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GUIDELINES FOR ECONOMIC EVALUATION OF COAL CONVERSION PROCESSES. FINAL REPORT ON TASK 010

ENGINEERING SOCIETIES COMMISSION ON
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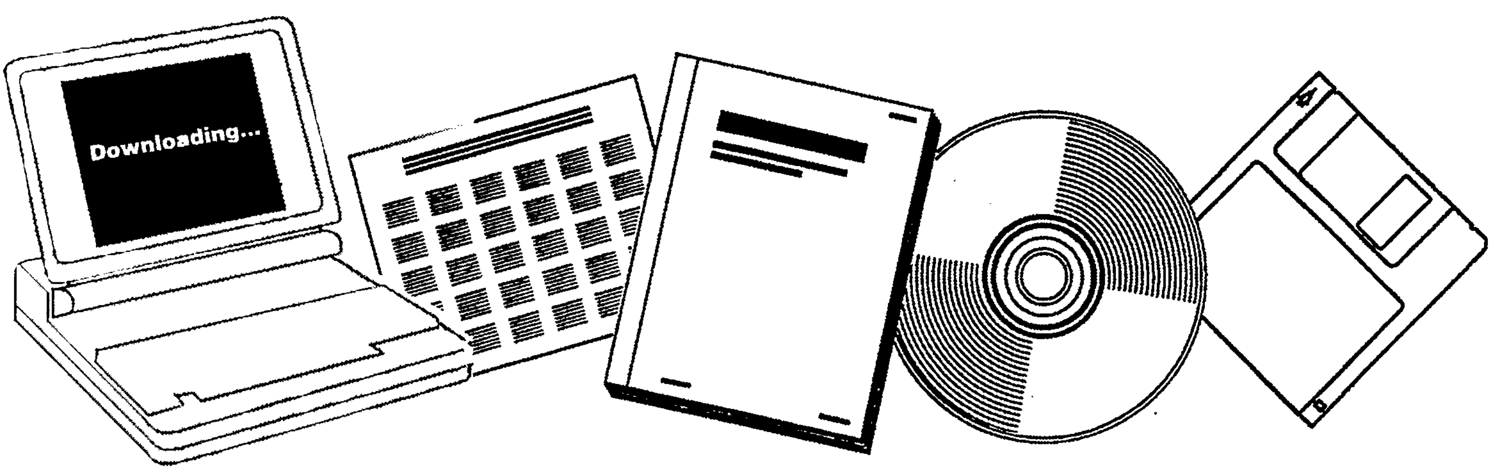

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Final Report
on
Task 010

GUIDELINES FOR ECONOMIC EVALUATION OF COAL CONVERSION PROCESSES

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ACKNOWLEDGMENTS

This task has enlisted the efforts of many people. The need for the guidelines to reflect the consensus of a broad group of companies and agencies was recognized in forming the task plan. An Advisory Board of seven members was formed and met twice in Washington, D.C.; first to provide advice on the direction of the guidelines; and second to review and advise on the final draft. Their broadly based points of view were an important factor in the task effort. Members of the Advisory Board are:

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Manager, Cost Engineering
Salt River Project

Morris Fitzgerald
Director, Division of Audits
Office of Chief Accountant
Federal Energy Regulatory Commission

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Director, Process Engineering Group
El Paso Natural Gas Company

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Bache Halsey Stuart Shields, Inc.

Paul Wellman
Manager, Process Engineering
Synthetic Oil Department
Ashland Oil, Inc.

Glenn J. Davidson, Assistant General Manager of Gilbert Commonwealth, Inc., represented Mr. Hooten at the first Board meeting.

In addition to the Advisory Board, a Review Group was formed of several individuals with experience and interest in the procedure for determining energy costs. Members of the Review Group who reviewed drafts and provided comments and suggestions for improvement are listed in Appendix C.

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A significant amount of effort and information was furnished by others in forming the document. Dr. Fred Hayoz of TRW contributed the sections on plant design and cost estimating. Dr. Carlos W. DiBella of DOE contributed the section on scoping projects, in addition to his review and comments as draft material developed and his participation at Advisory Board meetings.

ESCOE staff members Thomas A. Boyce, Richard L. Thomas and Bernard C. McBeath contributed written material and edited the guidelines.

Dr. Christian W. Knudsen of DOE attended and participated with the Advisory Board in providing review and comment. ESCOE staff members, Dr. Lewis D. Conta, Dr. Richard F. Hill, Michael L. McKimmey, Vinod K. Nangia, William F. Reed, Jr., Dr. Kenneth A. Rogers, and Adrian S. Wilk reviewed the draft and provided comment for improvement.

These guidelines have been substantially improved by the information and suggestions of the participants. Their many hours of review, providing written comments, and attending discussions are appreciated.

We would welcome comments and suggestions for improvement from users of these guidelines.

Bernard C. McBeath
Task Manager

ESCOE TASK 010

GUIDELINES FOR ECONOMIC EVALUATION OF COAL CONVERSION PROCESSES

Page No.

SUMMARY

These guidelines were developed for use in preparing and reporting engineering designs, cost estimates and financial analyses of large-scale fossil energy facilities. They provide a uniform basis for presenting project expectations so that comparison between alternative projects can be done on a consistent basis by the U.S. Department of Energy and thereby assist in the establishment of technical development priorities.

The guidelines are primarily for the preliminary economic analysis of coal conversion projects, producing either gas or coal liquids. In a preliminary estimate, the process, equipment and site factors are sufficiently defined to justify a preliminary engineering design. However, the general structure and subject matter of these guidelines are applicable to either more simplified or more detailed analyses of energy facilities.

The guidelines are organized by types of information needed in evaluating the economics of a project. Documentation of specific items relating to project scope, process design, capital and operating cost estimates and financial analyses is required to aid in assessing and interpreting reported results. Particular emphasis is placed on the treatment of capital cost estimates of new processes at various stages of technical development. Also, the financial methods and parameters to be used in determining the required selling price of products are defined in order to establish a base case for sensitivity analysis of technical, locational or financial variables. In addition, an appraisal of the results is requested of those responsible for preparing the project evaluation report.

1.0 INTRODUCTION

The U.S. Department of Energy, through the Assistant Secretary of Energy Technology and particularly through the Office of Fossil Energy Programs which reports to the Assistant Secretary for Energy Technology, is responsible for developing new technology directed toward increasing utilization of coal and the supply of oil and gas. The ultimate goal for each technology being developed is the capability to be commercialized by the appropriate utility, industrial or mining sector.

In order to assure the commercial viability of a technology under development, the Office of Fossil Energy Programs periodically subjects each technology to an engineering design, cost estimate and financial analysis review. The results of such reviews are valuable in deciding technology development priorities, provided the design and estimates are performed and reported on a consistent basis with sufficient detail for analysis.

To provide a common basis for these reviews, the Engineering Societies Commission on Energy, Inc. (ESCOE) has undertaken the development of these guidelines that can be utilized by process developers and DOE.

ESCOE is a non-profit corporation established by the Five Founder Engineering Societies to provide independent, objective technical and economic assessments to the Department of Energy (DOE). The professional staff in ESCOE consists of Engineers in Residence who are on loan from their employers for approximately two years. Each Engineer in Residence has an outstanding record of experience and achievement related to fossil fuel energy technology.

Within these guidelines, the term "Economic Evaluation" is used to describe the process of estimating the cost of products produced by a fossil energy project. The contents of the guidelines are organized by the following broad steps necessary for carrying out such an economic evaluation.

- Assessing the state of technology development and the accuracy of the cost estimate.
- Defining the project scope.
- Developing a process design and evaluating the design risks involved.
- Preparing a capital and operating cost estimate for the project.
- Performing a financial analysis for the project.

2.0 REPORT SUMMARY REQUIREMENTS

This chapter outlines the types of information to be included in the summary of the economic evaluation report. The general purpose of this information is to describe the intended use of the project evaluation, the facilities under study, the technical stage of development of the processes involved and the accuracy of the cost estimate. Appendix B summarizes these requirements in addition to serving as a checklist of items to be included in the report.

2.1 Purpose of Evaluation

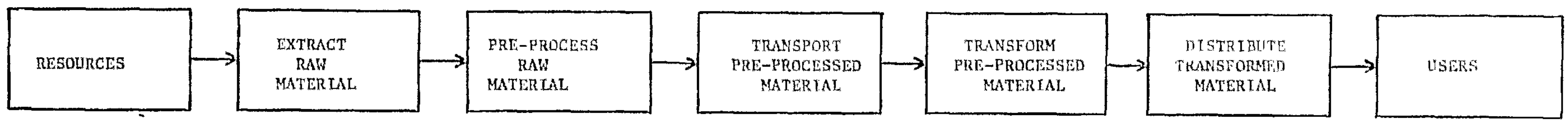
The purpose should be identified as to the intended use of the report; for example, feasibility analysis, comparative economics, and internal budgetary planning.

2.2 Description of Facilities

The project may encompass a particular type of facility, a specific unit operation or a complete sequence in an energy network as defined in Figure 2.1. The scope of facilities covered in the project should be specifically stated in a one paragraph description and may be illustrated by an elementary process schematic. The nominal and operating capacity should be stated.

FIGURE 2.1

ENERGY SUPPLY NETWORK FOR FOSSIL FUELS



Fossil Sources:	Example Facilities:	Example Facilities:	Example Facilities:	Example Facilities:	Example Facilities:	Form at End Use:
.Coal	.Surface Mine	.Prep. Plant	.Railroads	.Power Plant	.Electrical Grids	.Electricity
.Oil	.Undergr. Mine	.Prep-refining	.Pipelines	.Petroleum Refinery	.Pipelines	.Gas
.Gas	.On Shore Well	.Storage	.Waterways	.Gasification Plant	.Railroads	.Fuel Oil
.Oil Shale	.Off Shore Well	.Load Out	.Trucks	.Liquefaction Plant	.Trucks	.Gasoline
.Tar Sand				.MHD	.Water Transport	

Definitions:

1. Energy Supply Network: Pathway or chain of facilities which link an energy resource to an energy user.

2. Energy Supply Facility: A major, self-contained link in an energy supply network which is designed to extract, pre-process, transport, transform, or distribute energy resources. The design objective of a facility is achieved by a combination of process operations.

3. Energy Supply Unit: A major subsystem which accomplishes or supports one of the steps in the overall process of an energy supply facility.

4. Energy Supply Component: A small part or element which forms a part of an energy supply unit.

2.3 Stage of Technical Development

An important element in the economic evaluation of a project is an understanding of the stage of development of the technology for the processes involved. The stage of development may range anywhere from a theoretical concept to a well demonstrated use in industry. It may also vary for the different processes within a project.

Figure 2.2 presents a guide to estimating the stage of process development. The essential main processes or components in the project should be characterized by one or more of the stages described in the figure in order to select a classification which generally describes the project as a whole. The general project classification, plus the classification of the significant processes or components, should be reported in a one paragraph description.

2.4 Accuracy of Cost Estimate

The engineering effort and the resulting accuracy of the cost estimate should reflect the stage of technical development of the project as well as the intended use of the report. Three classes of cost estimates, with varying degrees of accuracy as a function of the amount of information available, are shown in Figure 2.3. The class of estimate should be specifically reported in a brief description relating the intended use, information available and procedures used as illustrated in Figure 2.3

As the use of these guidelines is primarily intended for preliminary cost estimating of coal conversion processes, it is expected that they would

FIGURE 2.2

TECHNICAL DEVELOPMENT OF PROCESS PLANTS
CLASSIFICATION OF PROJECT STAGES*

STAGE	PURPOSE	CHARACTERISTICS
Concept	The purpose of the concept stage is to provide a brief but complete description of an energy project and the essential processes so that initial judgments can be made for planning.	The concept study includes study of process reactions, materials and engineering requirements. Elementary flow diagrams and plans and results of laboratory tests and/or "bench" experimental work may have been used to establish scientific feasibility of the processes involved.
Process Development Unit (PDU)	The purpose of a PDU is to establish the basic technical feasibility of the process; acquire basic physical, chemical and engineering data needed to evaluate the process; and develop the design data necessary to allow further scale-up to a larger stage if feasible.	PDU's incorporate the results of laboratory "bench-scale" experimental work on key process steps. They form an integrated process unit sized to process the minimum amount of new material necessary to test the feasibility of the process. PDU's generally operate continuously and are a component of or contained in an existing facility (e.g., laboratory or plant).
Pilot Plant	The purpose of a pilot plant is to establish the integrated process feasibility by combining commercial type (not commercial size) components into a small model plant to test and evaluate the critical parameters of scale-up, and to acquire engineering data needed to assess economic feasibility and design a larger near-commercial-size plant.	Pilot plants are the first scale-up facility to produce enough endproduct to permit product testing and refinement. They are generally limited to three years or less of operating life and are subject to continuing and significant modifications. Pilot plants should provide sufficient data about operations for cost projections and development of commercial demonstrations.
Demonstration Plant	The purpose of a demonstration plant is to demonstrate and validate economic, environmental, and productive capacity of a near-commercial-size plant by integrating and operating a single modular unit using commercial-sized components.	Demonstration plants are still developmental in the sense that technological scale-up problems may occur and require engineering modification. They are planned to become part of a commercial plant and are used to demonstrate and verify those technologies not currently used commercially.
Commercial Demonstration Plant	The purpose of a commercial demonstration plant is to resolve commercial investment uncertainties by establishing the actual economic factors, environmental feasibility, socioeconomic impact, capital and resource requirements, constraints and product markets for currently available as well as newly introduced synthetic fuel products and encourage creation of a viable industry using these technologies	Commercial demonstration plants do not constitute R&D work. These plants combine modular production units using commercial scale equipment and conditions to produce commercially significant quantities of commercial grade product.

*Adapted from DOE/ET-0013 (78), pp. 457-9, see reference list.

FIGURE 2.3 CLASSIFICATION OF COST ESTIMATES*

CLASS OF ESTIMATES	ORDER OF MAGNITUDE, CLASS 1	PRELIMINARY (BUDGET) CLASS 2	DEFINITIVE, CLASS 3
Purpose	For management decisions on feasibility for further study.	For research and development planning and decisions for establishing technology development priorities.	For appropriation of funds for a project or for a construction contract price.
Quality (Error Range)	-30% to +50%	-15% to +30%	-5% to +15%
Information Available	The general type, quantity, and quality of main product(s) and supply(s). Individual process steps and major equipment items. Basic flow diagram. Location may be regional or a general site area.	Type, quantity, and quality of products and feedstock. Preliminary flow charts, plot plans, layouts, heat and material balance. Equipment types, sizes, and materials of construction. Building, storage, auxiliary requirements are known. Location may not be specific but general site conditions are known.	Specified type, quantity and quality of products and feed materials. Defined unit production capacities. Complete list of specified equipment. Engineered heat and material balance and complete flow diagram. Defined utility, storage, services, and handling requirements. Preliminary to complete design drawings showing special feature. Specific site conditions known.
Capital Cost Estimating Procedures	Cost-capacity curves or formulas. Ratio extrapolation for known equipment. Buildings at $/ft^2 rates. Percentage additions for indirect costs. Adjustment for time, size, and location.	Estimate individual equipment items using $/capacity, pressure, $/lb. of steel, etc. Increase total equipment cost for the total process cost by ratio. Building at $/ft^2 or parametric estimates. Inventory, start-up, working capital as percent of direct capital or based on production capacity. Adjustment for time, size and location.	Preliminary to final quotes on equipment and labor costs. Rough to detailed quantity take-off and labor estimates. Quantity or activity estimate for indirect costs. Adjustments for time, size and location.
Operating Cost Estimating Procedures	Percentage of capital cost. Cost-capacity curves or formula. Basic labor, materials and price extensions.	Estimate as percent of capital, size of plant, production rates. Estimated feed rate, production rates. Indirect costs as percent of capital cost or ratio of direct operating costs.	Detailed estimate of feedstock, supply and production rates. Breakout of maintenance and overhead by major departments. Adjustments for time and location.

*Based on classes and information from AACE (see reference list) normally be applied at the Process Development Unit stage of technical development, or beyond as depicted in Figure 2.2, to assure necessary physical, chemical and engineering information of sufficient accuracy and reliability for preliminary design. For processes at the Concept stage of development, an order of magnitude estimate would be more appropriate based on the quality of design information available for cost estimating versus the engineering effort required to carry out a preliminary cost estimate study. Conversely, the effort required for a definitive cost estimate is usually justified for the economic evaluation of a Commercial Demonstration Plant. The cost and elapsed calendar time expended in preparing the project cost estimate should be reported to assist in evaluating the overall quality of the design and cost estimate.

2.5 Construction and Operation Schedules

The construction time, production plans and manning levels should be summarized; see Chapters 5.0 and 6.0. In addition, any unusual schedule requirements, such as permit applications or site preparation, should be highlighted.

3.0 SCOPE OF PROJECT

The project scope provides the basis for preparing the engineering design, cost estimate and assessment of overall project economics. In addition to defining boundaries and desired performance of the project, the project scope establishes the necessary information concerning the conditions of the design and estimate to permit adjustments to be made by a skilled analyst in comparing projects. All manufacturing processes within the geographical boundary comprising the battery limit as well as provisions of storage, utilities, administrative buildings and other offsite facilities which provide services used by the manufacturing plant should be completely described. The following is a list of minimum requirements for documenting the project description and design basis of a preliminary estimate, i.e., the project scope:

- Capacity. The nominal plant size should be stated in terms of feedstock input and product output (tons/stream day as-received or dried coal, or million SCF, thousand barrels or million Btu/ stream day). The term "nominal capacity per stream day" refers to the input or output quantity in a 24-hour period if the plant operates at design capacity.

- Capacity factor (service factor). This is defined as the expected annual production divided by the nominal annual production (daily production per stream day times 365). This factor takes into account both the time the plant is operating (onstream time or plant availability) and the capacity at which it is operated. The assumed or targeted capacity factor must be consistent with sparing philosophy, number of parallel trains, intermediate tankage, scheduled maintenance, equipment reliability, etc.

- Site conditions. If the project is well defined, then the specific or generic site conditions should be listed to the maximum extent known. These should include location, elevation, barometric pressure, seismic zone, environmental zone, summer wet and dry bulb temperature, minimum winter ambient temperature, soil loading, etc. The source of water and contaminate composition, pH, etc., should be specified. This will reflect on the amount of process water or boiler feed water treatment that is required. Also, the cost and availability of local construction labor should be highlighted. If the design is for a more generic area, productivity and craft labor rates should be reflective of that area. Reference should be made to any site evaluation studies if available.

- Plant Life. The useful plant life (period of production) should be consistent with the amount of annual expenses allotted to maintenance, spare parts inventory, and the corrosion allowance used to design process equipment. In general, technical obsolescence and/or market reasons should not govern the plant design life of fossil energy projects.

- Feedstock Characteristics. The design coal properties and cost of coal should be listed. Among the important design characteristics are moisture, size, proximate and ultimate analysis, heating value, free swelling index, hardgrove grindability index, ash and sulfur analysis. Also, the acceptable variability in feedstock sources and specifications should be given. In addition, the form, composition, and method of delivery of catalysts and chemicals should be taken into account.

- Product Specifications. The quantity and analysis of the major products should be documented to the extent that processing data exists. For liquefaction products, the following is a list of characteristics that are to be included: heating value, API gravity, flash point, viscosity, elemental analysis (C,H,N,S,O), suspended solids, boiling range, etc. Similarly, for gasification products, the higher heating value, composition (CH_4, CO, CO_2, N_2, particulates, etc.) and delivery pressure and temperature should be stated as a minimum.

  The market specifications for which the above major products are intended should be stated. Particular attention should be directed to the quality of liquefaction products and whether further upgrading is required. Similarly, the types, form, quantity, purity and market specifications of each by-product should be included.

- Thermal Efficiency. There are many different measures of thermal efficiency that have been reported in the past. Since thermal efficiency figures are often used as measures of merit to compare different processes, standardization of the basis for efficiency calculations is required. The simplest definition of an overall thermal efficiency is based on the higher heating value (HHV) of all products and feeds that cross the plant boundary. This can be taken as the total energy output (from HHV) of all products and by-products (including sulfur and the heat equivalent of generated electricity at 10,000 Btu/kWh) divided by the total energy content of all inputs (based on the HHV of coal, other fuels, and the heat equivalent of import power). The heat content of by-product sulfur has been counted because the reported HHV of coal usually includes the sulfur contribution. In view of the numerous ways to assess thermal efficiency, actual calculations for the thermal efficiency should be included in the report.

- Process Schematic. The scope should include a process schematic or block diagram for the project which identifies the major processing steps and major stream flows.

- Offsite Facilities and Utilities. Most fossil energy project studies are for grass roots facilities and therefore the plant should be as self-contained as possible. The amount of storage for raw material and intermediate and finished products should be documented in addition to power requirements and whether on-site generation or purchased power is used.

  A description should also be included of the method and point of feedstock delivery (by rail, mine-mouth conveyor, etc.) raw material unloading, preparation, and storage facilities, the methods used for product storage and transportation, water treatment facilities, and the inclusion or exclusion of a maintenance shop and quality control laboratory. This list is by no means exhaustive, but does indicate the types of items to be documented. However, the coal mine required to supply the plant with feedstock is not to be included in the plant boundaries.

- Plant Expansion. It is typical to include in new grass roots plant designs excess capabilities in certain areas to allow for future expansion. For example, excess land is acquired, or water intake facilities and waste treatment may be considerably oversized. Also, process equipment such as towers and furnaces may be oversized or provisions in their installation such as foundations and piping may be for future expansion. The degree to which the initial design is to reflect capability for expansion should be documented.

- Plant Turndown and Operation on Alternate Feedstocks. The capability of the plant to operate at reduced capacities compared to design conditions should be documented as well as plant capacities based on feedstock variability and/or alternate feedstocks.

- Plant Manpower. The number of operators and maintenance personnel should be listed.

4.0 PROCESS DESIGN

This chapter outlines the documentation requirements for the engineering and design bases used in the process design for a preliminary estimate. For processes that are in the bench to pilot plant scale of development, a great number of processing and equipment performance assumptions will necessarily be used. Some assumptions are easily obtained from similar unit operations of commercial processes. Other assumptions must be regarded as speculative and subject to engineering judgments. It is not the intent of the guidelines to require more detail and effort than that necessary for a preliminary design. It is the intent that all assumptions and design practices should be fully documented. This will allow an assessment of their impact on the overall economics. The result of trade-off studies and the degree of subsystem optimization should be reported.

Documentation of the process design should include to the maximum extent, but not be limited to, the following elements.

4.1 Process Schematic Diagrams

A process schematic or block diagram which identifies the major processing steps and all major stream flows should be provided. The flow rates of all major input, output, intermediate and recycle streams should be listed.

4.2 Process Flow Diagrams

Each process step should have a flow diagram which identifies all unit operations and the quantity, composition and process conditions (tempera- and pressure) of all streams.

This is particularly important when package plants are used, for example, oxygen plants or sulfur recovery. In this case, all input and output streams must be fully characterized along with utility, water, and catalyst requirements. It is understood that the extent of detail may be limited by proprietary concerns and this should be so stated where applicable.

4.3 Heat and Material Balances

In addition to the material balances for the individual processing steps shown on the flow diagrams, an overall heat and material balance for the entire plant should be included. The basis for the energy balance should be documented (base temperature for enthalpy, heating values for feedstocks and products, the electric power basis, stack gas losses, evaporation losses, etc.). Separate process flow diagrams should also be drawn for the plant water system, the plant steam balance, and an overall sulfur balance. Heat, material, and elemental balances should close. Consideration should be given to developing separate battery limits process flow diagrams for nitrogen and oxygen balances.

Redundancy in reporting units is encouraged. Gas phase compositions can be reported in moles/hour or each species CFM, total pounds or total moles/hour along with volume percents of each species. Material balance tables as well as process flow diagrams can indicate the temperature and pressure of all streams.

4.4 Equipment Design and Selection

Efforts should be made to select equipment that has been proven in the same or similar service unless there is a substantial incentive for the use of equipment without this historical experience. When service conditions dictate that non-standard equipment or materials are required, the manufacturers of similar equipment should be contacted to establish reasonable extensions of current technologies and additional costs. Documentation of the selection and design of non-standard equipment should be included in the report. The equipment selected and the design practices used should be consistent with the targeted capacity factor (service factor) and plant life.

Non-standard equipment should be particularly well documented. These include thick walled pressure vessels, reactor configurations, vessel internals, and equipment whose size exceeds standard manufacturing limits. Of special concern are the reactors. Documentation should include the reactor shape and size, wall thicknesses, materials of construction, special cladding, refractory linings (type and thicknesses), special internals, critical features such as specially designed feed ports or reactor bottom. The designer should decide on the practical limits of vessel diameter, and other parameters that can be handled by shop fabrication. The equipment list should indicate which items are to be field fabricated.

Preliminary selection of materials of construction is required. The class of steel used in vessels, types of refractory linings, and internal pump material should all be included on the equipment lists. The corrosion allowance used to calculate wall thickness should be consistent with the targeted plant life and maintenance characteristics.

Size specifications on major and/or unusual equipment should be as complete as possible. While not mandatory, size specifications on other equipment items are desirable. As an example, information on pumps should include type, inlet temperature and pressures, head, horsepower, size and type of drive, casing and rotor materials, and capacity (gpm). As a minimum, the critical size specifications required for equipment costing should be reported.

All equipment lists should indicate the number of operating units and the number of spares of a particular equipment item. Equipment sparing should ensure that the plant can operate at the design capacity factor. The sparing philosophy, including emergency sparing provisions for critical processing steps, should be documented and be consistent with current industry practices. Additional spares should be considered in novel processing areas.

In many designs, package plants (for oxygen production, sulfur recovery, etc.) are employed and this is accepted practice. However, input and output streams (within battery limits or between package plants) should be characterized (temperature, pressure, composition) to the extent that is known to the designer or to the extent that proprietary information can be reported. It is also up to the designer to ensure that any vendor quotations on capital costs for package plants include the cost of all necessary and ancillary equipment and that the capacity factor is compatible with the overall plant design.

The trend in fossil energy conceptual designs is to consider a grass roots plant with power generation included within the project scope. Trade-off studies should be performed to justify on-site power generation as opposed to purchasing power and exporting char and/or coal fines.

Any trade-off studies made to sub-optimize various sections of the plant to determine the best processing technique should be reported. For example, there may be several acid gas removal systems that could be selected. After discarding those that will not perform under the desired process conditions, trade-off studies can be done on the remaining ones to determine the optimum. As a minimum, those trade-off studies required or recommended for optimization should be reported.

4.5 Waste Management

Conceptual designs are used for a number of purposes, one of them being environmental assessment. To assist in this goal, the waste management practices should be documented based on best available process information at the time the study is performed. The process design should include a description of the types of control technologies that are used. Where data is not available or quantities unknown at the present stage of process development, this should be so stated. The design should follow the available information in the Resources Conservation and Recovery Act (RCRA).

Toxic streams, both within the plant as well as the plant discharge, should be identified and special safety requirements documented.

Emissions fall into three categories: water, air, and solids. The documentation requirements for each are discussed below:

- Waste water effluents. Waste water treatment facilities are to be included within the project boundaries. The quality and quantity of waste water effluents must be identified. These effluents come from process wastes, cooling tower blowdown, utility blowdowns and coal pile runoffs. Some of the contaminants that should be quantitatively identified include phenols, cyanides, ammonia, sulfides, oils, greases, phosphorous, metals and suspended solids. The pH of the effluent streams should also be estimated. Since some streams are intermittent, an averaged monthly value can be reported.

  Levels of waste effluents should conform, at a minimum, to the current federal regulations of the Clean Air Act, the Federal Water Pollution Control Act and the Clean Water Act.

- Air emissions. The quantity and species of all air emissions from process streams and fugitive emissions should be identified. Particular attention should be directed to H_2S, SO_2, CO_2, NO_x, hydrocarbons, and particulates.

- Solid wastes. Provisions for solids disposal are to be included in the estimate. Examples include rail or conveyor facilities for ash disposal at the mine and landfills. The treatment and/or disposal of toxic solid wastes should be in accordance with available regulations. Such regulations should be referenced and requirements for landfill should be identified.

4.6 Engineering Assumptions

Three major areas of engineering assumptions are to be included. Sources of data, reaction assumptions, and unknown physical properties should be documented.

- Source of data. The source of process data should be documented, whether it be from pilot plant data supplied by the process developer, an earlier conceptual design, or a complete "paper" process fabricated from physical principles. If pilot plant data were used, indicate the specific run numbers that were taken as a representative basis for scale-up. Data summaries, and in some cases raw data reports, are recommended. All data sources should cite specific references where available. Methods used for data reduction and correlation should be specified.

- Reactor design assumptions. The reactor section of a coal conversion plant, including associated systems for feeding products and waste removal, is perhaps the unique feature of a process that distinguishes it from another. Because of this uniqueness, more detailed assumptions have to be reported concerning reaction conditions. Any vessel in which reactions occur (such as preheaters and methanators) are to be included. Among the assumptions that can be listed (if determined) are:

  All input and output stream flow rates and compositions

  Internal flow rates (if applicable)

  Temperature (and temperature profiles, if applicable)

  Pressure (and pressure profiles, if applicable)

  Residence times for each phase

  Heat transfer coefficients

  Catalyst life and activity change (if catalysts required)

  Catalyst circulation rates (if applicable when catalyst required)

  Catalyst makeup rates (if catalyst required)

  Percent conversion or conversion efficiency (define basis: carbon utilization, limiting reactant, heating value, etc.)

  Void volumes in packed beds

  Expanded bed densities in fluidized beds

  Recirculation rates in an ebullated bed

  Equilibrium temperature and equilibrium approach conditions

  Space velocities

  Superficial velocities

  Compositions and flow rates of all bypassing, recycle or intermediate withdrawal streams

  Characterization of contaminants in the reactor effluent: particulates (quantity and size distribution), tars (in the case of gasification, both quantity and composition), etc.

  All other pertinent factors used in reactor design

- Physical properties. Many physical properties of intermediate streams have to be assumed in order to size equipment. This may be due to a lack of full characterization from limited pilot plant or bench scale data. These assumptions may include heat capacities, phase equilibrium data, densities, thermal conductivities, viscosities, etc. If these data are required for equipment sizing, then they should be documented.

- Others. There are many other assumptions and key factors that are used for equipment sizing. These may include Murphree stage efficiencies in distillation columns, design air cooler inlet temperatures, pressure drops, separation efficiencies (solid/liquid), regeneration efficiencies, etc. All such data should be reported. An estimate of the turndown ratio comparing the minimum throughput capacity to the design capacity for the overall plant and major processing steps should be presented.

5.0 CAPITAL COST ESTIMATE

The estimate of the capital costs of a project is perhaps the most important factor in evaluating a project. In preliminary estimates, this figure is used as a basis for many of the elements that make up the operating costs. In the financial analysis, this figure is the basis for all capital related charges and returns on equity. While very significant, a single number reported as the total capital requirement is not meaningful for establishing the viability of a project. The independent reviewer or decision maker must know the accuracy as well as the background of the capital cost estimate: how it was developed, what elements it includes, the level of detail used, the sources of cost data, etc. This chapter outlines the minimum documentation which should accompany the preliminary capital cost estimate.

5.1 Methodology

Within the several classes of estimates (order of magnitude, preliminary, definitive, etc.) that are used for project evaluation, there are several methods that can be employed. For example, in preliminary estimates, some of the options are to use Lang factors, Guthrie's method, or the Chilton method. It is not the purpose of these guidelines to specify the method that is to be employed. Rather, it is to ensure that the method used is identified and documented.

Almost all methods rely on the estimated purchased equipment cost as a starting point. Then, installation factors are applied to obtain the installed cost. The purchased cost for each major piece of equipment should be listed. It is acceptable to list only the overall cost of a package unit (either purchased or installed), provided that package price contains all ancillary equipment associated with that unit. The same date for prices and costs should be used throughout the estimate. The year and month, or year and quarter, should be reported.

Likewise, installation factors should also be listed, either on an equipment basis (as in the Guthrie method) or as an overall plant factor (such as the Lang factors).

The documentation of the sources of equipment cost data should be included. It should be stated whether equipment costs came from current vendor quotes, updated cost curves or published data. If historic data is used (that is, published data from previous years), then the original price year and the method or index used to update this data (such as the Chemical Engineering Plant Index, Nelson's Refinery Index, the GNP deflator, the BLS index for pumps, etc.) should be stated.

5.2 Capital Cost Breakdown

All capital cost estimates should include a breakout of purchased equipment costs by major equipment item or package plant. The installation costs account for field labor, construction material, piping, foundations, instrumentation, etc. The summation of all equipment and installation costs is sometimes termed the process plant installed cost. In addition, there are costs associated with "offsite" equipment, sometimes referred to as general facilities and utilities. Included in this category are site preparation, buildings, storage facilities, utilities (electric power, plant water treatment, boilers, cooling towers, instrument air, etc.), yard piping, and auxiliary areas (blowdown and flare systems, waste-water treatment, incinerators, etc.). The envelope of what to include in the offsite category should be consistent with the project scope as outlined in Chapter 3. The sum of the process plant installed cost and off-site costs is the total installed cost.

The following is a list of items that are necessary to obtain the total project capital cost as summarized in Figure 5.1. Tax treatment of the individual items varies and this is covered in Chapter 8.0, Financial Analysis.

- Land (non-depreciable). Cost of acquisition of the site itself.
- Total Installed Cost. The sum of the process plant installed cost and offsites installed costs.
- Paid-up Royalties. Process royalty cost paid to licensor to permit design, construction and operation of process plant (does not include "running" royalties which are part of the plant operating costs).
- Initial Catalyst, Chemicals and Operating Supplies. Materials consumed in the manufacturing operation but not appearing as a product.
- Working Capital (non-depreciable). The funds in addition to fixed and land investment, which are tied up in the operation of a project. These funds cover such items as minimum cash required for smooth financial operations; raw material, unfinished and finished project inventories; warehouse stocks of chemicals, catalysts, small tools and spare parts. Report the basis of the estimate.
- Start-up Cost. The operating costs incurred to bring a plant on-stream. Additional capital required to correct plant problems, operator training, equipment testing, temporary labor, etc., is generally included.
- Contractor's Home Office Cost and Fee. Usually taken as a percentage of installed cost to cover contractor's fee for services as well

as direct costs associated with a project which can be assigned to engineering, procurement, expediting, inspection, reproduction, telephone, telegraph, etc.

- Owner's Cost. Includes process studies, market survey, site selection, environmental studies, owner's engineering offices, and the costs for obtaining construction permits.

- Project Contingency. Taken as a percentage of total installed cost to cover uncertainties during project execution such as equipment damaged during construction, delayed delivery of equipment, etc.

- Process Contingency. Taken as a percentage of installed costs of major process sections of the process plant involving unproven technology in order to quantify uncertainties in process equipment design performance and cost. Process contingency allowances should be reported separately and their bases documented as part of the process plant estimate.

  The assigned values of process contingency should reflect the stage of technical development of the process and/or the quality or reliability of the data being used for design. In the absence of prior experience with the development of similar processes, the following guidance is provided to aid in assigning process contingency allowances.

DEVELOPMENT STAGE FROM WHICH PROCESS DATA IS AVAILABLE	PROCESS CONTINGENCY AS PERCENT OF INSTALLED SECTION COST
Concept with bench-scale work	50%
Process development unit	25%
Pilot plant	15%
Demonstration plant	10%
Commercial demonstration plant	5%

5.3 Construction Schedule

An estimated construction schedule should be provided in the form of a milestone chart or other means to show the cumulative purchases and erection progress of all parts of the project. Any unusual construction components imposed by the design or by site location or conditions, including the need to complete offsite facilities, should be reported. For a preliminary estimate a typical "S" curve is acceptable. Chapter 8 specifies a schedule for baseline study. A definitive estimate will require an analysis of manpower distribution, craft mix, delivery schedules, etc.

5.4 Capital Recovery at End of Project Life

It is usually assumed that most of the outlay for working capital is recovered at the end of the project life. However, this capital recovery item, as well as the project salvage value, is often neglected if a discounted cash flow analysis is used for project evaluation. Further requirements for treatment of these and other capital accounts are covered in Chapter 8.

Figure 5.1 - CAPITAL COST SUMMARY

Capital Cost Items	Line Item Estimates	Totals
Land (1)		
Working Capital		
Subtotal (Non-depreciable items)		
Total Installed Cost (2)		
This includes process contingencies which total $____________		
Initial Catalyst, Chemicals, Operating Supplies		
Start-up Costs		
Contractor Cost and Fee		
Owner's Cost		
Project Contingency		
Subtotal (Depreciable Plant Costs) (3)		
TOTAL (Estimated Construction Costs) (4)		

*All estimates in ______ year dollars (base year date).

Notes: (1) Where cost of land is relatively small, it may be stated as less than "____" percent of total and not reported as separate item.

(2) Total installed cost to be further broken down into separate estimates for process blocks and offsite facilities, and reported separately. Show any process contingency.

(3) To be used as Depreciable Plant Costs in Figure 8.1.

(4) To be used as Estimated Construction Costs in Figure 8.1

6.0 OPERATIONS COST ESTIMATE

In addition to the total capital investment, an accurate estimate of the annual operating cost is required to evaluate the economic feasibility of a project. In preparing a preliminary estimate, many operating costs, for example, maintenance, insurance and ad valorem taxes, may depend on the capital cost estimate. This chapter will discuss estimating methods and the required components that make up the annual cost.

6.1 Estimating Methods

In a preliminary estimate, only a few basic quantities are required. The quantities of raw materials are obtained from the material balances. Catalyst and chemical requirements are taken from the stated makeup and consumption rates. The unit costs of the materials should be taken from vendor quotes or such sources as the Chemical Marketing Reporter. In cases involving proprietary catalysts, where only past costs are available, up-to-date costs may be obtained by escalating prices with some inflation index, such as the Chemical Index from Chemical and Engineering News. The date for price and costs, or the adjusted price and costs, should be consistent with the date used in Chapter 5 for the capital cost estimate. In any event, the source data must be referenced. All annual cost items are based on the stated capacity factor. Other estimating factors and methods are discussed in the following section on annual cost breakdowns.

6.2 Annual Cost Breakdown

The following is a list of items to be included in the annual costs as summarized in Figure 6.1.

- Feed Materials. This includes feedstocks and raw materials which appear in some form as a product. For coal conversion projects list "Feed Material-Coal" and "Feed Material-Other" separately to permit sensitivity analysis for coal price. Annual costs should be based on the stated capacity factor. Quality, quantity and unit prices are to be specified.

- Catalysts, Chemicals and Operating Supplies. This includes all materials consumed in the manufacturing operation but not appearing as a product. Catalyst and chemical quantities are dependent on catalyst replacement rates (based on catalyst life) and chemical makeup rates. The annual costs are determined by prices and the annual capacity factor. Annual quantities and unit costs should be reported. Operating supplies costs may be taken as a percentage of operating labor costs.

- Utilities and Fuel. The fuel, steam, air, power and water which must be purchased or generated to support the plant operations. If a siting area is chosen for the plant (for example Appalachia, Midwest or Western), the effects of regional differences on costs for utilities and fuels, especially water, must be considered.

- Operating Labor. This is determined by the number of operators required per shift and the annual wage rate. In general, this item is independent of the capacity factor. The number of operators per shift is, in turn, determined by the complexity of the process, the number of processing steps, and the degree of automation. It is usually estimated from experience with similar unit operations from known processes. For a detailed estimate, the number of operators is taken from manning tables and shift schedules worked up from a detailed analysis of the processing steps. The level of reporting should be consistent with the level of detail demanded by the estimate type. As a minimum, the number of operators, total salary costs at hourly or annual rate and the source of the rates should be documented. The rates should be based on the region applicable to the plant location.

- Maintenance. This is the expense incurred to keep manufacturing facilities operational. In a preliminary estimate, the total annual maintenance cost for a particular processing unit is usually taken as a percentage of the capital investment of that unit. This total annual maintenance cost is then divided between maintenance labor and maintenance supplies. Maintenance labor is determined as a percentage of total maintenance cost or from a detailed manning table. The total cost for maintenance must be consistent with the assumed capacity factor, the sparing philosophy, and the assumed production life of the project. The method used to compute maintenance costs should be documented.

- Supervisory Labor. For preliminary estimates this is often taken as a percent of operating and maintenance labor.
- Administration and General Overhead. For preliminary estimates this is usually a percentage of total labor.
- Fringe Benefits. This includes payroll costs other than wages and salary paid directly to employee - usually estimated as a percent of the labor plus supervision cost to cover such items as holidays, vacations and sick leave, federal old age insurance, pensions, life insurance, savings plans.
- Local Taxes and Insurance. These estimates are related to the total plant investment. Unless specified otherwise, typical values to use are 2% of the total plant investment for property taxes and 0.75% for insurance for a total of 2.75%.
- Royalties. These are "running" royalties paid to others for the use of a proprietary process. Report the basis of the estimate.
- Waste Disposal. This is the expense incurred for the removal of chemical and material wastes generated as a result of manufacturing operations. Each case where significant amounts of waste are involved should be calculated individually.

6.3 Total Annual Operating Costs

Figure 6.1 reports the estimate of the total annual operating costs. This should be the estimate of annually recurring disbursements directly attributable to the production schedule. By-product credits and other annual adjusting accounts such as debt interest and depreciation are covered in the following chapters of these guidelines.

6.4 Production Schedule

An annual operating schedule should be provided indicating the hours per year devoted to production and to downtime. Allowances should be made for reduced production capability during plant start-up and initial operations as shown in Figure 8.2. Also any allowances for future changes such as major equipment replacement or rehabilitation should be reported. Downtime for scheduled maintenance and repairs as well as unscheduled plant outages should be included in the capacity factor.

FIGURE 6.1 SUMMARY OF ANNUAL OPERATING COSTS*				
Cost Group	Estimate Base Unit	 Quantity	 Price	Annual Cost*
Feed Materials - Coal				
Feed Materials - Other				
Catalysts, Chemicals and Operating Supplies				
Utilities and Fuels				
Operating Labor				
Maintenance				
Labor				
Material				
Supervisory Labor				
Administration and Overhead				
Fringe Benefits				
Local Taxes and Insurance				
Royalties				
Waste Disposal				
TOTAL**				

* All estimates are in _____ year dollars (base year date).
** To be used as Annual Operating Costs for Base Year Estimates in Figure 8.1.

7.0 MARKET STUDY AND BY-PRODUCT REVENUES

An assessment of market conditions considering the impact of production of all major products and by-products on the market and transportation systems should be carried out as part of the project evaluation. In addition, the revenues realized for by-products should be evaluated based on a realistic assessment of market value and the transportation, storing, handling and selling costs which take the by-product from the project site to the point of sale. The market study and by-product revenue reporting requirements for a project evaluation based on a preliminary estimate are outlined in this chapter. The estimating and reporting basis for major product revenues are presented in Chapter 8.

7.1 Market Study Requirements and Reporting

The assessment of market conditions for all major products and non-fuel by-products should reasonably fit the project study objectives. A brief summary should state the depth and scope of the market study and include a statement on each of the points below.

a. Location of the expected market relative to the project location.

b. Types of available transportation systems to transport product from the project to market, and the corresponding distances.

c. Estimate of the relative increased requirement the project production will have on the transportation system.

d. Estimate of the amounts of project production relative to total amounts in the market.

The purpose of this information is to provide a measure of the impact of plant production on the market and transportation systems as well to indicate any transportation or marketing problems. The effort as put forth in assessing market conditions should be consistent with the stage of technical development of the project. For a project evaluation utilizing a preliminary estimate based on pilot plant quality process data, supporting data for either generic or specific site determinations should be reported as appropriate to the study objectives.

7.2 Marketable By-Products and Their Prices

The reporting of quantity and quality of by-products is covered in Chapter 3, Project Scope. The bases for estimating the quantities and unit prices shall be reported in determing the by-product revenues. In the case of a fuel products project, a single fuel product contributing less than two percent of the total plant revenues may be treated as a by-product.

Report the source of price for each by-product bringing in revenue and adjust each to a unit price F.O.B. at the project site. The unit price of by-products should be taken from vendor quotes or such sources as the Chemical Marketing Reporter. Such spot prices should be reviewed for validity and adjustments should be made to reflect project location, transportation and market conditions. Prices may be updated by escalating prices with some inflation index, such as the Chemical Index from Chemical and Engineering News. The format in Figure 7.1, or a similar format, may be used to show adjustments. Indicate the effective date of all prices. Report any indexes that adjust prices and the original date of prices.

7.3 Revenue Schedule

The full revenue schedule for all products will be a part of the operating revenues and expenses schedule which is required under Chapter 8 of these guidelines. The revenues from individual by-products as well as the total product credit from the sale of by-products shall be reported in a format similar to Figure 7.2 for the expected annual production as defined in Chapter 6. Variations in schedule are treated in Chapter 8.

It should be noted that the by-product prices and revenue schedules developed in Figures 7.1 and 7.2 reflect only current market conditions. The assessment of future market prices and subsequent project revenues are beyond the scope and the intent of the market study required in these guidelines. Projects with unusual by-products or market conditions may be subjected to study under the Alternative Case Analysis procedure described in Section 8.4.

FIGURE 7.1
BY-PRODUCT PRICE ADJUSTMENT

All prices on a unit basis

1. Name of By-Product			
2. Unit of Sale			
3. Unadjusted Market Price			
a) Date of Price			
b) Adjustment Index			
4. Adjusted Price, Point of Sale			
5. Shipping and Selling (1)			
6. Price, F.O.B., Project Site			
(Adjusted prices are in ____ year dollars (base year date).			

(1) Allow for all costs for transporting, storing, handling and selling which take the product from the project site to the purchase point. of sale.

FIGURE 7.2
BY-PRODUCT REVENUE SCHEDULE*

Name of By-Product	Annual Amount	Unit Price	Revenue $1,000
1.			
2.			
3.			
etc.			
Total By-Products Revenue**			

* At the expected annual production after start-up.

** To be used for Annual By-product Revenue for Base Year Estimates in Figure 8.1.

8.0 FINANCIAL ANALYSIS

This chapter defines parameters and methods to be used in performing the financial analysis and the reporting of the analysis results. The primary objective is to determine the required selling prices of the major products identified in Chapter 7. The required selling price is that price of product required to meet all expenses and recover all investment at the defined rate of return. This required selling price is determined by project requirements and not by market conditions.

The methods set forth here are to be used in calculating the required selling price for the base case and for any sensitivity analysis on parameters values used in the base case. The base case is the set of estimates, parameter values, and the outcome of the analysis which is to be used as a reference datum.

8.1 Reporting Financial Analysis Parameters and Results

The analysis required uses a cash flow approach, which means total annual disbursements and receipts, and conventional time discounting methods. In performing and reporting a project financial evaluation it is helpful to keep in mind that the total estimates are based on the goods and services required to construct and operate the project and goods and services produced for sale by the project. Money is a yardstick for measuring those goods and services. The cash flow analysis expresses that measurement in terms of dollars for the quantity of goods and services transacted in each period of time.

Figure 8.1 summarizes the data required to perform a cash flow analysis and the reporting of the analysis results considering:

1. The sponsor type and dollar method of analysis which determine the parameter values to be used. See definitions in the following subparagraph.

2. The base year estimates of construction, depreciation, and operating costs defined in Chapters 5 and 6, and by-product revenues defined in Chapter 7.

3. The financial analysis parameters to determine investment return appropriate to the type of project sponsor.

4. Adjustment of the above base year data to the project start-up year based on construction, operating and retirement schedules established for the project.

5. The analysis results in terms of the required product price(s) and other measures of project performance.

The following paragraph subsections sequentially discuss each of these areas from Figure 8.1 in terms of their usage and definitions. Appendix E contains specified parameter values to be used with these guidelines on an initial basis.

8.1.1 Sponsor and Dollar Method

The sponsor is the combined group of investors, both those investing in debt financing and those investing in equity financing for the project.

The dollar method refers to the financial analysis method of dealing with inflation. A project financial analysis may deal with price change in one of two ways, (1) use of then-current dollars, or (2) use of constant-date dollars. Then-current dollars are the inflating dollar.

FIGURE 8.1
FINANCIAL ANALYSIS - DATA SUMMARY

Sponsor (Private/Utility) ________

Dollar Method (Then-current/Constant date) ________

Base Year Estimates

- Dollar Year for all Base Data ________
- Estimated Construction Costs (Fig. 5.1 total) ________
- Depreciable Plant Costs (1) ________
- Annual Operating Costs (Fig. 6.1 total) ________
- Annual By-product Revenue (Fig. 7.2 total) ________
- Net: Operating Costs Less By-Products Revenue ________
- Major Product(s) Output (2) ________

Analysis Parameters

Schedules

Schedules	Dates	Times, years
Construction	____ to ____	________
Operation	____ to ____	________
Retirement	____ to ____	________

- Construction Exp.
  - Rates (%/year) (3) ________
- Plant Start-up Rates (% Annual Production Rate) ________

Discount Rates (% per year)

- Construction Loans ________
- Debt Financing ________
- Equity Financing ________
- Overall Project Rate ________

Financial Structure

- Debt (% total) ________
- Equity (% total) ________

Escalation Rates (% per year)

- General Rate ________

Depreciation Methods

- Tax Life (years) ________
- Method ________

Analysis Parameters (cont.)

Tax Rate and Schedules (4)

- Effective Income Tax Rate ________
- Federal Income Tax Rate ________
- State/Local Income Tax Rate ________
- Effective Investment Tax Credit Rate (ITC) ________
- ITC Claim Schedule (year, % of investment) ________
- Income Tax Credit Treatment (5) ________

Base Data Adjusted to Start-up Date

- Total Capitalized Investment, TIC ($) ________
- Depreciable Plant Investment (1) ________
- Annual Operating Costs ________
- Annual By-product Revenue ________
- Net Annual Operating Cost ($/year) ________
- Year of Adjusted Data ________

Analysis Results

- Major Products Price ($/unit) (2) ________
- Price Date (dollar year) ________
- Overall Project Rate-of-Return (% per year) ________
- Equity Investors' Rate-of-Return (% per year) ________
- Payout Period (at zero interest) ________
- Levelized Product Price ________

Notes:
(1) Depreciable costs are total costs less nondepreciable items. See Figure 5.1 for items.
(2) List each product to be priced.
(3) Percentage of base year estimate.
(4) For income taxes and investment tax credits only.
(5) For cases where allowed deductible expenses exceed actual revenues.

The constant-date dollar is a method of analysis in which there is no inflation, prices do not change, and estimates of all project transactions are adjusted to prices which are in effect on a single selected date. Dollar year dates are required with either method.

8.1.2 Base Year Estimates

All figures under Base Year Estimates, Figure 8.1, should be for the same dollar year. Estimates of construction costs and the depreciable plant cost are those shown in Figure 5.1. Annual Operating Costs are taken from the total in Figure 6.1 and Annual By-Products Revenues from Figure 7.2 is to be subtracted for the Annual Net Operating Cost. Major Products Output is the annual production of the major product to be priced. This should be the same as the amount of product reported in Chapter 3 under "Product Specifications" for a normal year's production.

8.1.3 Analysis Parameters

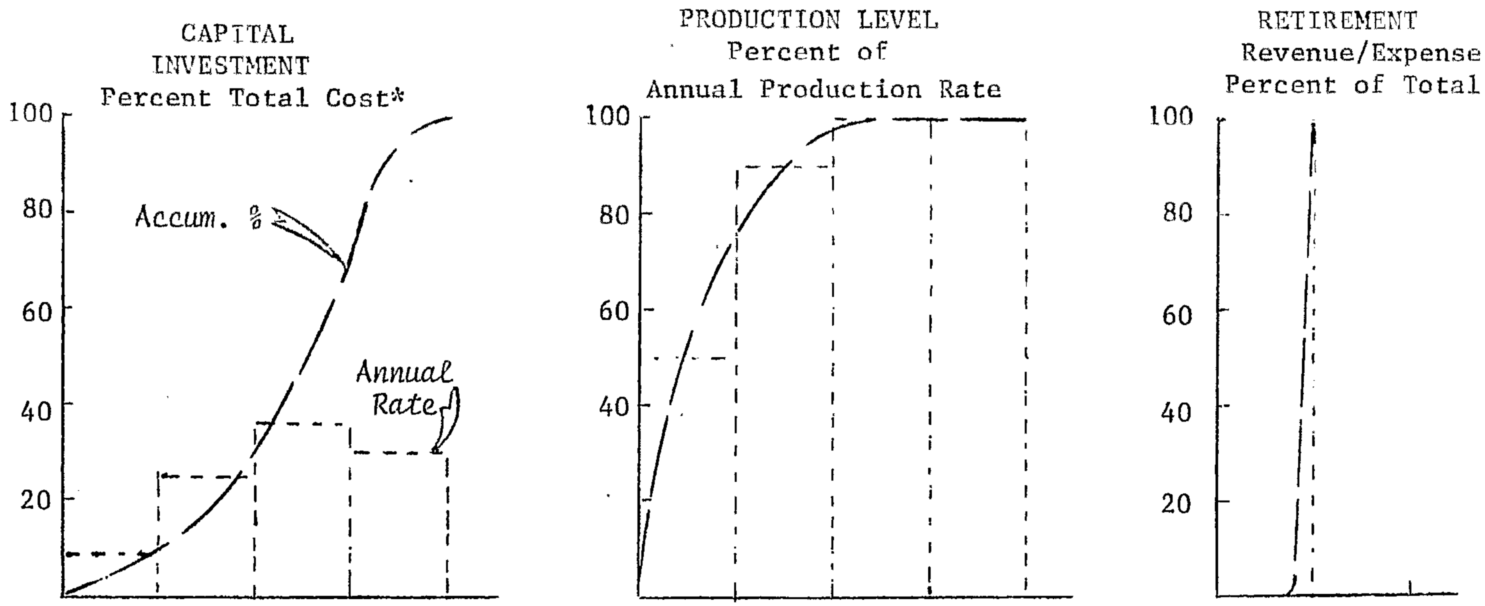
Schedules. The three phases of project activity considered are construction, operations, and retirement. Calendar year dates for each phase are required for then-current dollar analysis. The elapsed time for each phase must be shown.

The schedule for Construction Expenditure Rates is the percentage expended of the Estimated Construction Cost for each sequential year of the construction phase, using base year values. Plant Start-up Rates are the percentage of annual production achieved in each start-up year in sequence. See Figure 8.2 for graphic examples.

Discount Rates. These are annual rates of discounting to be used in the analyses whenever the specific item is being discounted. Rates may be for the three general types of finance sources as shown. The interest rate for debt financing and rate-of-return on equity for equity financing apply to the guidelines method.

The overall project rate is the weighted, after-tax rate for the debt equity structure indicated below. Its computation and use is discussed later.

FIGURE 8.2 EXAMPLE RATE SCHEDULES



	Capital Investment				Production Level				Retirement	
Period (1)		-3	-2	-1	1	2	3	4	20	21
Year (2)	1981	82	83	84	85	86	87	88	2004	2005
% Year (3)	9	25	36	30						
Accum. % (4)	9	34	70	100	50	90	100	100	100	

*Construction Expenditures

(1) Period with reference to plant start-up date.
(2) Show calendar year when applicable.
(3) Each schedule is based on a total estimate. Show each period's percentage of total.
(4) Show percentage accumulated at the end of each period.

Financial Structure. The financial structure is that combination of debt and equity financing making up the total capitalized cost at the start-up of the plant. It is described by the debt equity ratios. The debt ratio, r_d, is the total debt financing divided by total capitalized cost where $0 > r_d > 1$. The equity ratio is $(1-r_d)$.

Escalation Rates. Escalation is a price change of an item over time for any reason, including inflation. Some project evaluations may use different escalation estimates for each of several expense or revenue categories. However, for methods specified in this Chapter, the use of a single escalation rate is required.

Depreciation. Depreciation is a method for annual allocation of cost of an asset over its useful life. It is an account used in these analyses in determining income tax to be paid and is not a cash flow per se, as used in these guidelines. Both tax life of the project and method shall be consistent with IRS requirements, and with the project schedule.

Tax Rates and Schedules. These rates and schedules apply to income taxes and the investment tax credits and the year-of-claim schedules. The Effective Income Tax Rate combines federal and state income tax rates. The full Federal Income Tax Rate is to be used and reported.

The effective rate for Investment Tax Credit, ITC, and the schedule of time at which tax credit can be claimed is dependent on the type of sponsorship for the project. The credit amount and claim time is limited. At present, unused credit may be claimed on taxes due from the preceding three years through the following seven years. The time schedule and claim rate should be indicated.

The Income Tax Credit is a provision for the case where actual revenues are less than the allowed tax deductions. For these guidelines it is recommended that both ITC and income tax credit be treated as credit to the sponsor in the year-of-occurence. This assumes the sponsor has other tax obligations.

8.1.4 Base Data Adjustment to Start-Up Date

The Total Capitalized Investment, TIC, is defined as the investment in the project at start-up date. It includes the compounded value (future value at start-up date) of each year's net investment by the sponsor. The discount rate and Investment Tax Credit to be used on the investment depends on whether the sponsorship is private, utility, or public authority. Depreciable Plant Investment is Total Capital Investment less the non-depreciable cost items identified in Figure 5.1, which have been adjusted in the same ratio as the total.

The adjusted Annual Operating Costs less credit from Annual By-products Revenues are the Net Annual Operating costs. These costs and revenues must be adjusted for escalation changes between the base year date of the estimate and plant start-up date.

Methods for adjustment are discussed further under paragraph 8.2.

8.1.5 Analysis Results

For a project producing a single product, the required selling price is equal to the total required annual revenue divided by the total annual production.

Where more than one product is produced, the required selling price for each product is to be based similarly on its individual allocation of annual revenues and its production. However, for these guidelines the ratios of the revenue for each product line to each other should be kept constant. The ratios should reflect the established market price ratios in order to determine realistically the total revenue from all product lines.

The reference year selected for market prices should be the same as the base year selected for estimation of construction costs, operating expense cost, and by-products revenues estimate. The reference products should be the same as those specified for the project, or as close as possible to the specification for each product. When the analyst believes project or market conditions justify other assumptions about reference prices, those assumptions should be subjected to a sensitivity analysis, or an alternative case analysis.

Further discussion of price ratios is presented in Appendix D.7.

Example calculations for the overall project rate of return, equity investors' rate-of-return, levelized fuel products prices and payout period price are presented in Appendixes D.1, D.5, D.6, and D.7, respectively. If other single value measures are calculated, such values should be reported.

8.2 Cash Flow Schedules

A Cash Flow Schedule, as defined in Section 8.1, is required for the base case.

The Cash Flow Schedule is the schedule of annual disbursements and receipts for the defined project accounts, reported annually for the construction, operation, and retirement phases of the project. For convenience in discussing estimating and reporting, the Project Life Cycle has been divided into two parts, a Capital Investment Period and a Project Operating Period. A reporting form shown in Figure 8.3 or a similar form listing the suggested line items, should be used. All calculations must conform to the general requirements listed under subparagraph 8.2.3.

All dollars in ________ (1)

Escalation rate ________ (2)

FIGURE 8.3 PROJECT LIFE CYCLE - CASH FLOW
AMOUNT $\$10^6$

Item or Acct. No.	Description	Base Year Amount \ Col. No. / Yr. (3) / Per (4)	1	2	3	4	5	6	7	8	9	10
	INVESTMENT & RETIREMENT											
1	*Capital investments*											
2	*Returns from retirement*											
	PRODUCTION REVENUES											
3	*Principal product revenues*											
4	*Other revenues (By-products)*											
5	*Total revenues*											
	PRODUCTION EXPENDITURES (a)											
6	*Feedstock*											
7	*Other operating expenses*											
8	*Total expenditures*											
	CAPITAL RECOVERY & TAX											
9	*Debt interest*											
10	*Debt principal retired*											
11	*Equity return*											
12	*Equity - Retirement*											
13	*Income Tax*											
14	*Total Cap. Recovery Cost*											
	COMPUTATION ACCOUNTS											
15	*Net expenses (b)*											
16	*Depreciation*											
17	*Investors' Balance (c)*											
18	*Production level (d)*											

(a) *Excludes all capital recovery; including interest on debt.*

(b) *Line 6 plus line 7, less line 4.*

(c) *Debt and Equity investors' unrecovered balance, includes interest and return.*

(d) *Show onstream capacity percent if less than 100%.*

(1) Either "then-current" or date for constant-date dollars.
(2) General Rate. Indicate any different line item rates under description.
(3) Year. Calendar year is required with then-current dollar analysis.
(4) Period number with respect to plant start-up date.

8.2.1 Capital Investment Period

The information needed to prepare a schedule of Cash Flow for the Capital Investment Period is shown in Figure 5.1, Capital Cost Summary, and Figure 8.1, Financial Data Summary. An example is presented in Appendix D. That example shows the components which contribute to the total investment for each investment period year. These components are (1) the cash contribution to construction to be made by the investor, which has been adjusted for escalation and investment tax credit, (2) the unpaid interest on balance in the debt financing, (3) the upaid return for equity financing, and (4) the income tax reduction claimed as a credit for the debt interest in item 2. The total of these is repeated for each investment year on line 1, Capital Investments, Figure 8.3.

The following points are to be observed in treatment of the Total Capitalized Cost, TIC:

> The schedule in Figures 8.1 and 8.2 for the construction expenditure rates is based on constant-date dollars. It has not been adjusted for escalation.
>
> The annual net cash applied to the project is the construction expenditure less Investment Tax Credit.
>
> Where debt financing is used there will be income tax credit based on debt interest due. This is to be claimed in the year it occurs and applied to reduce that year's balance due the investors. Use of the overall project return rate for calculation will automatically effect this requirement.

8.2.2 Project Operating Period

The information needed to develop accounts under Cash Flow during the project operating period is shown in Figure 6.1, Summary of Annual

Operating Costs, Figure 7.2, By-product Revenue Schedule for Uniform Annual Production, and Figure 8.1, Financial Analysis Data Summary. The accounts and their components to be covered are listed in Figure 8.3. More detailed discussion is found in Appendix D, Sections D.2 and D.3.

The specific method of calculating these items is optional, but the following assumptions must be observed to determine the amounts for the Cash Flows in Figure 8.3:

No cash contributions are made by investors except those scheduled under capital investment.

In any one year all production revenues and production expenditures, including both Principal Product Revenues and Net Operating Expenses, vary directly with the operating level of the plant. Escalation is applied uniformly to both revenues and expenses.

The capital recovery costs, items 9 through 12 in Figure 8.3, include both debt and equity recovery. Income taxes, which are a function of debt retired plus equity recovered, are included in this group.

Income tax credits are claimed as they occur and may act as credit first to Debt Interest and Equity Return, then to Debt and Equity Retirement. Income tax calculations use full debt interest due.

If total revenues plus tax credits are not sufficient to cover expenses and capital recovery, the amount of the shortfall shall be added to the balance due to investors.

For the correct solution for the required selling price, the balance due to investors is zero at the end of the project. The present worth of all capital returns to investors is equal to the total investment taken at start-up date.

8.2.3 General Requirements

The calculations performed must conform to the following general requirements:

Estimates of all costs and by-product revenues shall be adjusted for the same base year.

Each annual account is considered to be a discrete end-of-year transaction. All discounting and escalation is to be done on the same basis.

Escalation of prices or cost estimates shall be applied at the full rate to each year's transaction. All cash flow transactions including construction expenditure, net operating expenses, and price of all products shall be escalated.

Investment tax credits are claimed in the year they occur. If they occur, income tax credits (when revenues are less than allowed tax deductions) are claimed in the year they occur.

Depreciation is used in computations for tax or rate base, but is not a cash flow item for these guidelines.

The project plant is assumed to operate at the capacity factor reported in Chapter 3, excepting the start-up production scheduled and shown under "Analysis Parameters" in Figure 8.1.

Estimated net retirement costs and capital recovery should be treated as occuring at the end of the last year of operation. Estimates showing a zero net may be appropriate but this should be noted in the report.

Investment capital shall be sufficient so that no cash deficits occur. This applies in particular to the start-up time.

8.2.4 General Assumptions Used in the Analysis

Two basic assumptions have been made which determine the outcome of the analysis. First, the product price is to be a single price at all times when that price will be expressed in constant-date dollars. For the base case that price will be expressed in then-current dollars and it can escalate only at the general inflation rate. Second, all changes to debt and equity investors' balance are done annually, and are made in amounts which maintain the original debt to equity ratio.

The examples cited in this guideline are for then-current dollars calculations from the point of view of a large private investor. The calculation method is the same for utilities and public authorities. However, the financial parameter values will be different. If results in constant-date dollar values are desired, a conversion using the escalation rate is recommended. This will avoid the difficulties in adjusting depreciation and tax rates. Further discussion of the guidelines method is continued with examples in Appendix D.

8.3 Sensitivity Analysis

A sensitivity analysis should be run for each of the selected parameters and other variables. The selected parameters and their test ranges are shown in Appendix E. Each sensitivity result shall show the change in the selected measure of project performance which is caused by change in that one parameter with all others held constant at the original base level. Report the parameters, ranges tested, and results in a format suggested in Figure 8.4.

Parameters may be classified as technical, locational, or financial. Technical parameters are related to the project process and include items affecting plant operation and plant construction. Locational parameters are those related to specific sites or geographical location. Financial parameters are those related to financing and prices of materials as determined by the general market.

8.4 Alternative Case Analysis

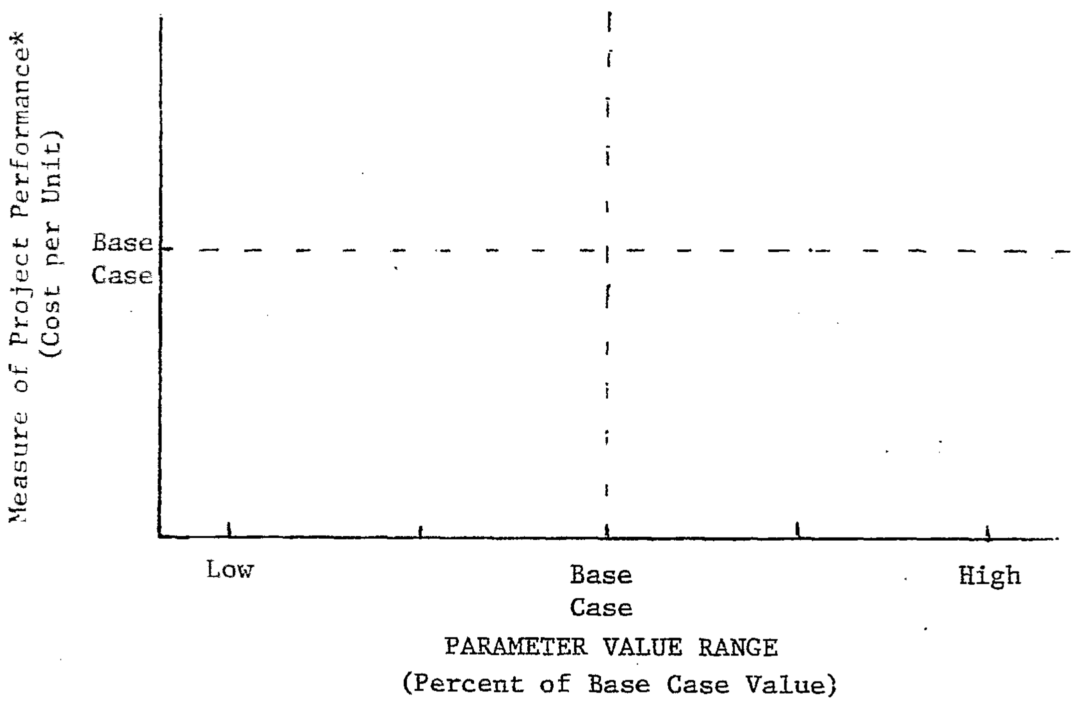
The alternative case analysis is defined here as an analysis using conditions not covered in the base case or by sensitivity analysis procedures. For example, interest on debt and return on equity could be raised and the debt to equity ratio lowered; a combination which would indicate scarcity of investment capital.

The alternative case analysis may also be used for changes in basic assumptions such as different escalation rates for product and feedstock, or for some other operating cost components. A different start-up costing procedure is another example of an alternative.

When any alternative case analysis is reported, the report should specify all assumptions and parameter values and indicate those which differ from the base case.

FIGURE 8.4

SENSITIVITY ANALYSIS



TABULATED PARAMETER VALUES AND

RESPONSE IN MEASURE OF PROJECT PERFORMANCE*

Parameter (a) Measure of Project Perf. (b)	Extreme Low	Moderate Low	Base Case	Moderate High	Extreme High
(a) (b)					
(a) (b)					
(a) (b)					
(a) (b)					

*For example, $\$/10^6$ Btu of Product, is a measure of project performance.

9.0 REPORT APPRAISAL

9.1 Purpose

The Report Appraisal is a means for the report writer to comment on results of the study, the report content and also to recommend usage, and limitations. The subjects suggested here are not intended to be a limit. The Report Appraisal should suggest any special use of value of the information in the report. In addition, limits and precautions in the use of report results should be clearly stated. Recommendations for further work may be included.

Discussion of report content in the Report Appraisal allows the reporter to interpret results of the base case study, sensitivity analysis, and selection of parameters and values.

9.2 Evaluating Parameter Specifications

These guidelines present specified parameter values and evaluation methods to be used. Some studies may have special circumstances not covered or not tested by guidelines procedures. Should this occur, the report writer should direct attention to the circumstance and evaluate its effect on the study outcome.

9.3 New Technologies and Materials

Parts of a project may require use of a technology or a material which has not been tested under expected operating conditions.

Chapters 2 and 3 call for identification of technological development of components. However, where the component is an essential part of the project a limited evaluation of alternatives for that component may be presented. If optimization studies for components were done the results of such studies should be summarized and reported.

9.4 Reporting Office or Groups' Interest in the Project

Some information about the office or groups performing the economic evaluation of the coal conversion process is useful for the report evaluation. A brief paragraph should be included which states the reporting organization's interest in the project and report. Such statements may cover work being done by the organization on similar projects, manufacture or use of materials used in the project, or potential follow-on studies, where these are known.

Apendix A

GLOSSARY

AFDC, Allowance for Funds During Construction. This is the accumulated return due on the capital investment at the time of plant start-up, assuming return rate applied to construction expenditures from payment date to start-up, or an equivalent allowance for the same.

Base Case or Baseline Study. The set of estimates, parameters and evaluation outcome for an economic evaluation of the project. It should be the estimate of the most probable outcome. It is used as a reference point in sensistivity analysis.

Battery Limit. A goegraphical boundary defining the manufacturing area of a proposed plant, including all equipment employed in the actual manufacturing process, but excluding provisions of storage, utilities, administrative buildings and other facilities which provide services used by the manufacturing plant.

Base Year. The calendar year selected for the first estimates of Capital Cost, Annual Operating Cost, and By-product Revenues. The prices used for estimates are either for that year or adjusted to it.

Capacity. The nominal plant size stated in terms of feedstock input or product output (tons/stream day as-received or dried coal, or million SCF, thousand barrels or million BTU/stream day). The term "nominal capacity per day" refers to the input or output quantity in 24-hour period if the plant operates at design capacity.

Capacity Factor (service factor). This is the expected annual production divided by the nomimal production (daily production per stream day times 365). This factor takes into account both the time the plant is operating (on-stream time or plant availability) and the capacity at which it is operated.

Cash Flow. The total of annual receipts and annual disbursements of cash for a project or project accounts, taken in annual sequence.

Constant-Date Dollar. A method of analysis where the purchasing power of the dollar remains constant. That value is determined by prices which exist on the single date selected for use in the analysis and all esitmates are adjusted to that date. The amount and year should be indicated; for example, $12,750(77).

Debt Financing. Capital investment from sources requiring a specific rate of interest and repayment terms. Bank loans and bond sales are two examples.

Depreciation. A systematic and rational way of allocating cost, less salvage value, of a tangible asset over the useful life, modified by tax regulation practices. Also, the annual amount allocated. An allocation, not valuation.

Discount Rate. The ratio of change in value of a transacted amount over a unit of time, usually expressed as percentage annually and used to determine the equivalent value over time.

Escalation. The percentage increase in one year in historic or estimated cost of equipment, materials, or labor as result of price increases.

Interest Rate. The ratio of interest payment to remaining principal for a given unit of time usually expressed as percent per year. Frequently used on a contractual basis, for exampe, savings deposits or bank loans.

Levelized Cost, Levelized Price. A goemetric series of costs or prices converted to a uniform series. As used in the guidelines, the costs or prices are the geometric series which increase at the escalation rate.

Life Cycle Costs. The stream of costs incurred by a project over its entire life from concept study through construction, operation, and retirement.

Net Salvage Value. The total of all receipts at retirement from sale of project salvage less all costs of retirement. It is part of the project capital accounting and can be positive or negative.

Parameters. A set of values of variables which determine the characteristics or behavior of something. The financial analysis parameters determine the relationship of the required prices to the cost estimates.

Process. A set of units operating together, or a single unit, which performs a defined conversion or transformation in the energy supply system. As used here, a project usually contains several processes, but may be a single process.

Project. A specific design or plan for an energy facility. This may vary from a complete unit which is part of a process to a complete energy system. (See Battery Limits.)

Required Selling Price. A calculated price which will pay all costs of production, including all operating expenses, taxes and a specified return on the capital investment. It is sometimes referred to as a minimum selling price, required revenue price, or a cost-based price.

Start-up Date. The calendar date beginning the continuous production run period for a project.

Then-Current Dollar. A dollar having the purchasing power as of the date of transaction. The amount and year should be indicated; for example, $15,500(81).

Turndown Ratio. A comparison of the minimum throughput capacity to the design capacity for the overall plant or major processor.

Working Capital. The amount of the funds in addition to fixed capital needed to meet current disbursements during the operational phase of the project. These funds cover such items as minimum cash required for smooth financial operations; raw materials, unfinished and finished project inventories; warehouse stocks of chemicals, catalysts, small tools and spare parts.

APPENDIX B

GUIDELINES CHECKLIST

This appendix summarizes the reporting requirements for an economic evaluation report based on a preliminary cost estimate. The numerical listing of items refers to chapters or articles in the guideline and is provided as a convenience to the guideline user. Where information relating to a specific item is beyond the scope of the study or the information is not known, this should be so noted. For projects utilizing processes at the concept stage of development, information relating to many of the items will be necessarily incomplete. Conversely, for a Commercial Demonstration Project, it is expected that information pertaining to each item will be fully available and the list considered a minimum for reporting and evaluation purposes.

Article No.	Description
2.1	Purpose of the Report.
2.2	Scope of facilities in one paragraph, including nominal and operating capacity.
2.3	Classification of project's stage of technical development.
2.4	Classification of cost estimate and preparation effort.
2.5	Construction, production and manpower schedules.
3.0	Project Scope. Capacity Capacity Factor Site Conditions Plant Life Feedstock Characteristics Product Specifications Thermal Efficiency Process Schematic Offsite Facilities and Utilities Plant Expansion Allowances Plant Turndown and Alternate Feedstock Capabilities Plant Manpower
4.0	Plant Design - Document the following:
4.1	Process schematic diagrams
4.2	Process flow diagrams

computation will then give a negative amount which should be treated as a credit. This implies the sponsor can apply that amount to taxes due on other programs, and claim credit for the project accounts. The algebraic treatment will remain the same.

Shortfall in Revenues.

The example shows a negative amount for the first year's change in investor's balance ΔBAL. This means revenues were insufficient to cover net expenses, interest on debt, return on equity and taxes, even though a tax credit occured. This shortfall should be distributed to debt principal retired, C_t, and equity retirement, H_t, in the regular way. No change in method is required, but debt interest and equity return should be footnoted to indicate that those amounts due are to be debited the amount of the shortfall.

Maintaining the algebraic sign in ΔBAL, as determined by the equation in Figure D.5, will correctly increase BAL by the amount of the shortfall. It also provides the correct amounts returned to debt investors $(B_t + C_t)$ and to equity investors $(S_t + H_t)$. This means $(B_t + C_t)$ and $(S_t + H_t)$ can continue to be used in present worth calculations.

The occurence of shortfall and tax credits for the project does not change the sponsor's debt service and tax obligations. It does provide an accounting method to assure the project investment return is met.

D.4 Equity Investors' Return.

The present worth of payments to debt and equity investors should equal the start-up date investment. This amount for the equity investors is the sum of the discounted values of each year's equity return plus retirement, $S_t + H_t$, taken at the equity discount rate i_s, or

$$(1 - r_d)\ (TIC) = \sum_{t=1}^{m}[(S_t + H_t)\ (1 + i_s)^{-t}]$$

The equity investor's rate of return is the value of i_s which makes the equation true. The rules established for calculating the base case are based on this relationship.

D.5 Levelized Fuel Products Price.

The levelized required price is a product price which remains uniform for the entire project life cycle. It is often used in stating the required price as determined by the utility financing method.

The levelized price or revenue is a geometric series converted to the equivalent uniform series for the discount rate selected. In the example, the principal product revenues are escalating geometrically at the escalation rate.

Mathematically, the levelized required revenues may be determined by taking the present worth of all product revenue, L_t, and converting that to equivalent uniform annual revenue.

A simpler method may be used with the data developed in the example. Use start-up date required revenue, L_o, to obtain the levelized required revenue, L', for i_p of 0.122 and j of 0.07.

$$\begin{aligned} L' &= L_o (1 + j) (P/A, i_p, j, m) (A/P, i_p, m) \\ &= 362.3 \times 1.07 \times 11.79 \times 0.136 \\ &= 619.4 \end{aligned}$$

The levelized price would have a ratio of 619.4/362.3, or 1.71, to the required price calculated for start-up time.

D.6 Payback Period.

Payback period is defined as the time required, using net revenues, to recover the initial investment at zero interest rate. Net revenues are defined as principal product revenues, L_t, less net expenses, N_t, less taxes, T_t. Mathematically it states

$$(TIC) \leq \sum_{t=1}^{x} [L_t - (N_t + T_t)]$$

where x is the minimum value that makes the inequality true. For the example $x = 7$.

D.7 Required Selling Price for Several Products

Section 8.1.5 presents the relationship required for determining required selling price for more than one major product. Where more than one product is produced, the required selling price for each product maintains a constant ratio to the required selling price of the other products. The ratio of the required revenues for each product line would also be constant. These should be based on established market price ratios in order to determine realistically the total revenue from all product lines.

The ratio of each of the product's selling price in any year, t, to its corresponding product price in a selected reference year will be the same for all major products. By maintaining the above relationships on price and revenue, plus equal escalation, the common ratio, c_t, for year t can be defined as

$$c_t = L_t/L_r$$

where L_r is a reference revenue based on the reference year prices, using the same production level for year t. If $p_{x,y}$ is the price of the xth product in year y and $Q_{x,y}$ is the quantity of product then

$$L_r = p_{1,r}\ Q_{1,t} + p_{2,t} + \ldots$$

and

$$L_t = c_t\ (p_{1,r}\ Q_{1,t} + p_{2,r}\ Q_{2,t}\ \ldots)$$

and the allocated required prices are $c_t, p_{1,r}$; $c_t\ p_{2,r}$ ... respectively. It is recommended that t be set for the start-up date (t=0) and all prices calculated accordingly. However a price for any year t may be converted to a price at start-up date by use of the escalation factors (1 + j)

$$P_0 - P_t \ (1 + j)^{-t}$$

D.8 Example Data Summary

Figure D.6 shows the Financial Analysis -- Data Summary with information developed in the example.

FIGURE D.6 EXAMPLE DATA
FINANCIAL ANALYSIS - DATA SUMMARY

Sponsor (Private/Utility) *Private*

Dollar Method (Then-current/Constant date) *Then-current*

Base Year Estimates

Dollar Year for all Base Data	1978
Estimated Construction Costs (Fig. 5.1 total)	873.4×10^6
Depreciable Plant Costs (1)	(90% TIC)
Annual Operating Costs (Fig. 6.1 total)	124.5×10^6
Annual By-product Revenue (Fig. 7.2 total)	0
Net: Operating Costs less By-products Revenue	124.5×10^6
Major Product(s) Output (2)	

Analysis Parameters

Schedules	Dates			Times, years
Construction	81	to	84	4
Operations	85	to	2004	20
Retirement	2004	to	-	0
Construction Exp. Rates (%/year) (3)	9, 25, 36, 30			

Plant Start-up Rates (% Annual Production Rate)	50,90,100 ...
Discount Rates (% per year)	
Construction Loans	
Debt Financing	10.0
Equity Financing	17.0
Overall Project Rate	
Financial Structure	
Debt (% total)	40
Equity (% total)	60
Escalation Rates (% per year)	
General Rate	7.0
Depreciation Methods	
Tax Life (years)	15
Method	SYD

Analysis Parameters (cont.)

Tax Rate and Schedules (4)	
Effective Income Tax Rate	0.50
Federal Income Tax Rate	0.46
State/Local Income Tax Rate	0.074
Effective Investment Tax Credit Rate (ITC)	0.09
ITC Claim Schedule (year, % of investment)	Yr. of occurrence
Income Tax Credit Treatment (5)	Yr. of occurrence

Base Data Adjusted to Start-up Date

Total Capitalized Investment, TIC ($)	1259.5×10^6
Depreciable Plant Investment (1)	1000.0×10^6
Annual Operating Costs	200.0×10^6
Annual By-product Revenue	0
Net Annual Operating Cost ($/year)	200×10^6
Year of Adjusted Data	1985

Analysis Results

Major Products Price ($/unit) (2)	50.19
Price Date (dollar year)	1985
Overall Project Rate-of-Return (% per year)	12.2
Equity Investors' Rate-of-Return (% per year)	17.0
Payout Period (at zero interest)	8 years
Levelized Product Price	51.81

Notes:

(1) Depreciable costs are total costs less nondepreciable items. See Figure 5.1 for items.

(2) List each product to be priced.

(3) Percentage of base year estimate.

(4) For income taxes and investment tax credits only.

(5) For cases where allowed deductable expenses exceed actual revenues.

APPENDIX E

RECOMMENDED BASE CASE PARAMETER VALUES

This appendix lists financial parameter values for use in the base case analysis. These are shown in Figure E.1. Value ranges for sensitivity analysis for six parameters are shown in Figure E.2.

The use of specified financial parameter values and the procedure in Chapter 8 are recommended to give a common basis for the financial analysis and the determination of the required price. The values specified in this appendix are the result of discussion among participants and review of data for reports on projects similar to those covered by the guidelines. Periodic updating should be done, but for the purpose of continuity a minimum period of two years is recommended.

Where the analyst believes there are more appropriate parameter values than those specified, an alternate case should be run, and results reported along with the basis for the changes as set forth in Article 8.4. Also, the alternative case approach is recommended for comparison of the project to other project studies which have already been completed and in which different values for parameters were used.

FIGURE E.1
RECOMMENDED FINANCIAL ANALYSIS PARAMETERS
FOR THE BASE CASE

Sponsor: A large investor-owned, non-utility firm. Capable of financing project and claiming tax credits as they occur.

Dollar Method: Then-Current Dollars.

Dollar Date for Base Year Estimate, 1979

Schedules	Dates	Time, Years
Construction	1981 – 1984 Incl.	4
Operations	1985 – 2004 Incl.	20
Retirement	2004	(Instant)
Construction Expenditure Rate (% year)		9/-4,25/-3,36/-2,30/-1
Plant Start-up Efficiences (% each year)		50/1,90/2,100/3, etc.
Discount Rates (% per year)		
Construction Loans		n/a
Debt Financing		10
Equity Financing		17
Financial Structure		
Debt (% total)		40
Equity (% total)		60
Escalation Rates (% per year)		
General Rate		7
Depreciation Methods		
Tax Life (years)		15
Method		SYD
Tax Rates and Schedules		
Effective Income Tax Rate		0.50
Federal Income Tax Rate		0.46
Effective Investment Tax Credit Rate (ITC), %		9%
ITC Claim Schedule & year, % of investment		Year of Occurence
Income and Other Tax Credit		Year of Occurence

FIGURE E-2

SENSITIVITY ANALYSIS
PARAMETERS

Parameter	Test Values				
	Low	Med. Low	Base Case	Med. High	High
<u>Financial</u>					
Financial Structure					
Debt (% Total)*	0	30	40	65	100
Escalation, %	4	6	7	9	12
Investment, % Base Case	90	-	100	-	200
Investment Tax Credit, %	0	-	9	-	-
<u>Locational</u>					
Coal Price $/Ton (Eastern)	17	22	25	30	40
Coal Price $/Ton	7	8	11	14	18

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4.3	Heat and material balances
4.4	Equipment design and selection listing Non-standard equipment Materials (e.g., linings, special steels, etc.) Specifications (e.g., size, type, etc.) Number of spares and operating units Package plants Power generation or source Results of trade-off studies
4.5	Waste Management Document process design, types of control technologies, toxic streams and their special safety requirements for water, air and solid emissions.
4.6	Engineering assumptions Data sources Reaction design assumptions All input and output stream flow rates and compositions Temperature (and temperature profiles, if applicable) Pressure (and pressure profiles, if applicable) Residence times for each phase Catalyst life (if catalyst required) Catalyst circulation rates (if catalysts required) Catalyst makeup rates (if catalysts required) Percent conversion or conversion efficiency (define basis) Void volumes in packed beds Expanded bed densities in fluidized beds Recirculation rates in an ebullated bed Equilibrium temperature Space velocities Superficial velocities Compositions and flow rates of all bypassing, recycle or intermediate withdrawal streams Characterization of contaminants in the reactor effulent: particulates quantity and size distribution, tars (in the case of gasification, both quantity and composition), etc. Stream physical properties of intermediate streams Other assumptions used for equipment sizing
5.1	Method of estimating capital cost Installation factors for equipment Source of equipment cost and price information Price year and escalation factors
5.2	Process and offsite purchased equipment and installation costs <u>A list of all major equipment and plant components</u>.

	Capital cost summary Land Total installed cost Paid-up royalties Initital catalyst chemicals and operating supplies Working capital Start-up cost Contractor's home office costs and fee Owner's cost Project contingency Process contingency
5.3	Construction schedule
5.4	Treatment of capital recovery
6.1	Source of price data for feed materials and other supplies Escalation and price index used
6.2	Estimates showing quantity and amount of the following annual costs: Feed materials - coal Feed materials - other Catalyst, chemicals, operating supplies Utilities and fuel Operating labor Maintenance Supervisory labor Administrative and general overhead Fringe benefits Local taxes and insurance Royalties Waste disposal
6.4	Production Schedule
7.1	Market study summary covering: Depth and scope of study Market location and types of available transportation Impact on transportation system capacity Impact of production size on market
7.2	For each by-product: Name Unit of sale Unadjusted market price, data source Adjusted price, point of sale Shipping and selling costs Price F.O.B., project site

7.3	For each by-product: Name Annual quantities Unit price Annual Revenue
8.1	Sponsor (type) Dollar method Base year date for all estimates Construction cost* Depreciable plant cost* Operating costs estimate* By-product revenues* Net expenses* *Also report adjusted estimates at start-up date Start-up date Construction schedule (dates) Operations period (dates) Retirement schedule (dates) Construction expenditure schedule, % each year Plant start-up efficiency, % each year Construction loan discount Debt interest rate Equity rate-of-return Overall project rate-of-return Debt as percentage of financing Equity as percentage of financing Escalation rate Depreciation method Depreciation period (tax life) Effective income tax rate Federal income tax rate State/local income tax rate Investment tax credit rate and schedule Income tax credit claim schedule Product price(s) and date of price Project rate-of-return realized Equity investors' rate-of-return realized Pay out period Levelized product price(s)
8.2	Year-by-year schedule of following: Capital investment Capital returns or losses on retirement Product revenues By-product revenues Feedstock expenses Other operating expenses Debt interest Debt retired Equity return and recovery

8.2	Year-by-year schedule of following: (cont.) Income taxes Depreciation
8.3	List of parameters and values for sensitivity analysis
8.4	For alternate case analysis - provide same information as 8.1, 8.2 and 8.3
9.0	Comment on: Recommended use of the report Parameter values validity New technologies and material reliability Status of the reporter

APPENDIX C

THE GUIDELINES REVIEW GROUP

When ESCOE announced the commencement of this task to prepare guidelines for estimating cost of energy projects there were several expressions of interest by individuals with knowledge and experience in dealing with this subject. An Advisory Board of seven had been formed to give a broad viewpoint, but it was apparent that the additional review would help. The Review Group members who provided review and comment are listed here. Their help has been a significant contribution and their efforts are appreciated. The final preparation and content of the guidelines, however, is the responsibility of the Task Manager.

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Appendix D

FINANCIAL ANALYSIS PROCEDURES

Appendix D gives background and examples for the financial analysis requirements of Chapter 8. This material uses the same basic calculation rules and assumptions that were set forth in that chapter. The financial analysis parameter values are taken from Figure E.1. Algebraic symbols and compound interest factors used in this appendix are shown in Figures D.1 and D.2, respectively.

D.1 Calculating Total Capitalized Cost, TIC

The examples in this discussion assume the estimated construction cost is $\$1,000 \times 10^6$, stated in prices as of start of construction date. That is shown as the base year amount in Figure D.3. The following steps are needed to complete the figure:

(1) Estimate the construction period discount rate. For private and utility financing use the overall project rate of return. This is the after tax weighted average; see the example below. For a public authority use the appropriate debt financing interest rate.

Example: After tax weighted return

Weighted return for project i_p

Effective income tax rate $f = 0.5$

Debt interest rate (10%) $i_d = 0.1$

Equity return rate (17%) $i_s = 0.17$

Debt financing ratio $r_d = 0.4$

$$i_p = (1-f) \times r_d \times i_d + (1-r_d)i_s$$

$$= 0.5 \times 0.4 \times 0.1 + (1-0.4) \times 0.17$$

$$= 0.122 \qquad (12.2\%)$$

Figure D.1

ALGEBRAIC SYMBOLS

Cash Flow Items*

B = Interest payment on debt
D = Debt principal retired
S = Equity return
H = Equity retired
L = Major product(s) revenue
N = Net operating expenses, total expenses less by-product revenues, but excluding depreciation or interest
T = Income taxes
W = Net retirement phase salvage or cost, including land and working capital

Non-Cash Flow Items*

Q = Quantity of major product(s) produced
D = Depreciation

Rates

i_d = Interest rate on debt
i_s = Rate of return on equity
i_p = Overall rate of return
j = Escalation or inflation rate

Other Variables

t = Year in a sequence, used as subscript
k = Tax life, for depreciation
m = Number of years productive operation
f = Effective income tax rate
e = Percent of annual production realized (for start-up schedule)*
c = Price coefficient**
p = Product price; may have subscripts for product number and year**
r_d = Debt financing to Total Capital Investment ratio

TIC = Total capitalized investment at start-up
BAL = Balance of unretired investment*
BV = Balance of depreciable investment, Book Value*
ECC = Estimated construction cost in base year

*Symbol is to be subcripted with t to indicate year of occurence.
**Used to allocate costs where there is more than one fuel product.

Figure D.2

COMPOUND INTEREST FACTORS DEFINITIONS AND FUNCTIONAL FORMS*

P = Present Amount (Present Worth)

F = Future Amount (Future Worth)

A = Annuity (equal annual or periodic amounts)

G = Gradient (equal linear increments)

i = Discount Factor (e.g., interest rate)

j = Exponential Increase (for inflation)

m = Number of Periods

Present Worth of a Future Amount

$$(P/F,i,m) = (1+i)^{-m}$$

Present Worth of an Annuity

$$(P/A,i,m) = [(1+i)^m - 1] / [\, i(1+i)^m]$$

Future Worth of an Annuity

$$(F/A,i,m) = [(1+i)^m - 1] / i$$

Present Worth of Gradient (beginning in second period)

$$(P/G,i,m) = [1 - (1+mi)(1+i)^{-m}]/i^2$$

Present Worth of Geometrically Increasing Annuity, (White, p. 72)

$$(P/A_1,i,j,m) = [1 - (1+j)^m(1+i)^{-m}]/(i-j);\ i \neq j$$

All factors are based on end-of-period transactions.

*Adapted from ANSI Z94.5 - 1972.

All dollars in *then-current*[a]
Escalation rate 7%

FIGURE D.3

EXAMPLE ACCOUNTS FOR TOTAL INVESTMENT ESTIMATE

($\$ \times 10^6$)

Item or Acct. No.	Description	Base Year Amount (78) / Col. No.	1	2	3	4	5
		Yr/(3)	81	82	83	84	
		Per	-4	-3	-2	-1	Start-up (Totals)
1	Scheduled Construction Estimate (not escalated)	873.44 (1000 in 1980)	(90.0)	(250.0)	(360.0)	(300.0)	
2	Escalated Estimate		96.3	286.2	441.0	393.2	1216.8
3	Investors Contribution[b]		87.6	260.5	401.3	357.8	1107.3[c]
4	Return due on Balance			10.7	43.7	98.1	152.5
5	Investors' Balance		87.6	358.8	803.9	1259.8	1259.8[d]

(a) Except row 1 is in 1980 constant-date dollars.

(b) The escalated construction estimate for the year less Investment Tax Credit, ITC.

(c) The example uses 90% of this amount as depreciable investment. This is $\$1,000 \times 10^6$.

(d) Total capitalized investment at start-up time, TIC.

(2) Scheduled construction estimate. Line 1 in Figure D.3 is an example. Allocate the base year unadjusted construction investment in accordance with the schedule of Construction Exp. Rates under Analysis Parameters in Figure 8.1. The schedule rates in percent/year specified in Figure E.1 are 9/-4, 25/-3, 36/-2, and 30/-1.

(3) Escalated estimate, line 2.
Adjust each year's scheduled construction estimate for escalation. Use an escalation factor $(1 + j)^{\Delta t}$ for escalation rate j, and time Δt from the base year of the estimate to year of construction.

(4) Investor's contribution, line 3.
Adjust each year's escalated estimate for the investment tax credit, ITC, to be claimed. This amount is the investor's net cash contribution for that year. The example uses ITC of 9%, or 0.09, and the third line is (1-0.09) times the escalated estimate.

(5) Interest on balance, line 4.
This is the interest plus return, less income tax credit due the investors. It is the overall return i_p, times the previous year's balance, $BAL_{(t-1)}$.

(6) Investor's balance, line 5.
This is the sum of the previous year's balance $BAL_{(t-1)}$, the Investor's Contribution and Interest on Balance. The balance at start-up time is the Total Capitalized Investment, TIC.

The use of the overall rate-of-return to determine interest on balance in step 5 implies that interest on debt is used in estimating an income tax credit that is claimed by the sponsor.

D.2 Principal Product Revenues Estimate

Principal Product Revenues, L_t, are the required revenues used in determining product required price. For each year the principal product revenue L_t, must cover debt interest B_t, debt retirement C_t, equity return and retirement S_t and H_t, income tax T_t and net expense N_t

$$L_t = B_t + S_t + H_t + T_t + N_t$$

where the income tax factor f is used to calculate tax T_t.

$$T_t = f\,[L_t - (N_t + B_t + D_t)]$$

The calculation methods described in this appendix require estimates of the following accounts at start-up date.

(1) Investor's Balance, BAL_o. This was determined by the procedure described above in Article D.1 and shown as an example in Figure D.3. The amount is $\$1,259.8 \times 10^6$ for the example.

(2) Depreciable Investment, or book value at start-up, BV_o was estimated in Figure D.3 as $\$1,000 \times 10^6$.

(3) Net Annual Operating Costs at Start-up, N_o.
Adjust the net annual operating cost for escalation changes between the base year date of the estimate in Figures 6.1 and 7.2 and plant start-up date indicated in Figure 8.1. This amount is also shown in Figure 8.1 under Base Data Estimates. As an example of adjustment of base year estimate in net operating cost, N_*, to a start-up value, N_o, over the period 1978 to 1985 assume Δt = 7% escalation, $j = 0.07$. Then,

$$\begin{aligned} N_o &= N_*(1+j)^{\Delta t} \\ &= 125 \times 1.07^7 \\ &= 200 \qquad \text{(A 60.6\% increase)} \end{aligned}$$

(4) Principal Product Revenue, L_o.
An approximate estimate of L_o may be obtained by the following:

$$L_o = N_o + (TIC)\,(A/P,\ i_p, m)$$

In the example:

$$\begin{aligned} L_o &= 200 + 1259.8 \times (A/P,\ 12.2,\ 20) \\ &= 200 + 1259.8 \times 0.1356 \\ &= 370.8 \end{aligned}$$

The solving value is 362.3.

D.3 Completing the Estimates for the Project Life Cycle - Cash Flow.

Figure D.4 shows the results of the example calculations for the capital investment period and four selected years during the 20-year investment period.

All dollars in then-current (1)

Escalation rate 7% (2)

FIGURE D.4 - EXAMPLE RESULTS
PROJECT LIFE CYCLE - CASH FLOW

Item or Acct. No.	Description	Base Year Amount '78 / Col No. / Yr. (3) / Per (4)	1	2	3	4	5	6	7	8	21	22
		Yr. (3)		81	82	83	84	Start-up	85	86		
		Per (4)	(Constr. Start)	-4	-3	-2	-1		1	2	15	16
	INVESTMENT & RETIREMENT											
1	*Capital investments*	816.3	1000.0	87.6	260.5	401.1	357.8					
2	*Returns from retirement*											
	PRODUCTION REVENUES											
3	*Principal product revenues*							362.3	193.9	373.4	999.7	1069.2
4	*Other revenues (By-products)*											
5	*Total revenues*											
	PRODUCTION EXPENDITURES (a)											
6	*Feedstock*											
7	*Other operating expenses*											
8	*Total expenditures*											
	CAPITAL RECOVERY & TAX											
9	*Debt interest*								50.4*	52.3*	42.8	38.9
10	*Debt principal retired*								-19.1	-7.0	39.0	48.4
11	*Equity return*								128.5*	133.4*	109.2	99.3
12	*Equity - Retirement*								-28.7	-10.5	58.5	72.5
13	*Income Tax*								-44.3	-0.8	195.4	220.2
14	*Total Cap. Recovery Cost*				10.7	43.7	98.1		86.9	167.3	447.9	479.5
	COMPUTATION ACCOUNTS											
15	*Net expenses (b)*							200	107.0	206.1	551.8	590.4
16	*Depreciation*		(900)					(1000)	125.0	116.7	8.3	0.0
17	*Investor's Balance (c)*			87.6	358.8	803.9	1259.8	1259.8	1307.6	1325.1	973.4	852.5
18	*Production level (d)*								0.5	0.9		
(a)	*Excludes all capital recovery, including interest on debt.*											
(b)	*Line 6 plus line 7, less line 4.*											
(c)	*Debt and Equity investors' unrecovered balance, includes interest and return.*											
(d)	*Show onstream capacity percent if less than 100%.*											

(1) Either "then-current" or date for constant-date dollars
(2) General rate. Indicate any different line item rates under description.
(3) Year. Calendar year is required with then-current dollar analysis.
(4) Period number with respect to plant start-up date.

*Amount due investor, adjust balance due by the amount of shortfall shown on the retirement line immediately below.

Investment and Retirement, Lines 1 and 2.

The method for obtaining the investment schedule was described in the example in Article D.1. Note in Figure D.4 that line 1, Capital Investments, shows the schedule of cash input to the project or the investor's contribution of Figure D.3. Line 14 shows the added obligation for interest and equity return less income tax credit. These two amounts are added to the previous year's balance to get the new balance on line 17. Actual construction payout is not shown, but would be line 1 plus the amount of that year's investment tax credit.

Production Revenues, Lines 3, 4, and 5.

A method for a preliminary estimate of Principal Product Revenues, L_o, was shown above. As stated in Chapter 8, any subsequent amount L_t, in year t varies directly with the inflation factor $(1+j)^t$ and production level e_t.

$$L_t = L_o (1+j)^t \times e_t$$

All revenues and expense items are treated as proportional to the plant production level and their corresponding prices are escalated at the same rate. The formula and example calculations are shown in Figure D.5.

By-products revenues is the only source of other revenues considered. The original data from Figure 7.2 should be adjusted for escalation and both amounts reported in Figure 8.1. No revenues are shown for by-products in the example in Figure D.4.

Production Expenditures, Lines 6, 7, and 8.

These expenditures have been divided into feedstock and other costs to permit sensitivity study on the former. Both data would be taken from Figure 6.1 and adjusted to start-up date. These are also treated as proportional to the plant production level and escalated at the same rate; that calculation procedure is the same as the one shown in Figure D.5 for Principal Product Revenue and for Net

Operating Expense. The example in Figure D.4 does not break out the production expenditure components.

Capital Recovery and Tax, Lines 9 - 14.

These are cash flow accounts. Their completion requires the use of the computation accounts below. The recovery of the equity investment has been broken into two accounts, return and retirement, so that any shortfall in return may be identified.

Computation Accounts, Lines 15 - 18.

These lines are computation accounts used to complete the cash flow accounts for each year and to provide other record information.

The computation for these last two sets is based on the rules set forth in Article 8.7 and the formulae presented in Article D.1.

Principal product Revenue L_t, must cover debt interest B_t, debt retirement C_t, equity return and retirement S_t and H_t, income tax T_t and net expense N_t

$$L_t = B_t + C_t + H_t + T_t + N_t$$

where

$$T_t = f\ [L_t - (N_t + B_t + D_t)]$$

Procedure for L_t has been covered above. Figure D.5 shows the formula and example computations for each of the line items.

There are two circumstances that require special consideration, income tax credit and shortfall in revenues for capital recovery. These are discussed below.

Treatment of Income Tax Credit.

As shown in the example, in the early years of operation, the allowed expenses for tax computation may be greater than income. The tax

FIGURE D.5

EXAMPLE CALCULATION FOR CASH FLOW

Line*	Item	Formula	Example t = 1	Example t = 16
3	Principal Product Revenue	$L_t=L_o(1+j)^t e_t$	$362.3\times1.07^1\times0.5$ = 193.9	$362.3\times1.07^{16}\times1$ = 1069.7
15	Net Operating Exp.	$N_t=N_o(1+j)^t e_t$	$200\times1.07^1\times0.5$ = 107.0	$200\times1.07^{16}\times1$ = 590.4
9	Debt Interest	$B_t=i_d r_d BAL_{(t-1)}$	0.10x0.4x1259.8 = 50.4**	0.10x0.4x973.4 = 38.9
16	Depreciation (SYD)	$D_t=2BV_o(k+1-t)/[k(k+1)]$	2x1000(16-1)/240 = 125.0	2x1000(16-16)/240 = 0
13	Income Tax	$T_t=f[L_t-(N_t+B_t+D_t)]$	0.5[193.9-(107+50.4+125)] = -44.3	0.5[1069.7-(590.4+38.9+0)] = 220.2
11	Equity Return	$S_t=i_s(1-r_d)BAL_{(t-1)}$	0.17(0.6)1259.8 = 128.5**	0.17(0.6)x973.4 = 99.3
-	Retire from Balance	$(\Delta BAL)=L-(N_t+B_t+T_t+S_t)$	193.9-(107+50.4-44.3+1285) = -47.8	1069.7-(590.4+38.9+220.2+99.3) = 120.9
10	Retire Debt Principal	$C_t=r_d(\Delta BAL)$	0.4(-47.8) = -19.1	0.4x120.9 = 48.4
12	Equity-Retirement	$H_t=(1-r_d)(\Delta BAL)$	0.6(-47.8) = -28.7	0.6x120.9 = 72.5
17	New Balance	$BAL_t=BAL_{(t-1)}-(\Delta BAL)$	1259.8-(-47.8) = 1307.6	973.4-120.9 = 852.5

* Line numbers as shown in Figure D.4.

** Indicate in the report that amount due must be adjusted for shortfall.

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