ENHANCING THE USE OF COALS BY
GAS REBURNING-SORBENT INJECTION

Quarterly Report No. 12
For the Period
July 1 through September 30, 1990

DE-FC22-87PC79796

Prepared for
U.S. Department of Energy
Gas Research Institute
State of Illinois Department of
Energy and Natural Resources

Prepared by
Energy and Environmental Research Corporation
18 Mason
Irvine, California 92718

Report No. 12

DEC 11 1990

October 20, 1990

U.S. DOE PATENT CLEARANCE IS NOT REQUIRED
PRIOR TO THE PUBLICATION OF THIS DOCUMENT

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

MASTER ps

TABLE OF CONTENTS

	LEGAL NOTICE	ii
1.0	SUMMARY	1-1
2.0	INTRODUCTION	2-1
3.0	PROJECT DESCRIPTION	3-1
4.0	PROJECT STATUS	4-1
4.1	Task 1 - Project Management	4-1
4.2	Task 2 - Installation and Startup	4-1
4.3	Task 3 - Technology Transfer	4-4
5.0	PLANNED ACTIVITIES	5-1
6.0	REPORT DISTRIBUTION LIST	6-1

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

LEGAL NOTICE

This report was prepared by Energy and Environmental Research Corporation (EER) as an account of work sponsored by the Gas Research Institute (GRI), the United States Department of Energy (DOE), and the State of Illinois Department of Energy and Natural Resources (ENR). Neither, GRI, DOE, ENR, nor members of GRI, DOE, ENR, nor any person acting on their behalf;

a. Makes any warranty or representation, express or implied with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately-owned rights, or

b. Assumes any liability with respect to the use of, or for damages resulting from the use of, any information, apparatus, method, or process disclosed in this report.

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, has been stopped 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

As reported in the last Quarterly, the Host Agreement Modification was signed with the owner-operator of the cyclone-fired boiler (Site C, City of Springfield, Department of Water, Light and Power, Lakeside Unit No. 7) on

June 7, 1990. Phase C-II scheduling and construction engineering work started at site C during the second half of June. During the past quarter, pre-engineering work, review of drawings and selection of subcontractors proceeded in coordination with the host utility. While awaiting the issuance of a construction permit by the Illinois EPA which is scheduled for November 8, limited civil work (excavations, etc.) has been initiated at Lakeside.

In Phase AII at Hennepin, Task 1 - Project Management coordinated the remaining construction and startup work. By the end of the quarter, construction work was essentially complete, with startup of the GR-SI installation in progress. It was recommended by EER, with the concurrence of the funding organizations, that the synergism between startup and Phase AIII testing work should overlap for the last quarter of the 1990 calendar year. This mode of conducting the project will result in significant savings in time and cost, thus improving cost effectiveness. Baseline characterization of the unit will be carried out during this period. Also, gas reburning results will be available earlier than originally projected. Monthly coordination meetings were held with Illinois Power at Hennepin and with CWLP at Lakeside. The meetings included arrangements made for gas supply to both sites, with Midcon transporting spot market natural gas to Illinois Power, and Panhandle Eastern providing natural gas to CILCO, CWLP's gas supplier. CILCO will install the new pipeline connection from the existing terminal to Lakeside Unit 7 for gas reburning. The funding organizations, DOE, GRI and ENR, were kept apprised of progress and issues through written, personal and telephone communications.

In Task 2 of Phase AII at Hennepin, Construction and Startup, ultrasonic tube wall thickness measurements were performed during an outage in September, and tube sections were removed for later metallurgical characterization. Checkout and startup were begun in September. The EER Continuous Emissions Monitoring System (CEMS) was refurbished, recalibrated and installed at Hennepin. It was ready to sample and analyze flue gas by the end of the last quarter.

In Task 3 of Phase AII, Technology Transfer, arrangements for the third Industry Panel meeting were finalized for November 8-9, 1990, at Starved Rock State park Lodge in Utica, Illinois, including a tour of the Hennepin GR-SI installation on November 7. As part of this task, a paper was presented on the project at the Seventh Annual Pittsburgh Coal Conference in September 1990.

Key Words

SO_x

SO₂

NO_x

NO

Pond

Startup

CEMS

Ash

Coal

Gas

Sorbent

Construction

Instrumentation

Industry Panel

Emission

Control

Boiler

Precipitator

Flue Gas

Contracts

Control

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, has been stopped 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. Site A (Hennepin No. 1)

1. Complete mechanical and electrical construction.
2. Complete preparation of Operation and Maintenance Manual.
3. Complete Startup Plan.
4. Operator Training.

5. Calibrate CEMS instruments and begin equipment checkout and startup.
6. Prepare revision of Phase III test plan details.
7. Conduct ultrasonic tube wall testing on unit during September outage.

B. Site C (Lakeside No. 7)

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.

C. Continue Technology Transfer activities with preparations for the November 7-8 Industry Panel Meeting at Starved Rock State Park Lodge, Utica, Illinois.

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 Continuation Application and Project Evaluation Report has been submitted for Phase AII, Hennepin. A Project Evaluation Plan has been submitted for Phase CII, Lakeside.

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 conferences and meetings at the Hennepin site.

Based on a review of project schedules, costs, and objectives, it was recommended to DOE and the Other Funding Organizations that the Phase AII startup should be overlapped with the Phase AIII testing at Hennepin. EER received verbal (and in the case of GRI, formal) approval to proceed in this manner. The requisite cost projections and other necessary documentation have been submitted to DOE, GRI and ENR.

Work was also coordinated for the initial portion of Phase CII, Construction and Startup, at Lakeside. Pre-engineering work, drawing reviews and selection of subcontractors proceeded in coordination with the host utility. At present, limited civil-type work has been authorized, while awaiting the issuance of the Illinois EPA construction permit on or about November 8, 1990.

4.2 Task 2 - Installation and Startup

Hennepin - A one-week IP Hennepin Unit 1 outage occurred from September 8 through 16 during which final nozzle and duct ties were completed at the boiler.

The sootblower air compressor was the only remaining major item not yet shipped.

The EER Continuous Emissions Monitoring System (CEMS) was reconditioned in Orrville and transported to Hennepin in late September. Testing ports and sampling systems were installed at the economizer, calibrations were performed and the system was ready for flue gas sampling on September 30.

During the September outage, ultrasonic tube wall thickness measurements were performed, tube samples were removed for later metallurgical examination and test ports were installed in the ductwork adjacent to the stack. Work was begun on sampling platforms in this area following the outage.

CWLP - During the last quarter, discussions with CWLP personnel have resolved issues involving selection of the ash handling subcontractor, installation of the natural gas line, determination of the gas supplier and rate, resolution of construction drawing discrepancies, and definition of the workscope for the boiler recirculation study to be performed by B&W. Also, the workscope for the civil construction effort was finalized in preparation for bidding.

4.2.1 Contracts

Hennepin - As construction nears completion at Hennepin, the best projections for the final costs of each contract (including change orders) are:

Mechanical	\$4,325,000
Electrical	\$ 690,000
Ash Sluice System	\$ 295,000

CWLP - The Construction Specification has been revised in preparation for subcontractor re-bids. Due to the necessity of having silo foundations in place prior to the winter season and in view of the current drawing revision status, a decision was made to solicit bids for civil-only work. The bidding process for the civil subcontractor is currently in progress with bids due on October 8. United Conveyor has been selected as the ash handling subcontractor. The bidding process for the remaining subcontracts will occur during the next quarter.

4.2.2 Construction CPM Scheduling

Hennepin - EER has updated the schedule for the remaining activities at Hennepin. The mechanical contractor plans to complete work by the end of October. The electrical work should be complete by early November. Punch lists are being monitored to see that all details are completed by each contractor. Checkout and startup were begun in September.

CWLP - Generation of the construction schedule by EER is underway and will be completed by the end of October. A separate schedule has been prepared for civil construction.

4.2.3 Construction Drawings

Hennepin - Hennepin construction drawings are completed. However, a few changes remain in order to document the as-built installation.

CWLP - The on-site review of construction drawings by EER and CWLP personnel has been completed. Drawings are currently being revised per the changes.

4.2.4 Equipment Purchasing

Hennepin - All equipment for Phase AII (Hennepin Unit 1) construction has been purchased. The last major item, the sootblower air compressor, will be delivered at the end of October.

CWLP - The engineering effort to define equipment parameters has continued. Orders for all major equipment will be placed during the next quarter.

4.2.5 Miscellaneous

Hennepin - Meetings between Illinois Power and EER were held at Hennepin in July and August. Representatives of the project funders attended some of the meetings.

The construction permits for the pH control system using liquid CO₂ injection for the ash sluice line was granted by the Illinois EPA within 30 days of the application.

The Operation and Maintenance Manual was completed. This document will be the text for the Operator Training Program scheduled to begin October 1.

CWLP - The construction and operating permit is expected to be issued by the Illinois EPA on November 8, 1990. Limited civil activity exclusive of concrete work is permitted prior to issuance. Therefore, the civil subcontractor will be mobilized at the end of October to begin excavation for foundations.

4.3 Technology Transfer

The arrangements made the previous quarter were finalized 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. As reported in the last Quarterly, 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, test plans and progress, followed by Panel discussions and feedback. This agenda will provide members of the Industry Panel to inspect the equipment directly and provide feedback to the project team. Responses to invitations indicate a prospective attendance of about 50 people, including representatives of the funding organizations, host sites, and EER.

A paper on the GR-SI project was presented at the Seventh Annual Pittsburgh Coal Conference in September 1990.

5.0 Planned Activities

During next quarter (October through December, 1990) the following work is planned:

A. Hennepin Unit 1 (Phases AII and AIII)

1. Complete mechanical and electrical construction.
2. Complete operator training program.
3. Complete instrument calibration and equipment checkout and startup.
4. Complete baseline tests using CEMS equipment supplemented by other measurements to characterize boiler performance without GR-SI.
5. Complete startup and short-term testing of GR-SI system.
6. Start optimization of the Gas Reburning Process.
7. Present test plan summary and any preliminary test data at industry panel meeting.
8. Carry out preliminary testing of Sorbent Injection process.
9. Hold Industry Panel meeting on November 7-8, 1990.
10. Continue standard project management activities of preparation of deliverables, coordination of the project team's activities, and reporting events and issues to the project sponsors on a timely basis.

B. Lakeside Unit 7 (Phase CII)

1. Award the civil contract, mobilize and begin construction.
2. Perform the re-bidding process for mechanical and electrical construction.
3. Order all major equipment.
4. Release the revised Project Manual.
5. Complete the detailed construction schedule.
6. Continue project management activities.

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

END

DATE FILMED

01 / 29 / 91