

CONCEPTUAL DESIGN FOR AN ATMOSPHERIC FLUIDIZED-BED
DIRECT COMBUSTION POWER GENERATING PLANT
Phase I - Commercial Plant Conceptual Design

Quarterly Report for the
Period January 3-April 30, 1977

Richard C. Norton

Date Published-May 6, 1977

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Under Contract No. EF-77-C-01-2583

PREPARED FOR THE
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

STONE & WEBSTER ENGINEERING CORPORATION
Boston, Massachusetts 02107

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ABSTRACT

A conceptual design has been undertaken for a commercial size (560 MW) complete power generating station, incorporating an atmospheric fluidized combustion boiler. It is to be developed as a variation of a base which is an established plant design with conventional pulverized coal suspension fired boiler with associated facilities. These include a flue gas scrubbing system and on-site provisions for disposal of scrubber sludge and fuel ash. The conceptual design with AFB combustion boiler will differ from the base only in respects dictated by the AFB application.

The conventional base plant design and cost estimate and performance description, culminating in the base plant report, was the main focus of activities during this first quarter. The start of the individual boiler manufacturers' participation was equally important although only accomplished at the beginning of the third month by placement of subcontracts with the Babcock & Wilcox Company and with Foster Wheeler, Incorporated. To the extent practical, S&W design work, preparatory to receiving fluidized bed boiler manufacturers' drawings, was started in anticipation of information expected in the next quarter.

Specialized supportive work under the subcontract of Pope, Evans and Robbins included the preparation of the current state-of-the-art of fluidized bed combustion report, the first issue of which is scheduled for release at the start of next quarter. Its purpose is to serve as reference for individual discussions of basic concepts with each boiler manufacturer. The objective of the discussion is to assure the best possibility of development of successful main and ancillary systems of the fluidized bed combustion stem generators.

OBJECTIVE AND SCOPE OF WORK

The overall objective of the project is to prepare a conceptual design for an electric power generating plant that will directly combust high sulfur coal in an atmospheric fluidized-bed boiler and generate electric power in an environmentally acceptable manner.

The work to attain the overall objective falls into two overlapping phases. Phase I involves the development of conceptual designs and examination of merit of a contemporary size (560 MW) plant including an atmospheric fluidized bed boiler of designs projected by each of the major boiler manufacturers, specifically Babcock & Wilcox and Foster Wheeler. The purpose of this first phase is to provide convincing evidence to the electric utilities to show that fluidized bed combustion is a better choice for future coal burning facilities than current conventional methods such as suspension burning of pulverized coal.

Phase II will be based on the development of Phase I, particularly with regard to the examination of risks associated with scale up of design features beyond the extent of their present demonstrated success. The objective of the second phase is the compilation of the conceptual design of an atmospheric fluidized bed combustion demonstration plant of size and extent acceptable from the standpoint of risk and general reasonableness toward attainment of goals to its owner and sponsors.

SUMMARY OF PROGRESS TO DATE

The total project input has been planned in terms of nine major tasks designated 1000 through 9000, as is illustrated in the attached planning program control diagram. Work of Phase I has focused mainly on Tasks 1000, to establish a broad background for the work, and 2000, base plant definition.

Subcontract work by Pope, Evans and Robbins, under Task 3000 has been applied largely to development of a current state-of-the-art report on atmospheric fluidized combustion in anticipation of consultations upcoming with the boiler manufacturers as they firm up the basic concepts from which their individual designs will evolve. Subcontracts with the boiler manufacturers have been initiated under Task 4000, but their work has only been started as of the close of this first quarter. Tasks 5000, 6000, and 7000 relate to the specific AFB plant designs and descriptions which remain to be undertaken in the next quarter. Task 8000 reports have been limited in issue to the three each preceding monthly technical and financial reports. However, two supplemental reports are substantially complete and will be issued soon. These are Base Plant Report and the FBC State-of-the-Art Report. Finally, Task 9000 relating to the demonstration plant, remains scheduled to start about the first of June.

II DETAILED DESCRIPTION OF QUARTERLY TECHNICAL PROGRESS

Task 1000 - Preliminary Engineering and General Administration Work Accomplished

Planning Program and Network Diagram - Supplementing the Planning Program Control diagram, a more detailed network was prepared. Diagram 12912-WB-1, Level I Network - Work Breakdown, and is attached with progress marked to the end of the quarter, April 30, 1977. As pointed out in the S&W proposal letter of September 3, 1976, the design drawings prepared by the respective boiler manufacturers are the fundamental prerequisite to start off the S&W AFB plant design work. The planning control diagram originally anticipated the boiler manufacturers' design work to start when the prime control was awarded. The latter was dated January 3, 1977, and received by S&W and its work started January 17, 1977. The start of the boiler manufacturers' work, however, did not develop until March 29, 1977, thirty days before the end of this quarter. Although the boiler manufacturers' time requirements to develop drawings is relatively fixed, as noted on their schedules, the Level 1 network was adjusted to the extent practical, to accommodate two months of the three-month late start of the boiler design work. On the basis of the schedules offered by the boiler manufacturers, Babcock & Wilcox are scheduled to prepare boiler drawings between the start of the second and the end of the fourth month after contract. This would be between June 1 and July 31. For Foster Wheeler, their indicated schedule is less precise, but it appears that it would fall in the same time frame as that of Babcock & Wilcox.

Work Forecast

To compensate for the indicated delay in boiler manufacturing information, S&W plans to go to the manufacturers' design offices to obtain the best preliminary information available in advance of the firm drawings and will work closely with them toward accelerating their drawing production schedule. Using the preliminary information, S&W will undertake the boiler room design, although recognizing the potential for needed changes when the firm drawings are received.

Task 2000 - Base Plant Definition
Work Accomplished

The base plant documentation is near issue at the close of this first quarter. Consistent with notes of conference of April 20, 1977, this will be presented as technical notes in three-ring binders so as to accommodate revisions or expansion as required.

Work Forecast

The basic task is completed, however, if necessary, the base plant documentation may be revised or corrected during the course of the project. It will become Volume I of one final report bound and issued at the completion of the project.

Task 3000 - Pope, Evans, and Robbins

Subtask 3100 - Preliminary Engineering and General Administration

Work Accomplished

Completed detailed analysis of coal and sorbent. Developing standard lab evaluation techniques for sorbents. Attended Mitre Conference, April 13-15, and ERDA Progress Meeting, April, 20.

Work Forecast

Will report on coal and sorbent study.

Progress meeting with ERDA scheduled for May 25.

Subtask 3200 - Base Plant Definition

Work Accomplished

Continued review of base plant selection and base plant general arrangement.

Work Forecast

Awaiting final base plant drawings in order to complete base plant material balance.

Subtask 3400 - Boiler Manufacturers

Work Accomplished

Prepared and submitted plans, elevations, and isometrics of presumed AFB boiler arrangement.

Work Forecast

Will furnish boiler manufacturers with state-of-the-art information and preliminary material balance analysis (via Stone & Webster). Will review design data as it becomes available. Review meetings planned at boiler manufacturers for May, 6 and May, 12.

Subtask 3500 - AFB Plants Design

Work Accomplished

Continuing with review meetings with major materials transport equipment manufacturers. Completed analysis of material crusher alternatives.

Work Forecast

The manufacturer's meetings described above will be reported to Stone & Webster. Based on availability of data from boiler manufacturers, detailed heat and material balances will be completed. Will submit PER generated fuel feed and bed removal system designs. Will submit preliminary evaluation of sorbent preparation study.

Subtask 3700 - AFB Evaluation of Merit

Work Accomplished

Intregrated presumptive 600 MW boiler design into plant, elevation and isometric drawings of base plant. Coal feed alternative analysis completed.

Work Forecast

Analysis of coal feeding alternatives will be submitted.

Subtask 3800 - Reports

Work Accomplished

State-of-the art and critical factors reports outlined and chapters assigned. Literature review completed. Six draft chapters completed.

Work Forecast

Completion of 65 percent of the state-of-the-art report in May.

Subtask 3900 - Demonstation Plant Preliminary Design

Work Accomplished

None.

Work Forecast

None during May.

Task 4100 - Babcock & Wilcox Company

Objective

To develop a preliminary design for a conceptualized 570 MW atmospheric fluidized bed boiler (AFB) capable of burning high sulfur coal in an environmentally acceptable manner without recourse to flue gas desulfurization. This preliminary design will be in sufficient detail to describe the technical feasibility and costs associated with the conceptualized AFB boiler and equipment.

Task 4110 - Overall Plant Design Bases

Work Accomplished

The overall scope of supply, design parameters, and heat balances from customer were reviewed.

In addition, available data from experimental fluid bed combustors have been correlated and combined with B&W fluid bed and boiler experience to develop a basis for fluid bed utility boiler design; to the best of our ability considering the spread of much of this data. From these studies, the following design parameters have been selected for this project:

Superficial bed velocity, ft/sec	8
Main bed operating temperature, °F	1550
Carbon burn-up bed operating temperature, °F	2000
Bed combustion efficiency, percent	88
Limestone/sulfur ratio has been set - Ca/S	2.5

Method of calculating the bed heat transfer coefficients has been finalized.

In addition, the full load heat balance has been established. The preliminary overall efficiency calculation is as follows:

Dry gas loss, percent	4.704
H ₂ O from fuel loss, percent	5.378
H ₂ O in air loss, percent	.117
Unburned combustible loss, percent	2.496
Radiation loss, percent	.160
Unaccounted for and mfrs. margin, percent	1.500
Stone reaction heat loss, percent	.318
Stone sensible heat loss, percent	.714
Total losses, percent	<u>15.387</u>

Efficiency, percent	84.613
Input in fuel (MKB/hr)	5908.06
Wet gas wt. (MLB/hr)	5860.21
Air flow in beds (MLB/hr)	5269.07
Fuel rate (MLB/hr)	533.17
Stone rate (MLB/hr)	113.03

A preliminary layout of the main boiler has been prepared.

Work Forecast

Based on current progress, bed pressure drop and general plant size should be completed.

Task 4132 - AFB Boiler Thermal Dynamic Design

Work Accomplished

The heat transfer up to the convective surface in the main boiler, at full load, has been calculated. The expected gas temperature entering the reheater is about 1600°F.

Work Forecast

It is expected that heat transfer work for the main boiler will be completed during this period for maximum rating steady state conditions. Work will commence on preliminary stress analysis.

Task 4135 - Boiler Suspension Steel

Work Forecast

Work on preliminary loadings for steel will be initiated.

Task 4137 - AFB Boiler Drawings

Work Forecast

Drafting work will commence on a preliminary arrangement of the main boiler unit.

Task 4138 - AFB Boiler Power Requirements

Work Forecast

Fan and air heater requirements will be developed in preparation for obtaining quotations.

Task 4200 - Foster Wheeler Energy Corporation

Subtask 4210 - Overall Plant Design

Work Accomplished

Work is progressing in the area of boiler configuration and size. Present design includes five (5) stacked beds, each bed 60 feet wide by 22 feet deep. Flue gas from each bed will exit into a common gas pass, then to a conventional parallel pass heat recovery area. A carbon burnup cell will be employed below the gas pass for recovery of the unburned combustibles from the five main beds.

Work Forecast

Based on finalization of the work noted under Task 4232, elevation drawings of the boiler will be initiated during the next report period.

Subtask 4232 - Boiler Thermal Design

Work Accomplished

The major work effort to date has been the thermodynamic design and layout of the boiler circuitry. This effort is approximately 75% complete.

Work Forecast

It is expected that boiler circuitry and design will be finalized during the next report period, with the results being utilized to prepare required energy balances, block diagrams and to further the work in the area of boiler and auxiliary equipment design as required under Tasks 4210, 4231, 4233, 4234 and 4236.

Subtask 4233 - Coal, Sorbent and Ash Systems

Work Accomplished

Under this task, work has been devoted mainly in the investigation of various coal feed systems for the fluidized bed boilers. Based on the high percentage of coal fines as indicated in the sample data it is presently felt that a pneumatically propelled underfeed system would be best suited for this application, however, contingencies are being allowed in the boiler design for the alternate feed system which appear promising.

Work Forecast

Work in this area is approximately 10% complete and effort will proceed through future report periods.

Task 5000 - AFB Design and Description

Work Accomplished

Turbine Room - Work continued on specifications, process system descriptions, flow/utility diagrams for non-AFB systems.

AFB Boiler Rooms - Work continued on specifications, process system descriptions, and flow/utility diagrams for non-AFB systems.

Materials Handling Concept Meetings - A meeting was held with Foster Wheeler Associates in Waltham, Massachusetts. It was concluded that all their work is geared toward PFB and does not appear suitable for AFB application.

Work Forecast

Definition of non-AFB unique systems and equipment will continue.

Boiler manufacturers data to support start of design of AFB boiler rooms is expected during the next reporting period.

Task 6000 - Plant Estimates

Work Accomplished

The order of magnitude cost estimate for the base plant was assembled during the quarter as an element of the documentation of the Volume I for comparative evaluation of the AFB combustion alternatives.

Work Forecast

The remaining estimating work covering the AFB alternatives is scheduled to be done in the last quarter of the year after the designs are completed and new equipment pricing has been obtained from the boiler manufacturers.

Task 7000 - Evaluation of Merit

Work Accomplished

Although the detail evaluation of AFB combustion features remain in the future, it is acknowledged that continuous contact with the utility industry is an obligation of the project from the start. Accordingly, a systematic plan for initial contact meetings was started during the quarter. Introductory presentations have been given to the following:

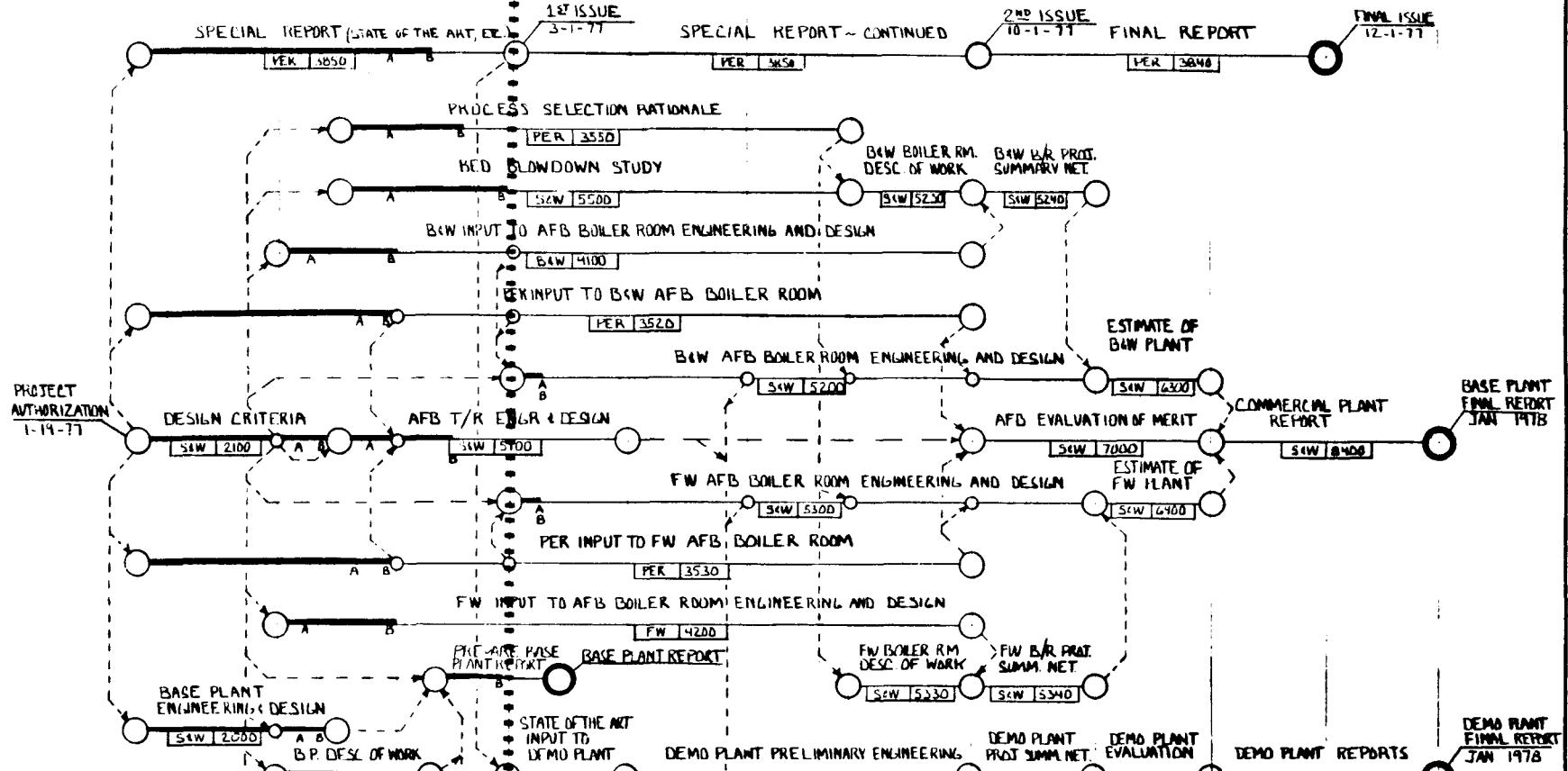
New England Power Service Company
Boston Edison Company
Tampa Electric Company
New England Gas and Electric Company

Work Forecast

Recognizing the recently expressed objective of ERDA to accelerate the program toward early designation of the next AFB combustion demonstration project (or projects), future S&W meetings with electric utility companies will emphasize the quest for a project host and suitable site. Anticipating that AFB combustion will be shown to be attractive before final commitment by the owner is required to a physical project, a utility may gain an advantage by early involvement. Additional introductory meetings with electric utilities will be arranged during the next quarter with this in mind.

1977

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN



SCHEDULE ANALYSIS

AS OF APRIL 30, 1977

(Back up for WB-1 from review of level II network)

Task 1000

All activities in this task have been completed.

Task 2000

All activities in this task were completed during the month of April. The Base Plant Report is being prepared and should be issued around the middle of May.

Task 3000

All Pope Evans and Robbins activities are associated with task number. Most of PER's activities that were scheduled to start have been started. The activities that are behind schedule are process selection rationale T-3550 and PER's input to B&W and F-W AFB boiler room effort T-3520 and T-3530 respectively.

Task 4000

The B&W effort T-4100 was started and is approximately 1 month behind schedule. B&W work load shows a month slack time before it is needed for the base Plant final report. As of this update there appears to be no problems providing all B&W Tasks are completed by November 1, 1977. The Foster Wheeler effort T-4200 is in the same status as Babcock & Wilcox effort.

Task 5000

All activities in this task have to do with the AFB turbine room design. All activities are on schedule with the exception of T-5120, T-5133 and T-5124 these activities are approximately two weeks behind schedule but the responsible engineers have indicated that they will be completed by the scheduled date of May 31, 1977.

Task 6000

The only activity that was scheduled to date and was completed is T-6100 Base Plant Estimate.

Task 7000

No activities in this task are scheduled to start as of this update.

Task 8000

All activities that have started in this task are on schedule.

Task 9000

No activities in this task are scheduled to start as of this update.

PLANNING PROGRAM CONTROL
ERDA - AFB STUDY

J.O.No. 12919

Issued: Sept. 2, 1976
Revised: April 30, 1977

TASK	DESCRIPTION	PROJECT MONTH											
		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1000	Preliminary Engineering and General Administration	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■
2000	Base Plant Definition	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■
3000	Pope, Evans & Robbins Efforts	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■
4000	Boiler Manufacturer's Efforts	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■
5000	AFB Plant Design & Description of Work	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■
6000	Investment & Performance Cost Development	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■
7000	Evaluation of Merit	●	●	●	●	●	●	●	●	●	●	●	●
8000	Reports	●	●	●	●	●	●	●	●	●	●	●	▼4
9000	Demonstration Plant Preliminary Engineering	●	●	●	●	●	●	●	●	●	●	●	▼5

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- Monthly Progress Reports
- ▼1 Boiler Manufacturer's Technical Data
- ▼2 Boiler Manufacturer's Pricing Data
- ▼3 Base Plant Report
- ▼4 Commercial Plant Report
- ▼5 Demonstration Plant Report

BUDGET REPORT (1000's)

	\$	MH
Total	1354	52.4
Spent	123	4.7
Planned	400	8.0
Variance	277	3.3

Underrun

