DOE/FE-0106

Comprehensive Report To Congress Clean Coal Technology Program

Nucla CFB Demonstration Project

A Project Proposed By
Colorado-Ute Electric Association, Inc.

July 1988

U.S. Department of Energy
Office of Fossil Energy
Washington, D.C. 20545

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

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. The Colorado-Ute Electric Association, Inc. (CUEA), proposal was initially determined to be an alternative to the nine finalists selected for negotiation by DOE in July 1986. CUEA's proposal was subsequently selected for negotiation on October 7, 1987, after negotiations with two of the first-round finalists were terminated.

CUEA requested financial assistance from DOE for the Nucla CFB Demonstration Project to test and evaluate the economic, environmental, and operational characteristics of circulating fluidized-bed (CFB) combustion boilers, as they apply to commercial generation of electrical power. CUEA has constructed the world's first utility-scale boiler using CFB combustion technology at its Nucla generating station in southwestern Colorado (see Figure 1). CUEA repowered the existing Nucla plant by installing and integrating into the plant a new 925,000 lbs/hr (pounds per hour) CFB boiler and a new steam turbine generator, raising the plant capacity from 36 MWe to 110 MWe.

Under the Cooperative Agreement, DOE will cost share a 2-year test program to demonstrate and evaluate this CFB boiler and its ancillary equipment. The project is estimated to cost $54,087,000 with the Government share being $19,920,000. The Participant has agreed to absorb any cost overruns and has agreed to a plan to repay the Government's contribution. The Participant will have completed the design and construction phases of the project prior to execution of the Cooperative Agreement by the DOE.

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, conversion, and utilization processes to provide efficient and economic energy options. These technology developments permit the attainment of environmental acceptance as well as the efficient utilization of coal resources.

2.1 REQUIREMENT FOR REPORT TO CONGRESS

In December 1985, Congress made funds available for a Clean Coal Technology (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. This Act provided funds ". . . for

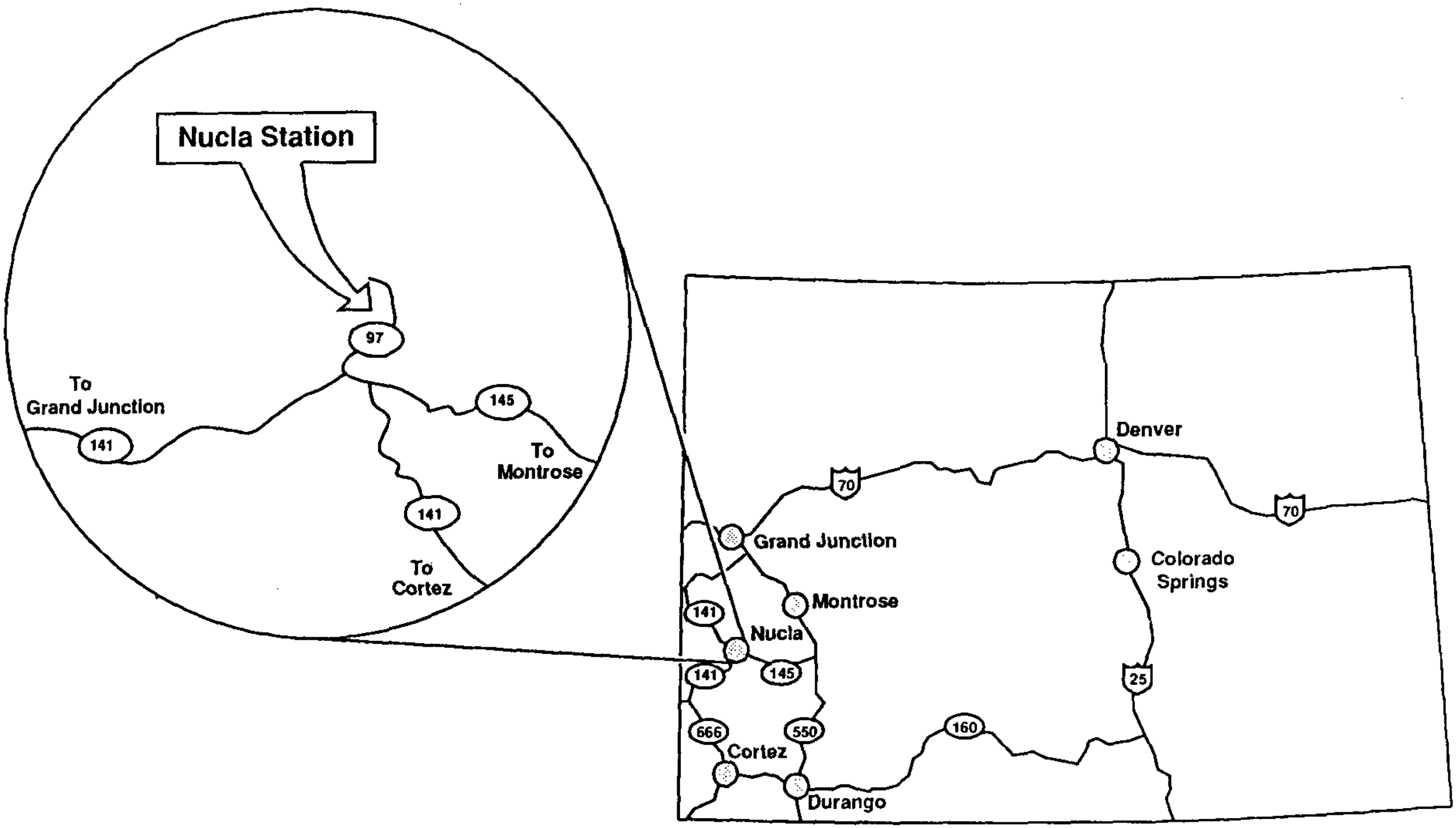

Figure 1. Location of Nucla CFB Demonstration Project

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 $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. Of this amount, $4.9 million will be reprogrammed for the Small Business and Innovative Research Program and is unavailable to the CCT Program.

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 outlines the solicitation process implemented by DOE for receiving proposals for CCT projects, summarizes the project proposals that were received, provides information on the technologies that were the focus of the CCT Program, and reviews specific issues and topics related to the solicitation.

Public Law No. 99-190 also 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 CUEA's Nucla CFB Demonstration Project to demonstrate the use of circulating fluidized-bed combustion for electric power generation at utility scale.

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 major category, "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 subcriteria 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," recognized the fact that the proposed demonstration project represents the critical step between "predemonstration" scale of operation and commercial readiness, and dealt with the proposed project itself. Subcriteria in "Demonstration Project Factors" allowed for consideration of technical readiness for scale-up, adequacy and appropriateness of the demonstration project, the EHSS and other site-related aspects, and the reasonableness and adequacy of the technical approach and 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:

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

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

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

An overall strategy for compliance with 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. Offerors were required to submit both programmatic and project specific environmental data and analyses as a discrete part of their proposal.

This strategy has three major elements. The first involves preparation of a comparative programmatic environmental impact analysis, based on information provided by the offerors and supplemented by DOE, as necessary. This environmental analysis ensures that relevant environmental consequences of the CCT Program and reasonable programmatic alternatives are evaluated in the selection process. The second element involves preparation of a preselection project-specific environmental review. The third element provides for preparation by DOE of site-specific 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 strategy, the proposal submitted by CUEA was determined to be an alternate to the nine finalists selected for negotiation in July 1986. After negotiations with two of the first-round finalists were terminated, replacement selections were made from the alternate list. On October 7, 1987, CUEA's proposal was selected for negotiation as one of the replacement proposals.

3.0 TECHNICAL FEATURES

3.1 PROJECT DESCRIPTION

The Nucla CFB Demonstration Project is an effort by CUEA and other participating organizations to demonstrate the feasibility of circulating fluidized-bed combustion technology and to evaluate the economic, environmental, and operational benefits of CFB steam generators on a utility scale. CUEA owns and operates the Nucla electrical power plant located near the town of Nucla, Colorado (see Figure 1). Before being repowered, the plant consisted of three 12-megawatt coal stoker-fired units. The plant was built in 1959 and was taken out of service in 1984 due to high fuel costs and low efficiency.

In 1982, CUEA projected a future need for additional power to supply its distribution network in the early 1990's. After reviewing many alternatives to produce the needed power, CUEA decided to repower the Nucla plant with a fluidized-bed combustion unit. Circulating fluidized-bed combustion was selected over bubbling-bed technology because it provided a higher combustion efficiency, a higher sulfur capture efficiency, and less opportunity for tube erosion. Construction on the Nucla CFB plant started in November 1984 and was completed in May 1987. A block diagram and a flow diagram of the Nucla CFB plant are presented in Figures 2 and 3.

Repowering of the Nucla plant included:

1. Retrofit installation of a new Pyropower Corporation (Pyropower) CFB boiler supplying 925,000 lb/hr of steam at 1,510 psig and 1,005°F with in-place retirement of three stoker-fired boilers.

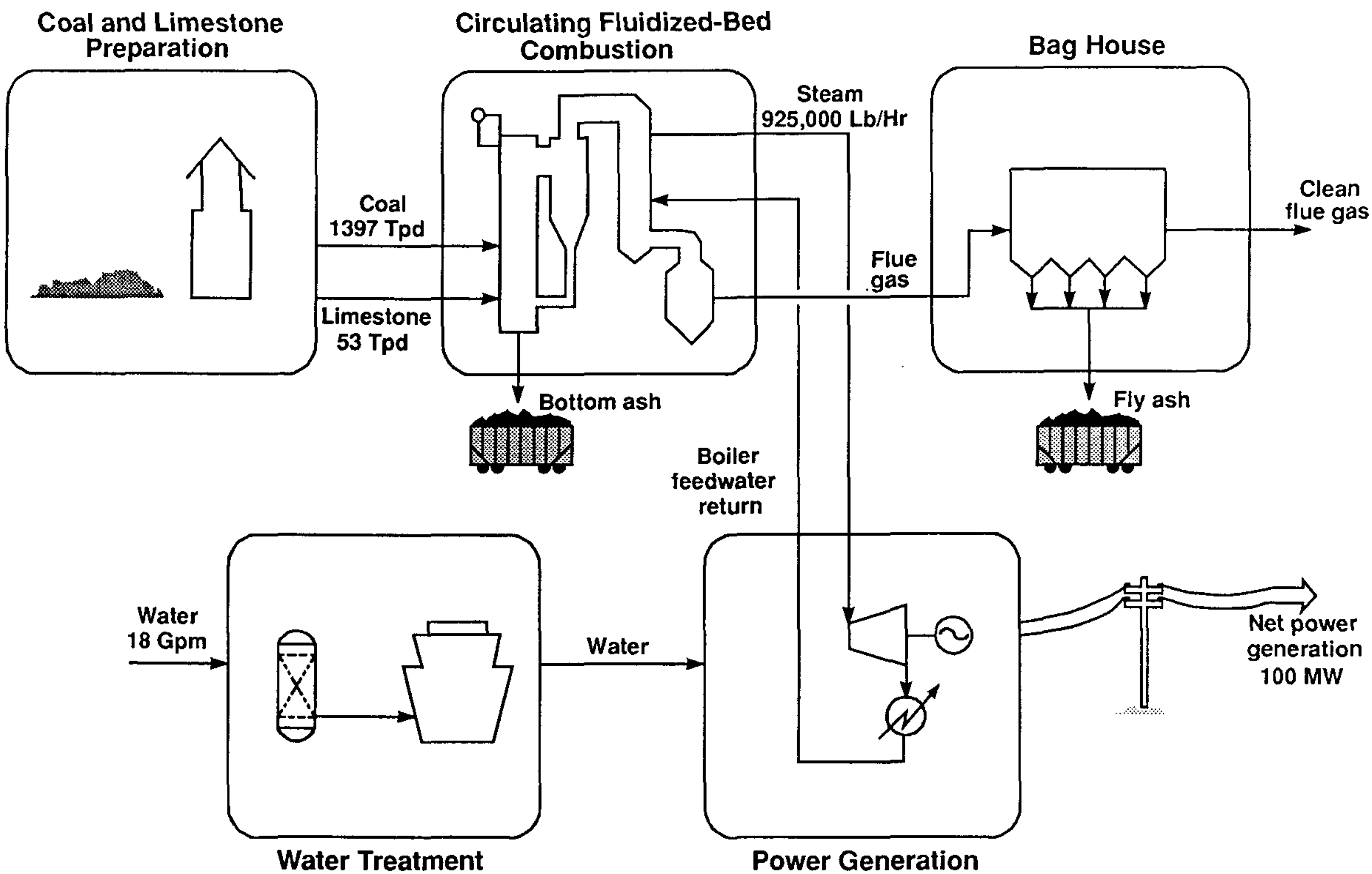

Figure 2. Nucla CFB Demonstration Project Block Diagram

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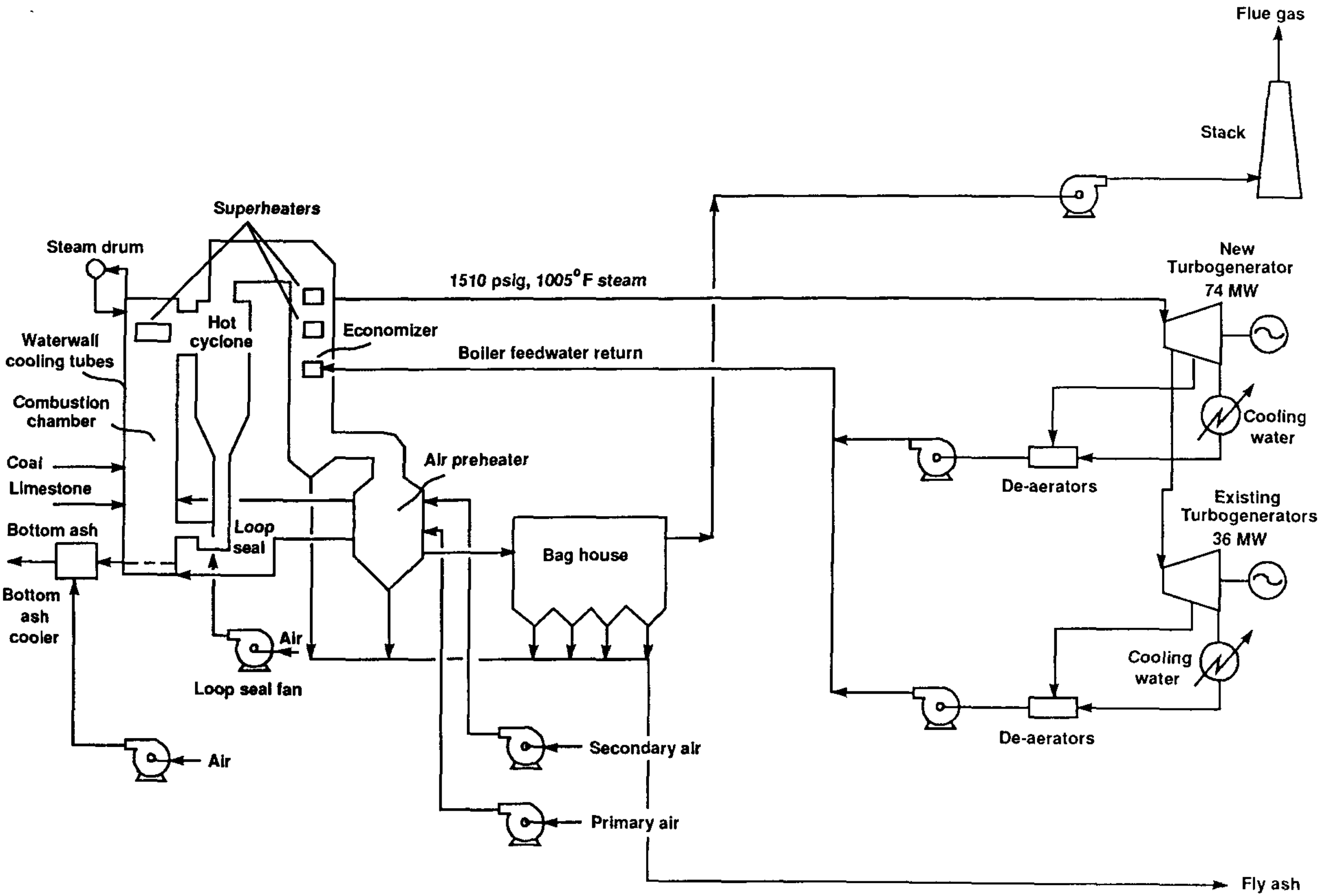

Figure 3. Nucla CFB Plant Flow Diagram

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2. Retrofit installation of a new high-pressure, 74-MWe steam turbine generator with automatic extraction to supply steam at 650 psig and 830°F to three existing 12-MWe steam turbine generators.

3. Modification and refurbishment of the three existing 12-MWe steam turbine generator units, coal system revisions, addition of another baghouse, and installation of a limestone handling system.

CUEA and DOE have agreed to cost share a 2-year test program designed to address the following objectives:

- Confirm the feasibility of replacing existing stoker-fired coal boilers with an atmospheric CFB combustion boiler of larger capacity.
- Optimize performance at the end of the test program.
- Support technology development by using the demonstration plant as the last incremental step in scale-up from the test units and industrial CFB units that were used as a basis for design.
- Demonstrate fuel flexibility on a commercial scale and evaluate parameters and design features that limit unit capacity for ranges of fuel.
- Perform integrated plant load following, control, and duty analyses to assess the capability of the technology to be applied to various load following and duty scenarios and identify rate limiting design features.
- Obtain commercial design, cost, performance, and environmental control data for subsequent comparisons with existing and alternative power generation options.

3.1.1 Project Summary

Title: The Nucla CFB Demonstration Project.

Proposer: Colorado-Ute Electric Association, Inc.

Location: Nucla, Montrose County, Colorado.

Technology: Pyropower circulating fluidized-bed combustion.

Applications: Utility and industrial electric power generation, retrofit or repowering of conventional pulverized coal power plants.

Coals Utilized: Subbituminous or bituminous coals.

Product: Electric power.

Project Size: 110 MW electrical; 925,000 lbs/hr of steam at 1,005°F and 1,510 psi.

Project Starting Date: August 1988.

Project Ending Date: August 1990.

3.1.2 Project Sponsorship and Cost

Project Sponsors: Colorado-Ute Electric Association, Inc.

Project Cofunders: DOE, Colorado-Ute Electric Association, and the Electric Power Research Institute.

Estimated Project Cost: $54,087,000.

Cost Distribution: Participant Share 63.2%.
DOE Share 36.8%.

3.2 CFB COMBUSTION 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 these units, but because they were more complex than stoker or pulverized coal-fired units, they were not commercialized.

In the 1970's, regulations to reduce atmospheric pollution from coal-fired power plants renewed interest in fluidized-bed combustion. Two different versions of fluidized-bed combustion technology were developed along parallel paths: bubbling fluidized-bed (BFB) and circulating fluidized-bed (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 cyclone where the "bed" material is separated from the flue gas and returned to the combustor. A CFB boiler does not have a distinct bed. In a CFB, steam is generated in tubes placed along the walls and superheated in tube bundles placed in the circulating stream and the flue gas stream.

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 pulverized coal-fired boilers. CFB boilers have slightly higher combustion efficiencies than BFB boilers, produce lower levels of nitrogen oxide emissions, and have higher sulfur capture efficiencies.

The major efforts to develop CFB technology have occurred in Finland, Sweden, and West Germany. The two major suppliers of CFB boilers are Ahlstrom (licensed

TABLE 1. Domestic Pyropower Circulating Fluidized-Bed Combustor Units in Operation

Customer	Start-Up	Fuel	Output	Output Conditions	Application
Gulf Oil Exploration, Bakersfield, CA	1983	Coal	50,000 lb/hr	2,500 psig; 670°F	Enhanced oil recovery
Cal Portland Cement, Colton, CA	1985	Coal	190,000 lb/hr	650 psig; 825°F	Cogeneration
B.F. Goodrich, Henry, IL	1985	Coal	125,000 lb/hr	500 psig; 470°F	Process steam
Central Soya, Chattanooga, TN	1985	Coal	88,000 lb/hr	190 psig; 389°F	Process steam
General Motors, Pontiac, MI	1986	Coal, plant wastes	300,000 lb/hr	1,460 psig; 955°F	Cogeneration
Iowa State University, Ames, IA	1987	Coal	2 x 170,000 lb/hr	410 psig; 750°F	Cogeneration
Colorado-Ute, Nucla, CO	1987	Coal	925,000 lb/hr	1,510 psig; 1,005°F	Electric power
Corn Products, Stockton, CA	1988	Coal	500,000 lb/hr	1,550 psig; 955°F	Cogeneration
Fort Drum, Watertown, NY	1988	Coal, oil, anthracite	3 x 175,000 lb/hr	1,525 psig; 950°F	Cogeneration
Gilberton Power Company, West Mahoney, PA	1988	100% Anthracite waste	2 x 355,000 lb/hr	1,500 psig; 955°F	Cogeneration
P.H. Glatfelter, Springs Grove, PA	1988	Coal, wood, culm, oil	400,000 lb/hr	1,500 psig; 950°F	Cogeneration

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to Pyropower in the U.S.) and Lurgi (licensed to Combustion Engineering in the U.S.). Studsvik of Sweden (licensed to Babcock and Wilcox in the U.S.) is not as advanced, but it has experimental and developmental facilities.

About 40 commercial CFB boilers are operating around the world 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. All of the currently operating units, except the CUEA Nucla, are small by utility standards, ranging from 50,000 to 500,000 lb/hr steam. Finland and the U.S. lead the world in CFB units in operation. Domestic plants, furnished by Pyropower, and their locations are listed in Table 1. Excluding the CUEA Nucla CFB unit to be tested under this Cooperative Agreement, the largest Pyropower CFB unit currently operating in the U.S. is operated by Corn Products, Inc., in Stockton, California. The CUEA Nucla unit at 925,000 lb/hr (100 MWe) is almost twice the size of the Corn Products, Inc., unit.

The U.S. electric utility industry currently projects a demand, beginning in the next 10 years, for small 100 to 200 MWe generation units both as add-on capacity and for repowering or retrofitting aging power plants. The primary candidates to meet this demand are fluidized-bed boilers, pulverized coal-fired boilers with flue gas desulfurization, and integrated gasification combined-cycle (IGCC) units. The CFB boiler excels as a candidate, because of its high combustion efficiency and low nitrogen and sulfur oxide emissions.

Although demonstrated to be commercially viable at small scale, CFB combustion has not been demonstrated at utility scale. Major concerns remain to be resolved before CFB combustion will be accepted by the utility industry:

- 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 superheater surfaces in the combustor withstand the hostile environment?

- Will the refractory-lined combustor and cyclone walls be sufficiently erosion and corrosion resistant to meet utility requirements?

- Are unit control, operability, reliability, maintainability, turndown, and cycling characteristics adequate for utility application?

The CUEA Nucla CFB Demonstration 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. In the combustion chamber, a stream of air fluidizes and entrains the bed material, which includes coal, coal ash, and a sulfur absorbent such as limestone. Combustion takes place at relatively low temperatures of 1,500° to 1,600°F. As the coal burns, it emits sulfur oxides, which are chemically combined with the calcium in the absorbant. Hot combustion gases, unused limestone, partially burned fuel, and fly ash reach the top of the combustion chamber and flow into a large hot cyclone. The cyclone separates the solids from the gases and the solids are recycled to the combustion chamber through a loop seal. This continuous circulation of coal and absorbant at high-velocity improves the mixing and extends the contact time of solids and gases, thus promoting high utilization of carbon in the fuel and high sulfur capture efficiency.

The general layout of the Nucla CFB plant is presented in Figures 2 and 3. The plant can be divided into five major process subsystems:

- Coal and limestone preparation, where the coal is crushed to less than 1/4 inch and limestone is pulverized to a fine powder.
- The CFB boiler, including the combustor, the hot cyclone, the heat transfer area, ash cooling, and the air preheater.
- The flue gas cleanup baghouse.
- The power generation system.
- The plant water treatment system.

Table 2 presents general information for the plant and anticipated operating characteristics.

TABLE 2. Nucla Plant Statistics

Plant Height	180 ft
Boiler Area	1,260 sq ft
Gross Electric Generation	110 MW
Bed Temperature	1,500°F
Steam Temperature	1,005°F
Steam Pressure	1,510 psig
Full-Load Coal Feed Rate	116,400 lb/hr
Full-Load Limestone Feed Rate	4,420 lb/hr
Main Steam Flow Rate	925,000 lb/hr
Predicted Boiler Efficiency	88 to 89%

During the project period, the Nucla plant will be operated like any other commercial power plant, feeding power into CUEA's electrical power grid. CUEA does not anticipate the need to utilize the plant continuously at full load during the project period and, within the constraints of its power grid, will make the plant available for operation under test conditions.

3.3 GENERAL FEATURES OF PROJECT

3.3.1 Evaluation of Developmental Risk

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

CUEA's Nucla CFB Demonstration Project includes a physically completed plant which is in the advanced stages of start-up. Recently, a performance run was conducted at a full output of 110 MWe. Testing facilities are already physically in place and formulation of test programs and plans is nearing completion. Operating staff is in place and learning to operate the facility routinely. The CFB boiler supplier, Pyropower, is contractually bound to make the boiler perform adequately to meet the stringent criteria of the acceptance tests. This advanced state of project development significantly reduces programmatic risk below that of most of the other Clean Coal Technology projects. The risks that were identified are discussed in more detail under 3.3.1.2, Technical Feasibility. These risks underscore the need for a demonstration project. Based on the reasonable assumption that the Nucla plant will perform according to design specifications prior to the start of Phase III activities, there is only a low risk that the planned evaluation program will not be completed for technical reasons.

CUEA has agreed that the Nucla plant will be available for testing during a 2-year period ending in 1990, after which the plant will be needed to serve CUEA's commercial power grid. During the test period the plant will also be called upon to help provide power during peak loads, and the power grid must be able to absorb the power generated by the plant during the testing period. The very comprehensive testing program presented in CUEA's test plan must be completed under these constraints.

DOE estimates of the time required to complete the proposed test plan, given a first-of-a-kind plant and the constraints presented above, indicate the 2-year test program will be adequate for the production of sufficient performance data to permit evaluation of commercial performance by DOE, EPRI, and the utility industry. To mitigate the risk associated with the possibility that insufficient test data will be available at the end of the 2-year test period, DOE has the right to continue the test program beyond 2 years if desired.

3.3.1.1 Similarity of Project to Other Demonstration and Commercial Efforts

About 40 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 fuels used in these units. By utility standards, all of these units are small. The CUEA Nucla facility, rated at 925,000 lbs/hr of steam, is nearly twice the size of any U.S. installation listed in Table 1. Another unique feature of the Nucla facility is its application as base load for a utility.

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 on a smaller scale in a number of installations, most of which are outside the U.S. These smaller scale units have not operated free from difficulties; however, the basic process features have been well demonstrated and accepted. Pyropower presently has 22 CFB units in operation with over 335,000 operating hours and 95.8 percent availability. While a major issue of CFB technology is scale-up from these industrial installations, the scale-up to the Nucla installation does not deviate from the basic design philosophy of past installations. For example, General Motors Corporation has a 300,000 lb/hr steam generating unit in operation, burning 2.5 percent sulfur coal, that has demonstrated compliance with environmental emission standards. In addition, a 500,000 lb/hr steam generating unit has been installed at Corn Products Corporation (CPC) in California and is scheduled to begin commercial operations in 1988. The significant features of this CPC installation are that there are performance guarantees to meet the stringent emission limitations in California and that the combustor, cyclones, heat exchangers, and ancillary equipment are essentially the same as the Nucla unit. The Nucla CFB will generate 925,000 lb/hr of steam, which is accomplished in two parallel boiler sections, each of which is the same size as the boiler at CPC in California. Thus, the scale-up concerns are significantly reduced because of the particular design of the Nucla plant. However, this is not to imply that there are not risks associated with demonstration of CFB technology in a utility application. The major concerns at the Nucla plant are listed below. These technical concerns essentially establish the need for a demonstration test program that will define the limitations and establish the technical viability of the technology in commercial operation on a utility grid.

- Combustion chamber configuration and efficiency.
- Performance and life of extra thick refractory-lined ducting.
- Performance of the massive high-temperature, refractory-lined cyclones.
- Operation of the recirculation loop seal.
- Erosion, corrosion, and deposition for materials and components.
- Gas/solids mixing in the bed.
- Superheater life.
- Transient responsiveness and dynamics.
- Fines generation and management.

Another area of potential concern regarding the performance of the Nucla plant is that the new CFB boiler was used to repower a "mothballed" power station. Numerous utilities in the United States are facing the reality of aging electrical generating stations, and this project is intended to demonstrate the feasibility of repowering such stations. As a result, the Nucla CFB boiler is integrated with, and dependent on, a number of refurbished support units. The general plant infrastructure support systems, makeup water intake system, and the three 12-MWe turbine generators were initially installed in 1959. Other system components, such as the coal handling equipment, the cooling tower, and three of the four baghouses, were installed between 1973 and 1974 while the fourth baghouse was installed at the same time as the CFB boiler. Obviously, the overall service factor of the Nucla plant will be significantly influenced by the durability and reliability of these refurbished system components. The demonstration test program is specifically oriented to address these reliability concerns.

A third principal area of concern with regard to the performance and service factors of the Nucla plant is that only a minimal degree of equipment back-up has been provided. Spares have not been provided for the primary and secondary air fans, induced draft fans, or the bottom ash cooling fans. In addition, although there are two separate cyclones, they cannot be operated independently. No automatic or manual bypass has been provided on the high-pressure steam system, and no separate means for quickly dumping hot bed material has been provided.

None of these technical concerns is considered a major obstacle to successful completion of the test program. While there are uncertainties concerning the sustained operability of the plant, it must be realized that the test program assumes a 50 percent service factor, not the 80 percent service factor that is expected of the commercial facility. This service factor is considered reasonable for a demonstration project and should not impact adversely on the test program. The effect of technical uncertainties on the test program will be small since the test program is laid out in short-duration, discrete elements that can be completed during any time that the Nucla plant is operating.

Pyropower is obligated to demonstrate unit performance at 110-MWe design conditions. This guarantee mitigates much of the risk associated with basic operability and kinetic performance of the unit, although it will have little effect on service life, transient behavior, and service factor. Since the proposed test program will not be initiated until after successful completion of Pyropower's acceptance test, the technical risk is significantly reduced. In fact, the plant has already been operated at full nameplate rating of 110-MWe gross output for short periods during recent start-up runs. This 110-MWe performance is a positive sign that the plant will be capable of operating at design conditions for sustained periods.

3.3.1.3 Resource Availability

All of the resources required for the project are available. CUEA has pledged the existing Nucla CFB facility and its share of project costs as prescribed in the Cooperative Agreement for 2 years of operation. The plant is staffed and contracts are in place for the required supplies and feedstocks.

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

The U.S. electric utility industry currently projects a demand, beginning in the next 10 years, for small 100- to 200-MWe generation units as add-on capacity and for repowering or retrofitting aging power plants. The CUEA Nucla CFB Demonstration Project, rated 110 MWe, is sized to demonstrate the technology at the low end of this range. Scaling to the upper end of the range is within the limits of accepted scale-up practice. In many applications, the CFB and its ancillary equipment may only require duplication, rather than scaling-up.

3.3.3 Role of Project in Achieving Commercial Feasibility of Technology

To facilitate commercialization, CUEA is involving other utilities, EPRI, and DOE to provide accurate, reliable, and first-hand knowledge on CFB technology to the utility industry. Utilities must be confident that the process will work at the 100-MWe to 200-MWe scale before orders will be placed.

The Nucla CFB Demonstration Project represents a scale-up of about two to one from the largest operating industrial CFB boiler and a proportionate increase in the size of all related equipment. The testing and documentation of the costs, operational characteristics, and scale-up success of the Nucla CFB Demonstration Project will provide utilities with information they will need to plan for replacement, retrofit, and new generating capacity in the near future.

Upon start-up of the Nucla CFB Project, the 2-year test program will establish operating parameters and evaluate costs. Fuel efficiencies will be confirmed and various fuels and sorbents will be tested to determine their costs and ability to minimize unwanted emissions. The project also entails the development of a computer model based on various grades of coals and sorbents, which will be useful for evaluating costs and future unit designs.

The 2-year test program will provide utilities substantial information to enable utility executives to fairly and accurately evaluate the CFB technology and permit the application of 100- to 200-MWe size boilers by the early 1990's. The initial commercial orders would likely be very close to the design of the Nucla boilers. This would save engineering and design 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. In this project, the environmental information was contained in an Environmental Assessment prepared by the Rural Electrification Administration in November of 1984. This detailed site and project-specific information was used as the basis for the NEPA review performed by DOE. Based on this review, DOE concluded that its involvement in the project, which is limited to receipt of data to be generated from project operation, clearly does not constitute a major Federal action significantly affecting the quality of the human environment. In accordance with the DOE guidance for implementing NEPA, this determination was documented in a Memorandum-to-File, and no further NEPA review is required.

5.0 PROJECT MANAGEMENT

5.1 OVERVIEW OF MANAGEMENT ORGANIZATION

The Participant will manage the project through a Project Manager, who will be assisted by a technical and managerial team (see Figure 4). This team includes personnel from the Electric Power Research Institute (test program manager) and Pyropower (the boiler manufacturer). Assisting this team is a Technical Advisory Group (TAG) consisting of other utilities, A&E firms, and other interested parties. The TAG was established by CUEA to obtain broad-based expertise for the project and to provide firsthand knowledge of the technology to the members for commercializing the technology.

CUEA will operate and maintain the Nucla plant during the project period. EPRI has primary responsibility to CUEA for the development and operation of the testing program. The testing program includes formulation of tests, collection and analysis of data, and dissemination of test results. EPRI will periodically review the testing program's overall progress and direction to ensure that the testing, when completed, will meet the goals of the project.

5.2 IDENTIFICATION OF RESPECTIVE ROLES AND RESPONSIBILITIES

5.2.1 DOE

DOE will be responsible for monitoring all aspects of the project and for granting or denying approvals required by the Cooperative Agreement.

5.2.2 Participant

Colorado-Ute Electric Association, Inc., as the Participant, will be responsible for all aspects of the project, including test design, operation, data collection, and reporting. The Participant will designate a Project Manager who will be responsible for all technical and administrative activities under the Cooperative Agreement.

5.3 PROJECT IMPLEMENTATION AND CONTROL PROCEDURES

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

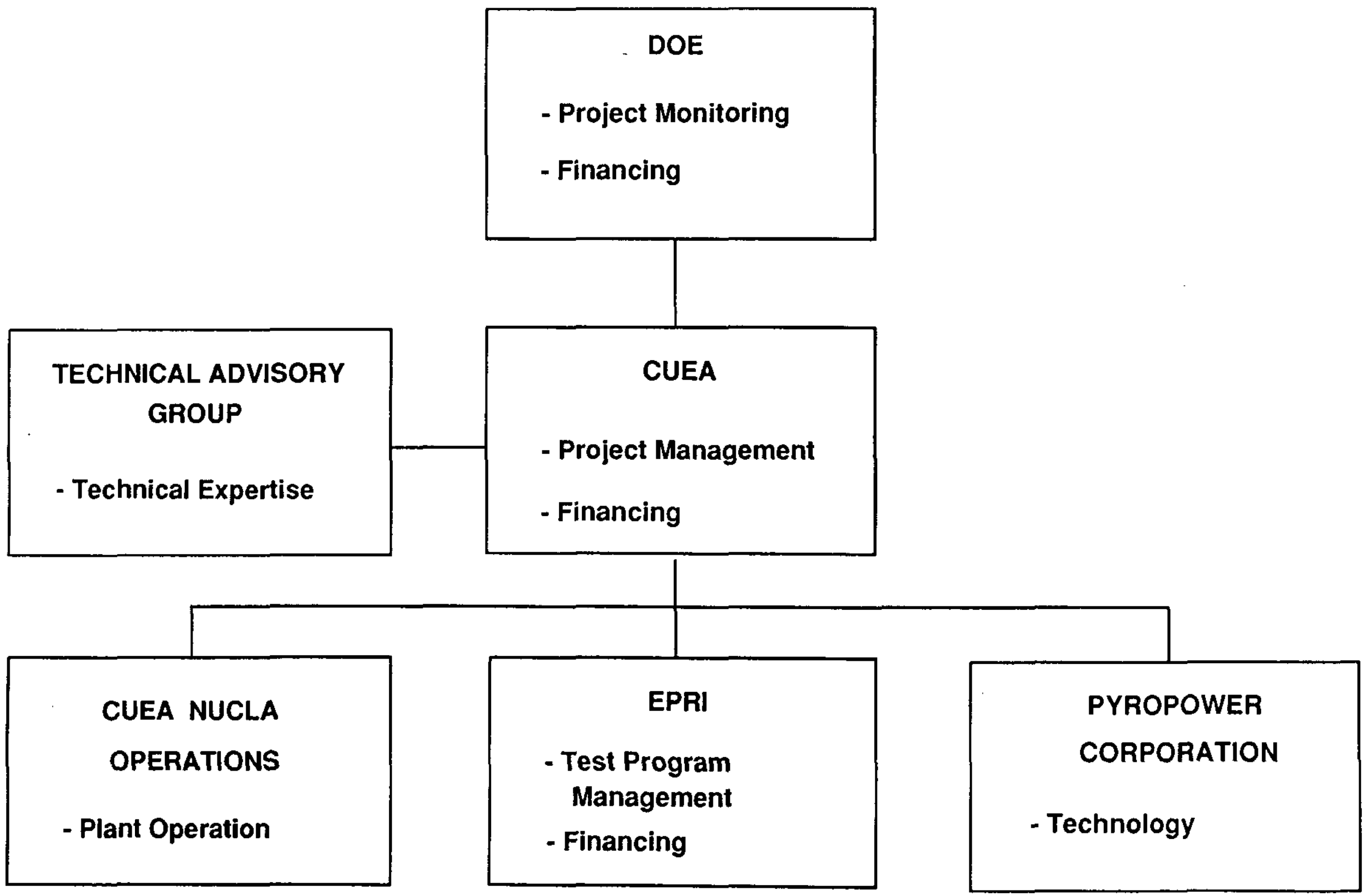


Figure 4. Project Organization

C88-1711-A CC8

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 CUEA and its subcontractors. DOE will have the further right to have most 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, CUEA has made an express contractual commitment to exercise its best efforts to commercialize, or to assist others to commercialize, in the United States, the Pyropower circulating fluidized-bed technology. In addition, Pyropower and its parent company, A. Ahlstrom Corporation, have both executed a letter of commitment to commercialize the technology, that commitment being valid for a 10-year period beginning in May 1988.

Pyropower 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, nontransferrable, and irrevocable paid-up license to practice or to have practiced any waived subject invention by or on behalf of the United States.

5.5 PROCEDURES FOR COMMERCIALIZATION OF TECHNOLOGY

Operation of the Nucla 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 include actual integration of the CFB boiler into a commercial power plant. The Nucla CFB Demonstration Project will accomplish this and serve as an operating model at commercial scale which the private sector can use in making rational commercialization decisions.

When CFB combustion technology is successfully demonstrated at the nominal 110-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 power plants and building small power generation units 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 small enough to provide good load-growth matching without over capacity.

- 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 very low environmental impact.

6.0 PROJECT COST AND EVENT SCHEDULING

6.1 PROJECT BASELINE COSTS

CUEA and DOE have agreed to share the cost of a 2-year test program at the Nucla CFB facility. The test program corresponds to Phase III as defined in the PON. The design and construction of the facility, corresponding to Phases I and II, are not part of the Cooperative Agreement between CUEA and DOE. These two phases will have been completed prior to execution of the Cooperative Agreement by the DOE. The total estimated project costs applicable to the Cooperative Agreement are as follows:

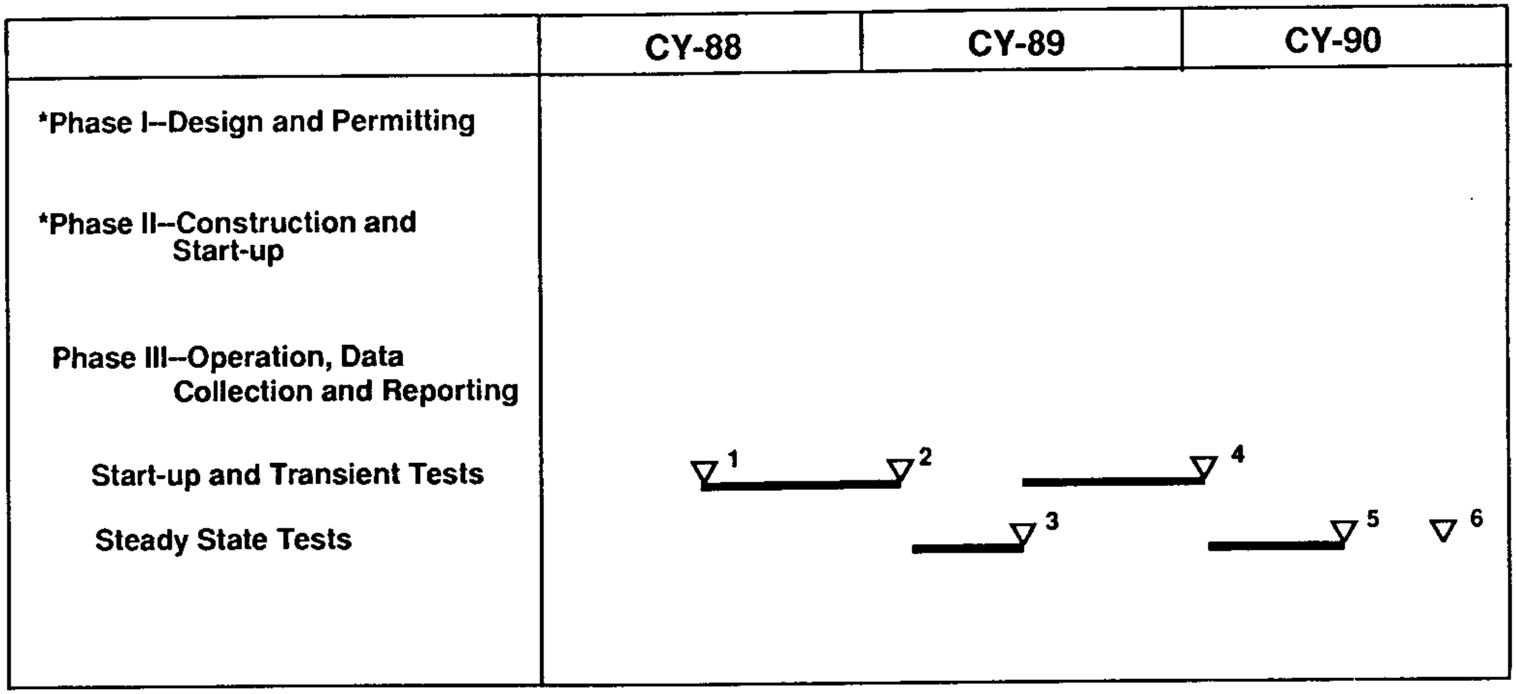
	Amount	Percent
DOE Share	19,920,000	36.8
Participant Share	34,167,000	63.2
Total	54,087,000	100

6.2 MILESTONE SCHEDULE

A project schedule is shown in Figure 5.

6.3 RECOUPMENT PLAN

In response to the stated policy of the DOE to recover an amount up to the Government's contribution to the project, the Participant agreed to repay the Government in accordance with the Recoupment Plan included in the Cooperative Agreement.



* Phase will have been completed prior to execution of the Cooperative Agreement by DOE

Milestone	Description
1	Execute Cooperative Agreement
2	Complete first set of Start-up and Transient Tests
3	Complete first set of Steady State Tests
4	Complete second set of Start-up and Transient Tests
5	Complete second set of Steady State Tests
6	Issue Final Report

Figure 5. Project Schedule

C88-1711-B CC8