Section 6

CAPITAL COST ESTIMATES AND ECONOMIC EVALUATION

BASIS OF EVALUATION

The economic evaluation has been made using the standard EPRI procedure, which employs discounted cash flow (DCF) analysis. The use of a standard procedure facilitates comparison of alternate cases whose costs may be taken from different sources.

A consistent set of criteria for estimating capital requirements and determining cost of the product was supplied by EPRI. These criteria are summarized in Table 6-1 which follows.

Plant investment estimates contain a contingency which is divided into two parts. The first part is a project contingency which is intended to cover additional equipment that would result from a more detailed design of a definitive project at an actual site. The second is a process contingency which is applied to unproven technology in an effort to quantify the uncertainty in the design, performance and cost of the commercial-scale equipment. Historically, as a new technology develops from the conceptual stage to commercial reality, a variety of technical problems emerge which were not considered during the early stages of the development. Solution of these problems generally results in an increase in the cost of the technology due to the need for more expensive materials of construction, more complex equipment specifications, and sometimes the need for additional processing equipment. A total plant process contingency is arrived at by applying a separate contingency to individual process units based on their state of development and accumulating the results.

Table 6-1

ECONOMIC PREMISES FOR FUEL CONVERSION PLANTS
UTILITY-TYPE FINANCING

CAPITAL INVESTMENT BASIS	
Total Plant Investment	Mid-1979 dollars with no escalation Illinois location Clear and level site
Total Plant Investment Definition	The total plant investment is defined as the sum of: • Process Plant Investment • General Facilities Cost • Project Contingency • Process Contingency These items are discussed below:
Process Plant Investment	Total constructed cost of all on-site processing and generating units, including all direct and indirect construction costs and all engineering and home office fees. These costs are broken down by major plant section. All sales taxes (5 percent of total materials) are included.
General Facilities Cost	The capital cost of the general (off-site) facilities is explicitly accounted for in the computation of total plant investment. Off-site facilities include roads, buildings, railroad loading and unloading systems, electrical distribution and substations, cooling-water systems,

Table 6-1 (Continued)

	inert gas systems, instrument air systems, laboratories, effluent water treatment facilities, etc. All sal-. taxes (5 percent of total materials) and home office fees are included.
Project Contingency	This contingency factor is intended to cover additional equipment that would result from a more detailed design of a definitive project at an actual site. Project contingency factors are itemized in Table 6-2.
Process Contingency	This is a capital cost contingency applied to new technology in an effort to quantify the uncertainty in the design and cost of the commercial-scale equipment. Process contingency factors are itemized in Table 6-2.
TOTAL CAPITAL REQUIREMENT	The total capital requirement includes all capital necessary to complete the entire project. These capital costs include the following: • Total Plant Investment • Prepaid Royalties • Preproduction Costs • Inventory Capital (working capital) • Initial Catalyst and Chemical Charge • Allowance for Funds During Construction (AFDC) • Land

Table 6-1 (Continued)

	These items are discussed below:
Prepaid Royalties	0.5 percent of the Process Plant Investment (excluding contingencies).
Preproduction Costs	The preproduction costs are intended to cover operator training, equipment checkout, major changes in plant equipment, extra maintenance, and inefficient use of coal and other materials during plant startup. The preproduction costs are estimated as follows: • One month of fixed operating costs. (These costs consist of operating and maintenance labor, administrative and support labor, and maintenance materials.) • One month of variable operating costs at full capacity excluding coal. (These costs consist of catalysts, chemicals, and other consumables, water, and waste disposal charges.) • 25 percent of full capacity coal cost for one month. (This charge is to cover inefficient operation during the startup period.) • 2 percent of Total Plant Investment. (This charge is to cover expected changes and modifications to equipment that will be needed to bring the plant up to full capacity.)
Inventory Capital	The value of inventories of coal and other consumables is capitalized and included in the inventory capital account. Inventory capital is the sum of the following:

Table 6-1 (Continued)

- Cost of a one-month supply of coal at full capacity operation.
- Cost of a one-month supply of catalysts, chemicals and other consumables (excluding water) based on full capacity operation.
- One-month supply of product inventory whose value is estimated as follows: one month of total operating costs (including feedstock) at full capacity plus 2 percent of total plant investments. (The 2 percent of TPI covers fixed charges associated with producing the product inventory for one month.)

Initial Catalyst and Chemicals Charge

The initial cost of the charge of catalysts or chemicals contained within the process equipment (but not in storage since this cost is covered in the Inventory Capital) is presented in Table 6-3.

Allowance for Funds During Construction (AFDC)

An AFDC charge is computed based on the time period from the center of gravity (cg) of expenditures until the plant is in commercial operation. The interest rate is 8 percent per year. The AFDC is then calculated from the total plant investment (TPI) as shown below:

$$AFDC = [(1.08)^{cg} - 1] (TPI)$$

The center of gravity time period (cg) is to be estimated by the contractor. The AFDC can also be computed from an estimate of the construction period cash flow.

Since the AFDC charge is to be expressed in the same year dollars as the total

Table 6-1 (Continued)

plant investment, cost escalation (inflation) is not included.

Land

Land costs are taken at $5000/acre.

CAPACITY FACTOR

For EPRI evaluation purposes the plant design is to be based on a 90 percent Capacity Factor (CF). The capacity factor, which is also known as a stream factor, is defined as:

$$CF = \frac{\text{Actual output (per year)}}{\text{Output at full capacity (per year)}}$$

The capacity factor is assumed to be constant over the life of the plant.

OPERATING COST BASIS

The operating costs are to be estimated on a first-year basis. The costs will also be presented on a 30-year levelized basis (details are given in the following section).

The operating costs are divided into fixed and variable costs. The fixed costs are essentially independent of capacity factor. The variable costs are directly proportional to the amount of product produced.

Fixed Operating Costs

Fixed operating costs include the following:

- Operating Labor
- Maintenance Costs (may also have a variable component)
- Overhead Charges

Table 6-1 (Continued)

These items are discussed below.

Operating Labor

Fluor has estimated the number of operating jobs (OJ) that are required to operate the plant. The operating labor charges (OLC) are then computed using the average labor rate (ALR) as follows:

$$OLC = (OJ) \times (ALR) \times (8760\ hr/yr)$$

The average labor rate is $12.50 per person hour. (This labor rate is based on a direct labor charge of $9.25 per hour plus a 35 percent payroll burden.)

Maintenance Costs

Annual maintenance costs for new technologies are often estimated as a percentage of the installed capital cost of the facilities. The percentage varies widely depending on the nature of the processing conditions and the type of design. Maintenance costs selected for use in this study are as follows:

Section	Maintenance % of Installed Plant Section Cost/yr
01	3.0
11	2.0
21	4.5
31	2.5
32	2.5
41	3.0
51	2.5
61	1.5
71	2.0
81	1.5
91	1.0

Table 6-1 (Continued)

	The maintenance costs are separately expressed as maintenance labor and maintenance materials. A maintenance labor/materials ratio of 40:60 is used for this breakdown if other information is not available.
Overhead Charges	The overhead charges include the following two items: • Administrative and Support Labor, estimated as 30 percent of operating and maintenance labor (including burden) • General and Administrative Expenses estimated as 60 percent of operating and maintenance labor (including burden)
VARIABLE OPERATING COSTS	The variable operating costs are dependent upon the plant capacity factor and are composed of the following charges: • Coal Cost • Raw Water • Consumable Catalysts and Chemicals • Ash Disposal These items are discussed below:
Coal Cost	The first-year coal cost is $\$1.00/10^6$ Btu (HHV) for Illinois coal.
Raw Water	The first-year raw water acquisition cost is 40¢/1000 gallons. Intake structures, treating costs and pumping costs are to be included in the process capital and operating and maintenance charges.

Table 6-1 (Continued)

Consumable Catalysts and Chemicals	The first-year catalyst, chemicals and other consumable costs are based on pricing data from vendors.
Ash Disposal	The first-year ash disposal charge is $4.00/ton.
BY-PRODUCT CREDITS	Sulfur — No credit
LEVELIZED OPERATING COSTS	Inflation will tend to increase the operating costs (in current dollars) over the life of the plant. In EPRI analysis, a long-term inflation rate of 6 percent per year is assumed in estimating the cost of capital (discussed in a following section) and in estimating the life cycle revenue requirements for other expenses. To represent these varying revenue requirements for fixed and variable costs (including feedstock), a single "levelized" value is computed using the "present-worth" concept of money. Based on the following assumptions: Inflation rate = 6%/yr Discount rate = 10%/yr The 30-year levelization factor (LF) for operating and maintenance (O&M) costs, (excluding feedstock) is 1.886. 30-year levelized O&M = 1.836 x (First year O&M) The 30-year LF for feedstock is 1.932.

Table 6-1 (Continued)

COST OF CAPITAL

The cost of capital is based on an assumed 6 percent per year inflation rate and the following assumptions:

Debt/Equity Ratio	50/50
Debt Cost	8%/yr
Preferred Stock Ratio	15%
Preferred Stock Cost	8.5%/yr
Common Stock Ratio	35%
Common Stock Cost	13.5%/yr
Weighted Cost of Capital	10%/yr
Federal and State Income Tax Rate	50%
Property Taxes and Insurance	2%/yr
Investment Tax Credit	0
Book Life	30 yr
Tax Life	20 yr
Iowa Type S_1 Retirement Dispersion	

The 30-year levelized fixed charge rate (LFCR) calculated from the above assumptions is 18 percent per year.

Levelized Fixed Charges (30-year plant)

The levelized fixed charges (LFC) are based on the total capital requirement (TCR) and are computed as follows:

$$LFC = (LFCR) \times (TCR)$$

Where

$$LCFR = 0.18$$

Levelized Fixed Charges (interim replacements)

If major portions of the plant have a short life (5 to 10 years), and would have to be capitalized as interim replacements, a fixed charge rate consistent with the shorter life must be applied to these capital items.

Table 6-1 (Continued)

PRODUCT COST

The product cost is presented in two forms:

- a 30-year levelized value, and
- a first-year value that increases 6 percent per year over the life of the project. The present value of the lifetime product revenues expressed in first-year dollars is identical for both methods of pricing.

30-year Levelized Price

This levelized price is the "present-worth" average product price which is a convenient way of expressing the life-cycle product cost as a single value. The levelized price is used to compare fuel conversion alternatives and it is not intended to represent an actual sales price.

First-year Product Price

A first-year product price that escalates at 6 percent per year (due to inflation) over the life of the plant is also to be calculated. This product price is intended to represent a potential sales price scenario that may represent the type of purchase agreement that would govern the plant product.

The first-year product price (FYP) consistent with the economic premises in this study (6 percent inflation, 10 percent discount rate) is computed as follows:

$$FYP = \frac{LPP}{LF}$$

Where

LPP = 30-year levelized product price
LF = 1.886 = levelization factor

Table 6-2

CONTINGENCY FACTORS ON CAPITAL INVESTMENTS

Unit	Section	Process Contingency, Percent	Project Contingency, Percent
01	Coal Preparation	0	15
11	Air Separation	0	20
21	Coal Gasification	10	30
31	Gas Processing and Cooling		
	COS Hydrolysis	0	20
	Shift Conversion	0	20
32	Acid Gas Removal (Rectisol)	0	20
41	Methanol		
	Methanol Synthesis	0	20
	Methanol Refining	0	20
51	Emissions Control		
	Claus Sulfur	0	20
	Tail Gas Treating	3	20
61	Steam and Power Generation		
	Boiler Plant	0	25
	Turbogenerators	0	25
71	Product Storage and Shipping	0	20
81	Utilities	0	25
91	Off-sites	0	30

Table 6-3

SUMMARY OF CATALYSTS AND CHEMICALS

Unit	Catalyst or Chemical	Initial Charge Amount	Initial Charge Cost, $	Annual Makeup Amount	Annual Makeup Costs, $
21	Waste Water Treating Chemicals				210,000
31	COS Hydrolysis Catalyst	103,000 lb	186,000	34,500	62,000
	Sour Shift Catalyst	480,000 lb	1,672,000	96,000	375,000
32	Methanol Solvent	210,000 gal	105,000	*	
41	Zinc Oxide Sulfur Adsorbent	167,000 lb	184,000	167,000	184,000
	Methanol Synthesis Catalyst		**		4,086,000
51	Activated Alumina	268,000 lb	134,000	50,000	25,000
	Cobalt Moly Catalyst		104,000		30,000
	Stretford Process Chemicals		154,000		100,000
81	Lime	35 ton	1,600	1,600	74,000
	Soda Ash	30 ton	2,400	1,400	112,000
	Sulfuric Acid (93 percent)	100 ton	5,200	2,160	112,000
	Caustic Soda (100 percent)	13 ton	2,200	150	25,000
	Cooling Water Chemicals		15,000		198,000
	Boiler Feedwater Chemicals		11,000		41,000
	Total		2,776,400		5,634,000

*Methanol solvent makeup supplied by methanol product and reflected in overall material balance

**Included in capital cost of Unit 41

PLANT INVESTMENT

The cost estimates presented herein are based upon mid-1979 pricing with no allowance made for escalation beyond that time. Field labor rates and productivities are representative of those to be expected in downstate Illinois. The required skilled labor is assumed to be available from the labor pool from the general area.

The site is assumed to be level and no piling will be required. An arbitrary allowance has been included for site preparation.

Estimating Basis

The costs are broken down in a number of functional sections in the presentation which follows. The cost estimates for these various sections were developed by several different estimating techniques. For several sections individual equipment prices were obtained, either from equipment vendors or from in-house sources, then total prices developed by factoring to selling prices based upon in-house cost correlations. For certain other sections, costs were derived by capacity factoring from similar services contained in prior Fluor studies. In some cases, the prices contained in these prior efforts were obtained from licensors on a total plant basis. A tabulation of the sources for pricing the various sections is presented below:

Unit	Description	Estimating Basis
01	Coal Preparation	Total unit price obtained by factoring from previous EPRI studies involving the receiving and handling of coal intended as feed to a Texaco unit.
11	Air Separation	Prices from study work done on Research Project 411-4, adjusted for use of steam turbine compressor drives in lieu of gas turbines.
21	Coal Gasification	Costs derived from previous EPRI studies in coal gasification as adjusted for operating pressures. Costs for superheating-type waste heat boilers developed from preliminary information furnished by equipment suppliers on a previous EPRI project.

Unit	Description	Estimating Basis
31	Gas Processing and Cooling	Prices for all major equipment obtained primarily from in-house sources and from equipment suppliers in a few instances.
32	Acid Gas Removal	Selling price for the Rectisol unit obtained from Linde AG through Lotepro, their U.S. affiliate. Fluor estimated the cost of the refrigeration unit from a previous study.
41	Methanol	Prices for all major equipment obtained primarily from in-house sources and from equipment suppliers in a few instances.
51	Claus Sulfur	Price for this unit factored from previous Fluor studies.
52	Tail Gas Treating	Price for this unit factored from previous Fluor studies.
61	Boiler Plant	Price based upon telephone quotation from equipment supplier.
61	Turbogenerator	Price for turbogenerators was developed by Fluor with assistance from vendors.
71	Product Storage and Shipping	Prices for tankage developed from previous Fluor studies and from in-house cost correlations.
81	Utilities	Prices for the various utility systems factored from prior Fluor work.
91	Off-sites	Costs were developed from previous Fluor projects.

Capital Cost Presentation

Tables 6-4 and 6-5 present the plant investment for the facility, broken down by section. Also included are the various cost categories of direct field material (DFM), direct field labor (DFL), and sales tax. The sum of DFM and DFL constitutes direct field costs (DFC). At EPRI's request, all subcontracts have been divided into DFM and DFL accounts on the basis of 75:25 materials to labor. The column identified as engineering and support costs represents the sum of indirect field costs, contractor's home office costs, and contractor's fee.

The costs are presented both on a site specific and a U.S. Gulf Coast basis.

Project and process contingencies, both as defined in the first subheading of this section, are also presented in this section.

Table 6-4

COAL TO METHANOL
MID-1979
Illinois Location

Plant Section	Cost Breakdown Without Contingencies, $1000						Contingencies		Total Plant Investment
	Direct Field Material	Direct Field Labor	Engineering and Support	By Others	Sales Tax	Total Cost	Process	Project	
Coal Preparation	8,682	3,494	6,535		448	19,159	-	2,874	22,033
Air Separation	58,174	13,497	33,955	107,929	2,771	216,326	-	43,265	259,591
Coal Gasification	114,396	35,677	71,118		5,780	226,971	22,697	68,091	317,759
Gas Processing and Cooling	14,922	8,333	13,915		708	37,878		7,576	45,454
Acid Gas Removal	12,644	5,318	13,593	74,867	655	107,077	-	21,415	128,492
Methanol	68,684	10,836	23,461		2,486	105,467	-	21,093	126,560
Emissions Control	5,643	1,112	3,026	7,369	289	17,439	232	3,488	21,159
Steam and Power Generation	25,881	7,100	14,646		1,292	48,919	-	12,230	61,149
Product Storage	12,396	9,780	13,204		300	35,680	-	7,136	42,816
Utilities	16,901	9,181	14,766		718	41,566	-	10,392	51,958
Off-sites	27,882	13,817	20,311		896	62,906	-	18,872	81,778
TOTAL	366,205	118,145	228,530	190,165	16,343	919,388	22,929	216,432	1,158,749

Table 6-5

COAL TO METHANOL
MID-1979
USGC Location

Plant Section	Cost Breakdown Without Contingencies, $1000						Contingencies		Total Plant Investment
	Direct Field Material	Direct Field Labor	Engineering and Support	By Others	Sales Tax	Total Cost	Process	Project	
Coal Preparation	8,676	2,687	5,105		441	16,909	-	2,536	19,445
Air Separation	57,967	10,605	28,928	107,929	2,748	208,177	-	41,635	249,812
Coal Gasification	114,257	27,536	56,733		5,713	204,239	20,424	61,272	285,935
Gas Processing and Cooling	14,839	6,493	10,691		693	32,716	-	6,543	39,259
Acid Gas Removal	12,636	4,089	11,413	74,867	645	103,650	-	20,730	124,380
Methanol	68,398	8,660	19,749		2,469	99,276	-	19,855	119,131
Emissions Control	5,643	853	2,565	7,369	287	16,717	232	3,344	20,293
Steam and Power Generation	25,840	5,498	11,822		1,279	44,439	-	11,110	55,549
Product Storage	12,035	7,943	10,132		286	30,396	-	6,079	36,475
Utilities	16,728	7,255	11,434		703	36,120	-	9,030	45,150
Off-sites	27,326	11,277	16,090		877	55,570	-	16,671	72,241
Total	364,345	92,896	184,662	190,165	16,141	848,209	20,656	198,805	1,067,670

TOTAL CAPITAL REQUIREMENT

Table 6-6 presents a tabulation of total capital required for these large coal conversion complexes. The capital required for royalties, preproduction costs, inventory capital, initial charge of catalysts and chemicals, allowance for funds during construction, and land are calculated according to the criteria presented in Table 6-1.

OPERATING REQUIREMENTS

Operating requirements are tabulated in Table 6-7.

PRODUCT COSTS

Table 6-8 presents a calculation of operating costs and product price.

The first-year product cost is determined to be 4.71 per million Btu.

Table 6-6

TOTAL CAPITAL INVESTMENT

	$1000
Total Plant Investment*	1,158,749
Prepaid Royalties	3,652
Preproduction Costs	31,511
Inventory Capital (Working Capital)	46,732
Initial Catalyst and Chemicals	2,776
Allowance for Funds During Construction	204,056
Land	1,312
Total Capital Requirement	1,448,788

*See Table 6-4

Table 6-7

SUMMARY OF OPERATING REQUIREMENTS
(AT 90 PERCENT OPERATING FACTOR)

	Illinois Case
Catalyst and Chemicals*	$5,634,000
Water Makeup (at $0.40/1000 gallons)	9,331 gpm
Ash to Disposal (at $4/dry ton)	547,000 tpy
Operating Jobs (per shift)	62
Coal Feedstock, tpy	4,746,168
Million Btu/yr x 10^3	120,263
Unit Cost, $/Million Btu	1.00

*From Table 6-3

Table 6-8

ANNUAL OPERATING COSTS AND PRODUCT PRICES

	Illinois Coal
Coal Cost, $/10^6 Btu (HHV)	1.00
FIXED OPERATING COSTS, $1000/YR	
Operating Labor	6,789
Maintenance Labor	12,845
Maintenance Materials	19,267
Adminstrative and Support Labor	5,890
General and Administrative Expense	11,780
Total Fixed O&M First Year	56,571
VARIABLE OPERATING COSTS EXCLUDING FEEDSTOCK (FIRST-YEAR) - $1000/YR	
Water	1,766
Catalysts and Chemicals	5,634
Ash Disposal	2,188
Total Variable (excluding feedstock)	9,588
BY-PRODUCT CREDITS (FIRST-YEAR), $1000/YR	0
FEEDSTOCK COST (FIRST-YEAR), $1000/YR	120,263
30-YEAR LEVELIZED O&M COSTS, $1000/YR	
30-Year Levelized Fixed O&M	106,693
30-Year Levelized Variable O&M (excluding feedstock)	18,083
30-Year Levelized By-Product Credit	0
30-Year Levelized Feedstock	232,348
30-YEAR LEVELIZED FIXED CHARGES (CAPITAL), $1000/YR	260,782
30-YEAR LEVELIZED PRODUCT COST, TOTAL (PERIOD 1985-2015), $1000/YR	617,906
30-YEAR LEVELIZED PRODUCT COST, $/10^6 Btu (HHV)	8.88
FIRST-YEAR (1985) PRODUCT COST WITH 6 PERCENT/YEAR PRICE INFLATION RATE, $/10^6 Btu (HHV)	4.71