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ENHANCING THE USE OF COALS BY GAS REBURNING-SORBENT INJECTION

Quarterly Report No. 11
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Prepared by
Energy and Environmental Research Corporation
18 Mason
Irvine, California 92718

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1.0 SUMMARY

The objective of this project is to evaluate and demonstrate a cost effective emission control technology for acid rain precursors, oxides of nitrogen (NO_x) and sulfur (SO_x), on two coal fired utility boilers in Illinois. The units selected are representative of pre-NSPS design practices: tangential and cyclone fired. Work on a third unit, wall fired, is "on hold" because of funding limitations. The specific objectives are to demonstrate reductions of 60 percent in NO_x and 50 percent in SO_x emissions, by a combination of two developed technologies, gas reburning (GR) and sorbent injection (SI).

With GR, about 80-85 percent of the coal fuel is fired in the primary combustion zone. The balance of the fuel is added downstream as natural gas to create a slightly fuel rich environment in which NO_x is converted to N_2. The combustion process is completed by overfire air addition. SO_x emissions are reduced by injecting dry sorbents (usually calcium based) into the upper furnace. The sorbents trap SO_x as solid sulfates that are collected in the particulate control device.

This project is conducted in three phases at each site: (1) Design and Permitting, (2) Construction and Startup, and (3) Operation, Data Collection, Reporting and Disposition. Technology transfer to industry is accomplished through the formation of an industry panel. Phase I of the project commenced on June 5, 1987 and concluded on May 15, 1989. It included five tasks as follows:

Task 1 - Project Management
Task 2 - Process Design
  Subtask 2.1 - Host Site Characterization
  Subtask 2.2 - Process Specification
Task 3 - Project Engineering
Task 4 - Environmental Reports, Permitting Plans and Design
Task 5 - Technology Transfer

During the period between May 15 and August 15, 1989, Phase AII-A overlap work was carried out for Hennepin Unit No. 1, the tangentially fired boiler (Unit A), to pre-engineer and procure long lead time items in

preparation for the beginning of Phase II proper, Construction and Startup, so that the Spring 1990 outage schedule of this unit could be met. Because of delays in finalizing negotiations with the utility, Phase AII-B, the balance of Phase II work for Hennepin could not be started on August 15, as planned. A Host Agreement Modification was signed on January 19, 1990 by the utility, Illinois Power Company, and EER. Work on Phase AII-B for the tangentially fired site was resumed immediately.

In Task 1, Project Management, the Phase AII-B Construction and Startup work at Hennepin was coordinated, while pursuing Host Agreement Modification negotiations with CWLP for the start of Phase CII, Construction and Startup work at Lakeside (Unit C). Monthly coordination meetings were held with Illinois Power at Lakeside (some of these were attended by Project Managers of the co-funders) and DOE, GRI and ENR have been kept apprised through written and verbal communications.

In Task 2, Construction and Startup, the engineering and installation work focused on the Hennepin boiler. This included updating the CPM Schedule, with all mechanical work to be completed by the end of August, and all electrical work to be completed by the end of September. Work on construction drawings with the subcontractors continued as a significant activity during the quarter. All equipment orders have been placed at Hennepin and most items received from vendors. During the April 14-June 10 outage of Unit A, most critical equipment component installation has been accomplished, only the injector nozzles need to be installed later because of a delay in the delivery of cooling fans. The ash line pH control will be accomplished by liquid CO_2 injection; IP has filed a permit application with the Illinois EPA. Hennepin Unit 1 is back on line after the eight week outage with no subsequent problems.

In Task 3, Technology Transfer, arrangements have been made to hold the third Industry Panel meeting on November 7-8, 1990, at Starved Rock State Park in Utica, IL, including a tour of the Hennepin GR-SI installation on November 7.

The Host Agreement Modification was signed with the owner of the cyclone-fired unit (City of Springfield, Department of Water, Light and Power, Lakeside Unit No. 7) on June 7, 1990. Scheduling and construction engineering work started during the second half of June.

Key Words

SO_x	Ash	Emission
SO_2	Coal	Control
NO_x	Gas	Boiler
NO	Sorbent	Precipitator
Pond	Construction	Flue Gas
Startup	Instrumentation	Contracts

2.0 INTRODUCTION

Clean Coal Technology implies the use of coal in an environmentally acceptable manner. Coal combustion results in the emission of two acid rain precursors: oxides of sulfur (SO_x) and oxides of nitrogen (NO_x). This clean coal technology project will demonstrate a combination of two developed technologies to reduce both NO_x and SO_x emissions: gas reburning and calcium based dry sorbent injection. The demonstrations will be conducted on two pre-NSPS utility boilers representative of the U.S. boilers which contribute significantly to the inventory of acid rain precursor emissions: tangentially fired and cyclone fired units. (A demonstration on another representative boiler type, wall fired, is "on hold" because of funding limitations.)

Gas reburning is a combustion modification technique that consists of firing 80-85 percent of the fuel corresponding to the total heat release in the lower furnace. Reduction of NO_x to molecular nitrogen (N_2) is accomplished via the downstream injection of the remaining fuel requirement in the form of natural gas (which also reduces the total SO_x emissions). In a third stage, burnout air is injected at lower temperatures in the upper furnace to complete the combustion process without generating significant additional NO_x.

Dry sorbent injection consists of injecting calcium based sorbents (such as limestone, dolomite, or hydrated lime) into the combustion products. For sulfation of the sorbent to $CaSO_4$, an injection temperature of about 1230°C is optimum, but calcium-sulfur reactions can also take place at lower temperatures. Thus, the sorbent may be injected at different locations, such as with the burnout air, at the exit from the superheater, or into the ducting downstream of the boiler with H_2O added for humidification. The calcium sulfate or sulfite products are collected together with unreacted sorbent by the particulate collection device, usually an electrostatic precipitator or bag filter.

The specific goal of this project is to demonstrate NO_x and SO_x emission reductions of 60 percent and 50 percent, respectively, on two coal fired utility boilers having the design characteristics mentioned above. Host Site Agreements have been signed by EER and three utility companies in the State of Illinois: Illinois Power Company (Test Site A, Hennepin Unit 1, 71 MW_{net}

tangentially fired boiler in Hennepin), Central Illinois Light Company (Test Site B, Edwards Unit 1, 117 MW_{net} front wall fired boiler in Bartonville), and City Water Light and Power (Test Site C, Lakeside Unit 7, 33 MW_{net} cyclone fired boiler in Springfield). (As discussed above, GR-SI demonstrations are now planned only at sites A and C.)

Co-funding for this project is provided by the Gas Research Institute (GRI) and the State of Illinois Department of Energy and Natural Resources (ENR)--the other Funding Participants. GRI and ENR are responsible for funding approximately one-third and one-sixth, respectively, of the total project costs.

To achieve the objectives of the project, it is being conducted in the following three phases at each host site.

Phase I: Design and Permitting
Phase II: Construction and Startup
Phase III: Operation, Data Collection, Reporting and Disposition

Phase I of the project was conducted in parallel for test sites A, B and C over a period of 22 months, starting in June 1987. During the period of May 15-August 15, 1989, Phase AII-A pre-engineering overlap work was conducted on the tangentially fired site A. After continuing negotiations with the host of site A, a Host Agreement Modification was signed on January 19 and Phase AII-B (the balance of the Construction and Startup work) was resumed immediately.

During the past quarter the principal objectives of the work performed were as follows:

A. <u>Site A (Hennepin No. 1)</u>

- Complete construction and installation of critical elements of the GR-SI equipment during the April-May outage of the unit.
- Continue post-outage installation work with a complete target of September 1990.
- Finalize the ash line pH control system design, based on liquid CO_2 injection.

- Develop an operator training program for implementation during the next quarter.
- Review progress and issues with Illinois Power at monthly meetings held at Hennepin.
- Apprise the funding organizations, DOE, GRI and ENR, of progress and new developments.
- Select location and timing for the third Industry Panel meeting focusing on the Hennepin GR-SI installation and test plans.

B. Site C (Lakeside No. 7)

- Complete negotiations with CWLP on the Host Agreement Modification for initiation of Phase CII work at Lakeside. The Host Agreement Modification was signed on June 7. 1990 by the Mayor of Springfield on behalf of CWLP.
- Establish schedule for Phase CII Construction and Startup work at Lakeside.
- Update subcontracts following the project delay.
- Initiate Phase CII engineering activity for Lakeside.
- Apprise the funding organizations, DOE, GRI and ENR, of progress and new developments.

3.0 PROJECT DESCRIPTION

Within the three phases of the project, the following tasks will be performed to demonstrate the cost effective control of NO_x and SO_x emissions from pre-NSPS coal fired utility boilers:

Phase I: DESIGN AND PERMITTING

Task 1 - Project Management

- Coordination of all Participant and subcontractor efforts
- Coordination with the host sites
- Planning and scheduling all tasks
- Monitoring all technical efforts
- Keeping DOE, GRI, and ENR fully informed of project status
- Continual review of relevant ongoing technical developments

Task 2 - Process Design

Subtask 2.1 - Host Site Characterization

- Establishment of the condition of each host site, including field evaluations.

Subtask 2.2 - Process Specification

- Preparation of GR-SI process designs, aiming at 60% and 50% reduction in NO_x and SO_x, respectively.
- Continuing bench scale tests to define key process parameters.

Task 3 - Project Engineering

- Preparation of site specific detailed engineering designs, construction plans and schedules, cost estimates, startup plans and Phase III test plans.

Task 4 - Environmental Reporting, Permitting, Plans and Design

- Preparation of relevant environmental data for obtaining NEPA approval.
- Preparation of Environmental Monitoring Plan.
- Assistance to host sites in obtaining environmental permits.

Task 5 - Technology Transfer

- Formation of an Industry Panel for technology transfer.
- Arrangement of Panel meetings on (1) process design and (2) detailed engineering design and plans for Phases II and III.

Phase II: CONSTRUCTION AND STARTUP

Task 1 - Project Management

- Continuation of Phase I project management activities.
- Arrangement of project review meetings at approximately the 40 and 90 percent completion points for each site.

Task 2 - Installation and Checkout

- Installation of the emission control and auxiliary equipment.
- Checkout of functional operation of all components.

Task 3 - Technology Transfer

- Continuation of technology transfer activities initiated in Phase I.
- Meetings with Industry Panel to review installations and plans.

Task 4 - Restoration

- Decision on disposition of test equipment if project is discontinued: to be retained by host sites or removal and restoration work.

Phase III: OPERATION, DATA COLLECTION, REPORTING AND DISPOSITION

Task 1 - Project Management

- Continuation of Phases 1 and 2 project management activities.
- Conducting final project review at conclusion of project.

Task 2 - Technology Demonstration

Subtask 2.1 - Optimization Testing

- Evaluation of effects of process variables on emission control performance.
- Determination of operating conditions for optimum overall performance.

Subtask 2.2 - Evaluation of Alternative Coals and Sorbents

- Evaluation of performance of alternative coals and sorbents:
  - High and medium sulfur coals, with consideration of cleaned and run-of-mine coals.
  - Selection of sorbents from high calcium and dolomite limestones, hydrated limestones and limes.

Subtask 2.3 - Long-Term Testing

- Operation of GR-SI equipment under optimized conditions for approximately one-year duration at each host site.
- Measurement of emission control system performance.
- Determination of boiler impacts.

Task 3 - Evaluation of Demonstration Results

- Analysis of test data.
- Preparation of guideline manuals for application of GR-SI technology, including design recommendations, cost projection and comparisons with competing technologies.

Task 4 - Restoration

- Disposition of GR-SI equipment installation:
  - To be retained by host site or removal and restoration work.

Task 5 - Technology Transfer

- Continuation of technology transfer activities from Phases I and II.
- Meeting with Industry Panel at one host site to review results obtained there and plans for other two host sites.
- Meeting with Industry Panel at completion of project.

4.0 PROJECT STATUS

4.1 Task 1 - Project Management

Monthly and other reporting activities were fulfilled according to the reporting requirements of the cooperative agreement. A Project Evaluation Plan (PEP) has been submitted for Phase AII.

Work progress has been monitored continuously. Coordination with IP took place at monthly meetings in Hennepin and by telephone. The project co-funders were apprised of progress and development through telephone contacts and meetings at the Hennepin site.

A meeting was held in Chicago on June 18, 1990 regarding gas supply and transport. Representatives of GRI, IP and EER participated in this meeting. It was agreed that IP will purchase the gas and arrange for its transportation charging the project, based on EER projections of gas requirements taking into account test plan and unit outage schedules.

Negotiation of the Host Agreement Modification has been completed with CWLP for Phase CII work at the Lakeside No. 7 site. The Agreement was signed in June and some preliminary scheduling and engineering work has started.

4.2 Task 2 - Construction and Startup

Almost all engineering and construction activity performed during this reporting period was for the IP Hennepin Station. This work has been designated as Phase AII-B Subtasks 1.2 and 2.2, respectively, for project management, and construction and startup. The overlap phases, Subtasks 1.1 and 2.1 have been completed.

The IP Hennepin Unit 1 outage occurred from April 14 through June 10, with most second quarter activities focused on completing the outage work on schedule.

Ten EER-placed purchase orders have delivery remaining for equipment or instruments.

Following the approval and signing of the Host Agreement Modification with Springfield City Water, Light and Power, project management and engineering home office support activities were begun. These include schedule preparation, detailed checking of drawings, and updating specs and proposals for purchased materials and contractors. CWLP work has been designated as Phase CII Tasks 1 and 2, respectively, for project management, and construction and startup.

4.2.1 Contracts

At Hennepin, the decision to permit use of the existing ash pond for the GR-SI ash cancelled further work on the ash pond design by Hammontree & Associates. Similarly, the Provost Constructors (construction scheduling) contract was dropped in favor of doing construction scheduling by EER.

Due to the delayed project construction start, it was necessary to negotiate changes in the dollar value of the construction contracts. Since mobilization, there have been additional change orders to account for interferences and other minor changes. The major mechanical change order was for work in the superheater area to realign the sagging tubes. The ash line contract has been modified to eliminate the new line to the new ash pond, and instead to replace major sections of the existing ash line.

Contracts for the Springfield City Water, Light and Power project (Phase CII) are being re-drawn to reflect minor changes to the existing workscope and lessons learned from the IP Hennepin project. Subcontractors will be requested to re-bid in September 1990.

4.2.2 Construction CPM Scheduling

EER has updated the schedule for the remaining activities at Hennepin. The mechanical contractor plans to complete work by the end of August. The electrical work should be complete by the end of September. Checkout and startup will begin in September.

4.2.3 Construction Drawings

Hennepin construction drawings have continued as a significant activity during the second quarter, 1990. Approvals of vendor and subcontractor

fabrication drawings for steel and ductwork have involved considerable effort. Field interferences also made it necessary to modify supports and routings, and to redesign tubewall penetration locations and slide plates.

Construction drawings for Springfield's CWLP are being revised as required prior to re-bid by subcontractors.

4.2.4 Equipment Purchasing

All equipment orders have been placed at Hennepin. All except the last 18 items from ten vendors have been received.

4.2.5 Miscellaneous

Meetings between Illinois Power and EER were held at Hennepin in April, May, and June. Representatives of the project funders attended some of the meetings.

The pH adjustment system for the ash sluice line was finalized as a CO_2 injection system. A construction permit application has been filed with the Illinois EPA.

The startup of Hennepin Unit 1 after the eight-week outage went well and the unit has remained on line with no subsequent problems.

The Illinois Environmental Protection Agency has applied for and received from Springfield CWLP a 120-day extension for review of the construction and operating permit. This moves the approval target date from July 8, 1990 to November 8, 1990. Note that the current project schedule has construction slated to begin in mid-November 1990.

4.3 Technology Transfer

Arrangements have been made to hold the third Industry Panel meeting near the Hennepin site, in Utica, Illinois, at the Starved Rock State Park Lodge on November 7-8, 1990. The meeting will start with a guided tour of the GR-SI installation on Hennepin Unit No. 1 on November 7. On November 8, presentations will be made on the construction work and test plans, followed by a discussion period. This agenda will provide members of the Industry

Panel to inspect the equipment directly and provide feedback to the project team. Invitations to attend will be mailed in July.

5.0 PLANNED ACTIVITIES

During the next quarter (July through September 1990) the following work is planned:

A. IP Hennepin Unit 1 (Phase AII-B):

1. Completion of mechanical and electrical construction.

2. Completion of Operation and Maintenance Manual.

3. Completion of Startup Plan.

4. Operator Training.

5. Beginning of instrument calibration and equipment checkout and startup.

6. Begin work on Phase III test plan details.

B. CWLP Lakeside Unit 7 (Phase CII):

1. Continue with final design and generation of construction drawings.

2. Submit revised subcontractor contracts for re-bid.

3. Order major and long-lead equipment.

4. Prepare detailed project equipment procurement/construction schedule.

5. Prepare the project manual.

Technology Transfer activities will continue with preparations for the November 7-8 Industry Panel Meeting

6.0 REPORT DISTRIBUTION LIST

The number in parentheses () indicates the total number of copies submitted.

6.1 Funding Organization Distribution

6.1.1 U.S. Department of Energy

Mr. Harry J. Ritz (2)
PETC Technical Project Manager
Mail Stop 920-L
U.S. Department of Energy/PETC
P.O. Box 10940
Pittsburgh, PA 15236

Mr. John Augustine (1)
Contracting Specialist
AD-21, Mail Stop 921-165
U.S. Department of Energy/PETC
P.O. Box 10940
Pittsburgh, PA 15236

Mr. Douglas Uthus (1)
HQ Program Manager
FE-22, 3E-042, Forrestal
U.S. Department of Energy
Washington, DC 20545

Office of Patent Counsel (1)
U.S. Department of Energy
9800 South Cass Avenue
Argonne, IL 60439

Department of Energy (3)
Office of Technology Transfer
Mail Stop 58-105
U.S. Department of Energy/PETC
P.O. Box 10940
Pittsburgh, PA 15236

Dr. S.N. Roger Rao (1)
Burns and Roe Technical Group Manager
P.O. Box 18288
Pittsburgh, PA 15236

Mr. Charles Drummond (1)
Mail Stop 920-L
U.S. Department of Energy/PETC
P.O. Box 10940
Pittsburgh, PA 15236

Mr. George G. Weth (1)
Senior Program Manager
Office of Clean Coal Technology
FE-24, C-177
U.S. Department of Energy
Washington, DC 20545

Dr. C. Lowell Miller (1)
Associate Deputy for Clean Coal
Office of Clean Coal Technology
FE-24, C-178
U.S. Department of Energy
Washington, DC 20545

6.1.2 Gas Research Institute

Mr. John Pratapas (10)
Gas Research Institute
8600 West Bryn Mawr Avenue
Chicago, IL 60631

6.1.3 Illinois Department of Energy and Natural Resources

Mr. Donald J. Farrell (10)
Illinois Department of Energy and Natural Resources
325 West Adams Street
Springfield, IL 62706

6.2 Host Utility Distribution

6.2.1 City Water Light and Power

Mr. James Rechner (6)
Electric Division Manager
City Water Light and Power
Municipal Building
Springfield, IL 62757

6.2.2 Illinois Power Company

Mr. T. J. May (6)
Illinois Power Company
500 South 27th Street
Decatur, IL 62521

6.2.3 Central Illinois Light Company

Mr. James F. Wittmer (6)
Central Illinois Light Company
300 Liberty Street
Peoria, IL 61602

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