

TBD: To be determined

Project Objectives:

To demonstrate commercial operation of a low-cost system for removing sulfur, ammonia, volatile organics, and particulates from coke oven gas with a minimal need for catalysts and chemicals, and producing essentially no solid waste.

Process Description:

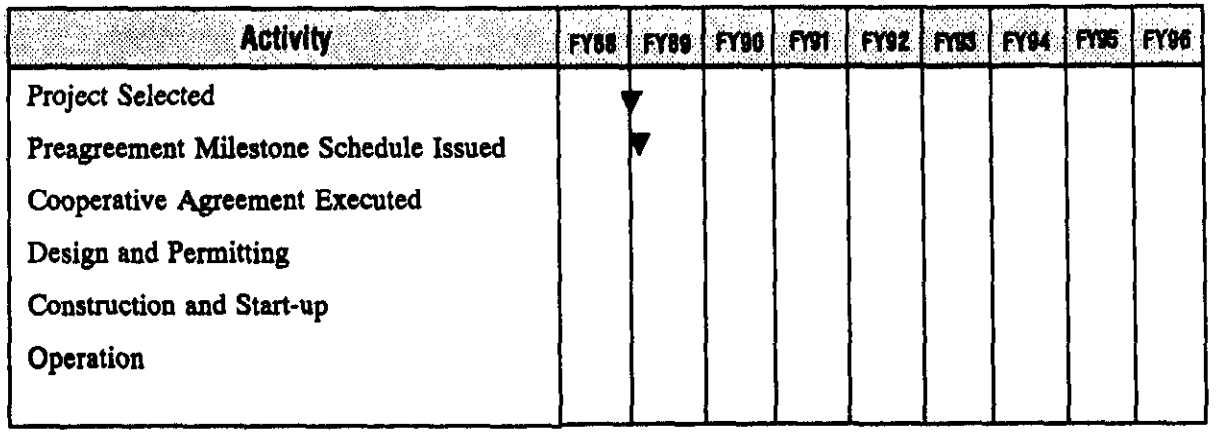
The existing coke oven battery and coal chemical facility at the Sparrows Point steel mill will be retrofitted with a gas cleaning/sulfur recovery system designed to process 74 million SCFD of dirty gas. In the coke making process, coal is carbonized to coke for use as a primary reductant and fuel in the blast furnace. A considerable amount of gas with a significant heating value is produced in the coke oven. This gas is composed of hydrogen, carbon monoxide, methane, other hydrocarbons, tar, oils, hydrogen sulfide, ammonia, and hydrogen cyanide. The process removes the hydrogen sulfide, ammonia, and hydrogen cyanide from the coke oven gas by absorption with ammonia and water. The absorbent is then steam stripped to produce a concentrated stream of hydrogen sulfide, ammonia, and hydrogen cyanide which is passed over a catalyst to convert the ammonia and hydrogen cyanide into nitrogen and water. Then a commercial Claus system destroys the hydrogen sulfide and produces by-product elemental sulfur for sale. Overall approximately 80 percent of the sulfur in the coke oven is removed. The gas cleaning system will include indirect cooling which will reduce the emissions of volatile organic compounds into the atmosphere. There will be essentially no solid waste produced by this cleanup system.

Coke Oven Gas Cleaning Demonstration Project
(Bethlehem Steel Corporation)

Key Milestone Dates:

DOE selected project	9/28/88
Kick-off meeting for fact-finding process	10/19/88
Issue preagreement milestone schedule	11/18/88
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Complete design and permitting	TBD
Complete construction	TBD
Begin operation	TBD
Complete project	12/92*

* Preliminary; subject to negotiation



Project Status:

Fact-finding and negotiating activities are in progress.

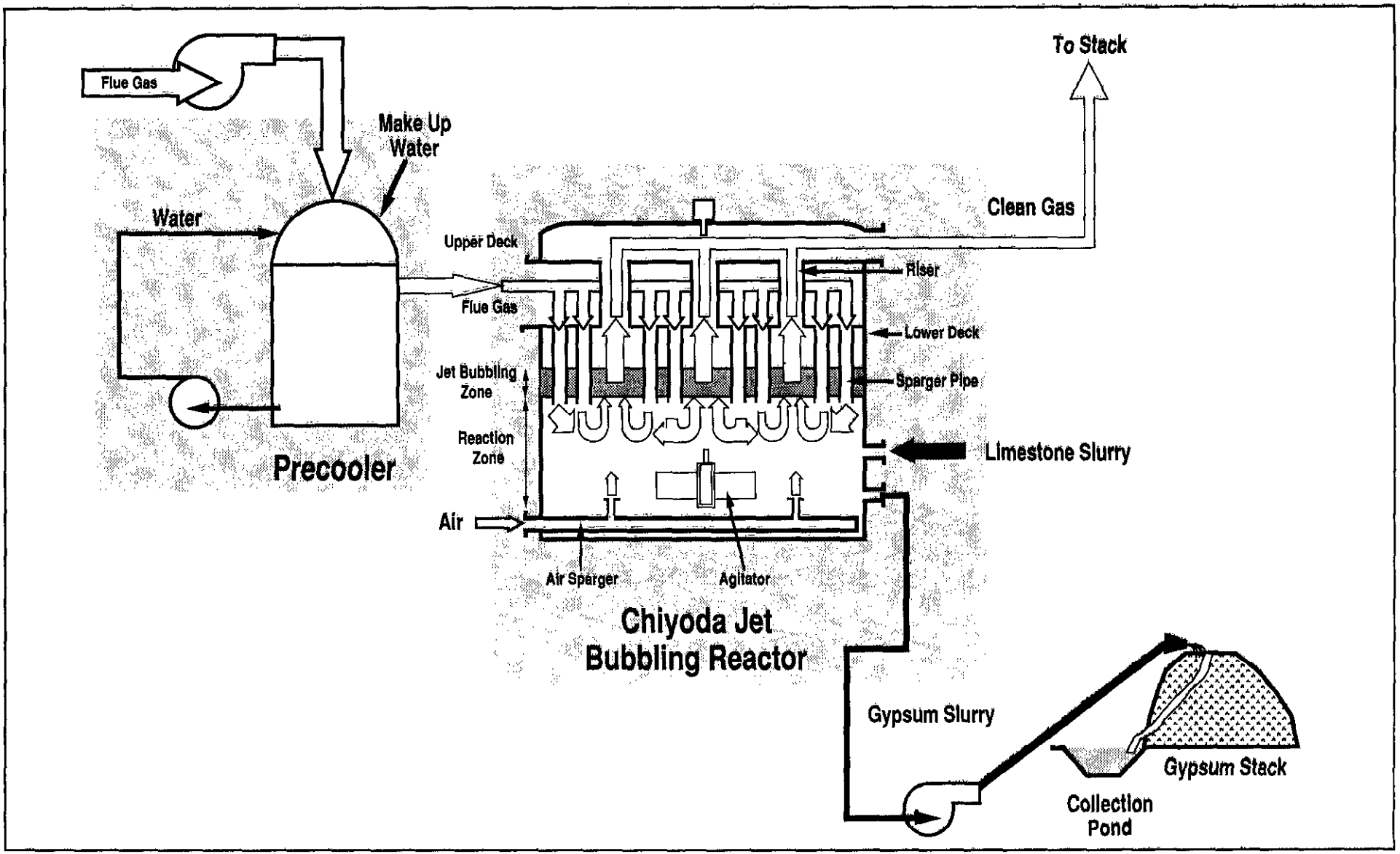
CT-121 FGD
Demonstration Project

Southern Company Services, Inc.

CT-121 FGD Demonstration Project

SOUTHERN COMPANY SERVICES, INC.

PROCESS FLOW DIAGRAM



Project: CT-121 FGD Demonstration Project

Industrial Participant:
Southern Company Services, Inc.

Cofunders:
Georgia Power Company (host utility)
EPRI

Process: Advanced flue gas desulfurization

Location: Newnan, Coweta County, GA (Plant Yates)

Coal Feed Characteristics:
Illinois bituminous coal (2.5% sulfur)

Plant Capacity: 100 MWe (425,000 SCFM flue gas generated)

Feed Rate: 960 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participant:	TBD

TBD: To be determined

Project Objectives:

To demonstrate the Chiyoda Thoroughbred-121 (CT-121) flue gas desulfurization system, including several design innovations, at the 100-MWe scale. Specific objectives are to demonstrate 90-percent SO_2 control at high reliability with and without simultaneous particulate control, further reductions in operating costs, and no need for flue gas reheat.

Process Description:

CT-121 is a second-generation FGD process developed as an improvement to conventional limestone FGD processes. The process employs a unique absorber design--called a jet bubbling reactor--to combine conventional limestone FGD chemistry, forced oxidation, and gypsum crystallization in one reaction vessel. The improvements this process employs eliminate many of the problems (e.g., poor sludge quality and chemical scaling) that often afflict conventional limestone FGD processes.

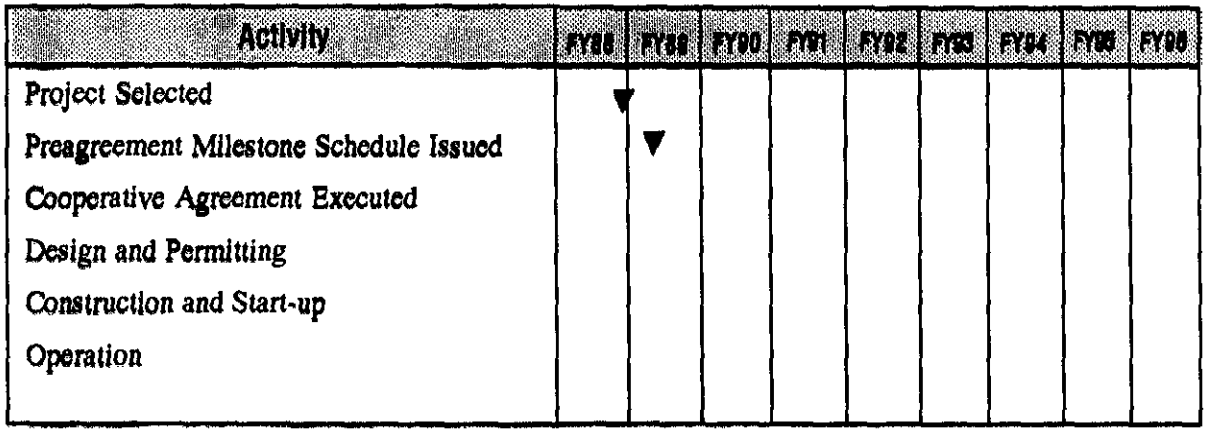
The process is designed to operate in a pH range of 3 to 5 where limestone is completely soluble and where the sulfite resulting from SO_2 absorption can be completely oxidized to sulfate. Calcium sulfute (gypsum) precipitation is controlled by providing seed crystals as nucleation sites and eliminating the attrition of gypsum crystals caused by large centrifugal recycle pumps.

CT-121 FGD Demonstration Project
(Southern Company Services, Inc.)

Key Milestone Dates:

DOE selected project	9/28/88
Kick-off meeting for fact finding process	10/19/88
Issue preagreement milestone schedule	1/89
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Complete design and permitting	TBD
Complete construction	TBD
Begin operation	TBD
Complete project	12/93*

* Preliminary; subject to negotiation



Project Status:

Fact-finding and negotiating activities are in progress.

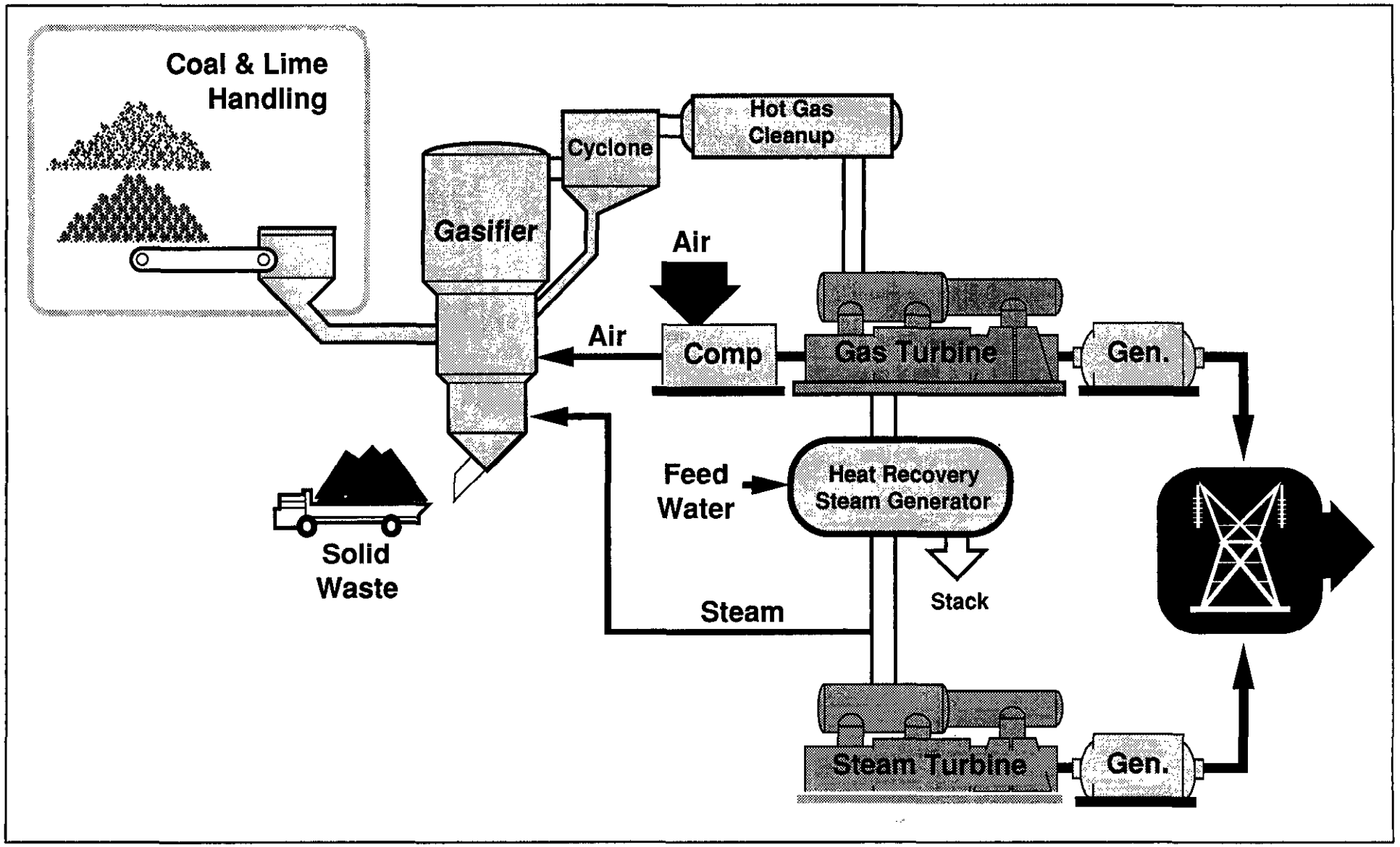
IGCC Repowering Project

Combustion Engineering, Inc.

IGCC Repowering Project

COMBUSTION ENGINEERING, INC.

PROCESS FLOW DIAGRAM



Project: IGCC Repowering Project

Industrial Participant:
Combustion Engineering, Inc.

Cofunders:
City Water, Light and Power (host utility)
Illinois Department of Energy and Natural Resources

Process: Integrated gasification combined-cycle

Location: Springfield, Sangamon County, IL (Lakeside Station)

Coal Feed Characteristics:
Illinois bituminous coal (2.5% sulfur)

Plant Capacity/Production: 65 MWe and 12 tons of sulfur per day

Feed Rate: 480 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participant:	TBD

TBD: To be determined

Project Objectives:

To demonstrate the repowering of a pulverized coal-fired power plant with an integrated gasification combined-cycle (IGCC) system using an air blown, dry feed, entrained flow, pressurized coal gasifier with limestone injection. Advanced coal feed and hot gas cleanup systems will be demonstrated in parallel with conventional systems.

Process Description:

This project will involve repowering an existing steam turbine at the Lakeside generating station of City Water, Light and Power. This plant has two currently retired 20-MWe coal-fired boilers/turbines which are being considered for reactivation to meet future power requirements. One of the steam turbine units will be equipped with a gasification combined-cycle system. This system will include a previously undemonstrated, two-stage, entrained flow coal gasifier with both conventional dry coal and kinetic coal feed systems, along with limestone injection to the gasifier followed by a moving bed, hot gas, zinc ferrite, sulfur and particulate cleanup system. In parallel with the hot system, a conventional cool gas cleanup system will be installed to mitigate risk and to provide a basis for comparison under similar operating conditions. Capacity of one steam turbine will be increased from 20 MWe to 65 MWe through the addition of a new gas turbine.

IGCC Repowering Project
(Combustion Engineering, Inc.)

Key Milestone Dates:

DOE selected project	9/28/88
Kick-off meeting for fact-finding process	10/27/88
Issue preagreement milestone schedule	12/20/88
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Complete design and permitting	TBD
Complete construction	TBD
Begin operation	TBD
Complete project	7/98*

* Preliminary; subject to negotiation

Activity	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96
Project Selected	▼								
Preagreement Milestone Schedule Issued		▼							
Cooperative Agreement Executed									
Design and Permitting									
Construction and Start-up									
Operation									

Project Status:

Fact-finding and negotiating activities are in progress.

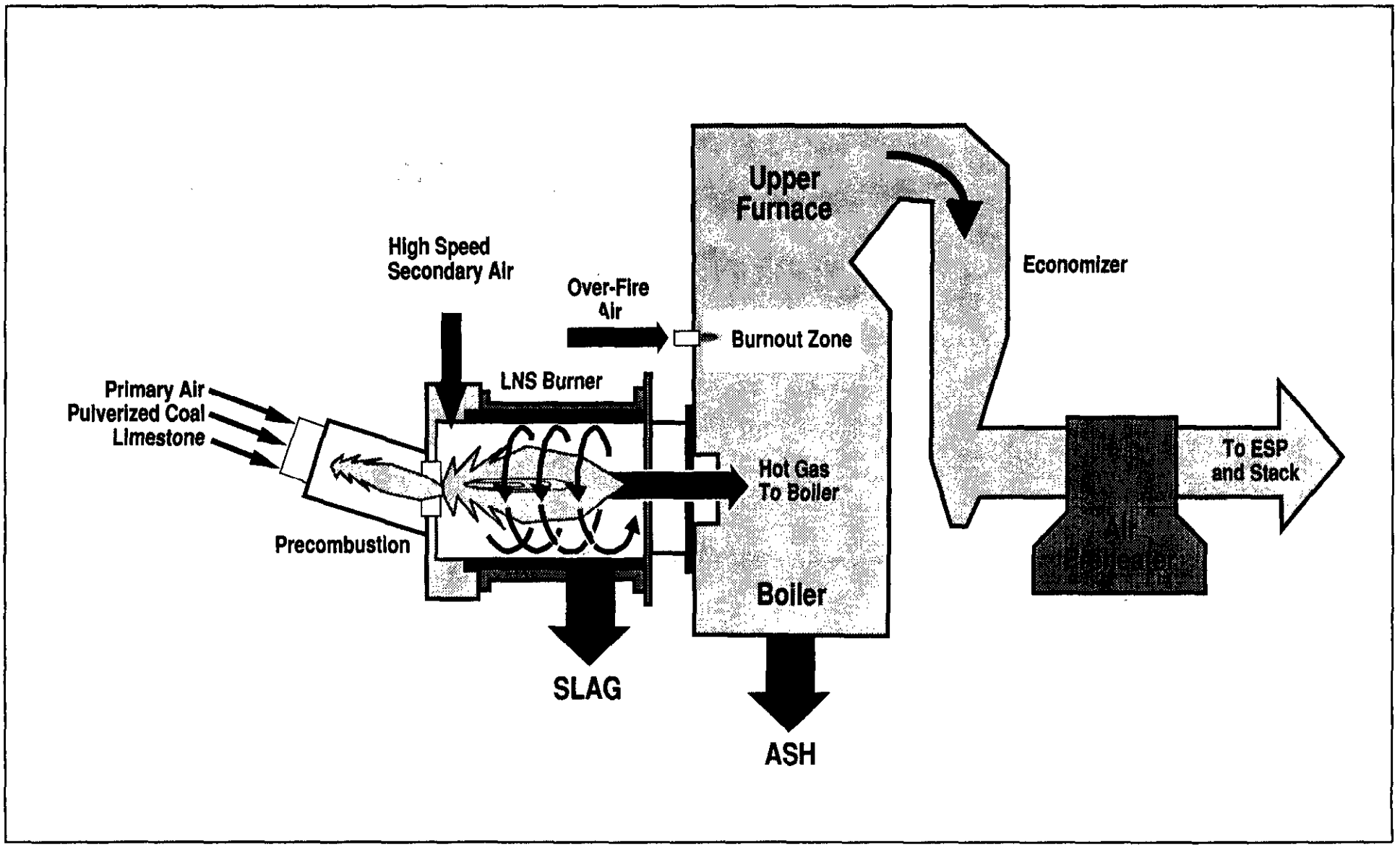
LNS Burner for Cyclone-Fired Boilers Demonstration Project

TransAlta Resources Investment Corporation

LNS Burner for Cyclone-Fired Boilers Demonstration Project

TRANSALTA RESOURCES INVESTMENT CORPORATION

PROCESS FLOW DIAGRAM



Project: LNS Burner for Cyclone-Fired Boilers Demonstration Project

Industrial Participant:
TransAlta Resources Investment Corporation

Cofunders:
Southern Illinois Power Cooperative (host utility)
Others dependent on negotiations

Process: Advanced slagging coal combustor

Location: Marion, Williamson County, IL (Marion Plant)

Coal Feed Characteristics: Illinois high-sulfur bituminous coal

Plant Capacity: 33 MWe

Feed Rate: 240 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participant:	TBD

TBD: To be determined

Project Objectives:

To demonstrate a low NO_x/SO_x (LNS) burner retrofitting a utility cyclone boiler. The project will demonstrate greater than 70-percent SO_x reduction on high-sulfur Illinois bituminous coals and control of NO_x emissions to less than 150 ppm.

Process Description:

This project will retrofit a cyclone-fired boiler with LNS burners and a coal pulverizer system at a 33-MWe unit of Southern Illinois Power Cooperative's Marion Plant. Two LNS burners, each rated at 200 MMBtu per hour, will be used to retrofit the existing cyclone boilers and are expected to reduce both NO_x and SO_x emissions. Retrofitting will also include a simple impact-type separator which is expected to remove up to 80 percent of the fly ash.

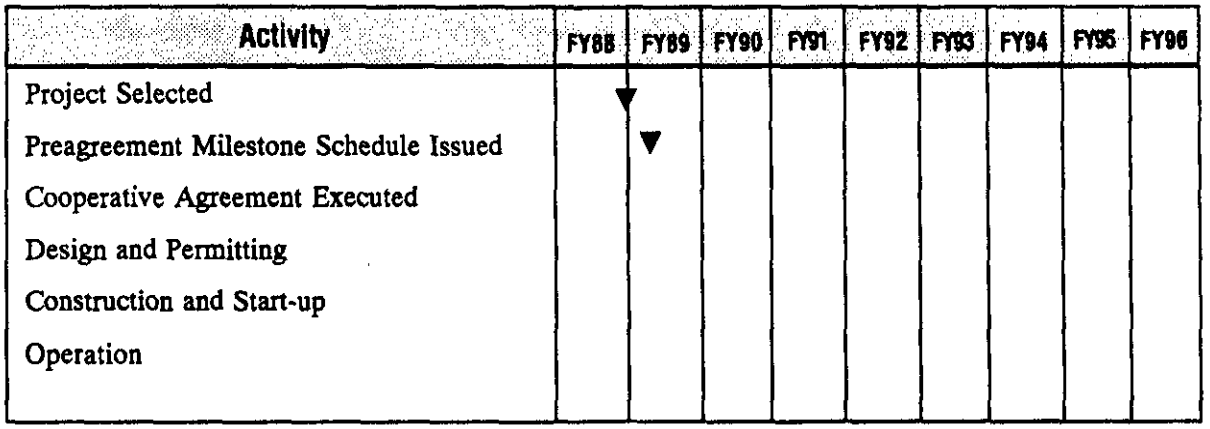
The LNS burner is a three-stage, entrained flow, slagging combustion system. Sulfur is captured by injecting limestone in the primary stage. In the second stage, gaseous nitrogenous compounds, including NO_x, are converted to molecular nitrogen. In the third stage, excess air is added to complete combustion and to obtain full heat release. It is in the second, or NO_x destruction, stage that combustion temperatures are sufficiently high to allow removal of molten slag (which includes the captured sulfur) in a glassy ash matrix.

LNS Burner for Cyclone-Fired Boilers
Demonstration Project
(TransAlta Resources Investment Corporation)

Key Milestone Dates:

DOE selected project	9/28/88
Kick-off meeting for fact-finding process	10/19/88
Issue preagreement milestone schedule	2/89
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TDB
Complete design and permitting	TBD
Complete construction	TBD
Begin operational testing	TBD
Complete project	8/91*

* Preliminary; subject to negotiation



Project Status:

Fact-finding and negotiating activities are in progress.

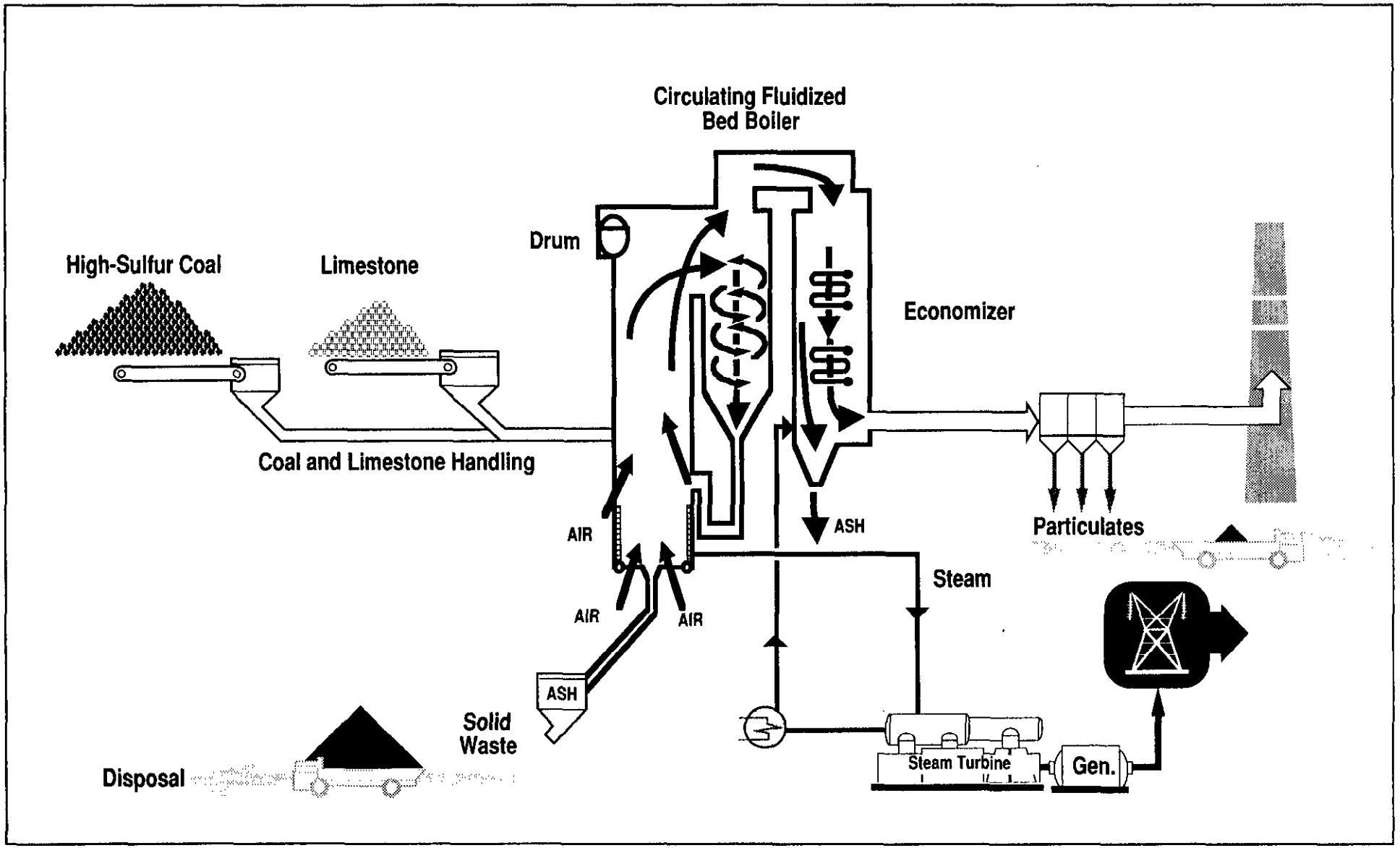
Nichols CFB Repowering Project

Southwestern Public Service Company

Nichols CFB Repowering Project

SOUTHWESTERN PUBLIC SERVICE CORPORATION

PROCESS FLOW DIAGRAM



Project: Nichols CFB Repowering Project

Industrial Participant:
Southwestern Public Service Company

Cofunder: None

Process: Circulating fluidized-bed

Location: Near Amarillo, Potter County, TX (Nichols Station)

Coal Feed Characteristics:
Bituminous and subbituminous coals from WY, NM, OK, OH, and KY

Plant Capacity: 250 MWe

Feed Rate: 2,352 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participant:	TBD

TBD: To be determined

Project Objectives:

To demonstrate the commercial aspects of circulating fluidized-bed (CFB) boiler technology in the 200-300 MWe range, which represents a scale-up factor of two from the largest CFB boilers proposed for commercial service.

Process Description:

This project involves repowering an existing steam electric generation plant using a scaled-up CFB boiler. Nichols Station, Unit 3, is a nominal 250-MWe generating station which entered commercial operation in 1968. A coal-fueled CFB steam generating system will completely replace the existing gas-fired steam generating system used to drive a reheat tandem compound steam turbine. The existing turbine-generator and the balance of the plant equipment will be retained.

This CFB boiler will include a complete solids fluidizing and recirculation system. Pulverized coal is injected into the furnace. Limestone is similarly introduced. These solids are fluidized with approximately 50 percent of the air necessary to sustain complete combustion. This primary air is accelerated through nozzles mounted in a bed plate located at the bottom of the furnace. As the solids are consumed and diminish in size, they are carried from the top of the furnace into a mechanical separator, typically a cyclone. The separated solids are then reinjected into the lower part of the furnace.

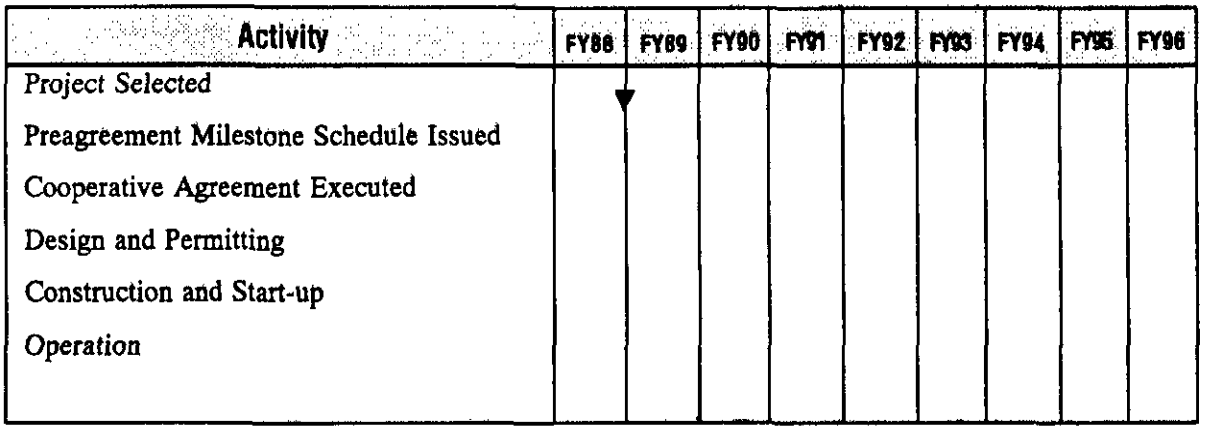
The balance of the requisite combustion air (secondary air) is introduced above the grate. The staged combustion accomplished by introducing the air at two separate locations reduces NO_x formation. The boiler will be designed to operate at the nominal 1600 $^{\circ}$F furnace exit temperature to maintain optimum limestone calcination and lime sulfation. NO_x generation is not significant at this low temperature. Primary furnace temperature control is achieved by regulating the quantity of solids suspended in the furnace. Increasing the solids content increases the heat transfer rate to the furnace walls. Excess solids are removed from the bottom of the furnace through a port in the bed drains.

Nichols CFB Repowering Project
(Southwestern Public Service Company)

Key Milestone Dates:

DOE selected project	9/28/88
Kick-off meeting for fact-finding process	11/2/88
Issue preagreement milestone schedule	TBD
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Complete design and permitting	TBD
Complete construction	TBD
Begin operation	TBD
Complete project	4/96*

*Preliminary; subject to negotiation



Project Status:

Fact-finding and negotiating activities are in progress.

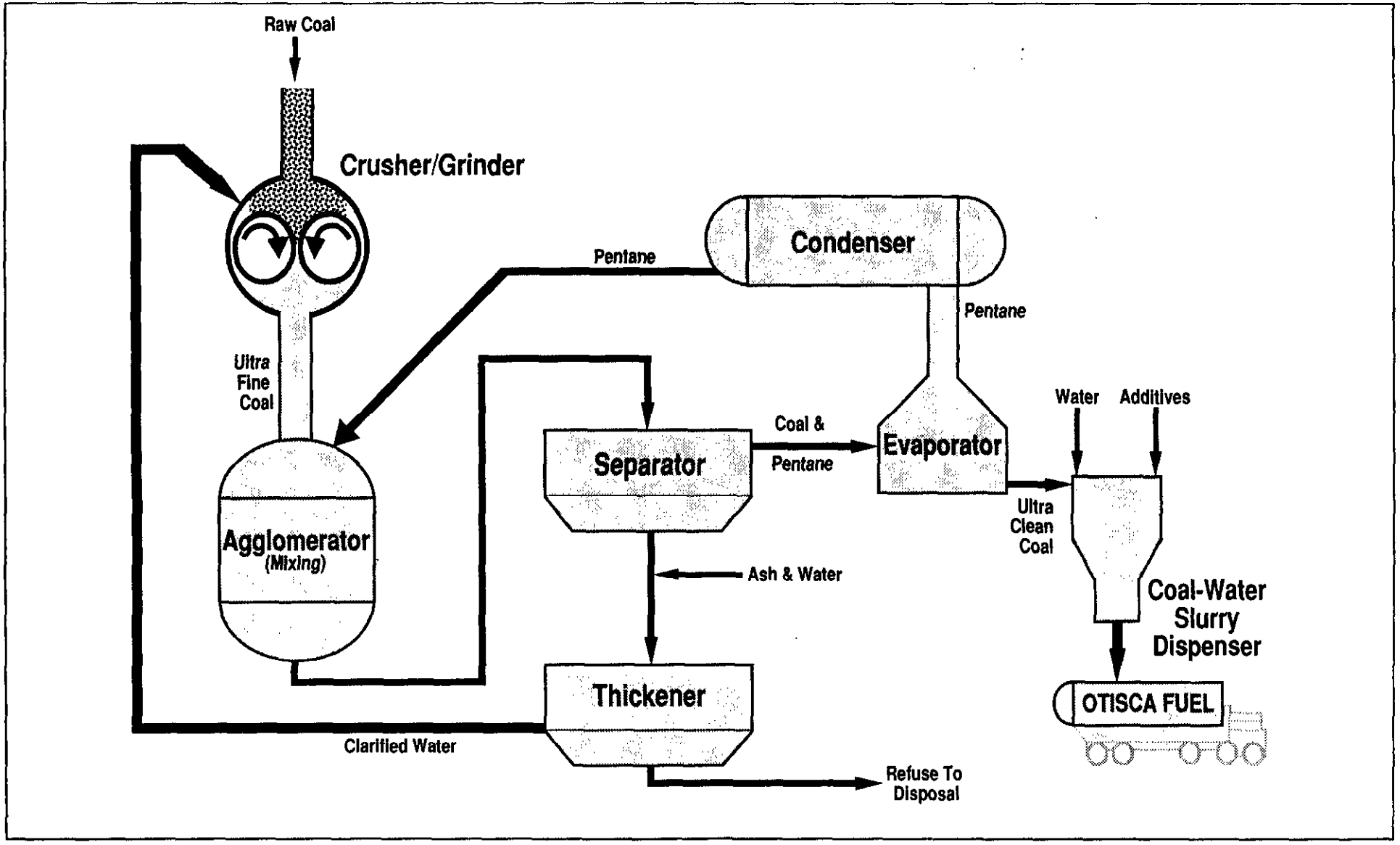
OTISCA Fuel Demonstration Project

Otisca Industries, Ltd.

OTISCA Fuel Demonstration Project

OTISCA INDUSTRIES, LTD.

PROCESS FLOW DIAGRAM



Project: OTISCA Fuel Demonstration Project

Industrial Participant:
Otisca Industries, Ltd.

Cofunder: None

Process: Otisca T-process

Location:
Syracuse, Onondaga County, NY
Jamesville, Onondaga County, NY
Oneida, Oneida County, NY

Coal Feed Characteristics:
Eastern bituminous, Taggart seam

Plant Production: 40,000 dry tons of OTISCA fuel per year

Feed Rate: 15 tons per hour

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participant:	TBD

TBD: To be determined

Project Objectives:

To demonstrate the manufacture, storage, handling, and utilization of an ultra-clean coal/water slurry, known as OTISCA fuel. The core of the manufacturing process is the Otisca T-Process, which consists of reducing the raw particle size to effect the releases of mineral matter from the coal, and recovering the ultra-clean coal via a selective agglomeration process that employs pentane as the agglomerating agent.

Process Description:

Otisca Industries, Ltd., developed a coal beneficiation technology (the Otisca T-Process) which is expected to remove over 95 percent of the pyritic sulfur and a significant quantity of mineral matter (ash) from virtually any coal while recovering over 95 percent of the energy value of the input coal in the product. Up to seven industrial boilers in the central New York State area currently configured to burn oil, gas, or high-sulfur coal will be retrofitted to allow for the use of Otisca fuel.

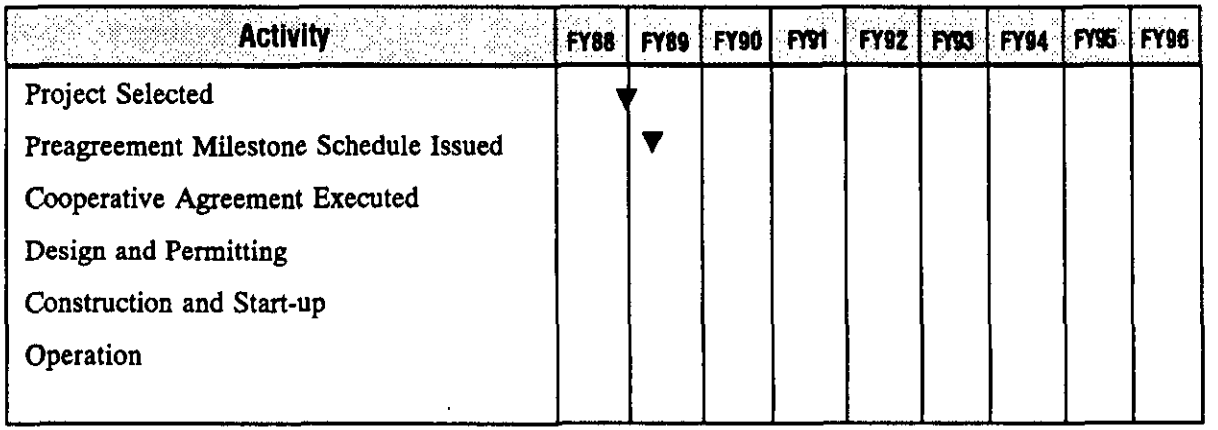
The process consists of first milling raw coal to very fine sizes, followed by an agglomeration step using pentane to recover the ultra-clean coal. Under such conditions complete separation of the two phases is achieved by a simple sieve bend or a cyclone. An added benefit of the separation is that the iron pyrite broken free from the coal matrix during milling behaves as the other mineral particles and is rejected from the coal product.

OTISCA Fuel Demonstration Project
(Otisca Industries, Ltd.)

Key Milestone Dates:

DOE selected project	9/28/88
Kick-off meeting for fact-finding process	10/19/88
Issue preagreement milestone schedule	12/16/88
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Complete design and permitting	TBD
Complete construction	TBD
Begin operation	TBD
Complete project	9/91*

* Preliminary; subject to negotiation



Project Status:

Fact-finding and negotiating activities are in progress.

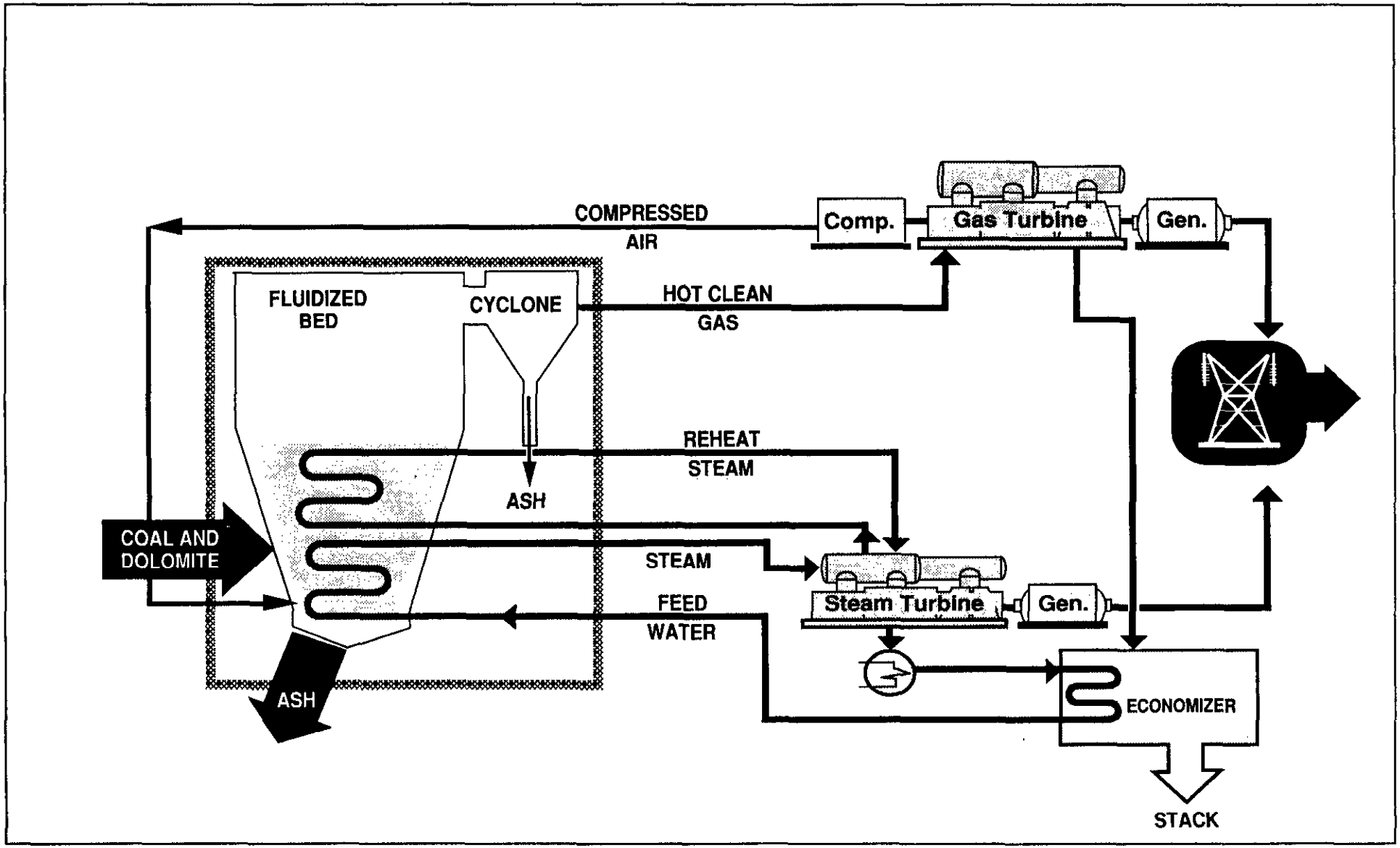
Philip Sporn PFBC Repowering Project

American Electric Power Service Corporation

Philip Sporn PFBC Repowering Project

AMERICAN ELECTRIC POWER SERVICE CORPORATION

PROCESS FLOW DIAGRAM



Project: Philip Sporn PFBC Repowering Project

Industrial Participant:
American Electric Power Service Corporation

Cofunder: None

Process: Pressurized fluidized-bed combustion

Location: New Haven, Mason County, WV (Philip Sporn Plant)

Coal Feed Characteristics:
High- and low-sulfur bituminous coals from WV, OH, and KY (1% to 4% sulfur)

Plant Capacity: 330 MWe

Feed Rate: 2,936 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participant:	TBD

TBD: To be determined

Project Objectives:

To demonstrate the commercial operation of a 330-MWe pressurized fluidized-bed combustion (PFBC) power plant to produce power more efficiently and with less SO_2 and NO_x emissions than existing pulverized coal-fired power plant technology. Performance objectives when burning high-sulfur (4 percent) coal are to demonstrate a steam cycle system integrated with PFBC, a sulfur capture level of 95 percent, and an NO_x emissions level below 0.2 lb/MMBtu.

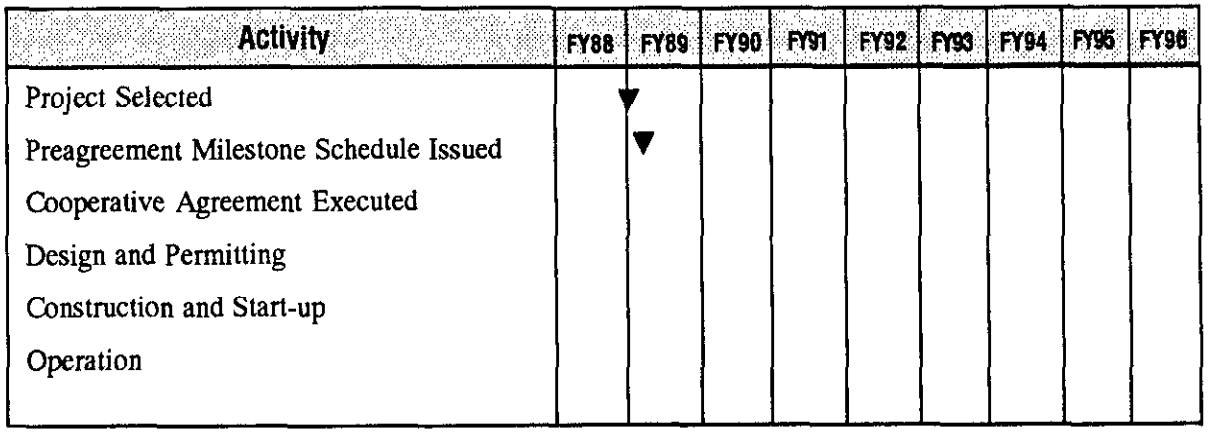
Process Description:

Two commercially operating 150 MWe pulverized coal-fired electric generating units will be repowered by replacing the two boilers with a single PFBC/gas turbine module. The units are located at AEP's Philip Sporn Plant in West Virginia. The project demonstrates commercial-scale repowering using combined-cycle PFBC, a process in which sulfur is removed during combustion through the use of a sorbent and NO_x formation is minimized due to a low bed temperature. The steam cycle will include a high-pressure steam system with reheat. A first-of-a-kind 75-MWe hot gas expansion turbine will comprise the gas cycle of the power generation system. The total generating capacity of the repowered units will be approximately 330 MWe, or 10 percent more than the present capacity. The net thermal efficiency of the repowered plant will be improved 2-3 percent.

Philip Sporn PFBC Repowering Project
(American Electric Power Service Corporation)

Key Milestone Dates:

DOE selected project	9/28/88
Kick-off meeting for fact-finding process	10/19/88
Issued preagreement milestone schedule	12/16/88
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Complete design and permitting	TBD
Complete construction	TBD
Begin operation	TBD
Complete project	10/97*



Preliminary; subject to negotiation

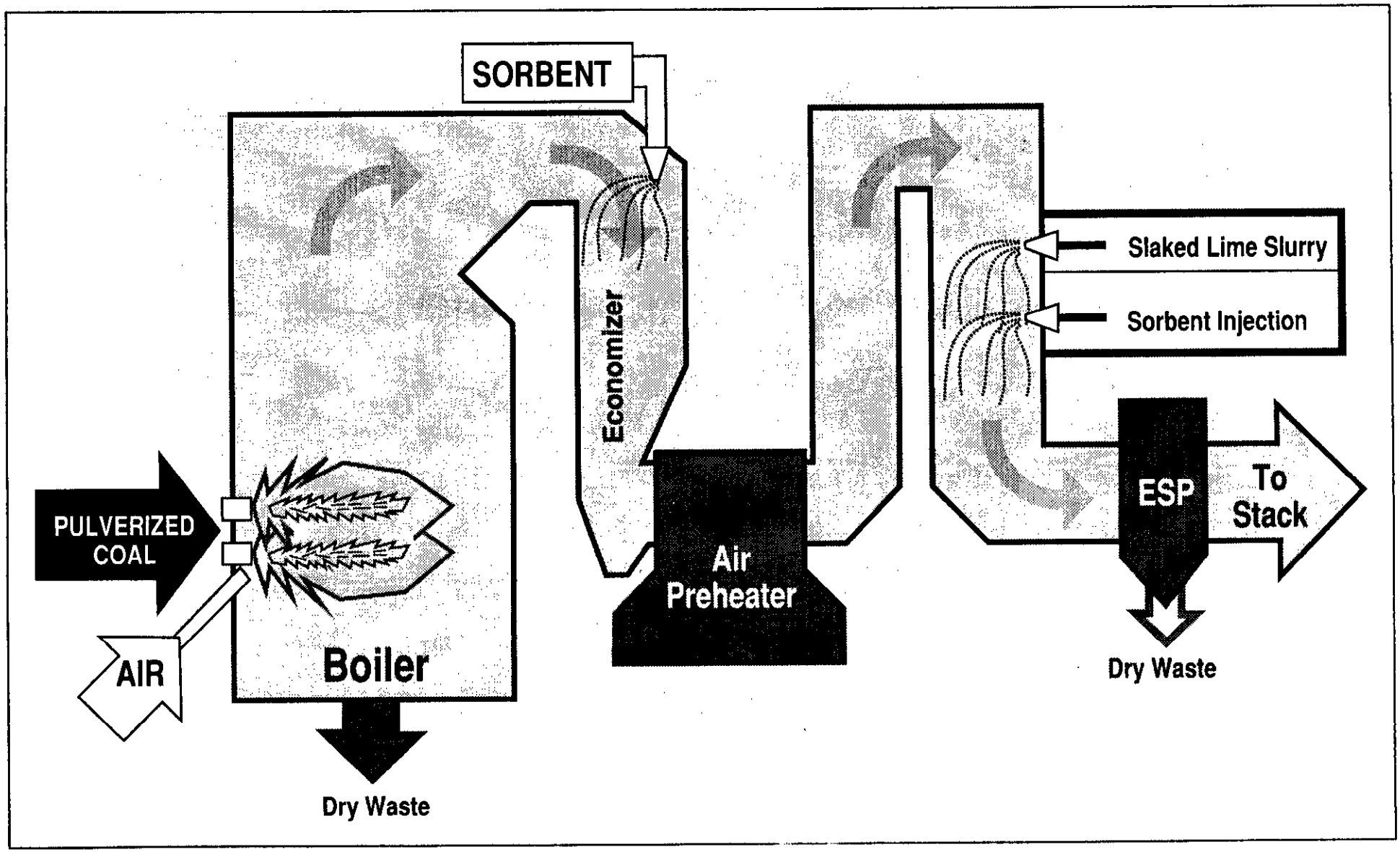
Post-Combustion Sorbent Injection Demonstration Project

Combustion Engineering, Inc.

Post-Combustion Sorbent Injection Demonstration Project

COMBUSTION ENGINEERING, INC.

PROCESS FLOW DIAGRAM



Project: Post-Combustion Sorbent Injection Demonstration Project

Industrial Participant:
Combustion Engineering, Inc.

Cofunders:
Virginia Power Company (host utility)
EPRI

Process: In-duct injection; in-duct spray drying; convective pass injection

Location: Yorktown, York County, VA (Yorktown Plant)

Coal Feed Characteristics:
Bituminous coals from KY, WV, and VA (2% to 2.5% sulfur)

Plant Capacity: 180 MWe

Feed Rate: 1,704 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participant:	TBD

TBD: To be determined

Project Objectives

To demonstrate the use of three dry sorbent injection technologies to reduce SO_x emission by 50 percent or more from the 180-MWe Yorktown Unit No. 2. The three technologies to be demonstrated are (1) in-duct injection (IDI), (2) in-duct spray drying (IDSD), and (3) convective pass injection (CPI).

Process Description:

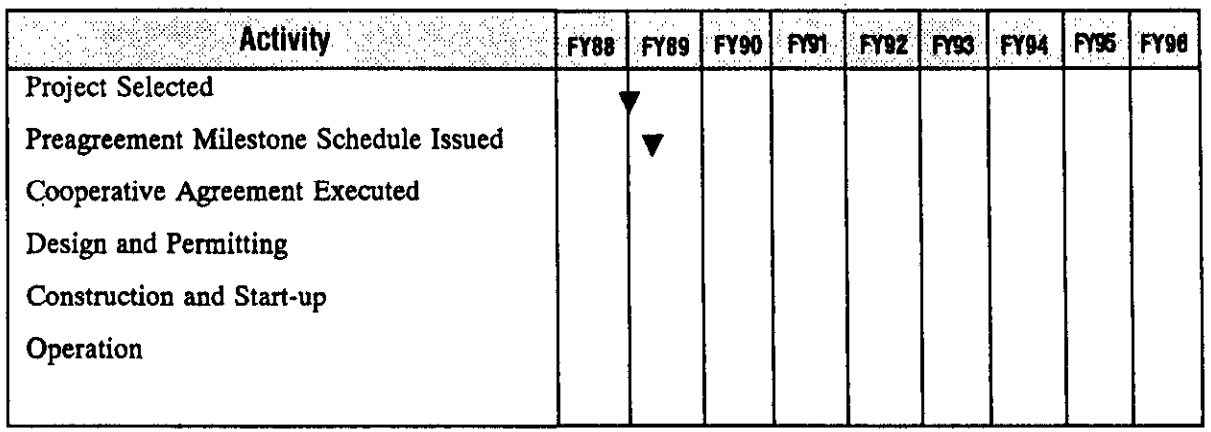
The three dry sorbent injection technologies being demonstrated involve injecting a calcium-containing sorbent into either the convective pass of the furnace or the duct between the air preheater and the particulate control device, normally an electrostatic precipitator or fabric filter. The SO_2 in the flue gas reacts with calcium to form dry calcium sulfite and calcium sulfate which are removed in the particulate control device along with fly ash. These technologies can readily be combined with installation of low-NO_x burners for reduction of NO_x emissions.

Post-Combustion Sorbent Injection
Demonstration Project
(Combustion Engineering, Inc.)

Key Milestone Dates:

DOE selected project	9/28/88
Kick-off meeting for fact-finding process	11/7/88
Issue preagreement milestone schedule	1/89
Issue comprehensive report to Congress	TBD
Execute cooperating agreement	TBD
Complete design and permitting	TBD
Complete construction	TBD
Begin operational testing	TBD
Complete project	12/94*

*Preliminary; subject to negotiation



Project Status:

Fact-finding and negotiating activities are in progress.

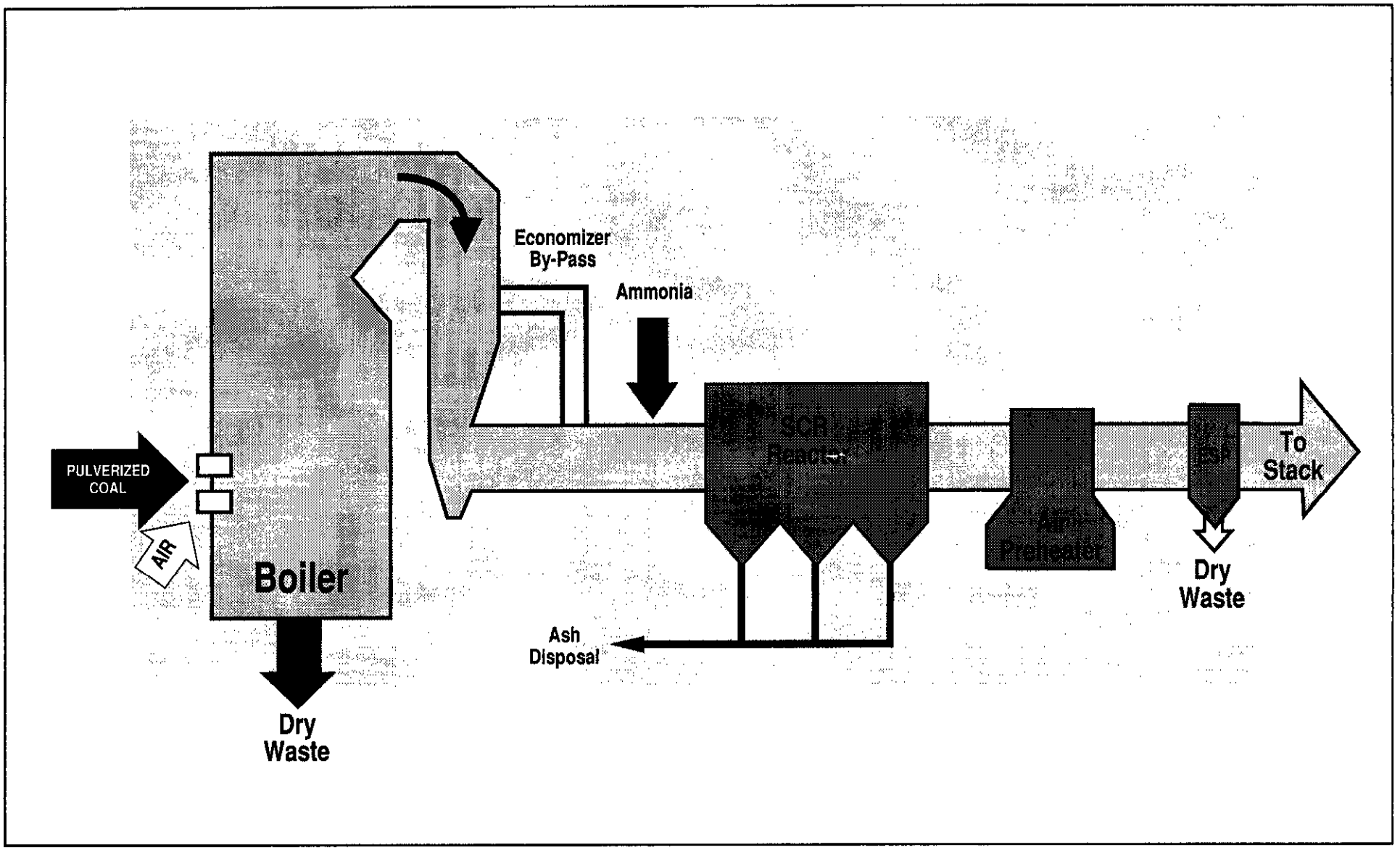
Selective Catalytic Reduction Demonstration Project

Southern Company Services, Inc.

Selective Catalytic Reduction Demonstration Project

SOUTHERN COMPANY SERVICES, INC.

PROCESS FLOW DIAGRAM



Project: Selective Catalytic Reduction Demonstration Project

Industrial Participant:
Southern Company Services, Inc.

Cofunders:
Gulf Power Company (host utility)
EPRI

Process: Selective catalytic reduction

Location: Pensacola, Escambia County, FL (Plant Crist)

Coal Feed Characteristics:
Primarily Illinois Nos. 5 and 6 and Pittsburgh No. 8 coal from IL, WV, AL, and KY (2.6% to 3.1% sulfur)

Plant Capacity: 7.5 MWe (equivalent)

Feed Rate: 72 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participant:	TBD

TBD: To be determined

Project Objectives

To demonstrate the use of selective catalytic reduction (SCR) as a means of reducing NO_x emissions from pulverized coal utility boilers using high-sulfur coal.

Process Description:

This project will demonstrate that SCR technology provides the most cost-effective means of reducing NO_x emissions from power plants firing high-sulfur U.S. coal. Located between Units 5 (75 MWe) and 6 (320 MWe) of Gulf Power Company's Plant Crist, the demonstration plant will have access to flue gas from approximately 3-percent sulfur coal under a variety of different NO_x and particulate levels. If it succeeds, the demonstration will show that SCR is a low-cost option for achieving 80-percent reduction in NO_x emissions from utility and industrial boilers. The technology could be used to retrofit all kinds of boilers, including boilers (e.g., cyclone-fired boilers) that cannot easily be retrofitted with other developing NO_x control technologies.

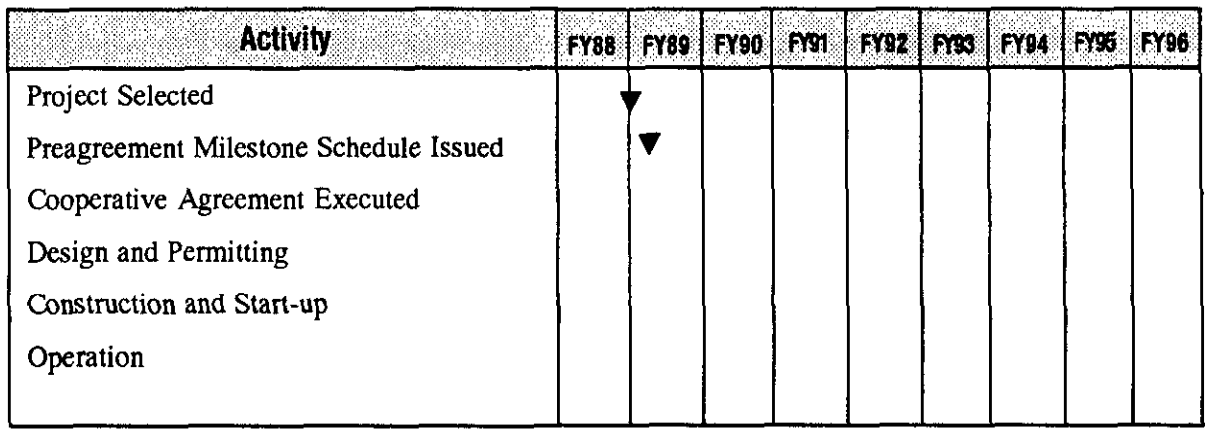
In the SCR process, a stream of ammonia (NH_3) diluted with air is injected into boiler flue gas at the conditions at which the flue gas exits the boiler's economizer. The quantity of NH_3 injected usually can be adjusted (within certain limits) to meet the desired NO_x removal targets. The flue gas containing NH_3 and NO_x then passes through a reaction chamber which contains a catalyst. Under the influence of the catalyst, NH_3 and NO_x react selectively to produce N_2 and H_2O. Several types of catalysts are available, with variations in chemical composition and geometric shape.

Selective Catalytic Reduction
Demonstration Project
(Southern Company Services, Inc.)

Key Milestone Dates:

DOE selected project	9/28/88
Kick-off meeting for fact-finding process	10/19/88
Issue preagreement milestone schedule	1/89
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Complete design and permitting	TBD
Complete construction	TBD
Begin operation	TBD
Complete project	10/93*

*Preliminary; subject to negotiation



Project Status:

Fact-finding and negotiation activities are in progress.

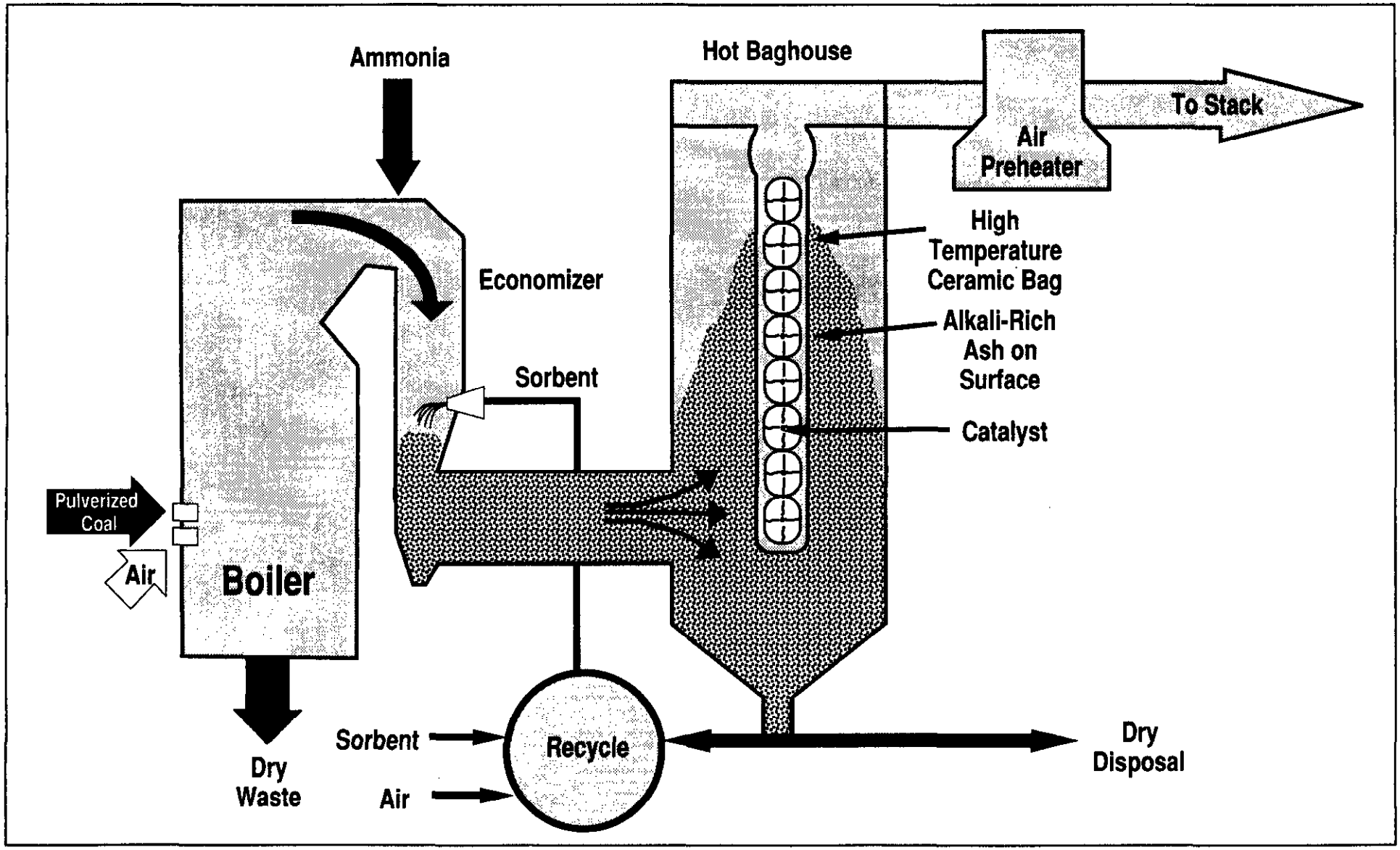
SOX-NOX-ROX Box Flue Gas Cleanup Demonstration Project

The Babcock & Wilcox Company

SOX-NOX-ROX Box Flue Gas Cleanup Demonstration Project

THE BABCOCK & WILCOX COMPANY

PROCESS FLOW DIAGRAM



Project: SOX-NOX-ROX Box Flue Gas Cleanup Demonstration Project

Industrial Participants:
The Babcock & Wilcox Company

Cofunders:
Ohio Edison Company (host utility)
Ohio Coal Development Office
EPRI
Others dependent on negotiations

Process: Combined SO_2, NO_x, and particulate control

Location:
Dills Bottom, Belmont County, OH
(R.E. Burger Station)

Coal Feed Characteristics:
Ohio bituminous coals (2.5% sulfur)

Plant Capacity: 5-MWe slip-stream of flue gas from a 158-MWe plant

Feed Rate: 48 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participant:	TBD

TBD: To be determined

Project Objectives

To demonstrate that the SOX-NOX-ROX Box process, used in retrofitting a high-sulfur coal-fired power plant, can remove high levels of all pollutants using a single component for treating flue gas, thereby lessening onsite space requirements and capital costs.

Process Description:

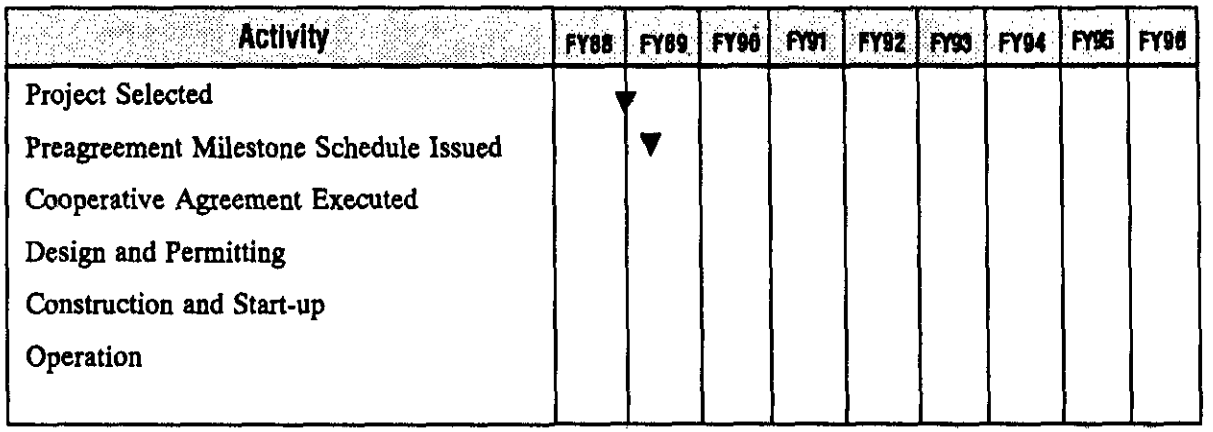
The SOX-NOX-ROX Box process is a post-combustion flue gas cleanup system that combines the removal of SO_x, NO_x, and particulates in one unit--a high-temperature baghouse. This technology will be demonstrated on a 5-MWe slip-stream of flue gas by retrofitting a 158-MWe coal-fired generating station. SO_2 removal is accomplished by injecting either calcium- or sodium-based sorbent into the flue gas. NO_x is removed by injecting NH_3 in the presence of a selective reducing catalyst. Particulates are removed before the air heater with high-temperature woven bags. If successful, the demonstration will show that a single unit can remove about 50 percent or more of the SO_x, about 90 percent of the NO_x, and more than 99 percent of the particulates.

SOX-NOX-ROX Box Flue Gas Cleanup Demonstration Project
(The Babcock & Wilcox Company)

Key Milestone Dates:

DOE selected project	9/28/88
Kick-off meeting for fact-finding process	10/19/88
Issue preagreement milestone schedule	1/89
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Complete design and permitting	TBD
Complete construction	TBD
Begin operation	TBD
Complete project	8/92*

* Preliminary; subject to negotiation



Project Status:

Fact-finding and negotiating activities are in progress.

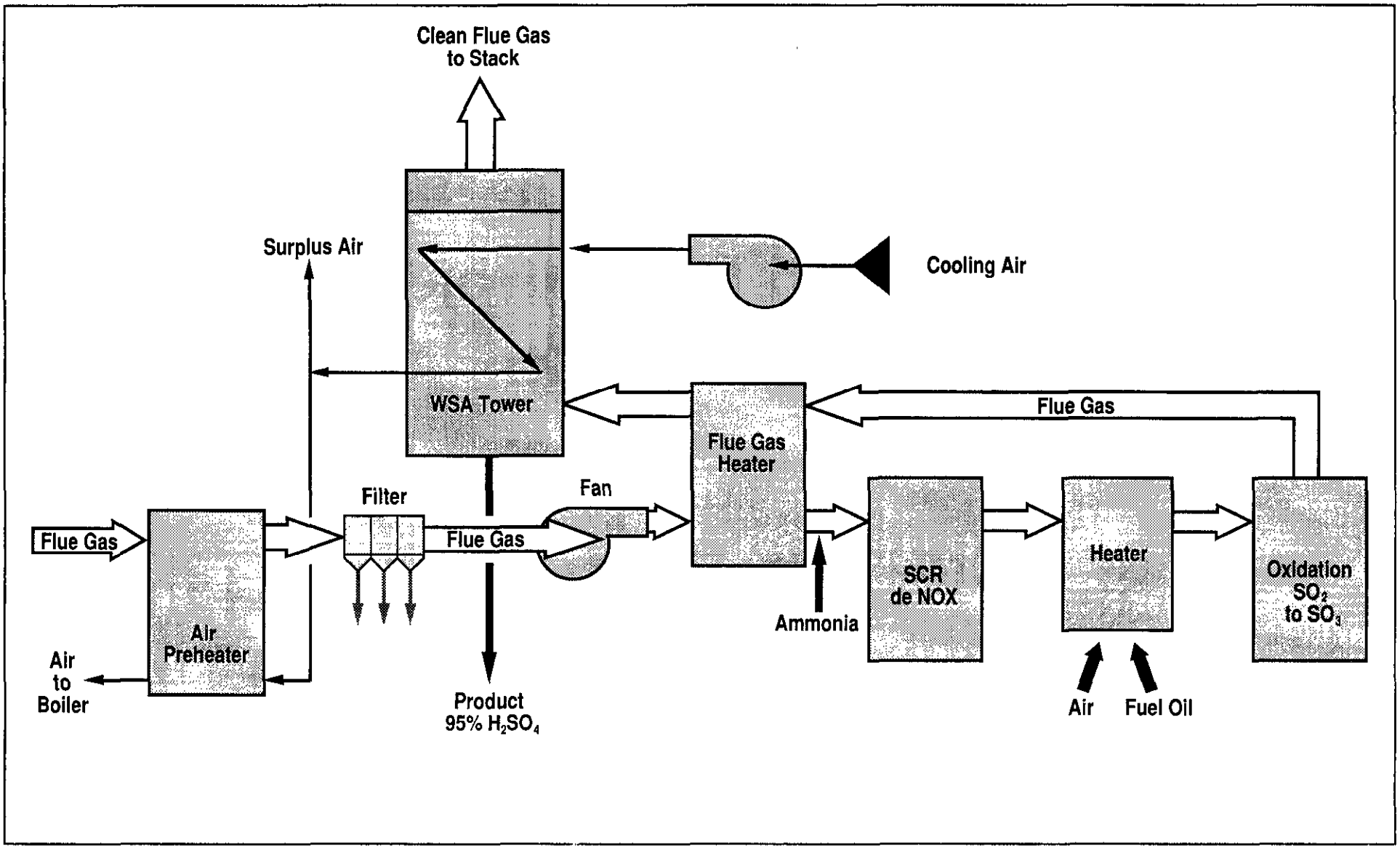
WSA-SNOX Flue Gas Cleaning Demonstration Project

Combustion Engineering, Inc.

WSA-SNOX Flue Gas Cleaning Demonstration Project

COMBUSTION ENGINEERING, INC.

PROCESS FLOW DIAGRAM



Project: WSA-SNOX Flue Gas Cleaning Demonstration Project

Industrial Participants:
Combustion Engineering, Inc.

Cofunders:
Ohio Coal Development Office
Ohio Edison Company (host utility)
Snamprogetti U.S.A., Inc.

Process: Advanced flue gas cleanup (catalytic)

Location: Niles, Trumbull County, OH (Niles Station)

Coal Feed Characteristics:
High-sulfur bituminous coals from OH

Plant Capacity/Production: 35 MWe and 42 tons of sulfuric acid per day

Feed Rate: 360 tons of coal per day

Estimated Total Cost:	Subject to negotiation
DOE:	TBD
Industrial Participant:	TBD

Project Objective:

To retrofit an electric power plant burning high-sulfur Ohio coals with WSA-SNOX technology, which catalytically removes 90 percent of the NO_x and SO_2 from flue gas and produces a salable by-product: concentrated sulfuric acid. No sorbents are used and no waste by-products are formed. Full-scale components and modules will be used in the demonstration.

Process Description:

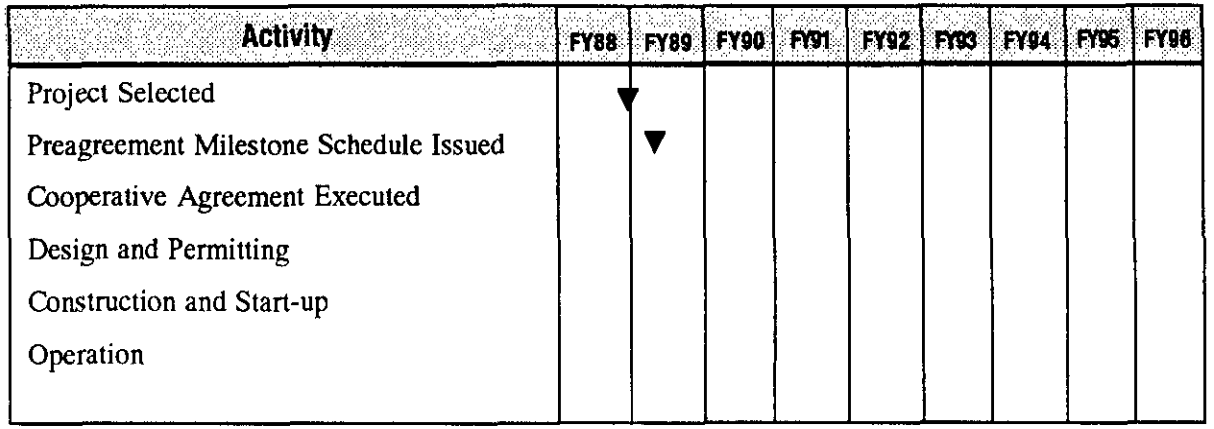
This demonstration will involve retrofitting a coal-fired boiler at Ohio Edison's 100-MWe Niles Station. In the WSA-SNOX process, flue gas is first processed through a bag filter to remove ash particles, then heated in an exchanger by the existing gas stream to required reaction temperature. A small amount of ammonia is added, and the mixture is then processed through a reactor that converts NO_x to nitrogen and water vapor. Gas exiting the NO_x converter is heated further, then processed through the SO_2 reactor in which SO_2 is converted to SO_3. The gas exiting the SO_2 reactor is passed through a heat exchanger that warms incoming feed gas to the NO_x reactor and then passed to the condensing tower in which highly concentrated sulfuric acid is formed.

WSA-SNOX Flue Gas Cleaning
Demonstration Project
(Combustion Engineering, Inc.)

Key Milestone Dates:

DOE selected project	9/28/88
Kick-off meeting for fact-finding process	10/19/88
Issue preagreement milestone schedule	12/23/88
Issue comprehensive report to Congress	TBD
Execute cooperative agreement	TBD
Complete design and permitting	TBD
Complete construction	TBD
Begin operation	TBD
Complete project	6/93*

* Preliminary; subject to negotiation



Project Status:

Fact-finding and negotiating activities are in progress.