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EVALUATION OF GAS-REBURNING AND LOW NO_x
BURNERS ON A WALL FIRED BOILER

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1.0 SUMMARY

Clean Coal Technology (CCT) implies the use of coal in an environmentally acceptable manner. Coal combustion results in the emission of oxides of nitrogen (NO_x), which are precursors of both acid rain and ozone formation. The primary objective of this CCT project is to evaluate the use of Gas Reburning and Low NO_x Burners (GR-LNB) for NO_x emission control from a wall fired boiler. It is anticipated that, if the demonstration is successful, the GR-LNB technology could become commercialized during the 1990's and will be capable of (1) achieving significant reduction in the emissions of nitrogen oxides and sulfur dioxide (another acid rain precursor) from existing facilities to minimize environmental impacts such as transboundary and interstate pollution and/or (2) providing for future energy needs in an environmentally acceptable manner.

Low NO_x burners are designed to delay the mixing of the coal fuel with combustion air to minimize the NO_x formation. Typically, one may obtain about 50% reduction in NO_x emissions through the use of LNB. For LNB applications, the technology is developed and a number of LNB designs are commercially available.

With GR, about 80-85 percent of the coal fuel is fired in the main 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 over-fire air addition. SO_x emissions are reduced to the extent that natural gas replaces sulfur-containing coal. The level of NO_x reduction achievable with 15-20% natural gas is on the order of 50-60%. Thus the emission reduction target of the combination of these two developed technologies is about 75%.

Specifically, the technical objectives of this project are to:

1. Demonstrate the full effectiveness of GR-LNB for NO_x emission control. This includes the performance of the separate technologies and of the integrated GR-LNB technology.

2. Demonstrate the compatibility of GR-LNB with existing wall fired boilers.
3. Demonstrate the additional reductions in SO₂, particulate and CO₂ achievable with GR-LNB.
4. Demonstrate the synergism of GR-LNB with sorbent injection for SO₂ control if a sorbent injection system is installed outside the scope of this project.
5. Develop a data base which can be used to establish the commercial viability of GR-LNB to meet existing and projected emission control regulations.
6. Transfer the project results to industry to ensure that GR-LNB is a recognized cost effective competitor for utility boiler emission control.

This project is being conducted in three phases at the host site, a 172 MW_e wall fired boiler of Public Service Company of Colorado (PSCo), Cherokee Unit 3 in Denver, Colorado: Phase I - Design and Permitting, Phase II - Construction and Start-up, and Phase III - 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 October 13, 1990. It includes six tasks as follows:

Task 1	- Project Management
Task 2	- Process Design
Task 3	- Engineering Design
Task 4	- Environmental Reports, Permitting, Plans and Design
Task 5	- Baseline Test and Phase III Test Plan
Task 6	- Technology Transfer

The Host Agreement was signed with the owner-operator of the wall-fired boiler on September 6, 1990. Phase I scheduling and preliminary testing work started during December. The process design has been completed and a report is being prepared. The engineering design is proceeding and the baseline test plan has been prepared.

Phase II of the project commenced on June 13, 1991. It includes the four tasks as follows:

Task 1 - Project Management

Task 2 - Installation / Check-out

Task 3 - Technology Transfer

Task 4 - Restoration

Key Words

SO _x	Ash	Emission
SO ₂	Coal	Control
NO _x	Gas	Boiler
NO	Low NO _x Burners	Precipitator
Burners	Construction	Flue Gas
Start-up	Instrumentation	Contracts
CEMS	Industry Panel	Control
Reburning	Injection	Ducts
Humidification		

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). In addition, NO_x emissions contribute to ozone formation, a major problem in ozone non-attainment areas. This clean coal technology project will demonstrate a combination of two developed technologies to reduce both NO_x and (to some extent) SO_x emissions: gas reburning and low NO_x burners. The demonstrations will be conducted on a pre-NSPS utility boiler representative of U.S. boilers that contribute significantly to the inventory of acid rain precursor emissions: a wall fired unit.

Low NO_x burners operate on the principle of delayed mixing between the coal fuel and burner air, so that less NO_x is formed. 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 the lower temperatures in the upper furnace to complete the combustion process without generating significant additional NO_x .

The specific goal of this project is to demonstrate NO_x emission reductions of 75 percent or more as a result of combining LNB and GR on a utility boiler having the design characteristics mentioned above. A Host Site Agreement has been signed by EER and a utility company in the State of Colorado: Public Service Company of Colorado (Cherokee Unit No. 3, 172 MW_e) front wall fired boiler near Denver.

Co-funding for this project is provided by the Gas Research Institute (GRI), the Public Service Company of Colorado (PSCo), Colorado Interstate Gas Company (CIG), Electric Power Research Institute (EPRI) and Energy and Environmental Research Corporation (EER)--the Other Funding Participants. These organizations are responsible for funding one-half of the total

project costs, while the U.S. Department of Energy will contribute the other one-half of the total project costs.

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

- Phase I: Design and Permitting
- Phase II: Construction and Start-up
- Phase III: Operation, Data Collection, Reporting and Disposition

Phase I of the project (Design and Permitting) officially began October 13, 1990, conducting Task 1, Project Management work. In December, furnace tests were arranged and conducted to provide preliminary data for modeling Cherokee Unit No. 3.

In July, August and September the work focused on completing the procurement and installation of equipment and materials that must be installed while the unit is out-of-service during August thru October.

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

1. Complete the design engineering and issue arrangement and detailed design drawings for construction.
2. Place contracts for mechanical and electrical installation work.
3. Complete the Baseline Test.

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

EER will provide the overall management necessary for completing successfully all aspects of Phase I. This will include the following:

- Coordination of all Participant and subcontractor efforts.
- Coordination with the host site.
- Planning and scheduling all tasks.
- Monitoring all technical efforts.
- Keeping DOE, GRI, PSCo, CIG and EPRI fully informed of project status.
- Continual review of relevant ongoing technical developments, particularly EER's Gas Reburning and Sorbent Injection CCT project, as well as other work supported by DOE, GRI, EPRI, EPA and commercial firms.

Task 2 - Process Design

In the Process Design task, GR-LNB process designs will be prepared. The process designs will be based on the maximum NO_x emission control commensurate with the design and operating constraints of the unit, improved unit operability and minimum cost of power generation to the maximum extent possible. The following work will be done:

- Brief field measurements will be conducted to obtain performance data necessary for process design.

The design and operation will be analyzed to provide functional designs and specifications for all components of the gas reburning and low NO_x burner system.

- Bench scale tests will be conducted as required to define key process parameters. This will include isothermal modeling of furnace/convective pass flow patterns and mixing studies.
- Thermal and emission reduction performances of the GR-LNB NO_x emissions control system will be predicted.
- Optimum designs for GR-LNB will be established based on isothermal kinetic and thermal modeling and on baseline characterization of the unit.
- The process design will be documented in a report submitted to DOE.

Task 3 - Engineering Design

Following approval of the process design (prepared in Task 2) EER will proceed with detailed engineering design. The engineering design will include preparation of the following:

- Site specific engineering, including process, civil, structural, mechanical and electrical design.
- Engineering drawings.
- Construction plans and schedule.
- Construction cost estimates.
- Start-up plan.

Task 4 - Environmental Reporting, Permitting, Plans and Design

A variety of environmental activities will be conducted. This will include the following:

- Preparation of relevant environmental data for obtaining NEPA approval. (This was updated during the Agreement negotiation phase.)
- Preparation of Environmental Monitoring Plan.
- Assistance to host site in obtaining environmental permits.

Task 5 - Technology Transfer

To help ensure the timely commercialization of this technology, the following technology transfer activities will be conducted:

- 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.
- Prepare and present technical papers at appropriate conferences and industry meetings.

Phase II: CONSTRUCTION AND START-UP

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.

Task 2 - Installation and Check-out

- Installation of the emission control and auxiliary equipment.

- Check-out 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 site or removal and restoration work.

Phase III: OPERATION, DATA COLLECTION, REPORTING AND DISPOSITION

Task 1 - Project Management

- Continuation of Phases I and II project management activities.
- Conducting final project review at conclusion of project.

Task 2 - Optimization Testing

- Optimization of LNB installation.
- Optimization of GR-LNB technology
- Evaluation of effects of process variables on emission control performance.
- Determination of operating conditions for optimum overall performance.

Task 3 - Long Term Tests

- Operation of GR-LNB equipment under optimized conditions for approximately one-year duration.
- Measurement of emission control system performance.
- Determination of boiler impacts.

Task 4 - Evaluation of Field Test Results

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

Task 5 - Restoration

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

Task 6 - Technology Transfer

- Continuation of technology transfer activities from Phases I and II.
- Meeting with Industry Panel to review results obtained.

4.0 PROJECT STATUS

4.1 Phase I Design and Permitting

4.1.1 Task 1 - Project Management

A Project Participants Review meeting was held in Denver, Colorado on September 24, 1991. The purpose of the meeting was to review the design and the results of the baseline testing. On September 25, 1991 a project inauguration conference was also held in Denver for the purpose of publicly announcing the Cherokee Clean Coal Technology Project. Work under this Task is complete.

4.1.2 Task 2 - Process Design

Computer and isothermal modeling of the Gas Reburning System for Cherokee 3 has been completed and the process design report has been prepared. The report is being reviewed by EER and will be submitted to the DOE and the Project funders for their review and comment.

4.1.3 Task 3 - Engineering Design

The Engineering Design of the Over-fire Air, Flue Gas Recirculation, and Natural Gas distribution systems has been completed. Mechanical and electrical detail design drawings have been released for construction. Work under this Task is complete.

4.1.4 Task 4 - Environmental Reporting, Permitting, Plans and Design

A meeting to review the Environmental Monitoring Plan (EMP) with DOE and PSCo was held on September 11, 1991 in Denver, Colorado. The EMP is now being circulated for the final comment and approval.

4.1.5 Task 5 - Baseline Test and Phase III Test Plan

The Baseline Testing was completed on July 26, 1991. A Baseline Test Report and the Phase III Test Plan are being prepared.

4.1.6 Task 6 - Technology Transfer

A technical paper entitled Field Evaluation of Gas Reburning with Low NO_x Burners for NO_x Emission Control in a Wall-fired Boiler was prepared for presentation at the International Joint Power Generation Conference in San Diego, California on October 8, 1991.

4.2 Phase II Construction and Startup

4.2.1 Task 1 - Project Management

The Project Management task is now focused on Phase II. A detailed construction activities schedule was prepared and EER is coordinating site activities with PSCo. Plans are being made for submittal of the Phase III Continuation Application.

4.2.2 Task 2 - Installation and Checkout

EER established a Cherokee site Construction Office on July 1, 1991. In order to make space for the over-fire air and flue gas recirculation fans, an old electrostatic precipitator, no longer in use at Cherokee, was removed. The Cherokee Unit 3 outage began on August 16, 1991 to allow for the installation of the Low NO_x burners (PSCo responsibility), boiler penetrations and nozzle cooling fans and associated ductwork. As of the end of September the outage work was on schedule and expected to be complete by October 23, 1991. The installation of mechanical and electrical equipment for the Gas Reburning and Low NO_x Burners is also proceeding according to schedule.

5.0 PLANNED ACTIVITIES

During the next quarter (October through December, 1991) the following work is planned:

1. Continue Project Management activities.
2. Complete the outage work including installation of all boiler penetrations, wallboxes, the natural gas feed tie-in, nozzle cooling fans, and necessary ductwork.
3. Complete the Baseline Test Report and the Phase III Test Plan.
4. Complete the Process and Engineering Design Reports.
5. Continue the installation of mechanical and electrical equipment, including the OFA and FGR fans, interconnecting ductwork, foundations, structural support steel, electrical switchgear, and instrumentation and controls.
6. Continue Technology Transfer by attending conferences and presenting symposia technical papers.

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