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FINAL REPORT

MICRONIZED COAL-FIRED RETROFIT SYSTEM FOR SO_x REDUCTION

Krakow Clean Fossil Fuels and Energy Efficiency Program

Prepared for

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FINAL REPORT

MICRONIZED COAL-FIRED RETROFIT SYSTEM FOR SO_x REDUCTION

Krakow Clean Fossil Fuels and Energy Efficiency Program

1.0 EXECUTIVE SUMMARY

This report describes results of a technical, financial and environmental assessment study for a project, which would have included a new TCS micronized coal-fired heating plant for the Produkcja I Hodowla Roslin Ogrodniczych (PHRO) Greenhouse Complex; Krzeszowice, Poland. Project site is about 20 miles west of Krakow, Poland. During the project study period, PHRO utilized 14 heavy oil-fired boilers to produce heat for its greenhouse facilities and also home heating to several adjacent apartment housing complexes. The boilers burn a high-sulfur content heavy crude oil, called mazute.

The project study was conducted during a period extended from March 1996 through February 1997.

For size orientation, the PHRO Greenhouse complex grows a variety of vegetables and flowers for the Southern Poland marketplace. The greenhouse area under glass is very large and equivalent to approximately 50 football fields.

The new micronized coal fired boiler would have: (1). provided a significant portion of the heat for PHRO and a portion of the adjacent apartment housing complexes, (2). dramatically reduced sulfur dioxide air pollution emissions, while satisfying new Polish air regulations, and (3). provided attractive savings to PHRO, based on the quantity of displaced oil.

TCS, Inc. (Oakland and Annapolis, Maryland) maintained primary project development responsibilities for implementation and planned to supply its proprietary coal micronization system to the project. Other planned U.S. equipment suppliers included:

* Babcock & Wilcox; Barberton, Ohio and Warsaw, Poland ("boiler-island")
* Amerex, Inc.; Woodstock, Georgia (fabric filter)
* Control Techtronics International; Harrisburg, Pennsylvania & Krakow, Poland (control system).

Concurrent to the project study, the Town of Krzeszowice was considering a district heating program that would have replaced some, or all, of the 40 existing small in-town heating boilers that presently burn high-sulfur content coal. Potentially, the district heating system could have been expanded and connected into the PHRO boiler network; so that, PHRO boilers could have supplied all, or a portion of, the Town's heating demand. The new TCS micronized coal system could have also provided a portion of this demand with available excess capacity.

The TCS system potentially could have provided several important advantages to PHRO and the Town of Krzeszowice, including: (1). displacement of a portion of the coal use and reduce a portion of the air emissions resulting from the existing small in-town coal fired boilers, (2). "ground-work" for installing a "second" TCS system to displace all of the remaining coal use and reduction of all of the remaining existing air emissions resulting from the 40 small in-town coal fired boilers, (3). reduction of sulfur dioxide emissions from existing PHRO and Town sources, and (4). attractive savings to PHRO, based on the quantity of oil displaced.

Micronized coal is coal micro-pulverized to a particle size consistency similar to a very fine talcum powder. Because of its micron-size particle distribution, micronized coal has unique combustion characteristics that are similar to those associated with oil. Reasons for the similarity to oil, is that micronized coal has: (a). high combustion reactivity, (b). earlier combustion completion, and (c). minimum slagging or erosion effects.

Sulfur dioxide reductions during combustion with micronized coal is possible by co-micronizing limestone with coal. Sulfur dioxide (SO_2) air emissions are reduced due to a number of synergistic causes, including: (a). intimate mixing and contact between coal and limestone particles, and (b). accelerated calcination and sulfation reactions resulting from the small particle distribution of coal and limestone.

Nitrogen oxide reductions utilizing a TCS system result primarily from: (a). lower excess air than other conventional coal combustion systems, and (b). staged combustion achieved with the proprietary Babcock & Wilcox XCL Low-NOx burner.

An analyses of PHRO's historic heat demand was conducted to determine the optimum size boiler to cost effectively displace the maximum quantity of mazute with coal, resulting in a size boiler of 12 megawatts-thermal (MWt).

A cost trade-off analyses was conducted to determine the economic differentials of using a washed vs. an unwashed coal. Results indicated that using an unwashed coal is about six percent more expensive than washed coal, based on higher operating costs and materials handling. In addition, the use of unwashed coal would require higher capital costs to accommodate larger material storage and handling systems.

Based on proximity to project site and cost, the selected project coal was a washed KWK Wesola coal from nearby Katowice, and the selected limestone for desulfurization was a Czerna limestone locally available in the Town of Krzeszowice. Ten tons of Wesola coal and three tons of Czerna limestone were shipped to the TCS Combustion Test Facility in Oakland, Maryland to determine the combustion characteristics and desulfurization capabilities of the materials. Results of the combustion tests were very successful, and in summary included the following:

	Sulfur Dioxide (g/GJ)	Nitrogen Dioxide (g/GJ)
* Baseline (no limestone):	241	163 to 207 (varied)
* With limestone (@ 2:1 Ca:S molar):	173	160 to 196 (varied)
* New 1998 Polish Emission Standards:	200	170

A computer based mass-energy balance program was developed to determine the specific flow regime of each equipment component and pipeline in the new proposed TCS heating plant. This analyses formed the basis of developing costs for all equipment and installation, to be supplied by U.S. and Polish organizations.

With the assistance of the Biuro Rozwoju Krakowa (BRK) and PHRO, TCS retained CTI Polska (teamed with Naftokrak-Naftobudowa) to assist in cost determination of the Polish supplied portion of equipment, materials and labor necessary to construct the heating plant and interconnection with existing PHRO facilities.

TCS requested and received cost quotes for U.S. supplied equipment from: (a). Babcock & Wilcox; Barberton, Ohio and Warsaw, Poland ("boiler-island"), (b). Amerex, Inc.; Woodstock, Georgia and Wroclaw, Poland (fabric filter), (c). Control Techtronics International; Harrisburg, Pennsylvania & Krakow, Poland (control system).

The total heating plant cost estimate was determined to be

* Boilerhouse	$1,840,139
* Exterior interconnections	349,177
* Optional equipment	91,800
	----------
* TOTAL PROJECT COST	$2,281,116

Several sources of funding or financial assistance were either available, or identified as viable candidates, for the project, including:

* U.S. Department of Energy
* Voivodship Fund for Environmental Protection (Krakow)
* EkoFundusz (Warsaw)
* Babcock & Wilcox
* PHRO

Based on these sources of funding, the following indicates a summary of the financial sources and requirements of the total project cost estimate of $2,281,116. To determine possible economic project viability, it was assumed that funding not available from USDOE, EkoFundusz and PHRO, would be obtained from the Voivodship Fund:

*	U.S. Department of Energy:	$700,000
*	EkoFunduz (30% x $2,281,116):	684,335
*	PHRO:	280,000
*	Voivodship Fund:	616,781
		---------
*	TOTAL PROJECT COST:	$2,281,116

A proforma cost analyses was conducted to determine if the project made economic sense based on the indicated construction, fuel and operating costs, as compared to the displaced cost of mazute. Results showed, that based on the stated assumptions, the project was economically viable.

Unfortunately, PHRO was reluctant to proceed with the project due to its unwillingness to enter into a debt relationship with the Voivodship Fund. As such, implementation of the project ceased to proceed in February 1997.

Another factor that had negative economic impact on the project was the exceedingly high cost that Polish coal had risen to in late-1996. At a Polish Government controlled price of over $66 per ton, it ranked as one of the most expensive coals in the world. On an energy equivalency basis, its price was about 2.5 times that of a general U.S. Eastern Bituminous coal.

2.0 PROGRAM INTRODUCTION

The project study was performed as part of the equipment assessment program in the Support for Eastern European Democracy (SEED) Act of 1989 (P.L. 101-179). Following guidance of this legislation, a U.S.-Poland Bilateral Steering Committee (BSC) was established to define the program. The BSC is directing a program of assistance to Poland that would reduce air pollution in Krakow, Poland from about 1,300 boiler houses that provide heat for industrial, commercial, and residential applications, plus about 100,000 small stoves for home heating. The 1,300 boiler houses and 100,000 home heating stoves in Krakow primarily utilize solid fossil fuels and have been collectively called "low emissions sources" because of their low stack heights and the consequent low elevation entry of flue gases into the ambient air.

In October 1991, a Memorandum of Understanding (MOU) was signed by the U.S. Department of Energy (USDOE) and the Ministry of Environmental Protection, Natural resources and Forestry of the Republic of Poland. The MOU is titled, "Collaboration on the Krakow Clean Fossil Fuels and Energy Efficiency Program, A Project of Elimination of Low Emission Sources in Krakow." This MOU described the cooperation that is being undertaken by the governments of the United States and the Republic of Poland to accomplish this program. Funding for the program is being provided through the Agency for International Development (AID).

The purpose of the program is to encourage formation of commercial ventures between U.S. and Polish firms to provide equipment and/or services to reduce pollution from low emission sources in Krakow, Poland. These commercial ventures may take the form of contracts, joint ventures, partnerships, or any other commercially feasible arrangements that accomplishes the purposes of the statute.

Project development support includes all activities that must be accomplished by U.S. organizations and their proposed team members before the enterprise can expect to receive revenues from its activities in Krakow. These activities may include efforts to determine how to establish a U.S.-owned business in Poland, identify the Polish regulations relevant to the proposed project, conduct marketing studies, identify facilities and a labor force for the venture, and acquire a manufacturing plant. The proposed activities may also include the construction and testing of equipment to be sold (e.g., furnaces) or to produce a fuel to be sold. The proposed activities may utilize Polish fuels, as appropriate, to confirm technical feasibility.

The assistance provided is through cost-shared cooperative agreements between the USDOE and U.S. companies. Participation of Polish firms through teaming arrangements with U.S. proposers, while not required, was strongly encouraged. Fifty percent minimum cost sharing was required.

The work conducted as part of the project described in this report involves assessment of installing a new TCS micronized coal-fired heating plant for the Produkcja I Hodowla Roslin Ogrodniczych (PHRO) Greenhouse Complex; Krzeszowice, Poland. The facility would have included: (a). new coal and limestone storage silos, (b). TCS Coal Micronization System, (c).

Babcock & Wilcox "boiler island", (d). Amerex fabric filter (baghouse), (e). Control Techtronics International control system, and (f). balance of plant and equipment supplied by various Polish engineering design and construction companies and equipment suppliers.

Primary objective was to: (a). provide significant reductions in air pollution emissions for PHRO, (b). demonstrate an important U.S. Clean Coal Technology utilizing Polish coal and limestone, and (c). lower PHRO's operating costs.

3. FACILITIES DESCRIPTION AND HEAT DEMAND PROFILE AT PHRO

3.1 General Facility Location and Facilities

Produkcja I Hodowla Roslin Ogrodniczych (PHRO) Greenhouse Complex; Krzeszowice, Poland is located about 20 miles west of Krakow, Poland. The greenhouse complex grows a variety of vegetables and flowers for the Southern Poland marketplace. The greenhouse area under glass is very large and equivalent to approximately 50 football fields.

Currently, PHRO utilizes 14 heavy oil-fired boilers to produce heat for its greenhouse facilities and also home heating to several adjacent apartment housing complexes. The boilers burn a high-sulfur content heavy crude oil, called mazute. Emissions from the facility are a major source of pollution in the region.

PHRO maintains two boiler houses at its Krzeszowice facility. At Boilerhouse No.1, there are eight (8) fire-tube boilers, Bulgarian designed Type BM 4. At boilerhouse No.2, there are six (6) boilers of the same type and manufacturer. Each boiler has a heat capacity of 4.65 MWt, for a total facility capacity of 65 MWt. Working pressure and temperature of all boilers is 0.41 MPa (60 psia) and 116 degC (240 degF).

Specifications of the Mazute includes:

Heating value:	41,200 kJ/kg (
Sulfur content:	1.0 percent
Ignition temperature:	188 degC
Solidification temperature:	28 degC
Density at 20 degC:	0.906 (API = 25)

PHRO was undergoing a replacement of all burners with new Italian supplied Riello burners. These burners were designed to enhance and improve combustion efficiency, while burning mazute.

3.2 Heat Demand Profile and Analyses

An analyses of PHRO's historic heat demand was conducted to determine the optimum size boiler to cost effectively displace with coal, the optimum cost effective quantity of mazute.

Table 3-1 indicates historic and adjusted energy consumption data for PHRO for the years 1991 through 1995. Section A of Table 3-1 presents raw data that includes a period from January 1994 through April 1995 that heating tar was used, rather than mazute. Section B of Table 3-1 adjusts the quantity of heating tar, so that it is equivalent to mazute on an energy equivalency basis. This allows an annual averaging based on mazute only (currently used fuel), as indicated in Table 3-1, Column 11.

In order to establish a "baseline" for evaluation, these annual average values were reduced by 10 percent, to reflect an anticipated higher combustion efficiency that should result from installation of the new Italian Riello burners. The result is Column 12 of Table 3-1, which

Table 3-1: HISTORIC AND ADJUSTED PHRO ENERGY CONSUMPTION PROFILE

A. PHRO ENERGY CONSUMPTION - Prior Five (5) Years
BASIS: Dec. 12, 1995 PHRO Data Sheet

	1991 (tons)	1992 (tons)	1993 (tons)	1994 (tons)	1995 (tons)
	1	2	3	4	5
JAN	1130	1150	995	1031 *	802 *
FEB	1605	1529	1451	1752 *	1126 *
MAR	1150	1190	1410	1748 *	1765 *
APR	892	807	920	980 *	1433 *
MAY	620	520	500	595 *	360
JUN	205	200	210	280 *	179
JUL	0	0	0	0 *	0
AUG	0	0	0	60 *	80
SEP	178	190	380	417 *	356
OCT	612	760	700	1223 *	700
NOV	910	820	1053	1000 *	1134
DEC	980	910	920	807 *	710
	-----	-----	-----	-----	-----
TOTALS	8282	8076	8539	9893	8645

NOTE: [*] = Heating Tar @ 36,000 Kj/kg
All other values = Mazute @ 41,200 Kj/kg

B. VALUES ADJUSTED - SO ALL [*] VALUES ARE EQUIVALENT TO MAZUTE
BASIS: All "*" Values reduced by (36,000/41,200)

	1991 (tons)	1992 (tons)	1993 (tons)	1994 (tons)	1995 (tons)	AVERAGE (tons)	REDUCE by 10% (New Burner Eff) (tons) [**]
	6	7	8	9	10	11	12
JAN	1130	1150	995	901 *	701 *	975	878
FEB	1605	1529	1451	1531 *	984 *	1420	1278
MAR	1150	1190	1410	1527 *	1542 *	1364	1228
APR	892	807	920	856 *	1252 *	945	851
MAY	620	520	500	520 *	360	504	454
JUN	205	200	210	245 *	179	208	187
JUL	0	0	0	0 *	0	0	0
AUG	0	0	0	52 *	80	26	24
SEP	178	190	380	364 *	356	294	264
OCT	612	760	700	1069 *	700	768	691
NOV	910	820	1053	874 *	1134	958	862
DEC	980	910	920	705 *	710	845	761
	-----	-----	-----	-----	-----	-----	-----
TOTALS	8282	8076	8539	8644	7998	8308	7477

NOTE: [**] = Each average value reduced 10 % = new burner higher efficiency.
BASIS: B&W 3/26/96 FAX

indicates an assumed adjusted mazute consumption annual total of 7,477 tons-mazute. This value is the baseline for computing energy reduction benefits that could result from installation of a TCS coal micronization heating plant.

To determine percentages of year that certain loads exist was determined from actual 1995 daily PHRO mazute consumption values that were "adjusted" to tally to the assumed annual consumption total of 7,477 tons-mazute. This is indicated on Table 3-2.

Each "adjusted" daily value from Table 3-2 was then presented as daily mazute consumption (tons/day) in descending order of magnitude (i.e., starts with coldest day and descends to warmest) as indicated in Table 3-3 (Column 2). To keep the analysis "manageable", the values are compartmented into data "bins" ("BINS"); wherein, the seven coldest days are shown as "daily" values (i.e., BIN No. 1-a,b,c,d,e,f,g), and the balance of the year as average "weekly" values for each of the remaining 51 week bins (i.e., BIN No. 2 - 52).

Additional information is presented in the following columns of Table 3-3:

Col.3: Average adjusted mazute consumption in tons/hour.
Col.4: Cumulative percent of time that each data BIN occurs.
Col.5: Equivalent thermal output (MWt) of each data BIN.

A trial and error analyses was conducted on these values for cumulative percent of time distribution and equivalent thermal output to determine the optimum size micronized coal boiler. The analyses resulted in an optimum size boiler of 12 MWt, as indicated in Table 3-4.

This boiler size (i.e., 12 MWt) is imposed into the analyses on Table 3-3 to show the percent of total heating load produced by coal (85.4%) and that which will continue to be provided by mazute (14.6%). This result is graphically shown in Figure 3-1.

Table 3-2: PHRO DAILY MAZUTE CONSUMPTION - (Based on "Adjusted" 1995 Data)

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL (tons)
						(tons Mazute per day)							
1	19.6	28.6	27.0	44.0	22.5	9.7	0.0	1.1	13.6	34.7	19.2	17.0	
2	29.4	38.9	31.7	33.1	17.7	7.3	0.0	0.8	10.3	25.9	28.8	25.4	
3	28.5	42.9	28.4	18.9	10.1	4.2	0.0	0.5	5.9	15.4	28.0	24.7	
4	30.2	45.2	24.2	38.6	19.6	8.5	0.0	1.1	12.0	30.3	29.7	26.2	
5	38.4	51.1	36.9	29.5	14.7	6.5	0.0	0.7	9.1	22.9	37.7	33.3	
6	38.2	43.1	29.4	31.5	16.8	6.9	0.0	0.8	9.8	24.6	37.5	33.1	
7	31.1	39.9	28.5	38.6	19.6	8.5	0.0	1.1	12.0	30.4	30.5	27.0	
8	27.4	46.6	30.0	55.8	28.8	12.3	0.0	1.5	17.3	44.3	26.9	23.8	
9	27.8	55.6	26.4	40.9	21.8	9.0	0.0	1.2	12.7	32.2	27.3	24.1	
10	27.4	42.8	33.9	39.1	19.9	8.6	0.0	1.1	12.1	30.8	26.9	23.7	
11	28.4	42.3	31.4	39.8	20.2	8.8	0.0	1.1	12.4	31.3	27.9	24.6	
12	29.8	37.8	46.5	45.9	24.5	10.1	0.0	1.3	14.2	36.3	29.3	25.9	
13	29.0	35.5	67.0	48.8	25.0	10.7	0.0	1.4	15.1	38.6	28.5	25.1	
14	37.0	31.8	61.2	41.8	22.3	9.2	0.0	1.2	13.0	32.9	36.4	32.1	
15	29.1	29.7	39.5	33.6	17.9	7.4	0.0	0.9	10.4	26.3	28.5	25.2	
16	24.8	32.6	43.2	23.4	12.5	5.1	0.0	0.7	7.3	19.0	24.4	21.5	
17	30.4	37.2	30.2	29.6	15.8	6.5	0.0	0.8	9.2	23.1	29.9	26.4	
18	33.8	40.3	30.4	24.2	12.9	5.3	0.0	0.7	7.5	19.6	33.2	29.3	
19	30.9	44.8	39.4	16.0	8.5	3.5	0.0	0.5	5.0	13.0	30.3	26.7	
20	32.4	49.5	42.3	16.2	8.6	3.6	0.0	0.5	5.0	13.1	31.8	28.1	
21	28.2	42.7	48.8	13.7	7.3	3.0	0.0	0.4	4.3	11.1	27.7	24.5	
22	24.6	56.6	45.8	10.6	5.6	2.3	0.0	0.3	3.3	8.6	24.2	21.4	
23	21.5	48.7	46.3	8.5	4.6	1.9	0.0	0.2	2.7	6.9	21.1	18.6	
24	22.8	58.3	35.9	14.3	7.6	3.1	0.0	0.4	4.4	11.6	22.4	19.8	
25	22.0	73.3	34.8	13.7	7.3	3.0	0.0	0.4	4.2	11.1	21.6	19.1	
26	19.0	61.2	40.4	20.9	11.2	4.6	0.0	0.6	6.5	17.0	18.7	16.5	
27	29.6	58.8	54.1	22.6	12.0	5.0	0.0	0.6	7.0	18.3	29.0	25.6	
28	25.4	62.2	48.9	22.1	11.8	4.9	0.0	0.6	6.9	18.0	24.9	22.0	
29	21.6	-	50.0	18.7	10.0	4.1	0.0	0.5	5.8	15.2	21.2	18.7	
30	26.5	-	48.6	16.6	8.9	3.7	0.0	0.5	5.2	13.5	26.0	23.0	
31	33.0	-	46.8	-	8.0	-	-	0.5	-	15.0	32.4	28.6	
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TOTALS	878.0	1278.0	1228.0	851.0	454.0	187.0	0.0	24.0	264.0	691.0	862.0	761.0	7477.0

Table 3-3: ASSUMED PHRO ANNUAL HEAT DISTRIBUTION ANALYSES

"BIN" No.	HISTORIC AVERAGE MAZUTE CONSUMPTION		CUMULATIVE PERCENT OF TIME	NEEDED THERMAL OUTPUT	SUPPLIED THERMAL OUTPUT BY FUEL TYPE	
					(Coal)	(Mazute)
1	2	3	4	5	6	7
	(Tons/Day)	(Tons/Hr)	(%)	(MWt)	(MWt)	(MWt)
Daily						
1a	73.3	3.05	0.27%	27.9	12.0	15.9
1b	67.0	2.79	0.55%	25.5	12.0	13.5
1c	62.2	2.59	0.82%	23.7	12.0	11.7
1d	61.2	2.55	1.10%	23.3	12.0	11.3
1e	61.2	2.55	1.37%	23.3	12.0	11.3
1f	58.8	2.45	1.64%	22.4	12.0	10.4
1g	58.3	2.43	1.92%	22.2	12.0	10.2
Weekly						
2	53.3	2.22	3.85%	20.3	12.0	8.3
3	48.2	2.01	5.77%	18.3	12.0	6.3
4	45.5	1.90	7.69%	17.3	12.0	5.3
5	43.0	1.79	9.62%	16.4	12.0	4.4
6	40.8	1.70	11.54%	15.5	12.0	3.5
7	39.0	1.63	13.46%	14.8	12.0	2.8
8	37.7	1.57	15.38%	14.3	12.0	2.3
9	35.8	1.49	17.31%	13.6	12.0	1.6
10	33.4	1.39	19.23%	12.7	12.0	0.7
11	32.5	1.35	21.15%	12.4	12.0	0.4
12	31.5	1.31	23.08%	12.0	12.0	0.0
13	30.5	1.27	25.00%	11.6	11.6	0.0
14	30.0	1.25	26.92%	11.4	11.4	0.0
15	29.5	1.23	28.85%	11.2	11.2	0.0
16	28.9	1.20	30.77%	11.0	11.0	0.0
17	28.5	1.19	32.69%	10.8	10.8	0.0
18	27.9	1.16	34.62%	10.6	10.6	0.0
19	27.0	1.13	36.54%	10.3	10.3	0.0
20	26.2	1.09	38.46%	10.0	10.0	0.0
21	25.4	1.06	40.38%	9.7	9.7	0.0
22	24.7	1.03	42.31%	9.4	9.4	0.0
23	24.2	1.01	44.23%	9.2	9.2	0.0
24	23.1	0.96	46.15%	8.8	8.8	0.0
25	22.2	0.92	48.08%	8.4	8.4	0.0
26	21.4	0.89	50.00%	8.1	8.1	0.0
27	20.0	0.83	51.92%	7.6	7.6	0.0

Table 3-3 (continued): ASSUMED PHRO ANNUAL HEAT DISTRIBUTION ANALYSES

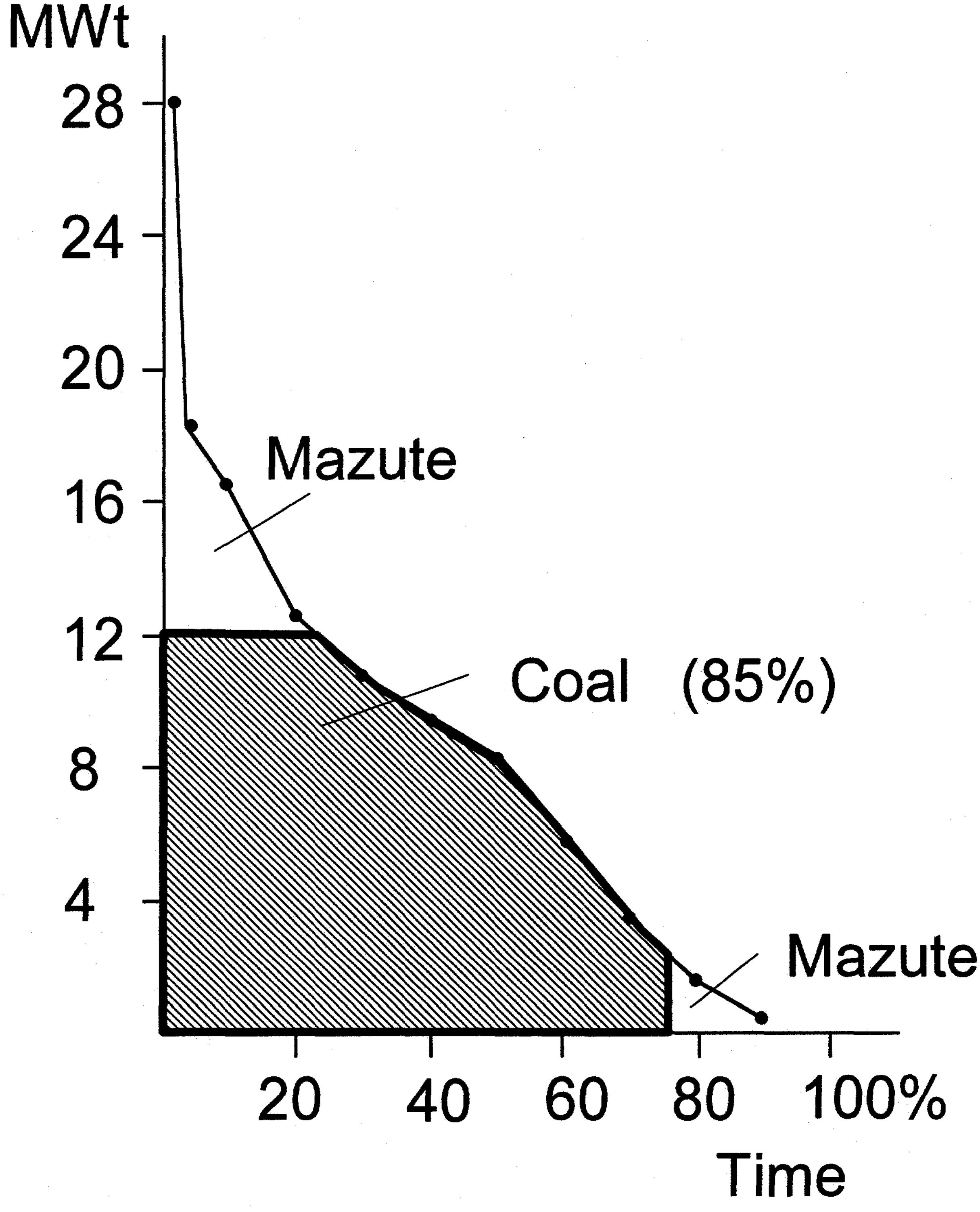
"BIN" No.	HISTORIC AVERAGE MAZUTE CONSUMPTION		CUMULATIVE PERCENT OF TIME	NEEDED THERMAL OUTPUT	SUPPLIED THERMAL OUTPUT BY FUEL TYPE	
					(Coal)	(Mazute)
1	2	3	4	5	6	7
	(Tons/Day)	(Tons/Hr)	(%)	(MWt)	(MWt)	(MWt)
28	19.1	0.80	53.85%	7.3	7.3	0.0
29	18.3	0.76	55.77%	7.0	7.0	0.0
30	16.8	0.70	57.69%	6.4	6.4	0.0
31	15.3	0.64	59.62%	5.8	5.8	0.0
32	13.7	0.57	61.54%	5.2	5.2	0.0
33	12.7	0.53	63.46%	4.8	4.8	0.0
34	11.8	0.49	65.38%	4.5	4.5	0.0
35	10.6	0.44	67.31%	4.0	4.0	0.0
36	9.6	0.40	69.23%	3.7	3.7	0.0
37	8.7	0.36	71.15%	3.3	3.3	0.0
38	8.0	0.33	73.08%	3.0	3.0	0.0
39	7.1	0.30	75.00%	2.7	2.7	0.0
40	6.2	0.26	76.92%	2.4	2.4	0.0
41	5.1	0.21	78.85%	1.9	1.9	0.0
42	4.3	0.18	80.77%	1.6	1.6	0.0
43	3.3	0.14	82.69%	1.3	1.3	0.0
44	1.7	0.07	84.62%	0.6	0.6	0.0
45	1.1	0.05	86.54%	0.4	0.4	0.0
46	0.7	0.03	88.46%	0.3	0.3	0.0
47	0.5	0.02	90.38%	0.2	0.2	0.0
48	0.3	0.01	92.31%	0.1	0.1	0.0
49	0.0	0.00	94.23%	0.0	0.0	0.0
50	0.0	0.00	96.15%	0.0	0.0	0.0
51	0.0	0.00	98.08%	0.0	0.0	0.0
52	0.0	0.00	100.00%	0.0	0.0	0.0
	------				------	------
TOTALS	7477.0				6381.7	1095.3
PERCENT	100.0%				85.4%	14.6%

Table 3-4: PHRO HEATING PLANT SIZE OPTIMIZATION ANALYSES

(Determines Optimum Capacity of TCS Heating Plant)

BOILER CAPACITY (MWt)	PERCENT OF PHRO'S MAZUTE DISPLACED BY MICRON COAL	PERCENT OF PHRO'S MAZUTE NOT-DISPLACED BY MICRON COAL	
10	78.4%	21.6%	
11	82.1%	17.9%	
12	85.3%	14.7%	------ OPTIMUM
13	87.1%	12.9%	
14	88.4%	11.6%	
15	89.3%	10.7%	
16	90.6%	9.4%	
17	90.7%	9.3%	
18	91.5%	8.5%	------ MAXIMUM DISPLACED
19	91.0%	9.0%	(But Not Economically)
20	90.3%	9.7%	
21	89.4%	10.6%	
22	89.6%	10.4%	

Figure 3-1: PHRO HEAT DISTRIBUTION PROFILE BY FUELS



4. TYPE OF COAL COST TRADE-OFF ANALYSES

A cost trade-off analyses was conducted to determine the economic differentials of using a washed vs. an unwashed coal.

Unwashed coal is less expensive on a per ton basis; however, its higher sulfur and ash contents, coupled with lower heat contents, result in greater operating costs to accommodate it efficiently and in an environmentally acceptable manner. In general, the following trade-offs are qualitatively indicated:

ITEM	WASHED COAL	UNWASHED COAL
Cost per ton:	Higher	Lower
Annual coal tons required:	Lower	Higher
Unit cost per BTU:	Slightly higher	Slightly lower
Boiler efficiency:	Slightly higher	Slightly lower
Ash and sulfur content:	Lower	Higher
Maintenance costs:	Lower	Higher
Annual sorbent tons required:	Lower	Higher
Ash disposal cost:	Lower	Higher

Table 4-1 quantitatively indicates these trade-offs based on estimated costs, derived from: (a). computed mass-energy balances for PHRO requirements, (b). cost estimates obtained from the Polish KWK Staszic Coal Company and Wesola Limestone Company, and (c). other reasonable assumptions.

Use of a unwashed coal is indicated to be about six percent more expensive than washed coal, based on operating costs. In addition, the use of unwashed coal would require higher capital costs to accommodate larger material storage and handling systems.

Results of this analyses, clearly indicates that the use of washed coal is more cost effective.

Table 4-1: PHRO GREENHOUSE: TRADE-OFF OF WASHED vs. UNWASHED COAL

	WASHED	UNWASHED
HEAT BALANCE CRITERIA - by coal		
Assumed hourly heat output to PHRO (MWt)	12.0	12.0
Equivalent hourly heat output to PHRO (MMBtu/hr)	42.0	42.0
Computed boiler efficiency (%)	87.2%	86.6%
Fuel input (MMBtu/hr):	48.2	48.5
Annual equivalent mazute displace by ... ... coal (tons/yr) (Table 3-3, Col.7):	6382	6382
Equivalent annual heat content of displaced ... ... mazute @ 17,750 BTU/lb (billion BTU /yr)	249.2	249.2
Equivalent heat input (@ assume mazute boiler EFF. = 82%)	204.4	204.4
COAL CRITERIA		
Heat content (MMBTU/m-ton):	25.5	18.0
Sulfur content (%):	0.5	0.8
Ash content (%):	7.5	28.0
Req SOx reduction to meet 1998 Polish Standards	17%	50%
MATERIALS MASS FLOWS		
Annual coal heat input based on computed boiler EFF.	234.4	235.9
Annual coal input as fuel weight (m-tons per year):	9183	13078
Sorbent (lb-sorbent / ton-coal)	70	112
Flyash produced (lb-ash /ton-coal)	220	719
UNIT COSTS		
Coal ($ /m-ton) (includes 12% VAT):	$66.30	$44.50
Sorbent ($ /m-ton) (includes 12% VAT):	$5.60	$5.60
Assumed ash disposal ($ /m-ton):	$10.00	$10.00
Mill power ($ /Kwh @ 40 Kwh /ton coal+sorbent):	$0.07	$0.07
Mill O&M ($ /ton-coal+sorbent):	$1.50	$1.50
Higher O&M cost differential: more materials handling	0	$10,000
TOTAL ANNUAL COSTS		
Coal	$608,847	$581,965
Limestone	1,646	3,735
Ash disposal	9,174	42,752
Power (@ 40 Kwh /ton coal+sorbent)	26,536	38,486
O&M (TCS mill):	14,216	20,617
O&M differential - material handling	0	10,000
	-------	-------
TOTAL	$660,418	$697,555

5. ENVIRONMENTAL ISSUES AND CONCERNS

5.1 General

This section describes results of laboratory and combustion tests that were conducted to determine air emission factors associated with the proposed TCS heating plant.

These results are compared to requirements of the New 1998 Polish Air Emission Standards.

Likewise, other environmental impacts are described and quantified, including: ash, water, wastewater, and land impact.

5.2 Laboratory Analysis of Candidate Coal

During an April 1996 site visit by TCS, a trip was made to the KWK Staszic Coal mine near Katowice, Poland. Based on cost, coal characteristics, and proximity to project site, it was determined that a KWK Wesola coal was suitable as the designated project coal.

Arrangements were made to ship ten (10) tons of the KWK Wesola coal to the TCS Combustion Test Facility in Oakland, Maryland for combustion tests (described below).

An ultimate chemical analyses of the Wesola coal include the following:

*	Carbon	68.00 percent
*	Hydrogen	4.30
*	Sulfur	0.65
*	Oxygen	10.30
*	Nitrogen	1.00
*	Moisture	8.25
*	Ash	7.50
		------
*	Total	100.00
*	Heating value	11,874 BTU/lb

5.3 Laboratory Analysis of Candidate Limestone

Four (4) limestone sources were identified in the general Krakow region, including: (a). Sitkowka, (b). Plaz, (c). Carbide Residue, and (d). Czerna. Samples from each of these sources was procured and sent to the Pennsylvania State University Coal Utilization Laboratory to conduct a series of chemical and physical analyses, including: (a). calcium and magnesium content, (c). other chemical components, and (c). thermogravametric analysis (TGA).

Results of the analyses included:

COMPONENT	SITKOWKA	PLAZ	CARBIDE RESIDUE	CZERNA
SiO_2	0.04	6.76	2.30	2.60
Al_2O_3	0.15	1.66	1.49	0.85
TiO_2	0.01	0.07	0.05	0.04
Fe_2O_3	0.08	0.85	0.39	0.36
MnO	0.44	0.04	0.01	0.04
CaO	56.80	43.10	70.10	53.20
MgO	< 0.02	5.72	0.12	1.62
Na_2O	< 0.02	< 0.02	< 0.02	< 0.02
K_2O	< 0.02	0.61	0.05	0.08
P_2O_5	< 0.02	0.10	0.02	0.07
BaO	< 0.01	< 0.01	0.02	< 0.01
SrO	0.03	0.02	0.05	0.03
SO_3	< 0.05	< 0.05	0.40	< 0.05
LOI [**]	41.30	41.60	24.50	40.80
Ca:S Molar Ratio	1.22	1.13	1.24	1.17
Lb-Sorbent Required per lb.-Sulfur	3.8	4.6	3.1	3.9

[**] LOI = Loss On Ignition, refers to the material that volatilizes during heating. In the case of limestones, this refers to CO_2 loss during heating to 900 degC.

In its report to TCS, the Pennsylvania State University Coal Utilization Laboratory indicated that the Ca:S molar ratio and lbs-sorbent/lb-sulfur for all four sorbents is well within the range of values obtained for sorbents that were successfully fired (i.e., maintained compliance for SO_2 emissions) in full-scale Atmospheric Fluidized Bed units. Based on Penn. State's experience, the performance (i.e., Ca:S molar ratio) of all four sorbents were well within acceptable and experimental error.

Since all four sorbents were, more-or-less, in the same range of desulfurization efficiency, the Czerna limestone was selected as the designated project sorbent. This decision was based on cost factors (i.e., both mine and transportation), because the Czerna limestone mine is located in Krzeszowice, Poland (about one mile from the PHRO project site).

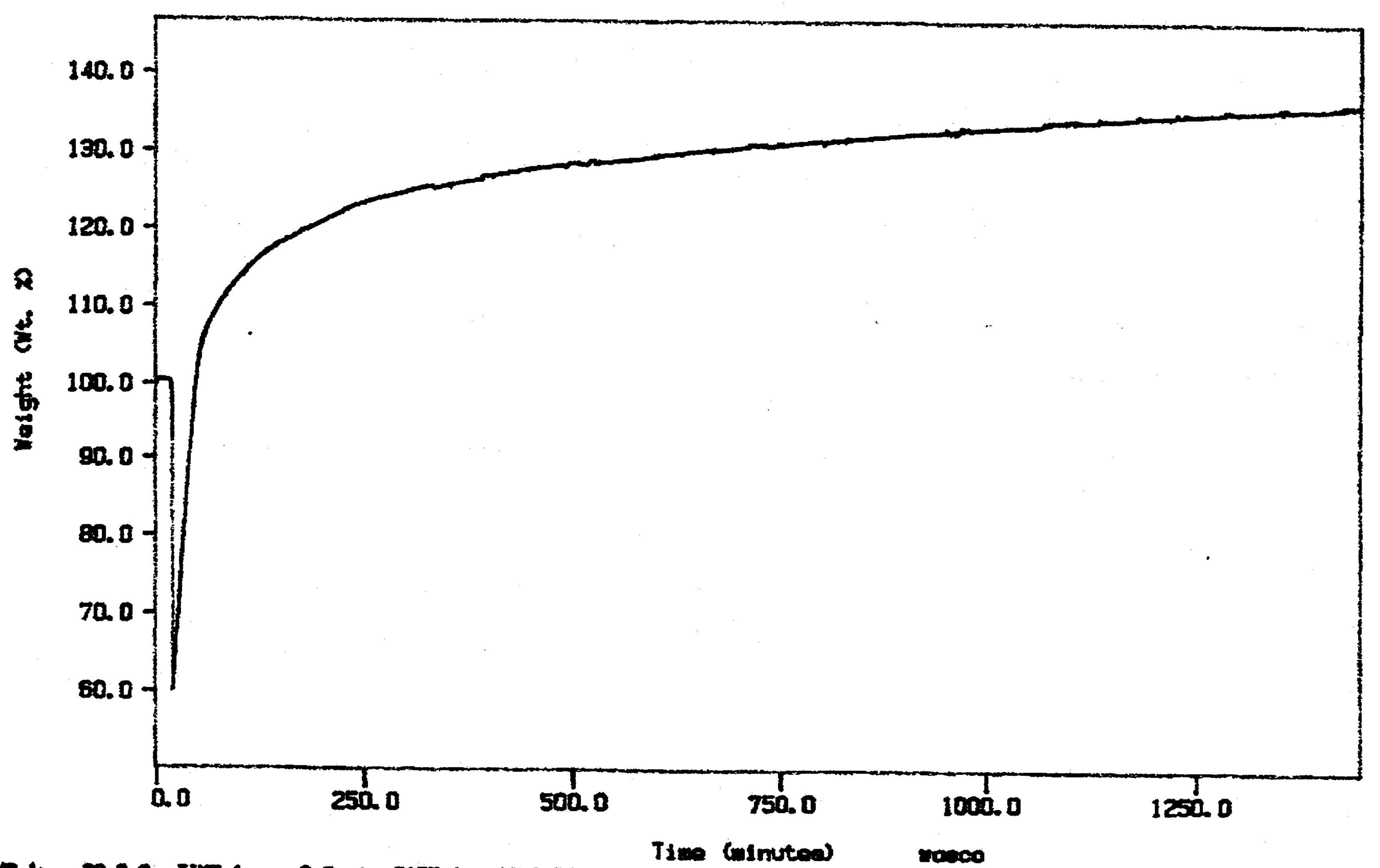
For orientation, Figure 5-1 presents a graphical result of the TGA analyses of the Czerna limestone as determined by the Pennsylvania State University Coal Utilization Laboratory.

Arrangements were made to ship three (3) tons of the Czerna limestone to the TCS Combustion Test Facility in Oakland, Maryland for combustion tests (described below).

Figure 5-1: TGA RESULTS FOR CZERNA LIMESTONE

TGA File Name: polo1
Sample Weight: 3.585 mg
Sun Nov 13 14:25:17 1994
Polish Sample #4

PERKIN-ELMER
7 Series Thermal Analysis System



TEMP 1: 30.0 C TIME 1: 0.0 min RATE 1: 10.0 C/min
TEMP 2: 200.0 C TIME 2: 0.0 min RATE 2: 200.0 C/min
TEMP 3: 900.0 C TIME 3: 1420.0 min

5.4 Combustion Tests

A series of combustion tests were conducted utilizing the KWK Wesola coal and Czerna limestone during July 1996.

The TCS Test Combustion Facility in Oakland, Maryland is equipped with the following systems:

* Solid material storage and screw-feed conveyor system.
* TCS Model CM32C micronization mill.
* Babcock & Wilcox Model XCL Low-NOx burner (modified), rated at approximately 16 MMBTU/hr. Combustion air to burner was preheated by an electric secondary air heater.
* Babcock & Wilcox Model FMD-9-34 "D"-Pattern floor mounted boiler, rated at 16,000 pph-steam @ 225 psig/SAT.
* Pulse-jet baghouse, equipped with FlexKleen filter media.
* All necessary auxiliary boiler and combustion equipment and controls.
* LAND Model 6500 Combustion Analyzer (CO, CO_2, O_2 and NO_x).
* Thermox (Ametek) Emission Monitoring System (O_2 and combustibles).

The purpose was to conduct a series of combustion tests; wherein, sufficient quantities of the KWK Wesola coal was: (a). micronized and burned individually for a baseline determination, and (b). co-micronized with varying quantities of the Czerna limestone and burned together to determine impact on desulfurization and other air emission factors during combustion.

Primary objectives were to determine: (a). desulfurization capabilities of the Czerna limestone, and (b). resulting NO_x and SO_x emissions, both without (i.e., baseline) and with limestone.

Results of the combustion tests were very successful, and in summary included the following:

	Sulfur Dioxide (g/GJ)	Nitrogen Dioxide (g/GJ)
* Baseline (no limestone):	241	163 to 207 (varied)
* With limestone (@ 2:1 Ca:S molar):	173	160 to 196 (varied)
* New 1998 Polish Emission Standards:	200	170

During the TCS tests, with a very acceptable Calcium/Sulfur molar ratio of 2:1, the Czerna limestone and Wesola coal combination achieved 28 percent desulfurization. This reduction is more than necessary, since only 17 percent is required for the Wesola coal to meet the new Polish emission standards (i.e., from 241 g/GJ to 200 g/GJ = 17% required reduction).

During the combustion tests, the primary objective was to optimize sulfur reduction. During the TCS tests, NO_x emissions varied slightly up-and-down; however, "fine-tuning" was able to achieve the required new Polish emission standard of 170 g/GJ.

TCS test baseline SO_x emissions closely corresponded to those results obtained during combustion tests conducted at the Krzeslawice Boilerhouse (Krakow) by USDOE while using a KWK Staszic washed coal. KWK Staszic and KWK Wesola coals are similar in their ultimate analyses and are mined by the same company at locations very close to each other near Katowice, Poland.

5.5 Air Emission Impacts on the Town of Krzeszowice

In addition to PHRO's mazute fired boilers, the Town of Krzeszowice has approximately 40 small coal-fired boilers currently operating as heating plants. To determine the impact that a new TCS heating plant would have on the Town's annual air emissions, The U.S. Department of Energy contracted the Biuro Rozwoju Krakowa (BRK) to conduct a study to quantify the impact on air emissions.

Data for the analyses was provided by: (a). estimated air emission factors for the proposed new TCS heating plant, (b). historic mazute consumption rates at PHRO, and (c). estimated coal consumption rates for the Town.

Three stages of implementation were assumed, including: (a). "Existing", (b). "Transitional", which assumes a new TCS heating plant at PHRO and the existing Town boilers continue to operate, and (c). "Final", which assumes all Town boilers are eliminated and heat is provided by utilizing existing PHRO mazute boilers, plus excess capacity in the TCS heating plant.

Table 5-1 indicates results of BRK's study.

5.6 Ash Disposal

Ash produced from micronized coal and limestone has unique physical characteristics which give it unique applications as a byproduct resource material with dollar value for the cement industry. Highlights of this unique ash characteristic includes:

(a). Micronized coal burns at a temperature range of 1900 to 2100 degF; therefore, it produces an ash which is pozzolanic (i.e., hardens in the presence of calcium and water).

(b). Micronized coal ash has a very fine particle size distribution and is cementitious in nature; thus, it has excellent byproduct value as a raw material supplement for cement manufacturing. Concrete will achieve higher structural strength during the "cementing-process" if it contains smaller particles; therefore, micronized coal ash is superior for this reason when compared to conventional coal ash.

Table 5-1: BRK STUDY RESULTS - AIR EMISSION IMPACTS OF TCS HEATING PLANT

POLLUTANT	***** EXISTING *****			************ TRANSITIONAL ************					*************** FINAL ***************				
	Mazute	Coke (Mg /year)	Total	Mazute	Coke (Mg /year)	TCS	Total	Change (+/-)	Mazute	Coke (Mg /year)	TCS	Total	Change (+/-)
SO2	156.8	55.1	211.9	23.0	55.1	47.3	125.4	-40.8%	78.1	0.0	50.4	128.5	-39.4%
NOx	41.3	7.0	48.3	6.1	7.0	40.2	53.3	10.4%	20.6	0.0	42.8	63.4	31.3%
CO	5.0	116.4	121.4	0.7	116.4	4.5	121.6	0.2%	2.5	0.0	4.8	7.3	-94.0%
CO2	13619	11172	24791	2000	11172	19643	32815	32.4%	6782	0.0	20922	27704	11.8%
Particulate	14.9	69.8	84.7	2.2	69.8	30.8	102.8	21.4%	7.4	0.0	32.8	40.2	-52.5%

NOTE: CONDITIONS =================
* EXISTING = Current conditions at PHRO and Town of Krzeszowice.
* TRANSITIONAL = TCS displaces 85% PHRO mazute, Town remains at current condition.
* FINAL = All Town boilers are shut down. PHRO & Town heat provided by mazute and TCS.

A cement manufacturing company located in the Town of Krzeszowice indicated to PHRO that it would be interested in utilizing the ash generated by the TCS heating plant. This was the planned method of disposing the TCS generated coal ash.

5.7 Water and Wastewater

Water that would be heated by the TCS heating plant for distribution to the greenhouse, would originate in the existing PHRO water treatment plant. No additional water would be consumed, since in effect, water currently used at PHRO's existing heating plants would be re-routed through the TCS heating plant.

Water consumed by the TCS heating plant would be used for boiler makeup and plant cleanup. The boiler makeup water is relatively small quantity and equates to about 0.4 gallons per minute (90 kg/hr). Its source would originate from the existing PHRO water supply system.

Primary wastewater generated by the TCS heating plant would be from the boiler blowdown and plant cleanup. The boiler blowdown is essentially the same quantity as indicated above for boiler makeup (i.e., 0.4 gpm, 90 kg/hr).

5.8 Land Impact

Land required for the TCS heating plant is less than an acre in size. Its designated location is a small parcel of land owned by PHRO; therefore, no impact would occur on property owned by the Town or others.

In addition to the two-day coal storage silo provided by the TCS heating plant, PHRO agreed to assume responsibility for constructing exterior on-ground coal storage facilities. It planned to incorporate a covered-sheltered type of structure to minimize rainwater runoff and fugitive dust emissions.

6. MASS ENERGY AND MATERIALS ANALYSES FOR EQUIPMENT DETERMINATION

In order to properly estimate and determine equipment and ancillary component sizing and costs, a mass energy and materials balance computer program was developed.

6.1 Mass and Energy Flow Computations

Figure 6-1 indicates the complete program flow diagram, with each flow line identified numerically.

Table 6-1 indicates each numbered heat/materials flow line, with its corresponding flow medium (i.e., water, steam, air, flue gases), flow rate, pressure and temperature. Units are expressed both in U.S. and metric.

6.2 Boiler Heat Balance

Table 6-2 is a computer print out of the mass-energy balance solely around the boiler, based on Wesola coal and PHRO's thermal requirements.

Printout indicates boiler efficiency, combustion air flow input, flue gas outflow, fuel consumption.

Results of these analyses form the basis of equipment sizing and costing indicated in the next report sections.

Figure 6-1: PHRO GREENHOUSE - TCS HEATING PLANT ENERGY & MATERIALS FLOW DIAGRAM

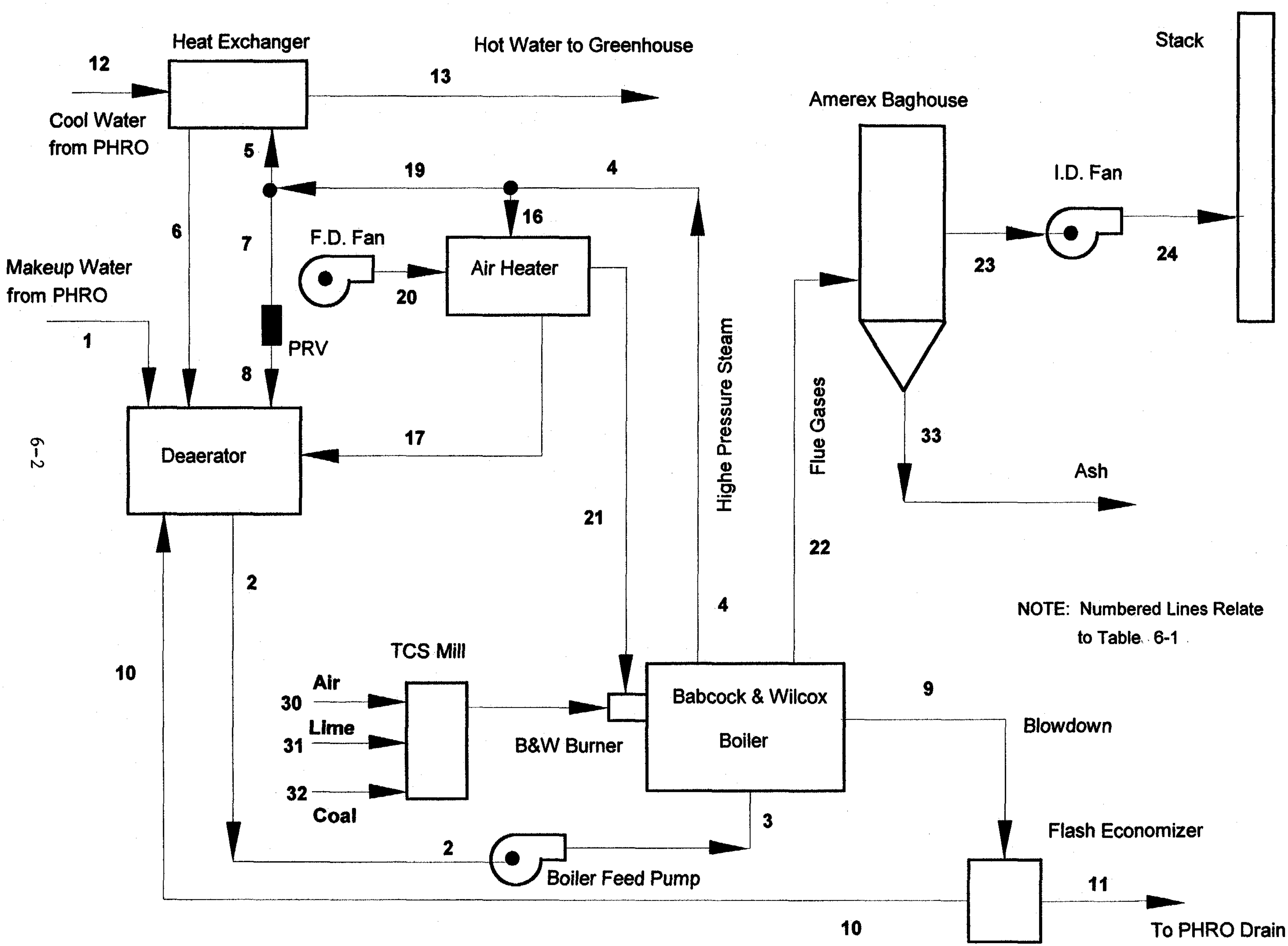


Table 6-1: PHRO GREENHOUSE - MATERIALS/ENERGY BALANCE FLOW LINE DESCRIPTION (Line Numbers Refer to Figure 6-1)

FLOW LINE	MEDIUM	****** FLOW ******		** PRESSURE **		** TEMPERATURE **		DESCRIPTION
		(kg/hr)	(1000 pph)	(MPa)	(psia)	(degC)	(degF)	
1	Water	95	0.21	0.17	25	15.6	60	Makeup to D/A from PHRO
2	Water	19,391	42.66	0.17	25	115.6	240	D/A drain to BF. Pump
3	Water	19,391	42.66	1.64	241	115.7	240	Boiler feed water from D/A to boiler
4	Steam	19,318	42.50	1.31	193	191.9	378	Boiler steam flow
5	Steam	16,786	36.93	1.31	193	191.9	378	Steam to Heat X-changer from boiler
6	Water	16,786	36.93	1.28	188	63.3	146	Drain flow from Heat X-changer to D/A
7	Steam	1,682	3.70	1.31	193	191.9	378	Steam flow to P.V. Valve from boiler
8	Steam	1,682	3.70	0.17	25	157.1	315	Steam flow to D/A from PRV
9	Water	95	0.21	1.64	241	202.5	397	Boiler blowdown to flash economizer
10	Steam	18	0.04	0.17	25	115.6	240	Steam from flash economizer to D/A
11	Water	82	0.18	0.17	25	115.6	240	Drain from flash econ. to sewer
12	Water	129,591	285.10	0.41	61	37.8	100	Cool water from PHRO
13	Water	129,591	285.10	0.41	61	115.6	240	Hot water to Greenhouses
14	N/A	-	-	-	-	-	-	-
15	N/A	-	-	-	-	-	-	-
16	Steam	827	1.82	1.31	193	191.9	378	Steam to steam coil air heater
17	Water	827	1.82	1.28	188	63.3	146	Air heater drain to D/A
18	N/A	-	-	-	-	-	-	-
19	Steam	18,468	40.63	1.31	193	191.9	378	Steam: Heat X-changer/PRV (inclu. line 5)
20	Air	17,350	38.17	1.99	8" w.g.	26.7	80	F.D. combustion air to Steam coil A/H
21	Air	17,350	38.17	1.49	6" w.g.	148.9	300	Comb. air from A/H to burner
22	Flue Gas	21,414	47.11	-0.25	-1" w.g.	157.2	315	Boiler flue gas exhaust to fabric filter
23	Flue gas	21,414	47.11	-2.24	-9" w.g.	148.9	300	Flue gas to I.D. fan
24	Flue gas	21,414	47.11	0.75	+3" w.g.	148.9	300	Flue gas to stack
25	N/A	-	-	-	-	-	-	-
26	N/A	-	-	-	-	-	-	-
27	N/A	-	-	-	-	-	-	-
28	N/A	-	-	-	-	-	-	-
29	N/A	-	-	-	-	-	-	-
30	Air	2,368	5.21	Atmos	Atmos	15.6	60	Air to TCS mill
31	Limestone	121	0.27	Atmos	Atmos	15.6	60	Czerna limestone
32	Coal	1,841	4.05	Atmos	Atmos	15.6	60	Wesola coal
33	Ash	324	0.71	Atmos	Atmos	15.6	60	-
34	Wastewater	(varies)	(varies)	Atmos	Atmos	15.6	60	Gravity drain to PHRO

Table 6-2

```
.......COMBUSTION CALCULATIONS .......
10-29-1996    19:29:11
================================================================================

                         *** RUN IDENTIFICATION ***
PROJECT NAME:  PHRO                    FUEL TYPE & SOURCE:  KWK WESOLA COAL
RUN NO. 1
                    *** ULTIMATE ANALYSIS, % BY WEIGHT ***
1. CARBON % 68                         2. HYDROGEN % 4.3
3. SULFUR % .5                         4. OXYGEN % 10.45
5. NITROGEN % 1                        6. WATER % 8.25
7. ASH % 7.5                           8. H. HEATING VALUE, BTU/LB 11874
9. % OF ASH THAT IS FLY ASH 100        10. TEMPERATURE OF FUEL, F 60
11. FUEL SP HT, BTU/LB-F COAL=.3,OIL=.53 .3
                         *** OTHER DATA INPUTS ***
1. LEAKAGE IN AIR HEATER % 0           2. EXCESS AIR, % 20
3. UNDIL EXIT GAS TEMP, F 300          4. AMBIENT AIR TEMP, F 60
5. CARBON IN REFUSE, % 3               6. BAROMETRIC PRESS, INHG 30
7. PRECIPITATOR EFFICENCY, % 99.6      8. RADIATION LOSS, % 1
9. MANUFACTURERS MARGIN, % 1.5         10. HEAT ABSORBED, MMBTU/HR 41.94
11. MOIST IN AIR,LB/LBAIR(.013?) .013
================================================================================

                                  RESULTS
                         *** PERCENTAGE LOSSES ***
LOSS DUE TO CO2 IN GAS %  1.0790       LOSS DUE TO CO IN GAS %  0
LOSS DUE TO SO2 IN GAS %  314E-5       LOSS DUE TO O2 IN GAS %  18406E-5
LOSS DUE TO N2 IN GAS %  4.1021        LOSS DUE TO STEAM IN GAS %  55119E-5
LOSS OF STEAM LAT HEAT %  4.1121       LOSS DUE TO CARB IN ASH %  27544E-5
LOSS DUE TO UNBURNED CO %  0           LOSS DUE TO RAD & MFG MRG %  2.5
TOTAL LOSS %  12.807                   FUEL TEMP CREDIT, BTU/LBF  0
                         *** GAS & AIR FLOWS ***
BOILER EFFICIENCY, %  87.192           TOTAL FUEL HEAT , MMBTU/HR  48.100
FUEL BURN RATE, KLB/HR  4.0508         AIR INTO BURNERS, KLB/HR  43.377
GAS LVING FURN, KLB/HR  47.114         AIR HTR LKG,KLB/HR  0
FLY ASH LVG FURN, KLB/HR  30381E-5     FLY ASH LVG PRECIP,KLB/HR  121E-5
BOTTOM ASH PRODUCED, KLB/HR  0
                    *** FLUE GAS  CHARACTERISTICS ***
DRY % VOL CO2  15.713                  DRY % VOL CO  0
DRY % VOL N2  80.675                   DRY % VOL O2  3.5678
DRY % VOL SO2  4347E-5                 TOTAL OF ABOVE  99.999
MOL WT OF GAS LVG HTR  29.585          DENS @ 60F/30INHG LB/CUFT  7795E-5
DILUT TEMP LVG AIR HTR F  300          CORR DENS @ FLOW CONDITIONS  5334E-5
                *** GAS ANALYSIS BY WEIGHT, FLOW RATES ***
CO2 KLB/HR  10.065                     CO KLB/HR  0
SO2 KLB/HR  4050E-5                    O2 KLB/HR  1.6621
H20 KLB/HR  2.4585                     N2 KLB/HR  32.887
TOTAL KLB/HR  47.114
```

7. PRELIMINARY ENGINEERING DESIGN OF BOILERHOUSE & ANCILLARY COMPONENTS

Based on results of the indicated mass-energy balance and PHRO site visits, the following preliminary engineering design was completed.

7.1 Preliminary TCS Heating Plant Design and Layout

Table 7-1 indicates an itemized listing and design criteria for the primary and secondary equipment components of the TCS heating plant. Design criteria for each component was designated based on results of the previously indicated mass-energy balances.

Table 7-2 presents a list of pipe size and dimensions for all water, steam, flue gas, air and wastewater flows. Flow line numbers correspond to the mass-energy diagram presented in Figure 6-1.

Figure 7-1 presents a plan and sectional views of the proposed TCS heating plant. Where possible, circle numbers on pipelines relate to flow lines indicated in the mass and energy flow diagram (Figure 6-1).

7.2 Site Layout

Based on the preliminary layout and dimensions of the proposed TCS heating plant, Figure 7-2 shows its site in relation to existing PHRO greenhouse facilities.

Table 7-1: PHRO GREENHOUSE - PRELIMINARY MATERIALS & EQUIPMENT LIST

A. BOILERHOUSE EQUIPMENT SUPPLIED BY U.S.A. SUPPLIERS ==========================

1 TCS CM32C micronization mill, no motor, spare rotor, parts package
... includes: temperature, vibration & oil lubrication sensors & controls
... includes: spare rotor, spare parts package.

2 TCS metal detection/rejection system.

3 Coal transport pipe system (mill to burner), NFPA valves

4 Babcock & Wilcox FM-117-97 package boiler (12 MWt @ 1.65 MPa, 200 degC)
... includes: burner, FD fan, boiler trim, sootblowers,
... includes: furnace floor puffer system, steam coil air heater.

5 Amerex REX-pulse Model RP-14-224/256 D6 fabric filter (7.1 kg/sec @ 150 degC)
... includes: ash screw conveyor, water spray nozzel, ash valve

6 Control Techtronics International burner mangagement & boiler control system.

B. BOILERHOUSE EQUIPMENT SUPPLIED BY POLISH SUPPLIERS ==========================

1 Loading hopper, screw conveyor -to- bucket elevator

2 15 mt. bucket elevator w/. directional flap gate at top.

3 22 mt-ton limestone, concrete stave storage silo, air blasters, shutoff valve

4 90 mt-ton coal, concrete stave storage silo, air blasters, shutoff valve.

5 Coal screw conveyor to TCS mill (1.8 mt-ton/hr, 4 mt length)

6 Limestone screw conveyor to TCS mill (0.12 mt-ton/hr, 3 mt length)

7 Motor for TCS mill (110 Kw, 1470 rpm)

8 Flue gas ducting (30 mt Length x 600 mm diam) plus fittings

9 Shell/tube heat exchanger (two-zone)
Shell side = 18,500 kg/hr @ 200 degC steam-to-condensate
Tube side = 130,000 kg/hr @ 40 degC cool side -to 115 degC hot side

10 Deaerator (4,000 kg storage tank)

11 Supporting structure for deaerator

12 Flash economizer

13 Boiler feed pump (20,000 kg/hr)

14 Piping, elbows

15 Pipe valves, fittings

16 Air compressor system, dryer, filter

17 Electric panel/motor control center, low voltage

18 Inside electrical wiring

19 High voltage center/cables-wires

20 Option on technical status of boiler house building

21 Foundations (boiler, silos, filter, TCS mill, oil tank)

22 Pre-engineered boiler house building

23 I.D. fan and motor

24 Steel stack (30m x 800 mm diam)

25 Auxiliary oil storage tank, (5 m3) with full connection

26 Boiler, filter, TCS mill installation

C. EXTERIOR INTERCONNECTIONS TO BOILERHOUSE ==================================

1 Preinsulated pipeline (200 mm diam, 2 x 620 m)

2 Pump station with required equipment

3 Control system for pump station

4 Insulation, heating, air blasters for coal & limestone hoppers

5 Ash storage silo

6 Water softener/treatment system

7 Connection to boilerhouse of: (a). sewage (50 mb x 200 mm),
(b). water (70 mb x 80 mm), (c). boiler water (80 mb x 80 mm)
(d). compressed air piping (115 mb)

8 Coal storage area (1,450 m2)

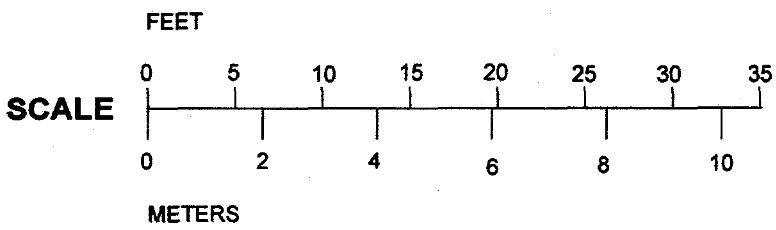
Table 7-2: PHRO GREENHOUSE - LIST OF PIPING DIMENSIONS (Line Numbers Refer to Figure 6-1)

FLOW LINE	MEDIUM	DESCRIPTION	PIPE DIAMETER (mm)	PIPE DIAMETER (in)	PIPE LENGTH (mt)	PIPE LENGTH (ft.)
1	Water	Makeup to D/A from PHRO	12	0.5	15.0	50
2	Water	D/A drain to BF. Pump	75	3.0	1.5	5
3	Water	Boiler feed water from D/A to boiler	75	3.0	9.0	30
4	Steam	Boiler steam flow	150	6.0	3.0	10
5	Steam	Steam to Heat X-changer from boiler	150	6.0	4.5	15
6	Water	Drain flow from Heat X-changer to D/A	75	3.0	8.0	25
7	Steam	Steam flow to P.V. Valve from boiler	50	2.0	1.5	5
8	Steam	Steam flow to D/A from PRV	100	4.0	6.0	20
9	Water	Boiler blowdown to flash economizer	20	0.8	15.0	50
10	Steam	Steam from flash economizer to D/A	25	1.0	1.5	5
11	Water	Drain from flash econ. to sewer	20	0.8	6.0	20
12	Water	Cool water from PHRO	200	8.0	8.0	25
13	Water	Hot water to Greenhouses	200	8.0	8.0	25
16	Steam	Steam to steam coil air heater	40	1.5	3.0	10
17	Water	Air heater drain to D/A	25	1.0	11.0	35
19	Steam	Steam: Heat X-changer/PRV (inclu. line 5)	150	6.0	4.5	15
20	Air	F.D. combustion air to Steam coil A/H	B&W ducting		B&W ducting	
21	Air	Comb. air from A/H to burner	B&W ducting		B&W ducting	
22	Flue Gas	Boiler flue gas exhaust to fabric filter	600	24.0	15.0	50
23	Flue gas	Flue gas to I.D. fan	600	24.0	15.0	50
24	Flue gas	Flue gas to stack	Amerex ducting		Amerex ducting	
30	Air	Air to TCS mill	TCS	TCS	-	-
34	Wastewater	Gravity drain to PHRO	25	1.0	9.0	30

Figure 7-1: PHRO GREENHOUSE

TCS HEATING PLANT

Preliminary Plan & Sections



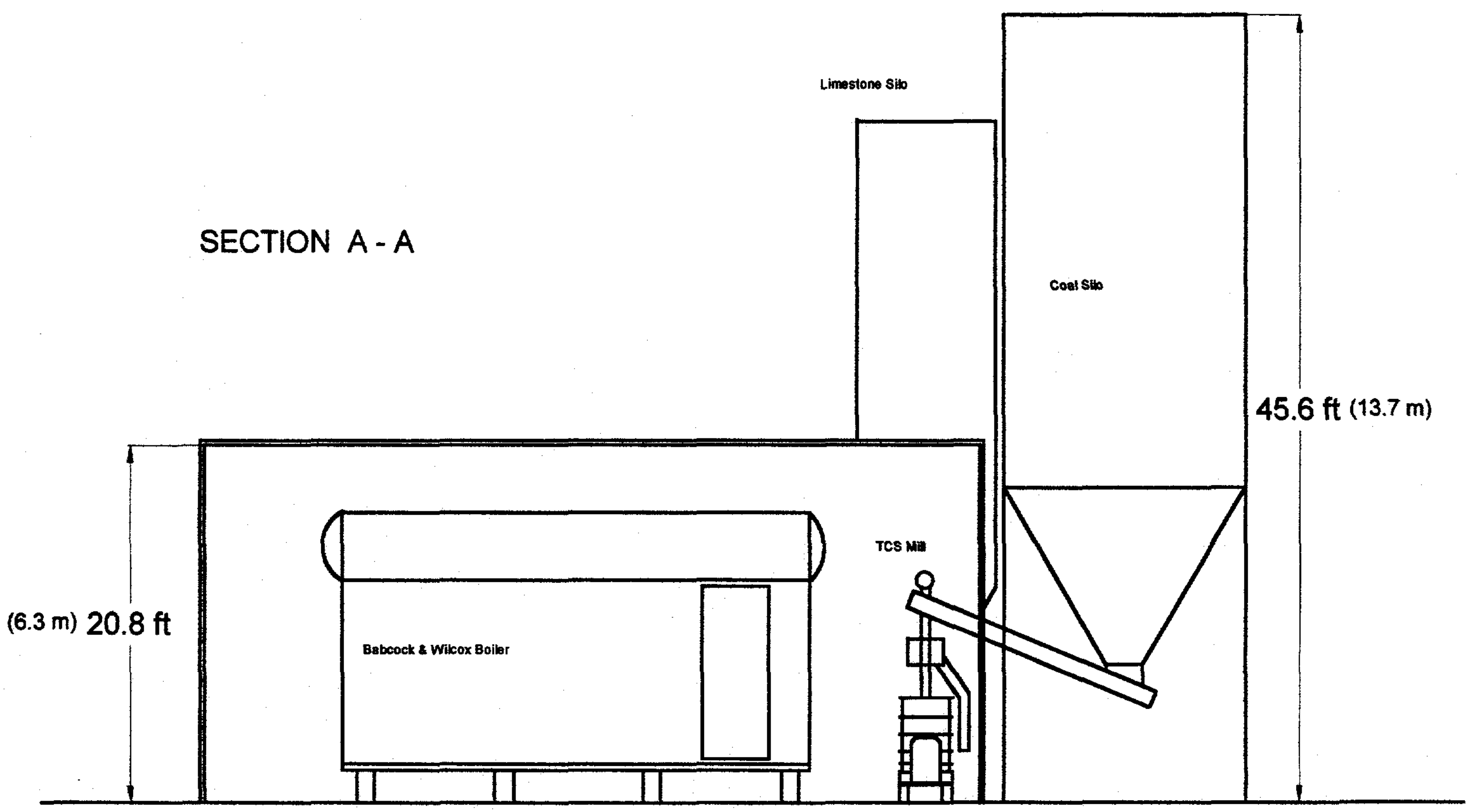


Figure 7-1 (continued)

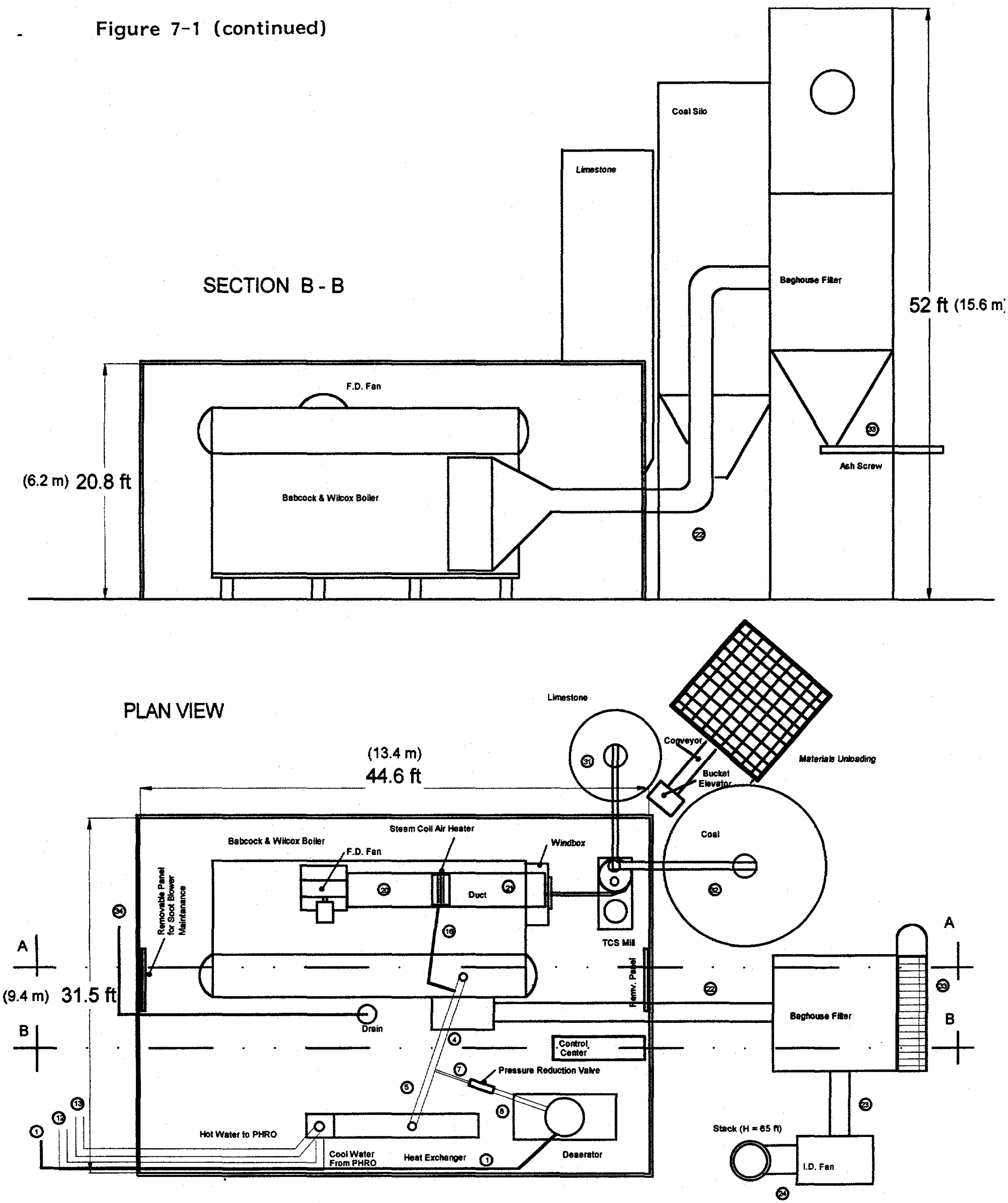
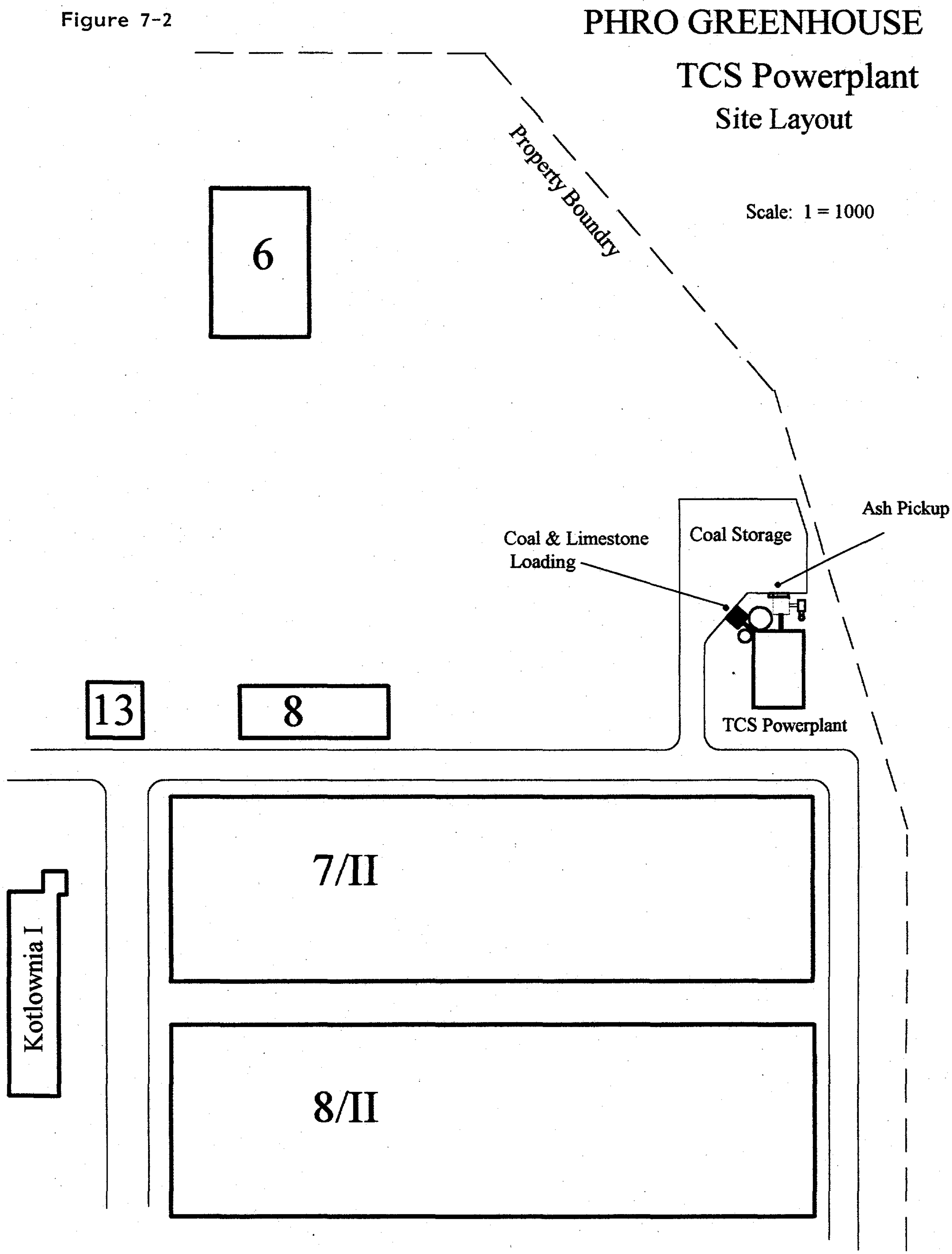


Figure 7-2


PHRO GREENHOUSE
TCS Powerplant
Site Layout
Scale: 1 = 1000
Property Boundry
6
Ash Pickup
Coal & Limestone Loading
Coal Storage
13
8
TCS Powerplant
7/II
Kotlownia I
8/II

8. COST ESTIMATES

8.1 U.S. Supplied Equipment

TCS requested, and received, cost estimates for required heating plant equipment from the key U.S. suppliers, including:

* Babcock & Wilcox; Barberton, Ohio and Warsaw, Poland ("boiler-island")
* Amerex, Inc.; Woodstock, Georgia and Wroclaw, Poland (fabric filter)
* Control Techtronics International; Harrisburg, Pennsylvania & Krakow, Poland (control system).

8.2 Polish Supplied Equipment and Labor

With the assistance of the Biuro Rozwoju Krakowa (BRK) and PHRO, TCS retained CTI Polska (teamed with Naftokrak-Naftobudowa) to assist in cost determination of the Polish supplied portion of equipment, materials and labor necessary to construct the heating plant and interconnection with existing PHRO facilities.

8.3 Construction Cost Summary

Table 8-1 presents a itemized listing of the construction cost estimate.

In summary, the itemized cost listing tallied to be:

*	Boilerhouse	$1,840,139
*	Exterior interconnections	349,177
*	Optional equipment	91,800
		----------
*	TOTAL PROJECT COST	$2,281,116

Table 8-1: PHRO GREENHOUSE - COST ESTIMATE OF PRELIMINARY MATERIALS & EQUIPMENT LIST

I. BOILERHOUSE CONSTRUCTION COST ITEMS =====================	EQUIP/ SHIPPING	INSTALL.	TOTAL
I.A EQUIPMENT SUPPLIED BY U.S.A. SUPPLIERS			
1 TCS CM32C micronization mill, no motor, spare rotor, parts package			
... includes: temperature, vibration & oil lubrication sensors & controls	$276,000	$0	$276,000
... includes: spare rotor, spare parts package.			
2 TCS metal detection/rejection system.	17,500	0	17,500
3 Coal transport pipe system (mill to burner), NFPA valves	7,800	0	7,800
4 Shipping: TCS equipment from USA to Poland	12,000	0	12,000
5 Babcock & Wilcox FM-117-97 package boiler (12 MWt @ 1.65 MPa, 200 degC)	659,946	0	659,946
... includes: burner, FD fan, boiler trim, sootblowers,			
... includes: furnace floor puffer system, steam coil air heater.			
6 Shipping: B&W boiler from Turkey to Poland (assumed single boiler shipping)	150,000	0	150,000
NOTE: If B&W boilers is shipped with Goodyear boilers (Sept 1997) = $80,000			
7 Amerex REX-pulse Model RP-14-224/256 D6 fabric filter (7.1 kg/sec @ 150 degC)	121,614	0	121,614
... includes: ash screw conveyor, water spray nozzel, ash valve			
8 Shipping: Amerex baghouse (portion from USA, portion in Poland)	15,000	0	15,000
9 Control Techtronics International burner mangagement & boiler control system.	128,000	included	128,000
I.B EQUIPMENT SUPPLIED BY POLISH SUPPLIERS			
1 Loading hopper, screw conveyor -to- bucket elevator	4,107	821	4,928
2 15 mt. bucket elevator w/. directional flap gate at top.	17,679	1,821	19,500
3 22 mt-ton limestone, concrete stave storage silo, air blasters, shutoff valve	15,964	1,857	17,821
4 90 mt-ton coal, concrete stave storage silo, air blasters, shutoff valve.	23,107	2,893	26,000
5 Coal screw conveyor to TCS mill (1.8 mt-ton/hr, 4 mt length)	2,357	286	2,643
6 Limestone screw conveyor to TCS mill (0.12 mt-ton/hr, 3 mt length)	1,607	214	1,821
7 Motor for TCS mill (110 Kw, 1470 rpm)	3,750	321	4,071
8 Flue gas ducting (30 mt Length x 600 mm diam) plus fittings	7,500	1,893	9,393
9 Shell/tube heat exchanger (two-zone)	18,714	2,000	20,714
Shell side = 18,500 kg/hr @ 200 degC steam-to-condensate			
Tube side = 130,000 kg/hr @ 40 degC cool side -to 115 degC hot side			
10 Deaerator (4,000 kg storage tank)	7,107	1,071	8,178
11 Supporting structure for deaerator	6,964	1,429	8,393
12 Flash economizer	643	71	714
13 Boiler feed pump (20,000 kg/hr)	15,357	1,821	17,178
14 Piping, elbows	1,929	857	2,786
15 Pipe valves, fittings	14,036	3,036	17,072

16 Air compressor system, dryer, filter	16,071	786	16,857
17 Electric panel/motor control center, low voltage	16,071	1,786	17,857
18 Inside electrical wiring	8,036	2,679	10,715
19 High voltage center/cables-wires	34,429	7,321	41,750
20 Option on technical status of boiler house building	0	4,107	4,107
21 Fund (boiler, silos, filter, TCS mill, oil tank)	11,600	7,696	19,296
22 Modifications to boiler house building	0	35,000	35,000
23 I.D. fan and motor	15,664	1,536	17,200
24 Steel stack (30m x 800 mm diam)	22,500	2,571	25,071
25 Auxiliary oil storage tank, (5 m3) with full connection	5,071	1,357	6,428
26 Boiler, filter, TCS mill installation	0	26,786	26,786
27 Final Engineering design for Boilerhouse only	0	27,143	27,143
28 Construction Management	0	6,071	6,071
29 Contingency	0	0	36,786
30 CONSTRUCTION SUBTOTAL COST FOR BOILER HOUSE ONLY	$1,658,123	$145,230	$1,840,139
	=========	========	=========
II. EXTERIOR INTERCONNECTIONS TO BOILERHOUSE =======================			
1 Preinsulated pipeline (200 mm diam, 2 x 620 m)	$167,893	$27,214	$195,107
2 Pump station with required equipment	18,964	9,000	27,964
3 Control system for pump station	15,714	1,429	17,143
4 Connection to boilerhouse of: (a). sewage (50 mb x 200 mm), (b). water (70 mb x 80 mm), (c). boiler water (80 mb x 80 mm) 9d). compressed air piping (115 mb)	3,321	4,000	7,321
5 Coal storage area (1,450 m2)	0	41,071	41,071
6 Pavement, grass, etc.	0	3,036	3,036
7 Final engineering design	0	23,571	23,571
8 Construction management	0	5,393	5,393
9 Contingeny	0	0	28,571
	=========	========	=========
10 CONSTRUCTION SUBTOTAL COST FOR EXTERIOR CONNECTIONS =============	$205,892	$114,714	$349,177
III. OPTIONAL EQUIPMENT FOR BOILERHOUSE SYSTEM =======================			
1 Insulation, heating, air blasters for coal & limestone hoppers	$40,928	$6,393	$47,321
2 Ash storage silo	17,179	2,071	19,250
3 Water softener/treatment system	20,429	429	20,858
4 Contingency (5%)	0	0	4,371
	=========	========	=========
5 CONSTRUCTION SUBTOTAL FOR OPTIONAL EQUIPMENT	$78,536	$8,893	$91,800

9. FINANCING CONSIDERATIONS

9.1 Sources of Project Financing

Several sources of funding or financial assistance were either available, or identified as viable candidates, for the project, including:

* U.S. Department of Energy
* Voivodship Fund for Environmental Protection (Krakow)
* EkoFundusz (Warsaw)
* Babcock & Wilcox
* PHRO

9.2 U.S. Department of Energy

The U.S. Department of Energy, as part of the Krakow Clean Fossil Fuels and Energy Efficiency Program, had agreed to provide partial funding for the project. Funds available were approximately $700,000.

9.3 Voivodship Fund for Environmental Protection (Krakow)

The Voivodship Fund for Environmental Protection program is funded from government penalties or fines imposed on organizations that exceed allowable environmental emission rates.

PHRO could have applied for a Voivodship Fund loan, which could possibly provide debt financing for a portion of the project cost, at lower than market rates. Likewise, it was possible that up to 50 percent of the principal of the loan could have been forgiven after three years of operation, if all environmental standards are satisfied.

9.4 EkoFundusz (Warsaw)

The EkoFundusz is a Polish government sponsored program that is funded from a portion of forgiven international loans previously made to Poland, with the stipulation that monies are used only for projects that enhance environmental quality. The EkoFundusz charter allows funding up to 30 percent of a project's total construction cost.

PHRO submitted a formal proposal to the EkoFundusz at the end of November 1996 for an anticipated grant approval of about 30 percent of the PROJECT cost. Early 1997 response indicated favorable reaction from the EkoFundusz.

9.5 Babcock & Wilcox

Babcock & Wilcox has indicated that, if necessary, assuming that the project was financially viable, that it was possible that B&W could arrange partial financing for its equipment through its sources, and in effect, provide an extended payment program plan.

9.6 PHRO

At the beginning of the project, PHRO indicated its willingness to provide funding for the external interconnections necessary to link the TCS heating plant with the existing facilities at the greenhouse. During a November 7, 1996 meeting with TCS, PHRO indicated that it had internal cash funds of $280,000 that could be committed to the project.

9.7 Proforma Cost Analyses

Based on the indicated project costs, sources of funding, estimated operating costs, a proforma cost analyses was conducted to determine if the project had economic possibilities.

9.7.1 Construction Cost Requirements

Based on the indicated sources of funding, the following indicates a summary of the financial sources and requirements of the total project cost estimate of $2,281,116. For economic possibility determination, it was assumed that funding not available from USDOE, EkoFundusz and PHRO, would be obtained from the Voivodship Fund:

*	U.S. Department of Energy:	$700,000
*	EkoFunduz (30% x $2,281,116):	684,335
*	PHRO:	280,000
*	Voivodship Fund:	616,781
		---------
*	TOTAL PROJECT COST:	$2,281,116

9.7.2 Operating Cost Estimates

9.7.2.1 Mazute

In order to determine a benchmark for PHRO's mazute pricing, TCS requested and received prices for delivered mazute to PHRO. PHRO provide actual historic records for the period between June 1995 and June 1996.

An analyses was conducted to determine a correlation factor between PHRO's delivered mazute pricing and the corresponding world oil pricing, as posted on the New York Mercantile Exchange. Table 9-1 indicates results of the analyses, which revealed a correlation factor of almost unity (i.e., 0.996) between the world's posted oil price one month before the current month's price (i.e., lagging month-to-month ratio) paid by PHRO for mazute, on an energy equivalency basis. Based on this determined almost unity factor, the proforma analyses below assumes that PHRO's delivered mazute pricing closely follows world oil pricing.

As previously indicated (Table 3-3, Col.7), 85.4 percent of PHRO's mazute consumption could realistically be displaced by coal. The displaced portion of mazute equals 6,382 tons per year, which equates to 44,700 Barrels (BBL) of crude oil on an energy equivalency basis.

Table 9-1: PHRO PURCHASED MAZUTE PRICING COMPARED TO WORLD OIL PRICING

MONTH	MAZUTE PURCHASED BY PHRO	DELIVERED MAZUTE COST PER MONTH	MAZUTE COST PER TON	MAZUTE COST PER BBL	AVERAGE POSTED WORLD CRUDE PRICE	LAGGING MONTH-TO MONTH RATIO MAZUTE-TO-CRUDE OIL PRICING
	(tons)	(Zl)	(ZL/ton)	($/BBL)	($/BBL)	(Factor)
1995						
JUN	-	-	-	-	$18.80	-
JUL	346	109,727	317.0	$19.82	$17.20	1.054
AUG	483	153,221	317.0	$19.82	$17.75	1.153
SEP	385	87,188	226.4	$14.16	$18.20	0.798
OCT	503	167,427	332.7	$20.81	$17.90	1.143
NOV	813	214,485	263.8	$16.50	$17.75	0.922
DEC	838	224,430	268.0	$16.76	$18.00	0.944
JAN	1157	337,181	291.3	$18.22	$19.20	1.012
FRB	1223	348,818	285.3	$17.84	$18.00	0.929
MAR	1694	528,534	312.1	$19.52	$19.80	1.084
APR	1368	460,724	336.8	$21.06	$22.00	1.064
MAY	677	214,913	317.7	$19.87	$20.80	0.903
JUN	563	178,182	316.3	$19.78	$20.70	0.951
TOTALS	10050	3,024,830	-	-	-	-
AVERAGES	-	-	301.0	$18.82	$18.94	0.996

Assumed currency exchange rate: Polish Zlote (Zl) to U.S. Dollar ($) = 2.5

Assuming a current (i.e., early-1997) prevailing world crude oil pricing of $21.00 per BBL, the potential value of displaced mazute equals $938,700 (i.e., 44,700 BBL x $21.00 /BBL).

9.7.2.2 Coal

On an energy equivalency basis, 9,183 M-tons of Polish Wesola coal is required to displace the indicated 85.4 percent of PHRO mazute.

Therefore, based on 1997 pricing of $66.30 per M-ton for Wesola washed coal, the annual coal price is estimated to be $609,000 (i.e., 9,183 M-tons x $66.30).

9.7.2.3 General Operating & Maintenance Costs

Because of the TCS heating plant, PHRO's existing operational costs associated with mazute would have been reduced. However, the TCS heating plant itself would require increased operating costs due to additional labor and costs associated with coal and materials handling. Because of the cost trade-offs (i.e., higher TCS costs, lower existing plant costs), PHRO was requested to indicate a reasonable operating cost "adder" to accrue toward the operating costs of the TCS plant.

PHRO indicated that an assumed increased labor, maintenance and operating cost "adder" of $60,000 per year, was reasonable.

9.7.2.4 Proforma Results

To determine if the project had potential economic viability, a proforma cost analyses was conducted based on the aforementioned assumptions, and the following financing mechanisms:

It was assumed that all project costs that were not available from: (a). grants (i.e., USDOE and EkoFunduz), and (b). PHRO cash on hand, was borrowed from the Voivodship Fund. Likewise, it was assumed that 50 percent of the principal of the loan could have been forgiven after three years of operation, since all environmental standards would have been satisfied.

Annual escalation rates were assumed at: (a). mazute @ 5.0 percent, (b). coal @ 4.0 percent, and (c). general O&M @ 3.0 percent.

It was assumed that during the initial three years of project operation, all savings realized by PHRO were placed in an interest bearing sinking fund to establish sufficient proceeds to retire 50 percent of the Voivodship Fund principal after three years of operation.

Table 9-2 indicates results of the proforma analyses, and shows that based on the stated assumptions, the project would have been financially viable.

Table 9-2: PHRO PROFORMA COST ANALYSES - TCS HEATING PLANT

FINANCING ASSUMPTIONS		
* U.S. Department of Energy		$700,000
* EkoFunduz		684,335
* PHRO		280,000
* Voivodship Fund	[**]	616,781
		---------
* TOTAL PROJECT COST		$2,281,116

OPERATING COST ASSUMPTIONS ---- ($ /yr) ----	
* Cost of displaced mazute:	$938,700
* Coal	$609,000
* Assumed O&M "adder":	$60,000

1	PROFORMA							
2		Escalate	1997	1998	1999	2000	2001	2002
3		Factor						
4		(% /yr)				(x $1000)		
5								
6	Cost of mazute	5.0%	$939	-	$1,035	$1,087	$1,141	$1,198
7								
8	Cost of coal	4.0%	$609	-	$659	$685	$712	$741
9	Assumed O&M "adder":	3.0%	$60	-	$64	$66	$68	$70
10					-----	---	-----	-----
11	Cost for TCS Heating Plant				$722	$751	$780	$810
12								
13	SAVINGS				$313	$336	$361	$388
14								
15	[**] Vovoidship Debt Service							
16	* interest (@ 12% - 3yr)				$74	$74	$74	$0
17								
18	Net cash flow to PHRO				$239	$262	$287	$388
19								
20								
21								
22	Initial Vovoidship Principal =			$616,781				
23								
24	PHRO SINKING FUND	(x $1000)						
25	Fund value at start of year				0	$246	$531	$551
26	Cash Inflow				$239	$262	$287	$388
27	Interest earned at 6%:				$7	$23	$40	$45
28	Repay 50 percent of Vovoidship Principal				$0	$0	$308	$0
29	Fund value at year of end				$246	$531	$551	$983

9.8 Project Termination

Unfortunately, PHRO was reluctant to proceed with the project due to its unwillingness to enter into a debt relationship with the Voivodship Fund. As such, implementation of the project ceased to proceed in February 1997.

As a side note, another factor that had negative economic impact on the project was the exceedingly high cost that Polish coal had risen to in late-1996. At a Polish Government controlled price of over $66 per ton, it ranked as one of the most expensive coals in the world. On an energy equivalency basis, its price was about 2.5 times that of a general U.S. Eastern Bituminous coal.