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Comprehensive Report to Congress Clean Coal Technology Program

Healy Clean Coal Project

A Project Proposed By: Alaska Industrial Development and Export Authority

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

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TABLE OF CONTENTS

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

In September 1988, Congress provided $575 million to conduct cost-shared Clean Coal Technology (CCT) projects to demonstrate technologies that are capable of retrofitting or repowering existing facilities. To that end, a Program Opportunity Notice (PON) was issued by the Department of Energy (DOE) in May 1989, soliciting proposals to demonstrate innovative energy efficient technologies that were capable of being commercialized in the 1990s, and were 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.

In response to the PON, 48 proposals were received in August 1989. After evaluation, 13 projects were selected in December 1989 as best furthering the goals and objectives of the PON. The projects were located in 10 different states and represented a variety of technologies.

One of the 13 projects selected for funding is the Healy Clean Coal Project proposed by the Alaska Industrial Development and Export Authority (AIDEA). This project will demonstrate the combined removal of SO_2, NO_x, and particulates from a new, 50 megawatt electric (MWe) coal-fired power plant using both innovative combustion and flue gas cleanup techniques.

Coal provided by the Usibelli Coal Mine, adjacent to the project site, will be pulverized and burned at the new facility to generate high-pressure steam. The high-pressure steam will be supplied to a steam turbine generator to produce electricity. Emissions of SO_2 and NO_x from the plant will be controlled using TRW's entrained combustor with limestone injection in conjunction with a boiler designed by Foster Wheeler. Further SO_2 and particulate removal will be accomplished using the Activated Recycle Spray Dryer Absorber System developed by Joy Technologies, Inc.

The TRW Entrained Combustor is designed to operate under fuel-rich conditions, utilizing staged combustion to minimize NO_x formation. These conditions are obtained using a precombustor for heating the fuel-rich main combustor for partial combustion with combustion completion occurring in the boiler. The first and second stages of combustion produce a temperature high enough to generate a slag (liquid ash) while reducing the fuel-bound nitrogen to molecular nitrogen (N_2). The final stage of combustion in the boiler occurs at a combustion temperature maintained below the temperature that will cause thermal NO_x formation.

The combustor is also used to reduce SO_2 emissions by the injection of pulverized limestone into the hot gases as they leave the combustor and enter the furnace. This technique changes the limestone into lime (flash calcination), which reacts with the sulfur compounds in the exhaust gas to form calcium sulfate. The flue gas, which contains the remaining sulfur compounds, calcium sulfate, and other solid particles leaves the boiler and passes through a spray dryer absorber and a bag filter for further SO_2 and particulate removal prior to exiting through the stack.

The innovative concept to be demonstrated is the reuse of the unreacted lime, which contains minimal fly ash, in the second-stage SO_2 removal. The majority of fuel ash was removed in the combustor in the form of slag. A portion of the solids collected from the spray dry absorber vessel and the bag filter are first slurried with water, chemically and physically activated, and then atomized in the spray dryer absorber vessel for second-stage SO_2 removal. Third stage SO_2 and particulate removal occurs in the bag filter as the flue gas passes through the reactive filter cake in the bags.

The use of limestone in the combustor, combined with the recycle system, displaces the more expensive lime required by commercial spray dryer absorbers, reduces plant wastes, and increases SO_2 removal efficiency when burning high- and low-sulfur coals.

The integrated process is expected to achieve SO_2 removal greater than 90%, a reduction in NO_x emissions to 0.2 pounds per million Btu, and a combustion efficiency of greater than 99.5%. The integrated process is suited for new facilities or for repowering or retrofitting existing facilities. It provides an alternative technology to conventional pulverized coal-fired boiler flue gas desulfurization (FGD) and NO_x reduction processes, while lowering overall operating costs and reducing the quantity of solid wastes.

The demonstration project will be built adjacent to the Golden Valley Electric Association (GVEA) existing Healy No. 1 pulverized coal-fired power plant. This site is located near Healy, Alaska, as shown in Figure 1. Alaskan bituminous and subbituminous coal (0.2 to 1.0% sulfur) will be tested by the project.

FIGURE 1. HEALY CLEAN COAL DEMONSTRATION PROJECT LOCATION.

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This demonstration project will be performed over a 72-month period and project activities include design, permitting, procurement, fabrication, construction, start-up, testing, and reporting of results. Following completion of the demonstration test program, the plant will continue to be operated and maintained as a commercial utility electric generation station.

The total project cost is $193,407,000. The co-funders are DOE ($93,862,000) and AIDEA ($99,545,000). Testing is scheduled to begin in the first quarter of 1996. Overall project completion is scheduled to occur in late 1996.

2.0 INTRODUCTION AND BACKGROUND

2.1 Requirement for a 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 (NEPA), the Council on Environmental Quality regulations for implementing NEPA (40 CFR 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 Alaska Industrial Development and Export Authority (AIDEA) Healy Clean Coal Project (HCCP) will demonstrate that the combination of TRW's Entrained Combustion System with limestone injection and Joy Technologies, Inc.'s (Joy), Activated Recycle Spray Dryer Absorber System is an efficient and economical means of removing the acid rain precursors (SO_2 and NO_x) from utility and industrial boiler flue gas.

The primary advantage of the integrated process over conventional pollution control processes is the combined removal of SO_2, NO_x, and particulates and the reuse of waste products from the bag filter for efficient second-stage SO_2 removal. The integrated process efficiently removes SO_2 even when burning high-sulfur coal, eliminates the need for expensive spray dryer absorber lime, minimizes solid and liquid waste products, and improves boiler combustion efficiency. These factors will make the technology attractive for new projects, repowering projects, and retrofit applications.

The demonstration project will be built adjacent to the Golden Valley Electric Association (GVEA) existing Healy No. 1 pulverized coal-fired power plant. GVEA will operate the plant during the demonstration and after the demonstration period when the plant is commercially operated. Alaskan bituminous and subbituminous coal (0.2 to 1.0% sulfur) will be used during the project. Design fuel will be a blend of currently wasted (high-ash) coal and run-of-mine coal provided by the Usibelli Coal Mine located adjacent to the Healy Plant.

The goal of this demonstration program is to demonstrate the technical and economic viability of the process. If successful, the process will achieve greater than 90% SO_2 removal, NO_x emissions of less than 0.2 pounds per million Btu, and greater than 99.5% combustion efficiency while firing a low-Btu, high-ash coal blend.

3.1.1 Project Summary

Project Title:	Healy Clean Coal Project
Proposer:	Alaska Industrial Development and Export Authority (AIDEA)
Project Location:	Healy, Alaska
Technology:	Entrained Combustion With Limestone Injection and Activated Recycle Spray Dryer Absorber Systems
Application:	Retrofit, Repowering, and New Coal-Fired Industrial and Utility Boilers
Types of Coal Used:	Low-Sulfur Alaskan Bituminous and Subbituminous Coals (0.2 to 1.0% Sulfur) - High-Ash Waste Coal
Product:	Environmental Control Technology
Project Size:	50 MWe
Project Start Date:	January 1991
Project End Date:	December 1996

3.1.2 Project Sponsorship and Cost

Project Sponsor: Alaska Industrial Development and Export Authority

Estimated Project Cost: $193,407,000

Cost Distribution:	Participant Share (%)	DOE Share (%)
	51.5	48.5

3.2 Integrated Entrained Combustion and Activated Recycle Spray Dryer Absorber System

3.2.1 Overview of Process Development

TRW Entrained Combustion System

TRW has been involved in the development of entrained combustors since the mid-1970s. TRW, DOE, and the Empire State Electric Energy Research Corporation (ESEERCO) have supported the development of both atmospheric pressure retrofit combustors and pressurized (six atmospheres) magnetohydrodynamic (MHD) combustors.

To date, over 1,100 tests have been performed on developmental combustors ranging in size from 1 to 200 million Btu/hr. Approximately half of these tests have been conducted in 10 and 50 million Btu/hr, one-atmosphere test units using a total of 15 different types of pulverized coals and coal-water slurries. The primary purpose of these tests was to develop hardware geometry and operating conditions to achieve 80-90% ash (slag) removal, while maintaining low NO_x emissions and high combustion efficiency. SO_2 reduction and configuration testing has been performed primarily at the 50 million Btu/hr scale.

With funding from the Ohio Coal Development Office (OCDO) and fifteen major industrial and utility corporations, a demonstration program was initiated in 1984 at TRW's manufacturing facility in Cleveland, Ohio. As part of the demonstration, a 50 million Btu/hr entrained combustor was retrofitted to an existing 30,000 lb/hr industrial boiler. More than 7500 hours of operation has been performed since the retrofit was completed. An OCDO-supported program is currently in progress at the Cleveland facility to test low-, medium-, and high-sulfur coals so that the data can be compared with Limestone Injection Multistage Burner (LIMB) data.

Activated Recycle Spray Dryer Absorber

Joy has been a leader in the development of the spray dryer absorption process. Many pilot- and full-scale tests have been performed by Joy using various absorbents from all over the world, including different types of calcined limestone materials. The first full-scale spray absorption system was placed in operation in 1983 at Antelope Valley Units No. 1 and No. 2. The system has achieved more than 85% SO_2 removal using high-calcium lignite ash as the sorbent.

Most of Joy's pilot-scale work has been performed at the Niro Atomizer Copenhagen Research Station. This plant can accurately simulate full-scale conditions and generate data for scaleup and design of full-scale utility FGD systems.

In 1981, pilot tests were performed at the Copenhagen facility with Flash Calcined Material (FCM) from Gardanne, France, and similar tests were performed in 1982 with FCM from the Voitsberg III power station in Austria. The Voitsberg III FCM was used as the sorbent in the spray dryer absorber system and an electrostatic precipitator was used as the dust collector. The tests achieved 55% to 95% SO_2 removal depending upon inlet SO_2 concentration. In 1984, extensive pilot tests were performed with high-calcium ash from West Germany. The tests achieved 85% to 98% SO_2 removal efficiency with the ash. In 1986, pilot tests were performed with FCM from Malmo Energiwerk, Sweden, and Institut fur Energetik, East Germany. The success of these tests resulted in the East Germans' use of FCM with the spray dryer absorber technology on several of their lignite-fired boilers.

Many of the tests using FCM were performed by injecting the material upstream of the spray dryer absorber, thereby simulating the combination of TRW's flash calcined material and the spray dryer absorber technology.

A full-scale demonstration using FCM in an FGD system was performed in Salzburg, East Germany, in 1988. The demonstration achieved 98% SO_2 removal using FCM containing 20-25% calcium oxide. Subsequently, Niro received an order for the Salzburg Nord FGD system, which will utilize FCM with 20-30% calcium oxide as the absorbent.

Full-scale utility demonstrations were also performed in 1989 at Northern States Power Company's Sherco Unit No. 3. The demonstrations showed that the required SO_2 removal efficiency can be attained using high-calcium ash as a sorbent. Other tests at Sherco Unit No. 3 using limestone, injected into the absorber, proved unsuccessful.

3.2.2 Process Description

AIDEA proposes to demonstrate a combination of combustion and post-combustion techniques by which SO_2, NO_x, and particulate emissions from pulverized coal-fired boilers can be reduced. The following describes the proposed techniques to be combined into the demonstration process.

TRW Entrained Combustion System

The TRW Entrained Combustion System is designed to be installed on boiler furnace walls in various arrangements that provide efficient combustion, maintain effective SO_2 removal, and minimize the formation of NO_x. As shown in Figure 2, the main system components include a precombustor, a main combustor, slag recovery section, secondary air windbox, pulverized coal and limestone feed system, and combustion air system.

The coal fired precombustor is used to increase the air inlet temperature to the main combustor for optimum slagging performance. It burns approximately 20-35% of the total coal input to the combustor and combustion is staged to minimize NO_x formation.

The main combustor consists of a water-cooled cylinder which is sloped toward a slag opening. The remaining coal is injected axially into the combustor, rapidly entrained by the swirling precombustor gases and additional air flow, and burned under sub-stoichiometric (fuel-rich) conditions for NO_x control. The ash contained in the burning coal forms drops of molten slag and accumulates on the water-cooled walls as a result of the centrifugal force resulting from the swirling gas flow. The molten slag is driven by aerodynamic and gravity forces through a slot into the bottom of the slag recovery section where it falls into a water-filled tank and is removed by the slag removal system. Approximately 80% of the ash in the coal is removed as molten slag.

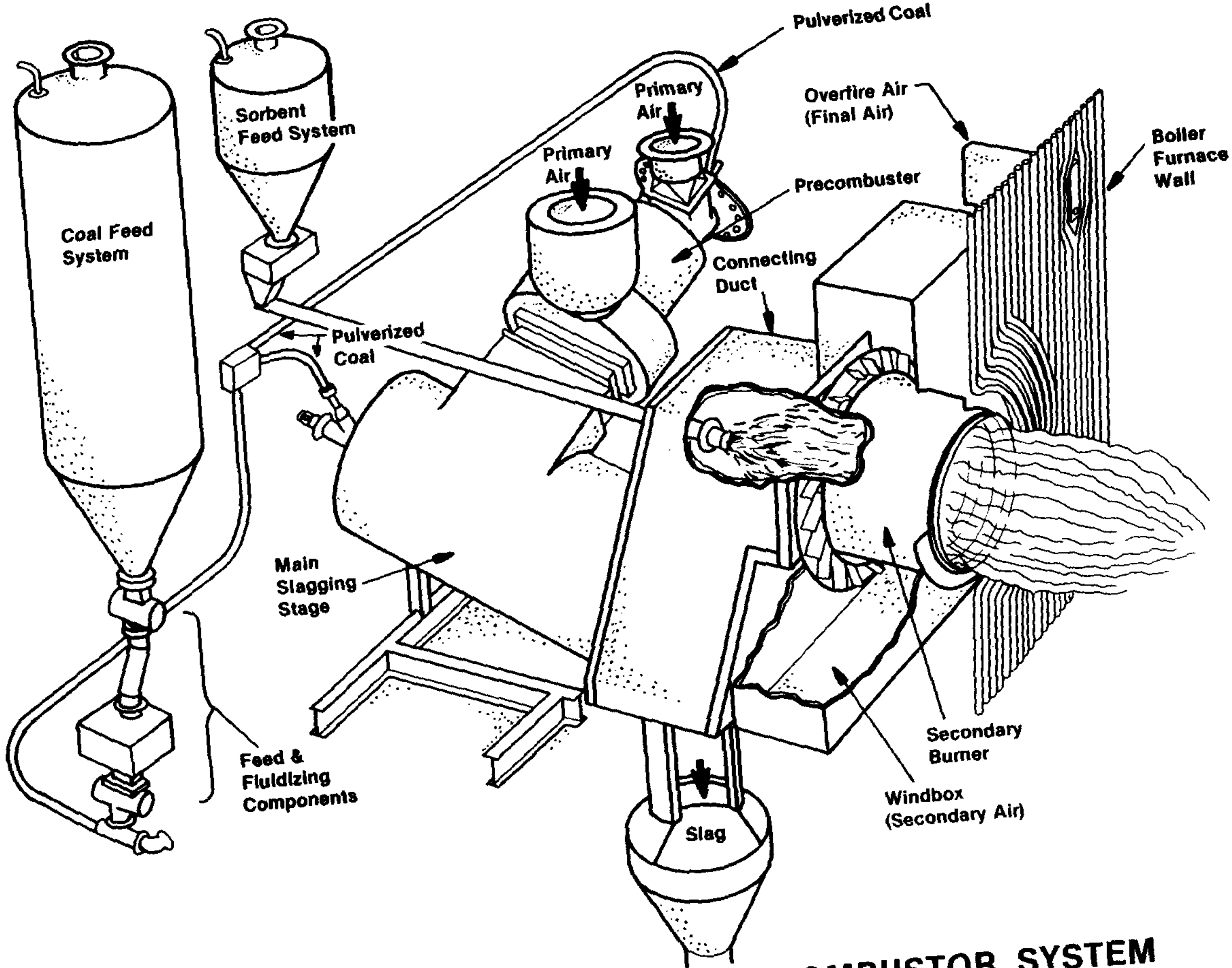

FIGURE 2. TRW ENTRAINED COAL COMBUSTOR SYSTEM

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The hot gas, rich in carbon monoxide and hydrogen, is then ducted to the furnace from the slag recovery section through the hot gas exhaust duct. To ensure complete combustion in the furnace, additional air is supplied from the secondary air windbox, from NO_x control ports located on both sides of the exhaust duct, and from overfire final air ports located above the exhaust duct.

First-stage SO_2 removal is accomplished by injecting a sorbent, such as limestone, into the combustor hot gas exhaust duct. The limestone is converted into lime by the rapid absorption of heat (flash calcined). As the FCM and fly ash pass through the boiler, SO_2 is absorbed by the FCM and the solid particles are then removed by the bag filter downstream of the spray dryer absorber system.

<u>Activated Recycle Spray Dryer Absorber System</u>

The material collected from the spray dryer absorber and the bag filter consists of calcium sulfate, minor amounts of non-reactive lime, fly ash, and unreacted lime FCM. These materials are normally discarded as plant waste, because the calcium sulfate disperses on the surface of the lime particles and blocks the pores. As such, the unreacted lime is not effectively reusable in the spray dryer absorber.

The Activated Recycle Spray Dryer System, however, is designed to reuse the unreacted lime. As shown in Figure 3, the collected material is made into a slurry in a heated mixing tank, activated by abrasive grinding in a pulverizer, and pumped back to the spray dryer absorber where it is atomized for maximum surface contact with the sulfur compounds in the flue gas. Activation of the material provides optimum conditions for slaking of the calcined lime, avoids the formation of coarse calcium hydroxide particles due to the presence of sulfate, and increases the surface area of the lime particles.

The use of inexpensive limestone for first-stage SO_2 removal combined with the recycle of activated flash-calcined lime for second- and third-stage SO_2 removal produces high removal efficiencies and reduces plant material costs and plant wastes.

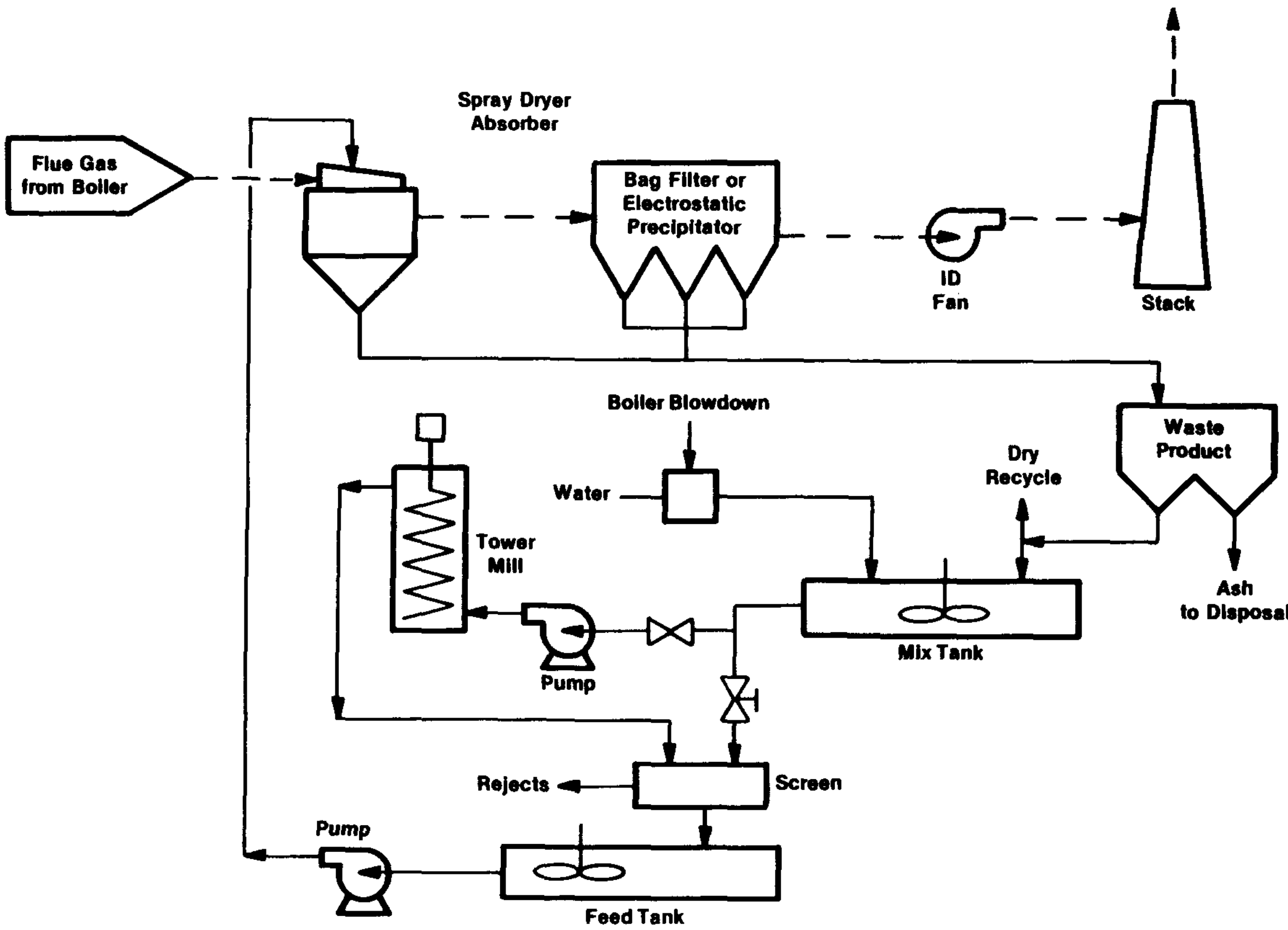

FIGURE 3. JOY ACTIVATED RECYCLE SPRAY DRYER ABSORBER SYSTEM SCHEMATIC.

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3.2.3 Application of Process in Proposed Project

The Healy Clean Coal Project will be a nominal 50 MWe facility consisting of a pulverized-coal-fired boiler, spray dryer absorber with activation and recycle equipment, bag filter, turbine generator, coal and limestone pulverizing and handling equipment, and associated auxiliary equipment. The boiler will be provided with two or three TRW Entrained Combustors. Figure 4 is an overall process schematic for the proposed project.

The specific objectives of the Healy Clean Coal Project demonstration are to: (1) demonstrate the use of Alaskan, low-sulfur bituminous and subbituminous coals of medium to high ash and moisture content; (2) demonstrate large utility boiler repowering capability of the TRW Entrained Combustion System; (3) demonstrate large utility boiler retrofit capability of the TRW Entrained Combustion System on oil-designed boilers with no derating and on pulverized coal and cyclone furnace design boilers with improved performance, and lower NO_x, SO_2, and particulate emissions; (4) demonstrate the TRW Entrained Combustion System's capability to simultaneously control NO_x and SO_2 using interfire NO_x ports, overfire air ports and limestone injection into the combustion products; (5) demonstrate the enhanced capability of the TRW Entrained Combustion System for simultaneous NO_x and SO_2 removal when combined with back-end SO_2 absorption techniques; (6) demonstrate the energy efficiency of the integrated technology; and (7) demonstrate the cost effectiveness of the technology.

3.3 General Features of the Project

3.3.1 Evaluation of Developmental Risk

As described earlier, much prior work has been performed on the individual portions of the process. The basic principles of the process are similar to other commercially available combustion and post-combustion technologies.

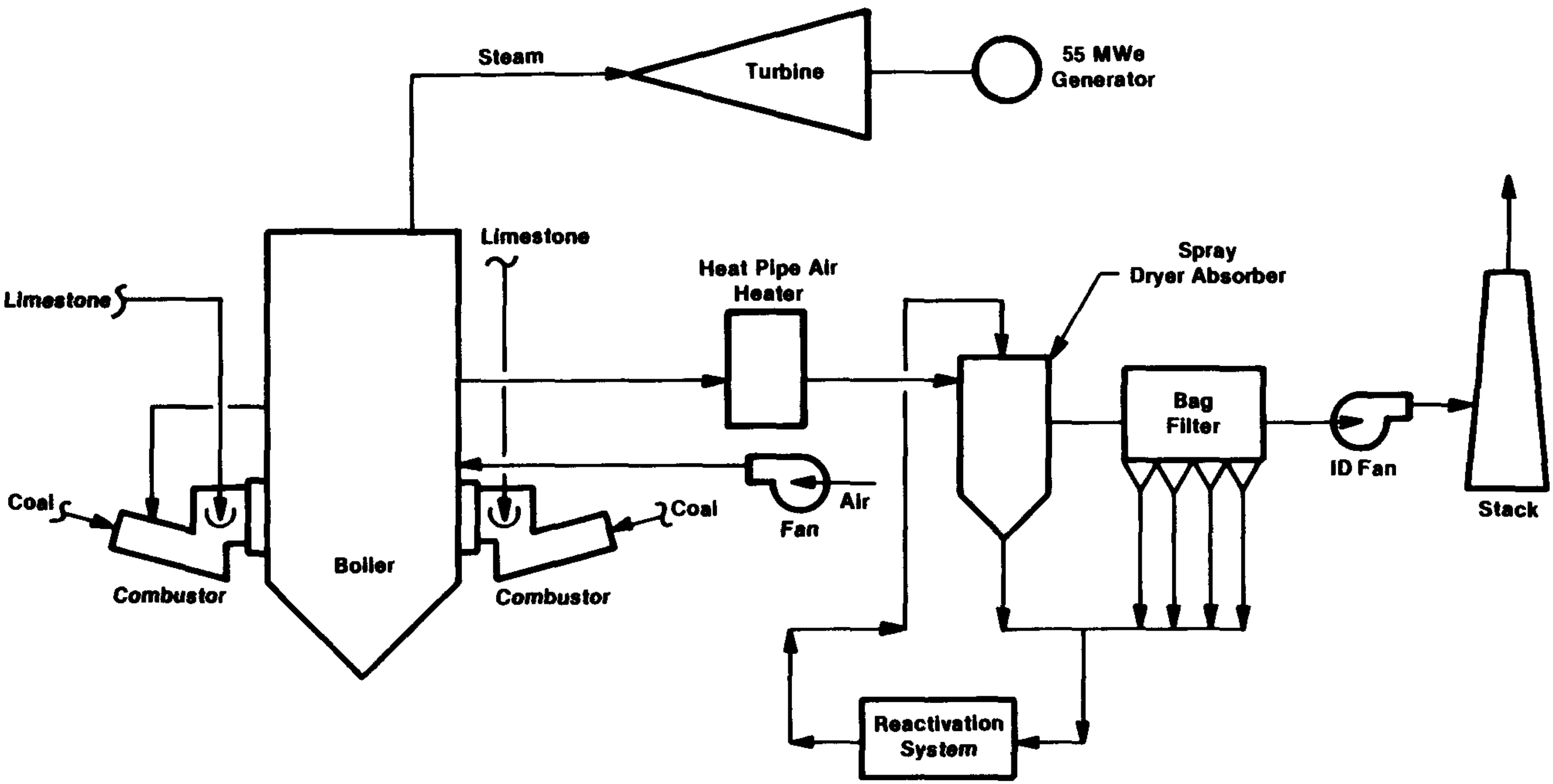

FIGURE 4. HEALY CLEAN COAL DEMONSTRATION PLANT PROCESS FLOW DIAGRAM.

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There is some risk, however, associated with this demonstration project, as described below:

- Problems may be encountered in scaling up to the combustors' size.
- The combustor cooling water circuit will use boiler water, taken from the new boiler's steam drum, as the cooling medium. This is different than previous designs and results in a two-phase (liquid-vapor) stream containing approximately 5% steam in the combustor coolant exit stream.
- Proper reaction between injected sorbent and flue gases may not be achieved and the reactivation of the calcined lime may be less efficient than that experienced in pilot-scale tests.
- High SO_2 removal (%) efficiencies may not be achievable using both low- and high-sulfur coals.

Although there is a small risk associated with scaleup of the combustor, the experience gained from the Cleveland demonstration project and TRW's continuing developmental effort will allow the larger combustors to be designed with a high degree of confidence in their reliability.

The two-phase flow in the combustor cooling system should not represent a significant risk, because the principles of design for two-phase cooling water circuits are well known and because TRW has completed significant development work for the two-phase flow design for its other combustor sizes.

It is Joy's opinion that flexibility exists in the proposed system sufficient to minimize the risks associated with not achieving proper oxidation of the sorbent material in the combustor, thus achieving high utilization of the recycle material. During tests performed at Northern States Power Company's Riverside Station and at the Antelope Valley Station, high SO_2 removal efficiencies were achieved using both low- and high-sulfur coals.

3.3.1.1 Similarity of the Project to Other Demonstration/Commercial Efforts

Most of the components that will be used in this demonstration are commercially proven and available, such as the spray dryer absorber, bag filter, pulverizers, heat pipe air heater, and limestone and coal handling systems. The boiler design to be used in the demonstration project is unique, but requires no new engineering development work beyond what would normally be encountered in any new power plant project.

The injection of sorbent into the combustion zone is similar to the Ohio Edison Edgewater Plant LIMB demonstration. The proposed three-stage sulfur removal system, however, has not been demonstrated anywhere at any scale.

3.3.1.2 Technical Feasibility

As described previously, TRW has been developing combustor systems since the mid-1970s and Joy has been involved in spray dryer absorber technology since the early 1980s. In addition, Joy has been testing flash-calcined material (FCM) produced from a TRW combustor installation since 1986. Joy has also had spray dryer absorbers in commercial operation since 1983.

The results of pilot-scale research indicate that the integrated process is ready for a full-scale demonstration. Additional pilot work funded by OCDO will produce more data to improve the expectation that the project will achieve its goals.

The experience of TRW and Joy, combined with the successful test programs and the commercial availability of much of the equipment used in the process, indicate that the technology is feasible and that this demonstration should achieve its goal of greater than 90% SO_2 removal, NO_x emissions of 0.2 lb/million Btu, and a combustion efficiency of 99.5%.

3.3.1.3 Resource Availability

Adequate resources are available for this project over the 72-month demonstration period.

The demonstration will have adequate coal and limestone supply both during the demonstration and over the working life of the plant. The coal will be provided by the Usibelli Coal Mine adjacent to the plant. Sorbent supply will be contracted and delivered to the site.

This program will involve a new boiler/turbine generator installation with appropriate facilities and scheduling flexibility to accommodate this project. The site selected for the proposed demonstration will provide an excellent opportunity to evaluate the technology in essentially all of the situations that are likely to be encountered in the commercialization of the technology. All appropriate resources, such as coal, limestone, water, etc., can be made available to the site. In addition, funds have been committed by the Participant sufficient to cover its share of the estimated project costs.

3.3.2 Relationship Between Project Size and Projected Scale of Commercial Facility

The Healy Clean Coal Project, at 50 MWe, is sufficient in size to avoid scaleup problems, while minimizing the cost associated with the new plant demonstration.

The TRW Entrained Combustors are of a size that is typical of many utility units. Scale up to larger units would generally require only a small increase in size and an increase in the number of combustors.

Spray dryer absorbers have been tested and used on units of the same size as the Healy Clean Coal Project and larger. These demonstrations include unit sizes ranging from 20 MWe through 860 MWe. Therefore, no scaleup risks are anticipated.

The lime activation process equipment is also commercial scale and no larger scale testing is considered necessary. The integrated entrained combustor providing FCM to the spray dryer absorber, however, has not been commercially demonstrated, but pilot-scale tests using FCM from the TRW entrained combustor have demonstrated that it is commercially feasible.

Based on the above, this demonstration should prove the technical and economic feasibility of integrating the TRW Entrained Combustion System and Joy's Activated Recycle Spray Dryer Absorber System into a commercial, coal-fired power generation station capable of exceeding all current requirements on regulated emissions.

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

This project will demonstrate, at the utility scale, a new integrated combustion and flue gas cleanup technology for the removal of acid rain precursors. Consequently, the commercialization of the technology requires a comprehensive data base that demonstrates the emission control, performance enhancements, reliability, and cost effectiveness of the technology. Commercialization also requires the means to transfer data regarding the technology directly to industry.

3.3.3.1 Applicability of the Data to be Generated

To collect the necessary data, the demonstration project will be fully instrumented and provided with microprocessor-based distribution control and data acquisition systems. Measurements that will be taken during the demonstration include fuel flow; sorbent flow; SO_2, NO_x, CO, CO_2, and O_2 levels; electric power generation and electric power consumption; and coal, sorbent, ash, and water chemical analyses.

Some of the information obtained from the data will include plant availability and reliability, overall energy efficiency, operability and performance of the plant systems, environmental performance as a function of coal and limestone quality, operating and maintenance costs, emission control and sorbent utilization capabilities, plant waste disposal requirements and costs, capital cost, and project schedule requirements. This information will be available to second generation plant designers to optimize and improve overall system performance, operability, reliability, and cost.

3.3.3.2 Identification of Features that Increase Potential for Commercialization

Once commercially proven the integrated Entrained Combustor and Activated Recycle Spray Dryer Absorber process will provide an economical and technically acceptable means for the simultaneous control of SO_2, NO_x, and particulates. The competitive capital and O&M costs will make this technology attractive for new repowering and retrofit applications.

The integrated process consists largely of proven, commercially available equipment such as combustors, air ports, dampers, ductwork, material handling equipment, spray dryer absorbers, bag filters, storage tanks, pulverizers, pumps, atomizers, piping, etc.

In summary, commercialization of the technology will be aided by its:

- o Simultaneous efficient control of SO_2, NO_x, and particulates
- o Low capital cost
- o Low to moderate operating and maintenance costs
- o Applicability to high- and low-sulfur coals
- o Reduced waste disposal costs
- o Minimized wastewater disposal
- o Reduced fly ash production
- o Reduced water consumption
- o Increased availability
- o Use of existing particulate removal equipment

The success of this demonstration will establish that use of the Entrained Combustor and Activated Recycle Spray Dryer Absorber Systems is an effective, reliable, and economic approach to the control of the two major pollutants associated with acid rain.

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

The commercial availability of cost effective and reliable systems for SO_2, NO_x, and particulate control is important to potential users who will be planning the installation of new generating capacity, repowering, or retrofits to existing capacity in anticipation of pending lower emissions limits. The spray dryer absorber and the wet FGD systems are commercially available for SO_2 control; however, each is limited in applicability and has inherent disadvantages such as the production of a sludge or higher sorbent requirements or the purchase of calcined lime. The project will demonstrate a technology that eliminates the disadvantages of both technologies.

The proposed technology requires lower capital and operating and maintenance costs compared with conventional systems, and can also increase plant efficiency. In addition, waste disposal costs will be less than that for conventional wet or dry scrubbers. The technology will also enable dry scrubbers to operate using limestone instead of expensive lime and perform effectively in installations burning high-sulfur coal.

4.0 ENVIRONMENTAL CONSIDERATIONS

The NEPA compliance procedure, cited in Section 2.2, contains three major elements: a Programmatic Environmental Impact Statement (PEIS); a pre-selection, project-specific environmental review; and a post-selection, site-specific environmental analysis. DOE issued the final PEIS to the public in November 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 focusing on environmental issues pertinent to decision-making was completed for internal DOE use. The review summarized the strengths and weaknesses of each proposal against the environmental evaluation criteria in the PON. It included, to the extent possible, a discussion of 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 proposals.

As the final element of the NEPA strategy, the Participant (Alaska Industrial Development and Export Authority) will submit to DOE the environmental information specified in the PON. This detailed site- and project-specific information will form the basis for the NEPA documents prepared by DOE. These documents, prepared in compliance with the Council on Environmental Quality regulations (40 CFR 1500-1508), 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.

5.0 PROJECT MANAGEMENT

5.1 Overview of Management Organization

The project will be managed by the Participant's (AIDEA's) Deputy Director of Development, who will be the principal contact with DOE for matters regarding the administration of the Cooperative Agreement between AIDEA and DOE. 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. An AIDEA Project Manager will also be assigned to the project to represent AIDEA on the technical committee and be the primary point of contact between the demonstration team members.

A management committee and a technical committee will be formed to provide direction to AIDEA to ensure that the project goals are met. The management committee, made up of representatives from AIDEA, GVEA, and the Alaska Energy Authority (AEA), will be involved in making policy decisions that will affect the commercial operation of the facility. The technical committee will consist of one representative from each of the team members and will provide direction for the design of the facility and execution of the demonstration project.

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 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 COTR who will be the authorized representative for all technical matters and will have 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, or suggest pursuit of certain lines of inquiry which assist in accomplishing the Statement of Work; and

- Approve those technical reports, plans, and items of 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 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; or

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

All Technical Advice shall be issued in writing by the DOE COTR.

Participant

The Participant (AIDEA) will be responsible for all aspects of project performance under the Cooperative Agreement as set forth in the Statement of Work. The Participant's Deputy Director of Development 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.

Golden Valley Electric Association, Inc. (GVEA), a Rural Electrification Authority utility serving the Northern Alaska Railbelt, will sublease the demonstration site to AIDEA, and will be the operator of the facility during the demonstration and after the facility is operated commercially. GVEA will also be associated with AIDEA in power sales and maintenance of the facility and will provide advice to the project team to ensure that the facility meets the operational requirements of GVEA and the interconnected railbelt's generation and transmission systems.

Stone & Webster Engineering Corporation (SWEC) will be responsible for overall design, construction support services, and testing of the facility. SWEC will also be responsible for collecting and reporting technical data to DOE and will coordinate and integrate the design and construction of all project components.

TRW will be responsible for the design and supply of the combustor, boiler, and associated systems.

Joy will be responsible for the design and supply of the spray dryer absorber, bag filter, fly ash recycle, and associated systems.

Usibelli Coal Mine, Inc. (UCM), will supply coal for the life of the plant and function in an advisory role concerning integration of the facility into existing waste disposal systems.

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

5.3 Summary of Project Implementation and Control Procedures

All work to be performed under the Cooperative Agreement is divided into three phases. These phases are:

Phase I: Design (26 months)
Phase II: Construction (42 months)
Phase III: Operation (12 months)

As shown in Figure 6, the total project encompasses 72 months. There will be an eight-month overlap between Phase I and Phase II, but Phase III will start upon completion of Phase II.

Three budget periods will be established. Consistent with P.L. 100-446, DOE will obligate funds sufficient 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 the project will be prepared by AIDEA/SWEC and provided to DOE.

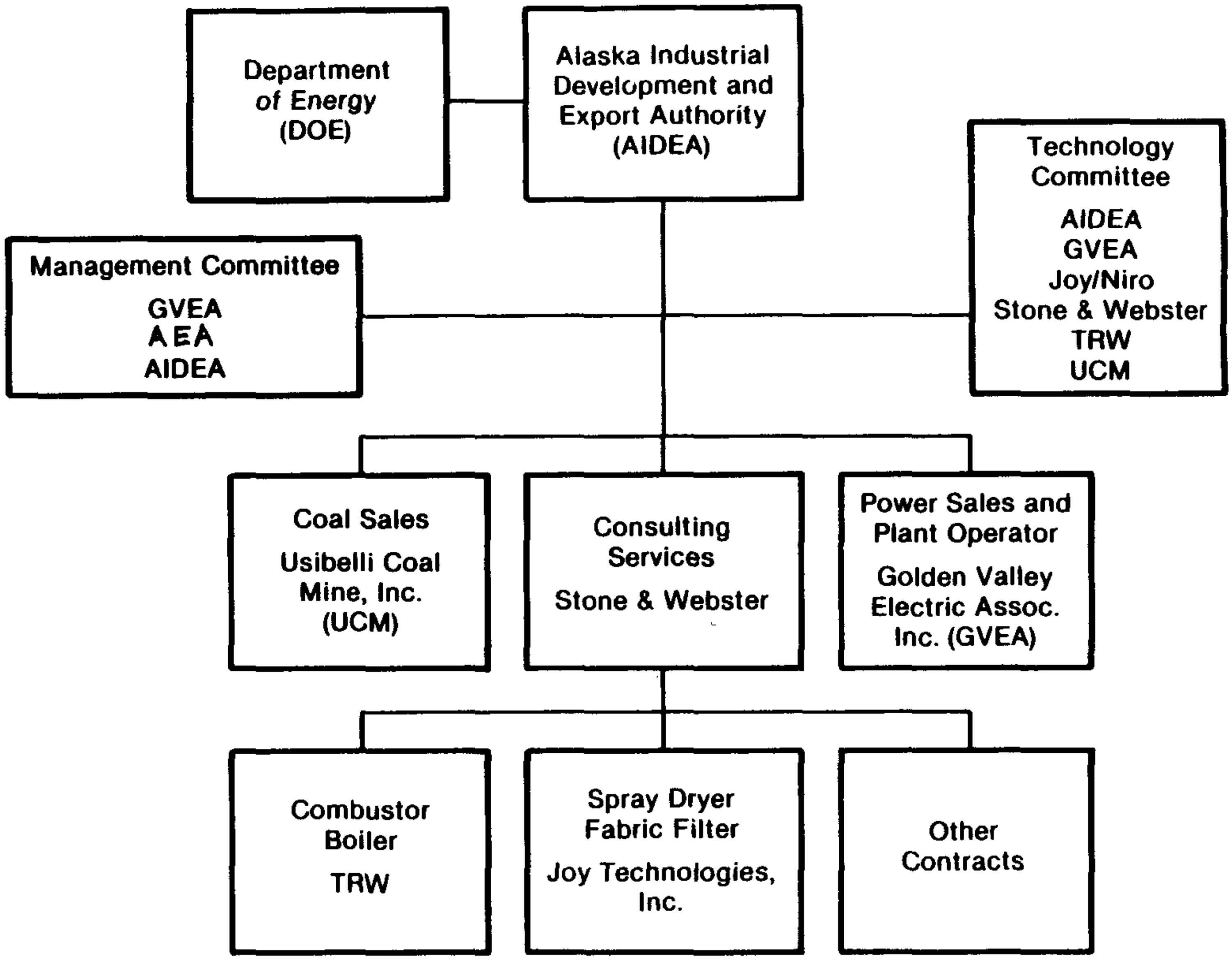

FIGURE 5. HEALY CLEAN COAL PROJECT ORGANIZATION.

NO/19,712

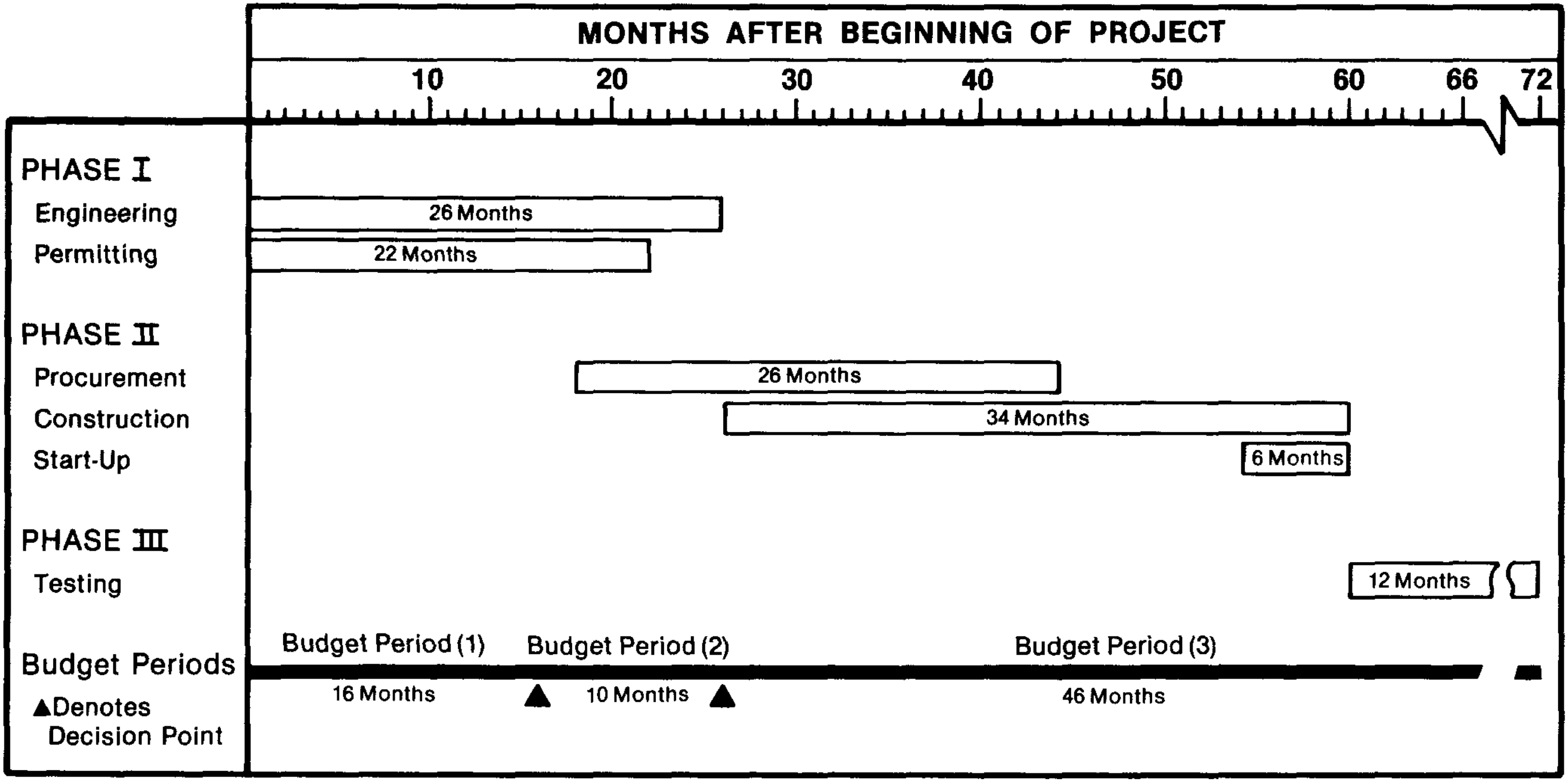

FIGURE 6. HEALY CLEAN COAL DEMONSTRATION PROJECT SCHEDULE.

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

TRW's and Joy's incentive to develop this process is to realize retrofit business from the utility and power boiler industry with respect to SO_2, NO_x, and particulate abatement technology.

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 rights to proprietary data and non-proprietary data sufficient to allow the Government to complete the project if the Participant withdraws.
- o A patent waiver may be granted by DOE giving TRW or Joy 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 TRW, Joy, and all of their subcontractors are included to assure commercialization of the technology.

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

5.5 Procedures for Commercialization of the Technology

Each of the project team members will be instrumental in the commercialization of the technology.

TRW is committed to this technology. Users of the technology will either be contacted directly or in conjunction with Architect/ Engineering or Engineering and Construction Firms for retrofit applications. For new applications, TRW will generally work with the original equipment suppliers. In foreign markets, TRW will license sales/service representatives and manufacturing firms.

TRW has completed a comprehensive analysis of the U.S. market and has established specific targets. TRW has also conducted market surveys, developed competitive assessments, and prepared market penetration plans for selected countries and established the capability to develop markets in power plant systems.

Joy's Environmental Systems Group, through its Western Precipitation Division (W.P.), is responsible for marketing of the air pollution control systems on a worldwide basis. W.P. markets directly, or through appropriate licensees, all products developed for use in the U.S. Since Joy is already an established supplier of FGD systems, baghouses, and electrostatic precipitators for the utility industry, it will easily be able to enhance the commercialization of the technology.

SWEC will assist in the commercialization of the technology through the dissemination of the information gained during the demonstration project. The data will be used by SWEC in future feasibility studies for industrial and utility clients in support of client decisions. In addition, SWEC is involved in technical societies and industrial development groups and, as such, will disperse the information gained through the demonstration project via presentations, technical papers, and membership contacts.

GVEA will also be a key contact for utility and industrial generators who are seeking information concerning the technology.

UCM is interested in expanding the UCM coal markets, particularly as related to the domestic power generation market and the Pacific Rim. Therefore, UCM will also disseminate information gained from the demonstration project.

The components associated with TRW's Entrained Combustor can be manufactured using conventional fabrication techniques; therefore, rapid market growth will not be affected by manufacturing limitations. In addition, the components of the boiler, spray dryer absorber, bag filter, and activation and recycle systems are currently manufactured at the required scale.

6.0 PROJECT COST AND EVENT SCHEDULING

6.1 Project Baseline Costs

The total estimated cost for this project is $193,407,000. The Participant's share and the Government's share in the costs of this project are as follows:

	Dollar Share ($)	Percent Share (%)
Pre-Award		
Government	$ 1,023,000	48.5%
Participant	$ 1,087,000	51.5%
Phase I		
Government	$10,520,000	40.0%
Participant	$15,780,000	60.0%
Phase II		
Government	$67,099,000	50.0%
Participant	$67,099,000	50.0%
Phase III		
Government	$15,220,000	49.4%
Participant	$15,579,000	50.6%
Total Project		
Government	$93,862,000	48.5%
Participant	$99,545,000	51.5%

Cash contributions will be made by the co-funders as follows:

DOE	$ 93,862,000
AIDEA	$ 99,545,000
TOTAL	$193,407,000

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

6.2 Milestone Schedule

The overall project will be completed in 72 months after award of the Cooperative Agreement. The project schedule, by phase and activity, is shown in Figure 6.

Phase I, which involves engineering and permitting, will start immediately after award and continue for 26 months. Phase II, construction, will overlap Phase I by 8 months and last for 42 months. Phase III, operation, will start upon completion of Phase II and last for 12 months.

6.3 Recoupment Plan

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.