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Comprehensive Report to Congress Clean Coal Technology Program

Arvah B. Hopkins Circulating Fluidized-Bed Repowering Project

A Project Proposed By:
The City of Tallahassee

October 1990

U.S. Department of Energy
Office of Fossil Energy
Washington, DC 20585

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1.0 EXECUTIVE SUMMARY

The FY 86 Appropriations Act, P.L. 99-190, included approximately $400 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 proven at the demonstration level.

In response to the resulting Program Opportunity Notice (PON), 51 proposals were received in April 1986. After evaluation, nine projects representing seven different technologies were selected in July 1986 for funding under the Clean Coal Technology (CCT) Program. In addition, a list of alternate candidates was established from which replacement selections could be made should any of the original nine not proceed. A proposal by the City of Tallahassee (CoT) was selected for negotiation from the alternate candidates list on June 23, 1989, after one of the previously selected participants and the Department of Energy (DOE) mutually agreed to terminate their Cooperative Agreement.

CoT requested financial assistance from DOE for the Arvah B. Hopkins Generating Station Unit 2 Circulating Fluidized-Bed Replacement Boiler Project, referred to herein as the Arvah B. Hopkins CFB Repowering Project. The project involves the repowering of a 250-megawatt electrical (MWe) natural gas- or oil-fired boiler with a coal-fired atmospheric circulating fluidized-bed (CFB) boiler to provide steam to an existing turbine generator. The boiler will be the largest of its type. After construction and shakedown, the CoT plant will be operated for 24 months with at least three different eastern coals. Final coal selection will be based on the Fuels Selection Study, which is part of Phase I-A of the project. Cost, financial, and technical data from the CoT CFB will be provided the utility industry for evaluation of a 250-MWe CFB as a commercially viable clean coal alternative.

The objective of the Arvah B. Hopkins CFB Repowering Project is to demonstrate an efficient, economical, and environmentally superior method of generating electric power from coal. The work to be performed under the Cooperative Agreement includes the design, construction, and operation of the demonstration plant. The project is estimated to cost $276,791,974 with the Government's share being $74,733,833 or 27.0 percent. Construction of the project is scheduled to begin by June 1992. Operation of the plant during the 24-month demonstration period, scheduled to begin in November 1995, will provide the information and experience needed for system commercialization.

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 20 years, considerable effort has been directed toward developing improved coal combustion, 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

In December 1985, Congress made funds available for a CCT Program in Public Law No. 99-190, an Act Making Appropriations for the Department of the Interior and Related Agencies for the Fiscal Year ending September 30, 1986, and for Other Purposes. The "Act" provided funds "... for the purpose of conducting cost-shared Clean Coal Technology projects for the construction and operation of facilities to demonstrate the feasibility for future commercial applications of such technology ..." and authorized DOE to conduct the CCT Program. Public Law No. 99-190 provided $400 million "... to remain available until expended, of which (1) $100,000,000 shall be immediately available; (2) an additional $150,000,000 shall be available beginning October 1, 1986; and (3) an additional $150,000,000 shall be available beginning October 1, 1987." However, Section 325 of the Act reduced each amount of budget authority by 0.6 percent so that these amounts became $99.4 million, $149.1 million, and $149.1 million respectively, for a total of $397.6 million.

In addition, in the conference report accompanying Public Law No. 99-190, the conferees directed DOE to prepare a comprehensive report on the proposals received, after the projects to be funded had been selected. The report was submitted in August 1986 and was titled "Comprehensive Report to Congress on Proposals Received in Response to the Clean Coal Technology Program Opportunity Notice" (DOE/FE-0070). Specifically, the report outlined the solicitation process implemented by DOE for receiving proposals for CCT projects, summarized the project proposals that were received, provided information on the technologies that were the focus of the CCT Program, and reviewed specific issues and topics related to the solicitation.

Public Law No. 99-190 directed DOE to prepare a full and comprehensive report to Congress on any project to receive an award under the CCT Program. This report is in fulfillment of this directive and contains a comprehensive description of CoT's Arvah B. Hopkins CFB Repowering Project.

2.2 EVALUATION AND SELECTION PROCESS

DOE issued a Program Opportunity Notice (PON) on February 17, 1986, to solicit proposals for conducting cost-shared CCT demonstrations. Fifty-one proposals were received. All proposals were required to meet preliminary evaluation requirements identified in the PON. An evaluation was made to determine if each proposal met those preliminary evaluation requirements and those proposals that did not were rejected.

Of those proposals remaining in the competition, separate evaluations were made for each offeror's Technical Proposal, Business and Management Proposal, and Cost Proposal. The PON provided that the Technical Proposal was of significantly greater importance than the Business and Management Proposal and that the importance of the Cost Proposal was minimal; however, everything else being equal, the Cost Proposal was very important.

The Technical Evaluation Criteria were divided into two major categories. The first, "Commercialization Factors," addressed the projected commercialization of the proposed technology. This was different from the proposed demonstration project itself and dealt with all of the other steps and factors involved in the commercialization process. The sub-criteria in this section allowed for consideration of the projected environmental, health, safety, and socioeconomic impacts (EHSS); the potential marketability and economics of the technology; and the plan to commercialize the proposed technology subsequent to the demonstration project.

The second major category, "Demonstration Project Factors," dealt with the proposed project itself. Sub-criteria in "Demonstration Project Factors" allowed for consideration of the following: technical readiness for scale-up; adequacy and appropriateness of the demonstration project; the EHSS and other site-related aspects; the reasonableness and adequacy of the technical approach; and the quality and completeness of the Statement of Work.

The Business and Management Proposal was evaluated to determine the business and management performance potential of the offeror and was used as an aid in determining the offeror's understanding of the technical requirements of the PON. The Cost Proposal was evaluated to assess whether the proposed cost was appropriate and reasonable and to determine the probable cost of the proposed project to the Government. The Cost Proposal was also used to assess the validity of the proposer's approach to completing the project in accordance with the proposed Statement of Work and the requirements of the PON.

Consideration was also given to the following program policy factors:

- The desirability of selecting for support a group of projects that represent a diversity of methods, technical approaches, or applications.

- The desirability of selecting for support a group of projects that would ensure a broad cross section of the U.S. coal resource base is utilized, both now and in the future.

- The desirability of selecting for support a group of projects that represent a balance between the goals of expanding the use of coal and minimizing environmental impacts.

An overall strategy for compliance with the requirements of the National Environmental Policy Act (NEPA) was developed for the CCT Program, consistent with the Council on Environmental Quality NEPA regulations and the DOE guidelines for compliance with NEPA. This strategy includes both programmatic and project specific environmental impact considerations, during and subsequent to the selection process.

In light of the tight schedule imposed by Public Law No. 99-190 and the confidentiality requirements of the competitive PON process, DOE established alternative procedures to ensure that environmental factors were fully evaluated and integrated into the decision-making process to satisfy its NEPA responsibilities. Under the terms of the PON, offerors were required to submit both programmatic and project specific environmental data and analyses as a discrete part of each proposal.

The DOE strategy for NEPA compliance for the CCT Program has three major elements. The first involves preparation of a programmatic environmental impact analysis, for internal DOE use, based on information provided by the offerors and supplemented by DOE, as necessary. This environmental analysis documents that relevant environmental consequences of the CCT Program and reasonable programmatic alternatives were considered in the selection process. The second element involves preparation of a pre-selection project-specific environmental review, also for internal DOE use only. The third element provides for preparation by DOE of publicly available site-specific NEPA documents for each project selected for financial assistance under the PON.

No funds from the CCT Program will be provided for detailed design, construction, operation, and/or dismantlement until the third element of the NEPA process has been successfully completed. In addition, each cooperative agreement entered into will require an Environmental Monitoring Plan to ensure that significant site- and technology-specific environmental data are collected and disseminated.

After considering the evaluation criteria, the program policy factors, and the NEPA requirements, proposals from nine offerors were initially selected for award. The proposal submitted by CoT was one of the proposals placed on an alternate list to be eligible for award if one or more of the projects selected did not culminate in an award or if a project was terminated after award. In place of a project that was terminated, the Arvah B. Hopkins CFB Repowering Project was selected from the alternate list on June 23, 1989.

3.0 TECHNICAL FEATURES

3.1 PROJECT DESCRIPTION

CoT has proposed to repower its Arvah B. Hopkins Unit 2 generating plant, located in Leon County, near Tallahassee, Florida (see Figure 1), using atmospheric CFB technology. The proposed repowering of the 250-MWe Arvah B. Hopkins Unit 2 will be the largest CFB unit scheduled for design and construction. The CoT CFB plant will use eastern coal as its performance coal and a CFB boiler supplied by Foster Wheeler Energy Corporation (FW).[1] Successful demonstration of the CoT plant will ensure the utility industry that a CFB in the size range of the CoT plant is commercially viable.

Arvah B. Hopkins Unit 2 is a nominal 250-MWe generating station which entered commercial operation in 1977. A gas- or oil-fueled steam generating system is

[1] After award of the Cooperative Agreement, Bechtel Power Corporation (Bechtel) and the CoT will negotiate a subcontract between Bechtel and FW, to be reviewed and approved by the DOE contracting officer prior to award, for installation of the CFB boiler. The Government will withhold payment to the CoT of any funds to be paid under the Cooperative Agreement until the DOE Contracting Officer approves the FW subcontract. If these negotiations are unsuccessful, a subcontract for the boiler will be negotiated with another boiler manufacturer.

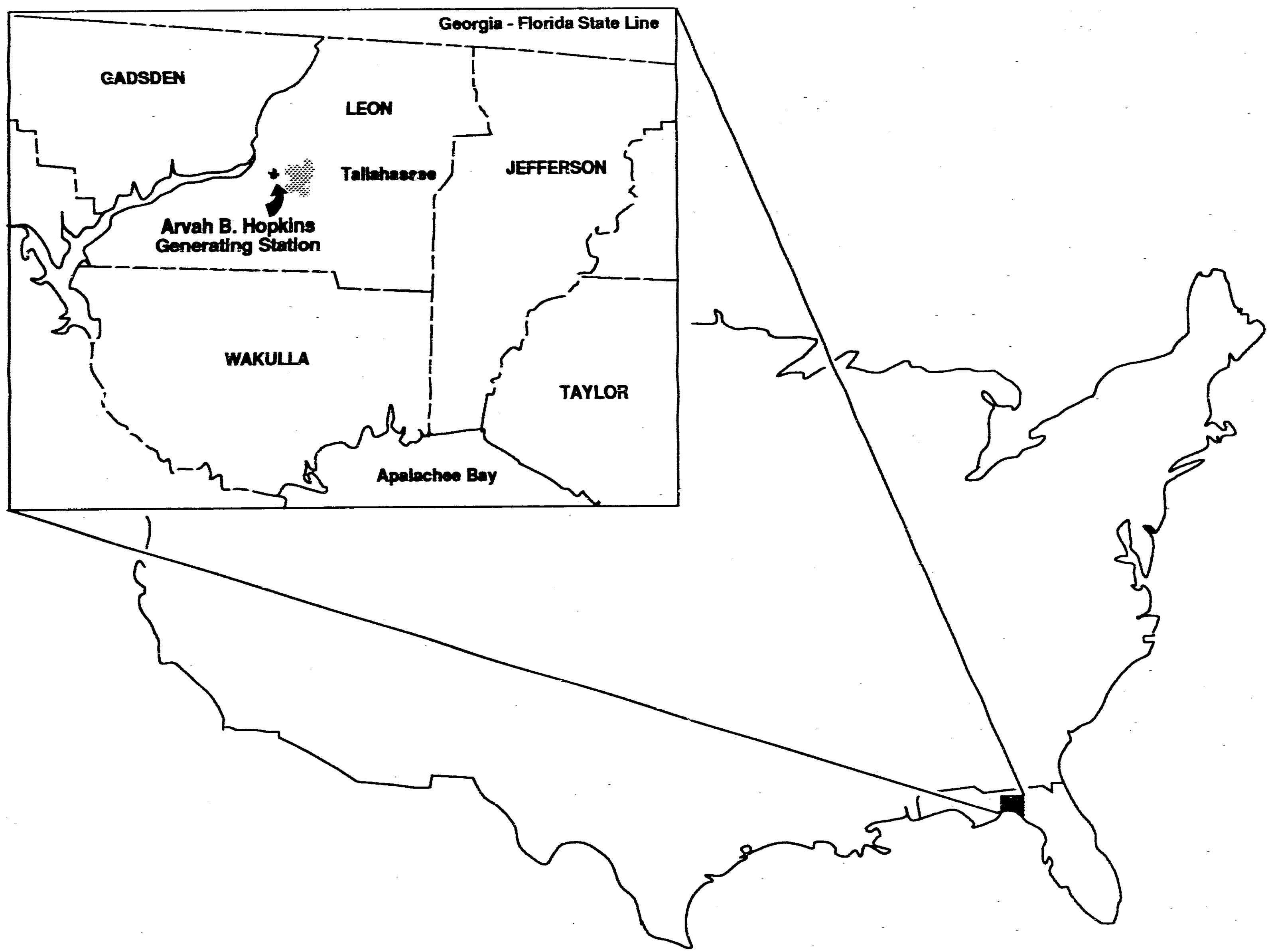

Figure 1. Site of Proposed CFB at Arvah B. Hopkins Station

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used to drive a reheat tandem compound steam turbine. CoT proposes to replace the existing steam generating system with a coal-fueled CFB steam generating system. CoT selected CFB technology over a pulverized coal-fueled (PC) steam generating unit using an electrostatic precipitator particulate cleanup system, a NO_x control system, and a wet flue gas desulfurization (FGD) system. CFB technology was selected because: the CFB eliminates the need for wet scrubbing and the resultant wet ash and scrubber sludge disposal problems; the dry ash from the CFB includes the captured sulfur in an environmentally manageable form; the CFB produces less NO_x than a PC boiler; and the CFB has a lower capital and operating cost than a PC boiler with FGD because of its less complex design. A flow diagram for the proposed Arvah B. Hopkins CFB Repowering Project is presented in Figure 2. A DOE report, "Conversion of Florida Electric Powerplants from Oil to Coal Burning" dated October 1983, concluded that Hopkins Station is considered to be one of the better candidates for fuel conversion in Florida. Further evaluation by CoT confirmed the results and prompted CoT to propose the repowering of Hopkins Unit 2.

Rail cars, shuttle locomotive, turbine-generator upgrade and refurbishing, and fuel inventory will be solely funded by CoT and are not included in the total project cost estimate. However, DOE will receive design, cost and operating information for the entire plant as part of the Cooperative Agreement. The cost-shared Arvah B. Hopkins CFB Repowering Project includes:

- Addition of a coal handling system to receive, store, crush, and convey coal.
- Addition of limestone handling and sizing equipment.
- Repowering of the gas/oil-fueled steam generator with a CFB.
- Addition of a baghouse to collect particulate.
- Addition of a stack.
- Addition of an ash storage and disposal system.
- Addition of a clay lined coal pile and ash disposal runoff control system.
- Installation of new plant instrumentation and control.

3.1.1 Project Summary

Title:	Arvah B. Hopkins CFB Repowering Project.
Proposer:	The City of Tallahassee.
Location:	Leon County, Florida.
Technology:	Atmospheric circulating fluidized-bed combustion.

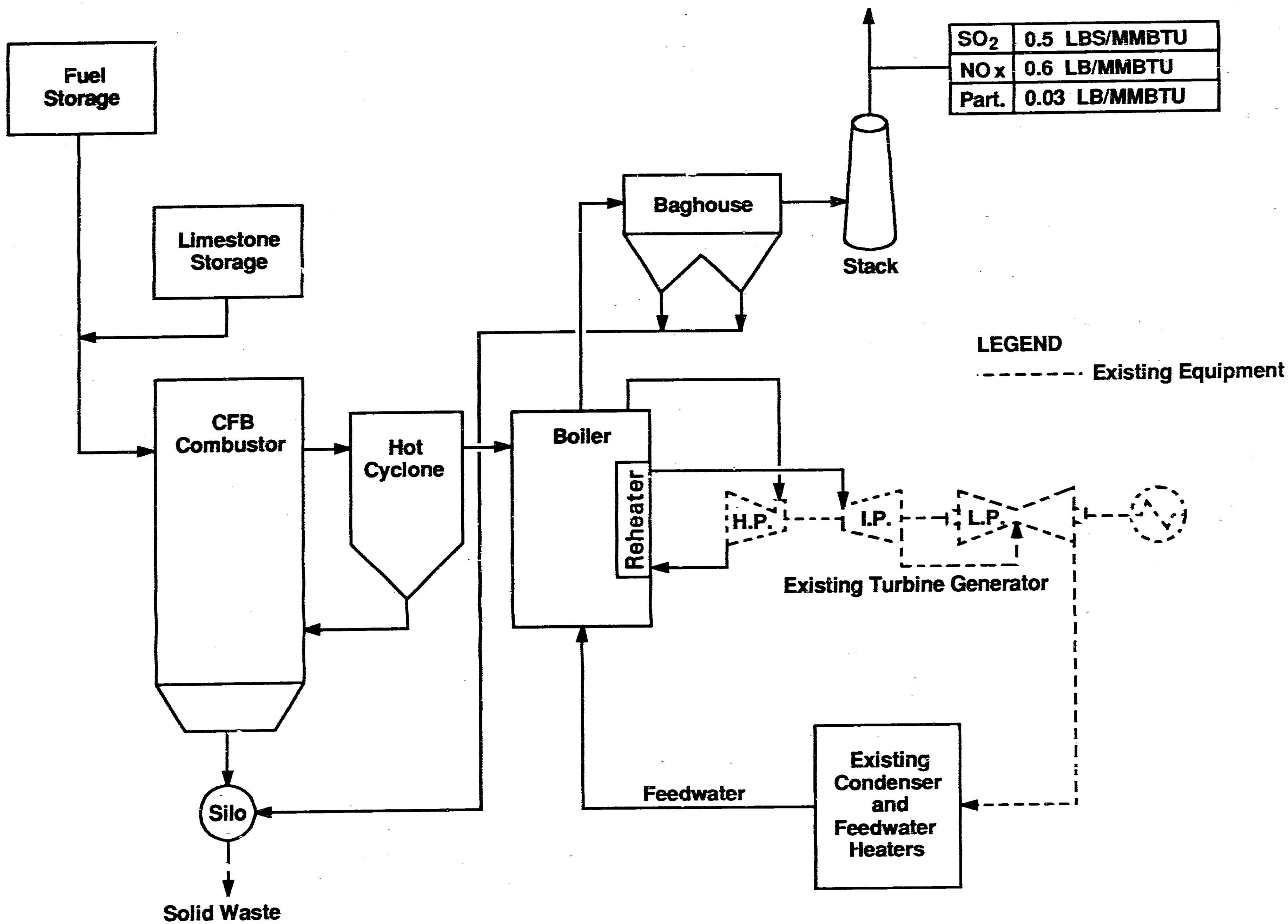

Figure 2. CoT Arvah B. Hopkins CFB Flow Diagram

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Applications:	Utility and industrial electric power generation, repowering of existing boilers or new plants.
Coals Utilized:	Eastern bituminous containing 4.0 percent sulfur as the design coal and other bituminous test coals containing 1.0 to 4.0 percent sulfur.
Project Size:	250 MW (nominal) electric; 1,790,000 lbs/hr of steam at 1,005°F and 1,940 psig; with steam reheat to 1,005°F.
Project Start Date:	December 1990.
Project End Date:	November 1997.

3.1.2 Project Sponsorship and Cost

Project Sponsor:	The City of Tallahassee.
Project Co-funders:	DOE and the City of Tallahassee.
Estimated Project Cost:	$276,791,974 (Cost shared scope only).
Cost Distribution:	Participant Share 73.0 Percent, DOE Share 27.0 Percent.

3.2 CFB PROCESS

3.2.1 Overview of Process Development

The commercial development of fluidized-bed technology can be traced back to the Winkler coal gasifiers built in Germany during the 1920's. By the 1950's, commercial fluidized-bed units were used as catalytic crackers in refineries, as roasters, and as calciners. Research on fluidized-bed combustion during this period proved the technical feasibility of this process, but because it was then more complex than stoker or pulverized coal-fired units, the process was not commercialized.

In the 1970's, regulations to reduce atmospheric pollution from coal-fired power plants led to a renewed interest in fluidized-bed combustion. Two different versions of atmospheric fluidized-bed combustion technology were developed along parallel paths: bubbling fluidized-bed (BFB) and CFB. A BFB boiler has a low fluidizing air velocity, a distinct bed of material, and heat transfer tubes submerged in the bed for generating steam. A CFB boiler has a higher fluidizing air velocity which entrains the bed material out of the combustor into a hot particle separator where the bed material is separated from the flue gas and returned to the combustor. A CFB boiler does not have a distinct bed. Generally in a CFB, steam is generated in tubes placed along the combustor's walls and superheated in tube bundles placed in the circulating stream and the flue gas stream. Depending upon the CFB boiler manufacturer, variations of steam generation exist. Each technology has its own advantages and disadvantages. Both technologies provide the ability to burn a wide variety of coals and other combustibles. Both have higher combustion efficiencies, reduced sulfur and nitrogen emissions, and lower coal crushing costs than conventional PC boilers. CFB boilers have slightly higher combustion efficiencies than BFB boilers, produce lower levels of nitrogen oxide, and have higher sulfur capture efficiencies.

The largest domestic developer of CFB technology is FW which has been involved with fluidized-bed development since the 1940's. FW's first commercial CFB plant at Fort Howard Paper Company has been operating since 1988. The newest and largest FW CFB is a 120-MW unit at the Nelson Industrial Steam Company (NISCO) plant in West Lake, Louisiana scheduled for a 1992 start-up. The major foreign efforts to develop CFB technology have occurred in Finland, Sweden, and West Germany. The two major suppliers of CFB boilers using foreign developed technology are Ahlstrom (licensed to Pyropower in the U.S.) and Lurgi [licensed to ABB Combustion Engineering (CE) in the U.S.]. Some of the other established CFB suppliers that have commercialized their CFB technology and have applicable operating experience include: Tampella Keeler, Gotaverken, and Studvick (licensed to Babcock and Wilcox in the U.S.).

There are numerous commercial CFB boilers, manufactured by the various suppliers, that are operating around the world and in various stages of design, construction and start-up. These boilers are operating or will operate on a variety of fuels including coal, lignite, peat, coke, and wood wastes. The units are used to generate steam or for cogeneration of electricity and steam. Most of the operating units are small, by utility standards, ranging from 50,000 to 500,000 lb/hr steam. The Texas-New Mexico Power (TNMP) plant, currently under construction, will contain two 150-MWe CE CFB boilers. TNMP's Unit No. 1 achieved full load in May 1990 and completed its preliminary acceptance test in June 1990. Unit No. 2 is scheduled for operation in February 1991. The CoT FW CFB boiler will represent about a 1.7 to 1 scale-up of the TNMP units and will produce about 250 MW of electrical power using a high sulfur eastern bituminous coal as its performance coal. Successful demonstration of the CoT plant will ensure the utility industry that a CFB in the size range of 250 MW is commercially viable. The project will also provide a very useful technical, cost, and financial data base for deployment or development of a larger scale CFB.

Almost 50 percent of the current inventory of electrical generating capacity in the United States will be over 30 years old by 1997. Many of these plants are of the 100- to 300-MWe size and will need to be replaced or refurbished along with the addition of new capacity to keep pace with the demand for electricity. The primary candidates to meet this market are fluidized-bed boilers, pulverized coal-fired boilers with flue gas desulfurization and NO_x control, and integrated gasification combined cycle (IGCC) units. The CFB boiler is a competitive candidate, because of its high combustion efficiency and low nitrogen and sulfur oxide emissions.

Although demonstrated to be commercially viable at small (less than 150 MW) scale, CFB combustion has not been demonstrated at intermediate (200 to

500 MW) utility scale. Important concerns related to commercialization of the 250-MW size CFB include:

- Will performance be degraded as units are scaled to sizes required for commercial utility applications?
- Can very large high-temperature, refractory-lined cyclones perform satisfactorily in utility applications?
- Will the refractory-lined surfaces in the combustor, cyclones, seal legs and fluidized-bed heat exchangers be sufficiently erosion and corrosion resistant to meet utility requirements?
- Will the combustion efficiency, sulfur capture efficiency and heat transfer efficiency be affected by the scale-up?
- Are unit control, operability, reliability, maintainability, turndown, and cycling characteristics adequate for utility application?
- Can the dry ash products produced by the process be utilized as building or agricultural materials as opposed to land fill?

The Arvah B. Hopkins CFB Repowering Project provides an opportunity to address these concerns and to greatly expand the knowledge base for CFB technology.

3.2.2 Process Description

The CFB operates at atmospheric pressure. Coal, primary air, and a solid sorbent, such as limestone, are introduced into the lower portion of a waterwall combustor where initial combustion occurs. Combustion takes place at relatively low temperatures of 1,500°F to 1,600°F. As the coal is reduced in size through combustion and breakage, it is carried higher in the combustor where secondary air is introduced. As the coal continues to be reduced in size, the coal, along with some of the sorbent, is carried out of the combustor, collected via a particle separator, and recycled to the lower portion of the combustor. In addition to heat removal by the waterwalls, additional heat is removed by superheaters located within the circulating loop encompassing the combustor, particle separator, and solids recycle leg. Combustion gases which leave the particle separator are cooled in a convective back pass. The convective backpass contains additional superheaters, waterwalls, and an economizer. Sulfur is absorbed by the sorbent and removed with the ash.

The basic components associated with the Arvah B. Hopkins CFB boiler include the fluid-bed combustor; convective backpass; all heat transfer surfaces (superheaters, reheaters, economizers, and water-wall evaporative); particle separators; recycle conduits; ash cooler; fluid-bed and particle separator refractory systems; the interconnecting ducts; and control system.

The CFB is integrated into a power generating system as shown in the preceding Figure 2. Some of the major additional plant systems and hardware include:

- Coal and limestone receiving, storage and preparation where the coal is crushed to less than 1/4 inch and limestone is crushed and pulverized to about 300 microns.
- The flue gas cleanup baghouses.
- The primary, secondary and induced draft fans.
- The combustor ash cooling and removal system.
- The power generation system.
- The plant water treatment system.
- Dry ash disposal site.

During the operating phase of the project, the Arvah B. Hopkins CFB plant will be operated like any other power plant, feeding power into CoT's electrical power grid. A controlled systematic test plan will be followed throughout the operating phase.

3.3 GENERAL FEATURES OF PROJECT

3.3.1 Evaluation of Developmental Risk

Subsequent to selection and as part of the fact-finding process, DOE performed a detailed evaluation of the Arvah B. Hopkins CFB Repowering Project and determined it to be reasonable and appropriate. The evaluation focused on the project's cost, technical and schedule risk. A combination of experts from within DOE and available under contract to DOE contributed to the evaluation. The data base for evaluation included CoT furnished documentation, DOE fact-finding, and discussions with CoT.

The scope of the Arvah B. Hopkins CFB Repowering Project includes design, construction, start-up, and operation of the facility. The CFB design utilizes information available from a number of CFB's that have been designed, constructed and operated. The CFB boiler supplier, FW, will be contractually bound to make the boiler perform adequately to meet the stringent criteria of the acceptance tests. Design and operating experience obtained from the existing smaller commercial plants reduce the programmatic risk prevalent with first-of-a-kind plants. The risks that were identified are discussed in more detail under Section 3.3.1.2, Technical Feasibility. These risks underscore the need for a demonstration project. Based on the reasonable assumption that the Arvah B. Hopkins CFB plant will perform according to design specifications developed in the preliminary engineering phase and prior to the start of Phase III activities, there is only a low risk that the program will not be completed for technical reasons. Successful completion and operation of this unit will provide a firm base for commercialization of the CFB approach for the utility industry.

The 83-month schedule to design, construct, start-up and provide operational data allows sufficient time to perform preliminary engineering, order material, erect the boiler and other facilities, shut down the old boiler, start-up and demonstrate the plant's performance. Bechtel, the engineer-constructor, has designed and built many coal-fueled steam generator plants for the utility industry. This experience will help to meet the schedule objectives and mitigate schedule risks.

The 24-month operation period, Phase III, provides adequate time for all test objectives to be met. This operating period will guarantee that plant performance and commercial viability will be thoroughly evaluated.

The cost estimate, evaluated during the fact-finding process, was prepared for the CoT by Bechtel. Bechtel developed the estimate by factoring from actual costs from Bechtel projects for smaller CFB boilers. CoT is planning to use a fixed-price contract for supply of the turnkey plant. Based on the evaluation of the cost estimate and the reasonable assumption that the plant will be designed, built, and operated in accordance with the CoT plan, there is only a minimal risk that the actual cost will exceed the cost estimate.

3.3.1.1 Similarity of Project to Other Demonstration and Commercial Efforts

Atmospheric fluidized-bed (AFB) boilers that use bubbling-bed technology are being demonstrated in a 125-MWe unit at Northern States Power Company's Black Dog station in Burnsville, Minnesota, and in a 160-MWe unit operated by TVA at its Shawnee Plant in Paducah, Kentucky. Industry and utilities are moving away from BFB boilers in favor of CFB boilers. Many commercial CFB boilers are currently in operation around the world. These units are used for generating steam or for cogeneration of steam and electricity. Coal, lignite, peat, coke and wood wastes are examples of the fuel used in these units. By utility standards, all of these units are small, with the 110-MW Pyropower unit at Nucla, Colorado, and the 150-MW unit designed by CE for TNMP being at the small end of the practical utility size and CoT's 250-MW CFB being a practical utility size. The TNMP CFB's represent a CFB scale-up of about 1.5 to 1 relative to the Nucla plant. However, the actual scale-up of the TNMP combustor is greater than 1.5 to 1 because the Nucla CFB consists of two independent combustion chambers in a single enclosure. The CoT CFB represents a further scale-up of about 1.7 to 1 relative to TNMP. The 250-MW size of the Arvah B. Hopkins CFB will place it within the desired size range for deployment by the utility industry.

3.3.1.2 Technical Feasibility

One of the primary risks associated with CFB technology is scale-up. Basic CFB technology has been successfully proven at 100 MW and smaller in a number of installations which have operated with some difficulties. However, the basic process features of CFB technology have been well demonstrated and accepted. For example, a 32-MW unit at Fort Howard Paper Company has been in commercial operation since 1988. Scott Paper has a 650,000 lb/hr steam generating unit in operation, burning anthracite culm, that has met all performance guarantees and has demonstrated compliance with environmental emission standards. Another example is the 925,000 lb/hr utility boiler currently being operated at the Nucla power plant. This project, operating under a Cooperative Agreement with the DOE, has satisfied the performance guarantees and met emissions standards. TNMP's Unit No. 1 (150 MW) achieved full load in May 1990 and has met SO_2 emission requirements. In addition, the TNMP Unit No. 2 (150 MW) is scheduled for start-up in 1991 and the NISCO plant in Westlake, Louisiana, is scheduled for operation in early 1992. The significant features of the Fort Howard, Scott Paper, Nucla, NISCO, and TNMP installations are the cyclones, heat exchangers, and ancillary equipment that are fundamentally the same as the Arvah B. Hopkins unit. However, this is not to imply that there are not risks associated with the demonstration of CFB technology in a utility application such as Arvah B. Hopkins since the combustion chamber scale-up exceeds any CFB operating or scheduled for operation in the next few years. The major technical concerns for the Arvah B. Hopkins CFB project are listed below. These concerns essentially establish the need for a project that will define the design requirements, manufacturing and construction methods, and a test program that will define the limitations and establish the technical viability of the technology at this scale in commercial operation on a utility grid.

- Combustion chamber configuration, thermal efficiency, nitrous oxide control and sulfur capture efficiency.
- Design and performance of coal and sorbent feed systems supplying the feedstock to the combustor.
- Design and performance effects from different fuels or fuel flexibility.
- Performance and life of extra thick refractory-lined ducting.
- Performance of the massive high-temperature, refractory-lined cyclones.
- Operation of the recirculation loop seals.
- Erosion, corrosion, and deposition of component materials.
- Gas/solids mixing in the bed.
- Heat exchanger tube life.
- Transient responsiveness and dynamics.
- Fines generation and management.
- Overall plant availability factor.

None of these technical concerns is considered a major obstacle to successful completion of the project.

3.3.1.3 Resource Availability

All of the resources required for the project are available. CoT has pledged the existing Arvah B. Hopkins facility and its share of project costs as prescribed in the Cooperative Agreement for the 83-month period required to design, construct, start-up, and operate the facility. In addition, CoT will assume overall responsibility for the project. Bechtel will be CoT's contractor for the design, construction, and start-up of the facility. FW, an experienced boiler manufacturer, will supply the CFB boiler. CoT will be responsible for the operation of the plant and will provide the necessary resources for this activity. Only the coal and limestone sorbent need to be brought to the plant site. Eastern bituminous will be the primary coal and will be obtained on the best terms available. Other coals that are to be tested will be purchased on the spot market. Limestone will be obtained from existing suppliers in northern Florida, southern Georgia, or Alabama. Labor for constructing the plant will be obtained locally and is expected to aid the local economy.

3.3.2 Relationship Between Project Size and Projected Scale-Up of Commercial Facility

The U.S. electric utility industry currently expects a market to develop beginning in the next 10 years, for 100- to 300-MWe generation units as add-on capacity and for repowering or retrofitting aging power plants. The Arvah B. Hopkins CFB Repowering Project, rated at 250 MWe, is sized to demonstrate the technology near the high end of this range. Scaling to the upper range is within accepted scale-up practice. The Nucla CFB, rated at 110 MWe, represents a scale-up of CFB technology at the bottom of this range and the TNMP and NISCO projects represent a scale-up to the middle of this range. Therefore, only minimal additional scale-up will be required to prepare this technology for the market.

3.3.3 Role of Project in Achieving Commercial Feasibility of Technology

The Arvah B. Hopkins CFB Repowering Project represents a scale-up of about 3 to 1 from the largest operating single combustor CFB (Scott Paper CFB) and a proportionate increase in the size of related equipment. This is less than the FW scale-up from operating Fort Howard (32 MW) unit to NISCO (120 MW) which is scheduled for operation in 1992. The design, construction, testing, documentation of costs, operational characteristics, and scale-up success of the Arvah B. Hopkins CFB Repowering Project will provide utilities with information they will need to plan for replacement, retrofit, and new generating capacity in the near future.

Upon completion of the design, construction and start-up, the 24-month test program will establish operating parameters and evaluate cost. Performance parameters will be confirmed and various fuels and/or sorbents will be tested to determine operating costs and performance to minimize unwanted emissions. The time allowed for the test program will also provide a data base for refractory, heat exchanger tubes and other material performance.

The 24-month test program will provide utilities with substantial information to enable utility executives to fairly and accurately evaluate the CFB technology and permit application of a 250-MWe size CFB boiler by the mid 1990's. The initial commercial orders would likely be very close to the design of the

Arvah B. Hopkins CFB boiler. This would save engineering, design, and construction time and help expedite commercialization.

4.0 ENVIRONMENTAL CONSIDERATIONS

The PON requires that, upon award of financial assistance, the Participant will be required to submit the environmental information specified in Appendix J of the PON. CoT provided this information prior to award. This detailed site- and project-specific information will be used as the basis for site-specific NEPA documents to be prepared by DOE for the selected project. Such NEPA documents shall be prepared, considered, and published in full compliance with the requirements of 40 CFR 1500-1508 and in advance of a go/no-go decision to proceed beyond preliminary design. Federal funds from the CCT Program will not be provided for detailed design, construction, operation, and/or dismantlement until the NEPA process has been successfully completed.

5.0 PROJECT MANAGEMENT

5.1 OVERVIEW OF MANAGEMENT ORGANIZATION

Figure 3 shows the Project Organization. CoT, as signatory to the Cooperative Agreement will have overall responsibility for the entire project and plans to subcontract most of the work. After award of the Cooperative Agreement, the CoT intends to enter into a fixed-price contract with Bechtel to design, construct, and start up the facility. The CoT also intends to enter into a contract with R. W. Beck and Associates for environmental permitting and project management support. Prior to award of both of these contracts, the CoT must submit these contracts to the DOE contracting officer for review and approval.

CoT will provide a Project Manager who will work closely with the Bechtel design and construction management team. The repowered Arvah B. Hopkins CFB facility will be operated by the CoT. Operation includes the development and implementation of the test program, collection and analysis of data, and dissemination of the test results. Some contractor support may be used by the CoT for operation.

DOE will monitor all aspects of the project, including the overall progress and direction of design, construction, start-up, and operation to ensure all goals of the project are met. This monitoring will include DOE participation at critical review points and granting or denying approvals required by the Cooperative Agreement.

5.2 IDENTIFICATION OF RESPECTIVE ROLES AND RESPONSIBILITIES

5.2.1 DOE

A DOE Project Manager will be designated by the DOE Contracting Officer. The Project Manager will be the primary point of contact for the project and responsible for DOE management of the project.

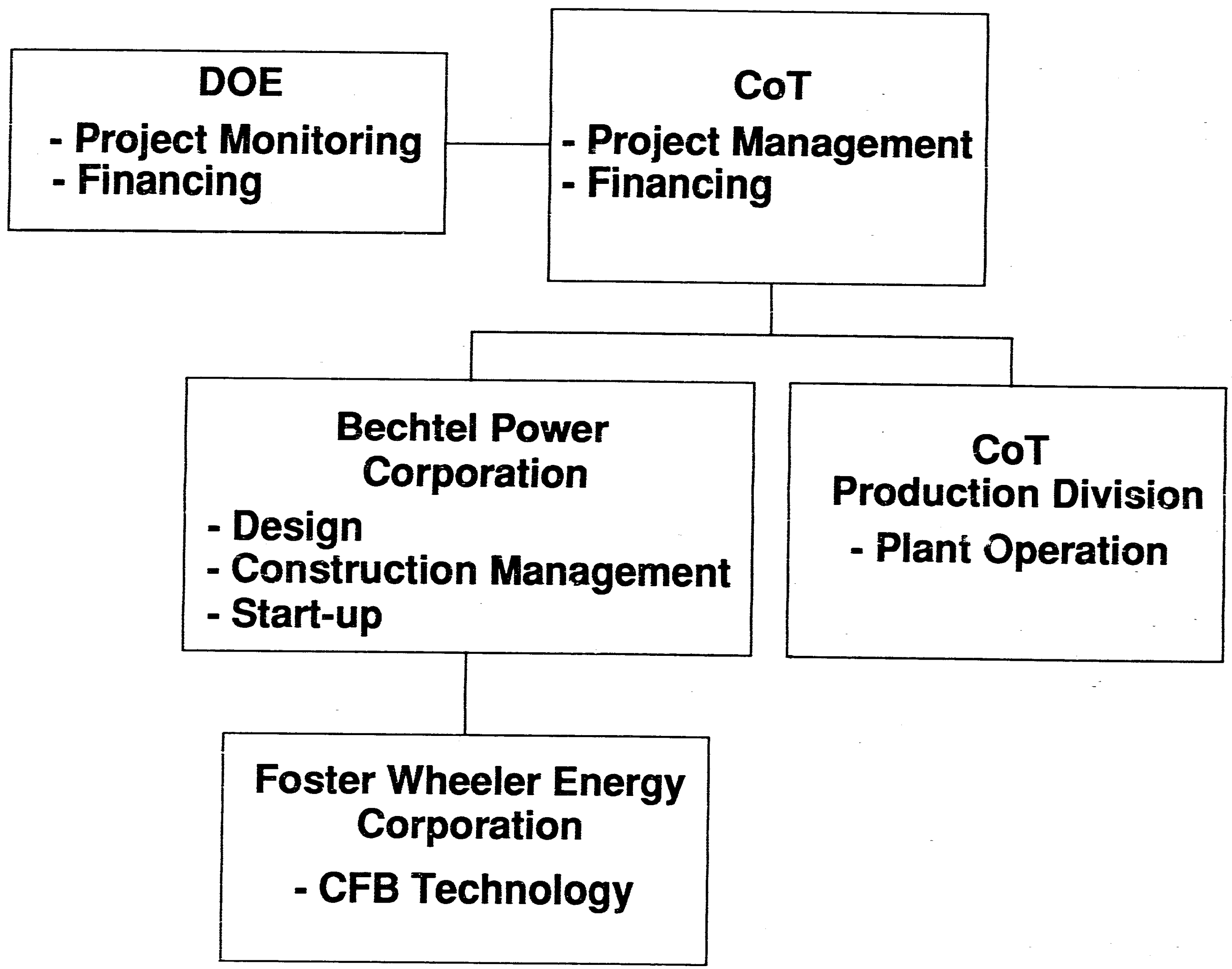

Figure 3. Project Organization

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5.2.2 Participant

CoT, as the Participant, will be responsible for all aspects of the project, including design, permitting, construction, operation, data collection, and reporting. The Participant will designate a Project Manager who will be responsible for all technical and administrative activities to be performed under the Cooperative Agreement.

5.3 PROJECT IMPLEMENTATION AND CONTROL PROCEDURES

All work to be performed under the Cooperative Agreement is divided into the following four phases:

Phase I-A -- Preliminary Design and Permit Application.

Phase I-B -- Engineering, Permitting, and Detailed Design.

Phase II -- Construction and Start-Up.

Phase III -- Operation, Testing, Data Collection, and Reporting.

Budget periods will be established to coincide with the project phases. Consistent with P.L. 99-190, DOE will obligate sufficient funds to cover its share of the cost for each budget period. Throughout the course of this project, reports dealing with the technical, management, cost, and environmental monitoring aspects of this project will be prepared by the Participant and provided to DOE.

The Participant will prepare and maintain a project management plan that presents project procedures, controls, schedules, budgets, and other activities required to adequately manage the project. This document will be prepared shortly after execution of the Cooperative Agreement and will be used to implement and control project activities.

5.4 KEY AGREEMENTS IMPACTING DATA RIGHTS, PATENT WAIVERS, AND INFORMATION REPORTING

With respect to data rights, DOE has negotiated terms and conditions which will generally provide for rights of access by DOE to all data generated or utilized in the course of or under the Cooperative Agreement by CoT and its subcontractors. DOE will have the further right to have certain proprietary data delivered to it under suitable conditions of confidentiality. DOE will also have unlimited rights in data first produced in the performance of the Cooperative Agreement.

With regard to patents, data, and other intellectual property, CoT has made an express contractual commitment to exercise its best efforts to assist others to commercialize in the United States, the technology demonstrated under the Cooperative Agreement, in accordance with prevailing market opportunities, reasonable and prudent business practices, and provisions of the Cooperative Agreement. CoT and FW have agreed in principle that a commitment to commercialize the technology to be demonstrated under the Cooperative Agreement will be included in the FW supply contract for the boiler. The Cooperative Agreement gives DOE the right to review and approve the boiler supply contract.

FW has requested a waiver of patent rights in any subject invention, i.e., any invention or discovery conceived or first actually reduced to practice in the course of or under the Cooperative Agreement. Any grant of a patent waiver will reserve to the Government a nonexclusive, nontransferable, and irrevocable paid-up license to practice or have practiced any waived subject invention by or on behalf of the United States. The terms and conditions of the waiver granted to FW will include march-in rights and U.S. preference provisions. In addition, FW has agreed to be responsive to its commitment to commercialize the demonstrated technology and to participate in the plan to repay the Government's cost share as additional equities in support of receiving the waiver of patent rights. The patent waiver provisions will be included in FW's subcontract with Bechtel for supply of the CFB boiler.

5.5 PROCEDURES FOR COMMERCIALIZATION OF TECHNOLOGY

Design, construction and operation of the Arvah B. Hopkins plant to demonstrate CFB combustion is a vital step in the commercialization of that technology. To allay the concerns of a generally conservative industry, it is essential that a demonstration of CFB technology, at the scale of this project include actual integration of the CFB boiler into commercial power plants. The Arvah B. Hopkins CFB Repowering Project will accomplish this and serve as an operational model at commercial scale which the private sector can use in making rational commercialization decisions.

When CFB combustion technology is successfully demonstrated at the 250-MWe size, the availability of this technology to utilities is expected to result in substantial penetration into the commercial market. The preferred utility approach is expected to be one of repowering plants and building new power generation units of a size which can better match load growth and which can be brought on line in 3 to 4 years rather than 8 to 10 years, thus lowering costs for work in progress.

The CFB boiler to be demonstrated in this project will offer utilities several advantages that will increase the potential for the commercialization of this technology:

- It is a commercial size unit which can be replicated with little risk.
- It is of a size that will provide good load-growth matching without overcapacity.
- Its efficiency and costs are more attractive than conventional coal-fired plants.
- It can be built in 4 years or less.

- It can be built in single or multiple units, phased as required to meet any projected load.
- Permitting will be facilitated because of its low environmental impact.

6.0 PROJECT COST AND EVENT SCHEDULING

6.1 PROJECT BASELINE COSTS

CoT and DOE have agreed to share the cost of the Arvah B. Hopkins CFB Repowering Project. The estimated cost and the cost sharing for the work to be performed under the Cooperative Agreement are as follows:

Phase I-A		
DOE Share	$ 2,007,725	50.0%
Participant Share	2,007,725	50.0%
Total	$ 4,015,450	100.0%
Phase I-B		
DOE Share	$ 9,750,850	50.0%
Participant Share	9,750,850	50.0%
Total	$ 19,501,700	100.0%
Phase II		
DOE Share	$ 52,559,786	24.5%
Participant Share	162,139,214	75.5%
Total	$214,699,000	100.0%
Phase III		
DOE Share	$ 10,415,472	27.0%
Participant Share	28,160,352	73.0%
Total	$ 38,575,824	100.0%
Total Estimated Project Cost		
DOE Share	$ 74,733,833	27.0%
Participant Share	202,058,141	73.0%
Total	$276,791,974	100.0%

At the beginning of each budget period, DOE intends to obligate sufficient funds to pay its share of expenses for that budget period. Budget periods coincide with project phases.

6.2 MILESTONE SCHEDULE

The project is divided into four phases and is expected to take 83 months to complete. The phases and their expected durations are as follows:

Phase I-A: Preliminary Design and Permit Application -- 7 months

Phase I-B: Engineering, Permitting, and Detailed Design -- 11 months

Phase II: Construction and Start-Up -- 41 months

Phase III: Operation, Testing, Data Collection, and Reporting -- 24 months

A project schedule that includes major milestones for the project is shown in Figure 4. Construction and start-up are expected to be completed during the fourth quarter of calendar year 1995 and project completion is scheduled for the fourth quarter of 1997.

6.3 REPAYMENT PLAN

In response to the stated policy of the DOE to recover an amount up to the Government's contribution to the project, the Cooperative Agreement includes a Repayment Plan that meets the requirements of the PON.

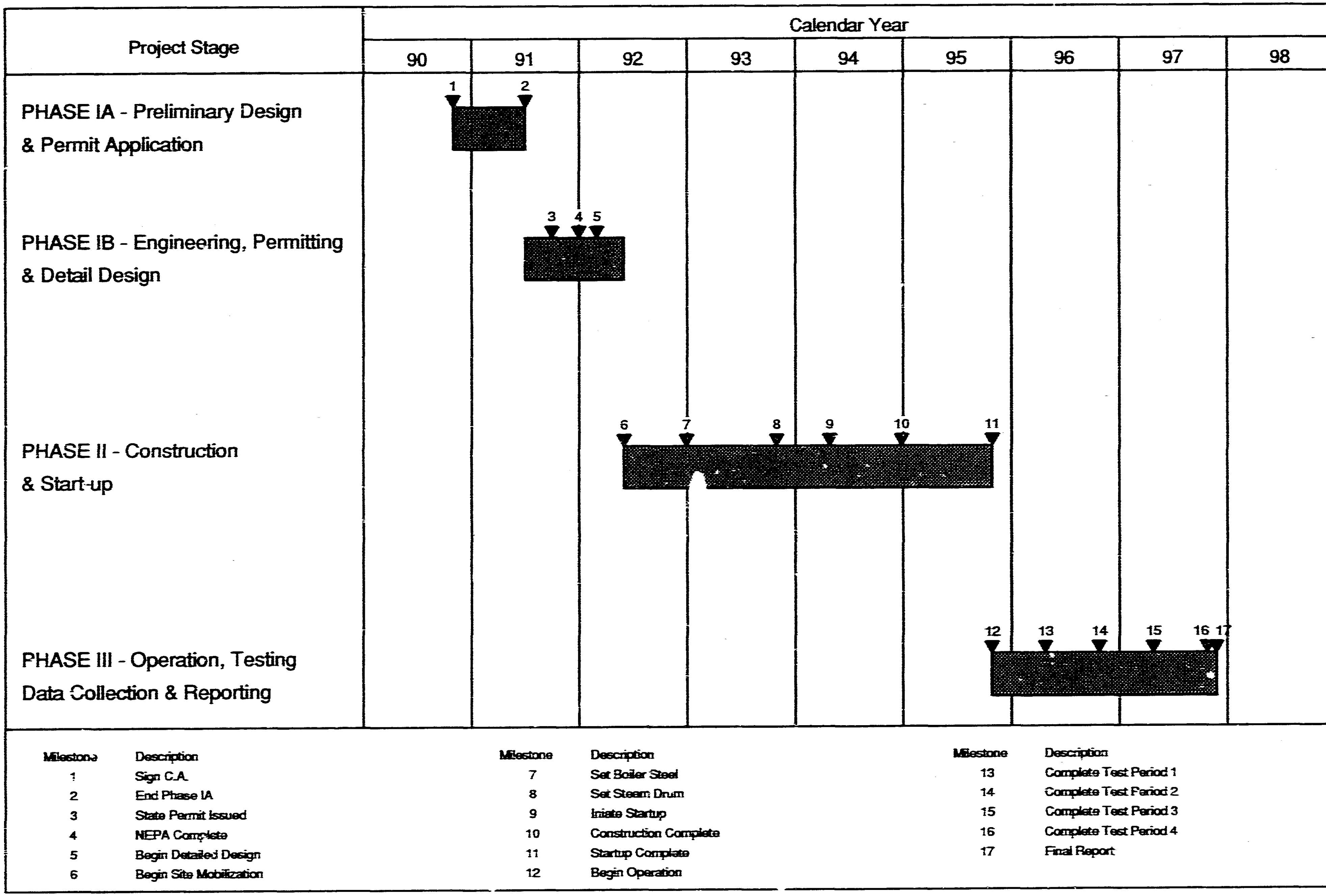

Figure 4. Project Schedule

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