Industrial Fuel Gas Demonstration Plant Program

CONCEPTUAL DESIGN AND EVALUATION
OF
COMMERCIAL PLANT

VOLUME III - ECONOMIC ANALYSES

MASTER

Prepared For
The Department of Energy
Under Contract ET-77-C-01-2582

MEMPHIS LIGHT, GAS AND WATER DIVISION
P.O. BOX 430, MEMPHIS, TENNESSEE 38145

In Association with
FOSTER WHEELER ENERGY CORPORATION
INSTITUTE OF GAS TECHNOLOGY
DELTA REFINING COMPANY

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MEMPHIS INDUSTRIAL FUEL GAS

DEMONSTRATION PLANT PROJECT

CONCEPTUAL DESIGN AND EVALUATION
OF COMMERCIAL PLANT & RECOMMENDATIONS
FOR DEMONSTRATION PLANT (TASK I REPORT)
(Deliverable #15, 16)

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PREPARED FOR THE
U. S. DEPARTMENT OF ENERGY
ASSISTANT SECRETARY OF FOSSIL ENERGY

UNDER CONTRACT DE-AC02-77ET13406
(FORMERLY CONTRACT ET-77-C-01-2582)

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December 20, 1978
Letter No. ME-33F

U. S. Department of Energy
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9800 South Cass Avenue
Argonne, Illinois 60439

Attention: Dr. P. Lui

MLGW Reference No. 8802
DOE Reference No. 2582

Subject: Task I Report
Volume III

Dear Dr. Lui:

We are completing the report covering the Phase I, Task I effort required by our Contract ET-77-C-01-2582. The report, titled "Conceptual Design and Evaluation of Commercial Plant", will be issued in four volumes:

Volume I - Executive Summary
Volume II - Commercial Plant Design
Volume III - Economic Analysis
Volume IV - Demonstration Plant Recommendations

Enclosed is Volume III, Economic Analysis, for your approval. Volume II is being sent separately. Volumes I and IV will follow in January.

Very truly yours,

R. W. Gray

RWG:RJS:au

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INDUSTRIAL FUEL GAS COMMERCIAL PLANT

DESIGNED FOR THE U.S. DEPARTMENT OF ENERGY
BY
MEMPHIS LIGHT GAS AND WATER DIVISION
PRIME CONTRACTOR
IN ASSOCIATION WITH
FOSTER WHEELER ENERGY CORPORATION
INSTITUTE OF GAS TECHNOLOGY
DELTA REFINING COMPANY

**MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM**

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CONCEPTUAL DESIGN

ECONOMIC ANALYSES

ABSTRACT

Memphis Light, Gas and Water Division (MLGW), supported by Foster Wheeler Energy Corporation, Institute of Gas Technology, and Delta Regining Company, is under Contract ET-77-C-01-2582 with the U.S. Department of Energy. The contract calls for the program development and conceptual design (Phase I) of an industrial fuel gas demonstration plant. Later phases envision demonstration plant design, procurement and construction (Phase II) and demonstration plant operation (Plant III).

This report presents the results of Task I of Phase I in the form of a "Conceptual Design and Evaluation of Commercial Plant" report. The report is presented in four volumes as follows: I - Executive Summary, II - Commercial Plant Design, III - Economic Analyses, IV - Demonstration Plant Recommendations.

Volume III presents the economic analyses for the commercial plant and the supporting data. General, cost and financing factors used in the analyses are tabulated. Three financing modes are considered, namely: municipal financing "MLGW case"), investor owned with 25% equity ("Utility Case"), and 100% equity discounted cash flow ("Industrial Case"). The plant budget capital cost estimate of \$139.4 million is summarized, including a summary of the cost for each process and offsite section, and a list of equipment and building costs. The plant organization, functions, staffing and payroll cost is also detailed.

The product gas cost calculation procedure is identified and appendices present computer inputs and sample computer outputs for the MLGW, Utility, and Industry Base Cases. The results of the base case cost analyses for plant fenceline gas costs are as follows:

. Municipal Utility	(e.g. MLGW)	\$3.76/MM BTU
. Investor Owned Utility	(25% equity)	\$4.48/MM BTU
. Investor Case	(100% equity)	\$5.21/MM BTU

The results of 47 IFG product cost sensitivity cases involving a dozen sensitivity variables are presented. Plant half size, coal cost, plant investment, and return on equity (industrial) are the most important sensitivity variables.

Volume III also presents a summary discussion of the socioeconomic impact of the plant and a discussion of possible commercial incentives for development of IFG plants.

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DEMONSTRATION PLANT PROGRAM**

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TASK I - COMMERCIAL PLANT
CONCEPTUAL DESIGN

"CONCEPTUAL DESIGN AND EVALUATION
OF
COMMERCIAL PLANT"
Volume III -- ECONOMIC ANALYSES

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CONCEPTUAL DESIGN

"CONCEPTUAL DESIGN AND EVALUATION OF COMMERCIAL PLANT"

Section 1.0

INTRODUCTION

1.1 PROGRAM SUMMARY

The United States Department of Energy (DOE) executed a contract with Memphis Light, Gas and Water Division (MLGW) which requires MLGW to perform process analysis, design, procurement, construction, testing, operation, and evaluation of a plant which will demonstrate the feasibility of converting high sulfur bituminous coal to industrial fuel gas with a heating value of 300 $\pm$ 30 Btu per standard cubic foot (SCF). The demonstration plant is to be based on the U-Gas process, and its product gas is to be used in commercial applications in Memphis, Tenn.

In order to perform this work, MLGW has established an industrial team, which includes:

MLGW - Memphis Light, Gas and Water Division, Memphis, Tenn.
The prime contractor and distributor of the industrial fuel gas.

FWEC - Foster Wheeler Energy Corporation, Livingston, N.J.
The engineer-construction manager.

IGT - Institute of Gas Technology, Chicago, Illinois.
The process developer.

DRC - Delta Refining Company, Memphis, Tenn.
To provide operating experience.

The contract specifies that the work is to be conducted in three phases. Phase I costs are financed entirely by DOE. Costs for Phases II and III will be shared equally by DOE and MLGW. The Phases are:

Phase I - Program Development and Conceptual Design
Phase II - Demonstration Plant Final Design, Procurement and Construction
Phase III- Demonstration Plant Operation

Task I of Phase I requires the preparation of a conceptual design of a commercial plant based on the U-Gas process which is to be demonstrated. The commercial plant design consists of an engineering design and cost estimate. Also required as part of Task I is an economic evaluation of the commercial plant and recommendations for the demonstration plant.

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CONCEPTUAL DESIGN**

The results of these Task I efforts are presented in four volumes, which are:

- Volume I - Executive Summary
- Volume II - Commercial Plant Design
- Volume III- Economic Analysis
- Volume IV - Demonstration Plant Recommendations

Throughout the report reference is made to various sections of the plant. Table 1-1 is a List of Plant SEctions, divided into process units ("onsite" sections) and support facilities ("offsite" sections).

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DEMONSTRATION PLANT PROGRAM

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TABLE 1-1

LIST OF PLANT SECTIONS

PROCESS UNITS

("Onsite" Sections)

Section	100c	COAL GASIFICATION
	200c	GAS COOLING
	300c	GAS SCRUBBING
	400c	GAS TREATING
	500c	SULFUR RECOVERY
	600c	TAIL GAS TREATING
	700c	AIR SEPARATION
	1000c	COAL HANDLING & PREP.
	1500c	ASH HANDLING

SUPPORT FACILITIES

("Offsite" Sections)

Section	2000c	STEAM GENERATION AND DISTRIBUTION
	3000c	RAW WATER STORAGE
	3200c	BOILER FEEDWATER TREATMENT
	3400c	COOLING WATER SYSTEM
	3600c	WASTE WATER TREATMENT
	4000c	FLARE SYSTEM
	4400c	PLANT AIR & INSTRUMENT N ₂
	5400c	INTERCONNECTING PIPING
	5600c	BUILDINGS
	5800c	ROADS AND FENCES
	6000c	FIREWATER SYSTEM
	6400c	ELECTRIC POWER DISTRIBUTION, LIGHTING, COMMUNICATION
	6600c	SITE PREPARATION, DRAIN & SEWER
	8000c	DOCK FACILITIES

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1.2 PLANT SUMMARY

The Industrial Fuel Gas Commercial Plant produces 50 billion BTU/day of product gas, which is equivalent in energy output to approximately a 10,000 barrel/day oil refinery. At 300+30 BTU/scf, approximately 175 million scf/day of product U-Gas is produced. Total plant input includes 2792 t/d of coal and 44MWe of electricity. Overall IFG plant thermal efficiency is 74.8%.

Figure 1.1 is a simplified plant block flow diagram showing the process sequence and nominal plant material and energy balance. Figure 1.2 is a Commercial Plant key plot plan showing how the key sections are arranged. Each process unit is described briefly in the following summary.

- Section 700C, the Air Separation Plant, compresses intake air, liquefies it, and separates it into oxygen and nitrogen. The oxygen is compressed and sent to the gasifiers. A small portion of the nitrogen is returned for plant use, but the bulk of it is vented or sold.
- Section 1000C, Coal Handling and Preparation, receives the incoming raw coal (2" x 0") from barges and transports it to a seven day live coal storage pile. From there it goes to the dryer-mill area where it is crushed to 1/4" x 0" and dried. The coal is then pneumatically conveyed to the cyclones for separation. The fines carryover from the cyclones is collected in the secondary bag filter and conveyed to the coal mainstream which goes either to the coal silo or to the gasifiers. Dual conveying system is provided from this point up to the gasifiers, with one serving as a spare. Each gasifier has two feed hopper systems, each consisting of a receiving hopper, lock hopper and feed injection hopper. Coal is withdrawn from the injection hopper by a screw feeder and then fed pneumatically to the gasifier. Sized coke is also received in the plant for start-up. A drying and storing facility is provided for coke preparation. A one month dead coal storage pile is also included.
- Section 100C, Coal Gasification, contains the three coal gasifiers where steam and oxygen react with the coal in a fluidized bed at about 1850°F and 75 psig to produce hot, raw gas (CO, CO₂ and H₂). Within the reaction zone of the fluidized bed is an ash-agglomerating zone. The ash agglomerates drop into a water quench. Fines carried over with the hot, raw gas are returned to the gasifier through external cyclones.

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- . Section 200C, Gas Cooling, cools the gas from 1838°F to 328°F. The gas passes in sequence through a high pressure steam generator, a h.p. steam superheater, a medium pressure steam superheater, a m.p. steam generator, and a boiler feedwater preheater. Section 100C, 200C and 300C through the scrubbers are three parallel trains. The balance of the plant is one train.
- . Section 300C, Gas Scrubbing, passes the cooled raw gas through water scrubbers. In the scrubbers particulate matter is removed, the chlorides and some of the NH_3 and H_2S are dissolved by adjusting the water pH with caustic, and the gas is further cooled to its saturation temperature of 235°F. The gas is again cooled, passes through a knockout drum, and then is compressed to 190 psig. The sour water from the knockout drum passes through a sour water stripper; the overheads going to sulfur recovery, the water effluent to recycle or waste water treatment. The slurry water from the scrubber goes through a slurry water stripper; the water being recirculated and the particulate going to a filtration system before disposal.
- . Section 400C, Gas Treating, receives the cooled gas from the compressor in Section 300C. It passes through a hydrolysis reactor to change carbonyl sulfide (COS) to H_2S . It then passes to a Selexol unit where H_2S and COS are reduced to 10 and 60 ppmv, respectively. The product gas then is odorized and metered before being discharged to the product gas pipeline distribution system.
- . Section 500C, Sulfur Recovery, receives sour water gas from 300C and some acid gas from 400C. It is passed through an acid gas burner and then a three stage, catalytic, Claus type sulfur recovery unit to achieve 96% sulfur recovery. Sulfur goes through condensers, seal pit and rundown pit, and storage tank before being loaded into tank trucks.
- . Section 600C, Tail Gas Treating, receives the tail gas from 500C. It then goes to a Beavon unit package where remaining sulfur is converted to H_2S , and to a Stretford section where H_2S is removed. The tail gas is then discharged to the atmosphere.
- . Section 1500C, Ash Handling, receives the agglomerated quenched ash slurry from the gasifier (Section 100C) and conveys it hydraulically to the dewatering bins. The dewatered ash is then discharged into trucks for disposal to the ash pile. The water from the dewatering bins is collected in the clarifier where clean water overflows into a sump tank while the underflow is pumped back to the dewatering bins. The clean water is then recycled to the gasifiers. A start-up pump is provided for initial transport of slurry to the dewatering bins when the gasifier pressure is still low for conveying.

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The offsite sections include the following functions:

• Water Systems

Section 2000c	Steam Generation
Section 3000c	Raw Water Treatment
Section 3200c	Boiler Feedwater Treatment
Section 3400c	Cooling Water System
Section 3600c	Waste Water Treatment
Section 6000c	Firewater System

• Utilities

Section 4000c	Flare System
Section 4400c	Plant Air & Instrument N ₂
Section 5400c	Interconnecting Piping
Section 6400c	Power Distribution

• Facilities

Section 5600c	Buildings
Section 5800c	Roads and Fences
Section 6600c	Site Preparation
Section 8000c	Dock Facilities

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TASK I COMMERCIAL PLANT

SIMPLIFIED PLANT
BLOCK FLOW DIAGRAM

FIGURE 1.1

FORM NO. 285-63-C

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DEMONSTRATION PLANT PROGRAM**

TASK 1 COMMERCIAL PLANT

KEY PLOT PLAN

FIGURE 1.2

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ECONOMIC ANALYSES

2.1 GENERAL, COST, AND FINANCING FACTORS

2-1

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2.1.2 Cost Factors

Table 2.1 shows the general assumptions and cost factors used to perform the economic analyses. Reference is made to supporting data (e.g. plant direct investment cost and plant staffing cost) in relevant sections of the report, or to supporting calculations in tables 2.2, 2.3, and 2.4 (for working capital, maintenance, chemicals and catalysts, and annual operating costs).

The coal price used in these base case calculations is \$26.00 per ton, delivered. The sulfur by-product is credited at a value of \$48.00 per long ton. Not included is potential by-product credit for ash, N₂ or CO₂ which are discussed in section 4.2.9 of Volume II.

Maintenance costs are estimated* as percentages of plant investment cost. Table 2.3 shows the calculation of annual maintenance costs.

Startup costs are estimated to be 20% of the net annual operating costs, at 90% service factor, for the MLGW case. This amounts to \$8,768,000 which will be incurred during the first year of plant operation. This cost is exclusive of salaries, overhead, and direct coal, electricity, water and chemicals. These costs are included as part of the regular operating costs during the first year.

2.1.3 Financing Factors

The calculation of gas cost for the output of the Commercial Plant is presented for three "base" cases; namely:

- a. "MLGW case" - A municipal utility or municipality who is exempt from taxes and would finance the plant with municipal bonds whose interest is tax exempt, and who would use 100% debt.
- b. "Utility case" - An investor owned utility, whose financing would be part debt and part equity.
- c. "Industrial case" - An industrial owner whose financing is 100% equity funded.

Table 2.5 summarizes the financing factors used for each of the above cases. These assumptions are in addition to those shown in section 2.1.1 and 2.1.2.

*Per U.S. ERDA, "Factored Estimates for Western Coal Commercial Concepts," 1/30/76.

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TABLE 2.1
COST FACTORS

<u>No.</u>	<u>Item (and Bases)</u>	<u>Cost</u>	<u>Reference</u>			
1.	<u>Plant Direct Investment Cost</u>	\$120,804M	Vol. III, Table 2.1			
2.	<u>Plant Depreciable Investment Cost</u> (Includes Item 1 plus 2a thru 2d)	\$140,940M				
	a. Construction Management	\$ 7,705M				
	b. Engineering	\$ 10,240M				
	c. Owner Home Office	\$ 1,500M				
	d. Miscellaneous (ins.)	\$ 691M				
3.	<u>Land</u> (125 acres x \$5,000/acre)	\$ 625M				
4.	<u>Working Capital</u>	\$ 7,645M	Table 4.2			
5.	<u>Plant Total Capital Investment Cost</u> (Includes Items 2 + 3 + 4)	\$149,210M				
6.	<u>Cash Flow During Engineering/Construction</u>		Vol. III, Section 3.2.1 and 3.2.2			
	<u>Year</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>Total</u>
	Allocation (%)	5	20	50	25	100%
	Cost (\$MM)	7.0	28.2	70.5	35.2	\$140.9
7.	<u>Input/Output Costs</u>					
	a. Coal, delivered	\$	26.00/ton			
	b. Sulfur Byproduct	\$	48.00/long ton			
	c. Chemicals and Catalysts: Inventory	\$1,000M				Table 2.4-1,
	" " " : Usage	\$ 250M/yr.				Vol. II
	d. Electricity	\$	0.02/Kwhr			
	e. Water	\$	0.25/1,000 gal.			
8.	<u>Maintenance Cost</u> (Supplies & Subcontract)	\$4,506M/year				Table 2.3 Item 1+10
9.	<u>Plant Annual Operating Cost</u>					
	a. 100% Service Factor	\$47,181M/year				Table 4.4
	b. 90% Service Factor	\$43,839M/year				Table 4.4
10.	<u>Startup Costs</u> (at 20% of Item 9B)	\$ 8,768M				

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TABLE 2.2

CALCULATION OF WORKING CAPITAL

WORKING CAPITAL

<u>Item</u>	<u>Basis</u>	<u>Value</u>
Coal Inventory	40 days x 2,792 $\frac{\text{ton}}{\text{day}}$ x $\frac{\$26}{\text{ton}}$	\$2,904M
Catalyst and Chemicals Inventory	See Table 2.4-1, Volume II	\$1,000M
Materials and Supplies	0.9% x Plant Direct Investment Cost*	\$1,087M
Cash	1/24 of Annual Revenue estimated at \$4/MM Btu*	<u>\$2,654M</u>
TOTAL WORKING CAPITAL		\$7,645M

*Per U.S. ERDA, "Factored Estimates for Western Coal Commercial Concepts," 1/30/76.

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TABLE 2.3

CALCULATION OF ANNUAL MAINTENANCE COST

Maintenance costs are calculated according to the statistical method specified by U.S. E.R.D.A. in its "Factored Estimates for Western Coal Commercial Concepts" January 30, 1976, complemented by consideration of inplant maintenance personnel specific costs as presented in Table 4.2.

A. BASE LABOR AND MATERIALS COST

<u>Plant Sections</u>	<u>Plant Direct Investment Cost</u>	<u>% Specified For Maintenance</u>	<u>Maintenance Base Labor and Materials Costs</u>
100, 200, 300, 1000, 1500	\$ 41,067M	6%/yr.	\$2,464M/yr.
400, 500, 600, 700 3,000, 3200, 36000	54,177	3%/yr.	1,625
All other sections	<u>25,560</u>	1%/yr.	<u>256</u>
TOTALS	\$120,804M		\$4,345M/yr.

B. ALLOCATION OF BASE LABOR AND MATERIAL COST

		<u>\$M/yr.</u>
1. Materials & Supplies	\$4,345M x 0.4	1,738
2. Total Base Labor	\$4,345M x 0.6	2,607
3. Inplant Base Labor	65 men, Table 4.2	1,165
4. Contracted Base Labor	Item 2 - Item 3	1,442

C. CALCULATION OF TOTAL MAINTENANCE COST

5. Inplant Supervision	16 men, Table 4.2	320
6. Inplant Direct Burden	0.3 (Items 3) + 0.35 (Item 5)	462
7. Contracted Supervision	0.2 (Item 4)	288
8. Contracted G&A	0.6 (Item 4+7)	1,038
9. Inplant Labor Subtotal	Items 3 + 5 + 6	1,947*
10. Contracted Labor Subtotal	Items 4 + 7 + 8	2,768
11. TOTAL MAINTENANCE COST	Items 1 + 9 + 10	6,453*
12. MAINTENANCE %	\$6,453M/\$120,804M	5.3%*

*This cost excludes inplant labor indirect burden cost which is included in Table 4.2.

TABLE 2.4
CALCULATION OF ANNUAL OPERATING COSTS (MLGW CASE)

No.	Item	Calculation Basis for 100% Service Factor (S.F.)	Annual Cost	
			100% S.F. (A)	90% S.F. (B)
1.	<u>Coal</u>	$2792 \frac{t}{d} \times 365 \frac{d}{yr} \times \$26.00 \frac{\$}{t}$	\$26,514	\$23,863
2.	<u>Catalysts & Chemicals</u>	Volume II, Section 2.4	250	225
3.	<u>Water</u>	$1976 \frac{Mgal}{d} \times 365 \frac{d}{yr} \times \$0.25 \frac{\$}{Mgal}$	180	162
4.	<u>Purchased Electricity</u>	$43,400 \frac{Kwhr}{hr} \times 24 \frac{hr}{d} \times 365 \frac{d}{yr} \times \$0.02 \frac{\$}{Kwhr}$	7,609	6,848
5.	<u>Operating Supplies</u>	30% Process Labor (C)	610	549
6a.	<u>Maintenance Supplies</u>	Table 2.3, Item 1	1,738	1,738
6b.	<u>Maintenance S/C Labor</u>	Table 2.3, Item 10	2,768	2,768
7.	<u>Labor, Supervision, G&A</u>	Table 4.2	6,493	6,493
8.	<u>Local "In Lieu of Taxes"</u>	\$3.74/\$100 assessed (@55% PDIC - 10%) (D)	2,581	2,581
9.	<u>Insurance</u>	\$0.25/\$100 investment	174	174
10.	TOTAL GROSS OPERATING COSTS		\$48,917	\$45,401
11.	<u>Sulfur Credit</u>	$89 \frac{LT}{d} \times 365 \frac{d}{yr} \times \$48 \frac{\$}{LT}$	- 1,736	- 1,562
12.	NET ANNUAL OPERATING COSTS		<u>\$47,181</u>	<u>\$43,839</u>

NOTES: (A) 100% service factor cost is calculated for use in the PRP computer program.
 (B) 90% service factor cost is expected, and is calculated by multiplying variable items 1 through 5 by 90%, and holding overhead items 6 through 9 constant.
 (C) Per U.S. ERDA, "Factored Estimates for Western Coal Commercial Concepts," 1/30/76.
 (D) PDIC = Plant Depreciable Investment Cost, item 2, table 2.1 and section 2.5.1.

TABLE 2.5

FINANCING FACTORS FOR THREE FINANCING OPTIONS

No.	Financing Factor	"MLGW Case"	"Utility Case"	"Industrial Case"
	Case Description	Municipal Financing	Investor Owned	Discounted Cash Flow
1.	<u>Source of Capital</u>	Municipal Bonds at 6% interest redeemed as plant is depreciated	25% equity 75% debt at 9% interest	100% equity
2.	<u>Rate of Return on Equity</u>	Not Applicable	12%	12%
3.	<u>Method of Handling Startup Costs</u>	Experienced in year 5	Experienced in year 5	Experienced in year 5
4.	<u>Depreciation Method</u>	20 years straight line	20 years straight line declining balance	15 years declining balance
5.	<u>Interest During Construction (IDC)</u>	Calculated and expensed	Calculated and added to depreciable capital	Calculated and added to depreciable capital
6.	<u>Federal Taxes</u>	None	48% + 10% investment tax credit*	48% 10% investment tax credit*
7.	<u>State Taxes</u>	None	3% income + 1½% gross revenue	3% income + 1½% gross revenue
8.	<u>Local Taxes</u>	\$3.74 per \$100 Assessment**	2.7% of plant Total investment	2.7% of plant Total investment
9.	<u>Insurance</u>	\$0.25 per \$100 Assessment	Inc. in 8 above	Inc. in 8 above

*Utilized to offset up to half of taxes otherwise payable in any given year.

**Assessment value equals 55% of plant investment less 10% reduction.

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2.2 PRODUCT GAS COST CALCULATION PROCEDURE

The IFG product gas cost for each case has been calculated by computer utilizing PRP - a Discounted Cash Flow Program for Calculating the Production Cost (Product Price) of a Product from a Process Plant developed by Oak Ridge National Laboratory for the Department of Energy. (A)

- Appendix A-1 shows the detailed input for the base case calculations.
- Appendix A-2 shows the changes made to the base case calculations in order to achieve the various alternate cases.
- Appendix A-3, A-4 and A-5 are sample computer printouts for the base case calculations for the MLGW Utility and Industrial Cases, respectively.
- Appendix A-6 shows the gas cost calculation for the Commercial Plant based on the C. F. Braun guidelines prepared for U.S. Energy. (B)

The MLGW base case calculation is essentially the same as Appendix A-6 with the following values substituted: $d = 1.0$; $r = 0$; C without IDC; with startup costs capitalized; and with 90% service factor for all 20 years.

References:

- A. Salmon, R, "PRP - A Discounted Cash Flow Program for Calculating the Production Cost (Product Price) of the product from a Process Plant," ORNL-5251, 3/77.
- B. Skamser, R, "Coal Gasification Commercial Concepts Gas Cost Guidelines", C.F. Braun & Co., FE-1235-1, 1/76.

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2.3 SUMMARY OF BASE CASE IFG PRODUCT GAS COSTS

The product price (gas cost) from the commercial plant is dependent on the method of project financing. Specific costs, for coal at \$26.00 per ton and the other general, cost and financing factors presented in section 4.1 are:

<u>Case Name</u>	<u>Case Description</u>	<u>Plant Fenceline Gas Cost</u>
A. MLGW Case	Municipal Utility	\$3.76/MM Btu
B. Utility Case	Investor Owned Utility (25% Equity, 12% ROE)	\$4.48/MM Btu
C. Investor Case	(100% Equity, 12% ROE)	\$5.21/MM Btu
D. C.F. Braun	Utility Financing	\$4.24/MM Btu (average) \$4.91/MM Btu (1st year)
E. PRP/CFB	PRP Program version using C.F. Braun assumptions	\$4.36/MM Btu (average)

The essential conclusion for the MLGW case is that at this time \$/MMBTU cost is competitive with SNG from Naphtha and higher than No. 2 fuel oil. However, a higher rate of escalation for No. 2 fuel oil is likely than for coal, thereby making this gas even more competitive during the likely period of plant operation (1985 +).

The utility and investor base cases reflect the higher costs, relative to MLGW base case, due to inclusion of federal taxes and effect of return on equity (ROE) rather than debt payment.

The difference between Case D and E can be attributed to the difference in total interest paid during the life of the project. The C.F. Braun method is a return on rate base concept, which requires a utility to charge a higher price for the product of a new facility than for one near the end of its book life. In this example, the gas cost in the first year is calculated at \$4.91 per MM Btu. In subsequent years the required gas cost would be less. The arithmetical mean of these required yearly gas costs is the \$4.24 figure. Since medium Btu fuel gas plants are not common, the effect of the C. F. Braun method of calculation is to require a direct pass through of these higher costs, during the early project life, to gas consumers. The PRP program provides an average gas cost of \$4.36 over the entire 20 year project life. This is the cost of gas in year 1 as well as year 20.

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2.4 IFG PRODUCT GAS COST SENSITIVITY ANALYSES

2.4.1 Summary of Sensitivity Analyses

Numerous sensitivity analyses were conducted for each of the three financing options, namely "MLGW", "Utility", and "Industry" cases. Table 2.6 lists the different cases studied. Where the term "N/A" is shown, the result is not applicable for that particular case. As an example, changes in Return on Equity are not applicable for the MLGW cases since the MLGW case is 100% debt with no equity. Each analysis was done separately. That is, for each case, only the variable to be studied was changed. A total of 47 sensitivity analyses were performed.

Table 2.6 summarizes the results of each sensitivity analysis in the form of an IFG product gas cost in \$/MM Btu and also as a percent change from the base case for the given financing method.

Sensitivity may be defined as follows:

$$\text{Sensitivity} = \frac{\% \text{ change in IFG Gas Price}}{\% \text{ change in Sensitivity Variable}}$$

Using this definition the following sensitivities are obtained:

<u>Sensitivity Variable</u>	<u>Sensitivity (%/%)*</u>
1. Plant Service Factor	-0.57 to 0.85
2. Plant Half Size	-0.70 to 0.71
3. Plant Double Size	-0.13 to 0.14
4. Return on Equity (Industrial)	+0.40 to 0.44
5. Plant Investment	+0.30 to 0.45
6. Coal Cost	+0.29 to 0.40
7. Federal Tax Rate (Industrial)	+0.11 to 0.15
8. Return on Equity (Utility)	+0.09 to 0.10
9. Federal Tax Rate (Utility)	+0.03 to 0.04

* The sensitivity results above may be interpreted as follows:

1. If there is a minus sign the product cost increases or decreases when the sensitivity variable decreases or increases, respectively. If there is a plus the product cost changes in the same direction as the sensitivity variable changes.
2. The higher the sensitivity number the greater the percentage change in cost for a given percentage change in sensitivity variable. Thus the sensitivity variables with the highest sensitivity values are the ones with the greatest effect on product cost. This technique permits comparison of sensitivity variables which are essentially quite different in nature.
3. Note that the sensitivity is a dimensionless number in percent divided by percent. There is not a dollar value change in cost.

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Table 2.6
SUMMARY OF RESULTS OF SENSITIVITY ANALYSES

	MLGW Cases		Utility Cases		Industrial Cases	
	\$/MMBTU	% vs Base	\$/MMBTU	% vs Base	\$/MMBTU	% vs Base
Case 0 (Base Case)	3.76	Base	4.48	Base	5.21	Base
Case 1 Coal Price + 20%	4.06	+ 8.0	4.78	+ 6.7	5.51	+ 5.8
Case 2 Coal Price - 20%	3.46	- 8.0	4.17	- 6.9	4.90	- 6.0
Case 3 Plant Investment + 20%	3.98	+ 5.6	4.82	+ 7.6	5.67	+ 8.8
Case 4 Plant Investment - 20%	3.54	- 5.9	4.14	- 7.6	4.74	- 9.0
Case 5 Debt/Equity Ratio 50:50	N/A	-	4.78	+ 6.7	N/A	-
Case 6 Return on Equity - 8%	N/A	-	4.34	- 3.1	4.51	-13.4
Case 7 Return on Equity 15%	N/A	-	4.59	+ 2.5	5.79	+11.1
Case 8 Plant Half Size	5.10	+35.6	6.06	+35.3	7.04	+35.1
Case 9 Plant Double Size	3.29	-12.5	3.87	-13.6	4.46	-14.4
Case 10 Straight Line Depreciation	N/A	-	N/A	-	5.30	+ 1.7
Case 11 Negative Inc. Tax Allowed	N/A	-	4.41	- 1.6	5.12	- 1.7
Case 12 State Income Tax at 0	N/A	-	4.46	- 0.4	5.16	- 1.0

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Table 2.6 (Page 2)
SUMMARY OF RESULTS OF SENSITIVITY ANALYSES

	MLGW Cases		Utility Cases		Industrial Cases	
	\$/MMBTU	% vs Base	\$/MMBTU	% vs Base	\$/MMBTU	% vs Base
Case 13 Treatment of Interest during Construction	N/A	-	4.53	+ 1.1	5.50	+ 5.8
Case 14 Interest Rates 3, 6, 6% Respectively	3.47	- 7.7	4.25	- 5.1	N/A	-
Case 15 Unlimited Loss Carryforward	N/A	-	4.48	0	5.21	0
Case 16 FED Tax Rate 21%	N/A	-	4.39	- 2.0	4.81	- 7.7
Case 17 FED Tax Rate 0%	N/A	-	4.34	- 3.1	4.62	-11.3
Case 18 Alternate Utility Method with Different Assumptions	3.70	- 1.6	4.36	- 2.7	N/A	-
Case 19 Accelerated Depreciation (DDB)	N/A	-	4.50	+ 0.4	N/A	-
Case 20 Service Factor 75%	4.12	+ 9.6	4.95	+10.5	5.80	+11.1
Case 21 Service Factor 60%	4.64	+23.4	5.64	+25.9	6.67	+28.0

2.4.2 Discussion of Sensitivity Alternatives Analyzed

- Coal Price

Adjustment of 20% in coal price (to \$31.20 and \$20.80 from the \$26.00 per ton base) causes a pronounced change in product cost from the base. The change for the MLGW case (8.0%) is higher because coal contributes a greater share of the product gas cost than for the other two cases which varied 6.7% and 5.8%.

- Plant Investment

A 20% change in plant investment produces a smaller change (5.6%) in the MLGW case gas cost because MLGW has no equity. The Utility and Industrial cases have greater changes (7.6% and 8.8%) because the required return on invested capital is very close for the assumed base case conditions.

- Debt/Equity Ratio

A lower ratio of debt to equity influences the price of the Utility case moderately (+6.7%).

- Return on Equity

The MLGW case is defined as a 100% debt case. Therefore, no return on equity is required. An increase in after tax return on equity from 12% to 15% in the Industrial case causes a significant 11.1% increase in gas cost, while a decrease to 8% causes a 13.4% decrease.

A required return on equity for the Utility case of 15% (from 12% for the base case) has a relatively minor (+2.5%) effect on gas cost because only 25% of the capital investment is equity. Similarly, a decrease to 8% ROE has a slight effect on cost (-3.1%).

- Plant Size

Economics of scale are shown in this analysis. However, markets for the gas of a double sized (100 MMM Btu per day) plant may be difficult to find. Capital and operating costs for these plants were factored from the base case.

- Straight Line Depreciation

The base Industrial case utilizes the double declining balance form of depreciation allowance. It is interesting to note that, for the utility case, the gas cost using accelerated depreciation is actually higher than with the straight line method. This is caused by a loss in allowable deductions because of the 7-year limit on loss carryforward in the tax codes.

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- Negative Income Tax Allowed

All base cases were calculated on a project basis. Negative income tax allowance would enable an owner, during the early years of the project, to apply losses to income derived from other sources. For a project with large interest payments, this provision can prove helpful.

- State Income Tax

The Utility and Industrial cases include state income taxes of 3%. Elimination of these taxes provides a reduction of 0.4% and 1.0% respectively.

- Treatment of Interest During Construction

This calculation does not depreciate interest during construction, and results in a 1.1% and 5.8% increase in gas cost for the Utility and Industrial cases.

- Interest Rate

Lower interest rates for debt has a fairly pronounced effect on the gas cost.

	<u>MLGW Case</u>	<u>Utility Case</u>
Base Case Interest Rate	6 %	9 %
New Interest Rate	3 %	6 %
% Reduction in Gas Cost	-7.1%	-5.1%

- Unlimited Loss Carryforward

This calculation eliminates the 7-year carryforward limit. As discussed in 7.2.6 above, this limit means a loss of tax deductions for the Utility case. The Industrial case has no large, deductibility interest payments and is not affected.

- Federal Tax Rate

A 50% reduction in Federal tax rate reduces the gas cost 2.0% in the Utility case and a sizeable 7.7% decrease in the Industrial case. Complete elimination of Federal income tax results in a 3.1% to 11.3% reduction in gas cost.

- Service Factor

The commercial plant is assumed to produce full output for 330 days per year (90% service factor) after the first year. Load reduction, caused by decreases in customer demand, which result in plant turndown can be simulated by a reduced service factor. Production rate has a very pronounced effect on gas cost, emphasizing the desirability to base load any commercial plant.

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2.5 SOCIOECONOMIC IMPACT OF PLANT

The conceptual design for the Commercial Plant is essentially a non-site-specific design which could be located anywhere in the United States as well as have many types of users. However, to permit meaningful design bases and analyses, it was assumed that the Commercial Plant was located near a city like Memphis, Tennessee.

The following socioeconomic impact analysis is performed from two points of views, using Memphis/Shelby County, Tennessee as a representative location.

- . Economic Impact of an Industrial Fuel Gas (IFG) Commercial Plant (includes consideration of construction impact, operations impact, employment, tax, infrastructure and business volume)
- . Economic Impact of Gas Product from an IFG Commercial Plant (includes consideration of gas curtailments without IFG commercial plant, impact of IFG gas from a specific plant, local impact from one IFG plant, national impact from many IFG plants).

2.5.1 Profile of Memphis/Shelby County

. Population: The population of Shelby County, Tennessee is about 800,000, of which the city of Memphis contributes about 700,000.

. Labor: The labor market comprises roughly the three-county region surrounding Memphis. Civilian labor force is over 350,000. The unemployment rate has been somewhat higher than the national rate. Major occupations in Memphis and the county are clerical and craftsmen/foremen. Some professional/technical and administrative personnel are available because a major university and several other colleges are in Memphis.

. Income: Per capita income in Shelby County exceeds \$5,700 per year, making a total of approximately \$5 billion income in the county.

. Economic Conditions: Memphis has a diversified industrial economy. Major firms include chemicals, oil refining, wood products, farm machinery, foods, beverages, paper and rubber products, pharmaceuticals, soybean and cotton oil derivatives and fertilizers. Manufacturing firms numbered 9550 in 1975 and employed 63,700 people.

Memphis also has a strong commercial sector. Nationally, it ranked 18th in 1972 as a wholesale and distribution center; sales volume was well over \$7 billion.

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As the largest retail center in the mid-South, Memphis ranks 15th in the nation. Sales volume was over \$2.9 billion in 1976. The primary retail market includes 31 counties in Tennessee, Arkansas and Mississippi. The major market includes 76 counties and extends into Missouri and Kentucky.

. Plant Tax Rates: Under Shelby County law, real property owned by governments is exempt from property taxation. The industrial fuel gas facility under discussion here would be owned by Memphis Light, Gas and Water division (MLGW). Instead, MLGW pays In Lieu of Tax. The tax rate is based on original capital cost of the plant. Tax rate is \$3.74 per \$100 of assessed value. The plant is assessed in the following way:

$$(\text{Capital cost} - 10\%) \times 55\% = \text{Assessed Value}$$

. Memphis Government Budget: is \$250 million for fiscal year 1979, including debt service but excluding capital improvement bonds.

2.5.2 Economic Impact of an IFG Commercial Plant

The overall economic impact of the industrial fuel gas facility on the Memphis region will be positive. The plant itself will employ surplus labor, create secondary jobs, provide income and tax revenues to the area, and stimulate local business from the purchase of supplies. These impacts are discussed in more detail below. Non-local impacts are also noted.

● LOCAL IMPACTS

. Construction Employment: The construction of a new plant brings to a region temporary employment of large numbers of construction workers and short-term high cash flow from their income and the local purchase of construction materials for the plant. It can stimulate economic growth and create secondary jobs to support construction workers.

The proposed facility will be constructed at a capital cost of about \$140 million. The on-site work force will consist of 3.0 million job site hours over 36 months. This will represent over a \$50 million payroll including indirect costs, over the construction period, and an onsite peak of 700 people. Construction labor force will be composed of the following kinds of crafts: pipefitters, boiler makers, iron workers, laborers, electricians, carpenters, operating engineers, millwrights, bricklayers, painters/insulators and cement workers.

. Direct Operations Employment: Annual operating payroll and burdens will be about \$6 million for a plant staff of about 200 persons. Of these, approximately 50 will be professionals: managers, superintendents and engineers. The balance will include 115 plant operators, as well as laboratory and engineering technicians and administrative support personnel. In the Memphis region, clerical and construction workers are available. However, the majority of professionals in the operations work force (about two-thirds)

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might be expected to be drawn from outside Memphis, such as from the Gulf coast petrochemical industry, because of the unique nature of the plant.

In addition to permanent plant staff of 290 people, some maintenance services and support service personnel (e.g. cafeteria, guard, janitorial) will be contracted for an estimated cost of \$2.8 million per year. This might add approximately 140 additional jobs.

. Secondary Employment: In addition to direct employment, the project will induce more full employment in support services. In a region like Memphis, it has been estimated by the government that as many as 2.3 people are needed to provide goods and services for every project-related worker. Therefore, the following secondary employment might be expected:

Construction: $700 \text{ (peak)} \times 2.3 = 1600 \text{ (peak)}$
Operation: $(290 + 140) \times 2.3 = 990$

. Business Impact: Economic impacts include taxes and business stimulated by the facility. Growth induced can be direct (in sectors of industries using the product gas or supplying raw materials) or indirect (in support services and industry). The multiplier used to estimate this impact could be as high as 2.3 for a region like Memphis.

For construction it is assumed here that 35% of the \$140 million plant capital cost, or about \$50 million will be spent locally. The remainder of the capital cost would be distributed nationally because of the purchase of some major components from firms outside the region. Applying the 2.3 factor results in approximately \$115 million of new business for Memphis. The impact of the operation phase would be smaller and longer term. The same multiplier of 2.3 would apply. Virtually all of the income produced by these operations jobs would be spent within the Memphis region. Thus, 15 million in annual business would be induced by the \$6.5 million annual operation payroll; and \$6.4 million in annual business would be induced by the \$2.8 million annual contracted services.

. Government Revenue "In Lieu of Taxes" would be about \$2.6 million per year according to the plant tax rate noted in paragraph 2.5.1.

. Social Impact: A metropolitan area with the size and economy of Memphis has enough reserve capacity in support services and a large enough labor pool so that it could absorb an IFG Commercial Plant without strain. No negative social impact is expected because relatively few people are expected to migrate to the area due to the plant.

Facilities and Services: Facilities and services as well as most infrastructure are already developed in Memphis and have sufficient excess capacity to support any new population brought in by the project. At the highest, 75 operation personnel could move into the area. The demographic, socioeconomic and economic impacts associated with this in-migration would be small. Depending on the actual site location, temporary impact (during construction) on roads leading to the site could be significant.

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• NON-LOCAL IMPACTS

Detailed evaluation of non-local economic impacts of an IFG Commercial Plant was not within the Scope of Task I. However, the following impacts may be noted:

<u>Step</u>	<u>Function</u>	<u>Approximate Cost</u>	<u>Basis</u>
IFG Plant	Engineering	\$10 Million	Table 3.1, Code 8000
IFG Plant	Procurement	\$80 Million	Table 3.1, 80% x Codes 1000 + 2000
Coal Mine	Construction	\$40 Million	1MM Tons/year, Underground
Coal Mine	Operation	\$23 MM/yr 200-300 miners	1MM t/yr x \$23/ton 3000 t/d; 10-15 t/manday
Coal	Transportation	\$3 MM/yr	1MM t/yr x \$3/ton

2.5.3 Economic Impact of IFG Product Gas

In addition to the impact of the IFG plant, noted in section 2.5.2, there is a significant economic impact due to IFG product gas.

The IFG product gas impact is highly dependent on specific plant site, users, and geographic area served. Detailed evaluation of the gas impact was not within the scope of Task I, but can be considered in the environmental report for a specific plant. However, preliminary analyses show that many more persons may be impacted by the availability of the product gas than are impacted by the plant, but the economic impact per person is less direct.

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2.6 INCENTIVES FOR COMMERCIAL DEVELOPMENT

2.6.1 General

Most observers agree that natural gas for industrial use will be in short supply in the early to mid 1980's. Therefore, IFG from coal will compete with No. 2 fuel oil (probably imported), propane (probably imported), and direct coal combustion as the viable alternatives for industry during the 1980's and beyond.

The IFG costs presented in this volume are, in today's dollars, higher than readily available alternate sources of energy. Late 1978 prices for No. 2 fuel oil range from \$2.75 to \$3.00 per MMBtu.

Many predictions and forecasts exist which attempt to determine the availability and price of oil, propane, coal and other energy sources in the future. These forecasts vary widely and are highly dependent on basic assumptions. This situation has tended to confuse the situation, and imposed a "wait and see" attitude on the part of industry.

This section is intended to suggest some ways in which the U.S. Government can provide incentives for the development of Industrial Fuel Gas. As discussed above, the options open to industry are primarily imported sources of energy. From a national standpoint, a move by industry to these imported sources of energy could further exacerbate our balance of payments and national security problems.

2.6.2 Possible Incentives

. Direct Subsidies

The U.S. Government could subsidize the cost of gas or the price of coal as a means of reducing gas cost. Also, direct participation in the capital cost of plants is possible. However, unless these subsidies are for a specific period of time or for a specific number of plants, this option could be expensive to the taxpayer; perhaps a declining subsidy could be explored.

. Indirect Action

Raising the cost of oil and natural gas relative to coal would spur coal development. Several provisions of the 1978 national energy act would accomplish this.

. Liberalized Accounting Methods

Elimination of the 7-year carryforward limitation would lower gas cost. Liberalized depreciation methods and increased investment tax credits would also help. However, as seen in Section 2.4 these effects are relatively minor.

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. Environmental Incentives

The operation of a central coal gasification facility is the most environmentally sound means for industry in a given area to utilize coal. Rather than having numerous point sources of direct coal fired boilers, ash disposal, sulfur emissions, etc., one plant would handle the coal and dispose of the waste. This concept would decrease the amount of time and money spent on environmental reports and also allow the Government to better control emissions. Regulatory and tax incentives should recognize central facility environmental incentives.

2.6.3 Recommended Incentives

Federal Government action to provide incentives for commercialization of coal gasification should include the following:

- . Directly subsidize the price of high sulfur bituminous coal used in gasification plants. This coal is not widely used for other purposes and its use would benefit the country. Also, this type of subsidy provides the most significant incentive for each dollar spent. This method also maintains the incentive for producers to achieve the highest possible conversion efficiency, which would not be true if the product price were subsidized.
- . Provide lower interest rates. Interest rates can be lowered by the federal guarantees, direct loans from the Government at interest rates comparable to Treasury bills, or legislative action to enable debt interest to be tax free for the lender. This method provides a significant incentive for commercialization at no direct cost to the Government.
- . Liberalize accounting methods to the producer in the form of greater investment tax credits or, better yet, a lower Federal income tax rate. Tax incentives for users should also be considered, since their use of this fuel is more environmentally acceptable than direct combustion of coal at their own facilities.

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Section 3.0

PLANT CAPITAL COST ESTIMATE

The total budget cost estimate for the commercial plant is \$139,440,000 (6/78 \$) (+25%, - 10%)*. Table 3.1 is a "Summary of Budget Cost Estimate". General notes and exclusions applicable to the budget cost estimate are presented in the following paragraphs.

• General

1. The estimate has been compiled by totaling the estimated costs of each item of equipment on a section by section basis. These costs include:
 - . Code 1000 - Materials - Process Equipment and Other Materials
 - . Code 2000 - Subcontracts - Material and Labor
 - . Code 3000 - Subcontracts - Field Labor Only

The following costs were calculated on an overall basis for all involved facilities:

- . Codes 5/7000 - Foster Wheeler Construction Management
- . Code 8000 - Foster Wheeler Engineering Costs
- . Code 9000 - Miscellaneous

Standard manhours for field labor can be computed as follows:

$$\begin{array}{l} \text{. Code 4000 - Field Labor (Std. Manhours) = } \frac{\quad (\$)}{(2.1 \times 10.50) (\$/\text{Mhr.})} \end{array}$$

2. The Beavon Tail Gas Treating Unit and the "Cold Box Package" of the Air Separation Unit have been quoted as totally erected projects. Royalty payment for the Beavon Tail Gas Unit has been included.
3. The FWEC Process Estimating Program, "PREP" was used to estimate the direct costs for the Gas Treating Section (Section 400C).
4. Cost of process equipment is based on vendor estimates and "in-house" estimates.
5. Estimate is based upon June 1978 price structure; forward escalation is not included.

*This accuracy range specifically means that the upper limit has a value of +25% over the estimated cost and the lower limit is represented by a number which is 10% below the estimated value of \$139,440,000.

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6. Site is assumed to be free of all major above and below ground obstructions with ground water level 6' below grade, and allowable soil bearing value of 4,000 PSF at 5' below grade.
 7. Estimate includes labor cost based on a single shift standard craft agreement workweek.
 8. All risk construction insurance is included.
- Exclusions
 1. Cost of land.
 2. Cost of all taxes, licenses, and permits.
 3. Warehouse spare parts.
 4. Product gas line from north fence line to industrial customers.
 5. Cafeteria Equipment.
 6. Coal, coke, catalysts, chemicals, and miscellaneous consumables (unless specifically noted).
 7. Start up expenses.
 8. Craft training program.
 9. Construction camp facilities.
 10. Forward escalation.
 11. Recognizing the conceptual nature of this estimate, no contingency has been included.
 12. Interest and financing charges during construction.
 13. Home office engineering costs for Memphis Light, Gas and Water Division, Delta Refining Co., and Institute of Gas Technology.

The following tables provide additional details of the cost estimate:

- . Table 3.2 List of Process Units Equipment and Costs
- . Table 3.3 List of Offsite Sections Equipment and Costs
- . Table 3.4 Cost of Buildings and Related Equipment

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TABLE 3.1

SUMMARY OF BUDGET COST ESTIMATES
(IN \$MM OF 1978 \$, ROUNDED)

<u>GRAND TOTAL</u>	<u>\$139.4MM</u>
Code 1000 Direct Material (Including Process Equipment)	43.8
Code 2000 Subcontracts (material and labor)	57.7
Code 3000 Subcontracts for Field Labor	19.3
Code 5/7000 Construction Management	7.7
Code 8000 Engineering Cost	10.2
Cost 9000 Miscellaneous (e.g. Insurance)	0.7

SUMMARY OF PROCESS AND OFFSITES SECTIONS

Section No.	Description	1000 \$MM	2000 \$MM	3000 \$MM	Total \$MM
		(rounded)			
	<u>Process Units</u>	<u>31.7</u>	<u>41.4</u>	<u>11.8</u>	<u>84.9</u>
100	Coal Gasification	2.73	4.38	2.30	9.41
200	Gas Cooling	2.66	0.38	1.25	4.29
300	Gas Scrubbing	4.69	0.68	2.29	7.66
400	Gas Treating	6.02	1.00	2.44	9.46
500	Sulfur Recovery	2.00	0.35	1.35	3.70
600	Tail Gas Treating	0.01	2.60	0.01	2.62
700	Air Separation	13.56	12.36	2.17	28.09
1000	Coal Handling & Prep.	----	16.15	----	16.15
1500	Ash Handling	----	3.55	----	3.55
	<u>Offsites</u>	<u>12.1</u>	<u>16.3</u>	<u>7.5</u>	<u>35.9</u>
2000	Steam Generation	----	1.20	----	1.20
3000	Raw Water Treat. & Stor.	----	0.50	----	0.50
3200	BFW Treatment	1.73	0.66	0.58	2.97
3400	Cooling Water System	0.59	0.64	0.65	1.88
3600	Waste Water Treatment	2.27	2.59	1.98	6.84
4000	Flare	0.33	0.12	0.26	0.71
4400	Plant Air & Instr. N ₂	0.31	0.02	0.12	0.45
5400	Interconnecting Piping	1.94	1.25	2.15	5.34
5600	Buildings & Equip.	----	5.29	----	5.29
5800	Roads & Fences	----	1.10	----	1.10
6000	Firewater System	0.37	0.11	0.55	1.03
6400	Power Distribution, Lighting, Communication	4.36	0.20	0.57	5.13
6600	Site Prep., Drain, Sewer	0.20	0.58	0.68	1.46
8000	Dock Facilities	----	2.00	----	2.00

Note: Code 4000 - Field Labor (Std. Manhours) = $\frac{(\$)}{(2.1 \times 10.50)} (\$/\text{Mhr.})$

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TABLE 3.2

LIST OF PROCESS UNITS EQUIPMENT AND COSTS

<u>Item No.</u>	<u>Item Nomenclature</u>	<u>Cost (\$M in 1978)</u>
<u>Section 100C - COAL GASIFICATION</u>		
RX-0101-1,2,3	Gasifier	3750
SX-0101-1,2,3	1st Stage Cyclone	{ 630
SX-0102-1,2,3	2nd Stage Cyclone	
HX-0101-1,2,3	Startup Heater	200
ELX-0101	Elevator	90
<u>Section 200C - GAS COOLING</u>		
DX-0201-1,2,3	H.P. Steam Drum	146
DX-0203-1,2,3	M.P. Blow Down Drum	32
EX-0201-1,2,3	H.P. Steam Generator	390
EX-0202-1,2,3	H.P. Steam Superheater	450
EX-0203-1,2,3	M.P. Steam Superheater	240
EX-0204-1,2,3	M.P. Steam Generator	120
EX-0205-1,2,3	BFW Preheater	81
MX-0201	Phosphate Tank Mixer	{ 4
AX-0201	Phosphate Addition Package	
PX-0201-1,2,3A/B	BFW Circulating Pump & Spare	70
<u>Section 300C - GAS SCRUBBING</u>		
TX-0301	Sour Water Stripper	138
TX-0302	Slurry Water Stripper	66
DX-0301	Compressor K.O. Drum	122
DX-0302	Stripper Reflux Drum	14
EX-0301-1,2,3	Scrubber Water Cooler	38
EX-0302	Raw Gas Air Cooler	368
EX-0303	Compressor Suction Cooler	43
EX-0304	Sour Water Preheater	16
EX-0305	Stripper Overhead Condenser	42
EX-0306	Stripper Reboiler	38
EX-0307	Stripper Water Cooler	40
EX-0309	Slurry Water Cooler	39
EX-0310	Stripped Water Trim Cooler	36
PX-0301-1,2,3A/B	Scrubber Cir. Pump & Spare	72
PX-0302A/B	Sour Cond. Booster Pump & Spare	10
PX-0303A/B	Stripper Reflux Pump & Spare	12
PX-0304A/B	Stripped Water Pump & Spare	19

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TABLE 3.2 (page 2)

LIST OF PROCESS UNITS EQUIPMENT AND COSTS

<u>Item No.</u>	<u>Item Nomenclature</u>	<u>Cost (\$M in 1978)</u>
<u>Section 300C - GAS SCRUBBING (Cont'd.)</u>		
PX-0305A/B	Slurry Water Pump & Spare	8
PX-0306A/B	Filtrate Pump & Spare	6
PX-0307A/B	Clarifier Water Pump & Spare	14
PX-0308A/B	Clarifier Decantor Pump & Spare	6
CX-0301	Raw Gas Compressor	1220
CLX-0301	Clarifier	55
AX-0301	Filtration System	42
SX-0301-1,2,3	Raw Gas Scrubber	240
<u>Section 400C - GAS TREATING</u>		
TX-0401	Solvent Absorber w/Packing, Trays	870
TX-0402	Solvent Stripper	364
EX-0401	Sour Gas Cooler	252
EX-0402	Product Exchanger	177
EX-0403	Solvent Chiller	154
EX-0404	Solvent Exchanger	250
EX-0405	Solvent Exchanger	210
CX-0401	Gas Compressor	575
AX-0401	Solvent Refrigeration Unit	750
RX-0401	Hydrolysis Reactor	93
DX-0402	Absorber KO Drum	31
DX-0403	Gas KO Drum	34
DX-0404	K.O. Drum	9
DX-0405	Flash Drum (Horiz.-18,000 gal.)	27
DX-0405	Flash Drum (Vert.-650 gal.)	5
DX-0406	Reflux Drum	8
TKX-0401	Solvent Sump	4
TKX-0402	Storage Tank	25
EX-0407	Stripper Reboiler	88
EX-0408	Condenser	68
EX-0409	Gas Cooler	7
PX-0401A/B	Solvent Pump & Spare	62
PX-0402A/B	Solvent Pump & Spare	97
PX-0403A/B	Reflux Pump & Spare	8
PX-0404	Solvent Sump Pump	3
DSX-0401	Resuperheater	2
FX-0401	Solvent Filter	3
—	Odorization Station	25
—	Metering Station	75

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LIST OF PROCESS UNITS EQUIPMENT AND COSTS

<u>Item No.</u>	<u>Item Nomenclature</u>	<u>Cost (\$M in 1978)</u>
<u>Section 500C - SULFUR RECOVERY</u>		
—	Claus Unit	3700
<u>Section 600C - TAIL GAS TREATING</u>		
AX-0601	Beavon Unit Package	2600
AX-0602	Phosphate Addition Package)	5
MX-0601	Phosphate Tank Mixer	
<u>Section 700C - AIR SEPARATION</u>		
DX-0701A/B	Intercooler K.O. Drum	110
DX-0702	Aftercooler K.O. Drum	107
EX-0701A/B	Air Compressor Intercooler	200
EX-0702	Air Compressor Aftercooler	90
EX-0703	Oxygen Comp. 1st. Stage Intercooler	50
EX-0704	Oxygen Comp. 2nd. Stage Intercooler	50
EX-0705	Oxygen Comp. 3rd. Stage Intercooler	50
CX-0701A	Air Compressor (Motor Drive)	1736
CX-0701B	Air Compressor (Motor & Turbine)	2045
CX-0702	Oxygen Compressor	780
AX-0701	Cold Box Package	6900
AX-0702	Plant Nitrogen Package	155
FX-0701A/B	Air Filter	84
<u>Section 1000C - COAL HANDLING & PREPARATION</u>		
AX-1001	Barge Unloading System	2000
AX-1002	Coal Crushing/Drying System	1565
AX-1003	Coke Drying System	225
MEX-1001/1002	Front End Loader	236
CRX-1001	Raw Coal Conveyor	154
CRX-1002	Stock Pile Feed Conveyor	260
CRX-1004	Dryer-Mill Feed Conveyor	161
CRX-1011	Coal/Coke Elevator	270
CRX-1014A/B	Gasifier Feed Conveyor	116
(18 items)	Gasifier Feed Receiving/Lock/ Injection Hoppers	1440
BVX-1001A/B	Stockpile Discharger	50
BVX-1002	Coal Silo Discharger	6
BVX-1003	Coal Silo Discharger	6

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LIST OF PROCESS UNITS EQUIPMENT AND COSTS

<u>Item No.</u>	<u>Item Nomenclature</u>	<u>Cost (\$M in 1978)</u>
<u>Section 1000C - COAL HANDLING & PREPARATION (Cont'd.)</u>		
CRX-1003	Stockpile Gathering Conveyor	48
CRX-1005	Coal Separator Conveyor	15
CRX-1007	Filtered Fines Conveyor	7
CRX-1008	Coke Reclaim Conveyor	114
CRX-1009	Dried Coke Conveyor	20
CRX-1010	Coal/Coke Elevator Feed Conveyor	19
CRX-1012A/B	Coal/Coke Conveyor	33
CRX-1013A/B	Gasifier Feed Transfer Conveyor	100
DCX-1002	Material Handling Dust Collection System	58
DCX-1003	Coke Dryer Dust Collection System	37
DPX-1001	Stockpile Dust Suppression System	40
FX-1002	Coal Silo Vent Filter	2
FX-1004	Coke Silo Vent Filter	2
FDX-1002A/B	Stockpile Discharge Feeder	14
FDX-1003A/B	Stockpile Alternate Feeder	14
FDX-1007	Coke Reclaim Feeder	3
FDX-1009	Coal Silo Discharge Feeder	14
FDX-1010	Coal Silo Discharge Feeder	7
SX-1001	Raw Coal Magnetic Separator	6
SX-1003-1,2,3,A/B	Gasifier Feed Magnetic Separator	31
SKX-1001	Stockpile Feed Stacker	40
SSX-1001	Raw Coal Sampling System	75
SSX-1002	Dryer Mill Feed Sampling System	75
SSX-1003A/B	Dried Coal Sampler & Spare	20
TKX-1003A/B	Stockpile Alternate Hopper	14
TKX-1004	Dryer Mill Surge Hopper	20
TKX-1005	Dried Coal Silo	322
TKX-1006	Coke Reclaim Hopper	15
TKX-1007	Coke Dryer Surge Hopper	16
TKX-1008	Coke Silo	322
WSX-1001	Raw Coal Scale	7

Note: Section 1000C items included in price of other items are not listed separately.

Section 1500C - ASH HANDLING

CLX-1501	Clarifier	1750
EX-1501	Recycle Water Cooler	25

Note: Section 1500C items included in CLX-1501 are not listed separately.

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TABLE 3.3

LIST OF OFFSITE SECTIONS EQUIPMENT AND COSTS

<u>Item No.</u>	<u>Item Nomenclature *</u>	<u>Cost (\$M in 1978)</u>
<u>Section 2000C - STEAM GENERATION</u>		
DX-2001	Continuous Blowdown Drum	8
DX-2002	Condensate Flash Drum	16
DX-2003	Blowdown Flash Drum	8
DX-2004	Intermittent Blowdown Drum	3
AX-2001	Phosphate Addition Package	5
DSX-2001	M.P. Desuperheater	2
SGX-2001A/B	Package Boiler	550
<u>Section 3000C - RAW WATER STORAGE</u>		
TKX-3001	City Water/Firewater Storage Tank	4 57
PX-3001A/B	City Water Pump and Spare	40
<u>Section 3200C - BOILER FEEDWATER TREATMENT</u>		
DX-3201	Sulfuric Acid Storage Drum	43
DX-3202	Caustic Storage Drum	43
TKX-3201	Demineralized Water Storage Tank	280
TKX-3203	Condensate Storage Tank	60
EX-3201	Cond./Demin. Water Exchanger	40
PX-3203A	Demineralized Water Pump	206
PX-3203B	Demineralized Water Pump Spare	
PX-3204A	Condensate Pump	35
PX-3204B	Condensate Pump Spare	
PX-3205A	EFW Pump	73
PX-3205B	EFW Pump Spare	
AX-3201	Demineralizer Package	520
AX-3202	Amine Injection Package	1
AX-3203	Hydrazine Injection Package	2
SCX-3201	EFW Sample Cooler	1
DAX-3201	Deaerator	75

* NOTE: Items included in cost of other items are not listed separately.

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TABLE 3.3 (Page 2)

LIST OF OFFSITE SECTIONS EQUIPMENT AND COSTS

<u>Item No.</u>	<u>Item Nomenclature</u>	<u>Cost (\$M in 1978)</u>
<u>Section 3400C - COOLING WATER SYSTEM</u>		
DX-3401	Cooling Tower Sulfuric Acid Drum	5
DX-3402	Corrosion Inhibitor Drum	1
DX-3403	Dispersant Drum	
DX-3404	Chromate Destruct Sulf. Acid Drum	
DX-3405	Sulfuric Acid Storage Drum	43
PX-3401A	Cooling Water Circ. Pump (Motor)	32
PX-3401B	Cooling Water Circ. Pump (Motor)	32
PX-3401C	Cooling Water Circ. Pump Spare (Turbine)	26
PX-3402	Corrosion Inhibitor Pump	8
PX-3403	Dispersant Pump	
PX-3404	Cooling Tower H ₂ SO ₄ Pump	
PX-3405	Chromate Destruct H ₂ SO ₄ Pump	4
CTX-3401	Cooling Tower	460
AX-3401	Chlorination Package	4
AX-3402	Cooling Water Monitoring System	6
AX-3403	Chromate Destruct Package	52
AX-3404	Settler/Thickener Package	50
<u>Section 3600C - WASTE WATER TREATMENT</u>		
EX-3651	Ozone Contactor	30
DX-3651	Oxygen Knockout Drum	22
TKX-3601	Lime Storage Tank	45
TKX-3602	Slop Oil Recovery Tank	12
TKX-3654	Carbon Backwash Water Tank	16
TKX-3656	Hydrated Lime Storage Tank	45
CLX-3601	Coal Pile Run-off Clarifier	28
MX-3601	Aerating Basin Aerator	12
MX-3652	Ozone Static Mixer	2
FX-3653A/B	Post Ozonation Pressure Filter	200
PX-3601	Primary Storm Water Lift Pump	5
PX-3602	Secondary Storm Water Lift Pump	7
PX-3603A/B	Treated Storm Water Lift Pump	7
PX-3604A/B	Treated Storm Water Lift Pump	14
PX-3605A/B	Slop Oil Transfer Pump	24
PX-3606A/B	Recovered Oil Pump & Spare	10
PX-3607A/B	Coal Pile Run-off Pump & Spare	10
PX-3608A/B	Treated C.P. Run-off Pump & Spare	14
PX-3609A/B	Refuse Sludge Pump & Spare	7
PX-3610	Sampling Basin Pump	6

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TABLE 3.3 (Page 3)

LIST OF OFFSITE SECTIONS EQUIPMENT AND COSTS

<u>Item No.</u>	<u>Item Nomenclature</u>	<u>Cost (\$M in 1978)</u>
<u>Section 3600C - WASTE WATER TREATMENT (Cont'd.)</u>		
PX-3651A/B	Clarifier Underflow Pump & Spare	6
PX-3653A/B/C	Ozone Contactor Bottoms Pump & Spare	16
PX-3654A/B	Dirty Backwash Pump & Spare	6
PX-3655A/B	Backwash Pump & Spare	18
PX-3656A/B	Activated Carbon Charge Pump	18
BX-3651	Carbon Dioxide Blower	2
AX-3601	Stormwater Holding Basin	40
AX-3602	Treated Stormwater Holding Basin	26
AX-3603	C.P. Run-off Holding Basin	73
AX-3604	Neutralization Basin	19
AX-3605	Aerating Basin	57
AX-3606	Stormwater Gravity Separator	15
AX-3607A/B	Sludge Pit	103
AX-3609	Sampling Basin	66
AX-3608	Dissolved Air Flotation Package	60
AX-3651	Physical Chemical Treat. Package	185
AX-3652	Ozone Generator	175
AX-3653	Activated Carbon Package	1500
AX-3656	Phosphoric Acid Feed System	5
AX-3657	Sludge Drying System	63
FDX-3601	C.P. Run-off Lime Feeder	5
<u>Section 4000C - FLARE SYSTEM</u>		
DX-4001	Flare Knock Out Drum	89
DX-4002	Steam Separator	5
DX-4003	Pilot Gas Knock Out Drum	5
PX-4001A/B	Flare Knock Out Drum Pump & Spare	20
FLX-4001	Elevated Flare	81
<u>Section 4400C - PLANT AIR & INST. NITROGEN</u>		
—	Process Equipment (based on FWEC Historical Data)	238
<u>Section 6000C - FIREWATER SYSTEM</u>		
PX-6001A	Firewater Pump, Motor	50
PX-6001B	Firewater Pump, Diesel	60
PX-6001C	Firewater Pump Diesel	60

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TABLE 3.4

COST OF BUILDINGS AND RELATED EQUIPMENT

<u>Item Nomenclature</u>	<u>Cost (\$M in 1978)</u>
<u>Section 5600C - BUILDINGS</u>	
Administration Building	540
Warehouse/Maintenance/Change House	1200
Laboratory/First Aid	160
Firehouse	86
Main Control House	360
Gasifier Control House	135
Utility Control House	300
Water Treatment	240
Gate Houses (Two)	70
Electrical Substations (Twelve)	374
Truck Scale	25
Equipment - Mobile	510
Equipment - Maintenance	750
Equipment - Warehouse	250
Equipment - Medical	40
Equipment - Labs	250
Furnishings - Administration	200

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Section 4.0

PLANT ORGANIZATION & PAYROLL

Typical plant organization and costs for a commercial plant are summarized as follows:

- . Figure 4-1 Plant Organization Chart
- . Table 4-1 Plant Organization Functions
- . Table 4-2 Plant Staffing Plan and Cost

Total plant annual payroll is \$6,848,000. Table 2.3 presents the calculation of maintenance costs.

1. The top position will be plant manager rather than president. Executive staff will be minimized.
2. Hourly workforce to supervisor ratio is about 10:1. Plant operator staffing is based on 24 hour, 7 day operation.
3. To the extent possible, purchased laboratory test equipment will be automatic, allowing a significant amount of testing to be performed by non-degreed technical personnel.
4. Plant engineering staff will be augmented during plant initial start-up and operations.
5. To the extent possible, support services will be contracted for rather than full time hires, e.g., janitorial, cafeteria, guard service.
6. To the extent possible, auxiliary services (e.g. accounting, computer) will be minimized on site and maximum use of existing home office facilities will be made.
7. EDP group will be primarily responsive to engineering data analysis. Data processing in support of people, e.g., payroll, cost accounting, will be accomplished on-site or through home office facilities.
8. Plant staff will work primarily in the plant and be stationed there.

The plant staffing shown will vary depending on the IFG product gas user, e.g. on-site user such as a refinery or steel mill versus offsite distribution system to multiple users. Pipeline and distribution organization and personnel requirements may range from minimal increase in an existing and extensive gas distribution parent company to a separate section in the plant staffing for a stand alone commercial plant and IFG distribution system. The former assumption, which is expected to be closer to a typical commercial application, is assumed.

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PLANT ORGANIZATION CHART

Fig. 4-1

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TABLE 4-1

PLANT ORGANIZATION FUNCTIONS

- I. PLANT MANAGER
 - Overall Plant Management
- II. OPERATIONS
- IIA. Operations
 - . Supervision
 - . Unit Operations
 - . Data Collection
 - . Raw Material Control
 - . Product Control
 - . By-Product Control
- IIB. Laboratory and Q.C. Services
 - . Raw Material Testing
 - . Intermediate Q/C
 - . Final Product Q/C
 - . By-Product Q/C
 - . Waste Treatment
 - . Fuels
 - . Water Treatment
- III. ENGINEERING
- IIIA. Process Engineering
 - . Unit Operations/Expertise
 - . Unit Improvements/Modifications
 - . Unit Training
 - . Data Reduction/Analysis
 - . Planning
- IIIB. Project Engineering
 - . Electrical
 - . Electronic
 - . Mechanical
 - . Civil
 - . Drafting
 - . Config. Control

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TABLE 4-1 (Page 2)

PLANT ORGANIZATION FUNCTIONS

IV. MAINTENANCE

IVA. Job Planning/Control

- . Work Order Control
- . Work Scheduling
- . Preventive Maintenance Program
- . Job Planning
- . Material Specification
- . Reporting
- . Turnaround Plans

IVB. Maintenance

- . Supervision
- . Execution of Maint. Work
- . Reporting

IVC. Purchasing/Warehouse

- . Purchasing
- . Records/Inventory/Control
- . Receiving/Storage/Delivery

V. MARKETING/SUPPLY

- . Coal Purchases/Contracts
- . Other Raw Material Purchases/Contracts
- . Sulfur Marketing/Contracts
- . Ash Marketing/Contracts
- . New Customer Contracts
- . Account Servicing

VI. ACCOUNTING/EDP SERVICES

VIA. Accounting

- . Payroll
- . Expenses
- . Budgeting
- . Control
- . Data Input to Home Office
- . Internal Data

VIB. EDP

- . Interface with Home Office
- . Internal Data Generation
- . Programming
- . Systems Analysis
- . Data Entry
- . Operator(s)

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TABLE 4-1 (Page 3)
PLANT ORGANIZATION FUNCTIONS

VII. EMPLOYEE RELATIONS

VIIA. Safety/Security/Health

- . Safety
- . Compliance
- . Health
- . Training
- . Reporting
- . Physical Security
- . Liaison with Local Authorities
- . Improvements

VIIB. Personnel Services

- . Recruiting
- . Hiring
- . Records
- . Forms
- . Benefits
- . Training/Development
- . Affirmative Action
- . EEO
- . Office Support

VIIC. Labor Relations

- . Negotiations
- . Grievances
- . Arbitrations
- . Organizing
- . Liaison

VIID. Public Relations

- . Information
- . Tours
- . Publicity
- . Speeches/Demonstrations
- . Potential Customer Information

**MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM**

FW FOSTER WHEELER
TASK I - COMMERCIAL PLANT
CONCEPTUAL DESIGN

**TABLE 4-2
PLANT STAFFING PLAN AND COST**

	<u>Position</u>	<u>Number</u>	<u>Estimated Salary Wage \$1000 (1978)</u>	<u>Yearly Payroll \$1000 (1978)</u>
I.	<u>PLANT MANAGER</u> (Subtotal)	<u>2</u>		<u>63</u>
	Plant Manager	1	50	50
	Plant Dir. Secretary	1	13	13
II.	<u>OPERATIONS</u> (Subtotal)	<u>139</u>		<u>2510</u>
	Operations Manager	1	35	35
	Opns. Dir. Secretary	1	11	11
	Opns. Clerk/Typist	1	8	8
IIA.	Operations Superintendent	1	30	30
	Gen. Opns. Supervisors	4	24	96
	Asst. Opns. Supervisors	6	22	132
	Operators	110	8.50/hr.*	1945
IIB.	Chief Chemist	1	28	28
	Lab Manager	1	23	23
	Chemist	2	18	36
	Testers	6	16	96
	Samplers	5	14	70
III.	<u>ENGINEERING</u> (Subtotal)	<u>21</u>		<u>438</u>
	Engineering Manager	1	32	32
	Engineering Dir. Secretary	1	11	11
	Engineering Clerk/Typist	1	8	8
IIIA.	Manager. Process Engineering	1	30	30
	Process Engr.-Gasifiers/Cooling	1	26	26
	Process Engr.-Treat/Byproducts	1	23	23
	Process Engr.-Air Plant/Coal Prep.	1	23	23
	Process Engr.-Pollution Control	1	23	23
	Process Engr.-Utilities	1	23	23
	Technicians		18	36
IIIB.	Manager Project Engineering	1	30	30
	Project Eng., Instrument	1	25	25
	Project Eng., Electrical	1	23	23
	Project Eng., Mechanical	1	23	23
	Project Eng., Civil/Structures	1	21	21
	Technicians	2	18	36
	Draftsmen	3	15	45

*Includes allowance for shift differential, 2080 hours/year.

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PLANT STAFFING PLAN AND COST

	<u>Position</u>	<u>Number</u>	<u>Salary/Wage</u> \$1000 (1978)	<u>Yearly</u> <u>Payroll</u> \$1000 (1978)
IV.	<u>MAINTENANCE</u> (Subtotal)	<u>81</u>		<u>1485</u>
	Maintenance Manager	1	32	32
	Maintenance Mgr. Secretary	1	11	11
IVA.	Preventive Maint. Mech Engr.	1	23	23
	Planner	2	18	36
	Scheduler/Control	1	15	15
IVB.	Maintenance Superintendant	1	30	30
	Maintenance Foreman	6	22	132
	Craftsmen	30	8.50/hr.*	585
	Apprentices	25	7.50/hr.*	430
	Laborers	10	6.50/hr.*	150
IVC.	Purchasing Agent	1	20	20
	Purchasing Specialist	1	12	12
	Purchasing Clerk/Typist	1	9	9
V.	<u>MARKETING/SUPPLY</u> (Subtotal)	<u>3</u>		<u>55</u>
	Marketing/Supply Manager	1	25	25
	Marketing/Supply Agent	1	20	20
	Marketing/Purch. Secretary	1	10	10
VI.	<u>ACCOUNTING/EDP</u> (Subtotal)	<u>13</u>		<u>180</u>
	Accounting/EDP Manager	1	25	25
	Accounting/EDP Secretary	1	9	9
VIA.	Accountant	1	18	18
	Clerks (Payroll, Payables, etc.)	4	9	36
VIB.	Mgr., EDP	1	22	22
	Systems Analyst	1	20	20
	Programmers	2	16	32
	Data Entry Clerk	2	9	18

*Based on 2200 hours/year, which includes 120 hours of overtime work.

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**TASK I - COMMERCIAL PLANT
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TABLE 4-2 (Page 3)

PLANT STAFFING PLAN AND COST

<u>Position</u>	<u>Number</u>	<u>Salary/Wage</u> \$1000 (1978)	<u>Yearly</u> <u>Payroll</u> \$1000 (1978)
VII. <u>EMPLOYEE RELATIONS</u> (Subtotal)	<u>13</u>		<u>191</u>
Emp. Relations Manager	1	26	26
Emp. Relations Secretaries	2	10	20
VIIIA. Safety Manager	1	18	18
Medical Doctor (part time)	1	20	20
Industrial Nurse	1	12	12
VIIIB. Mgr., Personnel Services	1	20	20
Personnel Specialist	1	12	12
Clerk/Typist	1	8	8
Switchboard/Receptionist	1	8	8
Messenger/Mail clerk	1	8	8
VIIC. Mgr., Labor Relations	1	22	22
VIID. Mgr., Public Relations	1	20	20
<u>DIRECT PAYROLL</u>	<u>292</u>		<u>4925</u>
<u>PAYROLL BURDEN</u>			<u>1568*</u>
Salaried Payroll Burden* ($\$1815M \times 35\% = 635$)			
Hourly Payroll Burden* ($\$3110M \times 30\% = 933$)			<u>6493**</u>
<u>TOTAL PAYROLL</u>			

NOTES

* Payroll Burden includes: (1) holidays, (2) vacations, (3) sick leave, (4) pension, (5) Social Security Taxes, (6) Unemployment Taxes, (7) Workmen's Comp., (8) Insurance

** When adding the cost for contracted maintenance labor (\$2768M from Table 2.3), the total labor, supervision and overhead cost is \$9261M. When using completely the method specified by U.S. E.R.D.A. in its "Factored Estimates for Western Coal Commercial Concepts": (process oper. labor & maint. labor) $\times 1.2 \times 1.6$ a value of \$ (1945 + 2607) $\times 1.2 \times 1.6 = \$8739M$ would be obtained.

MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM

FW FOSTER WHEELER
TASK I - COMMERCIAL PLANT
CONCEPTUAL DESIGN

APPENDICES TO VOLUME III

APPENDIX A-1

COMPUTER INPUT FOR BASE CASE CALCULATIONS

<u>Card No.</u>	<u>Variable Name</u>	<u>Value Entered</u>		
		<u>MLGW Case</u>	<u>Utility Case</u>	<u>Industrial Case</u>
1	LL (1)	1	1	2
	LL (2)	0	0	0
	LL (3)	1	1	1
	LL (4)	0	0	0
	LL (5)	1	1	1
	LL (6)	0	0	0
	LL (7)	0	2	2
	LL (8)	0	0	0
2	TXCRED	0.0	0.04	0.10
	FITTXR	0.0	0.48	0.48
	STAINC	0.0	0.03	0.03
	STAREV	0.0	0.015	0.015
	PROPTX	0.0185	0.017	0.017
	INSURE	0.00125	0.01	0.01
	DBTRFC	1.0	0.75	0.0
	EQFRAC	0.0	0.25	1.0
3	INTDBT	0.06	0.09	0.09
	PRPEXP	1.04	1.04	1.04
	TOLER	0.0001	0.0001	0.0001
	SALVGE	0.0	0.0	0.0
	INTCON	0.0	0.09	0.09
	INTTOT	0.0	0.0	0.0
	CNSTLN	0.0	139.44	139.44
4	NYRS	24	20	20
	NSTRT	5	1	1
	NTRIES	35	35	35
	NFDPRS	1	1	1
	NEQMAX	1	1	1
	NCARRY	7	7	7
	NCREDIT	7	7	7
	NCNSTR	4	4	4
5	INVEST (1)	7.047	140.94	140.94
	INVEST (2)	28.188	0.0	0.0
	INVEST (3)	70.470	0.0	0.0
	INVEST (4)	35.235	0.0	0.0
	INVEST (5-20)	0.0	0.0	0.0
	INVEST (21-24)	0.0	---	---

**MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM**

FW FOSTER WHEELER
TASK I - COMMERCIAL PLANT
CONCEPTUAL DESIGN

APPENDIX A-1 (Page 2)

<u>Card No.</u>	<u>Variable Name</u>	<u>Value Entered</u>		
		<u>MLGW Case</u>	<u>Utility Case</u>	<u>Industrial Case</u>
6	WORKCP (1)	0.625	8.270	8.270
	WORKCP (2)	0.0	0.0	0.0
	WORKCP (3)	0.0	0.0	0.0
	WORKCP (4)	0.0	0.0	0.0
	WORKCP (5)	7.645	0.0	0.0
	WORKCP (6-20)	0.0	0.0	0.0
	WORKCP (21-24)	0.0	---	---
7	EXTEXP (1)	0.0	8.768	8.768
	EXTEXP (2)	0.0	0.0	0.0
	EXTEXP (3)	0.0	0.0	0.0
	EXTEXP (4)	0.0	0.0	0.0
	EXTEXP (5)	8.768	0.0	0.0
	EXTEXP (6-19)	0.0	0.0	0.0
	EXTEXP (20)	0.0	-10.0	-10.0
	EXTEXP (21-23)	0.0	---	---
8	EXINIT	0.0	0.0	0.0
	EXPCON	10.999	10.999	10.999
	PL	3.00	3.00	3.00
	PH	6.00	8.00	8.00
	DELFPR	0.0	0.0	0.0
	TOLPRC	0.0001	0.0001	0.0001
9	NPRODS	2	2	2
	NFEEDS	2	2	2
10	PRICE (1)	4.0	4.0	4.0
	PRICE (2)	48.00	48.00	48.00
11	PRDRAT (1)	17.695	17.695	17.695
	PRDRAT (2)	0.036135	0.036135	0.036135
12	FEEDPR (1)	26.00	26.00	26.00
	FEEDPR (2)	0.02	0.02	0.02
13	FEEDRT (1)	1.01978	1.01978	1.01978
	FEEDRT (2)	380.444	380.444	380.444
14	RTNEW (1)	0.0	0.12	0.12
15	NCLS	1	1	1
	LIFE (1)	20	20	15

MLGW/DOE INDUSTRIAL FUEL GAS
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FW FOSTER WHEELER
TASK I - COMMERCIAL PLANT
CONCEPTUAL DESIGN

APPENDIX A-1 (Page 3)

<u>Card No.</u>	<u>Variable Name</u>	<u>Value Entered</u>		
		<u>MLGW Case</u>	<u>Utility Case</u>	<u>Industrial Case</u>
16	DPFRAC (1)	1.	1.0	1.0
17	EFFNCY (1)	0.0	.45	.45
	EFFNCY (2-4)	0.0	.9	.9
	EFFNCY (5)	0.45	.9	.9
	EFFNCY (6-20)	0.9	.9	.9
	EFFNCY (21-24)	0.9	---	---
18	FRCINV (1)	0.0	.05	.05
	FRCINV (2)	0.0	.20	.20
	FRCINV (3)	0.0	.50	.50
	FRCINV (4)	0.0	.25	.25

MLGW/DOE INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROGRAM

FOSTER WHEELER
TASK I - COMMERCIAL PLANT
CONCEPTUAL DESIGN

APPENDIX A-2

CHANGES TO INPUTS FOR ALTERNATE CASES

	<u>Case(s) Change Is Valid For</u>	<u>Card # Changed</u>	<u>Variable Changed</u>	<u>New Value</u>
Case 1				
Coal Price +20%	MLGW, Utility, & Industrial	12	FEEDPR(1)	31.20
Case 2				
Coal Price -20%	MLGW, Utility, & Industrial	12	FEEDPR(1)	20.80
Case 3				
Plant Investment +20%	MLGW	5	INVEST(1)	8.456
		5	INVEST(2)	33.826
		5	INVEST(3)	84.564
		5	INVEST(4)	42.282
	Utility & Industrial	3	CNSTLN	169.128
		5	INVEST(1)	169.128
Case 4				
Plant Investment -20%	MLGW	5	INVEST(1)	5.638
		5	INVEST(2)	22.550
		5	INVEST(3)	56.376
		5	INVEST(4)	28.188
	Utility & Industrial	3	CNSTLN	112.752
		5	INVEST(1)	112.752
Case 5				
Debt/Equity Ratio 50:50	Utility	2	DBTFRC	0.5
			EQFRAC	0.5
Case 6				
Return on Equity -8%	Utility & Industrial	14	RTNEW(1)	0.08

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APPENDIX A-2 (Page 2)

	<u>Case(s) Change Is Valid For</u>	<u>Card # Changed</u>	<u>Variable Changed</u>	<u>New Value</u>
Case 7				
Return on Equity -15%	Utility & Industrial	14	RTNEW(1)	0.15
Case 8				
Plant Half Size	MLGW	3	PRPEXP	5.20
		5	INVEST(1)	4.820
		5	INVEST(2)	19.282
		5	INVEST(3)	48.206
		5	INVEST(4)	24.103
		6	WORKCP(5)	3.747
		7	ESTESP(5)	5.180
		7	EXTEXP(24)	-6.00
		8	EXPCON	8.534
		10	PRICE(1)	5.0
		11	PRDRAT(1)	8.8475
		11	PRDRAT(2)	0.01805
		13	FEEDRT(1)	0.50989
		13	FEEDRT(2)	190.222
	Utility & Industrial	3	PRPEXP	5.20
		3	CNSTLN	96.411
		5	INVEST(1)	96.411
		6	WORKCP(1)	4.372
		7	EXTEXP(1)	5.180
		7	EXTEXP(20)	-6.00
		8	EXPCON	8.534
		10	PRICE(1)	5.0
		11	PRDRAT(1)	8.8475
		11	PRDRAT(2)	0.01805
		13	FEEDRT(1)	0.50989
		13	FEEDRT(2)	190.222

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APPENDIX A-2 (Page 3)

	<u>Case(s) Change Is Valid For</u>	<u>Card # Changed</u>	<u>Variable Changed</u>	<u>New Value</u>
Case 9 Plant Double Size	MLGW	3	PRPEXP	2.08
		5	INVEST(1)	11.277
		5	INVEST(2)	45.107
		5	INVEST(3)	112.767
		5	INVEST(4)	56.383
		6	WORKCP(1)	1.00
		6	WORKCP(5)	14.988
		7	EXTEXP(5)	16.335
		7	EXTEXP(24)	-16.5
		8	EXPCON	14.150
		11	PRDRAT(1)	35.390
		11	PRDRAT(2)	0.0722
		13	FEEDRT(1)	2.03956
		13	FEEDRT(2)	760.888
	Utility & Industrial	3	PRPEXP	2.08
		3	CNSTLN	225.534
		5	INVEST(1)	225.534
		6	WORKCP(1)	15.988
		7	EXTEXP(1)	16.335
		7	EXTEXP(20)	-16.5
		8	EXPCON	14.15
		11	PRDRAT(1)	35.390
		11	PRDRAT(2)	0.0722
		13	FEEDRT(1)	2.03956
		13	FEEDRT(2)	760.888
Case 10 Straight Line Depreciation	Industrial	1	LL(1)	1

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APPENDIX A-2 (Page 4)

	<u>Case(s) Change Is Valid For</u>	<u>Card # Changed</u>	<u>Variable Changed</u>	<u>New Value</u>
Case 11				
Negative Income Tax Allowed	Utility & Industrial	1	LL(6)	1
Case 12				
State Income Tax at 0	Utility & Industrial	2	STAINC	0.0
Case 13				
Treatment of Interest during Construction	Utility & Industrial	1	LL(7)	0
		3	CNSTLN	0.0
		4	NYRS	24
		4	NSTRT	5
		5	INVEST(1)	7.047
		5	INVEST(2)	28.188
		5	INVEST(3)	70.470
		5	INVEST(4)	35.235
		6	WORKCP(1)	0.625
		6	WORKCP(5)	7.645
		7	EXTEXP(1)	0.0
		7	EXTEXP(5)	8.768
		7	EXTEXP(20)	0.0
		7	EXTEXP(24)	-10.0
		17	EFFNCY(1-4)	0.0
		17	EFFNCY(5)	0.45
		17	EFFNCY(21-24)	0.9
		18	FRCINV(1-4)	0.0
Case 14				
Interest Rates 3, 6, 6% Respectively	MLGW	3	INTDBT	0.03
	Utility	3	INTDBT	0.06

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APPENDIX A-2 (Page 5)

	<u>Case(s) Change Is Valid For</u>	<u>Card # Changed</u>	<u>Variable Changed</u>	<u>New Value</u>
Case 15 Unlimited Loss Carryforward	Utility & Industrial	4	NCARRY	20
Case 16 FED Tax Rate 24%	Utility & Industrial	2	FITTXR	0.24
Case 17 FED Tax Rate 0%	Utility & Industrial	2	FITTXR	0.0
Case 18 Alternate Utility Method with Different Assumptions	MLGW	5 7 17	INVEST(4) EXTEXP(5) EFFNCY(5)	44.003 0.0 0.9
	Utility	3 5 7 17 18 18 18 18	CNSTLN INVEST(1) EXTEXP(1) EFFNCY(1) FRCINV(1) FRCINV(2) FRCINV(3) FRCINV(4)	149.708 149.708 0.0 0.9 0.0471 0.1883 0.4707 0.2939
Case 19 Accelerated Depreciation (DDB)	Utility	1	LL(1)	2

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APPENDIX A-2 (Page 6)

	<u>Case(s) Change Is Valid For</u>	<u>Card # Changed</u>	<u>Variable Changed</u>	<u>New Value</u>
Case 20				
Service Factor 75%	MLGW	17	EFFNCY(6-24)	0.75
	Utility & Industrial	17	EFFNCY(2-20)	0.75
Case 21				
Service Factor 60%	MLGW	17	EFFNCY(6-24)	0.60
	Utility & Industrial	17	EFFNCY(2-20)	0.60

TXCRFD, FITTXR, STAINC, STAKEV	0.0	0.0	0.0	0.0
PROPIX, INSURE, DBTRC, EQFRAC	0.0185	0.0013	1.0000	0.0
RTNEQY, INTDBT, PROJLF, DPSTRT	0.0	0.0600	24.0000	5.0000
PRPEXP, TOLER, SALVGE, CNSTLN	1.0400	0.0001	0.0	0.0
INTCON, INTTOT	0.0	0.0		
NYRS, NSTRT, NTRIES, NFDPRS	24	5	35	1
NEQMAX, NCARRY, NCFRDT, NCNSTH	1	7	7	4

DEPRECIABLE CAPITAL INVESTMT INPUTTED ON CARD 5 FOR EACH YEAR OF PROJECT LIFE, INVEST(N)

7.047000	28.188000	70.470000	35.235000	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

WORKING CAPITAL INVESTMENT INPUTTED ON CARD 6 FOR EACH YEAR OF PROJECT LIFE, WORKCP(N)

0.625000	0.0	0.0	0.0	7.645000	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OPERATING EXPENSES INPUTTED ON CARD 7 FOR EACH YEAR OF PROJECT LIFE, EXTEXP(N)

0.0	0.0	0.0	0.0	8.768000	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	-10.000000

PLANT ONSTREAM FACTOR INPUTTED ON CARD 17 FOR EACH YEAR OF PROJECT LIFE, EFFNCY(N)

0.0	0.0	0.0	0.0	0.450000	0.900000	0.900000	0.900000
0.900000	0.900000	0.900000	0.900000	0.900000	0.900000	0.900000	0.900000
0.900000	0.900000	0.900000	0.900000	0.900000	0.900000	0.900000	0.900000

EXINIT, EXPCON 0.0 10.9990

PRICES AND BASE PRODUCTION RATES FOR 2 PRODUCTS

4.0000	48.0000
17.6950	0.0361

PRICES AND CONSUMPTION RATES FOR 2 FEEDSTOCKS

26.000000	0.020000
1.019780	380.444000

APPENDIX A-3 (Page 1)

COMPUTER OUTPUT FOR MLGW BASE CASE

OBJECTIVE IS TO CALCULATE PRODUCT PRICE

BREAKDOWN OF TOTAL CAPITAL INVESTMENT

TOTAL DEPRECIABLE INVESTMENT AS INPUTTED	140.94000
CALCULATED INTEREST DURING CONSTRUCTION	0.0
TOTAL DEPRECIABLE INVESTMENT	140.94000
TOTAL WORKING CAPITAL AS INPUTTED	8.27000
TOTAL CALCULATED CAPITAL INVESTMENT	149.21000

TOTAL DEPRECIATION FOR TAX PURPOSES	140.94000
SALVAGE VALUE AT END OF PROJECT	0.0
TOTAL	140.94000

CALCULATED ANNUAL DEPRECIATION ALLOWANCES

BY STL METHOD

0.0	0.0	0.0	0.0	7.047000	7.047000	7.047000	7.047000
7.047000	7.047000	7.047000	7.047000	7.047000	7.047000	7.047000	7.047000
7.047000	7.047000	7.047000	7.047000	7.047000	7.047000	7.047000	7.047000

SUM OF DEPRECIATION ALLOWANCES	140.94000
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CALCULATION OF INTEREST DURING CONSTRUCTION

COMPOUND INVESTMENT FACTOR CMPDFC	0.0
TOTAL INTEREST DURING CONSTR INTDC	0.0

	1	2	3	4	5	6	7	8	9	10	11
	CPSTRT	EFFNCY	INCOME	PLTEXP	STLTAX	TXCRDT	FEDTAX	CASHFL	TOTRTN	AMORTZ	CAPEND
1	7.6720	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4603	-0.4603	8.1323
2	36.3203	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1792	-2.1792	38.4995
3	108.9695	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5382	-6.5382	115.5077
4	150.7427	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0446	-9.0446	159.7873
5	167.4323	0.4500	30.7391	35.7666	2.6074	0.0	0.0	-7.6349	10.0459	-17.6808	185.1131
6	185.1131	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	11.1068	4.9420	180.1710
7	180.1710	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	10.8103	5.2386	174.9325
8	174.9325	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	10.4959	5.5529	169.3796
9	169.3796	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	10.1628	5.8860	163.4936
10	163.4936	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	9.8096	6.2392	157.2544
11	157.2544	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	9.4353	6.6136	150.6408
12	150.6408	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	9.0384	7.0104	143.6304
13	143.6304	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	8.6178	7.4310	136.1994
14	136.1994	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	8.1720	7.8769	128.3226
15	128.3226	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	7.6994	8.3495	119.9731
16	119.9731	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	7.1984	8.8504	111.1227
17	111.1227	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	6.6674	9.3815	101.7412
18	101.7412	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	6.1045	9.9443	91.7969
19	91.7969	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	5.5078	10.5410	81.2559
20	81.2559	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	4.8754	11.1735	70.0824
21	70.0824	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	4.2049	11.8439	58.2385
22	58.2385	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	3.4943	12.5545	45.6840
23	45.6840	0.9000	61.4782	42.8220	2.6074	0.0	0.0	16.0488	2.7410	13.3078	32.3762
24	32.3762	0.9000	61.4782	32.8220	2.6074	0.0	0.0	26.0488	1.9426	24.1062	8.2700

THE LAST ENTRY IN THE FINAL YEAR SHOULD BE EQUAL TO THE WORKING CAPITAL INVESTMENT PLUS SALVAGE VALUE

WORKING CAPITAL RECOVERED INTACT AT END OF PROJECT LIFE =	8.27000
SALVAGE VALUE RECOVERED INTACT AT END OF PROJECT LIFE =	0.0
TOTAL	8.27000

KEY TO CALCULATIONS IS AS FOLLOWS.

COLUMN 1 = CAPITAL INVESTMENT OUTSTANDING AT START OF YEAR INCLUDING WORKING CAPITAL
 COLUMN 2 = ONSTREAM EFFICIENCY (PLANT OPERATING FACTOR)
 COLUMN 3 = GROSS INCOME FROM SALES
 COLUMN 4 = OPERATING EXPENSES EXCLUDING TAXES
 COLUMN 5 = STATE AND LOCAL TAXES
 COLUMN 6 = FEDERAL INVESTMENT TAX CREDIT
 COLUMN 7 = NET FEDERAL INCOME TAX PAID
 COLUMN 8 = CASH FLOW AFTER TAXES
 COLUMN 9 = INTEREST ON DEBT AND RETURN ON EQUITY BASED ON COLUMN 1
 COLUMN 10 = REDUCTION OF OUTSTANDING CAPITAL INVESTMENT. COLUMN 8-9
 COLUMN 11 = OUTSTANDING CAPITAL INVESTMENT AT END OF YEAR INCL WORKING CAPITAL. COL 1-10
 COLUMN 11 PLUS NEW INVESTMENT = NEXT ENTRY OF COLUMN 1

	1	2	3	4	5	6	7	8	9	10	11
	INVEST	CPSTRT	DEPREC	INTRST	TXCRDT	TAXABL	FEDTAX	STXABL	EQYRTN	PROPTY	FEDTXN
1	7.0470	7.6720	0.0	0.4603	0.0	-0.4603	0.0	-0.4603	0.0	0.0	0.0
2	28.1880	36.3203	0.0	2.1792	0.0	-2.1792	0.0	-2.1792	0.0	0.0	0.0
3	70.4700	108.9695	0.0	6.5382	0.0	-6.5382	0.0	-6.5382	0.0	0.0	0.0
4	35.2350	150.7427	0.0	9.0446	0.0	-9.0446	0.0	-9.0446	0.0	0.0	0.0
5	0.0	167.4323	7.0470	10.0459	0.0	-24.7278	0.0	-22.1204	0.0	2.6074	0.0
6	0.0	185.1131	7.0470	11.1068	0.0	-2.1050	0.0	0.5024	0.0	2.6074	0.0
7	0.0	180.1710	7.0470	10.8103	0.0	-1.8084	0.0	0.7989	0.0	2.6074	0.0
8	0.0	174.9325	7.0470	10.4959	0.0	-1.4941	0.0	1.1133	0.0	2.6074	0.0
9	0.0	169.3796	7.0470	10.1628	0.0	-1.1610	0.0	1.4464	0.0	2.6074	0.0
10	0.0	163.4936	7.0470	9.8096	0.0	-0.8078	0.0	1.7996	0.0	2.6074	0.0
11	0.0	157.2544	7.0470	9.4353	0.0	-0.4334	0.0	2.1739	0.0	2.6074	0.0
12	0.0	150.6408	7.0470	9.0384	0.0	-0.0366	0.0	2.5708	0.0	2.6074	0.0
13	0.0	143.6304	7.0470	8.6178	0.0	0.3840	0.0	2.9914	0.0	2.6074	0.0
14	0.0	136.1994	7.0470	8.1720	0.0	0.8299	0.0	3.4372	0.0	2.6074	0.0
15	0.0	128.3226	7.0470	7.6994	0.0	1.3025	0.0	3.9099	0.0	2.6074	0.0
16	0.0	119.9731	7.0470	7.1984	0.0	1.8034	0.0	4.4108	0.0	2.6074	0.0
17	0.0	111.1227	7.0470	6.6674	0.0	2.3345	0.0	4.9418	0.0	2.6074	0.0
18	0.0	101.7412	7.0470	6.1045	0.0	2.8973	0.0	5.5047	0.0	2.6074	0.0
19	0.0	91.7969	7.0470	5.5078	0.0	3.4940	0.0	6.1014	0.0	2.6074	0.0
20	0.0	81.2559	7.0470	4.8754	0.0	4.1265	0.0	6.7339	0.0	2.6074	0.0
21	0.0	70.0824	7.0470	4.2049	0.0	4.7969	0.0	7.4043	0.0	2.6074	0.0
22	0.0	58.2385	7.0470	3.4943	0.0	5.5075	0.0	8.1149	0.0	2.6074	0.0
23	0.0	45.6840	7.0470	2.7410	0.0	6.2608	0.0	8.8682	0.0	2.6074	0.0
24	0.0	32.3762	7.0470	1.9426	0.0	17.0592	0.0	19.6666	0.0	2.6074	0.0

KEY TO CALCULATIONS IS AS FOLLOWS.

COLUMN 1 = NEW INVESTMENT MADE AT START OF YEAR
 COLUMN 2 = TOTAL CAPITAL AT START OF YEAR
 COLUMN 3 = DEPRECIATION ALLOWANCE FOR TAXES
 COLUMN 4 = INTEREST ON DEBT
 COLUMN 5 = INVESTMENT TAX CREDIT TAKEN THIS YR
 COLUMN 6 = FEDERAL TAXABLE INCOME
 COLUMN 7 = FEDERAL INCOME TAX PAID
 COLUMN 8 = STATE TAXABLE INCOME
 COLUMN 9 = AFTER-TAX RETURN ON EQUITY
 COLUMN 10 = LOCAL PROPERTY TAX PAID
 COLUMN 11 = CALCULATED FEDERAL INCOME TAX PRIOR TO NONNEGATIVITY CONSTRAINT

OBJECTIVE IS TO CALCULATE PRODUCT PRICE

BREAKDOWN OF TOTAL CAPITAL INVESTMENT

TOTAL DEPRECIABLE INVESTMENT AS INPUTTED	140.94000
CALCULATED INTEREST DURING CONSTRUCTION	27.64325
TOTAL DEPRECIABLE INVESTMENT	168.58325
TOTAL WORKING CAPITAL AS INPUTTED	8.27000
TOTAL CALCULATED CAPITAL INVESTMENT	176.85325

TOTAL DEPRECIATION FOR TAX PURPOSES	168.58325
SALVAGE VALUE AT END OF PROJECT	0.0
TOTAL	168.58325

CALCULATED ANNUAL DEPRECIATION ALLOWANCES

BY STL METHOD

8.429163	8.429163	8.429163
8.429163	8.429163	8.429163
8.429163	8.429163	8.429163

8.429163	8.429163
8.429163	8.429163
8.429163	

8.429163
8.429163

8.429163
8.429163

8.429163
8.429163

SUM OF DEPRECIATION ALLOWANCES

168.58325

CALCULATION OF INTEREST DURING CONSTRUCTION

COMPOUND INVESTMENT FACTOR CMPDFC	1.19613
TOTAL INTEREST DURING CONSTR INTDC	27.64325

	1	2	3	4	5	6	7	8	9	10	11
	CPSTRT	EFFNCY	INCOME	PLTEXP	STLTAX	TXCRDT	FEDTAX	CASHFL	TOTRTN	AMORTZ	CAPEND
1	176.8533	0.4500	36.4439	36.9998	2.9426	0.0	0.0	-3.4985	17.2432	-20.7417	197.5950
2	197.5950	0.9000	72.8878	44.0552	3.7013	0.0	0.0	25.1313	19.2655	5.8658	191.7292
3	191.7292	0.9000	72.8878	44.0552	3.7131	0.0	0.0	25.1194	18.6936	6.4258	185.3034
4	185.3034	0.9000	72.8878	44.0552	3.7262	0.0	0.0	25.1064	18.0671	7.0393	178.2640
5	178.2640	0.9000	72.8878	44.0552	3.7404	0.0	0.0	25.0922	17.3807	7.7114	170.5526
6	170.5526	0.9000	72.8878	44.0552	3.7560	0.0	0.0	25.0765	16.6289	8.4477	162.1049
7	162.1049	0.9000	72.8878	44.0552	3.7731	0.6889	0.6889	24.3705	15.8052	8.5653	153.5396
8	153.5396	0.9000	72.8878	44.0552	3.7905	1.4998	1.4998	23.5423	14.9701	8.5722	144.9674
9	144.9674	0.9000	72.8878	44.0552	3.8078	0.0	3.2689	21.7558	14.1343	7.6215	137.3459
10	137.3459	0.9000	72.8878	44.0552	3.8233	0.0	3.5085	21.5008	13.3912	8.1096	129.2363
11	129.2363	0.9000	72.8878	44.0552	3.8397	0.0	3.7633	21.2296	12.6005	8.6290	120.6073
12	120.6073	0.9000	72.8878	44.0552	3.8572	0.0	4.0345	20.9409	11.7592	9.1817	111.4256
13	111.4256	0.9000	72.8878	44.0552	3.8758	0.0	4.3231	20.6337	10.8640	9.7697	101.6559
14	101.6559	0.9000	72.8878	44.0552	3.8955	0.0	4.6301	20.3069	9.9114	10.3955	91.2604
15	91.2604	0.9000	72.8878	44.0552	3.9166	0.0	4.9568	19.9591	8.8979	11.0613	80.1991
16	80.1991	0.9000	72.8878	44.0552	3.9390	0.0	5.3045	19.5891	7.8194	11.7697	68.4294
17	68.4294	0.9000	72.8878	44.0552	3.9628	0.0	5.6744	19.1954	6.6719	12.5235	55.9059
18	55.9059	0.9000	72.8878	44.0552	3.9882	0.0	6.0680	18.7764	5.4508	13.3256	42.5803
19	42.5803	0.9000	72.8878	44.0552	4.0152	0.0	6.4868	18.3307	4.1516	14.1791	28.4013
20	28.4013	0.9000	72.8878	34.0552	4.3439	0.0	11.5884	22.9003	2.7691	20.1312	8.2701

THE LAST ENTRY IN THE FINAL YEAR SHOULD BE EQUAL TO THE WORKING CAPITAL INVESTMENT PLUS SALVAGE VALUE

WORKING CAPITAL RECOVERED INTACT AT END OF PROJECT LIFE =	8.27000
SALVAGE VALUE RECOVERED INTACT AT END OF PROJECT LIFE =	0.0
TOTAL	8.27000

KEY TO CALCULATIONS IS AS FOLLOWS.

COLUMN 1 = CAPITAL INVESTMENT OUTSTANDING AT START OF YEAR INCLUDING WORKING CAPITAL
 COLUMN 2 = ONSTREAM EFFICIENCY (PLANT OPERATING FACTOR)
 COLUMN 3 = GROSS INCOME FROM SALES
 COLUMN 4 = OPERATING EXPENSES EXCLUDING TAXES
 COLUMN 5 = STATE AND LOCAL TAXES
 COLUMN 6 = FEDERAL INVESTMENT TAX CREDIT
 COLUMN 7 = NET FEDERAL INCOME TAX PAID
 COLUMN 8 = CASH FLOW AFTER TAXES
 COLUMN 9 = INTEREST ON DEBT AND RETURN ON EQUITY BASED ON COLUMN 1
 COLUMN 10 = REDUCTION OF OUTSTANDING CAPITAL INVESTMENT. COLUMN 8-9
 COLUMN 11 = OUTSTANDING CAPITAL INVESTMENT AT END OF YEAR INCL WORKING CAPITAL. COL 1-10

COLUMN 11 PLUS NEW INVESTMENT = NEXT ENTRY OF COLUMN 1

	1	2	3	4	5	6	7	8	9	10	11
	INVEST	CPSTRT	DEPREC	INTRST	TXCHDT	TAXABL	FEDTAX	STXABL	EQYRTN	PROPTY	FEDTXN
1	140.9400	176.8533	8.4292	11.9376	0.0	-23.8653	0.0	-20.9227	5.3056	2.3960	-11.4553
2	0.0	197.5950	8.4292	13.3377	0.0	3.3645	0.0	7.0658	5.9278	2.3960	1.6150
3	0.0	191.7292	8.4292	12.9417	0.0	3.7485	0.0	7.4617	5.7519	2.3960	1.7993
4	0.0	185.3034	8.4292	12.5080	0.0	4.1693	0.0	7.8954	5.5591	2.3960	2.0013
5	0.0	178.2640	8.4292	12.0328	0.0	4.6302	0.0	8.3706	5.3479	2.3960	2.2225
6	0.0	170.5526	8.4292	11.5123	0.0	5.1351	0.0	8.8911	5.1166	2.3960	2.4648
7	0.0	162.1049	8.4292	10.9421	0.6889	5.6882	0.6889	9.4613	4.8631	2.3960	2.7303
8	0.0	153.5396	8.4292	10.3639	1.4998	6.2490	1.4998	10.0395	4.6062	2.3960	2.9995
9	0.0	144.9674	8.4292	9.7853	0.0	6.8103	3.2689	10.6181	4.3490	2.3960	3.2689
10	0.0	137.3459	8.4292	9.2708	0.0	7.3093	3.5085	11.1326	4.1204	2.3960	3.5085
11	0.0	129.2363	8.4292	8.7234	0.0	7.8403	3.7633	11.6800	3.8771	2.3960	3.7633
12	0.0	120.6073	8.4292	8.1410	0.0	8.4053	4.0345	12.2624	3.6182	2.3960	4.0345
13	0.0	111.4256	8.4292	7.5212	0.0	9.0064	4.3231	12.8822	3.3428	2.3960	4.3231
14	0.0	101.6559	8.4292	6.8618	0.0	9.6461	4.6301	13.5416	3.0497	2.3960	4.6301
15	0.0	91.2604	8.4292	6.1601	0.0	10.3267	4.9568	14.2433	2.7378	2.3960	4.9568
16	0.0	80.1991	8.4292	5.4134	0.0	11.0510	5.3045	14.9900	2.4060	2.3960	5.3045
17	0.0	68.4294	8.4292	4.6190	0.0	11.8216	5.6744	15.7844	2.0529	2.3960	5.6744
18	0.0	55.9059	8.4292	3.7737	0.0	12.6416	6.0680	16.6298	1.6772	2.3960	6.0680
19	0.0	42.5803	8.4292	2.8742	0.0	13.5141	6.4868	17.5292	1.2774	2.3960	6.4868
20	0.0	28.4013	8.4292	1.9171	0.0	24.1424	11.5884	28.4863	0.8520	2.3960	11.5884

KEY TO CALCULATIONS IS AS FOLLOWS.

COLUMN 1 = NEW INVESTMENT MADE AT START OF YEAR
 COLUMN 2 = TOTAL CAPITAL AT START OF YEAR
 COLUMN 3 = DEPRECIATION ALLOWANCE FOR TAXES
 COLUMN 4 = INTEREST ON DEBT
 COLUMN 5 = INVESTMENT TAX CREDIT TAKEN THIS YR
 COLUMN 6 = FEDERAL TAXABLE INCOME
 COLUMN 7 = FEDERAL INCOME TAX PAID
 COLUMN 8 = STATE TAXABLE INCOME
 COLUMN 9 = AFTER-TAX RETURN ON EQUITY
 COLUMN 10 = LOCAL PROPERTY TAX PAID
 COLUMN 11 = CALCULATED FEDERAL INCOME TAX PRIOR TO NONNEGATIVITY CONSTRAINT

PROPTX,INSURE,DTFRAC,EGFRAC	0.1000	0.4800	0.0300	0.0150
RTNEQY,INTDHT,PROJLF,DPSTRT	0.0170	0.0100	0.0	1.0000
PHPEXP,TOLER,SALVGE,CNSTLN	0.1200	0.0900	20.0000	1.0000
INTCON,INTTOT	1.0400	0.0001	0.0	140.9400
NYRS,NSTRT,NTRIES,NFDPHS	0.0900	0.0		
NEQMAX,NCARRY,NCRFDT,NCNSTR	20	1	35	1
	1	7	7	4

DEPRECIABLE CAPITAL INVESTMT INPUTTED ON CARD 5 FOR EACH YEAR OF PROJECT LIFE, INVEST(N)

140.940000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0				

WORKING CAPITAL INVESTMENT INPUTTED ON CARD 6 FOR EACH YEAR OF PROJECT LIFE, WORKCP(N)

8.270000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0				

OPERATING EXPENSES INPUTTED ON CARD 7 FOR EACH YEAR OF PROJECT LIFE, EXTEXP(N)

8.768000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	-10.000000				

PLANT ONSTREAM FACTOR INPUTTED ON CARD 17 FOR EACH YEAR OF PROJECT LIFE, EFFNCY(N)

0.450000	0.900000	0.900000	0.900000	0.900000	0.900000	0.900000	0.900000
0.900000	0.900000	0.900000	0.900000	0.900000	0.900000	0.900000	0.900000
0.900000	0.900000	0.900000	0.900000				

EXINIT, EXPCON 0.0 10.9990

PRICES AND BASE PRODUCTION RATES FOR 2 PRODUCTS

4.0000	48.0000
17.6950	0.0361

PRICES AND CONSUMPTION RATES FOR 2 FEEDSTOCKS

26.000000	0.020000
1.019780	380.444000

APPENDIX A-5 (Page 1)

COMPUTER OUTPUT FOR INDUSTRIAL BASE CASE

THE 10 TO CALCULATE PRODUCT PRICE

BREAKDOWN OF TOTAL CAPITAL INVESTMENT

TOTAL DEPRECIABLE INVESTMENT AS INPUTTED	140.94000
CALCULATED INTEREST DURING CONSTRUCTION	27.64325
TOTAL DEPRECIABLE INVESTMENT	168.58325
TOTAL WORKING CAPITAL AS INPUTTED	8.27000
TOTAL CALCULATED CAPITAL INVESTMENT	176.85325

TOTAL DEPRECIATION FOR TAX PURPOSES	168.58325
SALVAGE VALUE AT END OF PROJECT	0.0
TOTAL	168.58325

CALCULATED ANNUAL DEPRECIATION ALLOWANCES

BY DOB METHOD

22.477767	19.480731	16.883300	14.632194	12.681234	10.990403	9.525016	8.255014
7.665370	7.665370	7.665370	7.665370	7.665370	7.665370	7.665370	0.0
0.0	0.0	0.0	0.0				

SUM OF DEPRECIATION ALLOWANCES	168.58325
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CALCULATION OF INTEREST DURING CONSTRUCTION

COMPOUND INVESTMENT FACTOR CMPDFC	1.19613
TOTAL INTEREST DURING CONSTR INTDC	27.64325

	1	2	3	4	5	6	7	8	9	10	11
	CPSTRT	EFFNCY	INCOME	PLTEXP	STLTAX	TXCRDT	FEDTAX	CASHFL	TOTRTN	AMORTZ	CAPEND
1	176.8533	0.4500	42.2481	36.9998	3.0297	0.0	0.0	2.2186	21.2224	-19.0038	195.8571
2	195.8571	0.9000	84.4962	44.0552	4.2922	0.0	0.0	36.1487	23.5029	12.6458	183.2113
3	183.2113	0.9000	84.4962	44.0552	4.3702	3.7431	3.7431	32.3277	21.9854	10.3423	172.8689
4	172.8689	0.9000	84.4962	44.0552	4.4377	5.1290	5.1290	30.8742	20.7443	10.1299	162.7390
5	162.7390	0.9000	84.4962	44.0552	4.4962	5.2219	5.9446	30.0001	19.5287	10.4714	152.2676
6	152.2676	0.9000	84.4962	44.0552	4.5469	0.0	11.9537	23.9403	18.2721	5.6681	146.5995
7	146.5995	0.9000	84.4962	44.0552	4.5909	0.0	12.6360	23.2140	17.5919	5.6221	140.9774
8	140.9774	0.9000	84.4962	44.0552	4.6290	0.0	13.2273	22.5846	16.9173	5.6673	135.3101
9	135.3101	0.9000	84.4962	44.0552	4.6467	0.0	13.5018	22.2924	16.2372	6.0552	129.2549
10	129.2549	0.9000	84.4962	44.0552	4.6467	0.0	13.5018	22.2924	15.5106	6.7818	122.4731
11	122.4731	0.9000	84.4962	44.0552	4.6467	0.0	13.5018	22.2924	14.6968	7.5956	114.8775
12	114.8775	0.9000	84.4962	44.0552	4.6467	0.0	13.5018	22.2924	13.7853	8.5071	106.3704
13	106.3704	0.9000	84.4962	44.0552	4.6467	0.0	13.5018	22.2924	12.7645	9.5279	96.8425
14	96.8425	0.9000	84.4962	44.0552	4.6467	0.0	13.5018	22.2924	11.6211	10.6713	86.1712
15	86.1712	0.9000	84.4962	44.0552	4.6467	0.0	13.5018	22.2924	10.3405	11.9518	74.2194
16	74.2194	0.9000	84.4962	44.0552	4.8766	0.0	17.0708	18.4934	8.9063	9.5871	64.6323
17	64.6323	0.9000	84.4962	44.0552	4.8766	0.0	17.0708	18.4934	7.7559	10.7375	53.8948
18	53.8948	0.9000	84.4962	44.0552	4.8766	0.0	17.0708	18.4934	6.4674	12.0260	41.8688
19	41.8688	0.9000	84.4962	44.0552	4.8766	0.0	17.0708	18.4934	5.0243	13.4692	28.3996
20	28.3996	0.9000	84.4962	34.0552	5.1766	0.0	21.7268	23.5374	3.4080	20.1295	8.2701

THE LAST ENTRY IN THE FINAL YEAR SHOULD BE EQUAL TO THE WORKING CAPITAL INVESTMENT PLUS SALVAGE VALUE

WORKING CAPITAL RECOVERED INTACT AT END OF PROJECT LIFE =	8.27000
SALVAGE VALUE RECOVERED INTACT AT END OF PROJECT LIFE =	0.0
TOTAL	8.27000

KEY TO CALCULATIONS IS AS FOLLOWS.

COLUMN 1 = CAPITAL INVESTMENT OUTSTANDING AT START OF YEAR INCLUDING WORKING CAPITAL
COLUMN 2 = ONSTREAM EFFICIENCY (PLANT OPERATING FACTOR)
COLUMN 3 = GROSS INCOME FROM SALES
COLUMN 4 = OPERATING EXPENSES EXCLUDING TAXES
COLUMN 5 = STATE AND LOCAL TAXES
COLUMN 6 = FEDERAL INVESTMENT TAX CREDIT
COLUMN 7 = NET FEDERAL INCOME TAX PAID
COLUMN 8 = CASH FLOW AFTER TAXES
COLUMN 9 = INTEREST ON DEBT AND RETURN ON EQUITY BASED ON COLUMN 1
COLUMN 10 = REDUCTION OF OUTSTANDING CAPITAL INVESTMENT, COLUMN 8-9
COLUMN 11 = OUTSTANDING CAPITAL INVESTMENT AT END OF YEAR INCL WORKING CAPITAL. COL 1-10

COLUMN 11 PLUS NEW INVESTMENT = NEXT ENTRY OF COLUMN 1

	3	4	5	6	7	8	9	10	11		
	INVEST	CPSTRT	DEPREC	INTRST	TXCRDT	TAXABL	FEDTAX	STXARL	EQYRTN	PROPTY	FEDTXN
1	140.9400	176.8533	22.4778	0.0	0.0	-20.2592	0.0	-17.2295	21.2224	2.3960	-9.7244
2	0.0	195.8571	19.4807	0.0	0.0	16.6680	0.0	20.9602	23.5029	2.3960	8.0006
3	0.0	183.2113	16.8833	0.0	3.7431	19.1875	3.7431	23.5576	21.9854	2.3960	9.2100
4	0.0	172.8689	14.6322	0.0	5.1290	21.3710	5.1290	25.8087	20.7443	2.3960	10.2581
5	0.0	162.7390	12.6812	0.0	5.2219	23.2635	5.9446	27.7597	19.5287	2.3960	11.1665
6	0.0	152.2676	10.9904	0.0	0.0	24.9036	11.9537	29.4505	18.2721	2.3960	11.9537
7	0.0	146.5995	9.5250	0.0	0.0	26.3250	12.6360	30.9159	17.5919	2.3960	12.6360
8	0.0	140.9774	8.2550	0.0	0.0	27.5569	13.2273	32.1859	16.9173	2.3960	13.2273
9	0.0	135.3101	7.6654	0.0	0.0	28.1289	13.5018	32.7755	16.2372	2.3960	13.5018
10	0.0	129.2549	7.6654	0.0	0.0	28.1289	13.5018	32.7755	15.5106	2.3960	13.5018
11	0.0	122.4731	7.6654	0.0	0.0	28.1289	13.5018	32.7755	14.6968	2.3960	13.5018
12	0.0	114.6775	7.6654	0.0	0.0	28.1289	13.5018	32.7755	13.7853	2.3960	13.5018
13	0.0	106.3704	7.6654	0.0	0.0	28.1289	13.5018	32.7755	12.7645	2.3960	13.5018
14	0.0	96.8425	7.6654	0.0	0.0	28.1289	13.5018	32.7755	11.6211	2.3960	13.5018
15	0.0	86.1712	7.6654	0.0	0.0	28.1289	13.5018	32.7755	10.3405	2.3960	13.5018
16	0.0	74.2194	0.0	0.0	0.0	35.5643	17.0708	40.4409	8.9063	2.3960	17.0708
17	0.0	64.6323	0.0	0.0	0.0	35.5643	17.0708	40.4409	7.7559	2.3960	17.0708
18	0.0	53.8948	0.0	0.0	0.0	35.5643	17.0708	40.4409	6.4674	2.3960	17.0708
19	0.0	41.8688	0.0	0.0	0.0	35.5643	17.0708	40.4409	5.0243	2.3960	17.0708
20	0.0	28.3996	0.0	0.0	0.0	45.2643	21.7268	50.4409	3.4080	2.3960	21.7268

KEY TO CALCULATIONS IS AS FOLLOWS.

COLUMN 1 = NEW INVESTMENT MADE AT START OF YEAR
 COLUMN 2 = TOTAL CAPITAL AT START OF YEAR
 COLUMN 3 = DEPRECIATION ALLOWANCE FOR TAXES
 COLUMN 4 = INTEREST ON DEBT
 COLUMN 5 = INVESTMENT TAX CREDIT TAKEN THIS YR
 COLUMN 6 = FEDERAL TAXABLE INCOME
 COLUMN 7 = FEDERAL INCOME TAX PAID
 COLUMN 8 = STATE TAXABLE INCOME
 COLUMN 9 = AFTER-TAX RETURN ON EQUITY
 COLUMN 10 = LOCAL PROPERTY TAX PAID
 COLUMN 11 = CALCULATED FEDERAL INCOME TAX PRIOR TO NONNEGATIVITY CONSTRAINT