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CHARACTERIZATION & SUPPLY OF COAL BASED FUELS

Quarterly Report for the Period
February 1, 1987 to April 30, 1987

Energy International, Inc.
135 William Pitt Way
Pittsburgh, PA 15238

July, 1987

Prepared For:

U.S. Department of Energy
Pittsburgh Energy Technology Center

Under Contract No. DE-AC22-86 PC90258

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CHARACTERIZATION & SUPPLY OF COAL BASED FUELS

Technical Progress Report
for the Period
February 1 through April 30, 1987

Performed under Prime Contract No. DE-AC22-86 PC90258

Submitted July 1987 by

Energy International, Inc.
135 William Pitt Way
Pittsburgh, PA 15238

ACKNOWLEDGEMENT

Contributors to this report include: Daniel F. Petrunak and Christopher F. Welsh of Dravo Engineers Inc.; Raymond M. Henry, Russell C. Maxwell, Burl E. Davis, and Ronald W. Genser of Energy International, Inc.

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PATENT STATUS

This technical report is being transmitted in advance of DOE patent clearance and no further dissemination or publication shall be made of the report without prior approval of the DOE Patent Counsel.

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This technical report is being transmitted in advance of DOE review, and no further dissemination or publication shall be made of the report without prior approval from the DOE Program/Project Manager.

"CHARACTERIZATION & SUPPLY OF COAL BASED FUELS"

Quarterly Technical Report
for the Period
February 1 through April 30, 1987

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1.0 INTRODUCTION & BACKGROUND

Under the Department of Energy's Advanced Combustor Technology Program, approximately 11 combustor contractors (under 13 contracts) are developing combustion systems (during 1987-1989) for use in residential, commercial, light industrial and industrial retrofit markets. Sufficient quantities of well-characterized, coal-based fuels possessing specific, appropriate specifications are required by the contractors. Fuels may be dry pulverized coal or coal liquid fuels. In support of these equipment development efforts, the team of Energy International and Dravo Engineers will provide such fuels (under DOE Contract No. DE-AC22-86 PC90258 within the PETC Alternate Energy Program).

Nearly a third of the total energy use in the U.S. is in the residential, commercial, and light industrial sectors. Of this, about half of the energy is supplied by the direct consumption (not including electricity) of conventional oil and gas resources. Thus, there is a significant energy use component for which coal is not currently a viable user option.

For coal to significantly penetrate this important market sector, it must be demonstrated that:

- Premium coal-based fuels can be made, combusted, and used in low maintenance, automatic use systems to which such users are accustomed, i.e., be a direct replacement for conventional fuels and require only simple installation changes.
- Advanced coal fuel combustion systems can effectively combust coal based fuels while meeting economic, environmental, and performance standards.
- Coal fuels, combustion systems and service support are well matched, reliable, cost effective, and are anticipated to be available over the projected lifetime of the installations.

The key to development of fuel and combustor technologies for future application to the use of premium coal-based fuels in the residential, commercial and light industrial energy use sectors is to make available representative coal fuels for developmental testing. Current technologies in early development stages offer the promise to meet the market, the performance and the environmental acceptability that are expected to be required. However, the developmental testing of advanced combustion equipment systems requires fuels for testing; test experience and performance measures are needed to identify cost competitiveness in the market and specific market niches for early commercialization; and, commercial market opportunities are needed to justify and specify the development and installation of advanced fuels facilities for supplying the developmental testing needs.

The capability to produce significant quantities cannot be supported in the current economic and energy use situation. Once these pieces of experience and information begin to fall into place, the market driven needs will more clearly identify the suite of coals that will satisfy the markets and the performance requirements (i.e. cost, maintenance, energy efficiency, environmental). For now, it is important to provide sufficient

quantities of surrogate fuels to enable development testing to proceed. While the definitions of market and performance are not finalized nor quantitatively fixed and the eventual, economically acceptable fuel processes are not yet determined, it is possible to make use of current understanding of coal resources, markets, combustor and environmental requirements and specific available coal properties and characteristics to make reasonable selections of coals for fuels representative of future advanced fuels. With selected coals, conventional beneficiation methods can be used to prepare current versions of advanced premium coal-based fuels even though the associated excessive grinding, special processing, low energy recoveries and process economics would not be acceptable for eventual commercial operations.

The analysis of fuels needs, the selection of candidate coals, the characterization and supply in this contract are to be accomplished with the above in mind. The best choices of those available will be made based upon the available information, coal and processes. This will at least provide the developmental test fuels that will enable the DOE-PETC advanced combustion and fuels program to move forward. Following the fuels and combustor development activities that this supply contract will support, it is expected that additional optional candidate coals will become evident based on the new experience. In the meantime, these coal fuels will enable the program to proceed.

During the second quarter of this contract effort, the primary activities were involved with:

- Continuation of development of fuel requirements (i.e., specifications, quantities, schedule).
- Acquisition and bench-scale characterization of candidate coal samples.
- Selection of coal water slurry fuel manufacturer.
- Procurement of parent coal for fuel production.
- Deep cleaning by froth flotation of parent coal.
- Production of solid fuel (i.e., size reduction of deep cleaned parent coal) and delivery to combustors/experimenters.
- Production of slurry fuel and delivery to combustors/-experimenters.
- Completion of Final Version of First Quarterly Report.

The progress on the above activities is reported in the following sections of this report.

2.0 OBJECTIVES AND SCOPE OF WORK

2.1 Contract Objectives

Contract objectives are as follows:

- Develop fuel specifications to serve combustor requirements.
- Select coals having appropriate compositional and quality characteristics as well as an economically attractive reserve base.
- Provide quality assurance for both the parent coals and the fuel forms.
- Deliver premium coal-based fuels to combustor developers as needed for their contract work.

2.2 Contract Scope of Work

Energy International/Dravo will perform the following:

- From information obtained both from the combustor PRDA and from the combustor contractors, develop fuel specifications and schedule.
- Using published reports and databases, perform a market assessment and a resource assessment in order to identify acceptable coals within reasonable proximity to markets. In other words, determine the availability and applicability of a wide range of coals in order to produce premium coal-based fuels for specific markets.
- From all coal ranks and all domestic resources select eight coals which satisfy the requirements of combustion systems being developed.
- Procure premium coals having the ability to be processed to contain <1 lb ash per million Btu and <0.8 lbs sulfur per million Btu.
- Procure coals and produce coal liquid mixtures or dry pulverized coal and deliver these premium fuels to combustor contractors.

2.3 Task 1 Objectives

The objectives of Task 1, "Analysis of Fuels Needs", are as follows:

- To provide analyses, information and evaluation of coal resources, coal properties, and market opportunities to support the selection of coals for characterization, processing and supply.
- To assure that coals used in developmental testing are representative of future potential coal used in those applications and are:

- Available as U.S. domestic resource in sufficient quantity
 - Geographically proximate to the regional markets
 - Capable of being processed into premium coal-based fuels that have the properties to satisfy the combustor needs and market constraints (such as environmental)
- To evaluate, interpret and assess the available information on coal reserves, market opportunities, performance requirements, environmental acceptability, coal properties and specific characteristics to provide guidance in the selection of candidate coals for characterization and supply for developmental testing of advanced combustors for residential, commercial and light industrial applications.
 - To collect, review and evaluate information about specific, currently available coals that can be procured from existing mining operations to provide contracted quantities of development test fuels that satisfy the reserves, market, geographic, property, performance and environmental criteria.
 - To recommend candidate coals and then select specific coals to be purchased, processed into coal-based premium fuels, and supplied to DOE users.
 - To coordinate the performance requirements of combustor developers under DOE-PETC contract and in-house efforts with the selection and supply of coals.

2.4 Task 2 Objectives

The objectives of Task 2, "Characterization of Coal Based Fuels", are as follows:

- To procure representative samples of the eight coals selected in Task 1 and prepare them for characterization studies.
- To obtain baseline analytical data for each of the parent coals.
- To carry out bench scale froth flotation cleaning tests on each of the candidate coals to determine the yield of specification coal attainable from each.
- To carry out detailed washability studies for each coal to determine the effect of particle size reduction on mineral matter liberation as well as the coal yield as a function of the specific gravity of the separation.
- Based on the results of the characterization studies, to select a coal or suite of coals suitable for the preparation of the fuels to meet the specifications of the combustor contractors.

2.5 Task 3 Objectives

The objectives of Task 3, "Fuel Supply" are as follows:

- To design, construct, and operate a 2.5 ton/hr coal wash circuit.
- To design, construct, and operate a coal/water slurry preparation plant, if required.
- To purchase and arrange for the delivery of the appropriate coals for fuel preparation.
- To clean the coals to meet the specifications necessary for the specific fuel, i.e., slagging versus non-slagging, industrial versus residential, etc.
- To prepare the coal based fuels according to the specifications of the PRDA and as modified or requested by the combustor contractors.
- To deliver the fuel to the combustor contractor on schedule.
- To characterize each fuel prior to shipment to assure that the specifications are being met.

3.0 EXECUTIVE SUMMARY

Under the Department of Energy's Advanced Combustor Technology Program, approximately 11 combustor contractors (under 13 contracts) are developing combustion systems (during 1987-1989) for use in residential, commercial, light industrial and industrial retrofit markets. Sufficient quantities of well-characterized, coal-based fuels possessing specific, appropriate specifications are required by the contractors. Fuels may be dry pulverized coal or coal water fuels. In support of these equipment development efforts, the team of Energy International and Dravo Engineering Companies will provide such fuels under DOE Contract No. DE-AC22-86 PC90258.

During the second quarter of this contract effort, the primary activities were involved with:

- Preparation of the Topical Report describing the market survey, coal selection and fuels specification methodologies used in carrying out Task 1.
- Design, construction, and testing of the froth flotation cleaning circuit to be used for the preparation of deep cleaned coal.
- Selection of vendors to supply the coal water fuels and the micronized solid coals.
- Procurement and characterization of the candidate coals selected in Task 1.
- Preparation and delivery of the initial quantities of both the solid and slurry fuels.

Details of the efforts of each of the above activities are as follows.

Task 1 was completed and the preparation of a comprehensive report detailing the market survey, coal selection process and establishment of the fuel specifications was begun. The report will be issued during the next quarter.

The froth flotation coal cleaning circuit was installed and placed in operation at the Dravo Research Center facilities on Neville Island in Pittsburgh, PA. After a shake-down period, production of clean coal at a rate of 300 lbs/hour began April 28, 1987.

Samples of five of the eight coals selected in Task 1 were obtained. Bench scale froth flotation work was carried out on four of the coals. It was shown that the Upper Elkhorn #3 coal could be cleaned to a 1% ash level at recoveries of 60% or greater. Therefore, it was chosen as the baseline coal for the initial production of premium fuels.

A fully documented procurement procedure was implemented in order to identify and select a manufacturer for coal water fuels and to select a vendor for the production of pulverized and/or micronized coal. Based upon the response to the survey, OXCE Fuel Company was selected as the primary

coal water fuel supplier; and Fluid Energy Company for particle size reduction. However, an explosion and fire at the Fluid Energy facilities near Philadelphia forced the selection of an alternate grinding company for the initial micronized coal production. This was the Particle Reduction Services near Chicago, Illinois.

The first fuel shipments were made during this quarter. A 350 gallon batch of coal water fuel, prepared by the OXCE Fuel Company, and five tons of micronized coal, prepared by Particle Reduction Services, were sent to the Pittsburgh Energy Technology Center for use in their in-house combustor program.

4.0 TASK 1 - ANALYSIS OF FUEL NEEDS

With the exception of the administrative and reporting aspects and the final selection of slagging coals, the work for this Task has essentially been completed. A topical report is being prepared to describe the procedures used in the coal selection and fuel specification process. The report shall be issued in the next quarter.

5.0 TASK 2 - CHARACTERIZATION OF COAL BASED FUELS

5.1 Sample Procurement

Two fifty-five gallon drums of coal were obtained from each of the five coal beds selected and approved on January 26, 1987. The parent coals are identified in Table 5.1 along with the source and location of each coal.

Table 5.1

SELECTED COALS FOR RESIDENTIAL, COMMERCIAL AND LIGHT INDUSTRIAL MARKET

<u>Bed Number</u>	<u>Coal Bed Name</u>	<u>Related Name</u>	<u>Coal Source</u>	<u>Mine/ Plant</u>	<u>Mine Location</u>
151	Upper Elkhorn #3	Cedar Grove Jellico Taggart	Westmoreland Coal Company	Wentz Plant	Big Stone Gap, VA
154	Upper Elkhorn #2	Lower Cedar Grove	Beth Energy	Damron Plant 29	Jenkins, KY
157	Upper Elkhorn #1	Alma, Blue Gem	Old Ben Coal Company	Mine #20	WV
168	Lower Elkhorn	No. 2 Gas, Pond Creek	Mapco	Pontiki	Lovely, KY
755	Coal Basin D	Oliver	Westmoreland Coal Company	Orchard Valley	Paonia, CO

Each coal sample from each coal bed was obtained from operating facilities that utilize conventional cleaning equipment. Each sample was taken from stockpiles at its respective plant with no special plant operation being utilized. Proper sampling methods were utilized to the extent possible to insure representative samples of each coal seam. After obtaining the samples, the drums were shipped to Dravo for sample preparation and characterization.

5.2 Sample Characterization

Upon receipt of the parent coal samples, the two drums were blended and then split into two portions. One portion was placed back into one drum, sealed, and stored for future use if needed. Coal in the second drum was screened and crushed to minus 1/8 inch using an impact mill. The minus 1/8 inch material was then reblended and samples taken for characterization studies.

5.2.1 Parent Coal Analysis

A samples of each parent coal was submitted for proximate, ultimate, ash chemistry, ash fusion, and hardgrove analysis. The test results are given in Table 5.2.

5.2.2 Washability Studies

Coal washability studies were begun. Samples of the five coals listed in Table 5.1 have been received, sampled, and reduced to the desired particle sizes, i.e., 1/8"x0, 28x0 mesh, 100x0 mesh and 200x0 mesh. Each of these samples in turn are now being wet screened to obtain fractions of particle size ranges of 1/8"x28 mesh, 28x100 mesh, 100x200 mesh, 200x270 mesh and 270x400 mesh and 400x0 mesh. Each of these size ranges will then undergo sink/float analysis at specific gravities of 1.25, 1.275, and 1.30.

5.2.3 Beneficiation

5.2.3.1 Procedure

Bench scale flotation tests were performed on all coal samples except the Coal Basin D seam. Testing was performed using either a Denver or Wemco flotation cell. Samples were ground for the specified period of time using either rods or balls in a laboratory Abbe mill with the ground coal then placed into the flotation cell. A frother was then added and conditioned for at least 30 seconds. Air was then turned on and the froth removed for three minutes or until no additional froth could be obtained. The flotation procedure followed the Penn State starvation flotation method followed by at least two stages of cleaning of the froth product. Samples of all tailing products and the final froth were submitted for ash analysis. Test results for each seam follow.

5.2.3.2 Upper Elkhorn #1

Twelve flotation tests were performed on the Upper Elkhorn #1 (UE1) seam. Both grinding time and frother addition was varied to try to obtain maximum recovery of less than 1.5% ash in the final froth. As shown in Figure 5-1, the UE1 coal could produce ash in the range, however, recoveries were less than 15%. When trying to obtain one percent ash in the final product, recoveries approached 5% or less. Figure 5-1 also indicates that additional grinding beyond 30 minutes was not beneficial and the ultimate grind appears to be between 10 and 30 minutes. Higher frother addition rates increased recovery but reduced quality.

5.2.3.3 Upper Elkhorn #3

Five flotation tests were performed on the Upper Elkhorn #3 (UE3) seam. As shown in Figure 5-2, both grinding time and frother addition were varied in an attempt to obtain a final ash product or less than 1.5% and 1.0%. The UE3 coal produced significant quantities of both qualities with minimal report, with over 60% recoveries of 1% ash in the final flotation product. These high recoveries appear to be influenced by the low ash content of 2.5% in the UE3 feed, which is approximately 50% less in ash than the other seam samples. However, the UE3 coal floats very easily and should be a prime candidate for use in the production of the bulk samples for pilot plant operation.

TABLE 5.2

PARENT COAL ANALYSIS

Dry Basis

<u>Analysis</u>	<u>Upper Elkhorn #3</u>	<u>Upper Elkhorn #2</u>	<u>Upper Elkhorn #1</u>	<u>Lower Elkhorn</u>	<u>Coal Basin D</u>
Proximate					
Volatile Matter	35.97	35.50	34.13	35.12	39.60
Fixed Carbon	64.03	58.98	59.69	57.98	53.80
Ash	2.25	5.52	6.18	6.90	6.60
Sulfur	0.62	0.52	0.83	0.57	0.53
Btu/lb	14829	14331	14381	13763	12945
Ultimate					
Carbon	83.23	80.57	80.79	75.46	72.80
Hydrogen	5.14	4.81	4.76	4.81	4.78
Nitrogen	1.51	1.49	1.46	1.63	1.68
Ash Chemistry					
SiO ₂	45.27	54.61	48.96	51.03	61.95
Al ₂ O ₃	30.17	29.71	27.82	30.81	21.21
TiO ₂	1.40	1.61	1.50	2.18	0.82
Fe ₂ O ₃	13.26	7.49	12.24	6.32	5.47
CaO	2.56	1.61	2.38	2.92	2.39
MgO	1.06	0.91	1.13	0.88	1.06
K ₂ O	1.82	2.37	2.35	2.22	1.34
Na ₂ O	1.57	0.29	0.74	0.69	3.12
}	1.75	0.88	2.40	2.54	1.29
5	0.14	0.18	0.12	0.07	0.69
5	0.33	0.25	0.22	0.19	0.22
BaO	0.24	0.18	0.14	0.15	0.29
Mn ₃ O ₄	0.00	0.00	0.00	0.00	0.00
Base Acid Ratio	0.26	0.15	0.24	0.16	0.16
T 250 Temperature	2599	2872	2640	2832	>2900
Ash Fusion					
Reducing					
Initial	2560	2580	2350	2560	2200
Softening	2692	2690	2470	2670	2310
Fluid	+2700	2780	2600	2760	2440
Hardgrove	58	44	53	44	51

Figure 5.1
Upper Elkhorn #1
Froth Flotation Cleaning
(Three Stage)

Figure 5.2
Upper Elkhorn #3
Froth Flotation Cleaning
(Three Stage)

5.2.3.4 Upper Elkhorn #2

Figure 5-3 shows the results of some of the flotation studies on the Upper Elkhorn #2 coal. In this particular study the starvation flotation procedure was not used, i.e., in some cases additional frother was added between stages in an effort to increase the yield. Longer grind times were used to determine if better ash liberation could be achieved by reducing the particle size and the effect of the use of dispersants was also evaluated. It can be seen that a 1.5% ash product can be obtained with greater than a 50% yield. This was very encouraging since the parent coal had an ash content of greater than 5%. It is felt that with further refinement a reasonable yield of 1% or less ash content is achievable. This makes the Upper Elkhorn #2 coal an excellent candidate for the production of ultra-clean coal for the preparation of premium fuels for the combustor program.

5.2.3.5 Lower Elkhorn

As with the Upper Elkhorn #2 coal, flotation studies were carried out with the Lower Elkhorn coal using longer grind times, higher frother concentrations and with and without the use of chemical ash dispersants. The results are shown in Figure 5-4. A 40 to 50% yield of a 2.5% ash product was achieved. In this case it can be seen that increasing the grinding time from 60 to 120 minutes did not improve ash rejection and it drastically reduced the clean coal yield. The use of dispersants not only did not improve the yield but generally produced a higher ash product. These results indicate that, for this coal, obtaining a 1% or less ash product at a reasonable yield will be more difficult. The results of the washability studies described in the previous section will give a better indication of the ultimate cleanability of each of the candidate coals and help determine the best method for cleaning the coals.

5.3 Parent or Baseline Coal Selection

As indicated by the flotation test work, the Upper Elkhorn #3 seam yielded the highest recoveries at the lowest ash percent of the four seams treated thus far. The UE3 capability for such high recoveries while capable of producing a wider range of low ash values makes the UE3 seam very flexible in supplying to initial requirements for many of the DOE combustor contractors, and was therefore chosen to become the designated parent or base coal for the fuel supply program. Additional test work will continue on the remaining coals to determine their maximum recoveries.

Figure 5.3
Upper Elkhorn #2
Froth Flotation Cleaning
(Three Stage)

Figure 5.4
Lower Elkhorn Coal
Froth Flotation Cleaning
(Three Stage)

6.0 TASK 3 - FUEL SUPPLY

6.1 Production Facilities

As indicated in the preceeding section, the fuel requirements of the DOE combustor contractors are widely diverse in qualities, quantities, and fuel types. Generally, Table 6-1 indicates the fuel forms of bituminous coal that will be required.

Table 6-1

BITUMINOUS FUEL FORMS REQUIRED FOR THIS PROJECT

	<u>Dry Coal</u>		<u>Coal Water Fuels</u>	
	<u>Pulverized</u>	<u>Micronized</u>	<u>Pulverized</u>	<u>Micronized</u>
Deep Cleaned	X	X	X	X
Standard	X	X	X	X

Since no one company has the capability to supply fuels for the matrix, three main production facilities are required at this time. Dravo for deep cleaning of the coal, Oxco for preparation of the coal water mixtures, and dry grinding contractors for dry pulverized/micronized coals. Selection and facilities are described below.

6.1.1 Deep Cleaned Coal

Upon review of commercially available coal beneficiation facilities capable of conventionally deep cleaning selected coals and their ability to supply such coals over the life of the DOE contract, it was decided to utilize the facilities at the Dravo Research Center to furnish the FY87 deep cleaned requirements. This assessment was made because of Dravo's indication that the DOE's contract would have priority at its facility and that Dravo's Research Center had essentially all the equipment necessary to produce the deep cleaned coal. After review of the proposed facility, on February 6, 1987, the DOE gave verbal approval for Dravo to proceed in developing their flowsheet for obtaining deep cleaned coal at the Dravo Research Center.

After receiving approval, Dravo began immediately to design a circuit that would be able to obtain the low ash qualities required. As the circuit was designed to utilize the available equipment at the Research Center, a flowsheet was developed to process approximately 300 lb/hr of raw coal as feed to the circuit. A schematic of the basic flowsheet is shown in Figure 6-1 and is described below.

The raw coal is obtained from the coal stockpile and is fed into a hammermill (not shown) to crush the coal to minus 1/8 inch. The crushed coal is put into a hopper where a variable speed conveyor controls the feed rate to the ball mill. The ball mill grinds the coal to a nominal 100 mesh

Figure 6-1

DRAVO RESEARCH CENTER SMALL PILOT PLANT

in closed circuit with a classifying cyclone and Derrick screen. The screen undersize fraction is pumped to a conditioning tank which overflows into a bank of Wemco flotation cells. The froth is then pumped to Denver flotation cells where it is refloated in a cleaner stage. A second stage of cleaning is available if necessary. The product froth is collected and pumped to a disc filter for dewatering. Final dewatering is presently being performed in a batch oven, however, a continuous thermal dryer has been ordered. Tailings from the flotation circuit are combined and pumped to the tailings thickener for thickening and storage. A second filter is on order for tailings dewatering for disposal.

During February, March and April, Dravo Research began to modify and install the equipment at their pilot facilities on Neville Island in Pittsburgh, PA. Circuit testing on water was performed in early April to balance the circuit with coal added during mid-April. Start-up testing was performed on an Upper Elkhorn #3 and the circuit produced results similar to that obtained in bench scale testing. Upon completion of the circuit testing, the pilot circuit was then available for production April 21, 1987.

6.1.2 Coal-Water Fuels

A fully documented procurement procedure was implemented in order to identify and select a coal water fuels manufacturer.

A survey of the primary slurry manufacturers was carried out to determine their current status, capabilities and willingness to participate in the advanced combustor program for the contract term. The request for information was sent to the following vendors:

- Sohio Advanced Fuels Technology
- Amax Research & Development Center
- Atlantic Research Corporation
- Carbogel
- Methacoal, Inc.
- Otisca Industries, Ltd.
- OXCE Fuel Company

Based upon the replies to the survey and follow-up discussions with the vendors, OXCE Fuel Company was chosen to provide slurry fuels for this program. They are fully qualified to meet the requirements of the program and indicated a willingness to participate during the full term of the contract.

6.1.3 Dry Ground Coal

As indicated in Table 6-1, four different dry coal forms will be required by the DOE combustor contractors. As each product may require different grinding circuitry, much effort has been utilized in trying to find a company that has facilities to perform all or most of the required grinding. The following problems evolved during this search.

1. Most companies do not have the proper facilities or are reluctant to handle high volatile (>35%) coals.

2. Some companies can pulverize (to minus 150 micron), but do not have capability to micronize (to minus 40 micron).
3. Few companies have drying capability.
4. Some companies preferred to grind "white powder" and do not wish to contaminate their circuit with coal.
5. Some companies have grinding capability but are not production oriented. Their facilities are for research and testing to support their sales of equipment.
6. Their capacities are too small or they have no available openings in their schedules.

In addition, DOE combustor contractor schedules indicated that a supply of micronized coal was required by April, thereby causing problems in locating an available cost effective producer.

After having discussions with over a dozen potential dry grinding companies, Fluid Energy Company was selected to initially supply micronizing services for the April requirements. Three days before they were to start, they had an explosion and fire which has put them out of operation until approximately July. This caused an additional backlog at other grinding companies and it took until the end of April before obtaining an alternate micronizer, Particle Reduction Services Corporation in Illinois, for the initial production.

In mid-April, Request for Bid letters were sent to four prospective companies requesting proposals for grinding services during the next two years. These letters requested firm pricing and priority consideration in supplying the required grinding production for the DOE combustor contractor schedules. Due to an unsatisfactory response, additional bid proposals will be solicited in early May.

6.2 Production

6.2.1 Deep Cleaned Coal

Upon completion of the installation of the 300 lb/hr flotation circuit at Dravo Research, shakedown testing on coal began in mid-April. The coal used during the shakedown testing was from a 10 ton shipment of Upper Elkhorn #2 coal (UE2-089) which was purchased initially for use as dry micronized coal. Upon receiving the coal, it was found to be off quality specification and at this time it was shipped to Dravo Research to determine what could be done. Upon receiving the coal at Neville Island, screening results indicated that the plus 1/4 inch coal would meet future requirements for dry grinding qualities. The minus 1/4 inch was then used for the shakedown testing.

The minus 1/4 inch fines were fed into the pilot circuitry for three 8 hour shifts in an attempt to produce the quality results that were obtained in bench scale testing. On the first day of testing reagent overdosing caused product ash levels to exceed 1.75%; however, careful monitoring of frother on the following days achieved a 1.04% ash at approximately

41% weight recovery using only one stage of cleaning. This compared favorably to bench scale testing which obtained a 1.08% ash at a 53% weight recovery. Using three stages of cleaning approximately 1 1/2 tons of the minus 1/4 inch fines was consumed during the shakedown testing.

During this period a 21 ton bulk shipment of Upper Elkhorn #3 coal (UE3-106) was secured for cleaning. Production began on April 21, 1987 at a rate of 300 lb/hr. An hourly quality control sampling program was found to be necessary during the shakedown test and was, therefore, instituted as standard operating procedure. Initial plant quality requirements were specified at a range of 0.8-1.0 lbs ash/million Btu which is approximately 1.2-1.5% ash by weight. Daily production is indicated in Table 6-2 and a balance flowsheet is shown in Figure 6-2. The production in April on the Upper Elkhorn #3 coal represented 62 drums of deep cleaned coal. A representative sample of deep cleaned coal quality is shown in Table 6-3.

Table 6-2

APRIL DEEP CLEANED COAL PRODUCTION

<u>Date</u>	<u>% Ash</u>	<u>Drums</u>
4-21	1.67	4
4-22	1.27	3
4-23	1.29	6
4-24	1.52	4
4-27	1.27	13
4-28	1.32	7
4-29	1.24	13
4-30	1.33	12

6.2.2 Dry Powder

The first scheduled shipment of micronized coal was for the delivery of 10 tons of coal to PETC in February. PETC's requirement of $2 \pm 0.25\%$ ash coal required EI/Dravo to search for a supplier of precleaned coal that could meet this specification, as the Dravo pilot circuit was not operational at this time. In late February a 10 ton supply of Upper Elkhorn #2 coal (UE2-089) was purchased from Virginia Energy Coal Company and shipped to Fluid Energy Company for dry micronization.

Upon receiving the coal, Fluid Energy informed EI/Dravo that the coal was not in the size range expected. Analyses of samples of the coal indicated that the ash content did not meet specifications and was nearly 3% by weight. Discussions with Virginia Energy revealed that they had attempted to blend the stoker coal with higher ash fines because the stoker coal was less than 1.75% ash, and therefore, if the fines were screened out, the coarse coal would be within specifications. Laboratory analysis confirmed Virginia Energy Company's statements. Virginia Energy then stated that they could have another shipment ready in early March that they would guarantee would be on time as it would be part of a much larger shipment for overseas.

Figure 6-2

DRAVO RESEARCH CENTER SMALL PILOT PLANT

Table 6-3

SAMPLE ANALYSIS SHEET

Coal I.D.: UE3-115-DCC-D

Coal Description: Upper Elkhorn #3 Deep Cleaned - Shipped to Oxce for Slurry

Proximate:

Volatile Matter	36.62%
Fixed Carbon	61.90%
Ash	1.48%
Sulfur	0.60%
Btu/lb	15284

Ash Chemistry:

SiO ₂	42.48%
Al ₂ O ₃	30.70%
TiO ₂	2.03%
Fe ₂ O ₃	14.89%
CaO	3.23%
MgO	1.85%
K ₂ O	1.37%
Na ₂ O	1.76%
SO ₃	0.94%
P ₂ O ₅	0.50%
SrO	0.22%
BaO	0.35%
Mn ₃ O ₄	0.07%
Base Acid Ratio	0.89%
T - 250 Temp.	2551°F

Ultimate:

Carbon	83.71%
Hydrogen	5.22%
Nitrogen	1.53%

Ash Fusion: Reducing

Initial	2160%
Softening	2270%
Fluid	2400%

Free Swelling Index:

8.0%

After discussion with Fluid Energy about their coarse screening capability, which was minimal, it was decided to ship the UE2-089 coal to Pittsburgh for screening. The coarse coal was saved to be used at a later date and the fines used for the pilot circuit shakedown. A second shipment of coal from Virginia Energy (UE2-094) was ordered in mid-March. A visit was made by Dravo personnel to confirm the coal quality prior to shipment.

Three days prior to Fluid Energy beginning to micronize this second shipment, they had an explosion and fire causing Fluid Energy to curtail operations temporarily, (presently expected operation is scheduled for July). To overcome this situation, an alternate source for micronization was sought. Particle Production Services Corporation in Illinois indicated their availability and capability to micronize the coal. However, they could only do 5 tons immediately and would micronize the remaining 5 tons one month later. In late March, the UE2-094 coal was relocated from Fluid Energy to Particle Reduction Services.

During the latter part of April, Particle Reduction completed the micronizing of the first 5 tons of the UE2-094 coal and upon verification of the size analysis using a Microtrac, the micronized coal (UE2-114) was shipped to PETC on May 5, 1987. The particle size distribution and chemical analysis of this shipment are given in Table 6-4.

6.2.3 Coal Water Fuel

The first shipment of a coal water fuel under this contract was sent to the Pittsburgh Energy Technology Center for their in-house combustion program. OXCE Fuel Company prepared and shipped 350 gallons of a standard grind coal water slurry prepared from Elk Creek coal. The Elk Creek coal was used instead of one of the selected coals because the Dravo cleaning circuit was not yet in operation, OXCE had a supply of this coal on hand and extensive experience in formulating it, and there was an immediate need for the fuel. The slurry analysis as furnished by OXCE is given in Table 6-5.

Table 6-4

SAMPLE ANALYSIS SHEET

Coal I.D.: UE2-114-MCO-C

Coal Description: Upper Elkhorn #2 Seam - Dry Micronized
Coal Shipped to PETC - May 5, 1987

Proximate:

Moisture	1.26%
Volatile Matter	35.00%
Fixed Carbon	62.93%
Ash	2.07%
Sulfur	0.58%
Btu/lb	15015

Ash Fusion: Reducing

Initial	2300°F
Softening	2425°F
Fluid	2540°F

Free Swelling Index:

8.0%

Ash Chemistry:

SiO ₂	50.45%
Al ₂ O ₃	26.93%
TiO ₂	1.71%
Fe ₂ O ₃	8.05%
CaO	2.97%
MgO	0.78%
K ₂ O	1.49%
Na ₂ O	2.78%
SO ₃	2.27%
P ₂ O ₅	0.15%
SrO	0.64%
BaO	0.69%
Mn ₃ O ₄	0.06%
Base Acid Ratio	0.20%
T - 250 Temp.	2715°F

Size Analysis:

Microns

Cum. Wt%
Passing

176	100.0
125	100.0
88	100.0
62	100.0
44	99.8
31	98.1
22	90.3
16	81.3
11	65.5
7.8	45.4
5.5	30.6
3.9	16.5
2.8	6.7

Ultimate:

Carbon	83.82%
Hydrogen	5.37%
Nitrogen	1.52%

Table 6-5

SAMPLE ID # ELC-108-CWF-F

Wt.% Solids	68.36%
Density	1.20 g/cc
pH	7.12

Viscosity (low shear)

@ 110 sec ⁻¹	786 cp
55	853 cp
22	976 cp
11	1165 cp
2.2	2469 cp
1.1	3360 cp
K	3549
n	0.5319

Viscosity (high shear)

@ 900 sec ⁻¹	390 cp
1560	449 cp
2260	465 cp
2866	489 cp

Viscosity Temp. Stability

Temp. °C initial increase	60-65°C
Temp. °C failure	85°C

Particle Size Distribution

MMD (microns)	22.76
% -30 mesh	100%
-50 mesh	99.96%
-80 mesh	99.46%
-200 mesh	87.44%

7.0 FUTURE PLANS

During the next quarter the washability and characterization of the five candidate coals will continue. Samples of the three additional coals selected in Task 1 will be obtained and their characterization begun. Coal cleaning, fuel preparation and fuel shipment will be carried out to meet the needs of the combustor contractors.

Planned deliveries of specific fuels are shown in Tables 7.1 "Schedule for Deliveries of Coals" and 7.2 "Schedule for Deliveries of Coal Water Slurries". Quantities for the future years are estimates which will be confirmed approximately three to four months prior to production.

Table 7.2
 SCHEDULE OF DELIVERIES OF COAL WATER SLURRIES
 (Including quantity and properties)
 as of 4-30-87

RMS 4-30-87
 fil:Slurry

CONSTRUCTION CONTRACTOR (Application)	COAL WATER SLURRY PROPERTIES	Notes	FY 87					FY 88			
			MAY	JUNE	JULY	AUGUST	SEPT	FIRST QTR	SECOND QTR	THIRD QTR	FOURTH QTR
AVCO (residential) (contract in May)	lignite, WMSZ, 302H20 <12 ash, 0.315, hi AFI 10000 Btu, FC45Z, 70Z solids, low vis, top 10u	specs & schedule per letter Feb 9						2000 lbs.			12 months
CONSTRUCTION ENGINEERING & (industrial retro)	3 to 6Z ash, 150u 2800 AFI, .72 S, 57Z FC 13500Btu; >84Z solids yet. Atomic surfac tants 330ZVM, C2.2R	revised schedule & spec on the way			2000gal <150u 3-6Zash	5000g 3-6Z ash <15u	6000g 3-6Z ash <45u	11000g 3-6ZASH <45u	20,000gal		20,000gal
ENERGY & ENVIRONMENTAL RESEARCH, Inc. & (residential)	70Z solids, 5u WMD 40u top, vis 1000cp 1Z ash, 0.5 S, 45Z VM	per letter April 3	55 gallon					100g in CA ??			
MICI (residential)	<1Z ash micronized 30u topsize	45-70Z solids	2000 lb 10u WMD						2000 lb <30u top 10u WMD		
(industrial)	<1Z micronized, 10u WMD 30u topsize		6000lb 10u WMD							30,000 lb 10u WMD in NJ	
(residential)	<1Z pulverized 30u WMD 149u topsize	2000 lbs 30u WMD							2000lbs 30u WMD		
(industrial)	<1Z pulverized 30u WMD 149u topsize		6000lbs 30u WMD							30,000 lb <30u in NJ	
NAVY/CATHOLIC UNIVERSITY (commercial)	70Z solids, <2000cps at 50/sec	still awaiting specs & schedule ultrathine coal						<-----est. 77	10-100 TONS <40u topsize, 100Z -400 mesh (38u)		
PETC 1A-HOUSE (industrial & commercial boilers)	eastern bituminous <0.6Z S, >50Z solids 500-700cp 100Z -100 mesh		2000g 5-10Zash		2000g 5-10Zash		4000g 5-10Zash		2000g 5-10Zash		2000g 5-10Zash
TEDESIN & (residential)	>55Z solids, <1Z ash <12S, 5u WMD, 20u topsz >2550 AFI	letter 4-29-87 only CMF Once??	2000g <1Z ash (fill.cake /Once May 1)		2000g <1Z ash plus ----)	2000g <1Z ash			2000g <1Z ash		2000g <1Z ash
TOM (industrial) (aid-May contract)		still awaiting specs & schedule	2 x 55 gal 500 gal asap			4500gal life of contract					
Univ. Tenn. Space Inst. (industrial, May)	<1ash, <12S, >2500AFI 10uWMD, 74u top	letter april 16						48 tons			
Vortex (sub BERL) & (industrial)	needs coal specs asap	slurry next year								1000 gallons	

Note: & means "under contract"

Table 7.1

SCHEDULE OF DELIVERIES OF COAL
(Including quantity and properties)
as of 4-30-87

RNG/5-1-87
Filed Coal

CONSUMPTION CONTRACTOR (Application)	COAL PROPERTIES	Notes	FY 87					FY 88					FOURTH QTR	12 months
			APRIL	MAY	JUNE	JULY	AUGUST	SEPT	FIRST QTR	SECOND QTR	THIRD QTR	FOURTH QTR		
AVCO Research Lab # (residential)	lignite < 0.5% ash 0.3 S 10,000 Btu/lb 35 micron topsize	letter Feb 9 specs & schedule					2000 lbs.							
COMPOSITION ENGINEERING # (industrial)	micronized sorbent, dry ultrafine	still awaiting specs & schedule							70 tons		5 tons			
ENERGY & ENVIRONMENTAL RESEARCH, Inc. #	bituminous 40u topsize low ash fus. temp.	still awaiting specs & schedule		55 gallons										
MITCI (residential) #	< 12 ash dry micronized		2000 lbs < 30u	4000 lbs < 30u						2000 lbs < 30u	20000 lb < 30u M.J.			
(industrial)	< 12 ash dry pulverized				2000 lbs < 14%u	4000 lbs < 14%u				2000 lbs < 14%u	20000 lb < 14%u M.J.			
NAVY/CATHOLIC UNIVERSITY (residential)		still awaiting specs & schedule							----- 10 to 100 tons estimated -----					
FEIC IN-HOUSE # (GILBERT/COMMO/EA/TH) (industrial boiler)	22 ash micronized bituminous		10 tons 22 ash		10 tons 22 ash			10 tons 22 ash	10 tons 22 ash					
Science Applications IC # (seal oxidation)	lignite/subbituminous				1 ton		1 ton							
TECOGEN # (residential)	micronized bituminous	still awaiting specs & schedule		100 lbs low ash bituminous										
T&W (sorbent, industrial)		still awaiting specs & schedule		100 lbs										
UNIV. North Dakota #	lignite low ash													
UTSI	subbituminous bituminous (12 ash < 40 mesh, lignite Ergon process	letter April 16 specs & schedule									48 tons			
Vortec (sub BEPL) # (industrial)	1 to 82 ash, pulverized 3 bitum. coals								5 to 10 tons	5 to 10 tons	5 to 10 tons	5 to 10 tons	1 ton	

Note: # means "under contract"

**DATE
FILMED**

8 / 23 / 93

END