DOE/PC/92159--T2

RECEIVED
JUL 16 1993
OSTI

TECHNICAL PROGRESS REPORT NO. 2 JANUARY - MARCH 1993

U.S. DEPARTMENT OF ENERGY
PITTSBURGH ENERGY TECHNOLOGY CENTER
CONTRACT DE-AC22-92PC92159

FOR

ENGINEERING DEVELOPMENT OF ADVANCED COAL-FIRED
LOW-EMISSION BOILER SYSTEM

SUBMITTED BY:

COMBUSTION ENGINEERING, INC.

1000 PROSPECT HILL ROAD

P.O. BOX 500

WINDSOR, CONNECTICUT 06095-0500

MAY 28, 1993

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.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

JP

DISCLAIMER

This report was prepared as an account of work sponsored by the United States Government. Neither the United States Government nor the United States Department of Energy, nor Combustion Engineering, Inc., nor any of their employees, subcontractors, suppliers or vendors, 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.

PATENT STATUS

Patents cleared by Chicago OIPC May 11, 1993.

TABLE OF CONTENTS

	Page
Introduction	4
Summary	7
Task 1 - Project Management	8
Task 2 - Concept Development	10
Task 3 - Research, Development, and Test Plans	14
Plans for Next Quarter	15
Task 1	
Task 2	
Task 3	
Task 4	
Appendix A - Summary Report (DOE Form 1332.2)	
Appendix B - February 10, 1993 Meeting with DOE	

INTRODUCTION

The Pittsburgh Energy Technology Center of the U.S. Department of Energy (DOE) has contracted with Combustion Engineering, Inc. (ABB CE) to perform work on the "Engineering Development of Advanced Coal-Fired Low-Emission Boiler Systems" Project and has authorized ABB CE to complete Phase I on a cost-reimbursable basis.

The overall objective of the Project is the expedited commercialization of advanced coal-fired low-emission boiler systems. The specified primary objectives are:

- NO_x emissions not greater than one-third NSPS.
- SO_x emissions not greater than one-third NSPS.
- Particulate emissions not greater than one-half NSPS.

The specific secondary objectives are:

- Improved ash disposability and reduced waste generation.
- Reduced air toxics emissions.
- Increased generating efficiency.

The final deliverables are a design data base that will allow future coal-fired power plants to meet the stated objectives and a preliminary design of a commercial generation unit.

The deliverables for Phase I are a Project Work Plan covering all four phases, concept and component evaluation and selection, an R&D Test Plan, a preliminary Commercial Generating Unit design, and a Phase I Report. The work in Phase I which will cover a 24-month period, is organized in the following six Tasks:

- Task 1 - Prepare, and obtain DOE approval of, a comprehensive Management Plan and manage the Project as described therein. Prepare a detailed Project Work Plan, Milestone Schedule/Plan, Cost Plan, Notice of Energy R&D Project, QA/QC Plan, and Hazardous Substance Plan.
- Task 2 - A comprehensive assessment and system analysis of candidate technologies which have the potential to achieve the primary objectives and one or more of the secondary objectives. This work includes coal selection, subsystem technical assessment, concept development and evaluation, a Concept Selection Report,

and preliminary engineering design of subsystems to demonstrate uncertain technologies.

- Task 3 -** Produce the Research, Development and Test (R&DT) Plan. The process will involve preparation of a draft R&DT Plan; preparation of a Design Deficiency Analysis which identifies information and data required, recommended approach to generating it, and estimated resources and time required; preparation of a detailed R&DT Plan to include engineering analysis, component development via generating design data and experimental work, and finally subsystem testing.
- Task 4 -** Implement component definition with engineering analysis, modeling, and experimental R&D and testing to support preliminary design of a low-emission boiler system, design of the POC Test Facility, and the Subsystem Test Design. An additional objective is to identify the POC Test Facility site.
- Task 5 -** Using the results of the preceding activities, select one low-emission boiler system concept from the Concept Selection Report and develop a Preliminary Engineering Design for a 350 MWe coal-fired unit. With this design in view, the Design Deficiency analysis and the R&DT Plan will be reviewed to ensure that Phase II R&D and testing satisfy system development needs.
- Task 6 -** Issue a Phase I Final Report which will include a summary and description of the results of the work performed in Phase I, through documentation of the Commercial Generating Unit Design, a detailed documentation of all R&D and testing conducted in Phase I, and a thorough description of the updated Project Work Plan for Phases II and III.

The Project will be managed by ABB CE as the contractor and the work will be accomplished and/or guided by this contractor and the following team members:

- Ratheon Engineers and Constructors, Inc.
- ABB Environmental Systems, Inc.
- Energy and Environmental Research Corporation
- Dr. Jonas Beér, MIT and Dr. John McGowan, U. of Mass.

- **Electric Power Research Institute**
- **Association of Edison Illuminating Companies - Power Generation Committee**
- **Advanced Energy Systems Corporation**

SUMMARY

Work continued as planned and scheduled. All deliverables were issued on schedule except the "Draft Concept Selection Report" which was one week late. Expenditures to date are below budget. A revised Statement of Work was received and accepted.

Technology transfer activities included preparing a presentation for DOE's Combustion 2000 Workshop (April 16, 1993), drafting two technical papers, and submitting an abstract for a third. A meeting was held at which subsystem and system candidate technologies and the evaluation approach were presented to, and accepted by, the DOE. This meeting was preceded by a similar meeting with cognizant in-house management and engineering personnel.

Subsystem Technical Assessment and also Concept Development and Evaluation, including the "Draft Concept Selection Report," were completed. Six alternative systems incorporating seven of the short listed subsystems were evaluated. Three of the systems were selected for further evaluation with the objective of selecting one for the preliminary CGU design.

Work commenced on preparing the R, D, & T Plan for Task 4 which will commence in the next quarter.

See Appendix A for summaries of the status of Cost, Labor, and Milestones.

TASK 1- PROJECT PLANNING AND MANAGEMENT

All work in Task 1 and all Task 1 deliverables for the reporting period were completed on schedule except the "Draft Concept Selection Reports" which was one week late. All monthly Status, Summary, Milestone Schedule, and Cost Reports were submitted on schedule. Expenditures to date are below budget.

Received a revised Statement of Work from DOE on January 26, 1993. The two major changes are:

- More detailed design of the POC Test Facility from Phase III to Phase IV.
- Provide two Research, Design, and Test Plans - one for Phase IB, Task 4 and one for Phase II, Tasks 7, 9, 11. The latter is to be submitted in draft form with the Phase I Final Report.

Advised the DOE verbally that the revised SOW is acceptable with no change in cost or overall schedule. However, since it was received nine days after the originally planned R, D, and T work (Task 3) was scheduled to start, the end dates of Task 3 were extended two weeks. However, because of the change in the DOE's approval process, the start date of Task 4 may not change.

A major unprogrammed activity was preparation for the DOE's Combustion 2000 Workshop scheduled to be held on April 16, 1992. This activity was given top priority at the DOE's request.

Another major activity was a meeting of DOE, ABB CE, ABB ES, and RE&C in RE&C's offices February 10, 1993. The agenda and a list of attendees are included in Appendix B. The basic purpose of the meeting was to present to DOE a short list of candidate subsystem technologies and the six alternative systems made up of those subsystem technologies. The DOE accepted the subsystems, the systems, and the general approach to evaluating them. This meeting was preceded by a tour of the Philadelphia Electric - Eddystone Unit No. 1 on February 9, 1993. This unit encompasses an ultra supercritical steam cycle, an MgO FGD system, and a maintenance and diagnostics center. In preparation for the February 10 meeting ABB held an in-house technical and commercial review with cognizant management and engineering personnel.

Other major activities were preparation of the "Draft Concept Selection Report," drafting a technical paper for Ninth Annual Coal Preparation, Utilization, and Environmental Control Contractors' Conference, drafting a technical paper for the 1993 International Joint Power Generation Conference, and submitting an abstract of a paper for the Tenth Annual International Pittsburgh Coal Conference.

Mr. K. C. Robertson, Vice President for Fossil Projects and Services, replaced Dr. C. Braun as RE&C's Program Director for the LEBS Project. Mr. Robertson remains as a UE&C Corporate Sponsor of the Project. Our EPRI interface is now with Mr. George Offen, Program Manager - Air Quality Control. Our AEIC interface is now with Mr. Philip Moor, Secretary of the Power Generation Committee.

TASK 2 - CONCEPT DEVELOPMENT

The major Task 2 activity during the reporting period was preparation of the "Draft Concept Selection Report." It was issued one week late due to underestimating the magnitude of the effort (>200 pages) and the complexity of the coordination (six coauthors plus eighteen contributors). Unprogrammed commitments also had an impact.

2.1 COAL SELECTION

Completed in previous quarter. No further activity.

2.2 SUBSYSTEM TECHNICAL ASSESSMENT

The following approach was employed in the assessment process:

- Select design coal. (Illinois #6 with $\geq 3\%$ sulfur).
- Evaluate and select a steam cycle (advanced supercritical - 4500 psi, 1100°F, 1100°F, 1100°F).
- Identify and assess candidate subsystem technologies and produce a "short list."
- Evaluate systems containing various combinations of short listed subsystems.
- Finally, select the system(s) with the greatest potential for achieving the objectives.

Using this approach, the team developed, with DOE approval, the following short list of subsystem technologies:

NOx Control -	*1. Advanced Low-Nox Burners*2. Coal Reburn.*3. High-temperature SNCR.*4. Catalytic Filter (fabric or ceramic).5. SCR for cost comparison.
SOx/Particulate Control -	*6. Advanced Wet Limestone Scrubber with EP.*7. Thioclear Scrubber Process with EP.*8. SNOX Process with Baghouse.9. Catalytic Baghouse with WSA Tower.10. Catalytic Baghouse with Wet Scrubber.*Selected for systems analysis (alternate systems 1-6).

2.3 CONCEPT DEVELOPMENT AND EVALUATION

The subsystem technologies described above were evaluated as integral parts of six advanced supercritical power generation systems. Since all the primary and secondary objectives can be met by the six systems evaluated, the main evaluation criteria came down to the potential for commercial success and the cost of electricity. The six alternative systems and their assessments are as follows:

	System	NOx lb/Million Btu	Potential for Commercialization	C.O.E.* Mills/Kwh	Net Plant** Efficiency Increase
1	Advanced Burners	0.2	Very High	97.6	3.46
	Advanced Wet Limestone			(0)	
	Advanced Electrostatic Precipitator				
2	Advanced Burners with Coal Reburn	<0.2	Moderate to High	99.0	3.43
	Advanced Wet Limestone FGD			(0)	
	Advanced Electrostatic Precipitator				
3	Adv. Burners + High-Temp SNCR	≈0.1	Very High <u>if</u> the	98.6	3.46
	Advanced Wet Limestone FGD		the SNCR technology	(0)	
	Advanced Electrostatic Precipitator		works		
4	Advanced Burners	0.2	High	97.2	3.67
	ThioClear FGD			(0.6)	
	Advanced Electrostatic Precipitator				
5	Advanced Burners	≤ 0.05	High	96.4	3.89
	SNOX Process			(3.2)	
6	Advanced Burners	≤ 0.05	High	95.4	4.60
	SNOX Hot Scheme			(3.2)	

* The values assigned to by-products are given in parenthesis. No value was given to gypsum (Systems 1 - 4), full value was given to magnesium hydroxide (System 4), and 3/4 of the expected value was given to sulfuric acid (Systems 5 and 6). ** Net plant efficiency increase, in percentage points, over a current "NSPS" plant. The plant heat rate and efficiency, and thus the cost of electricity, can and will be further optimized in Task 5 for the selected system(s).

Based on evaluations of these concepts, the Team selected a wet FGD system (System 1 or System 4) and a

catalytic system (System 6) for further development in later Phases of the Project. However, we will continue development, or monitoring development by others, of all the subsystem technologies not in Systems 1, 4, or 6. Commercialization of one or more of the Systems is programmed for the year 2000 or sooner. One system will eventually be chosen for the preliminary design of a commercial generating unit in Task 5. Systems 1 and 4 are selected for collateral development until such time as one system is shown to be clearly superior to the other. Systems 1 and 4 meet the contract NO_x target of 0.2 lb/million Btu and Subsystem 6 meets ABB's optional target of approximately 0.05 lb/million Btu. These systems can be designed for SO_x and particulate emissions lower than the contract targets. Also, since Systems 4 and 6 both produce saleable by-products, they both meet the waste reduction objective.

For the following reasons none of the subsystem technologies should be abandoned at this time: (1) They may be more suitable for a particular project or customer. (2) They may be commercially available now or further along in development. (3) They would be fallbacks if a selected technology proves unsuccessful. (4) There is insufficient information to reject or select some of them at this time. (5) Their development will continue under other programs. (6) Air toxics emission limits and control technologies, when established, may favor these subsystems. It is entirely possible that the final output of the Project is one system design with a menu of options for emission control subsystems.

Note that a specific ash disposal technology was not selected. Because the choice is highly site-specific, the Team only identified and assessed candidate technologies and reduced the list to three: (1) chemical fixation with lime for stabilized landfill, (2) the Aardelite Process for producing light-weight aggregate from flyash, (3) vitrification. The latter two are being commercialized under other projects and all three will remain as options in future work on this Project.

The requirement that air toxics be "in compliance" is very nebulous at this time since regulations have not been established. Therefore, control technologies cannot be fixed. A separate topical report on air toxics will be written.

In summary, the concept selected by the ABB Team, namely an advanced supercritical power generation system with advanced tangential firing and the flexibility to incorporate a number of advanced SO_x, particulate, and additional NO_x control technologies will achieve all the Project objectives.

2.4 CONCEPT SELECTION REPORT

The "Draft Concept Selection Report" was issued March 26, 1993. DOE comments were pending at the close of the reporting period.

2.5 SUBSYSTEM PRELIMINARY ENGINEERING DESIGN

Per agreement with DOE, work will commence on the "Subsystem Preliminary Engineering Design" upon receipt of DOE comments on the "Draft Concept Selection Report" and will be completed thirty calendar days later.

TASK 3 - RESEARCH, DEVELOPMENT, AND TEST PLANS

Work commenced on February 1, 1993 in accordance with the latest schedule. Two planning meetings were held. In the first, the three in-furnace NO_x control subsystems - advanced burners, coal reburn, and high-temperature SNCR were discussed in terms of additional information needed to reduce the number of candidates. In the second meeting, work was initiated on planning a specific series of drop tube and bench scale tests in Task 4. Formal test plans and budgets were being developed which will be inputs to the Draft Research, Development, and Test Plan - Phase IB which was being drafted along with the Design Deficiency Analysis.

PLANS FOR NEXT QUARTER

TASK 1 - Project Planning and Management

Continue to execute the Management Plan, the Project Work Plan and the QA/QC Plan as written. Continue to issue all reports as scheduled. Closely monitor manpower availability. Continue video teleconferences between ABB CE and RE&C. Set up electronic mail between ABB CE and RE&C. Kickoff Task 4.

Participate in Combustion 2000 Workshop April 16, 1993. Finalize technical papers for the 1993 IJPGC and the Ninth Annual Coal Preparation, Utilization, and Environmental Control Contractors' Conference. Submit a paper to be presented at the Tenth Annual International Pittsburgh Coal Conference in September 1993.

TASK 2 - Concept Development

Issue final "Concept Selection Report" fifteen days after receipt of DOE final comments on the draft.

Issue "Subsystem Preliminary Engineering Design" thirty days after receipt of DOE final comments on the "Draft Concept Selection Report."

TASK 3 - Research, Development, and Test Plan

Prepare and issue the Design Deficiency Analysis and the R,D,&T Plan for Phase IB.

TASK 4 - Component Definition

Initiate work on Task 4 upon receipt of DOE comments on the R, D, & T Plan.

END

**DATE
FILMED**

8 / 25 / 93