DOE/FE-0197P

Comprehensive Report to Congress
Clean Coal Technology Program

Full-Scale Demonstration of Low-NOx Cell Burner Retrofit

A Project Proposed By:
Babcock & Wilcox Company

U.S. Department of Energy
Assistant Secretary for Fossil Energy
Office of Clean Coal Technology
Washington, D.C. 20585

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1.0 EXECUTIVE SUMMARY

The FY88 Appropriations Act, P.L. 100-466, included approximately $575 million to support the construction and operation of demonstration facilities using clean coal technologies. The Clean Coal projects cover a broad spectrum of technologies having the following things in common: (1) all are intended to increase the use of coal in an environmentally acceptable manner; and (2) all are ready to be proved at the demonstration level.

In response to the resulting Program Opportunity Notice (PON), 48 proposals were received in August 1989. After evaluation, 13 projects were selected in December 1989 for funding under the Clean Coal Technology (CCT) Program. One of the 13 projects selected was the full-scale retrofit demonstration of Low-NO_x Cell (LNC) Burners proposed by the Babcock & Wilcox Company (B&W).

The LNC burner was developed by B&W, with funding from the Electric Power and Research Institute (EPRI), to provide a cost effective means to reduce NO_x emissions in boilers equipped with standard cell burners. These boilers were originally designed to burn large amounts of fuel in a relatively small volume which required the standard cell burners to be spaced close together in the boiler. This arrangement results in combustion conditions that produce high NO_x emissions. Standard low-NO_x burners cannot be used in these boilers without pressure part modifications. This makes the standard low-NO_x burner economically unattractive.

The LNC burner is designed to provide an economical replacement for the standard cell burner, reduce NO_x emissions by 50%, and produce no impact on boiler operation and performance. In terms of the reduction of total acid emissions, the expected reduction in NO_x, on a tons removed basis, for the LNC burner technolgy results in the same environmental impact as an equivalent reduction in SO_2 emissions using another technology.

The LNC burner fits in existing standard cell burner wall tube openings and, therefore, does not require burner relocation or major boiler pressure part modifications. Retrofit materials generally consist of the LNC burners and coal piping and fittings. Potentially, the LNC burner can be retrofitted to all utility boilers containing two-nozzle cell burners and could possibly be adapted to three-nozzle cell burner installations.

The technology involves replacing the standard cell burner with an LNC burner which has an upper secondary air injection port and a single lower coal nozzle. Approximately 70% of the air theoretically required for complete combustion of the fuel is provided to the lower burner along with the coal. The remainder of the air, required to insure complete combustion, is introduced through the upper air port. The conditions produced by this arrangement minimize NO_x formation.

The project will be conducted at the 605 megawatts electric (MWe) pulverized-coal-fired Stuart Plant Unit No. 4, operated by Dayton Power & Light Company. Unit No. 4 is an operating baseload boiler. The station is located near Aberdeen, Ohio, as shown in Figure 1.

B&W and EPRI have performed pilot-scale testing of the LNC burner in pilot-scale test furnaces and have also tested a single full-size LNC burner at Stuart Unit No. 3, which is identical to Unit No. 4. The purpose of the proposed demonstration is to evaluate the NO_x reduction potential of the technology and the impact of the technology on boiler performance using a full-scale, full-boiler LNC burner retrofit. The LNC burner technology is expected to reduce NO_x emissions by 50% in boilers equipped with standard cell burners. The participant estimates that LNCB will cost significantly less than conventional low-NO_x burners, thermal de-NO_x systems, and selective catalytic reduction options.

This demonstration project will be performed over a 32-month period which includes design, pre-retrofit testing, permitting, manufacturing, installation of equipment, post-retrofit testing, data analysis, and reporting of results.

The total project cost is $9,796,204. B&W is the project sponsor and has obtained funding from EPRI, Dayton Power & Light Company, the Ohio Coal Development Office, and other utilities. Pre-retrofit testing is scheduled for mid-1990 while field testing of the retrofit is scheduled to begin in mid-1991. Overall project completion is scheduled to occur in late 1992.

2.0 INTRODUCTION AND BACKGROUND

The domestic coal resources of the United States play an important role in meeting current and future energy needs. During the past 15 years, considerable effort has been directed to developing improved coal combustion,

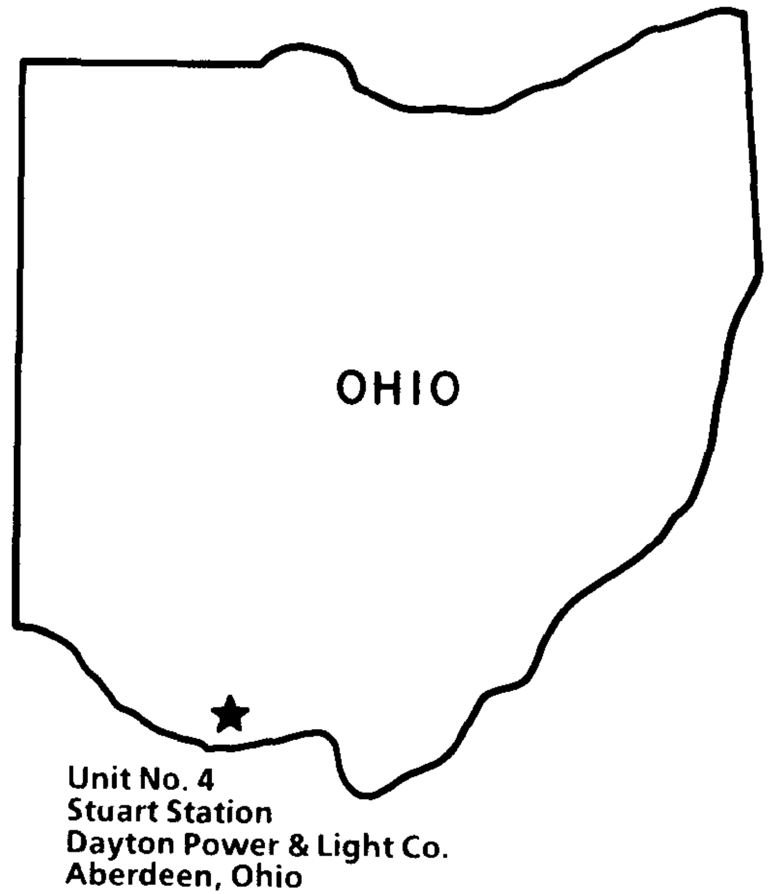

Figure 1. B&W Low-NO_x Cell Burner Retrofit Project Location.

conversion, and utilization processes to provide efficient and economic energy options. These technology developments permit the use of coal in a cost-effective and environmentally acceptable manner.

2.1 Requirement for Report to Congress

On September 27, 1988, Congress made available funds for the third clean coal demonstration program (CCT III) in Public Law 100-446, "An Act Making Appropriations for the Department of the Interior and Related Agencies for the Fiscal Year Ending September 30, 1989, and for Other Purposes" (the "Act"). Among other things, this Act appropriates funds for the design, construction, and operation of cost-shared, clean coal projects to demonstrate the feasibility of future commercial applications of such "... technologies capable of retrofitting or repowering existing facilities ...." On June 30, 1989, Public Law 101-45 was signed into law, requiring that CCT III projects be selected no later than January 1, 1990.

Public Law 100-446 appropriates a total of $575 million for executing CCT III. Of this total, $6.906 million are required to be reprogrammed for the Small Business and Innovative Research Program (SBIR) and $22.548 million are designated for Program Direction Funds for costs incurred by DOE in implementing the CCT III program. The remaining, $545.546 million was available for award under the PON.

The purpose of this Comprehensive Report is to comply with Public Law 100-446, which directs the Department to prepare a full and comprehensive report to Congress on each project selected for award under the CCT III Program.

2.2 Evaluation and Selection Process

DOE issued a draft PON for public comment on March 15, 1989, receiving a total of 26 responses from the public. The final PON was issued on May 1, 1989, and took into consideration the public comments on the draft PON. Notification of its availability was published by DOE in the Federal Register and the Commerce Business Daily on March 8, 1989. DOE received 48 proposals in response to the CCT III solicitation by the deadline, August 29, 1989.

2.2.1 PON Objective

As stated in PON Section 1.2, the objective of the CCT III solicitation was to obtain "proposals to conduct cost-shared, Clean Coal Technology projects to demonstrate innovative, energy efficient technologies that are capable of being commercialized in the 1990s. These technologies must be capable of (1) achieving significant reductions in the emissions of sulfur dioxide and/or the oxides of nitrogen 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."

2.2.2 Qualification Review

The PON established seven Qualification Criteria and provided that, "In order to be considered in the Preliminary Evaluation Phase, a proposal must successfully pass Qualification." The Qualification Criteria were as follows:

(a) The proposed demonstration project or facility must be located in the United States.

(b) The proposed demonstration project must be designed for and operated with coal(s) from mines located in the United States.

(c) The proposer must agree to provide a cost share of at least 50 percent of total allowable project cost, with at least 50 percent in each of the three project phases.

(d) The proposer must have access to, and use of, the proposed site and any proposed alternate site(s) for the duration of the project.

(e) The proposed project team must be identified and firmly committed to fulfilling its proposed role in the project.

(f) The proposer agrees that, if selected, it will submit a "Repayment Plan" consistent with PON Section 7.4.

(g) The proposal must be signed by a responsible official of the proposing organization authorized to contractually bind the organization to the performance of the Cooperative Agreement in its entirety.

2.2.3 Preliminary Evaluation

The PON provided that a Preliminary Evaluation would be performed on all proposals that successfully passed the Qualification Review. In order to be considered in the Comprehensive Evaluation phase, a proposal must be consistent with the stated objective of the PON, and must contain sufficient business and management, technical, cost, and other information to permit the Comprehensive Evaluation described in the solicitation to be performed.

2.2.4 Comprehensive Evaluation

The Technical Evaluation Criteria were divided into two major categories: (1) the Demonstration Project Factors were used to assess the technical feasibility and likelihood of success of the project, and (2) the Commercialization Factors were used to assess the potential of the proposed technology to reduce emissions from existing facilities, as well as to meet future energy needs through the environmentally acceptable use of coal, and the cost effectiveness of the proposed technology in comparison to existing technologies.

The Business and Management criteria required a Funding Plan and an indication of Financial Commitment. These were used to determine the business performance potential and commitment of the proposer.

The PON provided that the Cost Estimate would be evaluated to determine the reasonableness of the proposed cost. Proposers were advised that this determination "will be of minimal importance to the selection," and that a detailed cost estimate would be requested after selection. Proposers were cautioned that if the total project cost estimated after selection is greater than the amount specified in the proposal, DOE would be under no obligation to provide more funding than had been requested in the proposer's Cost Sharing Plan.

2.2.5 Program Policy Factors

The PON advised proposers that the following program policy factors could be used by the Source Selection Official to select a range of projects that would best serve program objectives:

(a) The desirability of selecting projects that collectively represent a diversity of methods, technical approaches, and applications.

(b) The desirability of selecting projects in this solicitation that contribute to near-term reductions in transboundary transport of pollutants by producing an aggregate net reduction in emissions of sulfur dioxide and/or the oxides of nitrogen.

(c) The desirability of selecting projects that collectively utilize a broad range of U.S. coals and are in locations which represent a diversity of EHSS, regulatory, and climatic conditions.

(d) The desirability of selecting projects in this solicitation that achieve a balance between (1) reducing emissions and transboundary pollution and (2) providing for future energy needs by the environmentally acceptable use of coal or coal-based fuels.

The word "collectively" as used in the foregoing program policy factors, was defined to include projects selected in this solicitation and prior clean coal solicitations, as well as other ongoing demonstrations in the United States.

2.2.6 Other Considerations

The PON provided that in making selections, DOE would consider giving preference to projects located in states for which the rate-making bodies of those states treat the Clean Coal Technologies the same as pollution control projects or technologies. This consideration could be used as a tie breaker if, after application of the evaluation criteria and the program policy factors, two projects receive identical evaluation scores and remain essentially equal in value. This consideration would not be applied if, in doing so, the regional geographic distribution of the projects selected would be altered significantly.

2.2.7 National Environmental Policy Act (NEPA) Compliance

As part of the evaluation and selection process, the Clean Coal Technology Program developed a procedure for compliance with the National Environmental Policy Act of 1969, the Council on Environmental Quality (CEQ) NEPA regulations (40 CFR Parts 1500-1508) and the DOE guidelines for compliance with NEPA (52 FR 47662, December 15, 1987).

This procedure included the publication and consideration of a publicly available Final Programmatic Environmental Impact Statement (DOE/EIS-0146) issued in November 1989, and the preparation of confidential preselection project-specific environmental reviews for internal DOE use. DOE also prepares publicly available site-specific documents for each selected demonstration project as appropriate under NEPA.

2.2.8 Selection

After considering the evaluation criteria, the program policy factors, and the NEPA strategy as stated in the PON, the Source Selection Official selected 13 projects as best furthering the objectives of the CCT III PON.

Secretary of Energy, Admiral James D. Watkins, U.S. Navy (Retired), announced the selection of 13 projects on December 21, 1989. In his press briefing, the Secretary stated he had recently signed a DOE directive setting a 12-month deadline for the negotiation and approval of the 13 cooperative agreements to be awarded under the CCT III solicitation.

3.0 TECHNICAL FEATURES

3.1 Project Description

The Babcock & Wilcox Company (B&W) project will demonstrate that the Low-NO_x Cell (LNC) Burner is suitable for coal-fired power plant retrofit applications to reduce NO_x emissions. It will be the first commercial-scale, full burner retrofit demonstration of this particular technology that has application to utility boilers in the United States.

The demonstration will be conducted at Dayton Power & Light Company's Stuart Station, Unit No. 4. This is a nominal 605-MWe, pulverized-coal-fired boiler with opposed-fired, two-nozzle cell burners. This boiler is identical to three other units at the station and is representative of the majority of utility boilers equipped with two-nozzle cell burners.

The goal of this program is to prove the technical and economic feasibility of the technology at a large, base-loaded (70% capacity factor or greater) coal-fired utility boiler. If successful, the Participant estimates that this technology will achieve a 50% NO_x reduction from uncontrolled levels at about one-half the cost of conventional low-NO_x burners and approximately one-tenth the cost of selective catalytic reduction (SCR) systems.

3.1.1 Project Summary

Project Title:	Full-Scale Demonstration of Low-NO_x Cell Burner Retrofit
Proposer:	The Babcock & Wilcox Company (B&W)
Project Location:	Aberdeen, Ohio (Stuart Station, Unit No. 4) Adams County
Technology:	Low-NO_x Cell Burners
Application:	Retrofit of coal-fired utility boilers equipped with standard cell burners
Types of Coal Used:	Kentucky, Ohio, and West Virginia bituminous coals (0.5 to 4.0% sulfur)
Product:	Environmental Control Technology
Project Size:	605 MWe
Project Start Date:	April 1, 1990
Project End Date:	November 30, 1992

3.1.2 Project Sponsorship and Cost

Project Sponsor:	The Babcock & Wilcox Company	
Proposed Co-Funders:	Electric Power Research Institute, Dayton Power & Light Company, the Ohio Coal Development Office, and other utilities.	
Estimated Project Cost:	$9,796,204	
Project Cost Distribution:	Participant Share	DOE Share
	$5,050,000	$4,746,204

3.2 Low-NO_x Cell Burner

3.2.1 Overview of Process Development

In the 1960s economic considerations led to the development of the cell burners. These burners were either of the two-nozzle or three-nozzle type and were designed to burn coal efficiently in a relatively compactly designed utility boiler. This resulted in tight burner spacing, which, when combined with the rapid fuel/air mixing of the cell, minimized the flame zone and maximized the heat release rate. However, these characteristics lead to increased NO_x formation over conventional burners. Boilers equipped with these burners account for approximately 15% of the total pre-NSPS pulverized coal wall-fired boiler capacity and generally operate in the range of 1.0 to 1.8 lbs. of NO_x per million Btu of heat input.

As a result of potential regulations which would mandate the reduction of NO_x emissions from these boilers, B&W, with funding from EPRI, developed the LNC burner specifically for pulverized-coal-fired units equipped with two-nozzle cell burners.

The B&W and EPRI research and development work was performed over four years. Small-scale screening tests were performed in the 6-million Btu/hr Combustion and Fuel Preparation Facility at B&W's Alliance Research Center in Ohio. The purpose of these tests was to compare a single-nozzle LNC burner design and a two-nozzle LNC burner design with the standard cell burner, so that the better design could be selected for further development.

The single-nozzle LNC burner design was selected and further characterization testing was performed at the 6-million Btu/hr scale.

Large-scale testing at the 100-million Btu/hr scale was then performed at EPA's 100-million Btu/hr Large Watertube Simulator located at the Energy and Environmental Research Corporation facility in Irvine, California. These tests were performed to obtain scale-up information and to verify burner performance.

In March 1985, a single, standard design two-nozzle cell burner was replaced with a single LNC burner at Dayton Power & Light Company's Stuart Station Unit No. 3. The burner has now been in service for over four years. Testing has included reliability, corrosion checks of furnace tubes surrounding the cell opening, visual observation of the flame, air flow measurements of secondary air, and temperature measurements of burner components.

3.2.2 Process Description

The standard cell burner boiler units were designed in the 1960s to provide a high heat release per unit volume. A typical standard cell burner, shown in Figure 2, consists of two circular register burners within one vertical assembly. This design promotes high velocity and turbulent mixing of the fuel and air to produce rapid combustion. The coal enters the burner at 90 degrees and is dispersed radially outward into the secondary air stream by an impeller located at the end of the coal nozzle. Secondary air from the windbox passes through an adjustable register into an annular passage around the coal nozzle. The register acts as both a flow control device and a swirl generator.

The inherent design features of the standard cell burner, however, result in high NO_x emissions. Typically, units equipped with these burners operate in the range of 1.0 to 1.8 lbs of NO_x per million Btu of heat input.

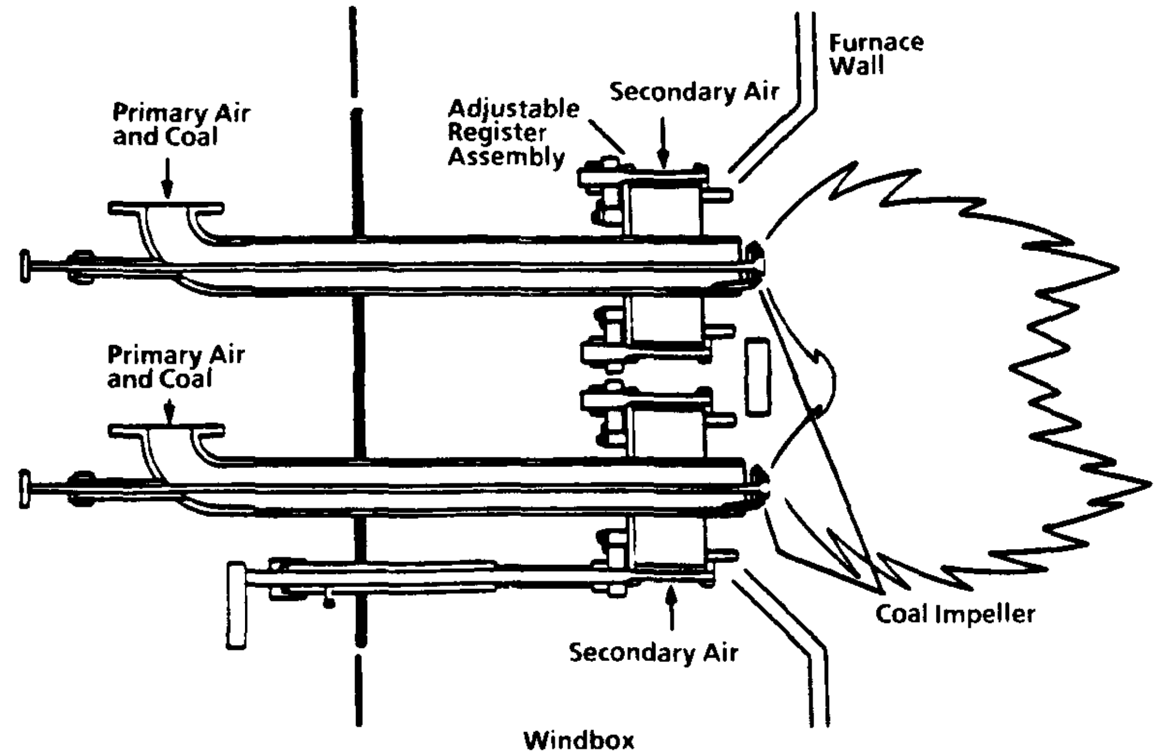

Figure 2. Typical Standard Two-Nozzle Cell Burner.

The use of conventional low-NO_x burners is not feasible in boilers equipped with cell burners, unless major boiler pressure part modifications are made. This is because the cell burner throat openings are too small to permit the low burner air velocities required for delayed combustion. Further, optimum NO_x reduction is achieved by the conventional low-NO_x burner when the heat release rate per unit volume is minimized. This is not readily achievable in a typical cell burner configuration which has closely spaced burners.

The LNC burner, however, was specifically designed to fit the standard two-nozzle cell burner openings and spacings without requiring major boiler pressure part modifications and, as such, constitutes the key attraction of this technology.

As shown in Figure 3, the LNC burner technology replaces the upper coal nozzle of the standard cell burner with secondary-air port. The lower burner throat is enlarged to accommodate a large coal nozzle that has the same fuel input capability as two standard coal nozzles.

The LNC burner operates on the principle of staged combustion to reduce NO_x emissions. Approximately 70% of the total air (primary, secondary, and excess air) is supplied through or around the coal feed nozzle to produce locally substoichiometric combustion conditions at the nozzle. The remainder of the air is directed to the upper port of each cell to complete the combustion process. The substoichiometric conditions allow conversion of the fuel bound nitrogen compounds to nitrogen gas and the reduced flame temperature produced by the slower mixing of the fuel and the air minimizes the formation of thermal NO_x.

The net effect of this technology is a 50% reduction in NO_x formation with minimal or no boiler pressure part changes and no impact on boiler operation or performance. In terms of the reduction of total acid emissions, the expected reduction in NO_x, on a tons removed basis, for the LNC burner technolgy results in the same environmental impact as an equivalent reduction in SO_2 emissions using another technology. In addition, the technology is compatible with several commercial and emerging SO_2 control technologies including Confined Zone Dispersion, Gas Suspension Absorption, duct injection, and advanced wet scrubbers.

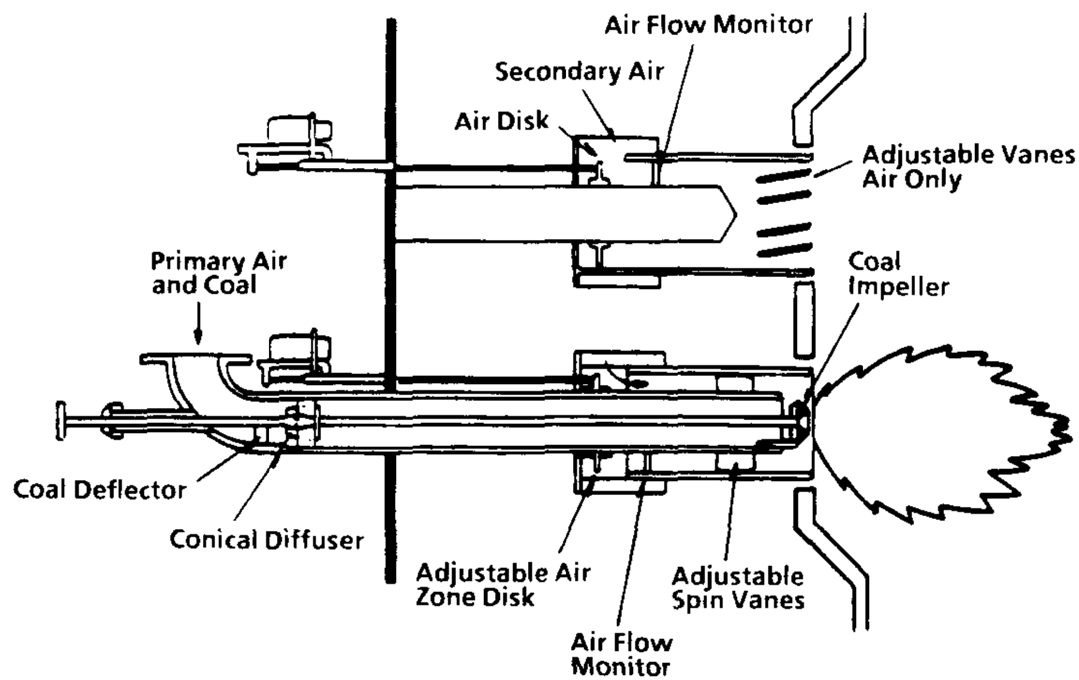

Figure 3. Typical LNC Burner.

3.2.3 Application of Process in Proposed Project

The demonstration project will be conducted at a full-scale utility plant owned by Dayton Power and Light Company, Cincinnati Gas and Electric Company, and Southern Ohio Electric Company. This plant is operated by Dayton Power & Light Company (for all three owners). The boiler unit is a B&W designed super-critical, once-through boiler equipped with an electrostatic precipitator. This unit contains 24 two-nozzle cell burners arranged in an opposed firing configuration. Twelve burners (arranged in two rows of six burners each) are mounted on each wall.

The proposed demonstration will require the removal of all 24 standard cell burners and the installation of 24 new LNC burners. Air flow controllers will be located on the LNC burner to ensure uniform air distribution to each burner. In addition, modifications to the coal piping will be required so that the primary air and coal mixture are transported to one coal nozzle per cell instead of two coal nozzles. Further, the burner controls will require modification to accommodate the LNC burner electric actuators. Figure 4 depicts a typical retrofit installation of one cell.

The LNC burner arrangement may increase the pressure loss on the secondary air system and accordingly, early in the project an engineering evaluation of the forced draft fans will be completed to determine if sufficient capacity exists to handle the flow resistance increase.

The specific objectives of the demonstration at the Stuart Station are to: (1) reduce NO_x formation by 50% over standard two-nozzle cell burners, without degradation of boiler performance or life; (2) acquire and evaluate emissions and boiler performance data before and after the retrofit to determine NO_x reduction and impact on overall boiler performance; and (3) demonstrate that LNC burner retrofits are a cost effective NO_x control technology for units equipped with cell burners.

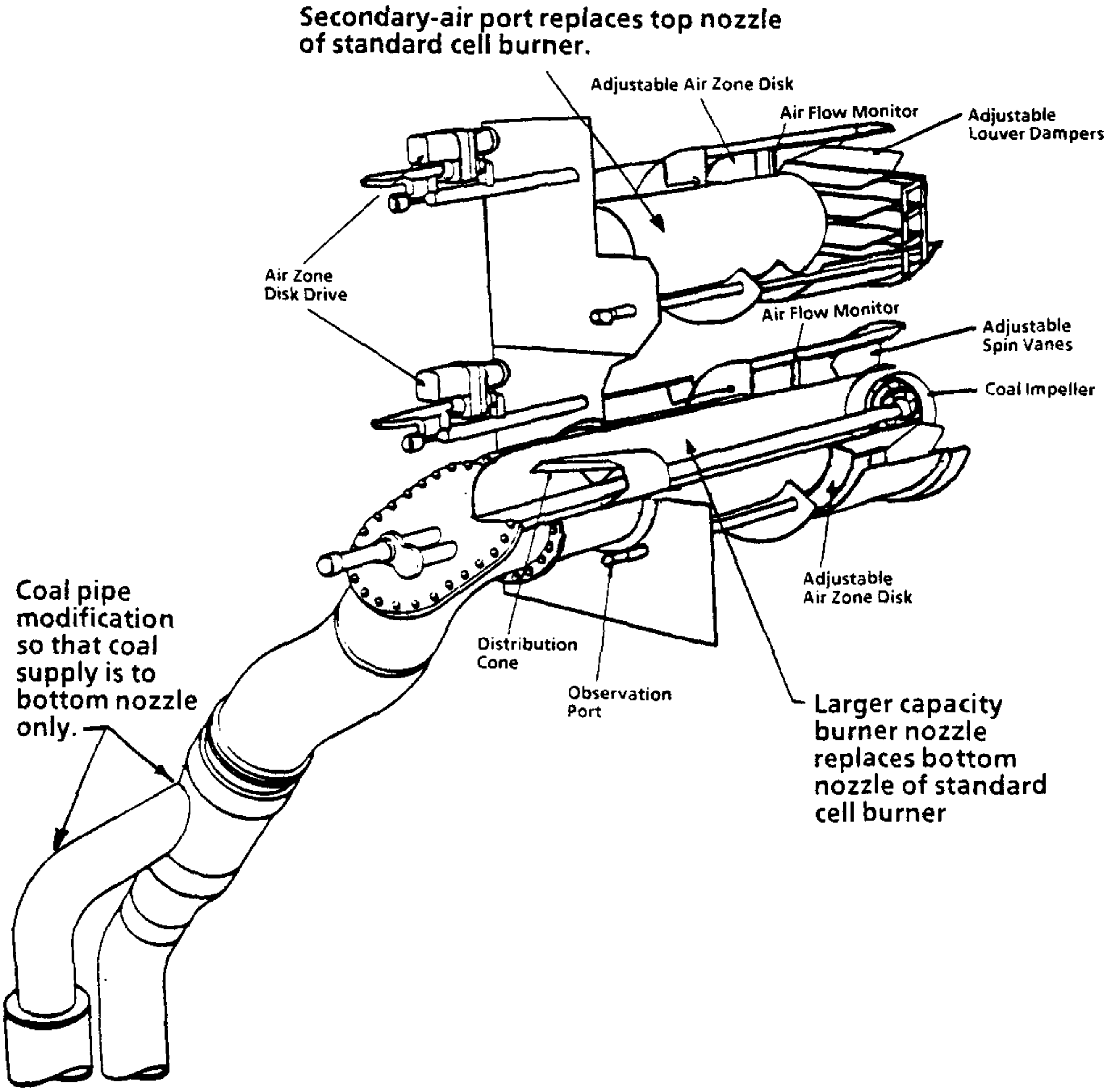

Figure 4. Single LNC Burner Retrofit.

3.3 General Features of the Project

3.3.1 Evaluation of Developmental Risk

As with any new technology this project involves some developmental risk. As discussed previously, however, substantial prior development work and testing has been performed by B&W and EPRI. In addition, the technology has been successfully demonstrated for over four years with one burner in an identical boiler at the Stuart Plant.

After reviewing the results of the development work, a low to moderate risk has been assigned to this project. There is some concern that the proposed technology may cause furnace wall tube corrosion, due to the reducing atmospheric condition that is produced, and that the LNC burner flame may be too long and impinge on the opposing wall tubes. These are considered to be minor risks, because tests conducted at Stuart Unit No. 3 have shown no significant tube corrosion and because combustion tests at the pilot-scale level have indicated that the flame length can be accommodated within the confines of the furnace.

3.3.1.1 Similarity of Project to Other Demonstration/Commercial Efforts

The Italian Electricity Board, ENEL, has eight 320-MWe units with two-nozzle cell burners. These units were supplied by Ansaldo Componenti, the Italian Licensee of B&W. In 1987 Ansaldo Componenti contracted B&W to design a retrofit low-NO_x burner that would achieve 50% NO_x reduction in these units. The burners will be similar to the Stuart Station retrofit LNC burners except that, in addition to pulverized coal, they will also be capable of full-load operation when firing natural gas or fuel oil. Although these burners have additional fuel firing capability the experience gained by B&W will be useful to the Stuart Station demonstration.

There are several CCT projects that will demonstrate various technologies that produce lower NO_x emissions.

In the first round of the CCT program (CCT I), Babcock & Wilcox, TRW, and Coal Tech are carrying out projects which include low-NO_x burners or combustors. CCT III projects that involve low-NO_x burners include projects to be carried out by the Public Service Company of Colorado, Energy and Environmental Research Coproration, and the Alaska Industrial Development and Export Authority.

Retrofit of any of these low-NO_x burners or combustors to boilers presently equipped with cell burners would require more extensive modifications to the boiler wall than will be necessary with LNC burners which are specifically designed for retrofit to boilers which use cell burners.

As part of CCT II, Southern Company Services is demonstrating special combustion techniques to reduce NO_x emissions. These techniques are directly applicable to specific boiler types and would not be directly applicable to burners equipped with cell burners.

Gas reburning and coal reburning are additional low-NO_x technologies that are being demonstrated in various rounds of the CCT program. While reburning may have some applicability to boilers equipped with cell burners, the relatively low volume of these boilers would make retrofit with a reburning technology more difficult because the significant amount of space required by the reburning technology may not be compatible with that available in the compact cell-burner equipped boilers.

Selective Catalytic Reduction (SCR) is being demonstrated in CCT II. This technology, which achieves up to 80 or 90% NO_x reduction is compatible with boilers equipped with cell burners. It does, however, have a greater space requirement than LNC burners. It also requires additional equipment, a catalyst, and an ammonia reagent.

In summary, there are a number of other low-NO_x technologies available that could, with varying degrees of difficultly and cost, be applied to boilers equipped with cell burners. However, LNC burners have been specifically designed to replace standard cell burners and this demonstration project is intended to show that LNC burners provide the best combination of cost and performance when applied to the boilers for which they were designed.

3.3.1.2 Technical Feasibility

Cell-type burner units account for approximately 26,000 MWe of electrical generation capacity in the United States. These units produce approximately 15% of the pre-NSPS utility NO_x emissions and, consequently, may be the target of legislation to reduce these emissions. IN response, B&W and EPRI initiated a program to design a low-NO_x cell burner specifically for boilers equipped with standard cell burners.

The LNC burner has been under development since the early 1980s. Pilot-scale testing has been performed at the 6-million Btu/hr and 100-million Btu/hr scales and a single burner has been tested at full scale at Dayton Power & Light Company's Stuart Unit No. 3. The pilot-scale testing developed and characterized the best equipment for NO_x reduction and the single burner retrofit testing verified the reliability of the hardware. Full-scale/full-unit retrofit testing is now required to obtain the necessary data to evaluate the NO_x reduction potential of the technology and its impact on boiler performance. The success of this demonstration will add credibility to the development work previously performed and will prove that 50% or greater NO_x reduction is possible with little or no risk to the user and without expensive modifications to the boiler.

3.3.1.3 Resource Availability

Adequate resources are available for this program. B&W and Dayton Power & Light Company will use present members of their staff to fill key positions. Additional personnel will be hired as needed. Adequate personnel are available in the local area. However, the need for additional personnel is minor and the hiring of additional personnel is not expected to have any significant impact on the local economy.

The proposed demonstration does not require any additional raw materials or raw material flow streams other than what is currently used for the standard cell burners. This project will not produce any additional solid waste and does not require additional water resources.

This demonstration involves a pre-NSPS 605-MWe, base-load operating boiler installation, with appropriate facilities to accommodate this project. Since the majority of boilers equipped with two-nozzle cell burners are virtually the same in design and size, this unit will provide an excellent opportunity to demonstrate the technology in most situations that are likely to be encountered when it is commercialized.

3.3.2 Relationship Between Project Size and Projected Scale of Commercial Facility

Within the United States there are 37 utility boilers equipped with cell-type burners. Of this total, approximately 90% are of the two-nozzle cell type. All 37 boilers are virtually identical in furnace geometry, volumetric heat release rate, and burner firing pattern. In addition, the average size of these boilers is 690 MWe. Considering the aforementioned and the fact that the proposed demonstration will be performed on a base-load utility unit, which is essentially of average size, the scale-up risk is considered to be minimal. The net effect is that this project will prove the applicability of the technology for retrofit on the majority of pre-NSPS two-nozzle cell-burner-equipped boilers without further demonstration.

3.3.3 Role of the Project in Achieving Commercial Feasibility of the Technology

The proposed demonstration will provide the means to gather the comprehensive data required to determine the commercial feasibility of the technology. The LNC burner has been tested on a full scale using a single cell burner retrofit. Such testing, however, does not provide data sufficient to adequately evaluate the technology's impact on emissions, combustion efficiency, and overall boiler performance. Since the commercialization of the technology is dependent on this data, full-scale, full-burner retrofit testing is required. Since the boiler used for this demonstration is a full-scale base-load operating boiler, and since all burners will be replaced, no additional scale-up will be required for commercialization of this technology.

3.3.3.1 Applicability of the Data to be Generated

The proposed demonstration will include several test programs to ensure that the data obtained accurately represents the impacts realized from the retrofit. These programs include a pre-retrofit unit condition assessment, diagnostic testing, and baseline characterization, and post-retrofit testing for optimization, characterization, and long-term evaluation. A data acquisition system and continuous flue gas monitoring system will be installed by B&W to obtain data during the baseline characterization and post-retrofit testing activities.

The unit condition assessment will be performed to document the condition of the unit prior to testing, to determine necessary maintenance activities prior to testing, to locate and install various taps for data acquisition, to ultrasonically test boiler tubes to determine tube wastage rates with the standard cell burners, and to calibrate plant instrumentation.

Following the unit condition assessment, pre-retrofit diagnostic testing and baseline characterization of the unit will be performed to allow for a comparison of the LNC burner with the standard cell burner. The pre-retrofit baseline characterization testing will be performed over the full operating load range of the unit.

Following installation of the LNC burners, post-retrofit optimization and characterization testing of boiler and combustion system performance will be performed to obtain data to compare with the pre-retrofit data and to provide the basis for commercialization of the technology. The post-retrofit optimization and characterization testing will be performed under similar load and operating conditions established during the pre-retrofit testing. The test instrumentation, methods of data acquisition, and methods and analytical techniques used during these tests will be similar to those used during the pre-retrofit testing.

Long-term testing (one-year duration) will then be performed to evaluate the LNC burners under normal load dispatch control. The data acquisition and continuous emissions monitoring systems will again be used to gather the necessary test data.

As a minimum, the data acquisition and continuous emissions monitoring systems will gather data to monitor the following parameters:

- Superheater steam temperature and pressure
- Feedwater temperature and pressure
- Gas and air temperatures entering and leaving the air heater
- Economizer outlet gas temperatures
- Gas and air differential pressures across the air heater

- Feedwater flow
- Steam flow
- Air flow
- Primary and secondary air temperatures
- Coal flow
- Flue gas NO_x, CO, CO_2, O_2, hydrocarbons composition, and particulate matter content

In addition to the above, coal and ash samples will be analyzed, sootblower frequency and flow will be monitored, furnace tube deposits will be observed and analyzed, and furnace tube corrosion will be determined.

Based on the data obtained from the demonstration, an economic and application evaluation will be performed to develop a revised assessment of the capital and operating costs to retrofit future commercial units. The results of the evaluation will be disseminated through EPRI.

3.3.3.2 Identification of Features that Increase Potential for Commercialization

There are approximately 37 units in the United States, all designed by B&W, with a total of 26,000 MWe of coal-fired generating capacity that are equipped with standard cell burners. These 37 units produce approximately 15% of the pre-NSPS utility NO_x emissions, which corresponds to an uncontrolled emission rate of approximately one million tons of NO_x per year.

These units are expected to continue to operate for many years, because of their large size and because they are of recent vintage. Although these units are pre-NSPS design, new acid rain and clean coal legislation may require significant reductions in NO_x emissions. Therefore, an efficient, economical, and reliable technology to control NO_x emissions is desirable.

B&W, with the support of EPRI, has developed the LNC burner, which replaces the standard cell burner without requiring expensive boiler pressure part modifications. Once commercially proven, this technology will provide an economical means to significantly reduce NO_x emissions from pre-NSPS boilers equipped with standard cell burners.

The LNC technology consists of commercially available equipment, such as burners, dampers, coal piping, duct work, and electric motor operators.

In summary, commercialization of this technology will be aided by:

- Reducing NO_x emissions by 50 percent
- Minimal retrofit costs because of minor or no pressure part changes
- Minimal impact on boiler operation and performance
- Using commercially available components
- Relatively easy retrofit
- Elimination of boiler derating
- Previous demonstration on a full-scale, base-load unit
- Application potential to 37 boilers totaling approximately 26,000 MWe of capacity

The success of this demonstration will establish that the LNC burner is an economical and reliable approach to reduce NO_x emissions in pre-NSPS boilers equipped with standard cell burners contingent upon the degree of NO_x control required. As such, the technology is expected to significantly penetrate this market.

3.3.3.3 Comparative Merits of Project and Projection of Future Commercial Economics and Market Acceptability

The LNC burner, assuming successful demonstration of the technology, will offer a viable alternative to commercial low-NO_x burners, selective catalytic reduction, and thermal de-NO_x systems at reasonable capital and operating costs.

One attractive feature of this project is that it will be performed on a full-scale, base-load unit that is typical of the units equipped with standard, two-nozzle cell burners. In addition, long-term testing will be performed while the unit is under load dispatch control. Since this project will include long-term tests on a full-scale base-load boiler, the results will accurately demonstrate, to potential users, a realistic and achievable level of performance of the technology.

The LNC burner technology is intended to provide an economical option for utilities which desire or will be required to reduce NO_x emissions from pre-NSPS boilers equipped with standard cell burners.

The Participant has made cost comparisons among conventional low-NO_x burners, thermal de-NO_x systems, SCR, and the LNC burner. The comparisons show that the capital cost to install LNC burners is approximately one-half of the cost to install conventional low-NO_x burners and thermal de-NO_x systems, and about one-tenth of the cost to install SCR systems. In addition, operating and maintenance costs associated with the LNC burner technology are substantially less than for thermal de-NO_x systems and SCR, and are essentially the same as the operating and maintenance costs associated with conventional low-NO_x burners.

4.0 ENVIRONMENTAL CONSIDERATIONS

The NEPA compliance procedure, cited in Section 2.2, contains three major elements: a Programmatic Environmental Impact Statement (PEIS); a preselection, project-specific environmental analysis; and a post-selection, site-specific environmental document. DOE issued the final PEIS to the public in November of 1989 (DOE/EIS-0146). In the PEIS, results derived from the Regional Emissions Database and Evaluation System (REDES) were used to estimate the environmental impacts expected to occur in 2010 if each technology were to reach full commercialization, capturing 100 percent of its applicable market. These impacts were compared to the no-action alternative, which assumed continued use of conventional coal technologies through 2010 with new plants using conventional flue gas desulfurization to meet New Source Performance Standards.

The preselection, project-specific environmental review, completed for DOE internal use, focuses on environmental issues pertinent to decision-making. The review summarized the strengths and weaknesses of each proposal relative to the environmental evaluation criteria in the PON. It included, to the extent possible, a discussion of the alternative sites and processes reasonably available to the offeror, practical mitigating measures, and a list of required permits. This analysis was provided for consideration of the Source Selection Official in the selection of projects.

To complete the final element of the NEPA strategy, the Participant (Babcock & Wilcox Company) submitted to the DOE the environmental information volume specified in the PON. This detailed site- and project-specific information forms the basis for the NEPA document required of DOE. This document, prepared in full compliance with the Council on Environmental Quality regulations for implementation of NEPA (40 CFR parts 1500-1508) and DOE guidelines for NEPA compliance (52 FR 47662), must be approved before federal funds can be provided for any activity that would limit the choice of reasonable alternatives to the proposed action.

In addition to the NEPA requirements outlined above, the Participant must prepare and submit an Environmental Monitoring Plan (EMP) for the project. The purpose of the EMP is to ensure that sufficient technology, project, and site environmental data are collected to provide health, safety, and environmental information for use in subsequent commercial applications of the technology.

Results derived from the REDES model are inadequate to develop projected environmental impacts from maximum commercialization of the Low-NOx Cell Burner technology. The REDES model does not address this technology because of the technology's limited applicability. This technology can only be used with boilers configured with cell-type burners. The retrofit market is limited to approximately 37 boilers with an installed capacity of 26,000 MWe, with no new construction projected. Approximately 10,000 MWe of this capacity are located in Ohio, with the balance located primarily in the Midwest and the Northeast.

These 37 boilers are estimated to emit approximately 728,000 to 1,312,000 tons of NO_x annually or roughly 10-20% of the total 1985 NO_x emissions (6,500,000 tons) from coal-fired utilities. Based on maximum penetration of the LNCB technology into the potential market (i.e., 100% capture of the available market) by the year 2010, it is expected that, in that year, NO_x emissions would be reduced by 364,000 to 656,000 tons or 4-8% of the projected 2010 no-action NO_x emissions of 8,400,000 tons. Baseline NO_x emission data for 1985 and the 2010 no-action scenarios are drawn from data available in the PEIS.

5.0 **PROJECT MANAGEMENT**

5.1 Overview of Management Organization

The project will be managed by B&W's Project Manager. He will be the principal contact with DOE for matters regarding the administration of the agreement. The DOE Contracting Officer is responsible for all contract matters and the DOE Contracting Officer's Technical Representative (COTR) is responsible for technical liaison and monitoring of the project.

The project, sponsored by B&W, will receive co-funding from EPRI, Dayton Power & Light Company, the Ohio Coal Development Office, and other utilities. An Advisory Committee will be formed and will consist of personnel from B&W, DOE, and the above participating organizations.

5.2 Identification of Respective Roles and Responsibilities

DOE

The DOE shall be responsible for monitoring all aspects of the project and for granting or denying all approvals required by the Cooperative Agreement. The DOE Contracting Officer is the authorized representative of the DOE for all matters related to the Cooperative Agreement.

The DOE Contracting Officer will appoint a Contracting Officer's Technical Representative (COTR) who is the authorized representative for all technical matters and has the authority to issue "Technical Advice" which may:

- Suggest redirection of the Cooperative Agreement effort, recommend a shifting of work emphasis between work areas or tasks, and suggest pursuit of certain lines of inquiry, which assist in accomplishing the Statement of Work.

- Approve those reports, plans, and technical information required to be delivered by the Participant to the DOE under the Cooperative Agreement.

The DOE COTR does not have the authority to issue any technical advice which:

- Constitutes an assignment of additional work outside the Statement of Work.

- In any manner causes an increase or decrease in the total estimated cost, or the time required for performance of the Cooperative Agreement.

- Changes any of the terms, conditions, or specifications of the Cooperative Agreement.

- Interferes with the Participant's right to perform the terms and conditions of the Cooperative Agreement.

All technical advice shall be issued in writing by the DOE COTR.

Participant

The Participant (B&W) will be responsible for all aspects of project performance under the Cooperative Agreement as set forth in the Statement of Work.

The Participant's Project Manager is the authorized representative for the technical and administrative performance of all work to be performed under the Cooperative Agreement. He will be the single authorized point of contact for all matters between the Participant and DOE.

B&W's responsibilities include overall project management, design, procurement, fabrication and installation of equipment, boiler performance testing, data analysis, reporting of results and commercialization of the technology. In addition, B&W will conduct the project reviews, serve on the Advisory Committee, and contribute to funding.

EPRI will participate with B&W in all aspects of the testing program; attend project reviews; serve on the Advisory Committee; participate in the selection of the environmental testing subcontractor; review the testing, data analysis, and reporting performed by B&W and the environmental subcontractor; and contribute to funding.

Dayton Power & Light Company will provide the host site; provide site access, load dispatch and operation and maintenance personnel; provide the test coal and utilities; attend project reviews; serve on the Advisory Committee; participate in the testing activities; review the testing, data analysis, and reporting performed by B&W and the environmental subcontractor; and contribute to funding.

Allegheny Power System, Centerior Energy Corporation, Duke Power Company, New England Power Company, the Ohio Coal Development Office, and the Tennessee Valley Authority will serve on the Advisory Committee, attend project reviews, and contribute to funding. The above participating utilities represent approximately 50% of the generation capacity of units equipped with cell burners.

The Participant will interrelate between the government and all other project participants as shown in Figure 5, Project Organization.

5.3 Summary of Project Implementation and Control Procedures

The work to be performed under the Cooperative Agreement is divided into the following phases and budget periods:

o Phase I:	Design (11 months)	Budget Period 1
o Phase IIa:	Procurement and Fabrication (8 1/2 months)	Budget Period 1
o Phase IIb:	Construction (4 months)	Budget Period 2
o Phase III:	Operation (18 months)	Budget Period 2

As shown in Figure 6, there will be a one-month overlap between Phase I and Phase IIa. Phase III, however, will start upon completion of Phase IIb. There are no pauses anticipated between phases.

Budget periods have been established for the project. Consistent with P.L. 100-446, DOE plans to obligate sufficient funds to cover its share of the cost of each budget period. Throughout the course of this project, reports dealing with the technical, management, cost, and environmental monitoring aspects of the project will be prepared by B&W and will be provided to DOE.

5.4 Key Agreements Impacting Data Rights, Patent Waivers, and Information Reporting

B&W's incentive to develop this process is to realize retrofit business from, and produce new designs for, the utility and power boiler industry for NO_x abatement technology.

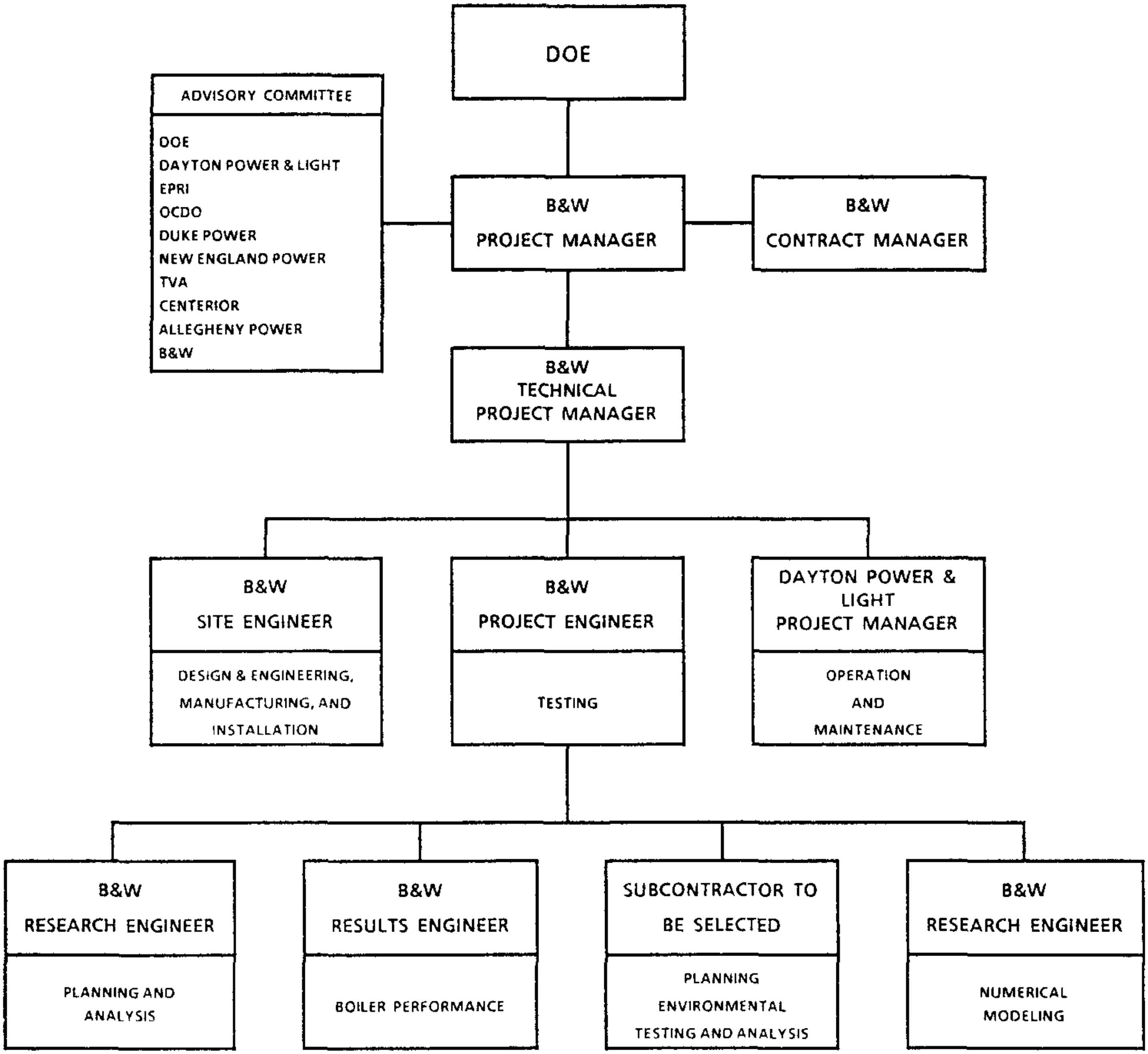

Figure 5. Project Organization.

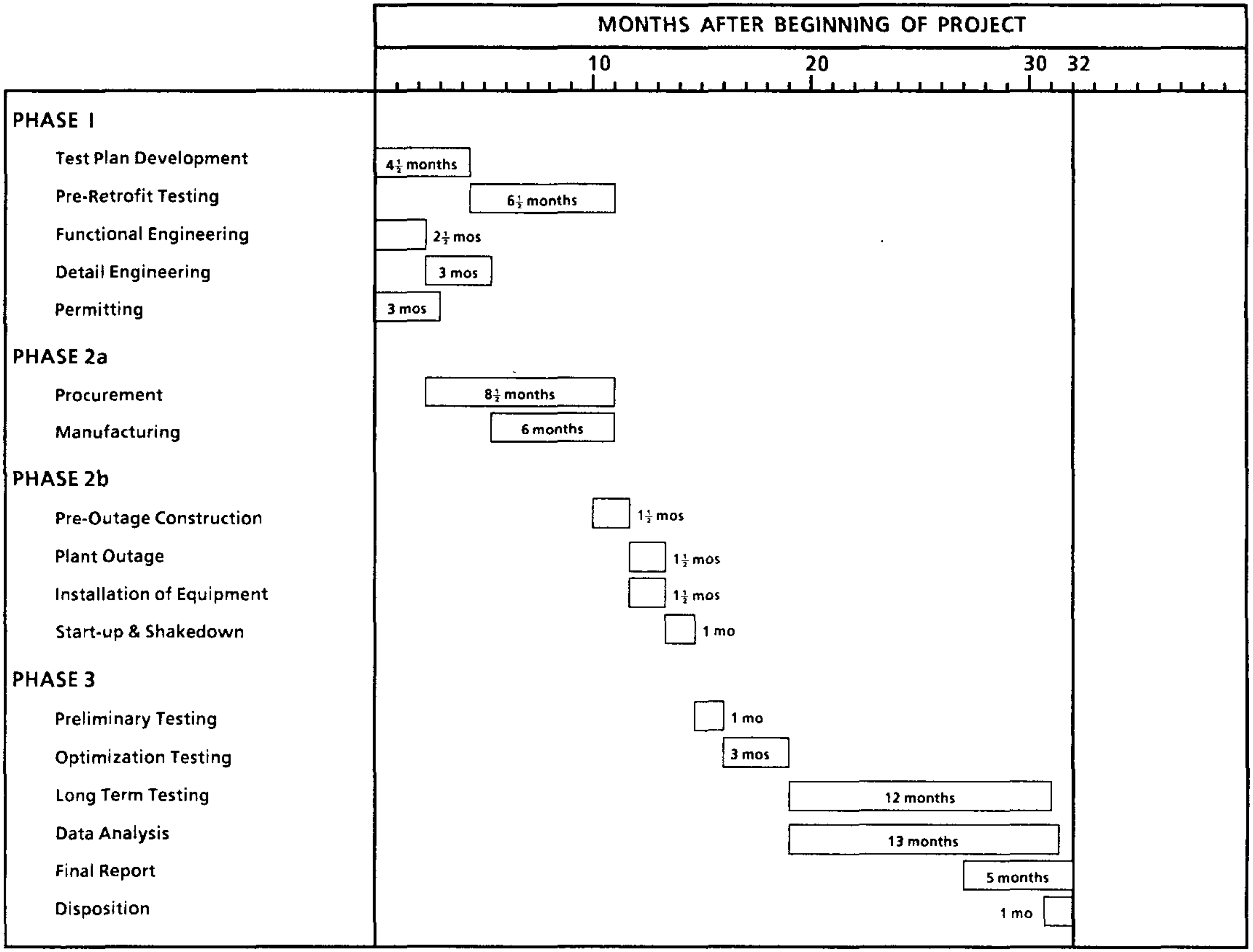

Figure 6. Overall B&W Project Schedule for Low-NO_x Cell Burner Retrofit.

The key agreements in respect to patents and data are:

- o Standard data provisions are included, giving the Government the right to have delivered, and use, with unlimited rights, all technical data first produced in the performance of the Agreement.

- o Proprietary data, with certain exclusions, may be required to be delivered to the Government. The Government has obtained sufficient rights to proprietary data, and non-proprietary data, to allow the Government to complete the project if the Participant withdraws.

- o A patent waiver may be granted by DOE giving B&W ownership of foreground inventions, subject to the march-in rights and U.S. preference found in P.L. 96-517.

- o Rights in background patents and background data of B&W and all of its subcontractors are included to assure commercialization of the technology.

B&W will make such data, as is applicable and non-proprietary, available to the U.S. DOE, U.S. EPA, Ohio EPA, other interested agencies, and the public.

5.5 Procedures for Commercialization of Technology

The LNC burner is one component of the overall B&W clean coal technology strategy for the utility and industrial markets. The overall B&W objective is to profitably supply low-cost retrofit pollution control equipment to utility and industrial customers to reduce emissions from fossil fuel boilers and combustors and to meet regulatory requirements. A broad line of products will be offered by B&W on a customized, site-specific basis to achieve the objective. These products will be geared to reduce SO_x, NO_x, particulates and other emissions from stationary sources. LNC burners represent one key component of this strategy, which is intended to meet the demands of a regulation-driven market.

Proposed acid rain and clean coal legislation may potentially require retrofitting of pre-NSPS boilers and power systems with control technologies to significantly limit NO_x and SO_x emissions. Retrofit regulation-driven markets tend to start slowly, grow rapidly and then decline rapidly as the target population is retrofitted. It is, therefore, critical to have the technology fully demonstrated before the market develops, otherwise, even very cost-effective emissions control technologies may be precluded from use by time and risk constraints.

B&W and EPRI have spent four years developing the LNC burner. The proposed demonstration project represents the final step in the development process of the technology, because it will verify the operation and overall performance of the technology in a full-scale, full-burner replacement demonstration. From a business perspective, this is a key step in the rapid commercial success of this product. It will demonstrate the ability to reliably meet predicted performance on a full-scale commercial boiler and will expose any potential problem areas which must be addressed.

In conjunction with this demonstration, B&W intends to develop detailed marketing and manufacturing plans and engineering standards to market the technology. Being a designer and manufacturer of boilers, including burners and related equipment, B&W already has the systems in place to design, manufacture, install, and service the LNC burner.

Full commercialization of the technology is contingent upon the enactment of new environmental legislation or the revision of existing clean air regulations, which will require modifications of existing utility equipment. During the intervening period, performance of the demonstration unit will be monitored and the time will be used to communicate the performance and benefits of the LNC burner technology to the pre-NSPS standard cell burner boiler owners. This will further enhance commercial acceptance of this product by the potential users if legislation provides the impetus for boiler owners to install retrofit environmental control equipment.

6.0 **PROJECT COST AND EVENT SCHEDULING**

6.1 Project Baseline Costs

The total estimated cost for this project is $9,796,204. The Participants' cash contribution and the Government share in the costs of this project are as follows:

	Dollar Share ($)	Percent Share (%)
PRE-AWARD		
Government	96,800	48.4
Participant	103,200	51.6
PHASE I		
Government	995,051	48.4
Participant	1,060,840	51.6
PHASE IIa		
Government	1,160,719	48.4
Participant	1,237,460	51.6
PHASE IIb		
Government	1,216,187	48.4
Participant	1,296,597	51.6
PHASE III		
Government	1,277,447	48.6
Participant	1,351,903	51.4
TOTAL PROJECT		
Government	4,746,204	48.4
Participant	5,050,000	51.6

Cash contributions will be made as following:

DOE:	$4,746,204
B&W:	$ 500,000
DP&L:	$2,300,000
OCDO:	$ 500,000
EPRI:	$1,000,000
Other Utilities:	$ 750,000
TOTAL:	$9,796,204

At the beginning of each budget period, DOE intends to obligate sufficient funds to pay its share of the expenses for that budget period.

6.2 Milestone Schedule

The overall project will be completed within a 32-month period.

Phase I, which involves pre-retrofit testing, engineering, and permitting will last for eleven months.

Phase IIa, Procurement and Fabrication, will start 2 months into the project and last for 8 1/2 months. One month prior to the completion of Phases I and IIa, Phase IIb, Construction, will start and continue for four months. Phase III, Operation, will start upon completion of Phase IIb and continue for 18 months.

While, it is anticipated that the LNC burners will continue to be used after the demonstration, site restoration activities have been scheduled in the event that the host site elects to remove the LNC burners at the end of the demonstration.

6.3 Repayment Agreement

Based on DOE's recoupment policy as stated in Section 7.4 of the PON, DOE is to recover an amount up to the Government's contribution to the project. The Participant has agreed to repay the Government in accordance with a negotiated Repayment Agreement to be executed at the time of award of the Cooperative Agreement.