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PHASE IV FINAL REPORT

AND

FOURTH UPDATE

OF THE

ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

PREPARED FOR

THE U.S. DEPARTMENT OF ENERGY
(ARGONNE NATIONAL LABORATORY)
UNDER CONTRACT NUMBER 31-109-38-6411

VOLUME I OF I

BY

united engineers
& constructors inc

SEPTEMBER 1981

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September 30, 1981

Mr. L. W. Fromm
Office of International Energy
Development Programs
Building 362
Argonne National Laboratory
9700 South Cass Avenue
Argonne, IL 60439

Dear Mr. Fromm:

Subject: U. S. Department of Energy (Argonne National Laboratory)
Energy Economic Data Base (EEDB) Program-Phase IV
Contract No. 31-109-38-6411

We are transmitting herewith twenty-five (25) copies of "Phase IV Final Report and Fourth Update of the Energy Economic Data Base (EEDB) Program", dated September, 1981. By copy of this letter, these copies are distributed as indicated below, in accordance with the subject contract.

This document is the final report for work done under Phase IV of the subject contract. The report discusses the Energy Economic Data Base and presents the results of the Fourth Update of the data base, for the effective cost and regulation date of January 1, 1981. Section 4 in general, and Tables 4-1, 4-2, and 4-4, in particular, summarize the technical features and the capital, fuel and operating and maintenance costs of the 11 nuclear and alternative power generating stations in the data base.

This final report contains all of the deliverables required under the subject contract, with the exception of the CONCICE AND PEGASUS cost commodity and equipment computer printouts. CONCICE/PEGASUS cost/equipment and commodity computer printouts are bound separately because of their bulk. One (1) copy of each of 29 volumes of printouts were forwarded to Mr. R. J. Akin, ANL-GTN under cover of transmittal letter UE&C/DOE-EEDB-IV-11, dated September 4, 1981, in accordance with the subject contract.

Very truly yours,

R. E. Allen
EEDB Program Project Manager

REA/mab
Enclosures

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R. J. Akin, ANL-GTN (17)
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SECTION 1

1.0 INTRODUCTION

1.1 AUTHORIZATION

The Energy Economic Data Base (EEDB) Program, which deals with the development of cost data for nuclear and comparison electric power generating stations, is authorized by the U.S. Department of Energy (USDOE) and funded under Argonne National Laboratories (ANL) Contract Number 31-109-38-6411 with United Engineers & Constructors, Inc.

1.2 OBJECTIVE

The objective of the USDOE EEDB Program is to provide periodic updates of technical and cost (capital, fuel and operating and maintenance) information of significance to the U.S. Department of Energy. This information is intended to be used by USDOE in evaluating and monitoring U.S. Civilian nuclear power programs, and to provide them with a consistent means of evaluating the nuclear option and proposed alternatives.

1.3 THE FOURTH UPDATE

In achieving the objective of the EEDB Program, the first-order task of assembling the data base itself and of providing the Initial Update (1978) is complete. The second order task of providing periodic updates is initiated with the Second Update (1979) and continued with the Third Update (1980). This report presents the Fourth Update of the EEDB for a cost and regulation date of January 1, 1981, prepared during Phase IV of the EEDB Program.

The intent of the format and structure of this and prior reports is to provide a historical record of the evolution of the data base cost estimates and to provide convenience to the user. Therefore, the organization of the first report is retained and the important descriptive and tutorial information concerning the structure and use of the EEDB, is repeated. This should minimize the necessity to refer to previous reports in the use of this report but simplify such reference when it is required.

The data tables, which make up the bulk of the report, are updated to January 1, 1981. The data in these tables and in the backup data file, described in Section 2, supercede the information presented in the Third Update (1980). Where required, new descriptive information is added in the text to supplement the data tables.

1.4 CHANGES TO THE DATA BASE FOR THE FOURTH UPDATE

In general, the Fourth Update is a data base maintenance effort, because of a reduced availability of resources during FY 1981. This effort is consistent with and an extension of the major refinements made in the Third Update (1980). Specifically, the following activities are pursued in the Fourth Update, to improve the overall quantity of the data base:

a. Individual components of the data base are reviewed for technical adequacy and internal consistency.

b. Adjustments are made to the Nuclear Power Generating Station (NPGS) Technical, Capital Cost, and Operating and Maintenance Cost Models to reflect the lessons learned from the Three-Mile Island NPGS incident of March 28, 1979.

c. Modifications initiated in the Third Update, to improve the technical consistency of the PHWR and LMFBR, are continued in the Fourth Update.

d. Modifications initiated in the Third Update, to improve the technical adequacy of piping systems that are major cost drivers in various technical models, are continued in the Fourth Update.

e. Capital, Fuel, and Operating and Maintenance Costs are adjusted to reflect the results of the activities listed in paragraphs "a" through "d" above and are updated to January 1, 1981.

A more detailed discussion of each of these changes appears at the appropriate place in the text of this report.

1.5 DATA BASE COMPONENTS

Currently, the EEDB contains six nuclear power generating station (NPGS) technical models and five comparison coal-fired fossil power generating station (FPGS) technical models. Each of these technical models is a complete, detailed, conceptual design for a single unit, steam electric power generating station located on a standard, hypothetical "Middletown" site. Tables 1-1 and 1-2 list respectively the six nuclear and five comparison electrical power generating stations and their associated capabilities. A description of the "Middletown" site is provided in Appendix A-1 for nuclear plants, and Appendix A-2 for coal-fired plants.

Technical models and capital costs for these plants are based on evaluation of related capital cost studies prepared for the U.S. Department of Energy and its predecessor agencies, the Energy Research and Development Administration (ERDA) and the Atomic Eenrgy Commission (AEC), and for the Nuclear Regulatory Commission, (NRC) and its predecessor agency, the Atomic Energy Commission, over the last 18 years. In addition, other studies, prepared for various government agencies and other organizations, also contribute to the development of the capital, fuel, and operating and maintenance (O&M) costs data presented in this report. The Base Studies and Reports, from which this Fourth Update has evolved for the technical and capital, fuel and O&M cost data, are tabulated in Tables 1-3, 1-4, and 1-5. These and other associated studies and reports are tabulated more specifically in the list of references included in Section 8.

1.6 ORGANIZATION OF THE REPORT

Section 2 of this report provides a description of the current Data Base, as of September 30, 1981. In Section 3, assumptions and groundrules for this cost update are identified. Section 4 summarizes the Fourth Cost Update, with cost results summarized in Tables 4-4, 4-5, and 4-6. Section 5 presents the details of the Fourth Update of the technical conceptual design, the capital cost, the quantities of commodities and their unit costs, and the craft labor manhours and costs for each EEDB Program model. Section 6 and 7 describe the details of the Fuel Cost Fourth Update and the Operating and Maintenance Costs Fourth Update, respectively. Section 8 contains a glossary of acronyms and abbreviations used in this report, as well as the complete list of references cited above.

TABLE 1-1

ENERGY ECONOMIC DATA BASE

FOURTH UPDATE
NUCLEAR POWER GENERATING STATIONS

EEDB Model Number	Plant Type	Net Capacity
A1	Boiling Water Reactor Plant (BWR)	1190 MWe
A2	High Temperature Gas Cooled Reactor Plant - Steam Cycle (HTGR-SC)	858 MWe
A3	Pressurized Water Reactor Plant (PWR)	1139 MWe
A4	Pressurized Heavy Water Reactor Plant (PHWR)	1260 MWe
B1	High Temperature Gas Cooled Reactor Plant - Process Steam (HTGR-PS)	150 MWe
A5	Liquid Metal Fast Breeder Reactor Plant (LMFBR)	1457 MWe

TABLE 1-2

ENERGY ECONOMIC DATA BASE

FOURTH UPDATE
COMPARISON POWER GENERATING STATIONS

EEDB Model Number	Plant Type	Net Capacity
C1	Comparison High Sulfur Coal Plant (HS12)	1240 MWe
C2	Comparison High Sulfur Coal Plant (HS8)	795 MWe
C3	Comparison Low Sulfur Coal Plant (LS12)	1244 MWe
C4	Comparison Low Sulfur Coal Plant (LS8)	795 MWe
D1	Comparison Coal Gasification Combined Cycle Plant (CGCC)	630 MWe

Effective Date - 1/1/81

TABLE 1-3

ENERGY ECONOMIC DATA BASE

TECHNICAL AND CAPITAL COST MODELS BASE DATA STUDIES AND REPORTS

EEDB Model Number	Model Type	Base Data Study or Report*
A1	BWR	Commercial Electric Power Cost Studies - Capital Cost - Boiling Water Reactor Plant (NUREG-0242, COO-2477-6)
A2	HTGR-SC	The HTGR for Electric Power Generation - Design and Cost Evaluation (Gas Cooled Reactor Associates - GCRA/AE/78-1)
A3	PWR	Commercial Electric Power Cost Studies - Capital Cost - Pressurized Water Reactor Plant (NUREG-0241, COO-2477-5)
A4	PHWR	Conceptual Design of a Large HWR for U.S. Siting (Combustion Engineering, Inc. - CEND-379)
B1	HTGR-PS	1170 MWt HTGR Steamer Cogeneration Plant - Design and Cost Study (UE&C/DOE - 800716)
A5	LMFBR	NSSS Capital Costs for a Mature LMFBR Industry and Addendum (Combustion Engineering, Inc. - CE-FBR-78-532 & CE-ADD-80-310
C1	HS12	Commercial Electric Power Cost Studies - Capital Cost - High and Low Sulfur Coal Plants - 1200 MWe (Nominal) (NUREG-0243, COO-2477-7)
C2	HS8	Commercial Electric Power Cost Studies - Capital Cost - Low and High Sulfur Coal Plants - 800 MWe (Nominal) (NUREG-0244, COO-2477-8)
C3	LS12	Same as EEDB Model C1
C4	LS8	Same as EEDB Model C2
D1	CGCC	Study of Electric Plant Applications for Low Btu Gasification of Coal for Electric Power Generation (FE-1545-59)

* Refer to Section 8.1 for additional details

TABLE 1-4

ENERGY ECONOMIC DATA BASE

FUEL COST MODELS
BASE DATA STUDIES AND REPORTS

EEDB Model Number	Model Type	Base Data Study or Report*
A1	BWR	a. Commercial Electric Power Cost Studies - Fuel Supply Investment Cost: Coal and Nuclear (NUREG-0246, COO-2477-10) b. Commercial Electric Power Cost Studies - Total Generating Costs: Coal and Nuclear Plants (NUREG-0248, COO-2477-12) c. Fuel Cost Projections (NUREG/CR-1041) d. Fuel Cost Estimates for LWR, HTGR CANDU Type HWR, LMFBR and GCFR (NUS-3190)
A2	HTGR-SC	
A3	PWR	
A4	PHWR	
B1	HTGR-PS	
A5	LMFBR	
C1	HS12	
C2	HS8	
C3	LS12	
C4	LS8	
D1	CGCC	Study of Electric Plant Applications for Low Btu Gassification of Coal for Electric Power Generation (FE-1545-59)

* Refer to Section 8.1 for additional details

TABLE 1-5

ENERGY ECONOMIC DATA BASE

OPERATING AND MAINTENANCE COST MODELS
BASE DATA STUDIES AND REPORTS

EEDB Model Number	Model Type	Base Data Study or Report*
A1	BWR	A Procedure for Estimating Nonfuel Operating and Maintenance Costs for Large Steam-Electric Power Plants; ORNL/TM-6467
A2	HTGR-SC	Guidelines for Estimating Nonfuel Operating and Maintenance Costs for Alternative Nuclear Power Plants; ORNL/TM-6860
A3	PWR	Same as Model A1
A4	PHWR	Same as Model A2
B1	HTGR-PS	Same as Model A2
A5	LMFBR	Same as Model A2
C1	HS12	Same as Model A1
C2	HS8	Same as Model A1
C3	LS12	Same as Model A1
C4	LS8	Same as Model A1
D1	CGCC	Same as Model A1

* Refer to Section 8.1 for additional details

SECTION 2

2.0 DESCRIPTION OF THE ENERGY ECONOMIC DATA BASE

2.1 PURPOSE, CONTENTS AND USE OF THE DATA BASE

The economics of the nuclear option have been examined for years and many comparisons have been attempted. Some investigators have demonstrated that the nuclear option can compete with alternatives, while others have concluded the opposite. It is difficult to draw broad conclusions about the nuclear option and its alternatives from these studies, because it is often not clear under what circumstances the nuclear option is or is not competitive with alternatives. This uncertainty occurs because of conflicting claims, low visibility of study groundrules and assumptions, and differences or inconsistencies in what is included in the costs of the options that are compared.

In order to assess the economic viability of the nuclear option in a reasonable manner, relative energy costs must be evaluated for a variety of nuclear and alternative power generating stations on a common and consistent basis. The Energy Economic Data Base (EEDB) Program meets this objective for nuclear and comparison coal alternatives.

The EEDB contains capital, fuel and operating and maintenance costs for different types of nuclear and comparison coal-fired power generating stations. Each cost estimate is based upon a detailed technical model which includes system design descriptions for over 400 systems, a detailed equipment list containing over 1250 mini-specifications and up to 10,000 lines of commodity, material and equipment quantities, labor hours and costs. The technical models are based on actual power plant designs and over 50 years of power plant design and construction experience. Site related factors are normalized by locating each technical model on a common hypothetical "Middletown" site, for which there is a detailed written, geological and environmental description (refer to Appendices A1 and A2).

Costs are given in constant (inflation-free) dollars of the date of the estimate. The EEDB user may make credible cost comparisons among alternatives based on the data as presented. Additionally, the baseline data may be used to develop comparable and reliable life cycle costs and cash flow requirements, through the uniform application of the required factors, such as contingency and allowance for funds used during construction.

The EEDB approach promotes greater understanding and acceptance of comparisons, because all components of "bottom-line" numbers in the different estimates are readily identified. Consequently, differences or similiarities in compared alternatives may be identified as controllable or uncontrollable costs, as inflationary costs or as discretionary costs. The depth of detail furnished is the key to providing the necessary consistency to allow comparison of commodities and components among diverse alternatives and, thereby, to determine the reasons for cost differences.

2.2 SELECTION OF TECHNICAL MODELS FOR THE DATA BASE

Selection of power generating station types and associated fuel cycles to be included in the EEDB is based on the USDOE objectives discussed in Section 1 and the availability of existing cost information.

Nuclear power generating station types are selected to provide a cross-section of current and developing technology experience in the United States. Current technology experience is represented by light water reactor (LWR) power generating stations of intermediate capacity. Converters and breeders are included to represent high potential developing technologies.

Cross Section of Nuclear Technology Experience (See Table 1-1)

Current Technology	Developing Technology	
Light Water Reactors	Converters	Breeder
PWR	HTGR	LMFBR
BWR	PHWR	

Other plant types are selected to provide alternatives for comparison with the nuclear plant types. Current technology experience is represented by coal-fired power generating stations of appropriate size, including plants which burn either high sulfur or low sulfur coals. A coal gasification combined cycle plant is included to provide a basis for comparison to developing technologies.

Cross Section of Comparison Technology Experience (See Table 1-2)

Current Technology		Developing Technology
High Sulfur Coal	Low Sulfur Coal	
800 MWe	800 MWe	Coal Gasification Combined Cycle
1200 MWe	1200 MWe	

Fuel cycles are selected for the nuclear power generating stations that represent current technology and policies. The LWR's and converters are provided with "throwaway" fuel cycles, while the breeders are provided with plutonium recycle fuel cycles.

2.3 COMPOSITION OF THE DATA BASE

The data base is composed of the following five elements for each of the power generating stations listed in Tables 1-1 and 1-2:

a. A Technical (Conceptual Design) Model

b. A Capital Cost Model

c. A Fuel Cycle Cost Model

d. An Operating and Maintenance Cost Model

e. A Back-up Data File

2.3.1 Technical Models

The Technical Models are detailed conceptual descriptions of the plants in the data base, and appear in the Base Data Studies and Reports referenced in Table 1-3. They provide the basis for the level of detail found in the capital cost models and, consequently, to the degree of accuracy for the comparative results reported in the data base.

Each Technical Model is composed of:

a. Heat Cycle Diagram

b. Major System Flow Diagrams

c. Electrical One Line Diagram

d. Plot Plan

e. Major Building and Equipment Arrangement Drawings

f. Detailed Equipment List

Revision of the detailed equipment lists is the means for updating the technical models in the data base. The diagrams, plans and drawings in the base data studies and reports serve as resources for support of the equipment list revisions.

2.3.1.1 Equipment Lists

The detailed equipment lists are developed from PEGASUS (Power Plant Economic

Generator and Scale-Up System), a proprietary computer program of United Engineers & Constructors Inc. of Philadelphia, PA. PEGASUS utilizes an expanded Code-of-Accounts derived from "Guide for Economic Evaluation of Nuclear Reactor Plant Design," USAEC Report NUS-531 (1969), developed for the U.S. Atomic Energy Commission (now Department of Energy and Nuclear Regulatory Commission) by NUS Corporation of Rockville, MD.

The PEGASUS program tabulates engineering data, which describes the equipment and material used in the plant design and their quantities. This is accomplished through use of a mini-specification of standardized format developed for each account in the equipment listing. Mini-specifications are not used for material (e.g., concrete) listings. Samples of two mini-specifications, one for a circulating water pump and its motor and one for medium voltage electrical switchgear, are provided in Tables 2-1 and 2-2.

Additionally, the PEGASUS program contains unit cost data for material and equipment and associated labor data, such as craft manhours, composite craft mixes and craft labor rates. PEGASUS also has the capability of developing technical models for various capacity plants by scaling a known plant capacity model, in accordance with the procedure described in Section 4.

PEGASUS, as the basic Technical Model in the Data Base, directly supports the Capital Cost Models as discussed in Section 2.3.2.

2.3.1.2 Maturity of Technical Models

The structure of the expanded cost Code-of-Accounts, used in the Equipment List, permits the degree of detail entered in the model to vary according to the amount of information that is available. Consequently, mature models, where considerable information is available, are detailed to the "nine-digit" level, whereas less mature models are detailed to the "three-digit" or summary level. Table 2-3 shows the significance of the various levels of detail, as related to the information provided. Nuclear power generating station models detailed to the "nine-digit" level, contain approximately 10,000 lines of information, while comparison power generating station models detailed to the same level, contain approximately 5,000 lines of information. The difference is primarily due to the greater complexity and redundancy of systems in the nuclear power generating station models.

The current update of the EEDB contains technical models of varying degrees of detail. In Tables 1-1 and 1-2, the "A" and "C" models are detailed to the "five-digit" to "nine-digit" levels, and the "B" and "D" models to the "three-digit" or summary level.

2.3.2 Capital Cost Models

The Capital Cost Models for the plants in the data base are developed from CONCICE (CONceptual Construction Investment Cost Estimate), a proprietary computer program of United Engineers & Constructors Inc. of Philadelphia, PA. The CONCICE program utilizes extensive technical and unit cost data from PEGASUS, by means of an interface program, to develop capital cost models. Consequently, the more detailed the Technical Model in PEGASUS, the more detailed the Capital Cost Model developed by CONCICE can be. CONCICE is similar to and compatible with the U.S. Department of Energy CONCEPT code, as illustrated in Table 2-4.

CONCICE contains information for each account in the Technical Model in terms of Factory Equipment, Site Labor and Site Material costs. It categorizes these accounts into Direct and Indirect capital costs, and sums them into a total Base Construction Cost. Table 2-5 illustrates a typical CONCICE Capital Cost Model for a Boiling Water Reactor Plant at the "two-digit" level. When required, the CONCICE computer program can provide a number of economic analyses of the cost models in the data base, as follows:

a. Comparative Economics

b. Cost Projections

c. Cost Analysis

d. Cash Flow Analysis

e. Trend Analysis

f. Parametric Analysis

2.3.3 Fuel Cost Models

Two different fuel cost models are utilized in the EEDB; the Nuclear Fuel Cycle Cost Model and the Coal Fuel Cost Model. The two models are structured differently, as follows:

a. The nuclear fuel cycle model covers a complete reactor fuel cycle from mining of uranium ore through reprocessing of irradiated fuel, recovery of uranium, plutonium or thorium from spent fuel and shipment of high level waste to permanent storage.

b. The coal fuel model includes only the mining of coal and transportation to its point of use. Storage and disposal of wastes are accounted for in the coal plant Operating & Maintenance Cost models.

2.3.3.1 Nuclear Fuels

Nuclear fuel cycle costs are developed from the EEDB Approximation Factors Method (AFM). The AFM generally follows the methodology presented in "Guide for Economic Evaluation of Nuclear Reactor Plant Designs," USAEC Report NUS-531 (1969) and "Fuel Cycle Cost Estimates for LWR, HTGR, CANDU Type HWR, LMFBR and GCFR", Initial Update Report NUS-3190 (1978).

Nuclear fuel cycle costs for the EEDB Initial Update are based on cost analyses performed by NUS Corporation (NUS) of Rockville, Maryland, under contract to United Engineers. The current update of the nuclear fuel cycle costs extends the work done in the initial and succeeding updates by following a similar methodology, but utilizing data from more recent reports. Recent market costs are taken from "Fuel Cycle Cost Projections", NUREG/CR-1041 published by Batelle Pacific Northwest Laboratory in December, 1979. Mass flow data are taken from "Nuclear Proliferation and Civilian Nuclear Power Report of the Non-Proliferation Alternative Systems Assessment Program (NASAP)", DOE/NE-0001/9, Volume IX, published by USDOE in June, 1980.

The utility economics of using nuclear fuel for the generation of electricity is simulated by:

a. Providing Direct costs for materials, processes, and services as input.

b. Estimating Indirect costs by an "interest rate" approach which is derivable from a discounted cash flow approach.

The input values for direct costs are selected and adjustments are made to reflect the time-value of money spent before and after utilization of the fuel in the reactor. The net direct costs are amortized in proportion to the amount of energy generated over a fixed calendar time (usually one year). Indirect costs are treated like an interest cost on borrowed money. Such an interest rate may be considered as the composite cost of money, including such parameters as borrowing costs and the rate of return on equity and taxes.

The fuel cycle costs, both direct and indirect, are levelized over a 30-year period using an appropriate discount rate, as stated in the groundrules.

The input nuclear fuel cost components are given with appropriate account designations as unit costs by calendar years, shown typically in Table 2-6. The output nuclear fuel costs are given as 30-year levelized costs in cost per energy unit for appropriate account designations, shown typically in Table 2-7.

2.3.3.2 Coal

The costs of coal as fuel are based on a number of complicating factors which strongly affect the costs to the user. The preponderant coal cost factors are mine-mouth costs and transportation costs.

The quality of coal, as regards both heating value and sulfur content, influences the cost of use, but is so dependent on site specific factors that generalizations are not attempted. Typical costs for high and low sulfur content coals shipped to the representative "Middletown" site are derived, with the extraction and the transportation costs given explicity. The reagent cost for desulfurization products, are traditionally charged against operation and maintenance rather than attributed to the fuel costs. In the EEDB, these costs are included in the appropriate Operating and Maintenance Cost Models.

2.3.4 Operating and Maintenance Cost Models

The Operating and Maintenance (O&M) Cost Models in the EEDB are based on the Oak Ridge National Laboratory report ORNL/TM-6467, "A Procedure for Estimating Nonfuel Operation and Maintenance Costs for Large Steam-Electric Power

Plants." The cost estimating procedure involves the application of empirical functions that represent historical cost experience plus new factors arising from regulatory and economic considerations.

Oak Ridge National Laboratory (ORNL) provides O&M data in the form of staffing and material requirements for each of the EEDB technical models. The O&M costs are generated by OMCOST, a digital computer program developed by ORNL, based on the procedures given in report ORNL/TM-6467.

Although the intent is not to reflect specific operating philosophy or experience, data from published and private sources are examined to insure that the reference plants are realistic. Factors considered in formulating guidelines are plant design, staff training, personnel motivation, outage planning, regulatory provisions, operating load, hours of service, and number of outages and startups.

Tables 2-8 and 2-9 are typical outputs from the OMCOST program with a standard set of accounts for nuclear and fossil power generating stations.

2.3.5 EEDB Back-up Data File

The Back-up Data File contains all of the information and documentation acquired or developed, including the documents listed in Tables 1-3 through 1-5, for the successive updates to produce the data contained in the Data Base Reports. In the interest of keeping the EEDB reports to a manageable size, the following information is omitted from the reports, but is included in the Back-up Data File:

a. Technical Data, including the detailed Equipment Lists, other than the Base Parameter Summaries.

b. Capital Cost Data below the three-digit level.

c. Inflated Operating and Maintenance Cost Data.

d. Resource Data, including all of the documents listed in Tables 1-3, 1-4, and 1-5 and in Section 8.1.

Questions concerning information contained in the Back-up Data File may be addressed to:

United Engineers & Constructors Inc.
30 South 17th Street
P.O. Box 8223
Philadelphia, PA 19101

Attention: R. E. Allen
EEDB Program Project Manager
(215) 422-3734

2.4 APPROACH TO PRESENTATION OF COST DATA

The capital, fuel and operating and maintenance costs developed and presented in the EEDB reports are in constant January 1 dollars of the year covered by the report. The objective is to present comparable baseline costs in the three cost areas of interest that are unencumbered by controversial factors, such as the effects of future inflation, and non-uniform factors, such as costs arising from owner options or utility system configuration. The user of this data may add whatever factors may be desired to the base costs, in order to make reliable comparisons based on unique requirements. This approach promotes greater understanding and acceptance of disputed comparisons, because all components of "bottom-line" numbers are readily identified. Consequently, differences or similarities in compared alternatives may be identified as base costs, inflationary costs or preferential costs. Where comparisons are made of the capital costs of the various alternatives, unit costs, based on tabulated quantities of commodities, can be compared as credibility checks.

2.4.1 Items Not Included in Capital Cost Data

Preferential and utility system related cost components that are NOT included in the capital cost data presented in this report are tabulated in Table 2-10. Many of these non-uniform cost factors are dependent on the choice of the owner rather than on the intrinsic characteristics of the plant. These cost factors, especially those which are related to the time-value of money, are significant fractions of the total costs involved. Because of the variability of these cost factors, they are deliberately excluded from the costs presented herein.

The user of the EEDB may include these costs by making a consistent application of the necessary adders and multiplying factors to the Base Construction Costs for the alternatives of interest. Information related to owner's costs appear in NUREG-0248, "Commercial Electric Power Cost Studies - Total Generating Costs: Coal and Nuclear Plants."

2.4.2 Inflation, Escalation and Discount Rates

Certain time-value terms are used in the EEDB Program. These terms are defined as follows in accordance with their usage in the EEDB:

Inflation Rate (i) - the rate at which the average price of all goods and services in the economy increases.

Escalation Rate (e) - the rate at which the price of a commodity or service increases, independent of any changes due to inflation.

Real Interest Rate (r) - the rate above inflation that is required to attract investment.

Discount Rate (d) - the opportunity cost of capital seen by a firm when used in finding the present value of a series of future cash flows, where $d = (1 + i)(1 + r) - 1$.

Levelized Cost (C_L) - a constant annual cost of a commodity or service over the lifetime of a facility, in which the commodity or service is utilized, whose stream of payments has a present value equal to the present value of the actual or predicted annual costs (which may be variable) of the commodity or service over that period.

The capital, fuel and operating and maintenance costs are developed on an inflation-free (constant dollar) basis for the EEDB. Therefore, the inflation rate is zero ($i = 0$) for these cost components. The scarcity of material is negligible for capital and operating and maintenance costs, but may be significant for the cost of coal and nuclear fuels. Therefore, escalation for scarcity is considered to be zero ($e = 0$) for capital and operating and maintenance costs, but equal to or greater than zero ($e \geq 0$) for coal and nuclear fuel costs.

2.4.3 Total Generating Costs and Life Cycle Costs

The base capital, fuel and operating and maintenance costs in this report cannot be summed directly to obtain Total Generating and Life Cycle Costs. A simple summation of the capital, fuel, and operating and maintenance constant dollar unit costs can only give cost data which are useful for comparison of the relative costs of alternatives. These totals are not intended to represent the Total Generating or Life Cycle Costs.

To prepare Total Generating and Life Cycle Costs from data in this report, the excluded items described in paragraph 2.4.1 and the effects of inflation discussed in paragraph 2.4.2, must be combined with the base costs presented herein, in accordance with consistent and documented groundrules and assumptions. Preparation of Total Generating Costs and Life Cycle Costs is beyond the scope of the EEDB Program.

TABLE 2-1

ENERGY ECONOMIC DATA BASE

MINI-SPECIFICATION - CIRCULATING WATER PUMP
(Cost Basis 01/80)

PROG. CM-711 •PEG030•

EQUIPMENT LIST - REPORT 1

MODEL 148 - 1139 MWE/3425 MWT PWR - 2.5 IN HG AV - MIDDLETOWN,USA

ACCOUNT NUMBER	ITEM	DESCRIPTION	
262.1211	CIRCULATING WATER PUMP+MTR		
262.12111	CIRC WATER PUMP	QUANTITY	4 X 25 PCT
		TYPE	MIXED FLOW
		ORIENTATION	VERTICAL
		FLOW RATE	147,500 GPM
		SPEED	320 RPM
		TDH	105 FT
		BHP	4,414 HP
		NPSH	30 FT
		EFFICIENCY	88.6 PCT
		DESIGN PRESS	150 PSIA
		DESIGN TEMP	100 F
		MATERIAL	NI-RESIST COL. AND BOWL S.S. IMPELLER
		SAFETY CLASS	NNS
		SEISMIC CAT.	NONE
		DESIGN CODE	
262.12112	CIRC WATER PUMP MOTOR	QUANTITY -	4 X 25 PCT
		TYPE -	AC INDUCTION
		HORSEPOWER	5,000 HP
		SPEED	320 RPM
		VOLTAGE	13.2 KV, 3 PHASE, 60 HZ

TABLE 2-2

ENERGY ECONOMIC DATA BASE

MINI-SPECIFICATION - CIRCULATING WATER PUMP SWITCHGEAR
(Cost Basis 01/80)

PROG. CM-711 *PEG030*

EQUIPMENT LIST - REPORT 1

MODEL 148 - 1139 MWE/3425 MWT PWR - 2.5 IN HG AV - MIDDLETOWN,USA

ACCOUNT NUMBER	ITEM	DESCRIPTION
241.2131	NON-CLASS 1E 4.16 KV	TWO 4.16 KV BUSES CONSISTING OF INDOOR METAL CLAD SWITCHGEAR : NOMINAL VOLTAGE : 5 KV NOMINAL MVA CLASS : 350 MVA CONTINUOUS CURRENT - INCOMING LINE ACB : 1200 A FEEDER ACB : 1200 A BUS : 1200 A RATED SHORT CIRCUIT CURRENT: 41000 A. RMS@4.76 KV INTERRUPTING TIME : 5 CYCLES CLOSING AND LATCHING CAPABILITY : 78000 A, RMS QUANTITIES - INCOMING LINE : 4 FEEDER : 17 SPACE : 2 PT COMP'TS : 2 EACH BUS IS COMPLETE WITH METERING, PROTECTIVE RELAYING, AND CONTROL LOGIC

TABLE 2-3

ENERGY ECONOMIC DATA BASE

CODE OF ACCOUNTS
EXAMPLE OF LEVELS OF DETAIL

No. of Digits	No. of Account	Name of Account	Function/Level
2	26	Main Condenser Heat Rejection System	Name/Account
3	262	Mechanical Equipment	Name/Sub-Account
4	262.1	Heat Rejection System	Name/System
5	262.15	Main Cooling Twoer Make-up and Blowdown System	Name/Sub-System
6	262.151	Make-up Water System	Name/Sub-Sub-System
7	262.1511	Rotating Machinery	Class/Equipment Category
8	262.15111	Make-up Pump and Motor	Class/Equipment Sub-Category
9	262.151111	Make-up Pump	Class/Component

Note: The final account, in this case the 9th digit, is the line item where specific equipment and material technical and/or cost information is recorded. At levels above the 9th digit, cost information is collected from lower level accounts and recorded as the summation of the lower level accounts. Depending on the complexity of the system, or the level of detail available, the final account may appear at any digit level from the 5th digit to the 9th digit.

TABLE 2-4

ENERGY ECONOMIC DATA BASE

RELATIONSHIP OF "CONCEPT" TO "CONCICE"

"CONCEPT" PROGRAM EVOLUTION		DATA BASE INCORPORATED INTO "CONCICE" PROGRAM
Year of Publication	Name	
1971	CONCEPT I	EXPERIMENTAL VERSION
1973	CONCEPT II	WASH 1230
1974 (Unpublished)	CONCEPT III	WASH 1345
1975	CONCEPT IV	WASH 1345 MODIFIED
1978/1979	CONCEPT V	NUREG 0241 THROUGH 0248 AND EEDB-I (1978)
1981 (Unpublished)	CONCEPT V	EEDB-II (1979) AND EEDB-III (1980)

Notes: 1. The numbers used in CONCEPT II are those developed in WASH 1230, and similarly for each succeeding CONCEPT.
2. CONCEPT V cost models are revised annually as EEDB updates are completed and released.

TABLE 2-5

ENERGY ECONOMIC DATA BASE (EEDB)
UNITED ENGINEERS & CONSTRUCTORS INC.
EXAMPLE OF TWO-DIGIT LEVEL COST ESTIMATE
1190 MWe Boiling Water Reactor

SUMMARY PAGE - 1

PLANT CODE 201   COST BASIS 01/80

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,614,000	2,614,000
21 .	STRUCTURES & IMPROVEMENTS	5,948,078	8622946 MH	119,192,472	62,838,649	187,979,199
22 .	REACTOR PLANT EQUIPMENT	142,955,969	2947200 MH	45,524,161	12,239,234	200,719,364
23 .	TURBINE PLANT EQUIPMENT	129,929,083	2651597 MH	40,221,462	7,964,066	178,114,611
24 .	ELECTRIC PLANT EQUIPMENT	22,966,220	2128879 MH	29,751,797	9,356,756	62,074,773
25 .	MISCELLANEOUS PLANT EQUIPT	9,556,111	483240 MH	7,405,770	1,563,436	18,525,317
26 .	MAIN COND HEAT REJECT SYS	20,775,764	487365 MH	7,039,313	1,769,782	29,584,859
	TOTAL DIRECT COSTS	332,131,225	17321227 MH	249,134,975	98,345,923	679,612,123
91 .	CONSTRUCTION SERVICES	49,907,710	2851800 MH	41,025,600	35,453,000	126,386,310
92 .	HOME OFFICE ENGRG.&SERVICE	156,465,100				156,465,100
93 .	FIELD OFFICE ENGRG&SERVICE	70,613,400			2,744,500	73,357,900
	TOTAL INDIRECT COSTS	276,986,210	2851800 MH	41,025,600	38,197,500	356,209,310
	TOTAL BASE COST	609,117,435	20173027 MH	290,160,575	136,543,423	1,035,821,433

Effective Date: January 1, 1980
(1) System : PWR-U5(LE)/U-T
Start Up : January 1, 1987

TABLE 2-6

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

Account No.	Account Description	Units	1987	1992	1997	2002	2007	2012	2017
			SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS)						
.10	Initital Fuel Loaded	$/KgH							
.11	Uranium Supply	$/KgU							
.111	U_3O_8 Supply	$/lb U_3O_8	43	43	44.1	53.0	64.4	78.4	88.2
.112	UF_6 Conversion Services	$/KgU as UF_6	5.7	5.7	5.7	5.7	5.7	5.7	5.7
.113	Enrichment Services	$/SWU	99	105.6	116.6	123.2	124.3	123.2	122.1
.114	Depleted U Supply	$/KgU							
.12	Plutonium Supply	Parity value							
.13	U-233 Supply	Parity value							
.14	Thorium Supply	$/KgH							
.20	Fabrication	$/KgH	132	134.2	134.2	134.2	133.1	132	135.3
.21	Core Fabrication	$/KgH							
.22	Axial Blanket Fabrication	$/KgH							
.23	Radial Blanket Fabrication	$/KgH							
.30	Shipping to Temporary Storage	$/KgH							
.40	Temporary Storage	$/KgH							
.50	Shipping to Repository	$/KgH	26.4	24.2	22	22	19.8	19.8	17.6
.60	Disposal of Spent Fuel	$/KgH	140.8	140.8	140.8	140.8	140.8	140.8	140.8

(1) See Table 6-13 for System Designation

TABLE 2-7

Effective Date: January 1, 1980
(1) System : PWR-U5 (LF)/U-T
Start Up : January 1, 1987

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

Account No.	Account Description	OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu		
		Direct Cost	Indirect Cost	Total Cost
.00	Total	.66	0.04	0.70
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.33	0.03	0.36
.112	UF_6 Conversion Services	0.01	0.00	0.01
.113	Enrichment Services	0.21		0.23
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.06	0.00	0.06
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.01	(0.00)	0.01
.60	Disposal of Spent Fuel	0.04	(0.01)	0.03

(1) See Table 6-13 for System Designation.

TABLE 2-8

ENERGY ECONOMIC DATA BASE

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS FOR (PWR) NUCLEAR PLANT

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1980.0

PLANT TYPE IS PWR
WITH EVAPORATIVE COOLING TOWERS
NUMBER OF UNITS PER STATION 1
THERMAL INPUT PER UNIT IS 3412. MWT
PLANT NET HEAT RATE 10221.
PLANT NET EFFICIENCY, PERCENT 33.38
EACH UNIT IS 1139. MWE NET RATING
ANNUAL NET GENERATION, MILLION KWH 6989.
WITH A PLANT FACTOR OF 0.70

STAFF, $1000/YR	9377. (331 PERSONS AT $28328.)		
MAINTENANCE MATERIAL, $1000/YR	3201.		
FIXED		3201.	
VARIABLE		0.	
SUPPLIES AND EXPENSES, $1000/YR	5589.		
FIXED		5082.	
VARIABLE		507.	
INSURANCE AND FEES, $1000/YR	494.		
COMM. LIAB. INS.		344.	
GOV. LIAB. INS.		22.	
RETROSPECTIVE PREMIUM		7.	
INSPECTION FEES & EXPENSES		121.	
ADMIN. AND GENERAL, $1000/YR	2649.		
TOTAL FIXED COSTS, $1000/YR			20802.
TOTAL VARIABLE COSTS, $1000/YR			507.
TOTAL ANNUAL O & M COSTS, $1000/YR			21310.
FIXED UNIT O & M COSTS, MILLS/KWH(E)			2.98
VARIABLE UNIT O & M COSTS, MILLS/KWH(E)			0.07
TOTAL UNIT O & M COSTS, MILLS/KWH(E)			3.05

TABLE 2-9

ENERGY ECONOMIC DATA BASE

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS FOR (HS12) COAL PLANT

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1980.0

PLANT TYPE IS COAL
WITH EVAPORATIVE COOLING TOWERS
NUMBER OF UNITS PER STATION 1
WITH FGD SYSTEMS
THERMAL INPUT PER UNIT IS 3298. MWT
PLANT NET HEAT RATE 9134.
PLANT NET EFFICIENCY, PERCENT 37.36
EACH UNIT IS 1232. MWE NET RATING
ANNUAL NET GENERATION, MILLION KWH 7560.
WITH A PLANT FACTOR OF 0.70

STAFF, $1000/YR	7018. (259 PERSONS AT $27096.)		
MAINTENANCE MATERIAL, $1000/YR	2964.		
FIXED		2295.	
VARIABLE		669.	
SUPPLIES AND EXPENSES, $1000/YR	15579.		
FIXED		1694.	
VAR. - PLANT		457.	
- ASH & FGD SLUDGE		13428.	
ADMIN. AND GENERAL, $1000/YR	1101.		
TOTAL FIXED COSTS, $1000/YR			12107.
TOTAL VARIABLE COSTS, $1000/YR			14555.
TOTAL ANNUAL O & M COSTS, $1000/YR			26662.
FIXED UNIT O & M COSTS, MILLS/KWH(E)			1.60
VARIABLE UNIT O & M COSTS, MILLS/KWH(E)			1.93
TOTAL UNIT O & M COSTS, MILLS/KWH(E)			3.53

HEATING VALUE OF COAL, BTU/LB	11026.
COAL BURNED, TONS/YEAR	3131333.
PERCENT ASH	11.60
COST OF ASH DISPOSAL, $/TON	4.84
PERCENT SULFUR	3.50
SULFUR (ORIGINAL), TONS/YR	109597.
TONS LIMESTONE PER TON SULFUR	4.00
TONS/YEAR LIMESTONE	438387.
COST OF LIMESTONE, $/TON	12.10
COST OF SLUDGE DISPOSAL, $/DRY TON	14.52

TABLE 2-10

ENERGY ECONOMIC DATA BASE

COST BASES FOR POWER PLANT CAPITAL COST ESTIMATES

Include:	Exclude:
Site Characteristics - Middletown, USA	Owner's Cost (Consultants, Site Selection, etc.)
Code of Accounts - NUS-531 (Expanded)	Fees and Permits (Federal, State, Local)
Detailed Statement of Bases:	State and Local Taxes
Cost Date	Allowance for Funds Used During Construction
Applicable Regulations	Escalation
Applicable Codes & Standards	Contingency
Plant Design Description	Owner's Discretionary Items
	Switchyard and Transmission Costs
	Generator Step-up Transformer
	Waste Disposal Costs
	Spare Parts
	Initial Fuel Supply
	Nuclear Liability and Other Insurance
	Special Coolant Initial Inventory (e.g. helium for HTGR, heavy water for PHWR and sodium for LMFBR)

SECTION 3

3.0 ASSUMPTIONS AND GROUND-RULES FOR THE FOURTH COST UPDATE

3.1 EFFECTIVE DATE OF THE EEDB FOURTH UPDATE

The effective (cost and regulatory basis) date of this report is January 1, 1981.

3.2 COST PARAMETER GROUND-RULES

3.2.1 Base Costs

Base costs are developed in constant January 1, 1981 dollars, and are presented in the following forms:

a. Capital Costs

- Present Costs (\$) = Direct plus Indirect Costs (1)

- Capacity Costs (\$/kWe) $= \frac{\text{Present Costs(\$)}}{\text{(CAP)}}$ (2)

- Electric Energy Costs(m/kWh) $= \frac{\text{(Present Costs(\$))(1000 mills/\$)}}{\text{(CAP)(CF)(365 d/y)(24 h/d)}} \cdot \text{FCR}$ (3)

b. Fuel Costs

- Thermal Energy Costs (TEC) (¢/MBtu)

- Electric Energy Costs (m/kWh) = (TEC)(HR)(10 mills/¢)/(10^6) (4)

c. Operating and Maintenance Costs

- Present Annual Costs (PAC) (\$/y)

- Electric Energy Costs (m/kWh) $= \frac{\text{(PAC)(1000 mills/\$)}}{\text{(CAP)(CF)(365 d/y)(24 h/d)}} \cdot \text{LF}$ (5)

where:

CAP = Net Electrical Capacity in kWe*
(Net Power to Generator Step-Up Transformer)

CF = Capacity Factor in %+

FCR = Fixed Charge Rate in %/y+

HR = Net Station Heat Rate in Btu/kWh*

LF = Levelization Factor+

* These values are summarized for each model in Tables 4-1 and 4-2.
+ These values are given in Section 3.2.2.

3.2.2 Cost Parameters[1]

Cost parameters used are as follows:

Capacity Factor	70.0% (assumed)
Fixed Charge Rate	8.7%/y[2]
Inflation Rate	i = 0%/y
Escalation Rate	e = 0%/y[3]
Return on Investment	ROI = 3.5%/y[2]
Discount Rate	d = 3.5%/y[2]
Levelization Period (Fuel Cycle and O&M)	30 years (assumed)
Levelization Factor (O&M)	1[4]

Notes:

1. Costs reported in this update are derived on an inflation-free basis (i = 0%/y, e = 0%/y, d = 3.5%/y) as discussed in Section 2.4.2.

2. A discussion of the development of these eocnomic parameters are found in Appendix B.

3. The escalation rate is equal to or greater than zero for fuels, as discussed in Section 2.4.2.

4. A discussion of the development of this economic parameter may be found in Section 7.

3.2.3 Commercial Operation Dates

A commercial operation date is selected for each plant model to provide a basis for selecting fuel costs for the fuel cost models. This is necessary because fuel costs may escalate due to scarcity, as discussed in Section 2.4.2.

Commercial operation dates are assumed to be January 1 of the year indicated below. Case I represents a sequential scenario with start-up of plants occurring in the year when the technology is assumed to be ready. Case II is a scenario for the earliest year when all of the technologies are assumed to be ready.

EEDB Model Number	Model Type	Commercial Operation Dates Case I	Case II
A1	BWR	1981/1987	2001
A2	HTGR-SC	1995	2001
A3	PWR	1981/1987	2001
A4	PHWR	1995	2001
B1	HTGR-PS	2001	2001
A5	LMFBR	2001	2001
C1	HS12	1981/1987	2001
C2	HS8	1981/1987	2001
C3	LS12	1981/1987	2001
C4	LS8	1981/1987	2001
D1	CGCC	1987	2001

The BWRs and PWRs are the only full scale nuclear plants currently operating on a commercial basis in the United States. For this reason, the costs of the Light Water Reactors are included for the earliest study date, January 1, 1981. Four of the coal-fired generating stations are currently operational and the costs for these are also given for January 1, 1981. It is assumed that the technology supporting the other nuclear plant types will mature at later dates. Data are also provided for the Light Water Reactors and the coal-fired plants in 1987, because it is assumed that the CGCC coal plant option will be operational by that date. Costs projected to 2001 are given for all of the nuclear and coal comparison plants.

Comparisons of alternatives having significantly different capital and fuel costs need to be considered in terms of common startup dates. This is especially important if low fuel costs of a given alternative tend to offset high capital costs, because capital cost escalation is zero on a constant dollar basis, while fuel cost escalation is driven by scarcity.

3.3 TECHNICAL MODEL GROUND-RULES

3.3.1 General Ground-Rules

General assumptions and ground-rules for the Technical Models in the Base Data Studies and Reports listed in Table 1-3, and in the EEDB Initial and following updates, are given below. Except for the cost and regulation effective date of January 1, 1981, the same assumptions and ground-rules apply to the Fourth Update of the EEDB.

a. Cost data is based on prices effective as of January 1, 1981.

b. A full complement of licensing and design criteria, circa January 1, 1981, are utilized. Safety classifications, seismic categories and design codes for major structures and equipment are given in the Base Data Studies and Reports listed in Table 1-3.

c. The detailed technical models are developed for a single unit with sufficient land area to accommodate an identical second unit.

d. The design of the main heat rejection systems are based upon the use of mechanical draft wet cooling towers, and natural draft cooling towers (CGCC only). The nuclear plant ultimate heat sinks are based on mechanical draft wet cooling towers and mechanical draft dry cooling towers (HTGR only).

e. Each conceptual design utilizes two independent offsite sources of power; one at 500 kV and the other at 230 kV.

f. The design life for nuclear power generating stations (NPGS) is 40 years and for fossil power generating stations (FPGS) is 30 years; however, useful operating life is considered as 30 years for each.

g. Generating stations are base-loaded during the first part of their design life.

3.3.2 Specific Ground-Rules

Specific assumptions and ground-rules for each of the technical models of the Base Data Studies and Reports listed in Table 1-3 and for the EEDB Initial and following updates are given below. The same assumptions and ground-rules apply to the Fourth Update of the EEDB, with some modifications. Details of these modifications are given in Section 5.4.

3.3.2.1 Boiling Water Reactor (BWR) NPGS - Base Data Study

a. Plant design is based on the General Electric Technical Reference Plant Design, the General Electric Standard Safety Analysis Report (GESSAR), the General Electric 238 Inch Reactor Pressure Vessel (RPV) Nuclear Island Study Arrangements, and United Engineers' experience.

b. The reactor plant design is based upon the General Electric documents listed in paragraph a. above.

3.3.2.2 High Temperature Gas Cooled Reactor - Steam Cycle (HTGR-SC) NPGS - Base Data Study

a. Plant design is based on "The HTGR for Electric Power

Generation - Design and Cost Evaluation" study, September, 1980, performed by United Engineers for Gas Cooled Reactor Associates.

b. Reactor plant design is based on a 2240 MWt, 858 MWe, 1000°F, 2400 psig HTGR Nuclear Steam Supply System, developed by General Atomic Company for the study listed in paragraph a. above.

c. Helium inventory is not included.

d. This HTGR NPGS is located on a site in Eastern Pennsylvania. The EEDB incorporates the necessary modifications to meet the ground-rules that the HTGR NPGS is located on the "Middletown" site.

3.3.2.3 Pressurized Water Reactor (PWR) NPGS - Base Data Study

a. Plant design is based upon principal technical features corresponding to the Public Service Company of New Hampshire Seabrook Station, circa, July, 1976.

b. The reactor plant design is based upon the Westinghouse Reference Safety Analysis Report (RESAR-3S).

3.3.2.4 Pressurized Heavy Water Reactor (PHWR) NPGS - Base Data Study

a. Plant design is based upon the "Conceptual Design of a Large Heavy Water Reactor for U.S. Siting", report number CEND-379, September, 1979.

b. The reactor concept is a two-loop, pressure tube design, heavy-water cooled and moderated type developed by Combustion Engineering and United Engineers for the study listed in paragraph a. above.

c. Where insufficient information is available, application design data from the Base Data Study (See Table 1-3) for the Pressurized Water Reactor NPGS is utilized.

d. The inventory of heavy water for moderator and coolant is not included.

3.3.2.5 High Temperature Gas Cooled Reactor-Process Steam (HTGR-PS) NPGS Base Data Study

a. Plant design is based upon the "1170 MWt HTGR Steamer Cogeneration Plant - Design and Cost Study", report number UE&C/DOE 800716, August, 1980, performed by United Engineers and General Atomic Company for USDOE.

b. Reactor plant design is based upon a 1170 MWt, 150 MWe, 750°F, 650 psia HTGR Nuclear Steam Supply System, developed by General Atomic Company for the study listed in paragraph a. above.

c. Helium inventory is not included.

d. This HTGR NPGS is located on a site in Eastern Pennsylvania. The EEDB incorporates the necessary modifications to meet the ground-rule that the HTGR NPGS is located on the "Middletown" site.

3.3.2.6 Liquid Metal Fast Breeder Reactor (LMFBR) NPGS - Base Data Study

a. Plant design is based upon the target economic design described by Combustion-Engineering, Inc. in the Base Data Study (See Table 1-3) for a 1457 MWe LMFBR.

b. The reactor plant design is based upon the Combustion-Engineering, Inc., concept listed in paragraph a. above.

c. The inventory of sodium and NAK for primary and intermediate heat transport system coolant is not included.

3.3.2.7 High and Low Sulfur Coal-Fired (HS12, HS8, LS12 and LS8) FPGS - Base Data Studies

a. Plant designs incorporate a once-through, supercritical pressure, single reheat type, steam generator to supply steam to cross-compound, eight-flow turbines for the 1200 MWe units (HS12 and LS12) and to tandem-compound, four flow turbines for the 800 MWe units (HS8 and LS8.)

b. The steam generators for both the high sulfur coal-fired plants (HS12 and HS8) and the low sulfur coal-fired plants (LS12 and LS8) are designed for either a high sulfur Eastern coal or a low sulfur Western coal.

c. Each plant coal handling system is designed to unload a 100-car, unit train in five hours. The design provides indoor coal storage silos with a capacity sufficient for eight hours consumption at maximum rated capacity and an outdoor storage area with a capacity sufficient for 60 days consumption at maximum rated capacity.

d. Plant design for each high sulfur coal-fired plant (HS12 and HS8) includes a wet lime scrubber system for removal of sulfur-dioxide (SO_2) and an electrostatic precipitator for removal of particulates from the flue gas.

e. Plant design for each low sulfur coal-fired plant (LS12 and LS8) includes a dry lime scrubber and bag-house for removal of sulfur-dioxide (SO_2) and particulates from the flue gas.

3.3.2.8 Coal Gasification Combined Cycle (CGCC) FPGS - Base Data Study

a. Plant design is based on the reference process given in Table 1-3.

3.4 FUEL CYCLE COSTS GROUND-RULES

3.4.1 Nuclear Power Generating Stations

a. Operating life of nuclear plants are taken to be 30 years. Costs of individual expense items are given in the year of their occurrence and are levelized over the plant life.

b. Mass flow and related data are based upon NASAP (Non-Proliferation Alternative Systems Assessment Program) information.

c. Costs of current interest are those for "throwaway" cycles for the thermal reactors and plutonium recycle for the breeder reactors.

d. It is assumed that reprocessing of spent fuel is introduced when breeders are phased into use. Prior to that time, spent fuel elements from "throwaway" cycles are assumed to be shipped to a Federal repository.

e. Costs of onsite storage facilities for spent fuel are included in the plant capital costs in the Capital Cost Models, as described in Table 4-1.

f. It is assumed that plutonium bred from U-238 in breeder cycles has no economic value.

g. It is assumed that tails assay for enrichment is 0.2 percent by weight of U-235.

h. No credit is given for advanced isotope separation processes.

i. Uranium costs are used for Thorium costs in this update, because there is no current Thorium market from which to derive Thorium costs. When such a market develops, Thorium costs will be included in the update.

3.4.2 Fossil Power Generating Stations

a. Coal costs for plants starting up on January 1, 1981 reflect the results of the 1978 first quarter compensation settlement of the United Mine Workers contract. These additional cost effects are included in coal costs for plant startups in 1987 and 2001.

b. Coal cost data are derived from the sources listed below:

    1. Messing, R. F. and Harris, H. E.: "Comparative Energy Values to 1990," Report No. R770602, Impact Securities Corp., (Subsidiary), Arthur D. Little, Inc., Cambridge, MA 02140, June, 1977.

    2. Browne, Thomas E., et al. (Seven Authors): "Supply 77-EPRI Annual Energy Supply Forecasts," Report No. EA-634-SR, Electric Power Research Institute, Palo Alto, CA 94304, May, 1978.

    3. Private Communication - "Estimates of Baseline Delivered Coal Costs" (PWC Job No. 3592) - Paul Weir Co., 20 North Wacker Drive, Chicago, IL 60606, October 13, 1978.

    4. Monthly Energy Review, U.S. Department of Energy, Energy Information Administration, Washington, D.C. 20461 (Monthly Through September 1981).

SECTION 4

4.0 SUMMARY OF FOURTH COST UPDATE

4.1 TECHNICAL SUMMARY

The current status of the Technical Models Base Parameters for the Fourth Update is summarized in Table 4-1 for Nuclear Power Generating Stations and Table 4-2 for Comparison Plants. These summaries present a listing of important or key parameters that establish the technical envelope of each plant.

4.2 FUEL CYCLE SUMMARY

Mass flows selected for each of the nuclear plants are presented in Table 4-3. Much of this data was derived from Non-Proliferation Alternative Systems Assessment Program (NASAP) information. NASAP mass flow calculations are based on a capacity factor of 75 percent, while the capacity factor selected for the EEDB is 70 percent. However, review of sensitivity of Fuel Cycle Costs to such a change in capacity factor reveals that the impact on comparison of alternatives is negligible.

4.3 COST SUMMARY

Capital, Fuel, and Operating and Maintenance Costs are summarized for all plants, for their respective capacities, in Table 4-4. Tables 4-5 and 4-6 summarize the same data, except that the capital and O&M costs are normalized to the same net electrical and thermal capacities respectively. Table 4-7 lists footnotes for Tables 4-4, 4-5, and 4-6. The direct cost for each plant account at the two-digit level is normalized by using the following relationship and the appropriate scaling factor:

$$\frac{C_1}{C_2} = \left(\frac{P_1}{P_2}\right)^n \tag{6}$$

where: C_1 = Plant 1 Account Cost

C_2 = Plant 2 Account Cost

P_1 = Plant 1 Capacity

P_2 = Plant 2 Capacity

n = Scaling Factor

For the Fourth Update, values of "n" are estimated based on past experience. Values derived are 0.41 for BWR, PWR, and PHWR; 0.47 for HTGR and LMFBR; and 0.85 for HS12, HS8, LS12, and LS8. Since the indirect costs are directly proportional to the direct costs, the indirect costs are normalized by applying the following relationship:

$$\frac{C_{I1}}{C_{I2}} = \frac{C_{D1}}{C_{D2}} \tag{7}$$

where: C_{I1} = Plant 1 Total Indirect Cost

C_{I2} = Plant 2 Total Indirect Cost

C_{D1} = Plant 1 Total Direct Cost

C_{D2} = Plant 2 Total Direct Cost

Operating and Maintenance costs are normalized by recalculating the O&M costs from OMCOST with adjusted staffing and material inputs.

Care must be exercised in using the values developed in Table 4-6. At 3800 MWt, current domestic tandem-compound or cross-compound turbine technology is exceeded by the net electric capacity of 1456 MWe for the HTGR-SC plant, and is questionable at 1418 MWe and 1363 MWe respectively for the HS12 and LS12 plants, because the largest domestic steam turbine units presently available are approximately 1300 MWe. Design of such plants in 1981 would require twin-turbines with associated increased capital costs for the turbines, turbine pedestals, turbine building, auxiliary systems and equipment and additional steam header piping and valves. Therefore, for 1981, the capital costs in Table 4-6 for these two plants should be increased by 10-20 percent of their respective base direct costs. However, it is anticipated that at some point in the future, required turbine technology will be available for all of the base plants and the costs in Table 4-6 will apply, providing they are adjusted to current dollars of the year the technology is available.

4.4 COMMODITY AND MANHOUR SUMMARIES

Commodity summaries for nuclear and fossil power generating stations are given in Tables 4-8 and 4-9 respectively. Site labor summaries by craft are given for nuclear and fossil power generating stations in Tables 4-10 and 4-11 respectively. This information is derived from the data included in the Capital Cost Models for the base plants, which are presented in Section 5.

4.5 SUMMARY OF SIGNIFICANT COST PERTURBATIONS

The Fourth Update of the EEDB has evolved from the studies referenced in Tables 1-3 through 1-5 and the EEDB Initial and following updates, as discussed in Sections 1 and 2. Significant cost perturbations have occurred between the preparation of the Third Update and the cost and regulation date of this Fourth Update. These perturbations are addressed separately below for capital, fuel, and operating and maintenance cost.

4.5.1. Capital Costs

The direct costs of all of the base plants are escalated to January 1, 1981 in accordance with EEDB Capital Cost Update Procedure described in the Initial Update Report. Individual accounts are modified and improved in definition as discussed in Section 5.4. In the Fourth Update, the Technical and Capital Cost models for each of the Nuclear Power Generating Stations have been adjusted to account for the current industry response to the lessons learned from the Three-Mile Island NPGS incident of 1979. These adjustments are described in detail in Section 5.4.2.1. Additionally, labor costs are increased, as discussed in Section 5.5.1.

In the Third Update, the 1162 MWe, three loop CANDU type PHWR plant model is replaced with a 1260 MWe, two loop, U.S. design. The replacement is based upon a study for the conceptual design of a large heavy water reactor for U.S. siting. In this Fourth Update, modifications to the Base Data Study are continued, in order to improve the PHWR plant model relative to conformity with EEDB ground-rules and consistency with the conceptual designs of alternative Nuclear Power Generating Station Technical Models.

The LMFBR Plant model is based on a "Target Economics" approach, as described in the EEDB Initial Update. In the Second and Third Updates of the EEDB, significant improvement is made in definition and detail in the Nuclear Steam Supply System and the Balance-of-Plant. These improvements and refinements allow the LMFBR model to be reported at the nine-digit code-of-accounts level of detail for cost, equipment and commodity tabulations. Additional improvement is made in this Fourth Update of the EEDB. Resultant target costs reflect a commercial reactor deployed in the year 2001, utilizing unit costs and quantities that represent a lower bound of possible LMFBR capital costs.

4.5.2 Fuel Costs

The cost of raw U_3O_8 in the nuclear fuel cycle (except for breeders) accounts for roughly 50% of the total cycle cost. The behavior of the market in U_3O_8 over the past nine years is extremely erratic. Following the oil embargo of 1973, the forward price of U_3O_8 rose steadily, reaching a point about six times its price in 1973. However, new discoveries in Australia and Canada and the virtual elimination of new nuclear utility plant orders are currently causing the market to drop precipitiously.

In the Initial Update, concern is expressed that the price for U_3O_8 may understate the fuel cycle costs, especially in projections to later years. For the Second, Third, and Fourth Updates, it is thought that the initial values may be reasonably correct, and that the most recent long range projections may overstate the U_3O_8 cost. Predictions of U_3O_8 costs, especially those that extend into the next century, should be treated as educated guesses. For the Fourth Update, this view is tempered by the fact that U_3O_8 costs declined from 1980 to 1981, relative to the general advance in inflation.

The remaining portions of the nuclear fuel cycle are more stable; however, those portions of the cycle involving fuel reprocessing and recovery are based on predictive analyses from government weapons operations, rather than on commercial experience.

Coal costs used for plants that start-up on January 1, 1981, include the impact of the 1978 coal strike settlement. The coal costs projected for future years also take account of the results of the contract settlement. Effects of the coal strike settlement of 1981 will be included in future updates.

4.5.3 Operating and Maintenance Costs

O&M costs reported from OMCOST are refined on a continuous basis by ORNL to reflect the latest factors arising from regulatory and economic considerations. O&M cost projections for the Fourth Update are based on increased staffing to account for the current industry response to the lessons learned from the Three-Mile Island NPGS incident of 1979.

TABLE 4-1

ENERGY ECONOMIC DATA BASE

NUCLEAR PLANT TECHNICAL MODELS BASE PARAMETER SUMMARY

Model Key Elements	BWR	HTGR-SC	PWR	PHWR	HTGR-PS	LMFBR
General Site	←		Middletown* Appendix A-1			→
Operation	←		Base Load			→
Cost Estimate Ref. Data	←		January 1, 1981			→
Plant Life, Years	←		30 Years			→
Number of Units	Single	Single	Single	Single	Single	Single
Net Power to GSU+	1190 MWe	858 MWe	1139 MWe	1260 MWe	150 MWe	1457 MWe
Net Plant Heat Rate, Btu/kWh	10,261	8,440	10,224	10,338	21,572	8,994
Net Plant Efficiency, %	33.26	38.30	33.38	33.16	12.82	38.34
Fuel (Initial Core)	UO_2	UO_2 + Th	UO_2	UO_2	UO_2 + Th	UO_2 + PuO_2
	3% Enriched	20% Enriched	3% Enriched	Slightly Enriched	20% Enriched	0.88% Enriched
Nuclear Fuel Storage	5/4 Core	1.3 Core	4/3 Core	4/3 Core	1.3 Core	4/3 Core
LICENSING						
Codes and Standards Reference Year	←		January 1, 1981			→
CIVIL/STRUCTURAL						
Flooding Provision	←		No Special Provisions			→
Turbine Building	←		Enclosed			→
Seismic	←		SSE 0.25g			→
	←		OBE 0.125g			→
Foundations	←		Rock a) Cat I-Mat b) Non-Cat I-Spread Ftgs.			→

*Modified to reflect January 1981 criteria

+Generator Step-up Transformer

NUCLEAR PLANT TECHNICAL MODELS BASE PARAMETER SUMMARY

Model / Key Elements	BWR	HTGR-SC	PWR	PHWR	HTGR-PS	LMFBR
Containment	Steel Containment w/Reinf. Concrete	Reinforced Concrete w/ Steel Liner	Reinforced Concrete w/ Steel Liner	Reinforced Concrete w/ Steel Liner	Reinforced Concrete w/ Steel Liner	Reinforced Concrete w/ Steel Liner
Turbine Pedestal	← High Tuned →					
Grade Elevation	← + 18' 0" →					
Water Table	← + 10' 0" →					
100 Year Maximum	← + 8' 0" 100 Yrs. flood →					
External Missiles	← Tornadoes Only →					
MECHANICAL						
Steam Generator Type	None	Helical Coil Economizer/ Evaporator/ Superheater	Shell & Tube Heat Exchanger	Shell & Tube Heat Exchanger	Helical Coil Economizer/ Evaporator/ Superheater	Single Wall, Straight Tube Once Through Combined Evaporator/ Superheater
Primary Coolant Pumps						
Number	2	4	4	4	2	4/4**
Drive	Motor	Electric	Motor	Motor	Electric	Motor/Motor**
Flow	42,000 gpm	9.3×10^6 lb/h	94,400 gpm	70,300 gpm	4.9×10^6 lb/h	86,200 gpm/76,700 gpm**
Turbine Generator	Tandem Compound 6 flow, 1800 r/min 43" LSB	Tandem Compound 6 flow, 3600 r/min 31" LSB	Tandem Compound 6 flow, 1800 r/min 43" LSB	Tandem Compound 6 flow, 1800 r/min 43" LSB	Cross Compound 2 flow, 3600 r/min 6" LSB LP Turbine - 29% flow	Tandem Compound 6 flow, 1800 r/min 43" LSB
Main Steam Conditions at HP Turbine Inlet						
Pressure, psia	960	2415	975	1085	2415	2200
Temperature, F	544	1000	544	554	1000	850
Flow, 10^6 lb/h	13.9	7.3	13.7	16.3	3.8	14.39
Turbine Generator Rating	1235.4 MWe @ 2.5 in-HgA	935 MWe 2.5 in-HgA	1192.4 MWe @ 2.5 in-HgA	1343.6 MWe @ 2.5 in-HgA	187 MWe @ 2.5 in-HgA	1547 MWe @ 2.5 in-HgA
Condensers	3 Single Shell Transverse arrg. Two pass Split water box Single Pressure	3 Single Shell Longitudinal Two pass Split water box Single Pressure	3 Single Shell Transverse arrg. Two pass Split water box Single Pressure	3 Single Shell Transverse arrg. Two pass Split water box Single Pressure	1 Single Shell Longitudinal One pass Split water box Single Pressure	3 Single Shell Transverse arrg. Two pass Split water box Single Pressure

** Primary loop/Secondary loop

NUCLEAR PLANT TECHNICAL MODELS BASE PARAMETER SUMMARY

Model Key Elements	BWR	HTGR-SC	PWR	PHWR	HTGR-PS	LMFBR
MECHANICAL (Cont'd)						
Cooling Tower Design Conditions	← Mechanical Wet Evaporation Cooler →					
Approach	← 18F →					
Range	← 26F →					
Wet Bulb	← 74F →					
Ultimate Heat Sink (Cooling Tower Type)	Mechanical Wet Evaporative Cooling Tower	Mechanical Wet Evaporative Cooling Tower and Air Blast Heat Exchanger	Mechanical Wet Evaporative Cooling Tower	Mechanical Wet Evaporative Cooling Tower	Mechanical Wet Evaporative Cooling Tower and Air Blast Heat Exchanger	Air Blast Heat Exchangers
Boiler Feed Pumps						
Main: Number-Drive	2-Turbine	3-Turbine	2-Turbine	2-Turbine	2-Motor	2-Turbine
Other: Number-Service-Drive	1-Start-up-Motor	3-Booster Turbine	2-Emergency 1-Motor 1-Turbine 1-Start-up-Motor	2-Emergency-Motor	2-Booster-Turbine 3-Booster-Motor	2-Booster Motor
Boiler Feed Water Heater						
No. of Open Stages	None	1 @ 1 train	None	None	1 @ 1 train	1 @ 1 train
No. of HP Closed Stages	1 @ 2 trains	1 @ 2 trains and	1 @ 2 trains	2 @ 2 trains	1 @ 2 train	1 @ 3 trains*
No. of LP Closed Stages	4 @ 3 trains and 1 @ 2 trains	4 @ 2 trains	4 @ 3 trains and 1 @ 2 trains	4 @ 3 trains	2 @ 2 train	4 @ 2 trains
Stages of Reheat	One-Steam Reheat	None	One-Steam Reheat	One-Steam Reheat	None	Two Steam Reheat
ELECTRICAL						
Connection to Offsite Power	← 1 @ 500 kV 1 @ 230 kV →					
Generator						
Power Factor	0.9	0.9	0.9	0.9	0.9	0.9
Short Circuit Ratio	0.58	0.50	0.58	0.58	0.50	0.58
Rating	1,400 MVA	1,040 MVA	1,350 MVA	1,400 MVA	155 MVA 52 MVA	1718 MVA
Generator Disconnect	← Load Break Switch →					

* IP Closed Stage

TABLE 4-1

ENERGY ECONOMIC DATA BASE

NUCLEAR PLANT TECHNICAL MODELS BASE PARAMETER SUMMARY

Model Key Elements	BWR	HTGR-SC	PWR	PHWR	HTGR-PS	LMFBR
ELECTRICAL (Cont'd)						
Auxiliary Power System Voltage	13.8 kV, 4.16 kV and 480 Volts	13.8 kV and 480 Volts	13.8 kV, 4.16 kV and 480 Volts	13.8 kV, 4.16 kV and 480 Volts	13.8 kV and 480 Volts	13.8 kV, 4.16 kV and 480 Volts
Unit Auxiliary Transformer Nameplate Rating***	80 MVA	103 MVA	90 MVA	130 MVA	103 MVA	131 MVA
Reserve Auxiliary Transformer Nameplate Rating***	80 MVA	103 MVA	90 MVA	55 MVA	103 MVA	73 MVA
Control Room Wiring	← Wired Directly to Panels in Control Room →					
Multiplexing of BOP Cables	← None →					
Instrumentation	← Independent Sensors for Computer Input →					

*** Total of all transformers at top class of cooling rating.

ENERGY ECONOMIC DATA BASE

COMPARISON PLANT TECHNICAL MODELS BASE PARAMETER SUMMARY

Model Key Elements	HS12	HS8	LS12	LS8	CGCC
General Site	← Middletown* Appendix A-2 →				
Operation	← Base Load →				
Cost Estimate Ref. Date	← January 1, 1981 →				
Plant Life, Years	← 30 Years →				
Number of Units	← Single →				
Net Power To GSU+	1240 MWe	795 MWe	1244 MWe	795 MWe	630 MWe
Coal Firing Rate, Tons/Day	12,264	8,268	17,328	11,592	4,680
Net Plt Ht Rate, Btu/kWh	9,079	9,488	9,444	9,901	8,250
Net Plant Efficiency, %	37.59	35.97	36.14	34.46	41.37
Fuel	Eastern Coal Moisture (% by wt) 11.31 ----- Ultimate Analysis (% by wt dry) Carbon 69.33 Hydrogen 4.90 Nitrogen .86 Chlorine .04 Sulfur 3.61 Oxygen 9.64 ----- Calorific Value (Btu/lb) As Received 11,026 Dry 12,432	Same as HS12 ↓	Western Coal Moisture (% by wt) 31.8 ---- Ultimate Analysis (% by wt dry) Carbon 69.3 Hydrogen 5.2 Nitrogen 0.9 Chlorine - Sulfur 0.5 Oxygen 16.8 ----- Calorific Value (Btu/lb) As Received 8,164 Dry 11,970	Same as LS12 ↓	Pittsburgh Steam Coal Moisture (% by wt) 2.4 --- Ultimate Analysis (% by wt dry) Carbon 75.6 Hydrogen 5.2 Nitrogen 1.3 Chlorine - Sulfur 2.6 Oxygen 8.0 ----- Calorific Value (Btu/lb) As Received 13,156 Dry 13,480
Coal Delivery	100 Car Unit Train @ 5 hr. Max. Turn-around	100 Car Unit Train @ 5 hr. Max Turn-around	100 Car Unit Train @ 5 hr. Max Turn-around	100 Car Unit Train @ 5 hr. Max. Turn-around	Train Unloading 8 hrs/day
Coal Storage	← 60 Days @ Full Load 8 hrs. in Silos →				90 Days @ Full Load 16 hrs. in Silos

*Modified to reflect coal plant siting and January, 1981 criteria.
+Generator Step-up Transformer

COMPARISON PLANT TECHNICAL MODELS BASE PARAMETER SUMMARY

Model	HS12	HS8	LS12	LS8	CGCC
Key Elements					
CIVIL/STRUCTURAL					
Flooding Provision	← No Special Provisions →				
Turbine Building	← Enclosed →				
Boiler House	← Enclosed →				
Seismic	← Uniform Bldg. Code Zone 1 →				
Foundations	← Spread Footings on Rock →				
Turbine Pedestal	← High Tuned →				
Grade Elevation	← 18'0" →				
Water Table	← +10'0" →				
100 Year Maximum Water Level	← +8'0" 100 yrs. Flood →				
MECHANICAL					
Steam Generator Type	Pulverized Coal Pressurized Furnace	Pulverized Coal Balanced Draft	Pulverized Coal Pressurized Furnace	Pulverized Coal Balanced Draft	Waste Heat Boiler and Coal Gasifier (Pulverized Coal)
Forced Draft Fan					
Number	3	2	3	2	2
Drive	Motor	Motor	Motor	Motor	Motor
Flow, scfm	680,000	680,000	701,000	700,000	167,000
Induced Draft Fan					
Number	None	2	None	2	None
Drive		Motor		Motor	
Flow, scfm		900,000		1,100,000	
Number of Pulverizers	7	7	8	8	4
Stack Height	← 750 ft. →				270 ft. - Main Stack 250 ft. - Vent + Flare Stacks

TABLE 4-2

ENERGY ECONOMIC DATA BASE

COMPARISON PLANT TECHNICAL MODELS BASE PARAMETER SUMMARY

Model Key Element	HS12	HS8	LS12	LS8	CGCC
MECHANICAL (Cont'd)					
SO_2 Scrubber	Lime (Wet)#	Lime (Wet)#	Lime (Dry)##	Lime (Dry)##	H_2S Scrubber - Stretford
Sludge Fixation	On-Site	On-Site	Not Required	Not Required	Not Required
Spent Product Disposal	Trucked Off-Site	Trucked Off-Site	Trucked Off-Site	Trucked Off-Site	Not Required
Turbine Generator	Cross Compound 8 Flow 3600/3600 r/min. 30" LSB	Tandem Compound 4 Flow 3600 r/min. 33.5" LSB	Cross Compound 8 Flow 3600/3600 r/min. 30" LSB	Tandem Compound 4 Flow 3600 r/min. 33.5" LSB	Tandem Compound 2 Flow 3600 r/min. 33.5" LSB
Main Steam Conditions at HP Turbine Inlet	Supercritical	Supercritical	Supercritical	Supercritical	Superheated
Pressure, psia	3515/600	3512/637	3515/600	3512/637	2535/455
Temperature, F	1000/1000	1000/1000	1000/1000	1000/1000	1000/1000
Flow, 10^6 lb/h	9.1	5.8	9.1	5.8	2.0
Gross Turbine Generator Output	1317 MWe @ 2.5/1.7 in-HgA	854 MWe @ 2.5/1.7 in-HgA	1317 MWe @ 2.5/1.7 in-HgA	854 MWe @ 2.5/1.7 in-HgA	655 MWe** 2.0 in-HgA
Condensers	2 Single Shell Longitudinal Arrgt. One Pass Split Water Box Dual Pressure	1 Single Shell Longitudinal Arrgt. One Pass Split Water Box Dual Pressure	2 Single Shell Longitudinal Arrgt. One Pass Split Water Box Dual Pressure	1 Single Shell Longitudinal Arrgt. One Pass Split Water Box Dual Pressure	1 Single Shell Longitudinal Arrgt. Two Pass Split Water Milti-Pressure
Main Heat Sink	← Mechanical Wet Evaporative Cooling Tower →				Natural Draft Wet Hyberbolic Cooling Tower
Cooling Tower Design Conditions	← Approach 18°F/Range 26°F/Wet Bulb Temperature 74°F →				Approach 16°F/Range 24°F Wet Bulb Temperature - 74°F
Boiler Feed Pumps Main: Number - Drive	← 2 - Turbine →				
Other: Number - Service Drive	← 2 - Booster - Motor →				2 - Startup - Motor

** Steam Turbine - 1 @ 372 MWe @ 2.0 in-HgA and
Gas Turbine - 4 @ 79.8 MWe

\# With Electrostatic Precipitator

\## With Baghouse

ENERGY ECONOMIC DATA BASE

Effective Date - 1/1/81

Sheet 4 of 4

COMPARISON PLANT TECHNICAL MODELS BASE PARAMETER SUMMARY

Model / Key Elements	HS12	HS8	LS12	LS8	CGCC
MECHANICAL (Cont'd.)					
Boiler Feedwater Heaters					
No. of Open Stages	1 @ 1 Train	1 @ 1 Train	1 @ 1 Train	1 @ 1 Train	1 @ 1 Train
No. HP Closed Stages	3 @ 3 Trains	2 @ 2 Trains	3 @ 3 Trains	2 @ 2 Trains	None
No. LP Closed Stages	4 @ 2 Trains	4 @ 2 Trains	4 @ 2 Trains	4 @ 2 Trains	2 @ 1 Train
Stages of Reheat	← One Boiler Reheat →				
ELECTRICAL					
Connection to Off-Site Power	← 1 @ 500 kV 1 @ 230 kV →				1 @ 345 kV 1 @ 138 kV
Generator					
Power Factor	0.9	0.9	0.9	0.9	0.9
Short Circuit Ratio	0.58	0.58	0.50	0.50	-
Rating	2 @ 722 MVA	1050 MVA	2 @ 722 MVA	1050 MVA	1 @ 412.2 MVA 4 @ 72.9 MVA
Generator Disconnect	← None →				
Auxiliary Power System Voltage	← 13.8 kV, 4.16 kV and 480 Volts →				4.16 kV and 480 Volts
Unit Auxiliary Transformer Nameplate Rating ***	120 MVA	95 MVA	121 MVA	95.7 MVA	52 MVA
Reserve Auxiliary Transformer Nameplate Rating ***	60 MVA	47.5 MVA	61 MVA	47.85 MVA	52 MVA
Control Room Wiring	← Wired Directly to Panels in Control Room →				
Multiplexing of BOP Cables	← None →				
Instrumentation	← Independent Sensors for Computer Input →				

*** Total of all transformers at top class of cooling rating.

TABLE 4-3 Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE

MASS FLOWS SELECTED FOR NUCLEAR PLANT FUEL CYCLES

Model No.	Nuclear Plant	NASAP[1] Reactor Fuel Type Identification	Raw Data Source
A1	BWR	Same as PWR[2]	
A2	HTGR-SC	HTGR-U5/T/Th-20%-T (Throw-away)	GAC
A3	PWR	PWR-U5(LE)/U-T (Throw-away)	CE
A4	PHWR	PHWR-U5(SE)/U-T(CANDU) (Throw-away)	CE
B1	HTGR-PS	Same as HTGR-SC	
A5	LMFBR	LMFBR-Pu/U/U/U-HT	HEDL

LEGEND

CE - Combustion Engineering, Inc.
GAC - General Atomic Company
HEDL - Hanford Engineering Development Laboratory

NOTES:

(1) Non-Proliferation Alternative Systems Assessment Program
(2) BWR data is not available; therefore, PWR date is used for BWR (Model A1) fuel cycle costs

TABLE 4-4

Effective Date - 1/1/81
Sheet 1 of 2

ENERGY ECONOMIC DATA BASE

COST UPDATE SUMMARY ($1981)[1]
(See Table 4-7 for Footnotes)

			Capital Cost[4]			Fuel Cycle Costs						O&M Costs	
						1981 Startup[5]		Variable Startup		2001 Startup[6]			
Model	MWt	MWe	$10^6	$/kWe	m/kWh	¢/MBtu	m/kWh	¢/MBtu	m/kWh	¢/MBtu	m/kWh	$10^6/y	m/kWh
BWR	3578	1190	1158	973	13.8	67[d]	6.9[d]	71[e]	7.3[e]	88	9.0	36.5	5.0
HTGR-SC[a]	2240	858	1021	1190	16.9	*	*	83[f]	7.0[f]	89	7.5	35.7	6.8
PWR	3412	1139	1135	996	14.1	67	6.9	71[e]	7.3[e]	88	9.0	36.5	5.2
PHWR[b]	3800	1260	1301	1033	14.7	*	*	38[f]	3.9[f]	42	4.3	35.7	4.6
HTGR-PS[a]	1170	150	798	#	#	*	*	*	*	89	#	21.7	#
LMFBR	3800	1457	1764	1211	17.2	*	*	*	*	44	4.0	42.6	4.8
HS12	3299	1240	860	694	9.8	187	17.0	225[e]	20.4[e]	292	26.5	34.9	4.6
HS8	2210	795	592	745	10.6	187	17.7	225[e]	21.3[e]	292	27.7	29.4	6.0
LS12	3442	1244	809	650	9.2	272	25.7	320[e]	30.2[e]	378	35.7	23.3	3.1
LS8	2307	795	558	702	10.0	272	26.9	320[e]	31.7[e]	378	37.4	21.0	4.3
GGCC	1523	630[c]	493	783	11.1	*	*	219[e]	18.1[e]	288	23.8	11.5	3.0

* Not Applicable
# Not Applicable for Cogeneration Facility

TABLE 4-4

Effective Date - 1/1/81
Sheet 2 of 2

ENERGY ECONOMIC DATA BASE

COST UPDATE SUMMARY ($1981)[1]
(See Table 4-7 for Footnotes)

Model	MWt	MWe	Total Energy Costs by Year of Start-up (m/kWh) 1981	1987	1995	2001
BWR	3578	1190	25.7	26.1	*	27.8
HTGR-SC[a]	2240	858	*	*	30.7	31.2
PWR	3412	1139	26.2	26.6	*	28.3
PHWR[b]	3800	1260	*	*	23.2	23.6
HTGR-PS[a]	1170	150	#	#	#	#
LMFBR	3800	1457	*	*	*	26.0
HS12	3299	1240	31.4	34.8	*	40.9
HS8	2210	795	34.3	37.9	*	44.3
LS12	3442	1244	38.0	42.5	*	48.0
LS8	2307	795	41.2	46.0	*	51.7
CGCC	1523	630[c]	*	32.2	*	37.9

* Not Applicable
\# Not Applicable for Cogeneration Facility

TABLE 4-5

Effective Date - 1/1/81
Sheet 1 of 2

ENERGY ECONOMIC DATA BASE

NORMALIZED[2] COST UPDATE SUMMARY ($1981)[1]
(See Table 4-7 for Footnotes)

			Capital Cost[4]			Fuel Cycle Costs						O&M Costs	
						1981 Startup[5]		Variable Startup		2001 Startup[6]			
Model	MWt	MWe	$10^6	$/kWe	m/kWh	¢/MBtu	m/kWh	¢/MBtu	m/kWh	¢/MBtu	m/kWh	$10^6/y	m/kWh
BWR	3425	↑	1137	998	14.2	67[d]	6.9[d]	71[e]	7.3[e]	88	9.0	36.5	5.2
HTGR-SC[a]	2974		1166	1024	14.5	*	*	83[f]	7.0[f]	89	7.5	35.7	5.1
PWR	3412		1135	996	14.1	67	6.9	71[e]	7.3[e]	88	9.0	36.5	5.2
PHWR[b]	3435	1139	1248	1096	15.5	*	*	38[f]	3.9[f]	42	4.3	35.7	5.1
LMFBR	2971		1571	1379	19.6	*	*	*	*	44	4.0	42.4	6.1
HS12	3030		800	702	10.0	187	17.0	225[e]	20.4[e]	292	26.5	33.5	4.8
LS12	3151	↓	750	658	9.3	272	25.7	320[e]	30.2[e]	378	35.7	22.2	3.2

* Not Applicable

TABLE 4-5

Effective Date - 1/1/81
Sheet 2 of 2

ENERGY ECONOMIC DATA BASE

NORMALIZED(2) COST UPDATE SUMMARY ($1981)(1)
(See Table 4-7 for Footnotes)

Model	MWt	MWe	Total Energy Costs by Year of Start-up (m/kWh) 1981	1987	1995	2001
BWR	3425	↑	26.3	26.7	*	28.4
HTGR-SC[a]	2974		*	*	26.6	27.1
PWR	3412		26.2	26.6	*	28.3
PHWR[b]	3435	1139	*	*	24.5	24.9
LMFBR	2971		*	*	*	29.7
HS12	3030		31.8	35.2	*	41.3
LS12	3151	↓	38.2	42.7	*	48.2

* Not Applicable

TABLE 4-6

Effective Date - 1/1/81
Sheet 1 of 2

ENERGY ECONOMIC DATA BASE

NORMALIZED[3] COST UPDATE SUMMARY ($1981)[1]
(See Table 4-7 for Footnotes)

			Capital Cost[4]			Fuel Cycle Costs						O&M Costs	
						1981 Startup[5]		Variable Startup		2001 Startup[6]			
Model	MWt[3]	MWe	$10^6	$/kWe	m/kWh	¢/MBtu	m/kWh	¢/MBtu	m/kWh	¢/MBtu	m/kWh	$10^6/y	m/kWh
BWR	↑	1264	1187	939	13.3	67[d]	6.9[d]	71[e]	7.3[e]	88	9.0	36.7	4.7
HTGR-SC[a]		1456[g]	1308	898	12.7	*	*	83[f]	7.0[f]	89	7.5	35.9	4.0
PWR		1269	1187	935	13.3	67	6.9	71[e]	7.3[e]	88	9.0	36.7	4.7
PHWR[b]	3800	1260	1301	1033	14.7	*	*	38[f]	3.9[f]	42	4.3	35.7	4.6
LMFBR		1457	1764	1211	17.2	*	*	*	*	44	4.0	42.6	4.8
HS12		1428[g]	970	679	9.6	187	17.0	225[e]	20.4[e]	292	26.5	37.6	4.3
LS12	↓	1373	880	641	9.1	272	25.7	320[e]	30.2[e]	378	35.7	24.6	2.9

* Not Applicable

TAB[illegible] -6

Effective Date - 1/1/81
Sheet 2 of 2

ENERGY ECONOMIC DATA BASE

NORMALIZED[3] COST UPDATE SUMMARY ($1981)[1]
(See Table 4-7 for Footnotes)

Model	MWt	MWe	Total Energy Costs by Year of Start-up (m/kWh) 1981	1987	1995	2001
BWR	↑	1264	24.9	25.3	*	27.0
HTGR-SC[a]		1456[g]	*	*	23.7	24.2
PWR		1269	24.9	25.3	*	27.0
PHWR[b]	3800	1260	*	*	23.8	23.6
LMFBR		1457	*	*	*	26.0
HS12		1428[g]	30.9	34.3	*	40.4
LS12	↓	1373	37.7	42.2	*	47.7

* Not Applicable

TABLE 4-7 Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE

COST UPDATE SUMMARY ($1981)(1)
FOOTNOTES FOR TABLES 4-4, 4-5, AND 4-6

1. Data in Constant 1981 Dollars (Inflation-Free)
2. Normalized to a Plant Size Providing 1139 MWe (Net); Not Applicable to HTGR-PS, HS8, LS8, and CGCC
3. Normalized to a Plant Size Providing 3800 MWt (Net); Not Applicable to HTGR-PS, HS8, LS8, and CGCC
4. Total Base Cost = Direct Cost + Indirect Cost
5. Based on Plant Commercial Operation Date of January 1, 1981
6. Based on Plant Commercial Operation Date of January 1, 2001

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a. SC = Steam Cycle; PS = Process Steam Cogeneration

b. Reported costs do not include cost of the initial inventory of Heavy Water, which is estimated to be of the order of $\$75 \times 10^6$ for the 1260 MWe PHWR NPGS.

c. Four Gas-Turbine-Generators and One Steam-Turbine-Generator

d. BWR Fuel Cycle Data not available; PWR data are used for BWR Fuel Cycle Costs

e. Based on Plant Commercial Operation Date of January 1, 1987

f. Based on Plant Commercial Operation Date of January 1, 1995

g. Tandem-Compound or Cross-Compound Turbines are not available in this capacity in 1980; therefore, if Twin-Turbines are utilized, higher capital costs accrue for structures and Turbine Plant Equipment accounts.

TABLE 4-8

ENERGY ECONOMIC DATA BASE

COMMODITY SUMMARY OF NUCLEAR POWER GENERATING STATIONS#

Model/Rating (MWe)		BWR/1190		HTGR-SC/858		PWR/1139		PHWR/1260		LMFBR/1457	
Commodity	Unit	Qty.x10³	$/Unit@	Qty.x10³	$/Unit@	Qty.x10³	$/Unit@	Qty.x10³	$/Unit@	Qty.x10³	$/Unit@
Excavation	CY	536	14.10	423	6.77	529	14.22	523	14.01	780	16.73
Reinforcing Steel and Structural Steel	TN	31	1,647.00	31	1,639.00	33	1,675.00	35	1,616.00	56	1,667.00
Concrete	CY	206	108.32	169(a)	104.00(a)	175	106.75	175	106.07	264	110.71
BOP Pumps (1000 HP and UP)	HP	57	98.17	84	72.71	56	95.61	86	144.90	99	55.81
Piping+	LB	6,893	13.78	2,913	14.96	7,011	14.87	6,917	11.96	6,840	15.47
Wire and Cable	LF	4,550	5.44	4,062	5.95	4,608	6.41	5,170	5.10	6,474	5.21
Turbine-Generator	LT	-	87.47*	-	65.06*	-	84.65*	-	85.88*	-	75.17*
Nuclear Steam Supply System	LT	-	104.30*	-	200.14*	-	110.94*	-	131.92*	-	268.85*

HTGR-PS: Data not available from three-digit level Capital Cost Model

* Cost per Unit is in Dollars per Kilowatt ($/kW)

+ Includes Carbon Steel and Stainless Steel Piping

@ 1981 Constant Dollars

(a) Does not include pre-stressed concrete reactor vessel (PCRV)

TABLE 4-9

ENERGY ECONOMIC DATA BASE

COMMODITY SUMMARY OF FOSSIL POWER GENERATING STATIONS#

Model/Rating (MWe)		HS12/1240		HS8/795		LS12/1244		LS8/795	
Commodity	Unit	Qty.x10^3	$/Unit@	Qty.x10^3	$/Unit@	Qty.x10^3	$/Unit@	Qty.x10^3	$/Unit@
Excavation	CY	220	7.22	108	7.50	254	6.63	198	6.82
Reinforcing Steel and Structural Steel	TN	31	1,322.00	24	1,270.00	33	1,322.00	25	1,353.00
Concrete	CY	108	90.83	89	90.76	117	88.68	93	89.54
BOP Pumps (1000 HP and UP)	HP	104	43.83	66	51.58	104	43.83	66	51.58
Piping	LB	7,892	6.30	4,250	5.83	7,892	6.16	4,226	5.83
Wire and Cable	LF	3,986	3.73	3,421	3.75	3,989	3.73	3,423	3.75
Turbine-Generator	LT	---	68.76*	---	56.36*	---	69.87*	---	56.36*
Fossil Steam Supply System	LT	---	86.40*	---	91.63*	---	88.26*	---	92.65*

\# CGCC: Data not available from three-digit level Capital Cost Model

* Cost per Unit is in Dollars per Kilowatt ($/kW)

@ 1981 Constant Dollars

TABLE 4-10

ENERGY ECONOMIC DATA BASE

SITE LABOR SUMMARY FOR NUCLEAR POWER GENERATING STATIONS#

Model/MWe	BWR/1190		HTGR-SC/858		PWR/1139		PHWR/1260		LMFBR/1457	
Craft	MHx10³	$x10³*	MHx10³*	$x10³*	MHx10³	$x10³*	MHx10³	$x10³*	MHx10³	$x10³*
Boiler Makers	618	11,045	669	11,947	916	16,361	994	17,766	1,396	24,949
Carpenters	2,257	34,419	1,908	29,060	2,114	32,231	1,997	30,448	2,449	37,343
Electricians	2,618	43,404	2,314	38,370	2,581	42,797	2,903	48,139	3,950	65,494
Ironworkers	2,467	38,875	2,045	32,234	2,051	32,318	2,222	35,018	4,087	64,414
Laborers	2,234	25,381	1,686	19,150	2,088	23,723	2,039	23,162	2,859	32,480
Operating Engineers	1,515	24,153	930	14,821	1,263	20,135	1,275	20,326	1,975	31,478
Pipe Fitters	4,358	76,268	2,190	38,327	4,293	75,128	4,067	71,172	5,705	99,835
Others	1,675	24,519	1,805	27,367	1,368	19,855	1,452	19,196	2,244	32,999
TOTAL	17,742	278,064	13,545	211,276	16,673	262,548	16,949	265,227	24,665	388,992
MH/kW	14.9		15.8		14.6		13.4		16.9	

\# HTGR-PS: Data not available from three-digit Capital Cost Model

@ These numbers do not include the labor hours for erection of the Pre-stressed Concrete Reactor Vessel

* 1981 Constant Dollars

TABLE 4-11

ENERGY ECONOMIC DATA BASE

SITE LABOR SUMMARY FOR FOSSIL POWER GENERATING STATIONS#

Model/MWe	HS12/1240		HS8/795		LS12/1244		LS8/795	
Craft	$MHx10^3$	$\$x10^3$*	$MHx10^3$	$\$x10^3$*	$MHx10^3$	$\$x10^3$*	$MHx10^3$	$\$x10^3$*
Boiler Makers	290	5,188	209	3,742	158	2,953	116	2,076
Carpenters	448	6,828	367	5,591	448	6,837	352	5,374
Electricians	1,830	30,334	1,515	25,120	1,664	27,585	1,400	23,219
Ironworkers	942	14,849	717	11,297	918	14,463	720	11,353
Laborers	664	7,542	535	6,075	794	9,021	617	7,011
Operating Engineers	651	10,387	470	7,496	583	9,299	425	6,780
Pipe Fitters	3,783	66,196	2,488	43,536	3,598	62,964	2,321	40,619
Others	2,385	36,818	1,671	25,679	2,464	38,466	1,725	25,741
TOTAL	10,993	178,142	7,972	128,536	10,627	171,588	7,676	122,173
MH/kW	8.9		10.0		8.5		9.7	

CGCC: Data not available from three-digit level Capital Cost Model

* 1981 Constant Dollars

SECTION 5

5.0 CAPITAL COST FOURTH UPDATE

The Fourth Update of the Capital Costs in the Energy Economic Data Base is accomplished in two distinct steps. The first step is the evaluation and adjustment of the technical models to assure that they reflect current changes in state-of-the-art designs, regulations, codes and standards. The second step is the adjustment of the capital cost models to reflect escalation, and to accommodate the technical model revisions. This section of the report presents the detailed results of the capital cost update, followed by a description of the changes to the technical and capital cost models which support it.

5.1 CAPITAL COST UPDATE PROCEDURE

A specific capital cost update procedure is developed for the EEDB, and is described in the Initial Update Report.* This update procedure is utilized for the selected technical models given in Tables 1-1 and 1-2 to develop the Fourth Update of the Capital Cost.

5.2 CAPITAL COST SUMMARY

Capital costs are prepared for the EEDB as Base Construction Costs, which are the sum of the Direct and Indirect Capital Costs. Base costs include those cost elements listed in Table 2-10, as discussed in Section 2. Direct, Indirect and Base Capital Costs are summarized for all plants in Table 5-1.

Tables 5-2 and 5-3 also summarize the same data for all plants, except that the capital costs are normalized to the same net electrical and thermal capacities, respectively. The normalization process is discussed in Section 4.3. The net electrical capacity chosen for this process is that of the

* Refer to Section 8.1 for additonal details

Pressurized Water Reactor Nuclear Power Generating Station (NPGS) Technical Model, so that capital costs of the other technical models can be compared to this most frequently chosen industry cost base. The net thermal capacity chosen for the normalization process is the maximum licensable NPGS thermal rating of 3800 MWt, so that costs can be compared on the basis of maximum economy of scale.

5.3 DETAILED CAPITAL COSTS, COMMODITIES AND MANHOURS

Results of the Capital Cost Fourth Update are presented for each technical plant model at the two-digit and three-digit cost-code-of-accounts level in Tables 5-4 through 5-14 as follows:

Nuclear Plant Models	Table Number	Fossil Plant Models	Table Number
BWR	5-4	HS12	5-10
HTGR-SC	5-5	HS8	5-11
PWR	5-6	LS12	5-12
PHWR	5-7	LS8	5-13
HTGR-PS	5-8	CGCC	5-14
LMFBR	5-9		

The first sheet of each table is a two-digit level cost tabulation and the following four sheets are the three-digit level cost tabulation for each plant model.

Additional detail, down to the nine-digit cost-code-of-accounts level, is available in the Backup Data File, as discussed in Section 2.3.5. A total on the order of 10,000 computer sheets of cost and commodity detail is available from this file.

Commodities, including materials, equipment and craft labor manhours are tabulated for each technical plant model in Tables 5-15 through 5-23 as follows:

Nuclear Plant Models	Table Number	Fossil Plant Models	Table Number
BWR	5-15	HS12	5-20
HTGR-SC	5-16	HS8	5-21
PWR	5-17	LS12	5-22
PHWR	5-18	LS8	5-23
LMFBR	5-19		

Tabulations for the HTGR-PS Nuclear Plant Model and for the CGCC Fossil Plant Model are not included, because they have not yet been sufficiently detailed to produce this information. When necessary information becomes available to expand the technical models for HTGR-PS and CGCC to the required degree of detail, they will be included in the data base.

5.4 TECHNICAL MODEL UPDATE

The Base Data Studies and Reports listed in Table 1-3 are reviewed and modified in accordance with the EEDB update procedure. Section 3.3 gives the assumptions and ground-rules for each of the technical models of the Base Data Studies and Reports. Appendix C1 contains Section 5.4 of the Initial Update (1978), Appendix C2 contains portions of Section 5.4 of the Second Update (1979) and Appendix C3 contains Section 5.4.2 of the Third Update (1980). These sections discuss the detailed modifications made to the Technical Models in the Base Data Studies and Reports for the Initial and following updates of the EEDB.

This section discusses additional modifications to the Technical Models required for the Fourth Update of the EEDB to the cost and regulation date of January 1, 1981. The applicable Base Data Study or Report, together with the appropriate modifications listed in Appendices C1, C2, and C3 and this section, comprise the Technical Models for the Fourth Update of the Energy Economic Data Base.

5.4.1 General Modifications

A general review is done for each Technical Model in the Data Base, as modified for the Initial and following updates, to improve internal consistency among models and to assure that technical features and cost drivers are current. This review is accomplished in two phases. During the first phase, checks are made to assure that system, equipment, commodities and manhours track from model to model according to the Code-of-Accounts. Additionally, spot checks are made on cost significant items to assure that data has not been lost, misplaced or incorrectly entered in the update.

During the second phase of the general review, each model is modified, as required, to improve licensability, system performance, operability and constructability. As a first step in this phase, a review is made of the US Nuclear Regulatory Commission Regulatory Guides. New guides and revisions that have been issued since the Third Update cost and regulation date (1/1/80), but prior to the Fourth Update cost and regulation date (1/1/81) are identified. Each is evaluated for requirements necessitating addition or revision to existing design features. Modifications to Technical and Cost Models are then made based on this evaluation. Appendix D contains a tabulation of the results of the Regulatory Guide Review. Following incorporation of these modifications, a general review is made of the current state-of-the-art for nuclear and fossil-fired power generating stations. Where required, modifications are made to those Technical Models that are not in accord with current practice.

5.4.2 Specific Modifications

The following pages discuss the specific Technical Model modifications made during the Fourth Update. For convenience, the discussion of each plant model is started at the top of a new page.

5.4.2.1 EEDB Model Number A1, Model Type BWR, EEDB Fourth (1981) Update
EEDB Model Number A2, Model Type HTGR-SC, EEDB Fourth (1981) Update
EEDB Model Number A3, Model Type PWR, EEDB Fourth (1981) Update
EEDB Model Number A4, Model Type PHWR, EEDB Fourth (1981) Update
EEDB Model Number B1, Model Type HTGR-PS, EEDB Fourth (1981) Update
EEDB Model Number A5, Model Type LMFBR, EEDB Fourth (1981) Update

Base Data Studies: Commercial Electric Power Cost Studies - Capital Cost
(A1) Boiling Water Reactor Plant (NUREG-0242, COO-2477-6)
(A3) Pressurized Water Reactor Plant (NUREG-0241, COO-2477-5)
(A2) The HTGR for Electric Power Generation - Design and Cost Evaluation (GCRA/AE/78-1)
(A4) Conceptual Design of a Large HWR for U.S. Siting (Combustion Engineering, Inc. CEND-379)
(B1) 1170 MWe HTGR Steamer Cogeneration Plant - Design and Cost Study (UE&C/DOE-800716)
(A5) NSSS Capital Costs for a Mature LMFBR Industry and Addendum (Combustion Engineering, Inc. - (CE-FBR-78-532 & CE-ADD-80-310)

The following modifications are common to all of the nuclear power generating stations in the data base. These modifications take the form of additional design features that reflect the current industry response to lessons learned at the Three-Mile Island NPGS incident of March 28, 1979.

ACCOUNT 218L Technical Support Center

A Technical Support Center (TSC) is added to meet the criteria promulgated in NUREG-0696, "Functional Criteria for Emergency Response Facilities". The TSC is housed in a separate building for the BWR, HTGR-SC, PWR, and HTGR-PS. In the PHWR and LMFBR, the TSC is located in an existing building expanded for that purpose (refer to Sections 5.4.2.2 and 5.4.2.3 respectively).

ACCOUNT 227 Instrumentation and Control

Instrumentation is added for the following:

a. Relief and Safety Valve Testing
b. Direct Indication of Valve Position
c. Detection of Inadequate Core Cooling
d. Diverse Containment Isolation
e. Hydrogen Control
f. Plant Shielding Review

g. Auto-initiation of Auxiliary Feedwater
h. Auxiliary Feedwater Flow Indication
i. Post-Accident Sampling
j. High-Range Radiation Monitoring
k. Improved Iodine Monitors
l. Transient and Accident Analyses
m. Systems Integrity for High Radioactivity

ACCOUNT 242 Station Service Equipment

A non-Cleas 1E emergency power supply and auxiliaries is provided to support the Emergency Response Facilities.

ACCOUNT 243 Switchboards

Systems consoles are added for the Technical Support Center and the Operations Support Center.

Power distribution panels are added to control and distribute normal and emergency power to the Emergency Response Facilities.

ACCOUNT 245 Electrical Structures and Wiring Containers
ACCOUNT 246 Power and Control Wiring

Wiring and wiring raceways are added to interconnect the additional instrumentation (refer to Account 227), control consoles (refer to Account 243), emergency power supplies (refer to Account 242) and power distribution panels (refer to Account 243).

5.4.2.2 EEDB Model Number A4, Model Type PHWR, EEDB Fourth (1981) Update

Base Data Study: Conceptual Design of a Large HWR for U.S. Siting (Combustion Engineering, Inc. CEND-379)

ACCOUNT 218A Control Room/Diesel-Generator Building

The Control Room/Diesel-Generator Building is revised to include the function of the Technical Support Center (TSC) to meet the criteria promulgated in NUREG-0696, "Functional Criteria for Emergency Response Facilities". In the Fourth Update, an allowance is made in the Structures and Improvements Account capital costs.

ACCOUNT 218C Component Cooling Water Building

The Component Cooling Water Building is added to house the component cooling water heat exchangers and the pumps required for normal and emergency operating conditions (refer to Account 226). The building is a reinforced concrete Seismic Category I structure, located at grade. It is a one-story building, measuring 150 feet long, 150 feet wide, and 20 feet high, with a volume of approximately 450×10^3 cubic feet. Walls and roof are 2-feet thick and the base slab is 4 feet thick.

ACCOUNT 222A Main Heat Exchange Transport System

The equipment and piping system supports are modified. Auxiliary heat transfer equipment is modified to reflect design changes required to convert the refrigeration cooling system to a water cooling system (refer to Account 226).

ACCOUNT 222B Moderator Circuit

Piping supports are modified. The moderator pumps and moderator heat exchangers are redesigned to accommodate the changes from a refrigeration cooling system to a water cooling system (refer to Account 226).

ACCOUNT 226 Other Reactor Plant Equipment

The heavy water cooling water heat exchangers, pumps, and piping design is incorporated to provide a closed loop to contain any tritiated water from the moderator system. These exchangers are furnished cooling water from the service water system.

The primary component cooling water system pumps and heat exchangers are designed and incorporated in this update. These components replace the refrigeration cooling system incorporated in the Base Data Study.

The nuclear service water system pumps and the ultimate heat sinks are redesigned on the basis of the change from the refrigeration cooling to water cooling.

ACCOUNT 234 Feedwater Heating System

The main boiler feedwater pumps and turbine drives are changed from 3-50 percent to 2-50 percent units to be consistent with the EEDB PWR and BWR NPGS.

ACCOUNT 241 Switchgear
ACCOUNT 242 Station Service Equipment
ACCOUNT 245 Electric Structures and Wiring Containers
ACCOUNT 246 Power and Control Wiring

The electrical distribution system is modified to support the required design changes to accommodate the conversion from a refrigeration cooling system to a water cooling system and design changes related to other auxiliary systems (refer to Accounts 222A, 222B, 226, 234, 252, & 262).

ACCOUNT 252 Air, Water, and Steam Service Systems

The service water system is redesigned in this update to furnish cooling water to all plant services, including those previously furnished from the refrigeration cooling system (refer to Account 226). Service water pumps are changed from 2-100 percent pumps, each having a capacity of 11,000 gallons per minute, to 5-25 percent pumps each having a capacity of 30,000 gallons per minute.

ACCOUNT 262 Mechanical Equipment

The circulating water pumps are changed from 5-25 percent pumps, each with a capacity fo 161,500 gallons per minute, to 5-25 percent pumps, each with a capacity of 165,700 gallons per minute.

The main cooling towers are changed from 3-33 1/3 percent towers, each with a capacity of 307,670 gallons per minute, to 3-33 1/3 percent towers, each with a capacity of 276,167 gallons per minute.

5.4.2.3 EEDB Model Number A5, Model Type LMFBR, EEDB Fourth (1981) Update

Base Data Study: NSSS Capital Costs for a Mature LMFBR Industry and Addendum (Combustion Engineering, Inc. - CE-FBR-78-532 & CE-ADD-80-310)

ACCOUNT 214 Security and Technical Support Center Building

The Security Building is revised to include the function of the Technical Support Center (TSC) to meet the criteria promulgated in NUREG-0696, "Functional Criteria for Emergency Response Facilities". The structure is revised to that of a two-story building with one floor (the TSC) located below grade.

ACCOUNT 218A Control Building

The control building is revised to reflect the new arrangement required by the present fuel handling system and revised auxiliary heat transport system bay, and the requirement for "rattle-space" between the control building and the steam generator building.

ACCOUNT 224 Radwaste Processing

Two changes are incorporated in the gaseous waste processing systems. The tritium removal capability is deleted from the radioactive argon processing system (RAPS). Filters are added downstream of the tritium absorption units of the cell atmosphere processing system (CAPS).

ACCOUNT 262 Mechanical Equipment

The circulating water system is revised to reflect the revised water flow and the piping arrangement resulting from a change from three to two cooling towers. The cooling towers are recosted to reflect a decrease in heat load requirement

5.4.2.4 EEDB Model C1, Model Type HS12, EEDB Fourth (1981) Update
EEDB Model C3, Model Type LS12, EEDB Fourth (1981) Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - High and Low Sulfur Coal Plants - 1200 MWe (nominal) (NUREG-0243, COO-2477-7)

ACCOUNT 231 Turbine-Generator

The turbine-generator is reviewed for conformance with current manufacturers' quotations.

Recent improvements in turbine design provide a small increase in turbine generator unit output for the Fourth Update.

5.4.3 Ongoing Modifications

During the course of preparing the Third Update of the EEDB, it became apparent that general piping systems modifications were required for some of the Technical Models that would take more effort than could be allotted to the resources available for a single update. Development of the piping systems changes continued in the Fourth Update. Although the modifications are initiated in the Third Upuate, the results will not be reported until the Fifth Update is completed.

5.5 COST MODEL UPDATE

5.5.1 Direct Costs

Modifications to equipment, material and craft labor man-hours and associated costs are made, as required, to reflect the Technical Model modifications described in Section 5.4 above. Additionally, adjustments are made to reflect January 1, 1981 construction labor man-hours to arrive at new labor costs based on both the modified and unmodified labor hours. Total direct costs are revised accordingly.

5.5.2 Indirect Costs

Construction Services (Account 91), Home Office Engineering and Services (Account 92) and Field Office Engineering and Services (Account 93) are reviewed to assure that they continue to reflect direct Factory Equipment Costs, direct craft labor hour costs, direct craft labor hour costs and current field practice.

TABLE 5-1

ENERGY ECONOMIC DATA BASE

CAPITAL COST UPDATE SUMMARY
($1981 x 10^6)[a]

	Nuclear Plant Models						Comparison Plant Models				
Model	BWR	HTGR-SC	PWR	PHWR[b]	HTGR-PS	LMFBR	HS12	HS8	LS12	LS8	CGCC
MWt	3578	2240	3412	3800	1170	3800	3299	2210	3442	2307	1523
MWe	1190	858	1139	1260	150	1457	1240	795	1244	795	630
Direct Cost	761	654	745	884	480	1215	711	490	677	465	395
Indirect Cost	397	367	390	417	318	549	149	102	132	93	98
Base Cost	1158	1021	1135	1301	798	1764	860	592	809	558	493
$/kWe	973	1190	996	1033	(c)	1211	694	745	650	702	783

(a) Data in Constant $1981 (Inflation-Free)
(b) Reported costs do not include cost of the initial inventory of heavy water, which is estimated to be of the order of $75 x 10^6 for the 1260 MWe PHWR NPGS
(c) Not Applicable for Process Steam/Cogeneration Plant

TABLE 5-2

ENERGY ECONOMIC DATA BASE

NORMALIZED[a] CAPITAL COST UPDATE SUMMARY
($1981 x 10^6)[b]

	Nuclear Plant Models[c]					Comparison Plant Models[d]	
Model	BWR	HTGR-SC	PWR	PHWR[e]	LMFBR	HS12	LS12
MWt	3425	2974	3412	3435	2971	3030	3151
MWe	←		1139		→	← 1139 →	
Direct Cost	747	747	745	848	1082	661	628
Indirect Cost	390	419	390	400	489	139	122
Base Cost	1137	1166	1135	1248	1571	800	750
$/kWe	998	1024	996	1096	1379	702	658
PWR Cost Ratio $/kWe	1.00	1.03	1.00	1.10	1.38	0.70	0.66

(a) Normalized to a plant size providing 1139 MWe (Net)
(b) Data in Constant $1981 (Inflation-Free)
(c) Normalization not Applicable to HTGR-PS
(d) Normalization not Applicable to HS8, LS8, and CGCC
(e) Reported costs do not include cost of the initial inventory of heavy water

TABLE 5-3

ENERGY ECONOMIC DATA BASE

NORMALIZED[(a)] CAPITAL COST UPDATE SUMMARY
($1981 x 10^6)[(b)]

	Nuclear Plant Models[(c)]					Comparison Plant Models[(d)]	
Model	BWR	HTGR-SC	PWR	PHWR[(e)]	LMFBR	HS12	LS12
MWt	←	—	3800	—	→	← 3800	→
MWe	1264	1456[(f)]	1269	1260	1457	1428[(f)]	1373
Direct Cost	780	838	779	884	1215	802	736
Indirect Cost	407	470	408	417	549	168	144
Base Cost	1187	1308	1187	1301	1764	970	880
$/kWe	939	898	935	1033	1211	679	641
PWR Cost Ratio $/kWe	1.00	0.96	1.00	1.10	1.30	0.73	0.69

(a) Normalized to a plant size of 3800 MWt or its equivalent
(b) Data in Constant $1981 (Inflation-Free)
(c) Normalization Not Applicable to HTGR-PS
(d) Normalization Not Applicable to HS8, LS8, and CGCC
(e) Reported costs do not include cost of the initial inventory of heavy water
(f) Tandem-Compound or Cross-Compound Turbines are not available for this application in 1981; therefore, if Twin Turbines are utilized, higher capital costs accrue for Structures and Turbine Plant Equipment accounts

Effective Date - 1/1/81

TABLE 5-4

ENERGY ECONOMIC DATA BASE

1190 MWe BOILING WATER REACTOR NPGS

CAPITAL COST ESTIMATE

PLANT CODE 201 | COST BASIS 01/81

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
1190 MWE BOILING WATER REACTOR

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,750,000	2,750,000
21 .	STRUCTURES & IMPROVEMENTS	6,734,092	8917811 MH	132,372,467	70,998,376	210,104,935
22 .	REACTOR PLANT EQUIPMENT	159,267,737	2996968 MH	50,403,762	12,806,546	222,478,045
23 .	TURBINE PLANT EQUIPMENT	146,080,455	2680270 MH	44,159,961	9,091,929	199,332,345
24 .	ELECTRIC PLANT EQUIPMENT	26,580,617	2166089 MH	35,218,071	11,109,990	72,908,678
25 .	MISCELLANEOUS PLANT EQUIPT	10,890,114	485867 MH	8,150,004	1,653,271	20,693,389
26 .	MAIN COND HEAT REJECT SYS	23,173,977	495395 MH	7,759,750	1,983,108	32,916,835
	TOTAL DIRECT COSTS	372,726,992	17742400 MH	278,064,015	110,393,220	761,184,227
91 .	CONSTRUCTION SERVICES	58,808,301	2920244 MH	45,948,674	38,998,300	143,755,275
92 .	HOME OFFICE ENGRG.&SERVICE	172,111,610				172,111,610
93 .	FIELD OFFICE ENGRG&SERVICE	77,674,740			3,018,950	80,693,690
	TOTAL INDIRECT COSTS	308,594,651	2920244 MH	45,948,674	42,017,250	396,560,575
	TOTAL BASE COST	681,321,643	20662644 MH	324,012,689	152,410,470	1,157,744,802

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20	LAND AND LAND RIGHTS				2,750,000	2,750,000
211.	YARDWORK	247,750	670443 MH	9,013,079	6,964,495	16,225,324
212.	REACTOR CONTAINMENT BLDG	1,412,141	2892685 MH	44,654,419	25,576,427	71,642,987
213.	TURBINE ROOM + HEATER BAY	1,714,976	1837234 MH	26,750,743	16,971,230	45,436,949
214.	SECURITY BUILDING	46,994	50478 MH	750,125	379,963	1,177,082
215.	AUXILIARY BLDG + TUNNELS	404,696	569996 MH	8,368,239	3,033,483	11,806,418
216.	WASTE PROCESS BUILDING	200,941	467098 MH	6,849,543	2,910,550	9,961,034
217.	FUEL STORAGE BLDG	146,993	549528 MH	8,309,891	3,927,964	12,384,848
218A.	CONTROL RM/D-G BUILDING	1,611,574	1095740 MH	16,124,085	5,872,740	23,608,399
218B.	ADMINISTRATION+SERVICE BLG	836,659	285751 MH	4,422,384	2,698,670	7,957,713
218D.	FIRE PUMP HOUSE,INC FNDTNS	32,684	16410 MH	245,915	118,762	397,361
218K.	PIPE TUNNELS		32819 MH	473,983	156,846	630,829
218L.	TECHNICAL SUPPORT CENTER	42,303	28668 MH	433,408	205,733	681,444
218S.	HOLDING POND		12248 MH	174,520	57,490	232,010
218T.	ULTIMATE HEAT SINK STRUCT	36,381	393056 MH	5,595,083	2,061,505	7,692,969
218V.	CONTR RM EMG AIR INTK STR		15657 MH	207,050	62,518	269,568
21 .	STRUCTURES & IMPROVEMENTS	6,734,092	8917811 MH	132,372,467	70,998,376	210,104,935

PLANT CODE 201 | COST BASIS 01/81

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
1190 MWE BOILING WATER REACTOR

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
220A.	NUCLEAR STEAM SUPPLY(NSSS)	118,800,000				118,800,000
220B.	NSSS OPTIONS					
221.	REACTOR EQUIPMENT	772,158	770888 MH	13,014,795	4,210,071	17,997,024
222.	MAIN HEAT XFER XPORT SYS.	445,923	253977 MH	4,302,236	430,053	5,178,212
223.	SAFEGUARDS SYSTEM	7,994,745	627177 MH	10,590,896	1,051,255	19,636,896
224.	RADWASTE PROCESSING	12,291,204	415974 MH	7,018,528	1,610,743	20,920,475
225.	FUEL HANDLING + STORAGE	1,151,752	91617 MH	1,529,130	166,606	2,847,488
226.	OTHER REACTOR EQUIP.	6,190,854	484954 MH	8,184,460	2,634,749	17,010,063
227.	INSTRUMENTATION + CONTROL	11,621,101	128142 MH	2,080,729	178,180	13,880,010
228.	REACTOR PLANT MISC ITEMS		224239 MH	3,682,988	2,524,889	6,207,877
22 .	REACTOR PLANT EQUIPMENT	159,267,737	2996968 MH	50,403,762	12,806,546	222,478,045
231.	TURBINE GENERATOR	96,550,715	640288 MH	10,192,713	1,934,426	108,677,854
233.	CONDENSING SYSTEMS	18,142,810	415583 MH	6,995,103	1,354,250	26,492,163
234.	FEED HEATING SYSTEM	14,192,583	549666 MH	9,281,908	927,369	24,401,860
235.	OTHER TURBINE PLANT EQUIP.	15,666,390	827171 MH	13,733,921	1,633,696	31,034,007
236.	INSTRUMENTATION + CONTROL	1,527,957	74425 MH	1,207,690	107,479	2,843,126
237.	TURBINE PLANT MISC ITEMS		173137 MH	2,748,626	3,134,709	5,883,335
23 .	TURBINE PLANT EQUIPMENT	146,080,455	2680270 MH	44,159,961	9,091,929	199,332,345

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	7,521,909	93444 MH	1,515,557	154,356	9,191,822
242.	STATION SERVICE EQUIPMENT	16,402,784	159669 MH	2,559,888	400,643	19,363,315
243.	SWITCHBOARDS	1,269,066	17317 MH	281,118	114,219	1,664,403
244.	PROTECTIVE EQUIPMENT		113256 MH	1,850,826	804,540	2,655,366
245.	ELECT.STRUC +WIRING CONTNR		841505 MH	13,634,536	2,981,020	16,615,556
246.	POWER & CONTROL WIRING	1,386,858	940898 MH	15,376,146	6,655,212	23,418,216
24 .	ELECTRIC PLANT EQUIPMENT	26,580,617	2166089 MH	35,218,071	11,109,990	72,908,678
251.	TRANSPORTATION & LIFT EQPT	2,137,793	32909 MH	553,576	165,268	2,856,637
252.	AIR,WATER+STEAM SERVICE SY	5,205,081	406627 MH	6,848,569	1,200,383	13,254,033
253.	COMMUNICATIONS EQUIPMENT	2,334,807	34947 MH	571,091	258,000	3,163,898
254.	FURNISHINGS + FIXTURES	1,212,433	11384 MH	176,768	29,620	1,418,821
25 .	MISCELLANEOUS PLANT EQUIPT	10,890,114	485867 MH	8,150,004	1,653,271	20,693,389
261.	STRUCTURES	140,530	163374 MH	2,371,439	1,173,551	3,685,520
262.	MECHANICAL EQUIPMENT	23,033,447	332021 MH	5,388,311	809,557	29,231,315
26 .	MAIN COND HEAT REJECT SYS	23,173,977	495395 MH	7,759,750	1,983,108	32,916,835
	TOTAL DIRECT COSTS	372,726,992	17742400 MH	278,064,015	110,393,220	761,184,227

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		2528871 MH	39,791,138	12,003,200	51,794,338
912	CONSTRUCTION TOOLS & EQUIP		391373 MH	6,157,536	26,105,750	32,263,286
913.	PAYROLL INSURANCE & TAXES	58,808,301				58,808,301
914.	PERMITS,INS. & LOCAL TAXES				889,350	889,350
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	58,808,301	2920244 MH	45,948,674	38,998,300	143,755,275
921.	HOME OFFICE SERVICES	162,665,140				162,665,140
922.	HOME OFFICE Q/A	6,944,190				6,944,190
923.	HOME OFFICE CONSTRCTN MGMT	2,502,280				2,502,280
92 .	HOME OFFICE ENGRG.&SERVICE	172,111,610				172,111,610
931.	FIELD OFFICE EXPENSES				3,018,950	3,018,950
932.	FIELD JOB SUPERVISION	67,991,110				67,991,110
933.	FIELD QA/QC	5,737,820				5,737,820
934.	PLANT STARTUP & TEST	3,945,810				3,945,810
93 .	FIELD OFFICE ENGRG&SERVICE	77,674,740			3,018,950	80,693,690
	TOTAL INDIRECT COSTS	308,594,651	2920244 MH	45,948,674	42,017,250	396,560,575
	TOTAL BASE COST	681,321,643	20662644 MH	324,012,689	152,410,470	1,157,744,802

Effective Date - 1/1/81

TABLE 5-5

ENERGY ECONOMIC DATA BASE

858 MWe HIGH TEMPERATURE GAS COOLED REACTOR-STEAM CYCLE NPGS

CAPITAL COST ESTIMATE

PLANT CODE 338 | COST BASIS 01/81

UNITED ENGINEERS & CONSTRUCTORS INC
ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
858 MWE HIGH TEMPERATURE GAS COOLED REACTOR-SC

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND + LAND RIGHTS				2,750,000	2,750,000
21 .	STRUCTURES & IMPROVEMENTS	5,581,703	6680084 MH	99,157,624	55,547,333	160,286,660
22 .	REACTOR PLANT EQUIPMENT	208,949,465	2151389 MH	35,219,123	22,308,953	266,477,541
23 .	TURBINE PLANT EQUIPMENT	80,861,086	1890405 MH	31,131,100	5,662,705	117,654,891
24 .	ELECTRIC PLANT EQUIP	19,298,844	1985795 MH	32,197,349	12,320,051	63,816,244
25 .	MISC. PLANT EQUIP	8,026,827	365307 MH	6,100,543	1,327,914	15,455,284
26 .	MAIN COND HEAT REJECT SYS	18,423,442	473792 MH	7,470,433	1,736,681	27,630,556
	TOTAL DIRECT COSTS	341,141,367	13546772 MH	211,276,172	101,653,637	654,071,176
91 .	CONSTRUCTION SERVICES	45,152,940	2633358 MH	37,473,314	33,033,300	115,659,554
92 .	HOME OFFICE ENGRG.&SERVICE	173,882,390				173,882,390
93 .	FIELD OFFICE ENGRG&SERVICE	71,360,355			6,036,910	77,397,265
	TOTAL INDIRECT COSTS	290,395,685	2633358 MH	37,473,314	39,070,210	366,939,209
	TOTAL BASE COST	631,537,052	16180130 MH	248,749,486	140,723,847	1,021,010,385

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND + LAND RIGHTS				2,750,000	2,750,000
211.	YARDWORK	241,793	464894 MH	6,439,223	6,035,490	12,716,506
212.	REACTOR CONTAINMENT BLDG	861,358	2048905 MH	31,501,967	21,623,221	53,986,546
213.	TURBINE BUILDING	597,934	314706 MH	4,839,940	4,774,251	10,212,125
214.	SECURITY BUILDING	41,924	19944 MH	307,260	185,678	534,862
215.	AUX REACTOR SERVICE BLDG	778,446	554275 MH	8,116,960	4,220,729	13,116,135
216.	MAIN CIRC CONTROL BLDG	315,545	12364 MH	183,543	149,098	648,186
217.	LONG TERM FUEL STORAGE BLD	64,473	465745 MH	6,834,159	3,142,512	10,041,144
218A.	CONTROL, AUXIL & D.G.BLDG	1,617,889	1062568 MH	15,676,845	5,392,814	22,687,548
218B.	ADMIN + SERV BLDG	403,810	224846 MH	3,480,246	2,344,294	6,228,350
218D.	FIRE PUMP HOUSE	34,759	9099 MH	139,800	66,203	240,762
218E.	L.P. HELIUM STORAGE AREA		43116 MH	627,843	644,360	1,272,203
218F.	NON-VITAL SWITCHGEAR BLDG		6065 MH	90,865	78,667	169,532
218H.	DIES CLG + FL OIL STG BLDG	12,377	192465 MH	2,766,900	986,070	3,765,347
218I.	WAREHOUSE		8300 MH	123,521	110,795	234,316
218J.	CONTAINMENT ANNULUS BLDG	15,503	236165 MH	3,422,094	1,453,000	4,890,597
218K.	CONTAIN PENETRATION BLDG	484,561	426582 MH	6,134,654	1,799,413	8,418,628
218L.	TECHNICAL SUPPORT CENTER	42,303	28668 MH	433,408	205,733	681,444
218S.	HOLDING PUMP + CONTRL HSE		19517 MH	279,600	116,279	395,879
218T.	ULTIM HEAT SINK STR+TUNNLS	44,160	534693 MH	7,655,460	2,192,911	9,892,531
218V.	CTL RM EMG AIR IN STR	24,868	7167 MH	103,336	25,815	154,019
21 .	STRUCTURES & IMPROVEMENTS	5,581,703	6680084 MH	99,157,624	55,547,333	160,286,660

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
220A.	NUCLEAR STEAM SUPPLY(NSSS)	171,720,000				171,720,000
220B.	NSSS OPTIONS					
221.	REACTOR EQUIPMENT	569,918	997657 MH	15,882,570	18,791,582	35,244,070
222.	MAIN HEAT TRANS SYS.	1,879,329	171239 MH	2,989,858	296,289	5,165,476
[illegible]	SAFEGUARDS COOL. SYS.	5,762,041	194045 MH	3,275,307	356,583	9,393,931
224.	RAD WASTE PROCESSING	2,924,050	83499 MH	1,408,867	210,009	4,542,926
225.	NUCLEAR FUEL HANDLING + ST	6,003,982	101889 MH	1,704,955	151,463	7,860,400
226.	OTHER REACTOR PLANT EQUIP	14,746,750	334384 MH	5,639,837	2,100,743	22,487,330
227.	INSTRUMENTATION + CONTROL	4,898,595	119646 MH	1,941,471	52,538	6,892,604
228.	REACTOR PLANT MISC ITEMS	444,800	149030 MH	2,376,258	349,746	3,170,804
22 .	REACTOR PLANT EQUIPMENT	208,949,465	2151389 MH	35,219,123	22,308,953	266,477,541
231.	TURBINE GENERATOR	50,844,421	555901 MH	8,729,102	2,259,478	61,833,001
233.	CONDENSING SYS.	9,216,821	204428 MH	3,604,347	709,586	13,530,754
234.	FEED HEAT. SYS.	9,839,772	315815 MH	5,345,957	588,926	15,774,655
235.	OTHER TURB PLANT EQUIP	10,018,097	651256 MH	10,960,614	1,370,164	22,348,875
236.	INSTRUMENTATION + CONTROL	941,975	71329 MH	1,157,431	12,203	2,111,609
237.	TURBINE PLANT MISC ITEMS		91676 MH	1,333,649	722,348	2,055,997
23 .	TURBINE PLANT EQUIPMENT	80,861,086	1890405 MH	31,131,100	5,662,705	117,654,891

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	6,394,553	90065 MH	1,460,734	149,707	8,004,994
242.	STATION SERVICE EQUIP	10,831,170	140899 MH	2,238,465	379,533	13,449,168
243.	SWITCHBOARDS	1,203,895	18276 MH	297,180	35,473	1,536,548
244.	PROTECTIVE EQUIP		123274 MH	2,014,550	711,573	2,726,123
245.	ELEC STRUC + WIRING CNTNRS		763710 MH	12,302,727	2,711,246	15,013,973
246.	POWER & CONTROL WIRING	869,226	849571 MH	13,883,693	8,332,519	23,085,438
24 .	ELECTRIC PLANT EQUIP	19,298,844	1985795 MH	32,197,349	12,320,051	63,816,244
251.	TRANSPORTATION+LIFT EQUIP	2,392,970	27597 MH	464,198	46,419	2,903,587
252.	AIR WTR+STEAM SERV SYS	3,070,848	290848 MH	4,884,165	1,187,244	9,142,257
253.	COMMUNICATIONS EQUIP	1,362,112	34845 MH	568,169	47,877	1,978,158
254.	FURNISHINGS + FIXTURES	1,200,897	12017 MH	184,011	46,374	1,431,282
25 .	MISC. PLANT EQUIP	8,026,827	365307 MH	6,100,543	1,327,914	15,455,284
261.	STRUCTURES	235,509	126547 MH	1,866,606	1,034,639	3,136,754
262.	MECHANICAL EQUIPMENT	18,187,933	347245 MH	5,603,827	702,042	24,493,802
26 .	MAIN COND HEAT REJECT SYS	18,423,442	473792 MH	7,470,433	1,736,681	27,630,556
	TOTAL DIRECT COSTS	341,141,367	13546772 MH	211,278,172	101,653,637	654,071,176

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		2282763 MH	31,576,850	10,267,400	41,844,250
912.	CONSTRUCTION TOOLS & EQUIP		350595 MH	5,896,464	21,626,300	27,522,764
913.	PAYROLL INSURANCE & TAXES	45,152,940				45,152,940
914.	PERMITS,INS. & LOCAL TAXES				1,139,600	1,139,600
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	45,152,940	2633358 MH	37,473,314	33,033,300	115,659,554
921.	HOME OFFICE SERVICES	164,242,100				164,242,100
922.	HOME OFFICE Q/A	7,127,340				7,127,340
923.	HOME OFFICE CONSTRCTN MGMT	2,512,950				2,512,950
92 .	HOME OFFICE ENGRG.&SERVICE	173,882,390				173,882,390
931.	FIELD OFFICE EXPENSES				6,036,910	6,036,910
932.	FIELD JOB SUPERVISION	61,744,870				61,744,870
933.	FIELD QA/QC	5,638,985				5,638,985
934.	PLANT STARTUP & TEST	3,976,500				3,976,500
93 .	FIELD OFFICE ENGRG&SERVICE	71,360,355			6,036,910	77,397,265
	TOTAL INDIRECT COSTS	290,395,685	2633358 MH	37,473,314	39,070,210	366,939,209
	TOTAL BASE COST	631,537,052	16180130 MH	248,749,486	140,723,847	1,021,010,385

Effective Date - 1/1/ 81

TABLE 5-6

ENERGY ECONOMIC DATA BASE

1139 MWe PRESSURIZED WATER REACTOR NPGS

CAPITAL COST ESTIMATE

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
1139 MWE PRESSURIZED WATER REACTOR

PLANT CODE 148 COST BASIS 01/81

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,750,000	2,750,000
21 .	STRUCTURES + IMPROVEMENTS	9,781,599	7848603 MH	116,499,285	61,794,246	188,075,130
22 .	REACTOR PLANT EQUIPMENT	176,843,095	3057013 MH	51,529,875	14,316,017	242,688,987
23 .	TURBINE PLANT EQUIPMENT	135,678,569	2612179 MH	43,231,848	8,846,075	187,756,492
24 .	ELECTRIC PLANT EQUIPMENT	24,170,073	2143293 MH	34,846,182	10,947,962	69,964,217
25 .	MISCELLANEOUS PLANT EQUIPT	11,460,093	522197 MH	8,762,679	1,725,269	21,948,041
26 .	MAIN COND HEAT REJECT SYS	22,553,611	490546 MH	7,678,298	1,974,964	32,206,873
	TOTAL DIRECT COSTS	380,487,040	16673831 MH	262,548,167	102,354,533	745,389,740
91 .	CONSTRUCTION SERVICES	55,663,543	2809375 MH	44,138,013	37,364,800	137,166,356
92 .	HOME OFFICE ENGRG.&SERVICE	172,111,610				172,111,610
93 .	FIELD OFFICE ENGRG&SERVICE	77,674,740			3,018,950	80,693,690
	TOTAL INDIRECT COSTS	305,449,893	2809375 MH	44,138,013	40,383,750	389,971,656
	TOTAL BASE COST	685,936,933	19483206 MH	306,686,180	142,738,283	1,135,361,396

ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
1139 MWE PRESSURIZED WATER REACTOR

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20	LAND AND LAND RIGHTS				2,750,000	2,750,000

PLANT CODE 148 | COST BASIS 01/81

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
1139 MWE PRESSURIZED WATER REACTOR

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
211.	YARDWORK	247,750	667506 MH	8,969,812	6,905,310	16,122,872
212.	REACTOR CONTAINMENT BLDG	4,375,334	2473946 MH	37,976,338	20,589,210	62,940,882
213.	TURBINE ROOM + HEATER BAY	651,662	600763 MH	9,094,360	10,236,266	19,982,288
214.	SECURITY BUILDING	46,994	50478 MH	750,125	379,963	1,177,082
215.	PRIM AUX BLDG + TUNNELS	847,670	746670 MH	10,996,193	4,126,287	15,970,150
216.	WASTE PROCESS BUILDING	249,024	723879 MH	10,517,083	4,115,523	14,881,630
217.	FUEL STORAGE BLDG	859,545	347346 MH	5,346,144	2,316,690	8,522,379
218A.	CONTROL RM/D-G BUILDING	1,485,754	950238 MH	14,065,365	5,041,222	20,592,341
218B.	ADMINISTRATION+SERVICE BLG	834,885	285722 MH	4,421,815	2,698,483	7,955,183
218D.	FIRE PUMP HOUSE,INC FNDINS	32,684	16481 MH	247,114	119,436	399,234
218E.	EMERGENCY FEED PUMP BLDG	32,140	211185 MH	3,032,419	788,495	3,853,054
218F.	MANWAY TUNNELS (RCA TUNLS)	2,457	50949 MH	730,877	216,291	949,625
218G.	ELEC. TUNNELS	4,449	560 MH	9,452	3,732	17,633
218H.	NON-ESSEN. SWGR BLDG.	18,586	22206 MH	325,245	184,234	528,065
218J.	MN STEAM + FW PIPE ENC.	10,310	214105 MH	3,080,491	1,533,357	4,624,158
218K.	PIPE TUNNELS		26222 MH	379,382	125,089	504,471
218L.	TECHNICAL SUPPORT CENTER	42,303	28668 MH	433,408	205,733	681,444
218M.	HYDROGEN RECOMBINER STRUCT	3,671	9536 MH	136,791	64,993	205,455
218P.	CONTAIN EQ HATCH MSLE SHLD		14565 MH	208,295	44,950	253,245
218S.	HOLDING POND		12248 MH	174,520	57,490	232,010
218T.	ULTIMATE HEAT SINK STRUCT	36,381	379673 MH	5,397,006	1,978,974	7,412,361
218V.	CONTR RM EMG AIR INTK STR		15657 MH	207,050	62,518	269,568
21 .	STRUCTURES + IMPROVEMENTS	9,781,599	7848603 MH	116,499,285	61,794,246	188,075,130

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
220A.	NUCLEAR STEAM SUPPLY(NSSS)	126,360,000				126,360,000
220B.	NSSS OPTIONS					
221.	REACTOR EQUIPMENT	709,879	130170 MH	2,202,318	2,957,470	5,869,667
222.	MAIN HEAT XFER XPORT SYS.	5,978,923	556864 MH	9,499,768	938,583	16,417,274
223.	SAFEGUARDS SYSTEM	6,074,663	686378 MH	11,589,346	1,533,600	19,197,609
224.	RADWASTE PROCESSING	9,552,312	370284 MH	6,250,833	967,162	16,770,307
225.	FUEL HANDLING + STORAGE	3,981,124	89057 MH	1,482,549	165,315	5,628,988
226.	OTHER REACTOR PLANT EQUIP	10,803,936	909781 MH	15,358,416	4,719,985	30,882,337
227.	RX INSTRUMENTATION+CONTROL	11,290,246	94592 MH	1,536,324	133,174	12,959,744
228.	REACTOR PLANT MISC ITEMS	2,092,012	219887 MH	3,610,321	2,900,728	8,603,061
22 .	REACTOR PLANT EQUIPMENT	176,843,095	3057013 MH	51,529,875	14,316,017	242,688,987
231.	TURBINE GENERATOR	93,543,851	628024 MH	9,989,453	1,919,040	105,452,344
233.	CONDENSING SYSTEMS	14,957,918	401099 MH	6,748,501	1,329,652	23,036,071
234.	FEED HEATING SYSTEM	14,493,881	560795 MH	9,471,074	946,296	24,911,251
235.	OTHER TURBINE PLANT EQUIP.	11,121,516	795415 MH	13,406,814	1,601,029	26,129,359
236.	INSTRUMENTATION + CONTROL	1,561,403	57341 MH	930,467	79,482	2,571,352
237.	TURBINE PLANT MISC ITEMS		169505 MH	2,685,539	2,970,576	5,656,115
23 .	TURBINE PLANT EQUIPMENT	135,678,569	2612179 MH	43,231,848	3,846,075	187,756,492

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	7,673,344	92143 MH	1,494,450	152,245	9,320,039
242.	STATION SERVICE EQUIPMENT	13,771,769	149027 MH	2,383,786	369,164	16,524,719
243.	SWITCHBOARDS	1,269,066	17317 MH	281,118	114,219	1,664,403
244.	PROTECTIVE EQUIPMENT		113256 MH	1,850,826	804,540	2,655,366
245.	ELECT.STRUC +WIRING CONTNR		822113 MH	13,320,312	2,912,466	16,232,778
246.	POWER & CONTROL WIRING	1,455,894	949437 MH	15,515,690	6,595,328	23,566,912
24 .	ELECTRIC PLANT EQUIPMENT	24,170,073	2143293 MH	34,846,182	10,947,962	69,964,217
251.	TRANSPORTATION & LIFT EQPT	2,696,574	42216 MH	710,126	180,922	3,587,622
252.	AIR,WATER+STEAM SERVICE SY	5,216,279	433650 MH	7,304,694	1,256,727	13,777,700
253.	COMMUNICATIONS EQUIPMENT	2,334,807	34947 MH	571,091	258,000	3,163,898
254.	FURNISHINGS + FIXTURES	1,212,433	11384 MH	176,768	29,620	1,418,821
25 .	MISCELLANEOUS PLANT EQUIPT	11,460,093	522197 MH	8,762,679	1,725,269	21,948,041
261.	STRUCTURES	140,530	163374 MH	2,371,439	1,173,551	3,685,520
262.	MECHANICAL EQUIPMENT	22,413,081	327172 MH	5,306,859	801,413	28,521,353
26 .	MAIN COND HEAT REJECT SYS	22,553,611	490546 MH	7,678,298	1,974,964	32,206,873
	TOTAL DIRECT COSTS	380,487,040	16673831 MH	262,548,167	102,354,533	745,389,740

PLANT CODE 148 | COST BASIS 01/81

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
1139 MWE PRESSURIZED WATER REACTOR

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		2433790 MH	38,236,487	11,561,550	49,798,037
912.	CONSTRUCTION TOOLS & EQUIP		375585 MH	5,901,526	24,932,050	30,833,576
913.	PAYROLL INSURANCE & TAXES	55,663,543				55,663,543
914.	PERMITS,INS. & LOCAL TAXES				871,200	871,200
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	55,663,543	2809375 MH	44,138,013	37,364,800	137,166,356
921.	HOME OFFICE SERVICES	162,665,140				162,665,140
922.	HOME OFFICE Q/A	6,944,190				6,944,190
923.	HOME OFFICE CONSTRCTN MGMT	2,502,280				2,502,280
92 .	HOME OFFICE ENGRG.&SERVICE	172,111,610				172,111,610
931.	FIELD OFFICE EXPENSES				3,018,950	3,018,950
932.	FIELD JOB SUPERVISION	67,991,110				67,991,110
933.	FIELD QA/QC	5,737,820				5,737,820
934.	PLANT STARTUP & TEST	3,945,810				3,945,810
93 .	FIELD OFFICE ENGRG&SERVICE	77,674,740			3,018,950	80,693,690
	TOTAL INDIRECT COSTS	305,449,893	2809375 MH	44,138,013	40,383,750	389,971,656
	TOTAL BASE COST	685,936,933	19483206 MH	306,686,180	142,738,283	1,135,361,396

TABLE 5-7

ENERGY ECONOMIC DATA BASE

1260 MWe PRESSURIZED HEAVY WATER REACTOR NPGS

CAPITAL COST ESTIMATE

PLANT CODE 165 COST BASIS 01/81

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
1260 MWE PRESSURIZED HEAVY WATER REACTOR

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND + LAND RIGHTS				2,750,000	2,750,000
21 .	STRUCTURES + IMPROVEMENTS	9,959,526	8630323 MH	126,093,186	81,093,221	217,145,933
22 .	REACTOR PLANT EQUIPMENT	246,343,895	2744174 MH	46,259,350	13,910,366	306,513,611
23 .	TURBINE PLANT EQUIPMENT	148,748,539	2784220 MH	46,162,958	9,163,395	204,074,892
24 .	ELECTRIC PLANT EQUIPMENT	23,040,504	2653636 MH	43,132,333	13,766,097	79,938,934
25 .	MISCELLANEOUS PLANT EQUIPT	15,883,183	754108 MH	12,603,880	1,975,027	30,462,090
26 .	MAIN COND HEAT REJECT SYS	32,166,133	566171 MH	8,953,738	2,101,923	43,221,794
	TOTAL DIRECT COSTS	476,141,780	18132632 MH	283,205,445	124,760,029	884,107,254
91 .	CONSTRUCTION SERVICES	59,819,315	2964654 MH	46,377,639	40,686,250	146,883,204
92 .	HOME OFFICE ENGRG.&SERVICE	183,547,320				183,547,320
93 .	FIELD OFFICE ENGRG&SERVICE	83,419,820			3,527,150	86,946,970
	TOTAL INDIRECT COSTS	326,786,455	2964654 MH	46,377,639	44,213,400	417,377,494
	TOTAL BASE COST	802,928,235	21097286 MH	329,583,084	168,973,429	1,301,484,748

PLANT CODE 165 COST BASIS 01/81

ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
1260 MWE PRESSURIZED HEAVY WATER REACTOR

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20	LAND + LAND RIGHTS				2,750,000	2,750,000
211.	YARDWORK	247,019	658506 MH	8,817,897	6,357,097	15,422,013
212.	REACTOR CONTAINMENT BLDG	3,762,095	3021570 MH	46,176,140	24,839,561	74,777,796
213.	TURBINE ROOM + HEATER BAY	764,583	615773 MH	9,346,271	10,856,772	20,967,626
214.	SECURITY BUILDING	46,994	49903 MH	742,961	374,463	1,164,418
215.	RX SERV.& F.H. BUILDING	1,101,428	1158031 MH	15,355,256	5,617,199	22,073,883
216.	D2O UPGRADING TOWER STRUCT	132,171	129424 MH	1,743,575	1,435,907	3,311,653
218A.	CONTROL RM/D-G BUILDING	1,687,441	1048831 MH	15,357,295	4,536,220	21,580,956
218B.	ADMINISTRATION+WAREHOUSE	797,974	284799 MH	4,406,060	2,692,620	7,896,654
218C.	COMP COOLING WATER BUILD.	290,514	235828 MH	3,467,474	1,641,046	5,399,034
218D.	FIRE PUMP HOUSE,INC FNDTNS	27,349	16303 MH	244,112	119,072	390,533
218J.	PENETRATIONS BUILDING	106,274	215291 MH	3,100,757	9,972,477	13,179,508
218K.	PIPE TUNNELS		26222 MH	379,382	125,089	504,471
218L.	TECHNICAL SUPPORT CENTER	42,303	28668 MH	433,408	205,733	681,444
218S.	HOLDING POND		10125 MH	142,990	47,090	190,080
218T.	ULTIMATE HEAT SINK STRUCT	36,381	320392 MH	4,558,558	4,744,540	9,339,479
218V.	CONTR RM EMG AIR INTK STR		15657 MH	207,050	59,335	266,385
219.	AFI	917,000	795000 MH	11,614,000	7,469,000	20,000,000
21	STRUCTURES + IMPROVEMENTS	9,959,526	8630323 MH	126,093,186	81,093,221	217,145,933

PLANT CODE 165 | COST BASIS 01/81

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
1260 MWE PRESSURIZED HEAVY WATER REACTOR

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
220A.	NUCLEAR STEAM SUPPLY(NSSS)	166,222,760				166,222,760
220B.	NSSS OPTIONS					
221.	REACTOR EQUIPMENT	1,161,570	317403 MH	5,367,975	4,083,454	10,612,999
222A.	MAIN HEAT XFER XPORT SYS.	7,151,635	603152 MH	10,291,819	1,365,484	18,808,938
222B.	MODERATOR CIRCUIT	1,741,708	227837 MH	3,848,153	395,482	5,985,343
223.	SAFEGUARDS SYSTEM	3,129,541	302760 MH	5,114,294	526,812	8,770,647
224.	RADWASTE PROCESSING	6,699,615	172284 MH	2,908,072	764,764	10,372,451
225.	FUEL HANDLING + STORAGE	3,137,217	142409 MH	2,382,946	255,368	5,775,531
226.	OTHER REACTOR PLANT EQUIP	35,922,430	544465 MH	9,193,485	2,989,034	48,104,949
227.	RX INSTRUMENTATION+CONTROL	11,048,407	123977 MH	2,033,285	175,240	13,256,932
228.	REACTOR PLANT MISC ITEMS	2,092,012	219887 MH	3,610,321	2,900,728	8,603,061
229.	AFI	8,037,000	90000 MH	1,509,000	454,000	10,000,000
22 .	REACTOR PLANT EQUIPMENT	246,343,895	2744174 MH	46,259,350	13,910,366	306,513,611
231.	TURBINE GENERATOR	105,746,447	674815 MH	10,798,952	2,011,522	118,556,921
233.	CONDENSING SYSTEMS	15,950,415	463787 MH	7,809,981	1,268,090	25,028,486
234.	FEED WATER HEATING SYSTEM	13,831,370	611997 MH	10,338,320	1,112,161	25,281,851
235.	OTHER TURBINE PLANT EQUIP.	11,830,937	796400 MH	13,423,909	1,603,074	26,857,920
236.	INSTRUMENTATION + CONTROL	1,389,370	56324 MH	913,970	77,832	2,381,172
237.	TURBINE PLANT MISC ITEMS		180897 MH	2,877,826	3,090,716	5,968,542
23 .	TURBINE PLANT EQUIPMENT	148,748,539	2784220 MH	46,162,958	9,163,395	204,074,892

PLANT CODE 165 COST BASIS 01/81 ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV

1260 MWE PRESSURIZED HEAVY WATER REACTOR 08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	6,650,459	98913 MH	1,604,242	157,183	8,411,884
242.	STATION SERVICE EQUIPMENT	11,391,714	158888 MH	2,541,995	383,983	14,317,692
243.	SWITCHBOARDS	1,152,646	17318 MH	281,118	101,465	1,535,229
244.	PROTECTIVE EQUIPMENT		113377 MH	1,852,796	608,465	2,461,261
245.	ELECT.STRUC +WIRING CONTNR		913615 MH	14,795,820	3,066,434	17,862,254
246.	POWER & CONTROL WIRING	1,251,685	1052525 MH	17,200,362	7,898,567	26,350,614
249.	AFI	2,594,000	299000 MH	4,856,000	1,550,000	9,000,000
24 .	ELECTRIC PLANT EQUIPMENT	23,040,504	2653636 MH	43,132,333	13,766,097	79,938,934
251.	TRANSPORTATION & LIFT EQPT	2,696,574	42216 MH	710,126	180,922	3,587,622
252.	AIR,WATER+STEAM SERVICE SY	9,762,770	524048 MH	8,833,283	1,275,223	19,871,276
253.	COMMUNICATIONS EQUIPMENT	2,242,541	176460 MH	2,883,703	489,262	5,615,506
254.	FURNISHINGS + FIXTURES	1,181,298	11384 MH	176,768	29,620	1,387,686
25 .	MISCELLANEOUS PLANT EQUIPT	15,883,183	754108 MH	12,603,880	1,975,027	30,462,090
261.	STRUCTURES	140,530	163374 MH	2,372,947	1,173,551	3,687,028
262.	MECHANICAL EQUIPMENT	32,025,603	402797 MH	6,580,791	928,372	39,534,766
26 .	MAIN COND HEAT REJECT SYS	32,166,133	566171 MH	8,953,738	2,101,923	43,221,794
	TOTAL DIRECT COSTS	476,141,780	18132632 MH	283,205,445	124,760,029	884,107,254

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		2568388 MH	40,179,436	12,487,200	52,666,636
912.	CONSTRUCTION TOOLS & EQUIP		396266 MH	6,198,203	27,200,800	33,399,003
913.	PAYROLL INSURANCE & TAXES	59,819,315				59,819,315
914.	PERMITS,INS. & LOCAL TAXES				998,250	998,250
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	59,819,315	2964654 MH	46,377,639	40,686,250	146,883,204
921.	HOME OFFICE SERVICES	173,595,070				173,595,070
922.	HOME OFFICE Q/A	7,453,600				7,453,600
923.	HOME OFFICE CONSTRCTN MGMT	2,498,650				2,498,650
92 .	HOME OFFICE ENGRG.&SERVICE	183,547,320				183,547,320
931.	FIELD OFFICE EXPENSES				3,527,150	3,527,150
932.	FIELD JOB SUPERVISION	73,191,690				73,191,690
933.	FIELD QA/QC	6,204,880				6,204,880
934.	PLANT STARTUP & TEST	4,023,250				4,023,250
93 .	FIELD OFFICE ENGRG&SERVICE	83,419,820			3,527,150	86,946,970
	TOTAL INDIRECT COSTS	326,786,455	2964654 MH	46,377,639	44,213,400	417,377,494
	TOTAL BASE COST	802,928,235	21097286 MH	329,583,084	168,973,429	1,301,484,748

Effective Date - 1/1/81

TABLE 5-8

ENERGY ECONOMIC DATA BASE

150 MWe HIGH TEMPERATURE GAS COOLED REACTOR-PROCESS STEAM NPGS

CAPITAL COST ESTIMATE

PLANT CODE 325 | COST BASIS 01/81

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
150 MWE HIGH TEMPERATURE GAS COOLED REACTOR-PS

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND + LAND RIGHTS				2,750,000	2,750,000
21 .	STRUCTURES & IMPROVEMENTS	5,145,442	5694204 MH	84,256,702	44,537,758	133,939,902
22 .	REACTOR PLANT EQUIPMENT	153,470,210	1540762 MH	25,234,666	15,429,438	194,134,314
23 .	TURBINE PLANT EQUIPMENT	46,204,549	1085470 MH	17,832,161	4,028,608	68,065,318
24 .	ELECTRIC PLANT EQUIP	15,792,350	1849609 MH	29,993,517	13,867,646	59,653,513
25 .	MISC. PLANT EQUIP	7,206,983	348396 MH	5,810,935	1,298,993	14,316,911
26 .	MAIN COND HEAT REJECT SYS	4,486,656	145630 MH	2,332,315	548,727	7,367,698
	TOTAL DIRECT COSTS	232,306,190	10664071 MH	165,460,296	82,461,170	480,227,656
91 .	CONSTRUCTION SERVICES	35,776,590	2238162 MH	31,655,862	25,561,800	92,994,252
92 .	HOME OFFICE ENGRG.&SERVICE	158,387,032				158,387,032
93 .	FIELD OFFICE ENGRG&SERVICE	61,489,742			5,186,126	66,675,868
	TOTAL INDIRECT COSTS	255,653,364	2238162 MH	31,655,862	30,747,926	318,057,152
	TOTAL BASE COST	487,959,554	12902233 MH	197,116,158	113,209,096	798,284,808

PLANT CODE 325 COST BASIS 01/81

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
150 MWE HIGH TEMPERATURE GAS COOLED REACTOR-PS

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND + LAND RIGHTS				2,750,000	2,750,000
211.	YARDWORK	241,872	324624 MH	4,414,377	3,903,614	8,559,863
212.	REACTOR CONTAINMENT BLDG	863,697	1611940 MH	24,816,195	16,849,848	42,529,740
213.	TURBINE BUILDING	621,303	208161 MH	3,211,667	2,269,592	6,102,562
214.	SECURITY BUILDING	41,924	19944 MH	307,051	185,678	534,653
215.	AUX. REACTOR SERVICE BLDG	582,934	537788 MH	7,870,366	4,004,053	12,457,353
216.	MAIN CIRC CONTROL BLDG	289,900	7189 MH	107,609	112,303	509,812
217.	FUEL STORAGE BLDG	64,559	327212 MH	4,823,540	2,102,112	6,990,211
218A.	CONTROL, AUXIL & D.G.BLDG	1,617,889	971800 MH	14,366,373	4,907,908	20,892,170
218B.	ADMIN + SERV BLDG	403,810	224846 MH	3,480,246	2,344,294	6,228,350
218D.	FIRE PUMP HOUSE	34,759	9099 MH	139,800	66,203	240,762
218E.	HELIUM STORAGE AREA		48209 MH	690,199	377,260	1,067,459
218F.	MAKE-UP WATER TREAT BLDG	108,264	302976 MH	4,157,375	1,342,380	5,608,019
218H.	DIES CLG + FL OIL STG BLDG	12,377	137475 MH	1,972,599	652,059	2,637,035
218I.	WAREHOUSE		8300 MH	123,521	110,795	234,316
218J.	CONTAINMENT ANNULUS BLDG	120,420	207291 MH	3,000,775	1,242,158	4,363,353
218K.	CONTAIN PENETRATION BLDG	30,486	426582 MH	6,134,654	2,206,655	8,371,795
218L.	TECHNICAL SUPPORT CENTER	42,303	28668 MH	433,408	205,733	681,444
218S.	HOLDING POND		12412 MH	176,790	58,390	235,180
218T.	ULTIMATE HEAT SINK STRUCT	44,077	272521 MH	3,926,821	1,570,908	5,541,806
218V.	CTL RM EMG AIR IN STR	24,868	7167 MH	103,336	25,815	154,019
21 .	STRUCTURES & IMPROVEMENTS	5,145,442	5694204 MH	84,256,702	44,537,758	133,939,902

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*********	************************	************	***********	************	************	*************
220A.	NUCLEAR STEAM SUPPLY(NSSS)	123,228,000				123,228,000
220B.	NSSS OPTIONS					
221.	REACTOR EQUIPMENT	460,418	623853 MH	10,167,437	13,275,176	23,903,031
222.	MAIN HEAT TRANS SYS.	1,447,219	87816 MH	1,531,652	153,410	3,132,281
223.	SAFEGUARDS COOL. SYS.	3,622,309	169556 MH	2,862,089	323,571	6,807,969
224.	RAD WASTE PROCESSING	2,341,632	73058 MH	1,232,640	95,132	3,669,404
225.	NUCLEAR FUEL HANDLING + ST	4,533,255	74674 MH	1,020,756	89,672	5,643,683
226.	OTHER REACTOR PLANT EQUIP	12,858,288	246381 MH	4,153,552	1,068,930	18,080,770
227.	INSTRUMENTATION + CONTROL	4,534,289	117883 MH	1,912,869	60,072	6,507,230
228.	REACTOR PLANT MISC ITEMS	444,800	147541 MH	2,353,671	363,475	3,161,946
22 .	REACTOR PLANT EQUIPMENT	153,470,210	1540762 MH	25,234,666	15,429,438	194,134,314
231.	TURBINE GENERATOR	19,695,786	288666 MH	4,526,841	1,192,999	25,415,626
233.	CONDENSING SYS.	1,789,739	118461 MH	2,023,307	343,935	4,156,981
234.	FEED HEAT. SYS.	6,509,277	169220 MH	2,870,194	320,556	9,700,027
235.	OTHER TURB PLANT EQUIP	17,384,015	377538 MH	6,335,991	964,519	24,684,525
236.	INSTRUMENTATION + CONTROL	825,732	70957 MH	1,151,391	567,901	2,545,024
237.	TURBINE PLANT MISC ITEMS		60628 MH	924,437	638,698	1,563,135
23 .	TURBINE PLANT EQUIPMENT	46,204,549	1085470 MH	17,832,161	4,028,608	68,065,318

PLANT CODE 325 | COST BASIS 01/81

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
150 MWE HIGH TEMPERATURE GAS COOLED REACTOR PS

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	6,202,640	93015 MH	1,508,598	161,061	7,872,299
242.	STATION SERVICE EQUIP	7,839,855	132290 MH	2,110,657	341,070	10,291,582
243.	SWITCHBOARDS	1,392,919	18276 MH	297,180	35,473	1,725,572
244.	PROTECTIVE EQUIP		123274 MH	2,014,550	773,637	2,788,187
245.	ELEC STRUC + WIRING CNTNRS		724627 MH	11,673,228	2,763,619	14,436,847
246.	POWER & CONTROL WIRING	356,936	758127 MH	12,389,304	9,792,786	22,539,026
24 .	ELECTRIC PLANT EQUIP	15,792,350	1849609 MH	29,993,517	13,867,646	59,653,513
251.	TRANSPORTATION+LIFT EQUIP	2,264,740	27597 MH	459,891	45,989	2,770,620
252.	AIR WTR+STEAM SERV SYS	2,651,437	274224 MH	4,603,552	1,156,244	8,411,233
253.	COMMUNICATIONS EQUIP	1,207,215	34845 MH	568,169	47,877	1,823,261
254.	FURNISHINGS + FIXTURES	1,083,591	11730 MH	179,323	48,883	1,311,797
25 .	MISC. PLANT EQUIP	7,206,983	348396 MH	5,810,935	1,298,993	14,316,911
261.	STRUCTURES	92,122	58952 MH	969,723	346,378	1,408,223
262.	MECHANICAL EQUIPMENT	4,394,534	86678 MH	1,362,592	202,349	5,959,475
26 .	MAIN COND HEAT REJECT SYS	4,486,656	145630 MH	2,332,315	548,727	7,367,698
	TOTAL DIRECT COSTS	232,306,190	10664071 MH	165,460,296	82,461,170	480,227,656

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		1904884 MH	25,993,334	7,770,400	33,763,734
912.	CONSTRUCTION TOOLS & EQUIP		333278 MH	5,662,528	17,076,400	22,738,928
913.	PAYROLL INSURANCE & TAXES	35,776,590				35,776,590
914.	PERMITS, INS. & LOCAL TAXES				715,000	715,000
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	35,776,590	2238162 MH	31,655,862	25,561,800	92,994,252
921.	HOME OFFICE SERVICES	150,094,220				150,094,220
922.	HOME OFFICE Q/A	6,131,620				6,131,620
923.	HOME OFFICE CONSTRCTN MGMT	2,161,192				2,161,192
92 .	HOME OFFICE ENGRG.&SERVICE	158,387,032				158,387,032
931.	FIELD OFFICE EXPENSES				5,186,126	5,186,126
932.	FIELD JOB SUPERVISION	52,261,072				52,261,072
933.	FIELD QA/QC	5,407,710				5,407,710
934.	PLANT STARTUP & TEST	3,820,960				3,820,960
93 .	FIELD OFFICE ENGRG&SERVICE	61,489,742			5,186,126	66,675,868
	TOTAL INDIRECT COSTS	255,653,364	2238162 MH	31,655,862	30,747,926	318,057,152
	TOTAL BASE COST	487,959,554	12902233 MH	197,116,158	113,209,096	798,284,808

Effective Date - 1/1/81

TABLE 5-9

ENERGY ECONOMIC DATA BASE

1457 MWe LIQUID METAL FAST BREEDER REACTOR NPGS

CAPITAL COST ESTIMATE

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20	LAND AND LAND RIGHTS				2,750,000	2,750,000
21	STRUCTURES + IMPROVEMENTS	13,771,148	11958118 MH	178,795,480	102,669,119	295,235,747
22	REACTOR PLANT EQUIPMENT	431,838,704	5215692 MH	87,785,231	23,817,752	543,441,687
23	TURBINE PLANT EQUIPMENT	153,081,198	2877838 MH	47,577,888	8,993,885	209,652,971
24	ELECTRIC PLANT EQUIPMENT	26,126,675	2972878 MH	48,221,720	15,205,831	89,554,226
25	MISCELLANEOUS PLANT EQUIPT	19,498,016	1019192 MH	16,754,349	2,413,893	38,666,258
26	MAIN COND HEAT REJECT SYS	24,149,747	621548 MH	9,857,546	2,220,958	36,228,251
	TOTAL DIRECT COSTS	668,465,488	24665266 MH	388,992,214	158,071,438	1,215,529,140
91	CONSTRUCTION SERVICES	82,414,480	4121442 MH	65,116,800	45,399,200	192,930,480
92	HOME OFFICE ENGRG.&SERVICE	256,939,870				256,939,870
93	FIELD OFFICE ENGRG&SERVICE	95,286,290			3,799,400	99,085,690
	TOTAL INDIRECT COSTS	434,640,640	4121442 MH	65,116,800	49,198,600	548,956,040
	TOTAL BASE COST	1,103,106,128	28786708 MH	454,109,014	207,270,038	1,764,485,180

PLANT CODE 401 COST BASIS 01/81

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
1457 MWE LIQUID METAL FAST BREEDER REACTOR

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,750,000	2,750,000
211.	YARDWORK	247,750	967920 MH	12,875,215	9,097,127	22,220,092
212.	REACTOR CONTAINMENT BLDG	5,863,108	5137337 MH	78,747,845	44,798,318	129,409,271
213.	TURBINE ROOM + HEATER BAY	646,969	668899 MH	10,205,160	11,185,581	22,037,710
214.	SECURITY + TSC BUILDING	90,471	83108 MH	1,242,105	615,652	1,948,228
215.	REACTOR SERVICE BUILDING	1,557,335	1097332 MH	16,344,372	7,237,093	25,138,800
216.	WASTE PROCESS BUILDING					
217.	FUEL STORAGE BLDG					
218A.	CONTROL RM/D-G BUILDING	2,338,454	1129684 MH	16,907,568	7,219,636	26,465,658
218B.	ADMINISTRATION BUILDING	221,466	92635 MH	1,408,064	906,710	2,536,240
218C.	D/G COOLING TOWER		92604 MH	1,337,749	526,640	1,864,389
218D.	FIRE PUMP HOUSE,INC FNDTNS	32,684	16481 MH	247,114	119,436	399,234
218E.	STEAM GENERATOR BUILDING	966,131	838567 MH	12,475,366	7,927,623	21,369,120
218H.	NON-ESSEN. SWGR BLDG.	20,824	33316 MH	488,301	272,387	781,512
218I.	AUXILIARY BUILDINGS	644,319	874272 MH	12,802,035	5,928,349	19,374,703
218K.	PIPE TUNNELS		35204 MH	507,483	186,509	693,992
218N.	MAINTENANCE BUILDING	641,006	201462 MH	3,117,741	1,904,530	5,663,277
218R.	AUXILIARY BOILER BUILDING	156,607	56567 MH	870,743	648,681	1,676,031
218S.	HOLDING POND		12248 MH	174,520	57,490	232,010
218T.	ULTIMATE HEAT SINK STRUCT	101,888	190838 MH	2,735,850	844,676	3,682,414
218V.	CONTR RM EMG AIR INTK STR		15657 MH	207,050	62,518	269,568
218W.	AUX HEAT TRANS SYS BAYS	242,136	413987 MH	6,101,199	3,130,163	9,473,498
21 .	STRUCTURES + IMPROVEMENTS	13,771,148	11958118 MH	178,795,480	102,669,119	295,235,747

PLANT CODE 401 COST BASIS 01/81

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
1457 MWE LIQUID METAL FAST BREEDER REACTOR

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
220A.	NUCLEAR STEAM SUPPLY(NSSS)	391,716,000				391,716,000
220B.	NSSS OPTIONS					
221.	REACTOR EQUIPMENT	3,795,656	406183 MH	6,874,566	5,289,393	15,959,615
222.	MAIN HEAT XFER XPORT SYS.	17,895,030	2833977 MH	47,965,417	4,638,610	70,499,057
223.	SAFEGUARDS SYSTEM	36,045	139515 MH	2,355,798	235,581	2,627,424
224.	RADWASTE PROCESSING	3,957,301	231574 MH	3,899,608	454,065	8,310,974
225.	FUEL HANDLING	2,754,000	343302 MH	5,805,640	546,134	9,105,774
226.	OTHER REACTOR PLANT EQUIP	5,504,733	769458 MH	12,775,830	1,666,366	19,946,929
227.	RX INSTRUMENTATION+CONTROL	3,460,324	149120 MH	2,429,909	210,525	6,100,758
228.	REACTOR PLANT MISC ITEMS	2,719,615	342563 MH	5,678,463	10,777,078	19,175,156
22 .	REACTOR PLANT EQUIPMENT	431,838,704	5215692 MH	87,785,231	23,817,752	543,441,687
231.	TURBINE GENERATOR	104,676,104	759564 MH	12,049,532	2,493,195	119,218,831
233.	CONDENSING SYSTEMS	19,966,680	603150 MH	10,235,731	1,097,085	31,299,496
234.	FEED HEATING SYSTEM	16,518,105	435140 MH	7,343,660	729,532	24,591,297
235.	OTHER TURBINE PLANT EQUIP.	10,368,574	834181 MH	14,061,079	1,414,897	25,844,550
236.	INSTRUMENTATION + CONTROL	1,551,735	57341 MH	930,467	87,704	2,569,906
237.	TURBINE PLANT MISC ITEMS		188462 MH	2,957,419	3,171,472	6,128,891
23 .	TURBINE PLANT EQUIPMENT	153,081,198	2877838 MH	47,577,888	8,993,885	209,652,971

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	8,990,274	121919 MH	1,977,396	200,611	11,168,281
242.	STATION SERVICE EQUIPMENT	14,276,141	159655 MH	2,556,152	391,791	17,224,084
243.	SWITCHBOARDS	1,269,066	17318 MH	281,118	114,219	1,664,403
244.	PROTECTIVE EQUIPMENT		113470 MH	1,854,326	822,308	2,676,634
245.	ELECT.STRUC +WIRING CONTNR		1242438 MH	20,012,720	4,466,744	24,479,464
246.	POWER & CONTROL WIRING	1,591,194	1318078 MH	21,540,008	9,210,158	32,341,360
24 .	ELECTRIC PLANT EQUIPMENT	26,126,675	2972878 MH	48,221,720	15,205,831	89,554,226
251.	TRANSPORTATION & LIFT EQPT	3,626,978	51225 MH	861,674	78,653	4,567,305
252.	AIR,WATER+STEAM SERVICE SY	11,969,076	917002 MH	15,070,016	2,041,326	29,080,418
253.	COMMUNICATIONS EQUIPMENT	2,568,288	38441 MH	628,205	259,939	3,456,432
254.	FURNISHINGS + FIXTURES	1,333,674	12524 MH	194,454	33,975	1,562,103
25 .	MISCELLANEOUS PLANT EQUIPT	19,498,016	1019192 MH	16,754,349	2,413,893	38,666,258
261.	STRUCTURES	140,530	163374 MH	2,372,937	1,173,551	3,687,018
262.	MECHANICAL EQUIPMENT	24,009,217	458174 MH	7,484,609	1,047,407	32,541,233
26 .	MAIN COND HEAT REJECT SYS	24,149,747	621548 MH	9,857,546	2,220,958	36,228,251
	TOTAL DIRECT COSTS	668,465,488	24665266 MH	388,992,214	158,071,438	1,215,529,140

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		3570804 MH	56,415,520	11,785,400	68,200,920
912.	CONSTRUCTION TOOLS & EQUIP		550638 MH	8,701,280	32,252,550	40,953,830
913.	PAYROLL INSURANCE & TAXES	82,414,480				82,414,480
914.	PERMITS,INS. & LOCAL TAXES				1,361,250	1,361,250
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	82,414,480	4121442 MH	65,116,800	45,399,200	192,930,480
921.	HOME OFFICE SERVICES	244,011,020				244,011,020
922.	HOME OFFICE Q/A	10,430,200				10,430,200
923.	HOME OFFICE CONSTRCTN MGMT	2,498,650				2,498,650
92 .	HOME OFFICE ENGRG.&SERVICE	256,939,870				256,939,870
931.	FIELD OFFICE EXPENSES				3,799,400	3,799,400
932.	FIELD JOB SUPERVISION	81,013,130				81,013,130
933.	FIELD QA/QC	8,548,650				8,548,650
934.	PLANT STARTUP & TEST	5,724,510				5,724,510
93 .	FIELD OFFICE ENGRG&SERVICE	95,286,290			3,799,400	99,085,690
	TOTAL INDIRECT COSTS	434,640,640	4121442 MH	65,116,800	49,198,600	548,956,040
	TOTAL BASE COST	1,103,106,128	28786708 MH	454,109,014	207,270,038	1,764,485,180

TABLE 5-10

ENERGY ECONOMIC DATA BASE

1240 MWe HIGH SULFUR COAL FPGS

CAPITAL COST ESTIMATE

PLANT CODE	COST BASIS	UNITED ENGINEERS & CONSTRUCTORS INC.	SUMMARY PAGE 1
610	01/81	ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV	
		1240 MWE HIGH SULFUR COAL	08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,750,000	2,750,000
21 .	STRUCTURES + IMPROVEMENTS	1,980,005	1690989 MH	24,627,763	41,606,300	68,214,068
22 .	BOILER PLANT EQUIPMENT	261,111,754	5633507 MH	93,328,241	26,729,048	381,169,043
23 .	TURBINE PLANT EQUIPMENT	135,103,573	1867269 MH	30,950,769	7,559,040	173,613,382
24 .	ELECTRIC PLANT EQUIPMENT	14,845,879	1254435 MH	20,364,238	11,183,975	46,394,092
25 .	MISCELLANEOUS PLANT EQUIPT	8,408,200	260122 MH	4,342,967	1,167,146	13,918,313
26 .	MAIN COND HEAT REJECT SYS	18,944,695	286741 MH	4,525,929	1,561,005	25,031,629
	TOTAL DIRECT COSTS	440,394,106	10993063 MH	178,139,907	92,556,514	711,090,527
91 .	CONSTRUCTION SERVICES	36,949,770	1564894 MH	25,440,090	27,762,900	90,152,760
92 .	HOME OFFICE ENGRG.&SERVICE	28,193,000				28,193,000
93 .	FIELD OFFICE ENGRG&SERVICE	29,054,520			1,657,700	30,712,220
	TOTAL INDIRECT COSTS	94,197,290	1564894 MH	25,440,090	29,420,600	149,057,980
	TOTAL BASE COST	534,591,396	12557957 MH	203,579,997	121,977,114	860,148,507

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,750,000	2,750,000
211.	YARDWORK	168,920	269124 MH	3,464,525	4,797,075	8,430,520
212.	STEAM GENERATOR BUILDING	662,262	560621 MH	8,413,609	18,390,756	27,466,627
213.	TURBINE,HEATER,CONTROL BLD	373,486	302153 MH	4,533,288	8,811,919	13,718,693
218B.	ADMINISTRATION+SERVICE BLD	265,284	69093 MH	1,070,044	1,266,313	2,601,641
218D.	FIRE PUMPHOUSE					
218I.	ELECTRICAL SWITCHGR BLDGS	31,475	7584 MH	118,103	65,933	215,511
218M.	COAL CAR THAW SHED		2582 MH	38,298	19,590	57,888
218N.	ROTARY CAR DUMP BLDG+TUNNL	5,118	43181 MH	607,523	546,526	1,159,167
218O.	COAL BREAKER HOUSE	81,467	21192 MH	323,552	546,269	951,288
218P.	COAL CRUSHER HOUSE	115,672	16343 MH	253,365	317,886	686,923
218Q.	BOILER HOUSE TRANSFR TOWER	3,936	6085 MH	94,505	214,194	312,635
218R.	ROTARY PLOW MAININCE SHED	8,870	112067 MH	1,589,035	1,14' 145	2,739,050
218T.	LOCOMOTIVE REPAIR GARAGE	16,991	5172 MH	79,313	96,298	192,602
218U.	MATERIAL HANDL+SERVICE BLD	20,171	10775 MH	162,913	202,056	385,140
218V.	WASTE WATER TREATMENT BLDG	4,353	12227 MH	171,549	141,877	317,779
218W.	MISC COAL HANDLING STRUCT	222,000	77397 MH	1,082,312	1,642,068	2,946,380
219.	STACK STRUCTURE		175393 MH	2,625,829	3,406,395	6,032,224
21 .	STRUCTURES + IMPROVEMENTS	1,980,005	1690989 MH	24,627,763	41,606,300	68,214,068

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
220A.	FOSSIL STEAM SUPPLY SYSTEM	87,542,856	1100000 MH	17,810,100	1,781,010	107,133,966
221.	STEAM GENERATING SYSTEM	1,893,699	37651 MH	637,096	69,036	2,599,831
222.	DRAFT SYSTEM	19,897,446	413826 MH	6,966,178	2,536,462	29,400,086
223.	ASH + DUST HANDLING SYSTEM	7,943,733	116147 MH	1,943,640	279,871	10,167,244
224.	FUEL HANDLING SYSTEMS	10,129,156	144286 MH	2,456,122	845,149	13,430,427
225.	FLUE GAS DESULFUR STRUCT	53,860	76206 MH	1,156,036	1,551,394	2,761,290
226.	DESULFURIZATION EQUIPMENT	129,907,477	3545233 MH	59,200,867	17,275,128	206,383,472
227.	INSTRUMENTATION + CONTROL	3,491,292	53628 MH	870,211	46,101	4 407,604
228.	BOILER PLANT MISC ITEMS	252,235	146530 MH	2,287,991	2,344,897	4,885,123
22 .	BOILER PLANT EQUIPMENT	261,111,754	5633507 MH	93,328,241	26,729,048	381,169,043
231.	TURBINE GENERATOR	82,192,308	376506 MH	5,877,100	2,370,043	90,439,451
233.	CONDENSING SYSTEMS	11,343,891	164834 MH	2,817,274	438,448	14,599,613
234.	FEED HEATING SYSTEM	22,905,601	312966 MH	5,288,151	529,128	28,722,880
235.	OTHER TURBINE PLANT EQUIP.	18,515,244	920340 MH	15,534,093	1,577,653	35,626,990
236.	INSTRUMENTATION + CONTROL	146,529	823 MH	13,355	668	160,552
237.	TURBINE PLANT MISC ITEMS		91800 MH	1,420,796	2,643,100	4,063,896
23 .	TURBINE PLANT EQUIPMENT	135,103,573	1867269 MH	30,950,769	7,559,040	173,613,382

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	7,966,112	67230 MH	1,090,391	117,192	9,173,695
242.	STATION SERVICE EQUIPMENT	5,130,601	60905 MH	968,350	197,561	6,296,512
243.	SWITCHBOARDS	833,020	10530 MH	170,945	96,045	1,100,010
244.	PROTECTIVE EQUIPMENT		85400 MH	1,398,348	1,102,792	2,501,140
245.	ELECT.STRUC +WIRING CONTNR		581100 MH	9,394,233	3,139,699	12,533,932
246.	POWER & CONTROL WIRING	916,146	449270 MH	7,341,971	6,530,686	14,788,803
24 .	ELECTRIC PLANT EQUIPMENT	14,845,879	1254435 MH	20,364,238	11,183,975	46,394,092
251.	TRANSPORTATION & LIFT EQPT	1,812,265	8125 MH	135,742	125,952	2,073,959
252.	AIR,WATER+STEAM SERVICE SY	4,683,763	182544 MH	3,076,678	364,277	8,124,718
253.	COMMUNICATIONS EQUIPMENT	166,889	25000 MH	408,550	254,135	829,574
254.	FURNISHINGS + FIXTURES	885,290	6717 MH	103,554	22,534	1,011,378
255.	WASTE WATER TREATMENT EQPT	859,993	37736 MH	618,443	400,248	1,878,684
25 .	MISCELLANEOUS PLANT EQUIPT	8,408,200	260122 MH	4,342,967	1,167,146	13,918,313
261.	STRUCTURES	130,272	82550 MH	1,201,483	1,012,833	2,344,588
262.	MECHANICAL EQUIPMENT	18,814,423	204191 MH	3,324,446	548,172	22,687,041
26 .	MAIN COND HEAT REJECT SYS	18,944,695	286741 MH	4,525,929	1,561,005	25,031,629
	TOTAL DIRECT COSTS	440,394,106	10993063 MH	178,139,907	92,556,514	711,090,527

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		1343098 MH	21,832,590	7,683,500	29,516,090
912.	CONSTRUCTION TOOLS & EQUIP		221796 MH	3,607,500	19,395,750	23,003,250
913.	PAYROLL INSURANCE & TAXES	36,949,770				36,949,770
914.	PERMITS,INS. & LOCAL TAXES				683,650	683,650
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	36,949,770	1564894 MH	25,440,090	27,762,900	90,152,760
921.	HOME OFFICE SERVICES	26,699,860				26,699,860
922.	HOME OFFICE Q/A					
923.	HOME OFFICE CONSTRCTN MGMT	1,493,140				1,493,140
92 .	HOME OFFICE ENGRG.&SERVICE	28,193,000				28,193,000
931.	FIELD OFFICE EXPENSES				1,657,700	1,657,700
932.	FIELD JOB SUPERVISION	27,819,110				27,819,110
933.	FIELD QA/QC	492,470				492,470
934.	PLANT STARTUP & TEST	742,940				742,940
93 .	FIELD OFFICE ENGRG&SERVICE	29,054,520			1,657,700	30,712,220
	TOTAL INDIRECT COSTS	94,197,290	1564894 MH	25,440,090	29,420,600	149,057,980
	TOTAL BASE COST	534,591,396	12557957 MH	203,579,997	121,977,114	860,148,507

TABLE 5-11

ENERGY ECONOMIC DATA BASE

795 MWe HIGH SULFUR COAL FPGS

CAPITAL COST ESTIMATE

PLANT CODE 640 | COST BASIS 01/81

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
795 MWE HIGH SULFUR COAL

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,750,000	2,750,000
21 .	STRUCTURES + IMPROVEMENTS	1,694,750	1404488 MH	20,440,295	32,815,040	54,950,085
22 .	BOILER PLANT EQUIPMENT	182,428,148	4023153 MH	66,555,321	19,001,439	267,984,908
23 .	TURBINE PLANT EQUIPMENT	72,157,461	1010939 MH	16,664,841	4,525,865	93,348,167
24 .	ELECTRIC PLANT EQUIPMENT	13,519,491	1090320 MH	17,701,477	9,860,020	41,080,988
25 .	MISCELLANEOUS PLANT EQUIPT	7,623,742	222754 MH	3,715,380	1,011,943	12,351,065
26 .	MAIN COND HEAT REJECT SYS	13,069,966	220027 MH	3,456,692	1,268,594	17,795,252
	TOTAL DIRECT COSTS	290,493,558	7971681 MH	128,534,006	71,232,901	490,260,465
91 .	CONSTRUCTION SERVICES	26,791,941	1181661 MH	19,080,071	19,444,700	65,316,712
92 .	HOME OFFICE ENGRG.&SERVICE	20,624,450				20,624,450
93 .	FIELD OFFICE ENGRG&SERVICE	14,567,190			1,191,850	15,759,040
	TOTAL INDIRECT COSTS	61,983,581	1181661 MH	19,080,071	20,636,550	101,700,202
	TOTAL BASE COST	352,477,139	9153342 MH	147,614,077	91,869,451	591,960,667

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,750,000	2,750,000
211.	YARDWORK	168,920	226642 MH	2,927,645	4,095,544	7,192,109
212.	STEAM GENERATOR BUILDING	541,058	411733 MH	6,167,965	12,656,073	19,365,096
213.	TURBINE,HEATER,CONTROL BLD	302,861	258756 MH	3,879,370	7,442,108	11,624,339
218B.	ADMINISTRATION+SERVICE BLD	242,142	62528 MH	971,579	1,110,360	2,324,081
218I.	ELECTRICAL SWITCHGR BLDGS	29,113	6999 MH	108,977	59,535	197,625
218M.	COAL CAR THAW SHED		2582 MH	38,298	19,590	57,888
218N.	ROTARY CAR DUMP BLDG+TUNNL	5,118	43181 MH	607,523	546,526	1,159,167
218O.	COAL BREAKER HOUSE	81,467	21192 MH	323,552	546,269	951,288
218P.	COAL CRUSHER HOUSE	115,672	15224 MH	236,617	287,768	640,057
218Q.	BOILER HOUSE TRANSFR TOWER	2,614	3107 MH	48,015	111,214	161,843
218R.	ROTARY PLOW MAINTNCE SHED	8,870	112067 MH	1,589,035	1,141,145	2,739,050
218T.	LOCOMOTIVE REPAIR GARAGE	16,991	5172 MH	79,313	96,298	192,602
218U.	MATERIAL HANDL+SERVICE BLD	20,171	10775 MH	163,461	202,056	385,688
218V.	WASTE WATER TREATMENT BLDG	4,353	9313 MH	131,985	114,203	250,541
218W.	MISC COAL HANDLING STRUCT	155,400	66906 MH	948,255	1,504,531	2,608,186
219.	STACK STRUCTURE		148311 MH	2,218,705	2,881,820	5,100,525
21 .	STRUCTURES + IMPROVEMENTS	1,694,750	1404488 MH	20,440,295	32,815,040	54,950,085

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
220A.	FOSSIL STEAM SUPPLY SYSTEM	59,734,800	736304 MH	11,921,498	1,192,150	72,848,448
221.	STEAM GENERATING SYSTEM	1,486,829	28830 MH	487,949	54,122	2,028,900
222.	DRAFT SYSTEM	11,584,233	269862 MH	4,533,064	1,623,100	17,740,397
223.	ASH + DUST HANDLING SYSTEM	5,786,360	102907 MH	1,717,838	227,222	7,731,420
224.	FUEL HANDLING SYSTEMS	9,596,222	125981 MH	2,135,226	572,699	12,304,147
225.	FLUE GAS DESULFUR STRUCT	38,287	60145 MH	909,620	1,249,581	2,197,488
226.	DESULFURIZATION EQUIPMENT	90,556,286	2485523 MH	41,486,843	12,356,734	144,399,863
227.	INSTRUMENTATION + CONTROL	3,392,896	81040 MH	1,315,020	91,017	4,798,933
228.	BOILER PLANT MISC ITEMS	252,235	132561 MH	2,048,263	1,634,814	3,935,312
22 .	BOILER PLANT EQUIPMENT	182,428,148	4023153 MH	66,555,321	19,001,439	267,984,908
231.	TURBINE GENERATOR	42,646,647	254633 MH	4,001,484	1,386,786	48,034,917
233.	CONDENSING SYSTEMS	8,956,322	127720 MH	2,185,809	297,315	11,439,446
234.	FEED HEATING SYSTEM	12,225,254	176888 MH	2,989,890	301,583	15,516,727
235.	OTHER TURBINE PLANT EQUIP.	8,182,709	372965 MH	6,294,776	659,888	15,137,373
236.	INSTRUMENTATION + CONTROL	146,529	823 MH	13,355	668	160,552
237.	TURBINE PLANT MISC ITEMS		77910 MH	1,179,527	1,879,625	3,059,152
23 .	TURBINE PLANT EQUIPMENT	72,157,461	1010939 MH	16,664,841	4,525,865	93,348,167

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	6,921,802	57640 MH	934,852	97,551	7,954,205
242.	STATION SERVICE EQUIPMENT	5,184,493	51295 MH	817,285	159,020	6,160,798
243.	SWITCHBOARDS	687,108	9030 MH	146,618	93,497	927,223
244.	PROTECTIVE EQUIPMENT		76400 MH	1,251,270	1,006,365	2,257,635
245.	ELECT.STRUC +WIRING CONTNR		510035 MH	8,244,748	2,755,828	11,000,576
246.	POWER & CONTROL WIRING	726,088	385920 MH	6,306,704	5,747,759	12,780,551
24 .	ELECTRIC PLANT EQUIPMENT	13,519,491	1090320 MH	17,701,477	9,860,020	41,080,988
251.	TRANSPORTATION & LIFT EQPT	1,716,201	7200 MH	120,177	124,396	1,960,774
252.	AIR,WATER+STEAM SERVICE SY	4,027,202	154468 MH	2,603,514	313,306	6,944,022
253.	COMMUNICATIONS EQUIPMENT	166,889	25000 MH	408,550	254,135	829,574
254.	FURNISHINGS + FIXTURES	885,290	6717 MH	103,554	22,534	1,011,378
255.	WASTE WATER TREATMENT EQPT	828,160	29369 MH	479,585	297,572	1,605,317
25 .	MISCELLANEOUS PLANT EQUIPT	7,623,742	222754 MH	3,715,380	1,011,943	12,351,065
261.	STRUCTURES	113,059	66037 MH	961,454	832,941	1,907,454
262.	MECHANICAL EQUIPMENT	12,956,907	153990 MH	2,495,238	435,653	15,887,798
26 .	MAIN COND HEAT REJECT SYS	13,069,966	220027 MH	3,456,692	1,268,594	17,795,252
	TOTAL DIRECT COSTS	290,493,558	7971681 MH	128,534,006	71,232,901	490,260,465

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		1028596 MH	16,610,043	5,904,800	22,514,843
912.	CONSTRUCTION TOOLS & EQUIP		153065 MH	2,470,028	13,055,900	15,525,928
913.	PAYROLL INSURANCE & TAXES	26,791,941				26,791,941
914.	PERMITS,INS. & LOCAL TAXES				484,000	484,000
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	26,791,941	1181661 MH	19,080,071	19,444,700	65,316,712
921.	HOME OFFICE SERVICES	19,335,800				19,335,800
922.	HOME OFFICE Q/A					
923.	HOME OFFICE CONSTRCTN MGMT	1,288,650				1,288,650
92 .	HOME OFFICE ENGRG.&SERVICE	20,624,450				20,624,450
931.	FIELD OFFICE EXPENSES				1,191,850	1,191,850
932.	FIELD JOB SUPERVISION	13,600,400				13,600,400
933.	FIELD QA/QC	348,480				348,480
934.	PLANT STARTUP & TEST	618,310				618,310
93 .	FIELD OFFICE ENGRG&SERVICE	14,567,190			1,191,850	15,759,040
	TOTAL INDIRECT COSTS	61,983,581	1181661 MH	19,080,071	20,636,550	101,700,202
	TOTAL BASE COST	352,477,139	9153342 MH	147,614,077	91,869,451	591,960,667

Effective Date - 1/1/81

TABLE 5-12

ENERGY ECONOMIC DATA BASE

1244 MWe LOW SULFUR COAL FPGS

CAPITAL COST ESTIMATE

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,750,000	2,750,000
211.	YARDWORK	168,920	281920 MH	3,620,617	5,006,475	8,796,012
212.	STEAM GENERATOR BUILDING	662,262	559121 MH	8,390,068	18,282,412	27,334,742
213.	TURBINE,HEATER,CONTROL BLD	373,486	302153 MH	4,533,288	8,818,575	13,725,349
218B.	ADMINISTRATION+SERVICE BLG	265,284	69093 MH	1,070,044	1,266,313	2,601,641
218D.	FIRE PUMPHOUSE					
218I.	ELECTRICAL SWITCHGR BLDGS	31,475	7584 MH	118,103	65,933	215,511
218L.	STACK/RECLAIM TRANSFR TOWR	7,930	11160 MH	162,769	131,017	301,716
218M.	COAL CAR THAW SHED		2582 MH	38,298	19,590	57,888
218N.	ROTARY CAR DUMP BLDG+TUNNL	5,118	43181 MH	607,523	546,526	1,159,167
218O.	DEAD STORAGE RECLM HOPPERS		24020 MH	346,265	279,610	625,875
218P.	COAL CRUSHER HOUSE	122,567	17619 MH	273,125	347,495	743,187
218Q.	BOILER HOUSE TRANSFR TOWER	3,936	6085 MH	94,505	214,194	312,635
218R.	DEAD STORAGE TRANSFER TUNL		62045 MH	889,174	586,123	1,475,297
218T.	LOCOMOTIVE REPAIR GARAGE	16,991	5172 MH	79,313	96,298	192,602
218U.	MATERIAL HANDL+SERVICE BLD	20,171	10775 MH	162,913	202,056	385,140
218V.	WASTE WATER TREATMENT BLDG	4,353	12227 MH	171,549	141,877	317,779
218W.	MISC COAL HANDLING STRUCT	1,184,000	196624 MH	2,479,114	2,157,860	5,820,974
219.	STACK STRUCTURE		175393 MH	2,625,829	3,406,395	6,032,224
21 .	STRUCTURES + IMPROVEMENTS	2,866,493	1786754 MH	25,662,497	41,568,749	70,097,739

PLANT CODE	COST BASIS	UNITED ENGINEERS & CONSTRUCTORS INC.	SUMMARY PAGE 1
630	01/81	ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV	
		1244 MWE LOW SULFUR COAL	08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20	LAND AND LAND RIGHTS				2,750,000	2,750,000
21	STRUCTURES + IMPROVEMENTS	2,866,493	1786754 MH	25,662,497	41,568,749	70,097,739
22	BOILER PLANT EQUIPMENT	229,049,289	5188970 MH	86,018,958	31,470,119	346,538,366
23	TURBINE PLANT EQUIPMENT	134,460,313	1867269 MH	30,950,769	7,559,039	172,970,121
24	ELECTRIC PLANT EQUIPMENT	14,669,929	1237091 MH	20,084,815	11,115,914	45,870,658
25	MISCELLANEOUS PLANT EQUIPT	8,408,200	260122 MH	4,342,967	1,167,146	13,918,313
26	MAIN COND HEAT REJECT SYS	18,944,695	286741 MH	4,525,929	1,561,804	25,032,428
	TOTAL DIRECT COSTS	408,398,919	10626947 MH	171,585,935	97,192,771	677,177,625
91	CONSTRUCTION SERVICES	35,704,104	1552004 MH	25,130,844	22,910,800	83,745,748
92	HOME OFFICE ENGRG &SERVICE	24,450,470				24,450,470
93	FIELD OFFICE ENGRG&SERVICE	22,105,490			1,385,450	23,490,940
	TOTAL INDIRECT COSTS	82,260,064	1552004 MH	25,130,844	24,296,250	131,687,158
	TOTAL BASE COST	490,658,983	12178951 MH	196,716,779	121,489,021	808,864,783

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
220A.	FOSSIL STEAM SUPPLY SYSTEM	89,702,640	1128000 MH	18,263,448	1,826,345	109,792,433
221.	STEAM GENERATING SYSTEM	1,893,699	37651 MH	637,096	69,036	2,599,831
222.	DRAFT SYSTEM	3,951,352	167186 MH	2,843,841	1,319,386	8,114,579
223.	ASH + DUST HANDLING SYSTEM	3,749,978	85228 MH	1,425,288	184,801	5,360,067
224.	FUEL HANDLING SYSTEMS	14,391,811	220446 MH	3,752,659	1,388,907	19,533,377
225.	FLUE GAS DESULFUR STRUCT	90,579	246016 MH	3,677,376	7,609,520	11,377,475
226.	FLUE GAS CLEANING EQUIP	111,448,915	3112463 MH	52,384,073	16,765,471	180,598,459
227.	INSTRUMENTATION + CONTROL	3,568,080	53620 MH	870,080	46,101	4,484,261
228.	BOILER PLANT MISC ITEMS	252,235	138360 MH	2,165,097	2,260,552	4,677,884
22 .	BOILER PLANT EQUIPMENT	229,049,289	5188970 MH	86,018,958	31,470,119	346,538,366
231.	TURBINE GENERATOR	83,846,476	376506 MH	5,877,100	2,370,042	92,093,618
233.	CONDENSING SYSTEMS	11,628,864	164834 MH	2,817,274	438,448	14,884,586
234.	FEED HEATING SYSTEM	21,395,729	312966 MH	5,288,151	529,128	27,213,008
235.	OTHER TURBINE PLANT EQUIP.	17,442,611	920340 MH	15,534,093	1,577,653	34,554,357
236.	INSTRUMENTATION + CONTROL	146,633	823 MH	13,355	668	160,656
237.	TURBINE PLANT MISC ITEMS		91800 MH	1,420,796	2,643,100	4,063,896
23 .	TURBINE PLANT EQUIPMENT	134,460,313	1867269 MH	30,950,769	7,559,039	172,970,121

PLANT CODE 630 COST BASIS 01/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	8,008,090	66705 MH	1,081,879	116,319	9,206,288
242.	STATION SERVICE EQUIPMENT	4,912,673	55006 MH	875,893	172,992	5,961,558
243.	SWITCHBOARDS	833,020	10530 MH	170,945	96,045	1,100,010
244.	PROTECTIVE EQUIPMENT		73400 MH	1,202,244	1,106,983	2,309,227
245.	ELECT.STRUC +WIRING CONTNR		581100 MH	9,394,233	3,074,579	12,468,812
246.	POWER & CONTROL WIRING	916,146	450350 MH	7,359,621	6,548,996	14,824,763
24 .	ELECTRIC PLANT EQUIPMENT	14,669,929	1237091 MH	20,084,815	11,115,914	45,870,658
251.	TRANSPORTATION & LIFT EQPT	1,812,265	8125 MH	135,742	125,952	2,073,959
252.	AIR,WATER+STEAM SERVICE SY	4,683,763	182544 MH	3,076,578	364,277	8,124,718
253.	COMMUNICATIONS EQUIPMENT	166,889	25000 MH	408,550	254,135	829,574
254.	FURNISHINGS + FIXTURES	885,290	6717 MH	103,554	22,534	1,011,378
255.	WASTE WATER TREATMENT EQPT	859,993	37736 MH	618,443	400,248	1,878,684
25 .	MISCELLANEOUS PLANT EQUIPT	8,408,200	260122 MH	4,342,967	1,167,146	13,918,313
261.	STRUCTURES	130,272	82550 MH	1,201,483	1,013,632	2,345,387
262.	MECHANICAL EQUIPMENT	18,814,423	204191 MH	3,324,446	548,172	22,687,041
26 .	MAIN COND HEAT REJECT SYS	18,944,695	286741 MH	4,525,929	1,561,804	25,032,428
	TOTAL DIRECT COSTS	408,398,919	10626947 MH	171,585,935	97,192,771	677,177,625

ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV

1244 MWE LOW SULFUR COAL

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		1322078 MH	21,410,568	6,212,800	27,623,368
912.	CONSTRUCTION TOOLS & EQUIP		229926 MH	3,720,276	16,105,100	19,825,376
913.	PAYROLL INSURANCE & TAXES	35,704,104				35,704,104
914.	PERMITS,INS. & LOCAL TAXES				592,900	592,900
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	35,704,104	1552004 MH	25,130,844	22,910,800	83,745,748
921.	HOME OFFICE SERVICES	22,957,330				22,957,330
922.	HOME OFFICE Q/A					
923.	HOME OFFICE CONSTRCTN MGMT	1,493,140				1,493,140
92 .	HOME OFFICE ENGRG &SERVICE	24,450,470				24,450,470
931.	FIELD OFFICE EXPENSES				1,385,450	1,385,450
932.	FIELD JOB SUPERVISION	21,175,000				21,175,000
933.	FIELD QA/QC	375,100				375,100
934.	PLANT STARTUP & TEST	555,390				555,390
93 .	FIELD OFFICE ENGRG&SERVICE	22,105,490			1,385,450	23,490,940
	TOTAL INDIRECT COSTS	82,260,064	1552004 MH	25,130,844	24,296,250	131,687,158
	TOTAL BASE COST	490,658,983	12178951 MH	196,716,779	121,489,021	808,864,783

Effective Date - 1/1/81

TABLE 5-13

ENERGY ECONOMIC DATA BASE

795 MWe LOW SULFUR COAL FPGS

CAPITAL COST ESTIMATE

PLANT CODE	COST BASIS	UNITED ENGINEERS & CONSTRUCTORS INC.	SUMMARY PAGE 1
620	01/81	ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV	
		795 MWE LOW SULFUR COAL	08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20	LAND AND LAND RIGHTS				2,750,000	2,750,000
21	STRUCTURES + IMPROVEMENTS	2,281,966	1437081 MH	20,663,939	32,309,689	55,255,594
22	BOILER PLANT EQUIPMENT	161,316,606	3698511 MH	60,032,683	22,644,441	243,993,730
23	TURBINE PLANT EQUIPMENT	72,501,247	1014365 MH	16,722,692	4,555,677	93,779,616
24	ELECTRIC PLANT EQUIPMENT	11,940,298	1082481 MH	17,575,415	9,875,316	39,391,029
25	MISCELLANEOUS PLANT EQUIPT	7,625,062	222845 MH	3,716,911	1,012,097	12,354,070
26	MAIN COND HEAT REJECT SYS	13,069,966	220165 MH	3,458,734	1,268,594	17,797,294
	TOTAL DIRECT COSTS	268,735,145	7675448 MH	122,170,374	74,415,814	465,321,333
91	CONSTRUCTION SERVICES	25,552,478	1170074 MH	18,614,646	16,965,200	61,132,324
92	HOME OFFICE ENGRG.&SERVICE	17,911,630				17,911,630
93	FIELD OFFICE ENGRG&SERVICE	12,989,350			955,900	13,945,250
	TOTAL INDIRECT COSTS	56,453,458	1170074 MH	18,614,646	17,921,100	92,989,204
	TOTAL BASE COST	325,188,603	8845522 MH	140,785,020	92,336,914	558,310,537

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,750,000	2,750,000
211.	YARDWORK	168,920	236870 MH	3,052,388	4,262,594	7,483,902
212.	STEAM GENERATOR BUILDING	541,058	411733 MH	6,167,965	12,656,073	19,365,096
213.	TURBINE,HEATER,CONTROL BLD	302,861	258756 MH	3,879,370	7,442,108	11,624,339
218B.	ADMINISTRATION+SERVICE BLD	242,142	62528 MH	970,013	1,110,360	2,322,515
218I.	ELECTRICAL SWITCHGR BLDGS	29,113	6999 MH	108,977	59,535	197,625
218L.	STACK/RECLAIM TRANSFR TOWR	6,153	7988 MH	116,802	92,988	215,943
218M.	COAL CAR THAW SHED		2582 MH	38,298	19,590	57,888
218N.	ROTARY CAR DUMP BLDG+TUNNL	5,118	43181 MH	607,523	546,526	1,159,167
218O.	DEAD STG RECLAIM HOPPER		24020 MH	346,265	279,610	625,875
218P.	COAL CRUSHER HOUSE	115,672	16343 MH	253,365	317,886	686,923
218Q.	BOILER HOUSE TRANSFR TOWER	2,614	3107 MH	48,015	111,214	161,843
218R.	DEAD STRG TRANSFER TUNNEL	12,800	45610 MH	653,774	412,955	1,079,529
218T.	LOCOMOTIVE REPAIR GARAGE	16,991	5172 MH	79,313	96,298	192,602
218U.	MATERIAL HANDL+SERVICE BLD	20,171	10775 MH	162,913	202,056	385,140
218V.	WASTE WATER TREATMENT BLDG	4,353	9313 MH	131,985	114,203	250,541
218W.	MISC COAL HANDLING STRUCT	814,000	143793 MH	1,828,268	1,703,873	4,346,141
219.	STACK STRUCTURE		148311 MH	2,218,705	2,881,820	5,100,525
21 .	STRUCTURES + IMPROVEMENTS	2,281,966	1437081 MH	20,663,939	32,309,689	55,255,594

PLANT CODE 620 COST BASIS 01/81

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
795 MWE LOW SULFUR COAL

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
220A.	FOSSIL STEAM SUPPLY SYSTEM	61,462,800	753315 MH	11,088,043	1,108,804	73,659,647
221.	STEAM GENERATING SYSTEM	1,489,029	28980 MH	490,480	54,375	2,033,884
222.	DRAFT SYSTEM	2,473,520	99731 MH	1,690,121	794,046	4,957,687
223.	ASH + DUST HANDLING SYSTEM	2,974,325	67096 MH	1,120,714	149,304	4,244,343
224.	FUEL HANDLING SYSTEMS	13,344,535	187008 MH	3,169,866	859,752	17,374,153
225.	FLUE GAS DESULFUR STRUCT	62,143	213028 MH	3,205,086	6,286,335	9,553,564
226.	FLUE GAS CLEANING EQUIP	75,887,806	2142633 MH	36,008,507	11,736,774	123,633,087
227.	INSTRUMENTATION + CONTROL	3,370,213	81040 MH	1,315,020	91,017	4,776,250
228.	BOILER PLANT MISC ITEMS	252,235	125680 MH	1,944,846	1,564,034	3,761,115
22 .	BOILER PLANT EQUIPMENT	161,316,606	3698511 MH	60,032,683	22,644,441	243,993,730
231.	TURBINE GENERATOR	42,617,891	254633 MH	4,001,484	1,415,378	48,034,753
233.	CONDENSING SYSTEMS	8,956,322	127720 MH	2,185,809	297,315	11,439,446
234.	FEED HEATING SYSTEM	12,598,271	180306 MH	3,047,602	302,789	15,948,662
235.	OTHER TURBINE PLANT EQUIP.	8,182,130	372973 MH	6,294,915	659,902	15,136,947
236.	INSTRUMENTATION + CONTROL	146,633	823 MH	13,355	668	160,656
237.	TURBINE PLANT MISC ITEMS		77910 MH	1,179,527	1,879,625	3,059,152
23 .	TURBINE PLANT EQUIPMENT	72,501,247	1014365 MH	16,722,692	4,555,677	93,779,616

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	6,311,973	58140 MH	942,962	98,362	7,353,297
242.	STATION SERVICE EQUIPMENT	4,214,997	46436 MH	739,983	143,605	5,098,585
243.	SWITCHBOARDS	687,240	9030 MH	146,618	93,497	927,355
244.	PROTECTIVE EQUIPMENT		72400 MH	1,185,902	1,010,498	2,196,400
245.	ELECT.STRUC +WIRING CONTNR		510035 MH	8,244,748	2,755,828	11,000,576
246.	POWER & CONTROL WIRING	726,088	386440 MH	6,315,202	5,773,526	12,814,816
24 .	ELECTRIC PLANT EQUIPMENT	11,940,298	1082481 MH	17,575,415	9,875,316	39,391,029
251.	TRANSPORTATION & LIFT EQPT	1,716,201	7200 MH	120,177	124,396	1,960,774
252.	AIR,WATER+STEAM SERVICE SY	4,028,522	154559 MH	2,605,045	313,460	6,947,027
253.	COMMUNICATIONS EQUIPMENT	166,889	25000 MH	408,550	254,135	829,574
254.	FURNISHINGS + FIXTURES	885,290	6717 MH	103,554	22,534	1,011,378
255.	WASTE WATER TREATMENT EQPT	828,160	29369 MH	479,585	297,572	1,605,317
25 .	MISCELLANEOUS PLANT EQUIPT	7,625,062	222845 MH	3,716,911	1,012,097	12,354,070
261.	STRUCTURES	113,059	66175 MH	963,496	832,941	1,909,496
262.	MECHANICAL EQUIPMENT	12,956,907	153990 MH	2,495,238	435,653	15,887,798
26 .	MAIN COND HEAT REJECT SYS	13,069,966	220165 MH	3,458,734	1,268,594	17,797,294
	TOTAL DIRECT COSTS	268,735,145	7675448 MH	122,170,374	74,415,814	465,321,333

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		1013113 MH	16,117,257	4,986,200	21,103,457
912.	CONSTRUCTION TOOLS & EQUIP		156961 MH	2,497,389	11,561,550	14,058,939
913.	PAYROLL INSURANCE & TAXES	25,552,478				25,552,478
914.	PERMITS,INS. & LOCAL TAXES				417,450	417,450
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	25,552,478	1170074 MH	18,614,646	16,965,200	61,132,324
921.	HOME OFFICE SERVICES	16,622,980				16,622,980
922.	HOME OFFICE Q/A					
923.	HOME OFFICE CONSTRCTN MGMT	1,288,650				1,288,650
92 .	HOME OFFICE ENGRG.&SERVICE	17,911,630				17,911,630
931.	FIELD OFFICE EXPENSES				955,900	955,900
932.	FIELD JOB SUPERVISION	12,302,070				12,302,070
933.	FIELD QA/QC	217,800				217,800
934.	PLANT STARTUP & TEST	469,480				469,480
93 .	FIELD OFFICE ENGRG&SERVICE	12,989,350			955,900	13,945,250
	TOTAL INDIRECT COSTS	56,453,458	1170074 MH	18,614,646	17,921,100	92,989,204
	TOTAL BASE COST	325,188,603	8845522 MH	140,785,020	92,336,914	558,310,537

Effective Date - 1/1/81

TABLE 5-14

ENERGY ECONOMIC DATA BASE

630 MWe COAL GASIFICATION COMBINED CYCLE FPGS

CAPITAL COST ESTIMATE

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				687,500	687,500
211.	YARDWORK	102,376	155070 MH	2,098,414	2,749,278	4,950,068
213.	TURBINE GENERATOR BLDG	287,792	192376 MH	2,965,074	7,045,020	10,297,886
214.	CONTROL BUILDING	81,506	46466 MH	719,238	840,675	1,641,419
218B.	ADMINISTRATION+SERVICE BLD		82200 MH	1,326,190	1,741,395	3,067,585
218C.	FUEL OIL STORAGE TANKS		7888 MH	125,037	104,820	229,857
218D.	FUEL OIL FORWARDING HOUSE	3,545	3221 MH	47,022	32,895	83,462
218I.	DIESEL GEN & SWITCHGR BLDG		16320 MH	256,693	309,861	566,554
218M.	COAL CAR THAW SHED		2538 MH	36,014	15,850	51,864
218N.	COAL UNLOADING FACILITY		3668 MH	52,164	30,475	82,639
218P.	COAL CRUSHER HOUSE		660 MH	10,600	8,612	19,212
218R.	ROTARY PLOW MAINTNCE SHED					
218T.	LOCOMOTIVE REPAIR GARAGE					
218U.	COAL HANDLING CNTRL HOUSE		930 MH	13,283	12,706	25,989
218V.	WATER TREATMENT BLDG.	15,011	17950 MH	258,568	243,061	516,640
218W.	MISC COAL HANDLING STRUCT	155,400	46681 MH	614,671	298,671	1,068,742
218Z.	MISC SMALL BUILDINGS				143,816	143,816
219A.	FLUE GAS STACK		148366 MH	2,219,393	2,883,800	5,103,193
219B.	VENT + FLARE STACK	1,785,416	29020 MH	422,761	283,248	2,491,425
21 .	STRUCTURES + IMPROVEMENTS	2,431,046	753354 MH	11,165,122	16,744,183	30,340,351

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
221.	GASIFIER SYSTEM	55,273,366	1211418 MH	20,221,676	685,575	76,180,617
222.	DRAFT SYSTEM	2,261,421	63812 MH	1,076,929		3,338,350
223.	ASH HANDLING SYSTEM	1,561,806	57289 MH	957,323	99,842	2,618,971
224.	FUEL HANDLING SYSTEMS	5,509,062	129353 MH	2,176,905	1,268,062	8,954,029
225.	PARTICULATE REMOVAL SYSTEM	14,076,029	298568 MH	5,022,272		19,098,301
226.	DESULFURIZATION SYSTEM	16,297,332	345670 MH	5,814,583		22,111,915
227.	STEAM GENERATING SYSTEM	21,092,790	496080 MH	8,313,649	464,829	29,871,268
228.	INSTRUMENTATION + CONTROL	3,073,082	92400 MH	1,499,357	78,376	4,650,815
229.	BOILER PLANT MISC. ITEMS	3,377,417	123476 MH	1,939,762	288,343	5,605,522
22 .	GASIFIER/BOILER PLT EQUIP.	122,522,305	2818066 MH	47,022,456	2,885,027	172,429,788
231.	STEAM TURBINE GENERATOR	28,869,650	113775 MH	1,803,765	611,699	31,285,114
232.	GAS TURBINE GENERATORS	70,457,449	1429894 MH	24,024,735	195,283	94,677,467
233.	CONDENSING SYSTEMS	3,774,741	65239 MH	1,111,351	121,620	5,007,712
234.	FEED HEATING SYSTEM	3,594,274	67260 MH	1,138,366	99,017	4,831,657
235.	OTHER TURBINE PLANT EQUIP.	2,130,522	106182 MH	1,792,226	177,662	4,100,410
236.	INSTRUMENTATION + CONTROL					
237.	TURBINE PLANT MISC ITEMS		66450 MH	1,108,583	1,119,629	2,228,212
23 .	TURBINE PLANT EQUIPMENT	108,826,636	1848800 MH	30,979,026	2,324,910	142,130,572

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	3,268,686	31052 MH	503,625	54,392	3,826,703
242.	STATION SERVICE EQUIPMENT	2,936,920	27009 MH	434,930	63,502	3,435,352
243.	SWITCHBOARDS	279,910	3370 MH	54,657	5,466	340,033
244.	PROTECTIVE EQUIPMENT		88600 MH	1,450,642	1,057,809	2,508,451
245.	ELECT.STRUC +WIRING CONTNR		448430 MH	7,328,243	2,422,056	9,750,299
246.	POWER & CONTROL WIRING	1,110,285	436035 MH	7,125,680	5,935,967	14,171,932
24 .	ELECTRIC PLANT EQUIPMENT	7,595,801	1034496 MH	16,897,777	9,539,192	34,032,770
251.	TRANSPORTATION & LIFT EQPT	301,152	2740 MH	46,089	73,385	420,626
252.	AIR,WATER+STEAM SERVICE SY	1,435,929	134980 MH	2,269,703	374,372	4,080,004
253.	COMMUNICATIONS EQUIPMENT	195,046	37620 MH	614,786	61,479	871,311
254.	FURNISHINGS + FIXTURES	174,334	1300 MH	21,869		196,203
25 .	MISCELLANEOUS PLANT EQUIPT	2,106,461	176640 MH	2,952,447	509,236	5,568,144
261.	STRUCTURES	5,875	26355 MH	380,991	295,088	681,954
262.	MECHANICAL EQUIPMENT	7,365,775	93303 MH	1,511,076	203,825	9,080,676
26 .	MAIN COND HEAT REJECT SYS	7,371,650	119658 MH	1,892,067	498,913	9,762,630
	TOTAL DIRECT COSTS	250,853,899	6751014 MH	110,908,895	33,188,961	394,951,755

PLANT CODE 660 | COST BASIS 01/81

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE IV
630 MWE COAL GASIFICATION COMBINED CYCLE

08/21/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		853400 MH	14,086,816	6,419,050	20,505,866
912.	CONSTRUCTION TOOLS & EQUIP		140560 MH	2,333,220	14,844,900	17,178,120
913.	PAYROLL INSURANCE & TAXES	23,110,215				23,110,215
914.	PERMITS,INS. & LOCAL TAXES				490,050	490,050
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	23,110,215	993960 MH	16,420,036	21,754,000	61,284,251
921.	HOME OFFICE SERVICES	19,337,010				19,337,010
922.	HOME OFFICE Q/A					
923.	HOME OFFICE CONSTRCTN MGMT	1,288,650				1,288,650
92 .	HOME OFFICE ENGRG.&SERVICE	20,625,660				20,625,660
931.	FIELD OFFICE EXPENSES				1,234,200	1,234,200
932.	FIELD JOB SUPERVISION	13,597,980				13,597,980
933.	FIELD QA/QC	344,850				344,850
934.	PLANT STARTUP & TEST	618,310				618,310
93 .	FIELD OFFICE ENGRG&SERVICE	14,561,140			1,234,200	15,795,340
	TOTAL INDIRECT COSTS	58,297,015	993960 MH	16,420,036	22,988,200	97,705,251
	TOTAL BASE COST	309,150,914	7744974 MH	127,328,931	56,177,161	492,657,006

TABLE 5-15

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

1190 MWe BOILING WATER REACTOR NUCLEAR POWER GENERATING STATION

NUCLEAR PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit(a)	Commodity (cont'd)	Unit	Quantity	Cost/Unit(a)
Excavation	CY	536,000	14.10	Valves	LT	--	14.84*
Fill	CY	396,000	3.35	Fire Protection	LT	--	0.78*
Formwork	SF	2,416,000	18.17	BOP Pump (1000 HP & above)	HP	57,400+	98.17
Reinforcing Steel	TN	20,402	1,615.00	Heat Exchangers	LT	--	35.50*
Concrete	CY	205,727	108.32	Turbine Generator	LT	--	87.47*
Embedded Steel	TN	698	9,411.00	Instrumentation and Control	LT	--	18.48*
Structural Steel	TN	10,871	1,667.00	Lighting & Service Power	LT	--	4.24*
Special Steel Liners	LT	--	36.79*	Duct Runs and Containers	LF	496,114	31.49
Carbon Steel Piping (NS)	LB	1,857,481	16.60	Wire and Cable	LF	4,550,000	5.44
Stainless Steel Piping (NS)	LB	224,986	64.50	Electrical Balance of Plant	LT	--	29.55*
Carbon Steel Piping (NNS)	LB	4,477,000	8.90	Nuclear Steam Supply System	LT	--	104.30*
Stainless Steel Piping (NNS)	LB	334,000	29.34	All Others	LT	--	444.22*

* Cost per unit is in dollars per kilowatt
\+ Includes Boiler Feed Pumps
(a) Data in Constant $1981 (Inflation-Free)

(NS) = Nuclear Safety Grade (NNS) = Non-Nuclear Safety Grade

NUCLEAR PLANT MANHOURS

Craft	Manhours	Cost x 10^3(a)	Craft (cont'd)	Manhours	Cost x 10^3(a)
Boiler Makers	618,054	11,045	Millwrights	311,174	5,420
Carpenters	2,256,991	34,419	Operating Engineers	1,515,233	24,153
Electricians	2,617,870	43,404	Pipe Fitters	4,358,134	76,268
Ironworkers	2,466,695	38,875	Sheet Metal Workers	304,426	5,047
Laborers	2,234,227	25,381	All Others	1,059,570	14,232
			TOTAL CRAFT LABOR	17,742,374	278,064

Effective Date - 1/1/81

TABLE 5-16

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

858 MWe HIGH TEMPERATURE GAS-COOLED REACTOR - STEAM CYCLE NUCLEAR POWER GENERATING STATION

NUCLEAR PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit[(a)]	Commodity (cont'd)	Unit	Quantity	Cost/Unit[(a)]
Excavation	CY	423,115	6.77	Valves	LT	--	12.84*
Fill	CY	338,408	8.15	Fire Protection	LT	--	1.47*
Formwork	SF	2,627,975	18.66	BOP Pump (1000 HP & above)	HP	84,100+	72.71
Reinforcing Steel	TN	22,618	1,623.00	Heat Exchangers	LT	--	35.20*
Concrete	CY	169,055#	104.00#	Turbine Generator	LT	--	65.06*
Embedded Steel	TN	817	8,849.00	Instrumentation and Control	LT	--	19.62*
Structural Steel	TN	8,395	1,679.22	Lighting & Service Power	LT	--	4.02*
Special Steel Liners	LT	--	27.88*	Duct Runs and Containers	LF	476,000	28.38
Carbon Steel Piping (NS)	LB	608,104	15.60	Wire and Cable	LF	4,062,084	5.95
Stainless Steel Piping (NS)	LB	133,028	62.97	Electrical Balance of Plant	LT	--	29.28*
Carbon Steel Piping (NNS)	LB	1,859,019	9.04	Nuclear Steam Supply System	LT	--	200.14*
Stainless Steel Piping (NNS)	LB	312,933	28.48	All Others	LT	--	562.58*

* Cost per unit is in dollars per kilowatt
\+ Includes Boiler Feed Pumps
(a) Data in Constant $1981 (Inflation-Free)

(NS) = Nuclear Safety Grade (NNS) = Non-Nuclear Safety Grade
\# = Does Not Include Pre-stressed Concrete Vessel

NUCLEAR PLANT MANHOURS

Craft	Manhours	Cost x 10^3[(a)]	Craft (cont'd)	Manhours	Cost x 10^3[(a)]
Boiler Makers	668,543	11,947	Millwrights	230,628	3,884
Carpenters	1,905,595	29,060	Operating Engineers	929,791	14,821
Electricians	2,314,205	38,370	Pipe Fitters	2,190,081	38,327
Ironworkers	2,045,277	32,234	Sheet Metal Workers	108,524	1,799
Laborers	1,685,698	19,150	All Others	1,468,436	21,684
			TOTAL CRAFT LABOR	13,546,778	211,276

TABLE 5-17

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

1139 MWe PRESSURIZED WATER REACTOR NUCLEAR POWER GENERATING STATION

NUCLEAR PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit[(a)]
Excavation	CY	529,000	14.22
Fill	CY	396,000	3.34
Formwork	SF	2,045,384	19.14
Reinforcing Steel	TN	21,600	1,683.00
Concrete	CY	175,000	106.75
Embedded Steel	TN	546	9,627.47
Structural Steel	TN	11,300	1,677.00
Special Steel Liners	LT	--	18.97*
Carbon Steel Piping (NS)	LB	1,500,300	15.85
Stainless Steel Piping (NS)	LB	440,170	61.08
Carbon Steel Piping (NNS)	LB	4,661,000	8.90
Stainless Steel Piping (NNS)	LB	410,000	29.46

Commodity (cont'd)	Unit	Quantity	Cost/Unit[(a)]
Valves	LT	--	13.37*
Fire Protection	LT	--	0.83*
BOP Pump (1000 HP & above)	HP	55,500+	95.61
Heat Exchangers	LT	--	34.37*
Turbine Generator	LT	--	84.65*
Instrumentation and Control	LT	--	17.25*
Lighting & Service Power	LT	--	4.41*
Duct Runs and Containers	LF	485,000	31.47
Wire and Cable	LF	4,608,000	6.41
Electrical Balance of Plant	LT	--	27.35*
Nuclear Steam Supply System	LT	--	110.94*
All Others	LT	--	458.73*

* Cost per unit is in dollars per kilowatt (NS) = Nuclear Safety Grade (NNS) = Non-Nuclear Safety Grade

\+ Includes Boiler Feed Pumps

(a) Data in Constant $1981 (Inflation-Free)

NUCLEAR PLANT MANHOURS

Craft	Manhours	Cost x 10^3(a)
Boiler Makers	915,547	16,361
Carpenters	2,113,519	32,231
Electricians	2,581,267	42,797
Ironworkers	2,050,602	32,318
Laborers	2,088,328	23,723

Craft (cont'd)	Manhours	Cost x 10^3(a)
Millwrights	243,344	4,098
Operating Engineers	1,263,202	20,135
Pipe Fitters	4,293,002	75,128
Sheet Metal Workers	178,000	2,951
All Others	946,958	12,806
TOTAL CRAFT LABOR	16,673,769	262,548

Effective Date - 1/1/81

TABLE 5-18

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

1260 MWe PRESSURIZED HEAVY WATER REACTOR NUCLEAR POWER GENERATION STATION

NUCLEAR PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit[(a)]	Commodity (cont'd)	Unit	Quantity	Cost/Unit[(a)]
Excavation	CY	534,874	14.01	Valves	LT	--	12.42*
Fill	CY	402,383	3.41	Fire Protection	LT	--	0.93*
Formwork	SF	1,791,418	19.98	BOP Pump (1000 HP & above)	HP	85,850+	144.90
Reinforcing Steel	TN	23,573	1,693.00	Heat Exchangers	LT	--	54.03*
Concrete	CY	175,281	106.07	Turbine Generator	LT	--	85.88*
Embedded Steel	TN	659	11,370.00	Instrumentation and Control	LT	--	14.86*
Structural Steel	TN	9,989	1,667.00	Lighting & Service Power	LT	--	3.26*
Special Steel Liners	LT	--	17.58*	Duct Runs and Containers	LF	540,500	30.95
Carbon Steel Piping (NS)	LB	1,631,098	17.78	Wire and Cable	LF	5,170,000	5.10
Stainless Steel Piping (NS)	LB	82,620	65.07	Electrical Balance of Plant	LT	--	25.49*
Carbon Steel Piping (NNS)	LB	5,104,389	8.88	Nuclear Steam Supply System	LT	--	131.92*
Stainless Steel Piping (NNS)	LB	99,000	30.75	All Others	LT	--	430.83*

* Cost per unit is in dollars per kilowatt (NS) = Nuclear Safety Grade (NNS) = Non-Nuclear Safety Grade
\+ Includes Boiler Feed Pumps
(a) Data in Constant $1981 (Inflation-Free)

NUCLEAR PLANT MANHOURS

Craft	Manhours	Cost x 10^3 (a)	Craft (cont'd)	Manhours	Cost x 10^3 (a)
Boiler Makers	994,200	17,766	Millwrights	280,706	4,727
Carpenters	1,996,617	30,448	Operating Engineers	1,275,135	20,326
Electricians	2,903,451	48,139	Pipe Fitters	4,066,955	71,172
Ironworkers	2,221,983	35,018	Sheet Metal Workers	103,376	1,714
Laborers	2,038,885	23,162	All Others	1,067,306	12,755
			TOTAL CRAFT LABOR	16,948,614	265,227

TABLE 5-19

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

1457 MWe LIQUID METAL FAST-BREEDER REACTOR NUCLEAR POWER GENERATING STATION

NUCLEAR PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit[(a)]	Commodity (cont'd)	Unit	Quantity	Cost/Unit[(a)]
Excavation	CY	779,943	16.73	Valves	LT	--	8.02*
Fill	CY	270,335	7.56	Fire Protection	LT	--	12.16*
Formwork	SF	2,240,890	17.18	BOP Pump (1000 HP & above)	HP	98,600+	55.81
Reinforcing Steel	TN	39,887	1,688.00	Heat Exchangers	LT	--	29.61*
Concrete	CY	264,245	110.71	Turbine Generator	LT	--	75.17*
Embedded Steel	TN	1,538	9,363.00	Instrumentation and Control	LT	--	8.82*
Structural Steel	TN	15,627	1,667.00	Lighting & Service Power	LT	--	5.95*
Special Steel Liners	LT	--	35.55*	Duct Runs and Containers	LF	780,165	28.23
Carbon Steel Piping (NS)	LB	555,097	9.02	Wire and Cable	LF	6,474,100	5.21
Stainless Steel Piping (NS)	LB	763,822	50.36	Electrical Balance of Plant	LT	--	23.35*
Carbon Steel Piping (NNS)	LB	5,039,891	8.90	Nuclear Steam Supply System	LT	--	268.85*
Stainless Steel Piping (NNS)	LB	816,000	21.47	All Others	LT	--	498.03*

* Cost per unit is in dollars per kilowatt
\+ Include Boiler Feed Pumps
(a) Data in Constant $1981 (Inflation-Free)

(NS) = Nuclear Safety Grade (NNS) = Non-Nuclear Safety Grade

NUCLEAR PLANT MANHOURS

Craft	Manhours	Cost x 10^3(a)	Craft (cont'd)	Manhours	Cost x 10^3(a)
Boiler Makers	1,396,134	24,949	Millwrights	409,907	6,904
Carpenters	2,448,713	37,343	Operating Engineers	1,974,773	31,478
Electricians	3,950,199	65,494	Pipe Fitters	5,704,864	99,835
Ironworkers	4,087,181	64,414	Sheet Metal Workers	405,297	6,720
Laborers	2,859,136	32,480	All Others	1,428,907	26,095
			TOTAL CRAFT LABOR	24,665,201	388,992

TABLE 5-20

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

1240 MWe HIGH SULFUR COAL-FIRED FOSSIL POWER GENERATING STATION

COMPARISON COAL PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit (a)
Excavation	CY	220,000	7.22
Fill	CY	99,000	7.62
Formwork	SF	1,067,000	8.68
Reinforcing Steel	TN	7,000	1,035.00
Concrete	CY	108,000	90.83
Embedded Steel	TN	369	5,795.00
Structural Steel	TN	24,400	1,383.00
Carbon Steel Piping	LB	4,672,573	5.01
Stainless Steel Piping	LB	600	18.51
Chrome-Moly Piping	LB	3,219,000	8.16
Valves	LT	--	3.40*
Fire Protection	LT	--	0.54*
Pumps (1000 HP & above)	HP	103,750+	43.83

Commodity (cont'd)	Unit	Quantity	Cost/Unit (a)
Heat Exchangers	LT	--	22.40*
Turbine Generator	LT	--	68.76*
Coal Handling #	LT	--	10.70*
Dust Col. & Elec. Precipitator	LT	--	16.22*
SO_2 Removal System & Structures	LT	--	168.67*
Heat., Ventilating, & Air Cond.	LT	--	5.77*
Ash Handling	LT	--	6.69*
Instrumentation and Control	LT	--	5.61*
Lighting & Service Power	LT	--	1.89*
Duct Runs & Wire Containers	LF	646,000	17.67
Wire and Cable	LF	3,986,000	3.73
Electrical Balance of Plant	LT	--	15.67
Fossil Steam Supply System	LT	--	86.40*
All Others	LT	--	158.98*

* Cost per unit is in dollars per kilowatt
(a) Data in Constant $1981 (Inflation-Free)
\+ Includes Boiler Feed Pumps

\# Does not Include Ignition Oil System

COMPARISON COAL PLANT MANHOURS

Craft	Manhours	Cost x 10^3 (a)
Boiler Makers	290,298	5,188
Carpenters	447,729	6,828
Electricians	1,829,575	30,334
Ironworkers	942,189	14,849
Laborers	663,910	7,542

Craft (cont'd)	Manhours	Cost x 10^3 (a)
Millwrights	315,118	5,307
Operating Engineers	651,660	10,387
Pipe Fitters	3,782,634	66,196
Sheet Metal Workers	@	@
All Others	2,070,051	31,511
TOTAL CRAFT LABOR	10,993,164	178,142

@ Not Applicable

Effective Date - 1/1/81

TABLE

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

795 MWe HIGH SULFUR COAL-FIRED FOSSIL POWER GENERATING STATION

COMPARISON COAL PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit[(a)]	Commodity (cont'd)	Unit	Quantity	Cost/Unit[(a)]
Excavation	CY	180,000	7.50	Heat Exchangers	LT	--	27.31*
Fill	CY	84,000	7.44	Turbine Generator	LT	--	56.36*
Formwork	SF	896,000	8.43	Coal Handling#	LT	--	15.37*
Reinforcing Steel	TN	5,500	1,032.00	Dust Col. & Elec. Precipitator	LT	--	15.35*
Concrete	CY	88,500	90.76	SO_2 Removal System & Structures	LT	--	184.40*
Embedded Steel	TN	314	5,795.00	Heat., Ventilating, & Air Cond.	LT	--	5.85*
Structural Steel	TN	18,000	1,378.00	Ash Handling	LT	--	7.61*
Carbon Steel Piping	LB	3,037,000	5.01	Instrumentation and Control	LT	--	8.93*
Stainless Steel Piping	LB	600	18.51	Lighting & Service Power	LT	--	2.41*
Chrome-Moly Piping	LB	1,212,000	7.87	Duct Runs & Wire Containers	LF	568,000	17.63
Valves	LT	--	4.11*	Wire and Cable	LF	3,421,000	3.75
Fire Protection	LT	--	0.80*	Electrical Balance of Plant	LT	--	22.34*
Pumps (1000 HP & above)	HP	66,320+	51.58	Fossil Steam Supply System	LT	--	91.63*
				All Others	LT	--	191.37*

* Cost per unit is in dollars per kilowatt

(a) Data in Constant $1981 (Inflation-Free)

\+ Includes Boiler Feed Pumps

\# Does not Include Ignition Oil System

COMPARISON COAL PLANT MANHOURS

Craft	Manhours	Cost x 10^3 (a)	Craft (cont'd)	Manhours	Cost x 10^3 (a)
Boiler Makers	209,399	3,742	Millwrights	231,953	3,906
Carpenters	366,631	5,591	Operating Engineers	470,269	7,496
Electricians	1,515,072	25,120	Pipe Fitters	2,487,750	43,536
Ironworkers	716,823	11,297	Sheet Metal Workers	@	
Laborers	534,777	6,075	All Others	1,439,107	21,773
			TOTAL CRAFT LABOR	7,971,781	128,536

@ Not Applicable

TABLE 5-22 Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

1244 MWe LOW SULFUR COAL-FIRED FOSSIL POWER GENERATING STATION

COMPARISON COAL PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit[(a)]	Commodity (cont'd)	Unit	Quantity	Cost/Unit[(a)]
Excavation	CY	253,603	6.63	Heat Exchangers	LT	--	26.47*
Fill	CY	123,993	7.62	Turbine Generator	LT	--	69.87*
Formwork	SF	1,062,866	8.70	Coal Handling#	LT	--	15.56*
Reinforcing Steel	TN	6,900	1,036.00	Dust Col. & Elec. Precipitator	LT	--	--
Concrete	CY	116,678	88.68	SO_2 Removal System & Structure	LT	--	154.32*
Embedded Steel	TN	389	5,795.00	Heat., Ventilating, & Air Cond.	LT	--	11.39*
Structural Steel	TN	26,330	1,385.00	Ash Handling	LT	--	6.69*
Carbon Steel Piping	LB	4,672,570	5.01	Instrumentation and Control	LT	--	4.91*
Stainless Steel Piping	LB	600	18.51	Lighting & Service Power	LT	--	1.90*
Chrome-Moly Piping	LB	3,219,000	7.83	Duct Runs & Wire Containers	LF	646,250	17.56
Valves	LT	--	3.61*	Wire and Cable	LF	3,989,000	3.73
Fire Protection	LT	--	0.56*	Electrical Balance of Plant	LT	--	15.25*
Pumps (1000 HP & above)	HP	103,750+	43.83	Fossil Steam Supply System	LT	--	88.26*
				All Others	LT	--	182.14*

* Cost per unit is in dollars per kilowatt
(a) Data in Constant $1981 (Inflation-Free)
\+ Includes Boiler Feed Pumps

COMPARISON COAL PLANT MANHOURS

Craft	Manhours	Cost x 10^3[(a)]	Craft (cont'd)	Manhours	Cost x 10^3[(a)]
Boiler Makers	158,276	2,953	Millwrights	340,056	5,727
Carpenters	448,299	6,837	Operating Engineers	583,381	9,299
Electricians	1,663,731	27,585	Pipe Fitters	3,597,955	62,964
Ironworkers	917,731	14,463	Sheet Metal Workers	@	@
Laborers	794,090	9,021	All Others	2,123,534	32,741
			TOTAL CRAFT LABOR	10,627,053	171,588

@ Not Applicable

TABLE 5-23 Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

795 MWe LOW SULFUR COAL-FIRED FOSSIL POWER GENERATING STATION

COMPARISON COAL PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit[a]
Excavation	CY	198,266	6.82
Fill	CY	101,228	7.57
Formwork	SF	856,460	8.44
Reinforcing Steel	TN	5,311	1,029.00
Concrete	CY	92,675	89.54
Embedded Steel	TN	325	5,795.00
Structural Steel	TN	19,380	1,464.00
Carbon Steel Piping	LB	3,013,380	5.01
Stainless Steel Piping	LB	600	18.51
Chrome-Moly Piping	LB	1,212,000	7.87
Valves	LT	--	4.31*
Fire Protection	LT	--	0.85*
Pumps (1000 HP & above)	HP	66,320+	51.58

Commodity (cont'd)	Unit	Quantity	Cost/Unit[a]
Heat Exchangers	LT	--	27.71*
Turbine Generator	LT	--	56.36*
Coal Handling#	LT	--	19.75*
Dust Col. & Elec. Precipitator	LT	--	--
SO_2 Removal System & Structures	LT	--	167.53*
Heat., Ventilating, & Air Cond.	LT	--	12.04*
Ash Handling	LT	--	7.87*
Instrumentation and Control	LT	--	7.99*
Lighting & Service Power	LT	--	2.42*
Duct Runs & Wire Containers	LF	567,500	17.64
Wire and Cable	LF	3,423,022	3.75
Electrical Balance of Plant	LT	--	19.02*
Fossil Steam Supply System	LT	--	92.65*
All Others	LT	--	152.63*

* Cost per unit is in dollars per kilowatt

\+ Includes Boiler Feed Pumps

\# Does Not Include Ignition Oil System

(a) Date in Constant $1981 (Inflation-Free)

COMPARISON COAL PLANT MANHOURS

Craft	Manhours	Cost x 10^3 [a]
Boiler Makers	116,154	2,075
Carpenters	352,411	5,374
Electricians	1,400,418	23,219
Ironworkers	720,350	11,353
Laborers	617,239	7,011

Craft (cont'd)	Manhours	Cost x 10^3 [a]
Millwrights	243,969	4,108
Operating Engineers	425,359	6,780
Pipe Fitters	2,321,084	40,619
Sheet Metal Workers	@	@
All Others	1,478,586	21,633
TOTAL CRAFT LABOR	7,675,570	122,173

@ Not Applicable

SECTION 6

6.0 FUEL COST FOURTH UPDATE

The Fourth Update of the fuel costs in the Energy Economic Data Base covers both fissle fuels (uranium, thorium and plutonium) and fossil fuels (coal). It provides fuel costs for all of the technical models in the Data Base, in accordance with a consistent set of ground-rules. Broad ground-rules and assumptions governing fuel costs are discussed in Section 3. This section presents the detailed bases for both the nuclear fuel cycle costs and the fossil fuel costs.

6.1 FUEL COST SUMMARY

Fuel costs are prepared for the EEDB as total thermal costs (¢/MBtu). Nuclear fuel cycle costs for the Fourth Update consist of Fuel, (including ore conversion and enrichment) Fabrication, Transportation, Reprocessing (Breeder option only) and Disposal costs. Costs for short term on-site spent fuel storage are included in the Capital Costs; long term storage is assumed to be off-site at a Federal depository. Coal fuel costs for the Fourth Update consist of Fuel and Transportation costs only. Costs for Flue-Gas-Desulfurization are not included in the coal fuel costs. These costs are included in the Capital and the Operating and Maintenance costs.

Fuel costs are summarized in Table 6-1 for all plants for startups in the year 2001. Table 6-2 summarizes fuel costs for the commercialized technologies for plant startup in the year 1981. Table 6-3 gives data for the advanced technologies for variable plant startups in the year when the technologies are expected to be deployed commercially. Table 6-3 includes the LWR plants and the conventional coal-fired plants for comparison.

6.2 NUCLEAR FUEL CYCLE COST UPDATE PROCEDURE

The Initial Update of the nuclear fuel cycle costs is a first-of-a-kind effort, performed by United Engineers & Constructors, Inc. and their subcontractor, the NUS Corporation, to produce a fuel cycle cost data base for the EEDB. In the Second Update, an Approximation Factors Method is developed as the EEDB nuclear fuel cycle cost update procedure, and is described in the Second Update Report.* This procedure is utilized to develop the nuclear fuel cycle costs for this Fourth Update, for the selected technical models given in Table 1-1.

6.3 DETAILED FUEL COSTS

Results of the Fuel Cost Fourth Update are presented for each technical plant model in the Tables listed below. Specific BWR mass flow data is not available for this study; therefore, PWR data is used for the BWR (Model A1).

Nuclear Plant Model	Year of Startup	Fuel Cycle Cost Table Number	Fossil Plant Model	Year of Startup	Fuel Cost Table Number
PWR	1981	6-4a/4b	HS12	1981	6-13a
PWR	1987	6-5a/5b	HS12	1987	6-13b
PWR	2001	6-6a/6b	HS12	2001	6-13c
HTGR	1995	6-7a/7b	HS8	1981	6-13a
HTGR	2001	6-8a/8b	HS8	1987	6-13b
PHWR	1995	6-9a/9b	HS8	2001	6-13c
PHWR	2001	6-10a/10b	LS12	1981	6-13a
LMFBR	2001	6-11a/11b	LS12	1987	6-13b
Explanation of Fuel Cycle System Designation		6-12	LS12	2001	6-13c
			LS8	1981	6-13a
			LS8	1987	6-13b
			LS8	2001	6-13c
			CGCC	1987	6-13b
			CGCC	2001	6-13c

* Refer to Section 8.1 for additional details

For the nuclear fuel cycle costs, "a" tables tabulate Input Cost Components and "b" tables tabulate Output Cost Components. In the "a" series of nuclear fuel cycle cost tables, the costs of the fuel cycle components are assumed to remain unchanged in terms of constant $1981. In the "b" series of nuclear fuel cycle cost tables, the costs are given for Direct, Indirect and Total Costs, levelized over the nominal 30-year plant lifetime from the year of plant startup. The values in the "a" tables are given in terms of unit market prices and in the "b" tables are given in $/MBtu.

The costs are based on the mass flow characteristics of the specific reactor type for which the costs are computed. These characteristics are applied as derived coefficients to the unit costs for the materials/services given in the "a" tables.

6.4 PROJECTION OF ECONOMIC PARAMETERS FOR FUEL

The projection of several national economic parameters is a key element in the calculation of nuclear and coal fuel cost estimates. Principal among these are the long term inflation rate, interest rate, and discount rate. They are particularly relevant in calculating the levelized fuel cost for either a nuclear or coal-fired power generating station.

The levelized fuel cost is the constant annual cost of the fuel over the lifetime of the plant, in which the fuel is utilized, whose stream of payments has a present value equal to the present value of the actual or predicted annual cost (which may be variable) of the fuel over that period.

Levelized values for each component of the nuclear fuel cycle are provided in constant 1981 dollars.

The coal fuel costs for the EEDB Fourth Update are stated in terms of first year costs in constant 1981 dollars for each year of startup. The assumption is made that no escalation will occur for coal, even though it is expected that coal will rise over time to the levels of more expensive, competing fuels. This is a conservative assumption in terms of the objective, assumptions and groundrules of the EEDB Program. This assumption is subject to examination in future updates. When valid information becomes available, projections of future coal costs will be incorporated. However, adjustments are made for startup years beyond 1981 to account for escalation due to rising scarcity.

For the case where it is desirable to incorporate the escalation of coal costs into a cost calculation, a levelization factor should be computed and applied to the first year costs reported in this update, before the fuel costs are added to levelized capital and operating and maintenance costs. Consistent rates of interest and escalation must be used in the computation for compatibility and consistency with the capital and O&M costs with which it is combined. An approximation of the necessary levelization factor may be computed with the following equation:

$$LF = \frac{d}{d-a} \cdot \left[\frac{(1+d)^n - (1+a)^n}{(1+d)^n - 1} \right] \qquad (8)$$

Where: LF = levelization factor* a = (1 + i) (1 + e) - 1*
d = discount rate per annum* i = inflation rate*
n = number of years* e = escalation rate*

*Refer to Section 2.4.2 for definitions of these terms as used in the EEDB Program

6.5 NUCLEAR FUEL CYCLE COSTS

The Nuclear Power Generating Stations (NPGS) currently deployed in the United States consist of Light Water Reactors (LWR's) and a single High Temperature Gas cooled Reactor (HTGR). The HTGR NPGS is a 300 MWe demonstration unit representing a one-of-a-kind situation, because commercialization of this design is indefinitely postponed. The Light Water Reactor NPGS utilize both Pressurized Water Reactors (PWRs) and Boiling Water Reactors (BWRs). The PWRs are manufactured by Westinghouse, Babcock and Wilcox and Combustion Engineering Companies. The General Electric Company is the sole manufacturer of the BWR.

In this update of the EEDB, nuclear fuel cycle costs are developed for five different reactor plant types; the Pressurized Water Reactor (PWR), the Boiling Water Reactor (BWR), the High Temperature Gas Cooled Reactor (HTGR), the Pressurized Heavy Water Reactor (PHWR) and the Liquid Metal Fast Breeder Reactor (LMFBR) Nuclear Power Generating Stations. The last two of these reactors have no commercial prototypes in existence in the United States today. Reactor and cost input data for the commercialized LWR fuel cycle are based on a significant amount of real operational experience. The extrapolation of this data is reasonable in predicting future costs. It is important to emphasize that the data in the fuel cycle costs for the remaining three reactor types are based entirely upon analytical and predictive models and not on commercial experience.

The similarities of the BWR and the PWR are such that the fuel utilization characteristics differ only slightly. Consequently, their fuel costs, levelized over the nominal plant lifetime, do not vary more than $\pm$ 10 percent. The fuel cycle for the LWRs is exemplified in this update by the PWR data. The values given in the NASAP (Nonproliferation Alternative Systems Assessment Program) are used to attain a normalized value for the LWRs as a class. Since there are minor but real variations among the LWR reactors currently operating and under construction, the use of NASAP data provides a neutral basis for the computation of costs. Therefore, the explicit fuel cycle costs calculated for the PWR are utilized to represent both PWRs and BWRs.

Because of the lack of experimental information regarding the three as yet uncommercialized reactors (HTGR, PHWR, and LMFBR), data on mass flow for these reactor types are also based on NASAP information, which represents a neutral and agreed upon body of data for the reactor types in question.

6.5.1 Nuclear Fuel Cycle Description

Nuclear fuel cycle cost analysis for this update of the EEDB is based on the steps in a typical uranium/plutonium fuel cycle, illustrated in Figure 6.1. This Figure shows a complete reactor fuel cycle from mining of uranium ore through reprocessing of irradiated fuel, recovery of uranium and plutonium from spent fuel and shipment of high level waste to permanent storage. Under this scheme, the uranium and plutonium are recycled through the reactor fuel cycle. It should be noted that the reprocessing portions of the fuel cycle shown in Figure 6.1 are included for completeness and to provide economic data for this option. Currently, reactor fuel for the commercial Light Water Reactors is not being reprocessed. The alternate back-end of the fuel cycle, without the reprocessing option shown in Figure 6.1, includes temporary storage and eventual disposal of the spent fuel without reprocessing.

A standardized cost code-of-accounts format for presentation of the fuel cycle costs is given which correlates to the steps in the typical uranium/plutonium fuel cycle. The cost code-of-accounts numbering system is an extension of the format developed by USAEC Report NUS-531, "Guide for Economic Evaluation of Nuclear Reactor Plant Designs."

6.5.2 Components of the Nuclear Fuel Cycle Cost Analysis

The total nuclear fuel cycle cost is composed of direct and indirect cost components. The direct cost component is the cost of the fuel consumed as reflected in the cost of the materials and services for each step of the nuclear fuel cycle. It is independent of calendar time and plant capacity factor. The indirect cost component is the carrying charge associated with the value of the reactor fuel during a given calendar period. It includes interest on borrowed money, return on equity, federal and state income taxes, and other costs associated with the time value of money. Since the indirect cost component is dependent on time, it is related to the plant's performance in terms of the plant's capacity factor. Both the direct and indirect cost estimates are developed on an inflation-free basis and reported in constant January 1 dollars of the year of the estimate.

The nuclear fuel cycle costs developed here are levelized over the life of the reactors, which is assumed to be 30 years. This permits comparison of the various reactor fuel cycle systems on the same economic basis.

In addition, the total nuclear fuel cycle costs include the economic impact of the initial core on the thirty year levelized fuel cycle cost. This effect is considered, because the initial core is larger and more expensive than the reloads, which represent only part of the core. The total impact of the initial core cost on the total levelized fuel cost is dependent on the reactor, fuel cycle and generating history.

6.5.2.1 Direct Costs

Direct costs are the costs of materials and/or services associated with each step in the fuel cycle shown in Figure 6.1. These are as follows:

a. The cost of U_3O_8 in dollars per pound - \$/lb U_3O_8.

b. The cost per kilogram for conversion of the U_3O_8 to UF_6 - \$/Kg U.

c. The cost for enrichment of the UF_6 to the level required by the particular reactor fuel cycle under consideration. The cost is given in dollars per separative work unit - \$/SWU.

d. The cost for fabrication, carrying the enriched UF_6 to pelletized UO_2 and encapsulating in a cladding material, followed by assembly of single fuel rods into a fuel element - \$/Kg U (or HM).

e. The costs for shipping fuel to the reactor site - the point of use - \$/Kg U (or HM); in this report, these costs are included in fabrication cost.

f. The cost of shipping spent fuel after on-site storage, to (a) reprocessing or (b) a Federal repository for spent fuel storage - \$/Kg HM.

g. The cost of spent fuel disposal - \$/Kg HM or the cost for reprocessing of spent fuel - \$/Kg HM.

h. The cost for disposal of waste from the reprocessing operation - \$/Kg HM.

i. The cost/refund value of the recovered U or Pu as shipped for fuel fabrication of mixed oxide fuel - MOX - \$/Kg HM.

The assignment of a specific dollar value to the individual steps of the direct costs in the nuclear fuel cycle remains open to discussion. In the Fourth Update of the EEDB, the costs for these steps have been derived from the best

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U_3O_8 = uranium ore concentrate
UO_2 = uranium oxide
HM = heavy metal
UF_6 = uranium hexafluoride
U = elemental uranium

information available and represent either a consensus of current estimates or actual costs. The values given in Tables 6-4a through 6-11a ("a" tables only) summarize the fuel cycle unit prices used in this evaluation.

It must be noted that the costs for natural uranium are taken over the period from 1981 to 2030, with values for these and the intervening years shown in Table 6-14.

Fuel fabrication costs depend on various fuel cycle options in the reactor types involved. These costs are summarized, by reactor type, in the "a" tables.

The shipping of fuel to a site usually constitutes a minor cost which is absorbed under fabrication costs. However, the handling of the plutonium-rich material from the LMFBR requires greater care and incurs greater shipping costs.

When spent fuel elemen. - are removed from the reactor, they are generally stored in a safe and shielded area on-site to permit the short-lived fission products to decay. Storage times may vary from 120 days to 10 years. Under the assumptions of the EEDB Program, the investment cost of this spent fuel storage is included in the capital cost of the plant. Consequently, there is no explicit charge given for on-site spent fuel storage facilities, even though the time value of money for the fuel storage period is included in the fuel cycle costs.

The shipping of spent fuel from the reactor site to a reprocessing plant or a temporary or permanent Federal repository for spent fuel elements, does require significant expenditures. These expenditures differ for the types of fuel shipped, and are shown in the "a" tables. The Fourth Update considers throwaway cycles for the non-breeders and plutonium recycle for the breeders.

The projected reprocessing costs for the breeder reactor is also given in the "a" tables. In terms of constant dollars, it has been assumed that there will be some productivity increase with the passing of time and that this productivity increase will be accompanied by a reduction in the cost of operation.

It is generally accepted that the value of the plutonium and of the uranium recovered in reprocessing, will be economically attractive only when that portion of the fuel cycle, with its attendant waste disposal, is shown to be less expensive than the use of fresh uranium and the subsequent steps of enrichment and fuel fabrication. For the fast breeder reactor, therefore, the assumption is implicit that the plutonium will be bred from depleted U-238, which is considered to have no value. This may be noted in the "a" tables.

6.5.2.2 Indirect Costs

In addition to the direct costs, there are related cost factors, which affect the overall fuel cycle cost. These indirect costs usually include:

- Interest on borrowed money,
- Return on equity,
- Federal and State income taxes,
- Other taxes
- Other costs related to the time-value of money.

The calculation of indirect fuel cycle costs requires that all the factors affecting them be projected over the time period for which they are being calculated. Indirect costs are related to the time when payments for materials and services are made, and the amount of time that the fuel spends in the reactor. Therefore, indirect costs are impacted by the lead and lag times associated with payments for materials and services and by the performance of the plant as measured by its capacity factor.

It is often not possible to establish a linear relationship between indirect costs and the direct costs for the associated fuel cycle steps. Generally, a discounted cash flow analysis is used to precisely determine the indirect costs, when the information available can support this level of accuracy. However, adequate estimates of indirect cost can be derived by an interest rate approach.

6.5.2.3 Other Factors

The operational lifetime for all reactors is assumed to be 30 years. The startup dates considered are discussed in Section 3.0.

The lead and lag times involved in the procurement of fuel, the reprocessing step (where reprocessing is involved), and the eventual crediting of the recovered materials, affect costs, because they represent a charge similar to an interest rate. The lead time is the length of time from the payment for materials and services at the beginning of the fuel cycle, to the time this fuel is placed in the reactor core. This lead time simulates the progress payment schedule. The lag time is the length of time from discharge of fuel from the reactor to the point when payments are made for materials and/or services at the back-end of the cycle, or to receipt of credit, if any, for recovered fuel. A summary of the lead and lag times used in the Fuel Cycle Cost Fourth Update are tabulated in Table 6-15.

In the various steps of the fuel cycles, where the fuel itself undergoes processing, some losses are inevitable. However, on the basis of experience, they are considered to be too small to significantly affect the overall costs in any step of the fuel cycle. For all of the reactor types and fuel cycle options presented, it is assumed that the tails assay for enrichment is approximately 0.2 weight percent U-235. Minor changes in the percentage of the tails assay are not expected to affect the costs of the fuel cycle significantly. Advanced isotope separation technology is not considered in this report.

6.5.3 General Approach to Nuclear Fuel Cycle Cost Analysis

The general approach to Nuclear Fuel Cycle Cost Analysis consists of the following activites:

1. Projection of general economic parameters over the period of interest, including long term escalation, interest and discount rates.
2. Selection of the nuclear fuel cycle calculation method that is appropriate for the level of accuracy required and the availability of the input data.
3. Selection of the desired combinations of reactor type and fuel cycle alternatives.
4. Acquisition of mass flow data for the selected combinations of reactor type and fuel cycle alternative.
5. Acquisition of input unit cost data projections for each step of each nuclear fuel cycle under consideration over the time period of interest

6. Calculation of the direct and indirect cost components for each step in the reactor-cycle combination being analyzed for the period of interest.

7. Calculation of the levelized total nuclear fuel cycle cost for each cycle case being analyzed over the period of interest.

The calculation of the direct costs is dependent on the reactor core design and the energy and mass balance associated with the cycle selected. The calculation of the indirect costs is dependent on time and reactor performance. Consequently, although the direct costs are the largest component of the fuel cycle, the indirect costs are the more difficult to calculate, because of the complexities associated with the time related accounting.

Since precise calculation of the nuclear fuel cycle costs requires an accurate calculation of the indirects, a detailed cash flow analysis, which is usually computerized, is utilized where great accuracy is required. Very complex and sophisticated programs have been developed. Their complexity is limited only by the level of accuracy desired for a specific application. Fuel management of operating reactors is an example of a situation which requires precise results. Bid evaluation of alternative U_3O_8 or fabricated fuel bids is another example where precision is important. In cases where such high precision is unneeded or unjustified, adequate estimates of indirect costs can be derived from an interest rate approach.

6.5.3.1 Selection of An Approximate Method

Review of the USDOE objectives for the EEDB Program results in a decision to adopt an approximate method of nuclear fuel cycle calculations, rather than to utilize a computerized, detailed cash flow technique. The reasons for this decision are as follows:

- The objective of the EEDB Program is to provide normalized comparisons between generic alternatives, rather than the detailed comparisons of specific alternatives found in actual industry cases.
- Use of the EEDB, following the Initial Update, has provided the experience that evaluation of alternatives on a quick response basis is often required. This experience indicates that a simpler and more flexible method for developing fuel cycle costs is required.
- The projections of input unit costs for each fuel cycle component have great uncertainity because they reflect a "national generic average value". The average value may differ substantially from the costs associated with specific bids in actual cases. The range of long term bid prices associated with different economic conditions at different times in different parts of the county results in this disparity. This is particularly true of the U_3O_8 price. (A review of the tables and charts on U_3O_8 contract prices in the USDOE, Grand Junction Office reports will demonstrate this fact.)
- The projection of input unit costs for each fuel cycle component over a period of fifty years is also subject to the uncertainties associated with political policy decisions, technological innovations and the general discontinuities of supply/demand interrelationships.
- Only the LWR reactor core with "once-through" fuel cycle has actual experience to support "precise" economic analyses. The HTGR, PHWR and LMFBR are based on conceptual designs and specifications.

Therefore, there is little justification to utilize highly accurate, but complex, calculation techniques for the purpose of comparing alternatives. The development of the approximate method is based upon the detailed data base developed for the Initial Update of the EEDB by United Engineers and its subcontractor, NUS Corporation of Rockville, MD.

6.5.3.2 Calculation Approach for the Approximation Factors Method

The Approximation Factors Method of nuclear fuel cycle calculation used in this update is based on NUS-3190, "Fuel Cycle Cost Estimates for LWR, HTGR, CANDU

Type HWR, LMFBR, and GCFR"; NUREG-0480, "Coal and Nuclear: A Comparison of the Cost of Generating Baseload Electricity by Region"; and other reports (Refer to Section 8.1, References 5, 6, 7, 8 and 9).

A set of direct cost proportionality constants or approximation factors are developed for the direct cost associated with each step of each reactor-cycle combination addressed. In order to maintain continuity and consistency with the EEDB Initial Update, mathematical relationships are established between the input cost per unit given in NUS-3190 and the direct cost value in terms of thermal costs given as output. The input unit costs are given in the "a" series of Tables 6-4 through 6-11. The direct costs answers are given in the "b" series of Tables 6-4 through 6-11. The direct cost approximation factors are verified by using the existing data to demonstrate their validity.

The approximate method utilizes an expression* to calculate the indirect cost as a function of the lead and lag times associated with the direct cost expenditure, the residence time of the fuel in the reactor and the cost of money used as a basis for calculating the carrying charges.

The impact of the initial core relative to the equilibrium core, on the total 30 year nuclear fuel cycle cost, varies with each reactor-cycle combination. To account for this impact, the approximate method distinguishes between the initial core and the equilibrium core in calculation of directs and indirects and combines them in the final operations of each calculation.

The Nuclear Fuel Cycle Update Procedure (Approximation Factors Method) is

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* The expression used is adapted from that given in NUREG-0480 at the bottom of page C-15. The general discussion of the nature of carrying charges which forms the basis for the approach is given on pages C-14, C-15, and C-16 of that source.

described in detail in the Second Update Report.*

6.5.4 Input Unit Cost Projections

The total nuclear fuel cycle cost is a function of the market prices of the materials, processes and services associated with each step of the cycle. These market prices are referred to as the input unit costs in this discussion. As previously noted, the principal fuel cycle cost experience is derived from operations with the LWRs. However, only a partial segment of the full fuel cycle is completely defined. Government policy decisions have not yet been made on the reprocessing of spent fuel and the disposal of high level radioactive wastes. Therefore, cost experience is lacking in these areas, as well as the associated area of the value of the recovery of spent fuel. It is important to recognize the absence of experiential cost data for the reprocessing portion of the fuel cycle in the case of the LMFBR, because the recycling of fuel is an integral part of this fuel cycle.

All values for unit input costs associated with the nuclear fuel cycle steps are given in constant 1981 dollars. In some cases, the costs of the fuel cycle steps remain constant or decline with respect to time. This effect is caused by such factors as the presumed savings resulting from familiarity with the processes, or from the quantity of the system throughput.

In other cases, particularly that of the uranium core, the costs may increase with time. In the inflation-free context of the EEDB Program, this increase is due to a change in the amount of effort required to extract ore from sources less rich in uranium, thereby requiring additional processing steps or longer application of the same processing steps. In other words, the increase in cost arises from a real change in the amount of energy, labor and materials

* Refer to Section 3.1 for additional details.

expended in producing the same product and quantity and is referred to as escalation caused by scarcity. This is an attempt to distinguish it from escalation caused by inflation, which represents a change in the value of money, rather than a change in the cost of the process. To illustrate the effect of input unit cost changes on fuel cycle costs, sensitivity studies were reported in NUS-3190. These are included in the Initial Update of the EEDB*. This work shows the impact of a change in a particular fuel cycle step on the total fuel cost.

6.5.4.1 Data Sources for Input Unit Costs

Although there are a number of references for projections of nuclear fuel cycle unit input costs, the one selected for this update of the EEDB is NUREG CR-1041, "Fuel Cycle Cost Projections," Battelle Pacific Northwest Laboratories; December, 1979. This report addresses input cost projections for six LWR cases. The projections represent three nuclear electric growth rates for a "once-through" fuel cycle environment and three nuclear electric growth rates for a "recycle" environment.

The ground-rules for the Fourth Update of the EEDB specify a "once through" cycle for the LWRs, HTGR and PHWR cases and the initiation of reprocessing for the LMFBR case to the extent necessary to support their operation. Therefore, the input unit costs for U_3O_8, conversion, fabrication and spent fuel shipping are taken from the case for a "once-through" fuel cycle with medium nuclear growth for all reactors. The reprocessing and high level waste disposal input unit costs for the LMFBR are adapted from the estimates of these costs for LWR fuel, as given in the case for "recycle" with medium nuclear growth. All unit cost projections in

* Refer to Section 8.1 for additional details

NUREG CR-1041 are based on zero inflation rate.

6.5.4.2 Adaptation of Input Unit Cost Data

The input costs given in NUREG CR-1041 are given in constant 1979 dollars. The Fourth Update of the EEDB adjusts all of the nuclear fuel cycle input costs components (except for U_3O_8) from 1979 to 1981 dollars by applying an escalation factor of 10 percent per year. Because of the current uncertainties associated with prediction of U_3O_8 pricing, this component is dealt with differently, as discussed in Section 6.5.4.3.

Although NUREG CR-1041 uses a 4 percent discount rate, for its fuel cycle calculations, the Fourth Update Groundrule for the discount rate cites a value of 3.5 percent. Therefore, the present worth calculation performed on the adjusted unit input cost projections utilizes a discount rate of 3.5 percent as part of the levelized price calculation. The input unit values given in the "a" tables (the "a" series of Tables 6-4 through 6-11) in this section are given in constant 1981 dollars. The output costs given in the "b" tables (the "b" series of Tables 6-4 through 6-11) in this section are the levelized fuel cycle costs.

Since the NUREG CR-1041 input data applies only to the LWR, it is necessary to adapt these inputs to create input unit costs for the HTGR, PHWR, and LMFBR reactors. This is accomplished by using the NUS-3190 data to develop ratio's between non-LWR reactors and LWR reactors for various fuel cycle steps. These ratio's are then applied to the appropriate LWR input unit costs to develop non-LWR input unit costs.

6.5.4.3 Discussion of U_3O_8 Costs

For non-breeder reactors, the cost of U_3O_8 is the largest contributor to the total nuclear fuel cost. This is particularly true when the reactors are coupled with a "once-through" fuel cycle. Changes in the cost of U_3O_8 have the largest impact on these reactor cycle combinations.

More U_3O_8 is consumed nationally during the thirty year life of a power generating station under a "once-through" scenario than is consumed under a "recycle" scenario. This results in a faster depletion of known uranium reserves for the "once-through" cycle. Therefore, the price of uranium during the life of a power plant should experience a larger escalation rate during a "once-through" case than during the "recycle" case, because of an incremental escalation associated with faster depletion of the reserves. In addition, if the deployment of nuclear power generating stations is very rapid, the demand for uranium increases the consumption of the lower cost reserves faster than if a medium or low deployment rate occurs.

NUREG CR-1041 recognizes these relationships by giving projections for six scenarios; three involving a "once-through" cycle and three involving a "recycle" scenario. The uranium cost projection based on a "once-through" cycle for all LWRs and a medium expansion rate in nuclear power plants is selected for the Fourth Update. It is, over the period examined, considerably higher than the recycle environment for LWRs with a medium expansion rate in nuclear power plants. Consequently, it is considered a conservative selection for use in comparing the "once-through" fuel cycle costs with coal alternatives.

The U_3O_8 cost projection is adjusted in the Fourth Update to account for the reduction in U_3O_8 demand that began during 1980 and is continuing in 1981. It is believed that this phenomenon is driven by a lack of new nuclear plant orders and the continued postponement and cancellation of plants on order. The adjustment consists of moving the U_3O_8 cost projection curve from NUREG CR-1041 forward in time by two years to account for the aforementioned factors. Thus, in the Fourth Update, the NUREG CR-1041 price in 1979 dollars predicted to occur in the year 2000 is delayed until the year 2002. In addition, the 1979 prices given in NUREG CR-1041 for U_3O_8 are not escalated as are the input unit cost projections for the remainder of the fuel cycle steps.

The U_3O_8 costs adopted from NUREG CR-1041 for the Fourth Update are considerably higher than that developed for the Initial Update of the EEDB. This is due, in part, to the development of a single average cost curve for U_3O_8 in the Initial Update, for use with both "once-through" and "recycle" operation modes. The NUREG CR-1041 study develops separate "once-through" and "recycle" scenario curves. Because of the current lack of policy on reprocessing, the NUREG CR-1041 "once-through" curve is the only realistic choice for the non-breeder reactors in the Fourth Update.

A general perception has been in vogue that the cost of uranium concentrate (U_3O_8 or "yellowcake") will increase over the next half century. This assumption arises from the very large increase in the forward price of U_3O_8, which occurred after the 1973 oil embargo and which was aggravated by the difficulties encountered by one of the major nuclear fuel suppliers in meeting its commitments. The price of U_3O_8 rose by a factor of six in the space of three years. In addition, projections of installed nuclear capacity in the early 2000 time-frame were higher during the mid-seventies than they are now.

Subsequently, a number of external factors are tending to lower the price of U_3O_8. Among these are the discovery of very large and rich new uranium deposits in Australia and Canada, the settlement of the suits brought against the major fuel supplier who could not meet commitments and the reduction in the projections of installed nuclear capacity in the early 2000 time period. In fact, the 1981 price of uranium in current dollars has declined to almost half the 1978 price. It has fallen much further in terms of constant dollars.

It can be seen that the forecasting of future fluctuations in the cost of "yellowcake" is complicated by the political, economic and demand uncertainties associated with nuclear energy. Projections for the Fourth Update are based on conservative and reasonable assumptions, that account for the factors discussed above. Projected U_3O_8 prices are given in Table 6-14.

6.5.5 Description of Reactor Types and Their Fuel Cycles

A description of the reactor types and their associated fuel cycles prepared for the Initial Update of the EEDB is included in Appendix F. This description includes the reactor-fuel cycle combinations being updated in the Fourth Update of the EEDB. It also includes descriptions of some cycles, which are deleted by the Third Update.

As noted earlier, the differences between the two LWR types, the Boiling Water Reactor and the Pressurized Water Reactor, have a relatively insignificant effect on the overall fuel cycle costs. Consequently, it is assumed during this analysis that the data developed for the PWR case also apply to the BWR case.

The descriptions of the reactor-fuel cycle combinations in Appendix F, which form the basis for the fuel cycle costs, are based on preliminary NASAP data. Final data is published in Volume IX of the NASAP study, DOE/NE-0001/9.

The rated powers of the nuclear systems listed in Table 1-1 differ in some cases from the nominal thermal powers listed for the preliminary NASAP systems. However, the mass flow relationships remain unchanged for a determinate reactor type over a relatively large range of output power. Thus, although the total mass of fuel used (200 MTU vs 150 MTU) is different for two PWRs of different thermal power, the level of initial enrichment (3%), the average burnup (30,000 MWd/T) and the heat rate (10,200 Btu/kWh) are approximately the same. Therefore, the total cost of fuel is different, but the specific costs in $/MBtu or mills/kWh are the same for the same portions of the nuclear fuel cycle. Consequently, the differences between the EEDB nuclear system's rated power and the preliminary NASAP nominal rated power do not affect the calculated costs of the nuclear fuel cycle for the reactor types studied.

6.5.6 Nuclear Fuel Cycle Cost Results

Nuclear fuel cycle costs are prepared for the reactor-cycle cases of interest in the Fourth Update of the EEDB for a cost and regulation date of January 1, 1981. These calculations use unit input data adapted from NUREG CR-1041 and an approximate method of nuclear fuel cycle calculation.

6.5.6.1 Detailed Results

The details of the input unit costs used for each case and the fuel cycle component costs are given in Tables 6-4a/4b through 6-11a/11b.

6.5.6.2 Summary Results

A summary of the 30-year levelized fuel cycle costs are given in Table 6-16 for the reactor types listed in Table 1-1. Both direct and indirect costs are given separately, as well as the total levelized cost, extending over the 30-years of plant operating life, beginning with the year of startup noted. Table 6-17 gives the breakdown of the levelized costs by individual cost component for various options in the fueling mode of the different reactor types. Note that for both tables, the breeder reactor cases involve a zero bred-fuel value. The total 30-year levelized fuel cycle cost in $/MBtu and m/kWh for the base reactors and their fueling modes is given in Table 6-18.

Table 6-19 shows the percentage of the total costs attributable to each cost component. For the thermal neutron spectrum reactors (LWRs, HTGRs, and PHWRs), the uranium supply is the largest single cost. This category includes the U_3O_8, conversion to UF_6 and enrichment to the desired concentration of U-235 (or U-233). For the fast neutron spectrum reactors, such as the LMFBR, the uranium supply cost is shown as zero. The intended fissle fuel is Pu and no value has been assigned to the enrichment processing tails or the depleted uranium recovered in reprocessing, either or both of which constitute the fertile portions of the cores and blankets.

6.5.6.3 Considerations Surrounding the Nuclear Fuel Cycle Cost Fourth Update

The principal fuel cycle cost experience is derived from operations with the LWRs. With the exception of the costs for uranium oxide fuel and enrichment prior to reactor operation, there is very little experience accessible for the remaining reactor fuel cycles. The government's current policy, not to permit reprocessing of LWR fuel, leaves the back-end of the LWR fuel cycle and its costs open to uncertainty, since there is no experience to support the projections, except reprocessing of naval reactor cores and weapons material. The fuel cycle costs presented in this section are, therefore, based as far as possible upon the past history of the light water reactors and the prevailing disposition of the uranium-oxide market. All of the values presented here represent points taken in a band of varying costs whose limits are not well defined and whose actual range is uncertain at this time. Despite these shortcomings, which are inherent in the current conditions of nuclear energy in the United States, the costs presented in this study permit an evaluation of:

- Comparison of different reactor types with each other.
- Comparison of different reactor types with alternatives

It must be emphasized that the data on costs permit comparison rather than the establishment of absolute values in the market place. Unless it is explicitly stated otherwise, all costs presented assume zero inflation and are given in terms of constant 1981 dollars.

6.6 COAL COSTS

6.6.1 Introduction

Coal costs are needed to assess the economics of coal-fired steam supply systems for central electric generating stations. Unlike the nuclear fuels, which are treated as quasi-capital investments with depreciation and potential salvage factors, coal is a consumable cost item. Although coal is often treated as an operational cost, the costs of coal are presented in this study as separate items of expense, to facilitate the economic comparison of nuclear and coal energy sources for production of electricity. Nuclear fuels are designed and fabricated to match reactor operating characteristics. Coal-fired boilers and associated systems, however, are designed to operate on existing coals with generically similar characteristics. For economic reasons, the selection and procurement of long-term coal supplies are frequently made concurrently with, and largely determine, the design of the coal-fired steam supply for the generating station.

The costs of coal are determined principally by:

a. the costs of extraction from the ground; and,

b. the costs of transportation to the site of use.

Coal in the United States varies widely in its characteristics, its accessibility, and its geographic distribution. This variability directly affects the costs to the user. The average calorific value of the coal, its sulfur content, the extraction method dictated by its underground location, and its distance from the user, all affect costs. It is not reasonable to expect, therefore, a single, clearly defined coal price.

6.6.2 Coal Cost Estimate

The coal costs for plants having startup in 1981 are shown in Table 6-13a. These values include the results of the United Mine Workers (UMW) strike settlement, concluded in the first quarter of 1978. The 1981 coal miner's strike occurred after the cost and regulation date of the Fourth Update (1/1/81). Incorporation of the effects of the 1981 UMW strike settlement will be included in future updates.

Values are also given for plant startups in 1987 and 2001 in Tables 6-13b and 6-13c. Table 6-20 shows the increase in the average delivered contract coal prices for the year 1980, up to the Fourth Update cost and regulation date of January 1, 1981.

The intent of the coal cost estimate is to provide costs for the years 1981, 1987 and 2001, in terms of constant 1981 dollars. The assumption is made that the levelization factor for coal costs is one, in each of the years of interest, because coal is assumed to be plentiful in that year. However, costs are escalated from 1981 to each of the startup years to reflect a degree of conservatism relative to the overall availability of coal in the future.

6.6.3 Data Sources Used for Coal Costs

Data for the coal costs were derived from studies by Electric Power Research Institute, by A. D. Little, by Paul Weir Company, and by United Engineers & Constructors, Inc., based on Federal Energy Regulatory Commission information, as referenced in Section 3.4.2b.

6.6.4 Productivity, Escalation and Inflation

The estimates provided include allowances for increases in costs resulting from known conditions such as productivity decreases at the mines and increased difficulties in mining methods, which reflect larger expenditures of energy and manhours. This approach is somewhat pessimistic since it ignores possible increases in productivity; however, recent industry experience shows a marked decline in productivity beginning in 1970. This fact is documented in EPRI Report No. EA-634-SR, entitled, "Supply 77-EPRI Annual Energy Supply Forecasts", published in 1978.

Inflation, which is understood as the change in the value of money, is explicitly excluded. The value of escalation for scarcity is also excluded, even though it is understood that the cost of coal may rise to the level of competitive fuels, except as discussed in Section 6.6.2 above.

6.6.5 Coal Transportation Costs

Transportation mileage costs for coal in selected cases represent a major contribution to the total coal costs to the utility. These costs are influenced by whether the coal cars and locomotives are owned by the carrier or by the user/shipper and whether eastern or western railroads are used. Costs for transportation are often equal to the mine-mouth costs, especially when coal is transported over 1,000 rail-miles. In the Fourth Update of the EEDB, the following assumptions are made:

a. The coal-fired plants are located at sites assumed to be 500 miles and 2,000 miles from the coal mine. The location of the hypothetical "Middletown" site is 2,000 miles from a western low sulfur coal mine and 500 miles from an eastern high sulfur coal mine.

b. All transportation equipment used belongs to the carrier.

c. Unit trains of 100 cars, at 70 to 100 tons per car, or 7,000 to 10,000 tons per unit train, are used in each shipment.

d. Mileage costs are computed from rail rates provided by the Interstate Commerce Commission for eastern and western railroad routes.

6.6.6 Characterization and Analysis of Coals

The two significant characteristics and analyses of coal for establishing costs are:

a. calorific/heating value in Btu/lb, and

b. impurity content; sulfur content in percentage points.

These two characteristics determine the price paid for coal by the utility. The analyses for the eastern and western mined coals discussed in this update are shown in Tables 6-21, 6-22, and 6-23.

The concern over the reactions from SO_2 and NO_x with water in the atmosphere to form both sulfur and nitrogen oxide is increasing, because they potentially have a deleterious effect on plant life and aquatic species. The effluents from burning coals used in the Fourth Update require scrubbing and particulate collection in various degrees. The coal-fired FPGS Technical Models include design features to accomplish the necessary scrubbing and particulate collection. However, costs for these design features are included in the capital costs and, therefore, do not contribute to coal fuel costs. Design features for stack effluent treatment for NO_x are not included.

The selection of a hypothetical plant site in the northeastern U.S. for low- or high sulfur FPGS has placed a burden on western coals, since the largest costs are for rail delivery of these coals. Since the Middletown site is 2,000 miles from the low-sulfur coal mine, but only 500 miles from the high-sulfur coal mine, eastern coals are favored over western coals in terms of total energy costs.

TABLE 6-1 — Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE

FUEL COST UPDATE SUMMARY - 2001 STARTUP

(¢/MBtu)[a]

	Nuclear Plant Models						Comparison Plant Models				
Model	BWR	HTGR-SC	PWR	PHWR	HTGR-PS	LMFBR	HS12	HS8	LS12	LS8	CGCC
MWt	3578	2240	3412	3800	1170	3800	3302	2210	3446	2307	1523
MWe	1190	858	1139	1260	150	1457	1240	795	1244	795	630
Fuel Cost	77[c]	80[b]	77[b]	33[b]	80	*	224	224	96	96	231
Fabrication Cost	7[c]	5	7	6	5	15	*	*	*	*	*
Transportation Cost	1[c]	2	1	1	2	4	68	68	282	282	57
Reprocessing	*	*	*	*	*	24	*	*	*	*	*
Disposal Cost	3[c]	2	3	2	2	1	+	+	+	+	+
TOTAL	88	89	88	42	89	44	292	292	378	378	288

* Not Applicable

\+ Disposal Costs for Coal-Fired Plants are Included in O&M Costs, Section 7

(a) Data in Constant $1981 (Inflation-Free)

(b) Cost of U_3O_8

(c) Complete BWR data are not Available; therefore, PWR Data are used for BWR (Model A1) Fuel Cycle Costs

TABLE 6-2

Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE

FUEL COST UPDATE SUMMARY - 1981 STARTUP

(¢/MBtu)[a]

	Nuclear Plant Models		Comparison Plant Models			
Model	BWR	PWR	HS12	HS8	LS12	LS8
MWt	3578	3412	3302	2210	3446	2307
MWe	1190	1139	1240	795	1244	795
Fuel Cost	56[b]	56	137	137	64	64
Fabrication Cost	7[b]	7	*	*	*	*
Transportation Cost	1[b]	1	50	50	208	208
Disposal Cost	3[b]	3	+	+	+	+
TOTAL	67[b]	67	187	187	272	272

* Not Applicable

\+ Disposal Costs for Coal-Fired Plants are Included in O&M Costs, Section 7

(a) Data in Constant $1981 (Inflation-Free)

(b) Complete BWR Data are not Available; therefore, PWR Data are used for BWR (Model A1) Fuel Cycle Costs

TABLE 6-3 Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE

FUEL COST UPDATE SUMMARY - VARIABLE STARTUP

(¢/MBtu)[a]

	Nuclear Plant Models				Coal Plant Models				
Model	BWR[b]	HTGR-SC[c]	PWR[b]	PHWR[c]	HS12[b]	HS8[b]	LS12[b]	LS8[b]	CGCC[b]
MWt	3578	2240	3412	3800	3302	2210	3446	2307	1523
MWe	1190	858	1139	1162	1240	795	1244	795	630
Fuel Cost	61[d]	73	61	29	166	166	75	75	170
Fabrication Cost	6[d]	6	6	6	*	*	*	*	*
Transportation Cost	1[d]	2	1	1	59	59	245	245	49
Disposal Cost	3[d]	2	3	2	+	+	+	+	+
TOTAL	71[d]	83	71	38	225	225	320	320	219

* Not Applicable

\+ Disposal Costs for Coal-Fired Plants are Included in O&M Costs, Section 7

(a) Data in Constant $1981 (Inflation-Free)

(b) 1987 Startup

(c) 1995 Startup

(d) Complete BWR Data are not Available; therefore, PWR Data are used for BWR (Model A1) Fuel Cycle Costs

Effective Date: January 1, 1981
(1) System : PWR-U5(LE)/U-T
Start Up : January 1, 1981

TABLE 6-4a

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1981 Dollars

Account No.	Account Description	Units	SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS) 1981	1985	1990	1995	2000	2005	2010
.10	Initital Fuel Loaded	$/KgH							
.11	Uranium Supply	$/KgU							
.111	U_3O_8 Supply	$/lb U_3O_8	43	43	43	43	47.7	57.3	69.7
.112	UF_6 Conversion Services	$/KgU as UF_6	6.3	6.3	6.3	6.3	6.3	6.3	6.3
.113	Enrichment Services	$/SWU	107.7	108.9	108.9	116.2	134.3	136.7	136.7
.114	Depleted U Supply	$/KgU							
.12	Plutonium Supply	Parity value							
.13	U-233 Supply	Parity value							
.14	Thorium Supply	$/KgH							
.20	Fabrication	$/KgH	145.2	145.2	147.6	148.8	147.6	146.4	145.2
.21	Core Fabrication	$/KgH							
.22	Axial Blanket Fabrication	$/KgH							
.23	Radial Blanket Fabrication	$/KgH							
.30	Shipping to Temporary Storage	$/KgH							
.40	Temporary Storage	$/KgH							
.50	Shipping to Repository	$/KgH	29.0	29.0	26.6	26.6	24.2	21.8	21.8
.60	Disposal of Spent Fuel	$/KgH	154.9	154.9	154.9	154.9	154.9	154.9	154.9

(1) See Table 6-12 for System Designation

Effective Date: Janua. 1981
(1) System : PWR-U5(LE)/U-T
Start Up : January 1, 1981

TABLE 6-4b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1981 Dollars

Account No.	Account Description	OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu Direct Cost	Indirect Cost	Total Cost
.00	Total	0.63	0.04	0.67
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.29	0.02	0.31
.112	UF_6 Conversion Services	0.01	0.00	0.01
.113	Enrichment Services	0.22	0.02	0.24
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.06	0.01	0.07
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.01	0.00	0.01
.60	Disposal of Spent Fuel	0.04	(0.01)	0.03

(1) See Table 6-12 for System Designation.

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				687,500	687,500
21 .	STRUCTURES + IMPROVEMENTS	2,431,046	753354 MH	11,165,122	16,744,183	30,340,351
22 .	GASIFIER/BOILER PLT EQUIP.	122,522,305	2818066 MH	47,022,456	2,885,027	172,429,788
23 .	TURBINE PLANT EQUIPMENT	108,826,636	1848800 MH	30,979,026	2,324,910	142,130,572
24 .	ELECTRIC PLANT EQUIPMENT	7,595,801	1034496 MH	16,897,777	9,539,192	34,032,770
25 .	MISCELLANEOUS PLANT EQUIPT	2,106,461	176640 MH	2,952,447	509,236	5,568,144
26 .	MAIN COND HEAT REJECT SYS	7,371,650	119658 MH	1,892,067	498,913	9,762,630
	TOTAL DIRECT COSTS	250,853,899	6751014 MH	110,908,895	33,188,961	394,951,755
91 .	CONSTRUCTION SERVICES	23,110,215	993950 MH	16,420,036	21,754,000	61,284,251
92 .	HOME OFFICE ENGRG.&SERVICE	20,625,660				20,625,660
93 .	FIELD OFFICE ENGRG&SERVICE	14,561,140			1,234,200	15,795,340
	TOTAL INDIRECT COSTS	58,297,015	993960 MH	16,420,036	22,988,200	97,705,251
	TOTAL BASE COST	309,150,914	7744974 MH	127,328,931	56,177,161	492,657,006

Effective Date: Janu 1, 1981
(1) System : PWR-U5(LE)/U-T
Start Up : January 1, 1987

TABLE 6-5b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1981 Dollars

		OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu		
Account No.	Account Description	Direct Cost	Indirect Cost	Total Cost
.00	Total	0.67	0.04	0.71
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.32	0.03	0.35
.112	UF_6 Conversion Services	0.01	0.00	0.01
.113	Enrichment Services	0.23	0.02	0.25
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.06	0.00	0.06
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.01	0.00	0.01
.60	Disposal of Spent Fuel	0.04	(0.01)	0.03

(1) See Table 6-12 for System Designation.

Effective Date: Janua., 1, 1981
(1) System : PWR-U5(LE)/U-T
Start Up : January 1, 2001

TABLE 6-6a

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1981 Dollars

Account No.	Account Description	Units	SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS) 2000	2005	2010	2015	2020	2025	2030
.10	Initital Fuel Loaded	$/KgH							
.11	Uranium Supply	$/KgU							
.111	U_3O_8 Supply	$/lb U_3O_8	47.7	57.3	69.7	84.8	91.4	91.4	91.4
.112	UF_6 Conversion Services	$/KgU as UF_6	6.3	6.3	6.3	6.3	6.3	6.3	6.3
.113	Enrichment Services	$/SWU	134.3	136.7	136.7	135.5	133.1	133.1	131.9
.114	Depleted U Supply	$/KgU							
.12	Plutonium Supply	Parity value							
.13	U-233 Supply	Parity value							
.14	Thorium Supply	$/KgH							
.20	Fabrication	$/KgH	147.6	146.4	145.2	145.2	148.8	146.4	146.4
.21	Core Fabrication	$/KgH							
.22	Axial Blanket Fabrication	$/KgH							
.23	Radial Blanket Fabrication	$/KgH							
.30	Shipping to Temporary Storage	$/KgH							
.40	Temporary Storage	$/KgH							
.50	Shipping to Repository	$/KgH	24.2	21.8	21.8	19.4	19.4	16.9	16.9
.60	Disposal of Spent Fuel	$/KgH	154.9	154.9	154.9	154.9	154.9	154.9	154.9

(1) See Table 6-12 for System Designation

Effective Date: Janu. , 1981
(1) System : PWR-U5(LE)/U-T
Start Up : January 1, 2001

TABLE 6-6b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1981 Dollars

Account No.	Account Description	Direct Cost	Indirect Cost	Total Cost
		OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu		
.00	Total	0.82	0.06	0.88
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.45	0.04	0.49
.112	UF_6 Conversion Services	0.01	0.00	0.01
.113	Enrichment Services	0.25	0.02	0.27
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.06	0.01	0.07
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.01	0.00	0.01
.60	Disposal of Spent Fuel	0.04	(0.01)	0.03

(1) See Table 6-12 for System Designation.

Effective Date: Janua., 1, 1981
(1) System : HTGR-U5/U/Th-20%-T
Start Up : January 1, 1995

TABLE 6-7a

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1981 Dollars

Account No.	Account Description	Units	SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS) 1995	2000	2005	2010	2015	2020	2025
.10	Initital Fuel Loaded	$/KgH							
.11	Uranium Supply	$/KgU							
.111	U_3O_8 Supply	$/lb U_3O_8	43.0	47.7	57.3	69.7	84.8	91.4	91.4
.112	UF_6 Conversion Services	$/KgU as UF_6	6.3	6.3	6.3	6.3	6.3	6.3	6.3
.113	Enrichment Services	$/SWU	116.2	134.3	136.7	136.7	135.5	133.1	133.1
.114	Depleted U Supply	$/KgU							
.12	Plutonium Supply	Parity value							
.13	U-233 Supply	Parity value							
.14	Thorium Supply	$/KgH							
.20	Fabrication	$/KgH	394.2	391.0	387.8	384.6	384.6	394.2	387.8
.21	Core Fabrication	$/KgH							
.22	Axial Blanket Fabrication	$/KgH							
.23	Radial Blanket Fabrication	$/KgH							
.30	Shipping to Temporary Storage	$/KgH							
.40	Temporary Storage	$/KgH							
.50	Shipping to Repository	$/KgH	415.6	378.1	340.6	340.6	303.1	303.1	264.1
.60	Disposal of Spent Fuel	$/KgH	427.6	427.6	427.6	427.6	427.6	427.6	427.6

(1) See Table 6-12 for System Designation

Effective Date: Janu ., 1981
(1) System : HTGR-U5/U/Th-20%-T
Start Up : January 1, 1995

TABLE 6-7b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1981 Dollars

		OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu		
Account No.	Account Description	Direct Cost	Indirect Cost	Total Cost
.00	Total	0.76	0.07	0.83
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.34	0.03	0.37
.112	UF_6 Conversion Services	0.01	0.00	0.01
.113	Enrichment Services	0.33	0.02	0.35
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.04	0.02	0.06
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.02	0.00	0.02
.60	Disposal of Spent Fuel	0.02	0.00	0.02

(1) See Table 6-12 for System Designation.

Effective Date: Januar[illegible] 1981
(1) System : HTGR-U5/U/Th-20%-T
Start Up : January 1, 2001

TABLE 6-8a

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1981 Dollars

			SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS)						
Account No.	Account Description	Units	2000	2005	2010	2015	2020	2025	2030
.10	Initital Fuel Loaded	\$/KgH							
.11	Uranium Supply	\$/KgU							
.111	U_3O_8 Supply	\$/lb U_3O_8	47.7	57.3	69.7	84.8	91.4	91.4	91.4
.112	UF_6 Conversion Services	\$/KgU as UF_6	6.3	6.3	6.3	6.3	6.3	6.3	6.3
.113	Enrichment Services	\$/SWU	134.1	136.7	136.7	135.5	133.1	133.1	131.9
.114	Depleted U Supply	\$/KgU							
.12	Plutonium Supply	Parity value							
.13	U-233 Supply	Parity value							
.14	Thorium Supply	\$/KgH							
.20	Fabrication(2)	\$/KgH	391.0	387.8	384.6	384.6	394.2	387.8	387.8
.21	Core Fabrication	\$/KgH							
.22	Axial Blanket Fabrication	\$/KgH							
.23	Radial Blanket Fabrication	\$/KgH							
.30	Shipping to Temporary Storage	\$/KgH							
.40	Temporary Storage	\$/KgH							
.50	Shipping to Repository(2)	\$/KgH	378.1	340.6	340.6	303.1	303.1	264.1	264.1
.60	Disposal of Spent Fuel	\$/KgH	427.6	427.6	427.6	427.6	427.6	427.6	427.6

(1) See Table 6-12 for System Designation
(2) Initial Core Fuel/Reload Fuel

Effective Date: Janu , 1981
(1) System : HTGR-U5/U/Th-20%-T
Start Up : January 1, 2001

TABLE 6-8b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1981 Dollars

Account No.	Account Description	OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu		
		Direct Cost	Indirect Cost	Total Cost
.00	Total	0.84	0.05	0.89
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.40	0.03	0.43
.112	UF_6 Conversion Services	0.01	0.00	0.01
.113	Enrichment Services	0.34	0.02	0.36
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.05	0.00	0.05
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.02	0.00	0.02
.60	Disposal of Spent Fuel	0.02	0.00	0.02

(1) See Table 6-12 for System Designation.

Effective Date: January 1, 1981
(1) System : PHWR-U5(SE)/U-T
Start Up : January 1, 1995

TABLE 6-9a

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1981 Dollars

Account No.	Account Description	Units	SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS) 1995	2000	2005	2010	2015	2020	2025
.10	Initital Fuel Loaded	\$/KgH							
.11	Uranium Supply	\$/KgU							
.111	U_3O_8 Supply	\$/lb U_3O_8	43.0	47.7	57.3	69.7	84.8	91.4	91.4
.112	UF_6 Conversion Services	\$/KgU as UF_6	6.3	6.3	6.3	6.3	6.3	6.3	6.3
.113	Enrichment Services	\$/SWU	116.2	134.3	136.7	136.7	135.5	133.1	133.1
.114	Depleted U Supply	\$/KgU							
.12	Plutonium Supply	Parity value							
.13	U-233 Supply	Parity value							
.14	Thorium Supply	\$/KgH							
.20	Fabrication	\$/KgH	87.4	86.7	86.0	85.3	85.3	87.4	86.0
.21	Core Fabrication	\$/KgH							
.22	Axial Blanket Fabrication	\$/KgH							
.23	Radial Blanket Fabrication	\$/KgH							
.30	Shipping to Temporary Storage	\$/KgH							
.40	Temporary Storage	\$/KgH							
.50	Shipping to Repository	\$/KgH	20.0	18.2	16.3	16.3	14.6	14.6	12.7
.60	Disposal of Spent Fuel	\$/KgH	95.9	95.9	95.9	95.9	95.9	95.9	95.9

(1) See Table 6-12 for System Designation

Effective Date: Janua. 1981
(1) System : PHWR-U5(SE)/U-T
Start Up : January 1, 1995

TABLE 6-9b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1981 Dollars

Account No.	Account Description	Direct Cost	Indirect Cost	Total Cost
		OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu		
.00	Total	0.38	0.00	0.38
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.21	0.01	0.22
.112	UF_6 Conversion Services	0.01	0.00	0.01
.113	Enrichment Services	0.06	0.00	0.06
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.06	0.00	0.06
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.01	0.00	0.01
.60	Disposal of Spent Fuel	0.03	(0.01)	0.02

(1) See Table 6-12 for System Designation.

Effective Date: January 1, 1981
(1) System : PHWR U5(SE)/U-T
Start Up : January 1, 2001

TABLE 6-10a

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1981 Dollars

Account No.	Account Description	Units	SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS) 2000	2005	2010	2015	2020	2025	2030
.10	Initital Fuel Loaded	\$/KgH							
.11	Uranium Supply	\$/KgU							
.111	U_3O_8 Supply	\$/lb U_3O_8	47.7	57.3	69.7	84.8	91.4	91.4	91.4
.112	UF_6 Conversion Services	\$/KgU as UF_6	6.3	6.3	6.3	6.3	6.3	6.3	6.3
.113	Enrichment Services	\$/SWU	134.1	136.7	136.7	135.5	133.1	133.1	131.9
.114	Depleted U Supply	\$/KgU							
.12	Plutonium Supply	Parity value							
.13	U-233 Supply	Parity value							
.14	Thorium Supply	\$/KgH							
.20	Fabrication	\$/KgH	86.7	86.0	85.3	85.3	87.4	86.0	86.0
.21	Core Fabrication	\$/KgH							
.22	Axial Blanket Fabrication	\$/KgH							
.23	Radial Blanket Fabrication	\$/KgH							
.30	Shipping to Temporary Storage	\$/KgH							
.40	Temporary Storage	\$/KgH							
.50	Shipping to Repository	\$/KgH	18.2	16.3	16.3	14.6	14.6	12.7	12.7
.60	Disposal of Spent Fuel	\$/KgH	95.9	95.9	95.9	95.9	95.9	95.9	95.9

(1) See Table 6-12 for System Designation

Effective Date: Jan 1, 1981
(1) System : PHWR-U5(SE)/U-T
Start Up : January 1, 2001

TABLE 6-10b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1981 Dollars

Account No.	Account Description	Direct Cost	Indirect Cost	Total Cost
		OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu		
.00	Total	0.42	0.00	0.42
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.25	0.01	0.26
.112	UF_6 Conversion Services	0.01	0.00	0.01
.113	Enrichment Services	0.06	0.00	0.06
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.06	0.00	0.06
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.01	0.00	0.01
.60	Disposal of Spent Fuel	0.03	(0.01)	0.02

(1) See Table 6-12 for System Designation.

Effective Date: January 1, 1981
(1) System : LMFBR-Pu/U/U/U-HT
Start Up : January 1, 2001

TABLE 6-11a

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1931 Dollars

Account No.	Account Description	Units	SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS) 2000	2005	2010	2015	2020	2025	2030
.10	Initial Fuel Loaded	$/KgH							
.11	Uranium Supply	$/KgU							
.111	U_3O_8 Supply	$/lb U_3O_8	0	0	0	0	0	0	0
.112	UF_6 Conversion Services	$/KgU as UF_6							
.113	Enrichment Services	$/SWU							
.114	Depleted U Supply	$/KgU	0	0	0	0	0	0	0
.12	Plutonium Supply	Parity value	0	0	0	0	0	0	0
.13	U-233 Supply	Parity value							
.14	Thorium Supply	$/KgH							
.20	Fabrication	$/KgH							
.21	Core Fabrication	$/KgH	641.3	636.0	630.8	630.8	646.5	636.0	636.0
.22	Axial Blanket Fabrication	$/KgH	40.9	40.5	40.2	40.2	41.2	40.5	40.5
.23	Radial Blanket Fabrication	$/KgH	147.6	146.4	145.2	145.2	148.8	146.4	146.4
.30	Shipping to Temporary Storage	$/KgH							
.40	Temporary Storage	$/KgH							
.50	Shipping to Reprocessor	$/KgH	142.2	128.1	128.1	114.0	114.0	99.3	99.3
.60	Reprocessing	$/KgH	509.0	435.6	361.9	347.6	341.4	341.4	341.4
.70	Disposal of Reprocessing Wastes	$/KgH	364.8	364.8	364.8	364.8	364.8	364.8	364.8
.80	Final Fuel Recovered (Credits)	$/KgH							
.81	Uranium	$/KgH	0	0	0	0	0	0	0
.811	Equivalent U_3O_8 Supply	$/lb U_3O_8							
.812	Equivalent UF_6 Conversion Services	$/KgU							
.813	Equivalent Enrichment Services	$/SWU							
.82	Fissile Plutonium	Parity value	0	0	0	0	0	0	0
.83	Bred U-233	Parity value							
.90	Refabrication of Recovered Fuel	$/KgH							

(1) See Table 6-12 for System Designation

Effective Date: January 1, 1981
(1) System : LMFBR-Pu/U/U/U-HT
Start Up : January 1, 2001

TABLE 6-11b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1981 Dollars

		OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu		
Account No.	Account Description	Direct Cost	Indirect Cost	Total Cost
.00	Total	0.43	0.01	0.44
.10	Initital Fuel Loaded			
.11	Uranium Supply(2)			
.111	U_3O_8 Supply	--	--	--
.112	UF_6 Conversion Services			
.113	Enrichment Services			
.114	Depleted U Supply			
.12	Plutonium Supply(3)	--	--	--
.13	U-233 Supply			
.14	Thorium Supply			
.20	Facbrication(4)			
.21	Core Fabrication	0.11	0.01	0.12
.22	Axial Blanket Fabrication	0.01	0.00	0.01
.23	Radial Blanket Fabrication	0.02	0.00	0.02
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Reprocessor	0.04	0.00	0.04
.60	Reprocessing	0.24	0.00	0.24
.70	Disposal of Reprocessing Wastes	0.01	0.00	0.01
.80	Final Fuel Recovered (Credits)			
.81	Uranium(2)			
.811	Equivalent U_3O_8 Supply			
.812	Equivalent UF_6 Conversion Services			
.813	Equivalent Enrichment Services			
.82	Fissile Plutonium(3)			
.83	Bred U-233			
.90	Refabrication of Recovered Fuel			

(1) See Table 6-12 for System Designation

(2) Final uranium value (account .81) is included in Uranium Supply (account .11) such that the value entered under account .11 represents the net uranium consumed.

(3) Final value of fissile plutonium (account .82 is included in Plutonium Supply (account .12) such that the value entered under account .12 represents the net fissile plutonium consumed.

(4) Includes fabrication of core, axial blanket and radial blanket (account .21, .22 and .23)

Effective Date - 1/1/81

TABLE 6-12

ENERGY ECONOMIC DATA BASE

EXPLANATION OF FUEL CYCLE SYSTEM DESIGNATION
(Refer to Tables 6-4 through 6-11)

System Designation	Reactor Type	Fuel-Type	Fuel Cycle Alternative
PWR-U5(LE)/U-T	LWR(PWR & BWR)	Low-enriched uranium (UO_2)	Throwaway
HTGR-U5/U/Th-20%-T	HTGR-SC & HTGR-PS	Medium-enriched uranium (20%) and thorium (UC_2-ThO_2)	Throwaway
PHWR-U5(SE)/U-T (CANDU)	PHWR	Slightly enriched (1.2%) uranium (UO_2)	Throwaway
LMFBR-Pu/U/U/U/HT	LMFBR	Pu/depleted uranium-core and depleted uranium blankets (PuO_2-UO_2/UO_2/UO_2)	Recycle of plutonium in breeders

Effective Date: January 1, 1981
System : Coal-Fired FPGS(5)
Startup : January 1, 1981

TABLE 6-13a
ENERGY ECONOMIC DATA BASE
COAL FUEL COST COMPONENTS
No Escalation
(Constant January 1, 1981 Dollars)

Plant Type		Coal	Coal Costs(1)		Transportation Costs(2)				Total
Model	MWe	Type(3)	$/tons	$/MBtu	$/t-mi(4)	Miles	$/ton	$/MBtu	$/MBtu
HS12	1240	EHS	30.14	1.37	0.022	500	11.00	0.50	1.87
HS8	795								
LS12	1244	WLS	10.41	0.64	0.017	2000	34.00	2.08	2.72
LS8	795								

(1) Coal Costs are FOB Mine-mouth
(2) Transportation Costs are "Delivered to User"
(3) EHS = Eastern (High Sulfur) Coal; WLS = Western (Low Sulfur) Coal. Refer to Tables 6-21 and 6-22 for Coal Constituents
(4) $/t-mi = $ per ton-mile
(5) FPGS = Fossil Power Generating Station

Effective Date: January 1, 1981
System : Coal-Fired FPGS[5]
Startup : January 1, 1987

TABLE 6-13b
ENERGY ECONOMIC DATA BASE
COAL FUEL COST COMPONENTS
No Escalation
(Constant January 1, 1981 Dollars)

Plant Type		Coal	Coal Costs[1]		Transportation Costs[2]				Total
Model	MWe	Type[3]	$/ton	$/MBtu	$/t-mi[4]	Miles	$/ton	$/MBtu	$/MBtu
HS12 HS8	1240 795	EHS	36.66	1.66	0.026	500	13.00	0.59	2.25
LS12 LS8	1244 795	WLS	12.27	0.75	0.020	2000	40.00	2.45	3.20
CGCC	630	PHS	44.84	1.70	0.026	500	13.00	0.49	2.19

(1) Coal Costs are FOB Mine-mouth
(2) Transportation Costs are "Delivered to User"
(3) EHS = Eastern (High Sulfur) Coal; WLS = Western (Low Sulfur) Coal; PHS = Pittsburgh Steam (High Sulfur) Coal. Refer to Tables 6-21, 6-22, and 6-23 for Coal Constituents
(4) $/t-mi = $ per ton-mile
(5) FPGS = Fossil Power Generating Station

Effective Date: January 1, 1981
System : Coal-Fired FPGS[5]
Startup : January 1, 2001

TABLE 6-13c
ENERGY ECONOMIC DATA BASE
COAL FUEL COST COMPONENTS
No Escalation
(Constant January 1, 1981 Dollars)

Plant Type		Coal	Coal Costs[1]		Transportation Costs[2]				Total
Model	MWe	Type[3]	$/ton	$/MBtu	$/t-mi[4]	Miles	$/ton	$/MBtu	$/MBtu
HS12	1240	EHS	49.32	2.24	0.030	500	15.00	0.68	2.92
HS8	795								
LS12	1244	WLS	15.75	0.96	0.023	2000	46.00	2.82	3.78
LS8	795								
CGCC	630	PHS	60.79	2.31	0.030	500	15.00	0.57	2.88

(1) Coal Costs are FOB Mine-mouth
(2) Transportation Costs are "Delivered to User"
(3) EHS = Eastern (High Sulfur) Coal; WLS = Western (Low Sulfur) Coal; PHS = Pittsburgh Steam (High Sulfur) Coal. Refer to Tables 6-21, 6-22 and 6-23 for Coal Constituents
(4) $/t-mi = $ per ton-mile
(5) FPGS = Fossil Power Generating Station

Effective Date 1/1/81

TABLE 6-14

ENERGY ECONOMIC DATA BASE
PROJECTED U_3O_8 COSTS
(January 1, 1981 Dollars)

YEAR	$/lb U_3O_8
1981 through 1997	43
1998	44
1999	46
2000	48
2002	52
2004	55
2006	60
2008	64
2010	70
2015	85
2020	91
2025	91
2030	91

TABLE 6-15 Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE

SUMMARY OF FUEL CYCLE LEAD AND LAG TIMES

(In Quarter-Years)

Lead Time (to reactor startup date)	PWR	HTGR	PHWR[f]	FBR
1. Payment for U_3O_8 purchased				
Initial core	7	7	5/5	(g)
Reloads	4	4	2/4	(g)
2. Payment for Plutonium purchased				
Initial core	--	--	--	5
Reloads	(a)	--	--	(h)
3. Payment for Conversion Services				
Initial core	5.667	5.667	-/-	--
Reloads	2.667	2.667	-/2.667	--
4. Payment for Enrichment Services				
Initial core	5	5	-/-	--
Reloads	2	2	-/2	--
5. Payment for Fabrication				
Initial core	2	2[d]	2/2	2
Reloads	1	1[d]	1/1	1
Lag Time (from discharge date from reactor)				
6. Payment for Spent Fuel Shipping	2/20[b]	2/20[b]	40/40	2
7. Payment for Reprocessing Services	2	2	--	2
8. Payment for Waste Disposal	2	2	--	--
9. Payment for Spent Fuel Disposal	20	20	40/40	--
10. Receipt of Credit for Uranium Recovered	3[c]	2[e]	--	3
11. Receipt of Credit for Plutonium Recovered	3[a]	--	--	3[h]

ENERGY ECONOMIC DATA BASE
SUMMARY OF FUEL CYCLE LEAD AND LAG TIMES
(In Quarter-Years)

(a) For recycle alternative, recovered plutonium will be recycled to the subsequent cycles with a lag time of 2 cycle lengths (self-generated mode).

(b) Recycle alternative/throwaway alternative.

(c) For recycle alternative, recovered uranium will be recycled to the subsequent cycles with a lag time of 2 cycle lengths (self-generated mode).

(d) Fabrication costs include material cost for THO_2.

(e) For recycle alternative, recovered uranium will be recycled to the subsequent cycles with a lag time of 1 cycle length (self-generated mode), based on GAC mass flows.

(f) Natural uranium fuel cycle/slightly enriched uranium fuel cycle; (CANDU).

(g) It is assumed that makeup uranium is depleted uranium whose value is zero.

(h) Recovered plutonium will be recycled to the subsequent cycles with a lag time of 2 cycle lengths. Net plutonium gained or added will be sold at the lag time, or purchased at the lead time, respectively.

TABLE 6-16 Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE

SUMMARY OF 30-YEAR LEVELIZED FUEL CYCLE COSTS

VARIABLE START-UPS

($MBtu, January 1981 Dollars)

Reactor/Fuel Cycle Designation	Direct Cost	Indirect Cost	Cycle Cost	Assumed Reactor Commercial Operation Date
PWR-U5(LE)/U-T	0.67	0.04	0.71	1987
HTGR-U5(SE)/U-T (CANDU)	0.76	0.07	0.83	1995
PHWR-U5(SE)/U-T (CANDU)	0.38	0.00	0.38	1995
HTGR-U5/U/Th-20%-T	0.84	0.05	0.89	2001
LMFBR-Pu/U/U/U-HT	0.43	0.01	0.44	2001

TABLE 6-[illegible]

Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE

SUMMARY BREAKDOWN OF 30-YEAR LEVELIZED FUEL CYCLE COSTS

VARIABLE START-UPS

($/MBtu, January 1981 Dollars)

Reactor/System Designation	Start-Up Year	Uranium Supply(1)	Plutonium Supply(2)	Fabrication(3)	Shipping(4)	Reprocessing or Disposal(5)	Total
PWR-U5(LE)/U-T	1987	0.61	0.00	0.06	0.01	0.03	0.71
HTGR-U5/U/Th-20%-T	1995	0.73	0.00	0.06	0.02	0.02	0.83
PHWR-U5(SE)/U-T (CANDU)	1995	0.29	0.00	0.06	0.01	0.02	0.38
HTGR-U5/U/Th-20%-T	2001	0.80	0.00	0.05	0.02	0.02	0.89
LMFBR-Pu/U/U/U-HT	2001	0.00	0.00	0.15	0.04	0.25	0.44

(1) Net uranium consumed including U-233 for those fuel cycles involving reprocessing. For throwaway fuel cycles, these figures represent the initial cost of uranium.

(2) Net plutonium consumed.

(3) Total fabrication of all types of fuel including recycle fuel or blanket fuel assemblies, where applicable.

(4) Shipping to reprocessor for those fuel cycles involving reprocessing, or shipping to permanent disposal facility for throwaway fuel cycles.

(5) Reprocessing and High Level Waste disposal, or permanent disposal of spent fuel assemblies.

TABLE 6-18

ENERGY ECONOMIC DATA BASE

BASE REACTORS AND THEIR FUELING MODES
30-YEAR LEVELIZED COSTS

VARIABLE START-UPS

(January 1, 1981 Dollars)

REACTOR TYPE	FUELING MODEL	ASSUMED REACTOR COMMERCIAL OPERATION DATE	COSTS	
			$/MBtu	m/kWh (2)
PWR and BWR (1)	Throwaway (U only)	1987	0.71	7.3
HTGR-SC	Throwaway (U only)	1995	0.83	7.0
PHWR	Throwaway	1995	0.38	3.9
HTGR-SC and HTGR-PS	Throwaway (U only)	2001	0.89	7.5 (3)
LMFBR	U Blanket Recycle Pu	2001	0.44	4.0

(1) BWR data not available for fuel costs; PWR data used for BWR (Model A1).

(2) Based on net plant heat rates given in Table 4-1.

(3) Not applicable for a Cogeneration Facility.

Effective Date - 1/1/81

TABLE 6-19

ENERGY ECONOMIC DATA BASE

FUEL CYCLE COST COMPONENTS
PERCENTAGE VALUES

VARIABLE START-UPS

(January 1, 1981 Dollars)

REACTOR TYPE	FUELING MODE	PERCENT OF TOTAL FUEL CYCLE COST		
		URANIUM SUPPLY	FUEL FABRICATION	SHIPPING AND REPROCESSING/ SPENT FUEL DISPOSAL
PWR BWR(1) 1987	Throwaway (U only)	85.9	8.5	5.6
HTGR-SC 1995	Throwaway (U only)	88.0	7.2	4.8
PHWR 1995	Throwaway	76.3	15.8	7.9
HTGR-SC HTGR-PS 2001	Throwaway (U only)	89.9	5.6	4.5
LMFBR 2001	U Blanket Recycle Pu	-	34.1	65.9

(1) BWR data not available for fuel costs; PWR data used for BWR (Model A1).

TABLE 6-20

ENERGY ECONOMIC DATA BASE

AVERAGE DELIVERED CONTRACT PRICES OF STEAM COAL[1]
($/short ton)

Date	Price
1976	18.39
1977	20.34
1978	23.75
1979	26.17
1980	
January	27.41
February	27.67
March	27.71
April	28.50
May	28.39
June	28.78
July	29.27
August	29.71
September	29.59
October	29.42
November	29.67
December	29.35
Average	28.80

(1) From: May 1981 USDOE Monthly Energy Review; p. 89

TABLE 6-21

ENERGY ECONOMIC DATA BASE

HIGH SULFUR COAL ANALYSIS

Coal Type : Eastern High Sulfur Bituminous Coal

Location :
State Illinois
County St. Clair
Seam Illinois No. 6

Reserves (Est.): 3,000,000,000 Tons

DESIGN BASIS COAL ANALYSIS

Moisture (Percent by Weight):	11.3
Proximate Analysis (Percent by Weight, Dry):	
Volatile Matter	39.72
Fixed Carbon	48.68
Ash	11.60
Ultimate Analysis (Percent by Weight, Dry):	
Carbon	69.33
Hydrogen	4.90
Nitrogen	.86
Chlorine	.04
Sulfur	3.61
Oxygen	9.64
Ash Analysis (Percent by Weight, Dry):	
P_2O_5	.05
SiO_2	45.73
Fe_2O_3	18.38
Al_2O_3	19.40
TiO_2	1.30
CaO	5.50
MgO	.95
SO_3	6.63
K_2O	1.53
Na_2O	.51
Undetermined	.02
Calorific Value (Btu/lb)	
As Received	11,026
Dry	12,432
Ash Fusion Temperature (^oF Red./^oF Ox.)	
Initial	1950/2270
H = W	2140/2380
H = 1/2W	2140/2400
Fluid	2250/2500

Effective Date - 1/1/81

TABLE 6-22

ENERGY ECONOMIC DATA BASE

LOW SULFUR COAL ANALYSIS

Coal Type :	Western Low Sulfur Sub-Bituminous Coal
Location :	
State	Wyoming
County	Campbell
Seam	Roland Smith
Reserves (Est.):	1,000,000,000 Tons

DESIGN BASIS COAL ANALYSIS

Moisture (Percent by Weight)	31.8
Proximate Analysis (Percent by Weight, Dry):	
Volatile Matter	47.6
Fixed Carbon	45.1
Ash	7.3
Ultimate Analysis (Percent by Weight, Dry):	
Carbon	69.3
Hydrogen	5.2
Nitrogen	0.9
Sulfur	0.5
Oxygen	16.8
Ash Analysis (Percent by Weight, Dry):	
SiO_2	28.8
Fe_2O_3	9.0
Al_2O_3	13.0
TiO_2	0.7
CaO	25.0
MgO	6.5
SO_3	18.0
K_2O	0.4
Na_2O	1.2
Calorific Value (Btu/lb)	
As Received	8,164
Dry	11,970
Ash Fusion Temperature (°F Red./°F Ox.)	
Initial	2140/2160
H = W	2180/2190
H = 1/2W	2200/2210
Fluid	2280/2370

Effective Date - 1/1/81

TABLE 6-23

ENERGY ECONOMIC DATA BASE

PITTSBURGH STEAM (HIGH SULFUR) COAL ANALYSIS

Coal Type : Eastern High Sulfur Bituminous Coal

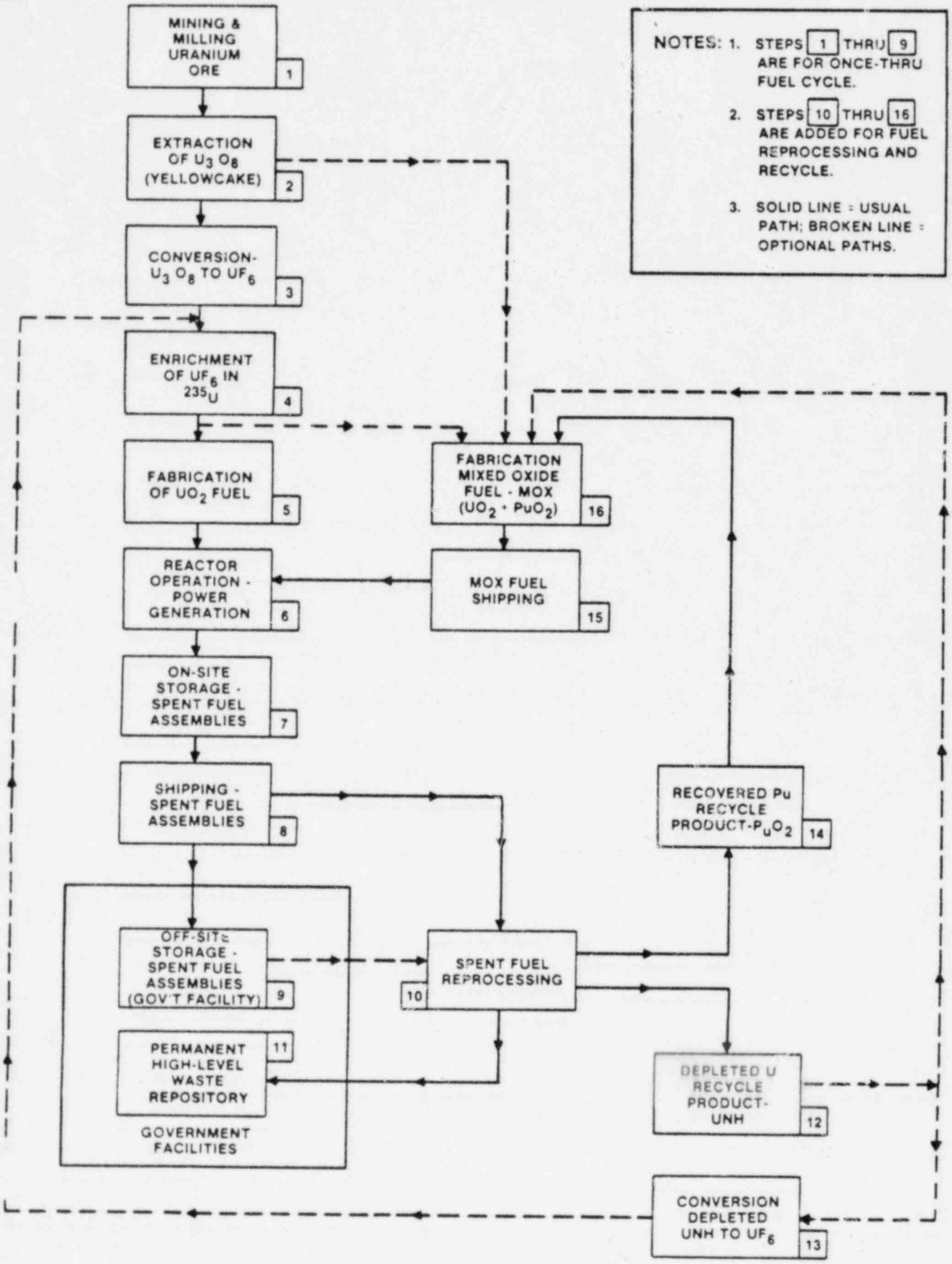
Location :
- State: Pennsylvania
- County: Washington
- Seam: Pittsburgh No. 8

Reserves (Est.): 6,600,000,000 Tons

DESIGN BASIS COAL ANALYSIS

Moisture (Percent by Weight)	2.4
Proximate Analysis (Percent by Weight, Dry):	
Volatile Matter	39.2
Fixed Carbon	51.2
Ash	7.3
Ultimate Analysis (Percent by Weight):	
Carbon	75.6
Hydrogen	5.2
Nitrogen	1.3
Sulfur	2.6
Oxygen	8.0
Ash Analysis (Percent by Weight, Dry):	
P_2O_5	.28
SiO_2	46.95
Fe_2O_3	18.4
Al_2O_3	25.64
TiO_2	1.01
CaO	2.0
MgO	.67
SO_3	1.97
K_2O	1.75
Na_2O	.45
Calorific Value (Btu/lb)	
As Received	13,156
Dry	13,480
Ash Fusion Temperature (^oF)	2,440

FIGURE 6-1
NUCLEAR FUEL CYCLE ACTIVITIES



SECTION 7

7.0 OPERATION AND MAINTENANCE COST FOURTH UPDATE

The Fourth Update of the EEDB Operation and Maintenance (O&M) costs is composed of nuclear and fossil-fired power generating stations O&M costs. For this report, the accounting breakdown includes the major cost areas for each type of plant, but does not define separate expenses for the reactor or boiler plant and the turbine plant. The O&M cost estimates accomodate state-of-the-art designs, regulations, codes and standards current as of January 1, 1981. This section of the report presents the detailed results of the O&M cost update with a description of the major cost changes.

7.1 OPERATION AND MAINTENANCE COST UPDATE PROCEDURE

The procedure for estimating O&M costs is developed by the Oak Ridge National Laboratory (ORNL) and reported in ORNL/TM-6467 "A Procedure for Estimating Nonfuel Operation and Maintenance Costs for Large Steam-Electric Power Plants." The cost estimating update procedure involves the combination of empirical functions, that represent historical experience, with new factors arising from regulatory and economic considerations. Implementation of the procedure is through OMCOST, a digital computer program developed by ORNL. OMCOST is applied to the selected technical models tabulated in Tables 1-1 and 1-2 to produce the Operation and Maintenance Cost Fourth Update. Input to OMCOST is staffing and material requirements. ORNL prepares and updates these data on a continuing basis.

7.2 OPERATION AND MAINTENANCE COST SUMMARY

O&M costs are prepared for the EEDB Fourth Update as the sum of staff, maintenance material and supply costs and expenses, insurance and fees, and administrative and general expenses. Total O&M costs are summarized for all plants for the year 1981 in Table 7-1.

7.3 DETAILED OPERATING AND MAINTENANCE COSTS

Results of the Operating and Maintenance Cost Fourth Update are presented for each technical plant model in Tables 7-2 through 7-12 as follows:

Nuclear Plant Model	Table Number	Fossil Plant Model	Table Number
BWR	7-2	HS12	7-8
HTGR-SC	7-3	HS8	7-9
PWR	7-4	LS12	7-10
PHWR	7-5	LS8	7-11
HTGR-PS	7-6	CGCC	7-12
LMFBR	7-7		

These tables contain all of the O&M data available in the EEDB. There are no additional data in the Backup Data File.

7.4 OPERATION AND MAINTENANCE COST MODEL UPDATE

To quantify staff requirements, staff for both nuclear and fossil-fueled plants are organized according to function. Fossil-fueled plants, although their organization is similar to that of nuclear plants with regard to plant operation functions, differ in personnel allotment and job classifications. In addition, they do not require staffing for quality assurance or health physics.

In the Fourth Update, substantial staffing increases are incorporated for the nuclear power generating station operation and maintenance. These increases reflect increased emphasis on security, response to lessons learned at TMI and the continuing refinement of EEDB O&M cost projections. The total staffing used in the Fourth Update for nuclear and fossil-fueled plants is tabulated in

Tables 7-13 through 7-19 as follows:

Plant Model	Table Number
LWR Power Plants (BWR and PWR)	7-13
HTGR-SC Power Plants	7-14
PHWR Power Plants	7-15
HTGR-PS Cogeneration Plants	7-16
LMFBR Power Plants	7-17
Coal-Fired Power Plants with FGD System	7-18

Although licensed reactor operators may receive a five to ten percent premium, nuclear and fossil-fueled plant personnel are assigned the same hourly rates. Nonlicensed jobs in nuclear and fossil work are not significantly different in function. However, considerably more preparation and training may be required to learn nuclear plant procedure for repairs and inspections.

The amount of the various major replacement items, expendable materials, and services used to maintain the power plant, is variable throughout the plant life. To date, historical data on new plant designs are not extensive enough to provide direct relationships for large plants. Therefore, the relationship of materials to maintenance labor as a percentage is estimated for a 70 percent plant capacity factor. Results were discussed with operating personnel as a check.

Operation and maintenance of coal-fired plants tend to be more labor intensive than that of nuclear plants because of the routine maintenance involved with burning coal and the effect of high operating temperatures on the equipment.

Maintenance costs are estimated for operation at base-load conditions near 100 percent capability.

Variable maintenance costs are judged on the basis that 25 percent of the total maintenance is subject to change with load when operating between 50 and 80 percent capacity factor. This judgment is based on factors known to influence incremental costs for coal pulverizers, fuel handling, heat transfer surfaces and certain nonfuel supplies sensitive to load.

The nonregenerative limestone-slurry scrubbing process is used to show a process with high sulfur removal and with economics intermediate among the various systems available for flue gas desulfurization (FGD). For both of the low sulfur coal-fired power plants, the operating cost of their dry scrubbing systems are estimated by using the cost of the wet scrubbing systems. Lower operating costs are expected for dry FGD systems; however, there is not sufficient operating experience with dry FGD systems to confirm this assumption. Estimate of O&M costs for dry FGD systems will be incorporated in future updates when sufficient data becomes available.

The maintenance material cost factors as a percentage of maintenance labor cost are as follows:

	Percentage of Maintenance Labor Cost		
	Fixed	Variable	Total
Nuclear	100	0	100
Coal with FGD	62	20	82

The O&M costs for cooling the main turbine condenser water and other plant heat exchangers are considered for evaporative cooling towers only. These costs range from $25,000 to $50,000 annually for both nuclear and coal plants.

Supplies and expenses include certain consumable materials and expenses that are unrecoverable after use in O&M activities. These include makeup fluids, chemical gases, lubricants, office and personnel supplies, monitoring and record services, and offsite contract services. Costs of limestone and off-site sludge disposal associated with the limestone slurry scrubbing process for flue gas desulfurization are also included.

Operators of nuclear power plants are required to maintain financial protection to a total limit of $580,000,000. This limit is divided as of January 1, 1981 as follows:

	$\$10^6$
Private Insurance	160
Retrospective Premium	340
Government Indemnity	80
	580

The estimated annual premiums for nuclear insurance are as follows:

Commercial Coverage ($160 million)	$284,000
Retrospective Premium	$ 6,000
Government Coverage ($ 80 million)	6 $/MWt to 3000 MWt

Safety, environmental, and health physics inspections are routinely performed at specified frequencies for purposes of reviewing a licensed program by the Nuclear Regulatory Commission. The annual estimate for these inspections is \$100,000 for the first unit and \$80,000 for each additional unit.

Administrative and general expenses include the owner's offsite salaries and expenses directly allocable to a specific power production facility. In this report, the magnitude of administrative and general expenses is related to fixed O&M costs, minus insurance and operating fees. Values of 10 and 15 percent of total fixed cost of staff, maintenance materials, and supplies and expenses have been used to estimate administrative and general costs for nuclear and fossil plants respectively.

7.5 LEVELIZATION FACTOR

The Operation and Maintenance costs for the EEDB Fourth Update are stated in terms of the first year cost (i.e., 1981 dollars). If one wishes to compute a unit electricity cost using the inflation-free operation and maintenance costs, then the first year cost, after conversion to an electric energy cost, may be added directly to the inflation-free capital and fuel cycle costs. For an inflated case, a levelization factor must be computed and applied to the first year cost, before the O&M costs reported in this update are added to the inflated capital and fuel costs. Consistent rates of interest and escalation must be used in the computation for compatibility and consistency with the capital and fuel costs with which it is combined. An approximation of the necessary levelization factor may be computed with the following equation:

$$LF = \frac{d}{d-a} \cdot \left[\frac{(1 + d)^n - (1 + a)^n}{(1 + d)^n - 1}\right]$$

Where: LF = levelization factor* a = (1 + i) (1 + e) - 1*
d = discount rate per annum* i = inflation rate*
n = number of years* e = escalation rate*
(e = 0 for O & M)*

7.6 TMI RELATED OPERATIONAL COSTS

The effects of the Three-Mile Island (TMI) NPGS incident result in significant changes in the operating costs of nuclear power plants in the Fourth Update. The most notable change is an increase of the station technical and engineering staff. Additionally, the operating staff is increased by an additional shift. The net effect of these changes is an increase of approximately 56 personnel in staff requirements as a point estimate.

The additional personnel resulting from TMI, tabulated by function, are:

Operations	26
Maintenance	43
Engineering	28
	97

Depending on the operating philosophy of individual utilities, the above increase in personnel may be considered typical. The actual range of personnel additions varies from 1 to 6 for operating staffs, 12 to 30 for engineering and technical personnel, and from 6 to 50 for additional maintenance personnel. The magnitude of change for a specific utility depends on the particular operating philosophy of that utility prior to the TMI accident.

The economic effects of the TMI accident reported in this Fourth Update are based on a preliminary analysis by Oak Ridge National Laboratory. ORNL is currently reviewing data supplied by utilities on O&M costs resulting from the TMI event. O&M costs reported in the Fourth Update will be reconciled with the final ORNL analysis during the next update.

*Refer to Section 2.4.2 for definitions of these terms as used in the EEDB Program.

TABLE 7-1

Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE

OPERATION AND MAINTENANCE COST UPDATE
(Constant $1981)

Model	MWe	$\$10^6$/yr.	Mills/KWh
BWR	1190	36.5	5.0
HTGR-SC	858	35.7	6.8
PWR	1139	36.5	5.2
PHWR	1260	35.7	4.6
HTGR-PS	150	21.7	*
LMFBR	1457	42.6	4.8
HS12	1240	34.9	4.6
HS8	795	29.4	6.0
LS12	1244	23.3	3.1
LS8	795	21.0	4.3
CGCC	630	11.5	3.0

* Not Applicable for Process Steam/Cogeneration Plant

TABLE 7-2

Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE
(Constant $1981)

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1981.0

PLANT TYPE IS BWR
WITH EVAPORATIVE COOLING TOWERS
NUMBER OF UNITS PER STATION 1
THERMAL INPUT PER UNIT IS 3578. MWt
PLANT NET HEAT RATE 10259.
PLANT NET EFFICIENCY, PERCENT 33.26
EACH UNIT IS 1190. MWe NET RATING
ANNUAL NET GENERATION, MILLION KWh 7302.
WITH A PLANT FACTOR OF 0.70

STAFF, $1000/YR.	15952.	(401 PERSONS AT $38189.)
MAINTENANCE MATERIAL, $1000/YR.	5932.	
FIXED		5932.
VARIABLE		0.
SUPPLIES AND EXPENSES, $1000/YR.	7730.	
FIXED		7000.
VARIABLE		730.
INSURANCE AND FEES, $1000/YR.	1002.	
COMM. LIAB. INS.		378.
GOV. LIAB. INS.		18.
RETROSPECTIVE PREMIUM		6.
INSPECTION FEES & EXPENSES		600.
ADMIN. AND GENERAL, $1000/YR.	5923.	
TOTAL FIXED COSTS, $1000/YR.		35809.
TOTAL VARIABLE COSTS, $1000/YR.		730.
TOTAL ANNUAL O & M COSTS, $1000/YR.		36539.
FIXED UNIT O & M COSTS, MILLS/KWh(E)		4.90
VARIABLE UNIT O & M COSTS, MILLS/KWh(E)		0.10
TOTAL UNIT O & M COSTS, MILLS/KWh(E)		5.00

TABLE 7-3

Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE
(Constant $1981)

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1981.0

PLANT TYPE IS HTGR-SC
WITH EVAPORATIVE COOLING TOWERS
NUMBER OF UNITS PER STATION 1
THERMAL INPUT PER UNIT IS 2240. MWt
PLANT NET HEAT RATE 8908.
PLANT NET EFFICIENCY, PERCENT 38.30
EACH UNIT IS 858. MWe NET RATING
ANNUAL NET GENERATION, MILLION KWh 5265.
WITH A PLANT FACTOR OF 0.70

STAFF, $1000/YR.	15952.	(401 PERSONS AT $39780.)	
MAINTENANCE MATERIAL, $1000/YR.	5932.		
FIXED		5932.	
VARIABLE		0.	
SUPPLIES AND EXPENSES, $1000/YR.	7028.		
FIXED		6389.	
VARIABLE		689.	
INSURANCE AND FEES, $1000/YR.	1004.		
COMM. LIAB. INS.		378.	
GOV. LIAB. INS.		18.	
RETROSPECTIVE PREMIUM		8.	
INSPECTION FEES & EXPENSES		600.	
ADMIN. AND GENERAL, $1000/YR.	5782.		
TOTAL FIXED COSTS, $1000/YR.		35059.	
TOTAL VARIABLE COSTS, $1000/YR.		639.	
TOTAL ANNUAL O & M COSTS, $1000/YR.		35698.	
FIXED UNIT O & M COSTS, MILLS/KWh(E)		6.67	
VARIABLE UNIT O & M COSTS, MILLS/KWh(E)		0.11	
TOTAL UNIT O & M COSTS, MILLS/KWh(E)		6.78	

TABLE 7-4

Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE
(Constant $1981)

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1981.0

PLANT TYPE IS PWR
WITH EVAPORATIVE COOLING TOWERS
NUMBER OF UNITS PER STATION 1
THERMAL INPUT PER UNIT IS 3412. MWt
PLANT NET HEAT RATE 10221.
PLANT NET EFFICIENCY, PERCENT 33.38
EACH UNIT IS 1139. MWe NET RATING
ANNUAL NET GENERATION, MILLION kWh 6989.
WITH A PLANT FACTOR OF 0.70

STAFF, $1000/YR.	15952.	(401 PERSONS AT $38189.)	
MAINTENANCE MATERIAL, $1000/YR.	5932.		
FIXED		5932.	
VARIABLE		0.	
SUPPLIES AND EXPENSES, $1000/YR.	7699.		
FIXED		7000.	
VARIABLE		699.	
INSURANCE AND FEES, $1000/YR.	1002.		
COMM. LIAB. INS.		378.	
GOV. LIAB. INS.		18.	
RETROSPECTIVE PREMIUM		6.	
INSPECTION FEES & EXPENSES		600.	
ADMIN. AND GENERAL, $1000/YR.	5917.		
TOTAL FIXED COSTS, $1000/YR.		35803.	
TOTAL VARIABLE COSTS, $1000/YR.		699.	
TOTAL ANNUAL O & M COSTS, $1000/YR.		36502.	
FIXED UNIT O & M COSTS, MILLS/kWh(E)		5.08	
VARIABLE UNIT O & M COSTS, MILLS/kWh(E)		0.10	
TOTAL UNIT O & M COSTS, MILLS/kWh(E)		5.18	

TABLE 7-5

Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE
(Constant $1981)

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1981.0

PLANT TYPE IS PHWR
WITH EVAPORATIVE COOLING TOWERS
NUMBER OF UNITS PER STATION 1
THERMAL INPUT PER UNIT IS 3800. MWt
PLANT NET HEAT RATE 10291.
PLANT NET EFFICIENCY, PERCENT 33.16
EACH UNIT IS 1260. MWe NET RATING
ANNUAL NET GENERATION, MILLION KWh 7732.
WITH A PLANT FACTOR OF 0.70

STAFF, $1000/YR.	14559. (366 PERSONS AT $39780.)		
MAINTENANCE MATERIAL, $1000/YR.	3461.		
FIXED		3461.	
VARIABLE		0.	
SUPPLIES AND EXPENSES, $1000/YR.	11713.		
FIXED - PLANT		5453.	
- HEAVY WATER LOSSES AND UPKEEP		5100.	
VARIABLE		1160.	
INSURANCE AND FEES, $1000/YR.	1010.		
COMM. LIAB. INS.		378.	
GOV. LIAB. INS.		24.	
RETROSPECTIVE PREMIUM		8.	
INSPECTION FEES & EXPENSES		600.	
ADMIN. AND GENERAL, $1000/YR.	4926.		
TOTAL FIXED COSTS, $1000/YR.			34509.
TOTAL VARIABLE COSTS, $1000/YR.			1160.
TOTAL ANNUAL O & M COSTS, $1000/YR.			35669.
FIXED UNIT O & M COSTS, MILLS/KWh(E)			4.46
VARIABLE UNIT O & M COSTS, MILLS/KWh(E)			0.15
TOTAL UNIT O & M COSTS, MILLS/KWh(E)			4.61

TABLE 7-6

Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE
(Constant $1981)

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1981.0

PLANT TYPE IS HTGR-PS
WITH EVAPORATIVE COOLING TOWERS
NUMBER OF UNITS PER STATION 1
THERMAL INPUT PER UNIT IS 1170 MWt
PLANT NET HEAT RATE 21572
PLANT NET EFFICIENCY, PERCENT 12.82
EACH UNIT IS 150 MWe NET RATING
ANNUAL NET GENERATION, MILLION kWh 920.
WITH A PLANT FACTOR OF 0.70

STAFF, $1000/YR.	8951.	(225 PERSONS AT 39780.)
MAINTENANCE MATERIAL, $1000/YR.	2966.	
FIXED		2966.
VARIABLE		0.
SUPPLIES AND EXPENSES, $1000/YR.	3514.	
FIXED		3195.
VARIABLE		319.
INSURANCE AND FEES, $1000/YR.	502.	
COMM. LIAB. INS.		189.
GOV. LIAB. INS.		9.
RETROSPECTIVE PREMIUM		4.
INSPECTION FEES & EXPENSES		300.
ADMIN. AND GENERAL, $1000/YR.	5782.	
TOTAL FIXED COSTS, $1000/YR.		21396.
TOTAL VARIABLE COSTS, $1000/YR.		319.
TOTAL ANNUAL O & M COSTS, $1000/YR.		21715.
FIXED UNIT O & M COSTS, MILLS/kWh(E)		NOT APPLICABLE
VARIABLE UNIT O & M COSTS, MILLS/kWh(E)		NOT APPLICABLE
TOTAL UNIT O & M COSTS, MILLS/kWh(E)		NOT APPLICABLE

TABLE 7-7

Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE
(Constant $1981)

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1981.0

PLANT TYPE IS LMFBR
WITH EVAPORATIVE COOLING TOWERS
NUMBER OF UNITS PER STATION 1
THERMAL INPUT PER UNIT IS 3800. MWt
PLANT NET HEAT RATE 8899.
PLANT NET EFFICIENCY, PERCENT 38.34
EACH UNIT IS 1457. MWe NET RATING
ANNUAL NET GENERATION, MILLION kWh 8940.
WITH A PLANT FACTOR OF 0.70

STAFF, $1000/YR,	15952.	(401 PERSONS AT $39780.)	
MAINTENANCE MATERIAL, $1000/YR.	9706.		
FIXED		9706.	
VARIABLE		0.	
SUPPLIES AND EXPENSES, $1000/YR.	8968.		
FIXED		7985.	
VARIABLE		983	
INSURANCE AND FEES, $1000/YR.	1010.		
COMM. LIAB. INS.		378.	
GOV. LIAB. INS.		24.	
RETROSPECTIVE PREMIUM		8.	
INSPECTION FEES & EXPENSES		600.	
ADMIN. AND GENERAL, $1000/YR.	6925.		
TOTAL FIXED COSTS, $1000/YR.			41578.
TOTAL VARIABLE COSTS, $1000/YR.			983.
TOTAL ANNUAL O & M COSTS, $1000/YR.			42561.
FIXED UNIT O & M COSTS, MILLS(kWh(E)			4.65
VARIABLE UNIT O & M COSTS, MILLS/kWh(E)			0.11
TOTAL UNIT O & M COSTS, MILLS/kWh(E)			4.76

TABLE 7-8

Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE
(Constant $1981)

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1981.0

PLANT TYPE IS COAL
WITH EVAPORATIVE COOLING TOWERS
NUMBER OF UNITS PER STATION 1
WITH FGD SYSTEMS
THERMAL INPUT PER UNIT IS 3299. MWt
PLANT NET HEAT RATE 9078.
PLANT NET EFFICIENCY, PERCENT 37.59
EACH UNIT IS 1240. MWe NET RATING
ANNUAL NET GENERATION, MILLION kWh 7609
WITH A PLANT FACTOR OF 0.70

STAFF, $1000/YR.	8462.	(259 PERSONS AT $32673.)
MAINTENANCE MATERIAL, $1000/YR.	3429.	
FIXED		2593.
VARIABLE		836.
SUPPLIES AND EXPENSES, $1000/YR.	20302.	
FIXED		2400.
VAR. - PLANT		756.
- ASH & FGD SLUDGE		17146.
ADMIN. AND GENERAL, $1000/YR.	2691	
TOTAL FIXED COSTS, $1000/YR.		16116.
TOTAL VARIABLE COSTS, $1000/YR.		18738.
TOTAL ANNUAL O & M COSTS, $1000/YR.		34854.
FIXED UNIT O & M COSTS, MILLS/kWh(E)		2.13
VARIABLE UNIT O & M COSTS, MILLS/kWh(E)		2.48
TOTAL UNIT O & M COSTS, MILLS/kWh(E)		4.61

TABLE 7-9

Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE
(Constant $1981)

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1981.0

PLANT TYPE IS COAL
WITH EVAPORATIVE COOLING TOWERS
NUMBER OF UNITS PER STATION 1
WITH FGD SYSTEMS
THERMAL INPUT PER UNIT IS 2210. MWt
PLANT NET HEAT RATE 9485
PLANT NET EFFICIENCY, PERCENT 35.97
EACH UNIT IS 795. MWe NET RATING
ANNUAL NET GENERATION, MILLION kWh 4878.
WITH A PLANT FACTOR OF 0.70

STAFF, $1000/YR.	8462. (259 PERSONS AT $32673.)	
MAINTENANCE MATERIAL, $1000/YR.	3429.	
FIXED		2593.
VARIABLE		836.
SUPPLIES AND EXPENSES, $1000/YR.	14877.	
FIXED		2400.
VAR. - PLANT		488.
- ASH & FGD SLUDGE		11989.
ADMIN. AND GENERAL, $1000/YR.	2691.	
TOTAL FIXED COSTS, $1000/YR.		16116.
TOTAL VARIABLE COSTS, $1000/YR.		13313.
TOTAL ANNUAL O & M COSTS, $1000/YR.		29429.
FIXED UNIT O & M COSTS, MILLS/kWh(E)		3.31
VARIABLE UNIT O & M COSTS, MILLS/kWh(E)		2.73
TOTAL UNIT O & M COSTS, MILLS/kWh(E)		6.04

TABLE 7-10

Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE
(Constant $1981)

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1981.0

PLANT TYPE IS COAL
WITH EVAPORATIVE COOLING TOWERS
NUMBER OF UNITS PER STATION 1
WITH FGD SYSTEMS
THERMAL INPUT PER UNIT IS 3442. MWt
PLANT NET HEAT RATE 9441.
PLANT NET EFFICIENCY, PERCENT 36.14
EACH UNIT IS 1244. MWe NET RATING
ANNUAL NET GENERATION, MILLION kWh 7633.
WITH A PLANT FACTOR OF 0.70

STAFF, $1000/YR.	8462. (259 PERSONS AT $32673.)	
MAINTENANCE MATERIAL, $1000/YR.	3429.	
FIXED		2593.
VARIABLE		836.
SUPPLIES AND EXPENSES, $1000/YR.	8738.	
FIXED		2400.
VAR. - PLANT		1138.
- ASH & FGD SLUDGE		5200.
ADMIN. AND GENERAL, $1000/YR.	2691.	
TOTAL FIXED COSTS, $1000/YR.		16146.
TOTAL VARIABLE COSTS, $1000/YR.		7174.
TOTAL ANNUAL O & M COSTS, $1000/YR.		23320.
FIXED UNIT O & M COSTS, MILLS/kWh(E)		2.13
VARIABLE UNIT O & M COSTS, MILLS/kWh(E)		0.95
TOTAL UNIT O & M COSTS, MILLS/kWh(E)		3.08

TABLE 7-11

Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE
(Constant $1981)

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1981.0

PLANT TYPE IS COAL
WITH EVAPORATIVE COOLING TOWERS
NUMBER OF UNITS PER STATION 1
WITH FGD SYSTEMS
THERMAL INPUT PER UNIT IS 2307. MWt
PLANT NET HEAT RATE 9902.
PLANT NET EFFICIENCY, PERCENT 34.46
EACH UNIT IS 795. MWe NET RATING
ANNUAL NET GENERATION, MILLION kWh 4878.
WITH A PLANT FACTOR OF 0.70

STAFF, $1000/YR.	8462.	(259 PERSONS AT $82673.)
MAINTENANCE MATERIAL, $1000/YR.	3429.	
FIXED		2593.
VARIABLE		836.
SUPPLIES AND EXPENSES, $1000/YR.	6451.	
FIXED		2400.
VAR. - PLANT		732.
- ASH & FGD SLUDGE		3319.
ADMIN. AND GENERAL, $1000/YR.	2691.	
TOTAL FIXED COSTS, $1000/YR.		16146.
TOTAL VARIABLE COSTS, $1000/YR.		4887.
TOTAL ANNUAL O & M COSTS, $1000/YR.		21033.
FIXED UNIT O & M COSTS, MILLS/kWh(E)		3.31
VARIABLE UNIT O & M COSTS, MILLS/kWh		1.00
TOTAL UNIT O & M COSTS, MILLS/kWh		4.71

TABLE 7-12

ENERGY ECONOMIC DATA BASE
(Constant $1981)

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1981.0

PLANT TYPE IS CGCC
WITH NATURAL DRAFT DRY COOLING TOWER
NUMBER OF UNITS PER STATION 1
WITH FGD SYSTEMS
THERMAL INPUT PER UNIT IS 1523 MWt
PLANT NET HEAT RATE 8250
PLANT NET EFFICIENCY, PERCENT 41.37
EACH UNIT IS 630 MWe NET RATING
ANNUAL NET GENERATION, MILLION kWh 3863
WITH A PLANT FACTOR OF 0.70

STAFF, $1000/YR	5564.	
MAINTENANCE MATERIAL, $1000/YR	2053.	
FIXED		1547.
VARIABLE		506.
SUPPLIES AND EXPENSES, $1000/YR	2825.	
FIXED		1544.
VARIABLE - PLANT		389.
- ASH & SULFUR DISPOSAL		892.
ADMINISTRATIVE AND GENERAL, $1000/YR	1091.	
TOTAL FIXED COSTS, $1000/YR		9746.
TOTAL VARIABLE COSTS, $1000/YR		1787.
TOTAL ANNUAL O&M COSTS, $1000/YR		11533.
FIXED UNIT O&M COSTS, MILLS/kWh (Σ)		2.52
VARIABLE UNIT O&M COSTS, MILLS/kWh (δ)		.46
TOTAL UNIT O&M COSTS, MILLS/kWh (Σ)		2.98

TABLE 7-13

ENERGY ECONOMIC DATA BASE

Effective Date - 1/1/81

STAFF REQUIREMENT FOR LWR POWER PLANTS

	UNIT SIZE RANGE MW(E) 701-1300 NO. UNITS PER SITE 1	2	3	4
PLANT MANAGER'S OFFICE				
MANAGER	1	1	1	1
ASSISTANT	1	2	3	4
QUALITY ASSURANCE	6	6	7	8
ENVIRONMENTAL CONTROL	1	1	1	1
PUBLIC RELATIONS	1	1	1	1
TRAINING	12	12	12	12
SAFETY	1	2	3	4
ADMIN. & SERVICES	49	55	65	78
HEALTH SERVICES	2	2	2	2
SECURITY	94	94	94	94
SUBTOTAL	168	176	189	205
OPERATIONS				
SUPERVISION (EXC. SHIFT)	9	9	18	18
SHIFTS	52	104	156	208
SUBTOTAL	61	113	174	226
MAINTENANCE				
SUPERVISION	12	14	26	28
CRAFTS	55	71	87	103
PEAK MAINT. ANNUALIZED	55	110	165	220
SUBTOTAL	122	195	278	351
TECHNICAL AND ENGINEERING				
REACTOR	5	5	7	7
RADIO-CHEMICAL	8	8	12	12
I & C	16	16	16	16
PERFORM., REPORTS, TECH.	21	30	39	48
SUBTOTAL	50	59	74	83
TOTAL	401	543	715	865
	===	===	===	===
LESS SECURITY	307	445	621	771
LESS SEC., PEAK MAINT.	252	339	456	551

TABLE 7-14

ENERGY ECONOMIC DATA BASE

Effective Date - 1/1/81

STAFF REQUIREMENT FOR HTGR POWER PLANTS

	UNIT SIZE RANGE MW(E) 700-1300 NO. UNITS PER SITE 1	2	3	4
PLANT MANAGER'S OFFICE				
MANAGER	1	1	1	1
ASSISTANT	1	2	3	4
QUALITY ASSURANCE	6	6	7	8
ENVIRONMENTAL CONTROL	1	1	1	1
PUBLIC RELATIONS	1	1	1	1
TRAINING	12	12	12	12
SAFETY	1	2	3	4
ADMIN. & SERVICES	49	55	65	78
HEALTH SERVICES	2	2	2	2
SECURITY	94	94	94	94
SUBTOTAL	168	176	189	205
OPERATIONS				
SUPERVISION (EXC. SHIFT)	9	9	18	18
SHIFTS	52	104	156	208
SUBTOTAL	61	113	174	226
MAINTENANCE				
SUPERVISION	12	14	26	28
CRAFTS	55	71	87	103
PEAK MAINT. ANNUALIZED	55	110	165	220
SUBTOTAL	122	195	278	351
TECHNICAL AND ENGINEERING				
REACTOR	5	5	7	7
RADIO-CHEMICAL	8	8	12	12
I & C	16	16	16	16
PERFORM., REPORTS, TECH.	21	30	39	48
SUBTOTAL	50	59	74	83
TOTAL	401	543	715	865
	===	===	===	===
LESS SECURITY	307	445	621	771
LESS SEC., PEAK MAINT.	252	339	456	551

TABLE 7-15

ENERGY ECONOMIC DATA BASE

Effective Date - 1/1/81

STAFF REQUIREMENT FOR PHWR POWER PLANTS

	UNIT SIZE RANGE (MW(E) 700-1300 NO. UNITS PER SITE 1	2	3	4
PLANT MANAGER'S OFFICE				
MANAGER	1	1	1	1
ASSISTANT	1	2	3	4
QUALITY ASSURANCE	6	6	7	8
ENVIRONMENTAL CONTROL	1	1	1	1
PUBLIC RELATIONS	1	1	1	1
TRAINING	12	12	12	12
SAFETY	1	2	3	4
ADMIN. & SERVICES	49	55	65	78
HEALTH SERVICES	2	2	2	2
SECURITY	94	94	94	94
SUBTOTAL	168	176	189	205
OPERATIONS				
SUPERVISION (EXC. SHIFT)	9	9	18	18
SHIFTS	52	104	156	208
SUBTOTAL	61	113	174	226
MAINTENANCE				
SUPERVISION	12	14	26	28
CRAFTS	55	71	87	103
PEAK MAINT. ANNUALIZED	55	110	165	220
SUBTOTAL	122	195	278	351
TECHNICAL AND ENGINEERING				
REACTOR	5	5	7	7
RADIO-CHEMICAL	8	8	12	12
I & C	16	16	16	16
PERFORM., REPORTS, TECH.	21	30	39	48
SUBTOTAL	50	59	74	83
TOTAL	401	543	715	865
	===	===	===	===
LESS SECURITY	307	445	621	771
LESS SEC., PEAK MAINT.	252	339	456	551

TABLE 7-16

ENERGY ECONOMIC DATA BASE

STAFF REQUIREMENT FOR HTGR-PROCESS STEAM COGENERATION POWER PLANTS

	UNIT SIZE MW(t)* 1170 NO. UNITS PER SITE 1	2	3	4
PLANT MANAGER'S OFFICE				
MANAGER	1			
ASSISTANT	3			
QUALITY ASSURANCE	3			
ENVIRONMENTAL CONTROL	1			
PUBLIC RELATIONS	1			
TRAINING	12			
SAFETY	1			
ADMIN. & SERVICES	13			
HEALTH SERVICES	1			
SECURITY	53			
SUBTOTAL	89			
OPERATIONS				
SUPERVISION (EXC. SHIFT)	3			
SHIFTS	34			
SUBTOTAL	37			
MAINTENANCE				
SUPERVISION	6			
CRAFTS	24			
PEAK MAINT. ANNUALIZED	41			
SUBTOTAL	71			
TECHNICAL AND ENGINEERING				
REACTOR	3			
RADIO-CHEMICAL	3			
I & C	4			
PERFORM., REPORTS, TECH	10			
SUBTOTAL	20			
TOTAL	217			
LESS SECURITY	164			
LESS SEC., PEAK MAINT	123			

*Process Steam - Cogeneration Plant

TABLE 7-17

Effective Date - 1/1/81

ENERGY ECONOMIC DATA BASE

STAFF REQUIREMENT FOR LMFBR POWER PLANTS

	UNIT SIZE RANGE MW(E) 700-1500 NO. UNITS PER SITE 1	2	3	4
PLANT MANAGER'S OFFICE				
MANAGER	1	1	1	1
ASSISTANT	1	2	3	4
QUALITY ASSURANCE	6	6	7	8
ENVIRONMENTAL CONTROL	1	1	1	1
PUBLIC RELATIONS	1	1	1	1
TRAINING	12	12	12	12
SAFETY	1	2	3	4
ADMIN. & SERVICES	49	55	65	78
HEALTH SERVICES	2	2	2	2
SECURITY	94	94	94	94
SUBTOTAL	168	176	189	205
OPERATIONS				
SUPERVISION (EXC. SHIFT)	9	9	18	18
SHIFTS	52	104	156	208
SUBTOTAL	61	113	174	226
MAINTENANCE				
SUPERVISION	12	14	26	28
CRAFTS	55	71	87	103
PEAK MAINT. ANNUALIZED	55	110	165	220
SUBTOTAL	122	195	278	351
TECHNICAL AND ENGINEERING				
REACTOR	5	5	7	7
RADIO-CHEMICAL	8	8	12	12
I & C	16	16	16	16
PERFORM., REPORTS, TECH.	21	30	39	48
SUBTOTAL	50	59	74	83
TOTAL	401	543	715	865
	===	===	===	===
LESS SECURITY	307	445	621	771
LESS SEC., PEAK MAINT.	252	339	456	551

TABLE 7-18

ENERGY ECONOMIC DATA BASE

Effective Date - 1/1/81

STAFF REQUIREMENT FOR COAL-FIRED POWER PLANTS WITH FGD SYSTEMS

	UNIT SIZE RANGE MW(E)							
	400-700				701-1300			
	NO. UNITS PER SITE				NO. UNITS PER SITE			
	1	2	3	4	1	2	3	4
PLANT MANAGER'S OFFICE								
MANAGER	1	1	1	1	1	1	1	1
ASSISTANT	1	2	3	4	1	2	3	4
ENVIRONMENTAL CONTROL	1	1	1	1	1	1	1	1
PUBLIC RELATIONS	1	1	1	1	1	1	1	1
TRAINING	1	1	1	1	1	1	1	1
SAFETY	1	1	1	1	1	1	1	1
ADMIN. & SERVICES	13	14	15	16	13	14	15	16
HEALTH SERVICES	1	1	1	2	1	1	1	2
SECURITY	7	7	9	14	7	7	9	14
SUBTOTAL	27	29	33	41	27	29	33	41
OPERATIONS								
SUPERVISION (EXC. SHIFT)	3	3	5	5	3	3	5	5
SHIFTS	45	50	60	65	45	50	60	65
FUEL AND LIMESTONE REC.	12	12	12	18	12	12	12	18
WASTE SYSTEMS	15	30	45	60	15	30	45	60
SUBTOTAL	75	95	122	148	75	95	122	148
MAINTENANCE								
SUPERVISION	8	8	10	12	8	8	10	12
CRAFTS	90	115	135	155	95	120	140	160
PEAK MAINT. ANNUALIZED	33	66	99	132	35	70	105	140
SUBTOTAL	131	189	244	299	138	198	255	312
TECHNICAL AND ENGINEERING								
WASTE	1	2	3	4	1	2	3	4
RADIO-CHEMICAL	2	2	3	4	2	2	3	4
I & C	2	2	3	4	2	2	3	4
PERFORM., REPORTS, TECH.	14	17	21	24	14	17	21	24
SUBTOTAL	19	23	30	36	19	23	30	36
TOTAL	252	336	429	524	259	345	440	537

SECTION 8

8.0 REFERENCES AND GLOSSARY

8.1 REFERENCES AND BIBLIOGRAPHY

1. "Commercial Electric Power Cost Studies," United Engineers & Constructors Inc., Philadelphia, PA 19101, NUREG: U.S. Nuclear Regulatory Commission and/or COO: U.S. Energy Research and Development Administration.

   a. "Capital Cost: Pressurized Water Reactor Plant," Volumes 1 and 2, NUREG-0241, COO-2477-5, June 1977.

   b. "Capital Cost: Boiling Water Reactor Plant," Volumes 1 and 2, NUREG-0242, COO-2477-6, June 1977.

   c. "Capital Cost: High and Low Sulfur Coal Plants - 1200 MWe (Nominal)," Volumes 1, 2 and 3, NUREG-0243, COO-2477-1, June 1977.

   d. "Capital Cost: Low and High Sulfur Coal Plants - 800 MWe (Nominal)," Volumes 1, 2 and 3, NUREG-0244, COO-2477-8, June 1977.

   e. "Capital Cost Addendum: Multi-Unit Coal and Nuclear Stations," Volume 1, NUREG-0245, COO-2477-9, June 1977.

   f. "Fuel Supply Investment Cost: Coal and Nuclear," Volume 1, NUREG-0246, COO-2477-10, April 1979.

   g. "Cooling Systems Addendum: Capital and Total Generating Cost Studies," Volume 1, NUREG-0247, COO-2477-11, September 1978.

   h. "Total Generating Costs: Coal and Nuclear Plants," Volume 1, NUREG-0248, COO-2477-12, February 1979.

   i. "Capital Cost: Pressurized Heavy Water Reactor Plant," Volumes 1 and 2, COO-2477-13, June 1977.

   j. "Capital Cost: Gas Cooled Fast Reactor Plant," Volume 1, COO-2477-16, September 1977.

2. "NSSS Capital Costs for a Mature LMFBR Industry for Energy Economic Data Base Program-Phase I," Combustion Engineering, Inc., Windsor, CT 06095, CE-FBR-78-532, United Engineers & Constructors Inc. Subcontract, October 1978.

8.1 (Cont'd)

3. "3360 MWt HTGR-Steam Cycle Reference Plant Design," United Engineers & Constructors Inc., Philadelphia, PA 19101, Volumes I through X, General Atomic Company Subcontract SC558623 Proprietary, August 1977.

4. "Study of Electric Plant Applications for Low Btu Gasification of Coal for Electric Power Generation," Combustion Engineering, Inc. Windsor, CT 06905, U.S. Department of Energy Contract FE-1545-TK59.

5. "Final Report on Nuclear Fuel Cycle Consulting Services for Energy Economic Data Base Program-Phase I," NUS Corporation, Rockville, MD 20850, NUS-3273 (Proprietary), United Engineers & Constructors Inc. Subcontract, October 1978.

   a. "Fuel Cycle Cost Estimates for LWR, HTGR, CANDU Type HWR, LMFBR and GCFR," NUS-3190.

   b. "Cost of Enrichment Services," NUS-3196.

   c. "UF_6 Conversion Cost," NUS-3198.

   d. "Heavy Water Production Costs," NUS-3199.

   e. "Spent Fuel and Reprocessing Waste Disposition," NUS-3203.

   f. "Costs for Spent Fuel Shipping," NUS-3204.

   g. "HTGR Fuel Cycle, "NUS-3207.

   h. "Costs of U_3O_8," NUS-3209.

   i. "A Survey of Fuel Costs for U.S. Nuclear Power 1973-1977," NUS-3223.

   j. "Reprocessing Cost Model for LWR, LMFBR and GCFR," NUS-3224.

   k. "Recommendations Relating to Acquisition of Mass Flow Data for the EEDB Program," NUS-3237.

   l. "Fabrication Costs for 'Rodded' Nuclear Fuels," NUS-3242.

   m. "Recommendations Relating to Evaluation of Nuclear Fuel Unit-Cost data for EEDB Program," NUS-3243.

   n. "Additional Fuel Cost Studies - Escalation, 2001 Startup and CANDU Thorium System," NUS-3244.

6. "Fuel Cycle Cost Projections", Batelle Pacific Northwest Laboratory, Richland, WA 99352, NUREG/CR-1041, December, 1979.

8.1 (Cont'd)

7. "Non-Proliferation Alternative Systems Assessment Program (NASAP)", U.S. Department of Energy, Washington, D.C. 20545, DOE/NE-0001/9, June, 1980.

8. "Coal and Nuclear: A Comparison of the Cost of Generating Base-load Electricity by Region", U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, NUREG 0480, December, 1978.

9. Messing, R. F. and Harris, H.E.: "Comparative Energy Values to 1990," Report No. R770602, Impact Securities Corp., (Subsidiary), Arthur D. Little, Inc., Cambridge, MA 02140, June 1977.

10. Browne, Thomas E., et al. (Seven Authors): "Supply 77-EPRI Annual Energy Supply Forecasts," Report No. EA-634-SR, Electric Power Research Institute, Palo Alto, CA 94304, May 1978.

11. Private Communication - "Estimates of Baseline Delivered Coal Costs," (PWC Job No. 3592), Paul Weir Co., 20 North Wacker Drive, Chicago, IL 60606, October 13, 1978.

12. Monthly Energy Review, U.S. Department of Energy, Energy Information Administration, Washington, DC 20461, (Monthly Through June 1980).

13. Myers, M.C., Fuller, L.C., "A Procedure for Estimating Non-Fuel Operating and Maintenance Costs for Large Steam - Electric Power Plants," Oak Ridge National Laboratory, Oak Ridge, TN 37830, ORNL/TM-6467, January 1979.

14. Myers, M.C., "Guidelines for Estimating Non-Fuel Operation and Maintenance Costs for Alternative Nuclear Power Plants," Oak Ridge National Laboratory, Oak Ridge, TN 37830, ORNL/TM-6860, September 1979.

15. Private Communication - "1979 Update of Operating and Maintenance Costs", Telephone Conversion, United Engineers & Constructors, Inc. Philadelphia, PA, Job No. 7149.050, E. J. Ziegler to M. C. Myers, October 30, 1980

16. Phung, Doan L., Perry, Alfred M., Whittle, Charles E., "Economics of Coal and Nuclear Electricity - A Treatment of Inflation and Differential Cost Increases," Volume 39, pp 407-415, Proceedings of the American Power Conference, 1977.

17. Stauffer, T. R., Palmer, R. S., Wyckoff, H. L., "Breeder Reactor Economics," Unnumbered: Breeder Reactor Corporation, July 1975.

8.1 (Cont'd)

18. "Engineering Economics, A Manager's Guide to Economic Decision Making," Third Edition, American Telephone and Telegraph Company, 1977

19. Crowley, J. H., et al, "The Need for and Deployment of Inexhaustible Energy Resource Technologies," Report of Technology Study Panel Inexhaustible Energy Resources Study by United Engineers & Constructors Inc., Philadelphia, PA 19101, Unnumbered Report: U.S. Energy Research and Development Administration September 1977.

20. "The HTGR for Electric Power Generation - Design and Cost Evaluation," United Engineers and Constructors, Inc., Philadelphia, PA 19101, Gas Cooled Reactor Associates Contract GCRA/AE/78-1 Proprietary, September, 1980 (Supercedes Reference 3).

21. "Conceptual Design of a large HWR for U.S. Siting," CEND-379; Combustion Engineering, Inc., Windsor, CT 06905 and United Engineers & Constructors, Inc., Philadelphia, PA 19101, U.S. Department of Energy Contract EN-77-C-01-5068, September, 1979 (Supercedes Reference 11).

22. "1170 MWt, HTGR Steamer Cogeneration Plant - Design and Cost Study," UE&C/DOE 800716; United Engineers & Constructors, Inc., Philadelphia, PA 19101 and General Atomic Company, La Jolla, CA, U.S. Department of Energy Contract DE-AC02-78ET34222, August, 1980

23. "NSSS Capital Costs for a Mature LMFBR Industry for Energy Economic Data Base Program - Phase I: Addendum," Combustion Engineering, Inc., Windsor, CT 06095, CE-ADD-80-310, United Engineers & Constructors, Inc. Subcontract, September 25, 1980 (Addendum to Reference 2).

24. "Final Report and Initial Update of the Energy Economic Data Base (EEDB) Program - Phase I", United Engineers & Constructors, Inc., Philadelphia, PA 19101, UE&C/DOE-790930, U.S. Department of Energy Contract EN-78-C-02-4954, December, 1979.

25. "Phase II Final Report and Second Update of the Energy Economic Date Base (EEDB) Program", United Engineers & Constructors, Inc., Philadelphia, PA. 19101, UE&C/DOE-810430, U.S. Department of Energy Contract DE-AC02-78ET33020, (formerly EN-78-C-02-4954), July, 1981.

26. "Phase III Final Report and Third Update of the Energy Economic Date Base (EEDB) Program", United Engineers & Constructors, Inc., Philadelphia, PA. 19101, UE&C/DOE-810731, U.S. Department of Energy Contract DE-AC02-78ET33020, (formerly EN-78-C-02-4954), July, 1981.

8.1 (Con'd)

27. "Projections of Cost, Durations, and On-site Manual Labor Requirements for Constructing Electric Generating Plants, 1979 - 1983", DOE/IR-057: DOL/CLDS/PPZ, U.S. Department of Labor and U.S. Department of Energy, September, 1979.

28. Kenneth C. Kusterer, "Labor Productivity in Heavy Construction: Impact on Synfuels Program Employment," Argonne National Laboratory, June, 1980.

8.2 GLOSSARY OF ACRONYMS AND ABBREVIATIONS

8.2.1 Governmental Organizations

AEC	- Atomic Energy Commission (Succeeded first by ERDA and then by DOE)
ANL	- Argonne National Laboratory
BNL	- Brookhaven National Laboratory
COO	- Chicago Operations Office - DOE
DOD (DoD)	- Department of Defense
DOE (DoE)	- Department of Energy (Successor to ERDA and AEC)
DOI	- Department of the Interior
EIA	- Energy Information Administration
EPA	- Environmental Protection Agency
ERDA	- Energy Research and Development Administration (Succeeded AEC and was then superseded by DOE)
FEA	- Federal Energy Administration
FERC	- Federal Energy Regulatory Commission
HEDL	- Hanford Engineering Development Laboratory
LASL	- Los Alamos Scientific Laboratory
LLL	- Lawrence Livermore Laboratory
NRC	- Nuclear Regulatory Commission
ORNL	- Oak Ridge National Laboratory
SC	- Sandia Corporation
SL	- Sandia Laboratories
US	- United States

8.2.2 Other Organizations

ADL	- Arthur D. Little, Inc.
ASTM	- American Society for Testing Materials
CE	- Combustion Engineering, Inc.
EEI	- Edison Electric Institute
EPRI	- Electric Power Research Institute
GAC	- General Atomic Company
GE	- General Electric Company
NUS	- NUS Corporation (Formerly Nuclear Utility Services Corporation)
UE&C	- United Engineers & Constructors Inc. (A Raytheon Subsidiary)
UMW	- United Mine Workers
WE WECO	- Westinghouse Electric Corporation

8.2.3 Technical Identification and Programs

BBL	- Barrels
bbl/d	- Barrels per day
BOP	- Balance of Plant
Btu BTU	- British Thermal Unit = 1055 Joules
BWR	- Boiling Water Reactor
C	- Temperature - Degrees Celsius (sometimes - incorrectly - Centigrade)
CANDU	- CANadian Deuterium Uranium (Alternate designation for PHWR)
CAP	- Net Electrical Capacity
CF	- Capacity Factor
CGCC	- Coal Gasification Combined Cycle Plant
CO	- Carbon Monoxide
CO_2	- Carbon Dioxide
CONCICE	- CONceptual Construction Investment Cost Estimate - UE&C Proprietary Code
COS	- Carbonyl Sulfide - Carbon Oxysulfide
CPGS	- Comparison Power Generating Station
CRBR	- Clinch River Breeder Reactor
CY cy	- Calendar Year
CY	- Cubic Yard - yd^3
e_i	- Escalation rate for money inflation - %/y
e_s	- Escalation rate for scarcity - reduced productivity - %/y

8.2.3 (Cont'd)

EBR	- Experimental Breeder Reactor (Two versions: -I and -II)
EEDB	- Energy Economic Data Base
EHS	- Eastern High Sulfur Coal
F	- Temperature - Degrees Fahrenheit
FBR	- Fast Breeder Reactor
FCR	- Fixed Charge Rate
FGD	- Flue Gas De-Sulfurization
FIT	- Federal Income Tax
FPGS	- Fossil Fired Power (Electrical) Generating Station
FUELCOST-V	- A NUS proprietary code
FY fy	- Fiscal Year
GCFR	- Gas Cooled Fast (Breeder) Reactor (Sometimes GCFBR)
GCR	- Gas Cooled Reactor - general designation for all gas-cooled reactor systems
GESSAR	- General Electric Standard Safety Analysis Report
GSU	- Generator Step-Up Transformer
GW	- Gigawatt = 10^9 Watts
h	- Hour
HLW	- High Level Waste (Radioactive)
HM	- Heavy Metal - fuels containing mixtures of U + Pu, U + Th, Pu + Th
HP	- Horsepower
hr	- Hour
HR	- Net Station Heat Rate in Btu/kWh
HS	- High Sulfur ($\geq$ 1.0%)

8.2.3 (Cont'd)

HSC	- High Sulfur Coal
HS8	- High Sulfur 800 MWe Coal-Fired Power Generating Station
HS12	- High Sulfur 1200 MWe Coal-Fired Power Generating Station
HTGR	- High Temperature Gas (Cooled) Reactor
H_2S	- Hydrogen Sulfide
HWR	- Heavy Water Reactor
I&C	- Instrumentation and Control
in HgA	- Inches of Mercury Pressure - Absolute = 25.4 Torr
kgH kgHM	- Kilograms Heavy Metal
kgU	- Kilograms Uranium
kV	- Volts x 10^3 - Kilovolts
kVA	- Volt Amperes x 10^3 - Kilovolt-Amperes
kW	- Watts x 10^3 - Kilowatt = 3414 Btu/hr
kWh	- Kilowatt-Hour - 3414 Btu
LB (lb.)	- Pound(s)
LF	- Linear Feet
LF	- Levelization Factor
LMFBR	- Liquid Metal Fast Breeder Reactor
LS	- Low Sulfur ($\leq$1.0%)
LS8	- Low Sulfur 800 MWe Coal-Fired Power Generating Station
LS12	- Low Sulfur 1200 MWe Coal-Fired Power Generating Station
LT	- Lot
LWR	- Light Water Reactor (includes BWR and PWR)

8.2.3 (Cont'd)

m	- Minute
¢/MBtu	- Cents per Btu x 10^6
$/MBtu	- Dollars per Btu x 10^6
min	- Minute
m/kWh	- Mills per Kilowatt Hour - $ x 10^{-3} per kWh
mm Hg	- Millimeter of Mercury Pressure
MOX	- Mixed Oxide Fuel - Mixed UO_2 - PuO_2 Fuel
MT	- Metric Tons - 2205 Pounds
MTH MTHM	- Metric Tons of Heavy Metal - HM
MTU	- Metric Tons of Uranium
MVA	- Volt Amperes x 10^6
MW	- Watts x 10^6 - Megawatt
MWd/MT	- Megawatt-Days per Metric Ton
MWD/T	- Megawatt-Days per Ton
MWe	- MegaWatts (Watts x 10^6) - Electrical
MWt	- MegaWatts (Watts x 10^6) - Thermal
Na	- Element No. 11 - Sodium - Liquid Metal Coolant
NaK	- Sodium/Potassium - Liquid Metal Coolant Mixture
NASAP	- Nonproliferation Alternative Systems Assessment Program

NASAP Codes

- (DE) - Denatured (U-233/U-235 mixed with U-238)
- (HE) - High Enrichment
- (LE) - Low Enrichment (in U-235)
- (ME) - Medium Enrichment

8.2.3 (Cont'd)

NASAP CODES (Continued)

- (NAT) - Natural Uranium - 0.7 w/o U-235
- Pu - Plutonium (Fissile Pu)
- RE - Reprocess
- T - Throwaway
- Th - Thorium
- 20% - 20 Weight Percent U-235
- U - Uranium
- U5 - Uranium-235
- U3 - Uranium-233

NNS - Non-Nuclear Safety

Np - Element No. 93, Neptunium - Does not occur in nature - intermediate in formation of Pu-239

NPGS - Nuclear Power (Electrical) Generating Station

NS - Nuclear Safety

O&M - Operation and Maintenance

OMCOST - An ORNL code for Operation and Maintenance costs

Pa - Element No. 91 - Protactinium

PEGASUS - Power Plant Economic Generator And Scale-Up System - UE&C Proprietary Code

PHS - Pittsburgh High Sulfur (Steam) Coal

PHWR - Pressurized Heavy Water Reactor

PLBR - Prototype Large Breeder Reactor

PSI (psi) - Pounds per Square Inch

PSIA (psia) - Pounds per Square Inch - Absolute

PSIG (psig) - Pounds per Square Inch - Gauge (14.7 psia = 0 psig)

Pu - Element No. 94 - Plutonium - Does not occur in nature; two isotopes thermally fissile Pu-239, Pu-241

8.2.3 (Cont'd)

PuO_2	- Plutonium Dioxide
Pu_2O_3	- Plutonium Sesquioxide
Pu-241 Pu-239	- Thermally Fissile Isotopes of Pu produced by neutron capture in U-238
PWR	- Pressurized Water Reactor
QA	- Quality Assurance
QC	- Quality Control
r rev	- Revolutions
RESAR	- Westinghouse Reference Safety Analysis Report
ROI	- Return on Investment
RPCW	- Reactor Plant Cooling Water
RPM r/m	- Revolutions per Minute
s	- Second
SCF	- Standard Cubic Feet - one cubic foot of gas at $0^{o}C$ and 760 Torr
SCFD SCF/D scf/d	- Standard Cubic Feet (per) Day (Also SCFM (per minute) and SCFH (per hour) @ 760 Torr and $0^{o}C$)
sec	- Second
SF	- Square Feet - ft^2
SO_2	- Sulfur Dioxide
SRC	- Solvent Refined Coal
ST	- Tons - a short ton = 2000 pounds
SWU	- Separative Work Unit - for Uranium Enrichment
TEC	- Thermal Energy Costs
Th	- Element No. 90, Thorium - fertile Th-232 - the naturally occuring Th isotope $\sim$100% abundance

8.2.3 (Cont'd)

TM-xxxx	- Technical Memorandum
\$/t-mi	- Dollars per Ton Mile (coal transportation)
TN	- Ton(s) - A short ton = 2000 pounds
Torr	- Torricelli - 1 mm mercury; 760 Torr = 1 atmosphere = 14.7 pounds/in.^{2}
U	- Element No. 92 - Uranium
UC	- Uranium Monocarbide (also uranium carbide)
UC_2	- Uranium Dicarbide
U_2C_3	- Uranium Sesquioxide
UF_6	- Uranium Hexafloride (Gas)
UO_2	- Uranium Dioxide - Fuel
U_3O_8	- Triuranium Octoxide - Raw Uranium Oxide Yellowcake - Uranium Oxide
U-233	- Thermally Fissile Isotope of Uranium produced by neutron irradiation of Th-232
U-235	- Thermally Fissile Isotope of Uranium; only naturally occurring fissile element - abundance 0.7%
U-238	- Not Thermally Fissile Isotope of Uranium; most abundant naturally occurring, abundance 99.3% fertile target for production of thermally fissile Pu-239
Watt	- Btu/HR x 3.414 Watts/hr = Btu
W(e)	- Watts - Electrical
W(t)	- Watts - Thermal
WLS	- Western Low Sulfur Coal
Y / yr	- Year = 8760 Hours = 3.154×10^7 sec.

APPENDIX - A1

PHASE IV FINAL REPORT AND FOURTH UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

APPENDIX A-1

DESCRIPTION OF STANDARD HYPOTHETICAL MIDDLETOWN SITE FOR NUCLEAR POWER PLANTS

SITE DESCRIPTION

A1.1 GENERAL

This site description provides the site and environmental data, derived from Appendix A of "Guide for Economic Evaluation of Nuclear Reactor Plant Designs", USAEC Report NUS-531, modified to reflect current requirements. These data form the bases of the criteria used for designing the facility and for evaluating the routine and accidental release of radioactive liquids and gases to the environment.

A1.2 TOPOGRAPHY AND GENERAL SITE CHARACTERISTICS

The site is located on the east bank of the North River at a distance of twenty-five miles south of Middletown, the nearest large city. The North River flows from north to south and is one-half mile (2600 ft) wide adjacent to the plant site. A flood plain extends from both river banks an average distance of one-half mile, ending with hilltops generally 150 to 250 ft above the river level. Beyond this area, the topography is gently rolling, with no major critical topographical features. The plant site itself extends from river level to elevations of 50 ft above river level. The containment building, other seismic Category I structures and the switchyard are located on level ground at an elevation of 18 ft above the mean river level. This elevation is ten feet above the 100-year maximum river level, according to U.S. Army Corps of Engineers' studies of the area.

In order to optimize land area requirements for the nuclear power plant site, maximum use of the river location is employed. The containment structure is located approximately 400 ft from the east bank of the river. The site land area is taken as approximately 500 acres.

A1.3 SITE ACCESS

Highway access is provided to the hypothetical site by five miles of secondary road connecting to a state highway; this road is in good condition and needs no additional improvements. Railroad access is provided by the construction of a spur which intersects the B&M Railroad. The length of the required spur from the main line to the plant site is assumed to be five miles in length. The North River is navigable throughout the year with a 40 ft wide by 12 ft deep channel. The distance from the shoreline to the center of the ship channel is 2000 ft. All plant shipments are assumed to be made overland except that heavy equipment (such as reactor vessel and generator stator) may be transported by barge. The Middletown Municipal Airport is located three miles west of the State highway, 15 miles south of Middletown, and ten miles north of the site.

A1.4 POPULATION DENSITY AND LAND USE

The hypothetical site is near a large city (Middletown, 250,000 population) but in an area of low population density. Variation in population with distance from the site boundary is:

Miles	Cumulative Population
0.5	0
1.0	310
2.0	1,370
5.0	5,020
10.0	28,600
20.0	133,000
30.0	1,010,000

There are five industrial manufacturing plants within 15 miles of the hypothetical site. Four are small plants, employing less than 100 people each. The fifth, near the airport, employs 2,500 people. Closely populated areas are found only in the centers of the small towns so that the local land area used for housing is small. The remaining land, including that across the river, is used as forest or cultivated crop land, except for railroads and highways.

A1.5 NEARBY FACILITIES

Utilities are available as follows:

- Natural gas service is available two miles from the site boundary on the same side of the river.
- Communication lines are furnished to the project boundaries at no cost.
- Power and water for construction activities are available at the southwest corner of the site boundary.
- Two independent offsite power sources (one at 500 kV and one at 230 kV) are available at the switchyard.

A1.6 METEOROLOGY AND CLIMATOLOGY

A1.6.1 Ambient Temperatures

The winters in the Middletown area are moderately cold, with average temperatures in the low 30s. The summers are fairly humid with average temperatures in the low 70s, and with high temperatures averaging around 82°F. The historic maximum wet bulb and dry bulb temperatures are 78°F and 99°F respectively.

The year-round temperature duration curves for the dry bulb temperatures and coincident wet bulb temperatures are shown in Figure A1.1.

A1.6.2 Prevailing Wind

According to Weather Bureau records at the Middletown Airport, located ten miles north of the site on a low plateau just east of the North River, surface winds are predominantly southwesterly 4 - 10 knots during the warm months of the year, and westerly 6 - 13 knots during the cool months.

There are no large diurnal variations in wind speed or direction. Observations of wind velocities at altitudes indicate a gradual increase in mean velocity and a gradual veering of the prevailing wind direction from southwest and west near the surface to westerly and northwesterly aloft.

In addition to the above, studies of the area indicate that there is a significant channeling of the winds below the surrounding hills into the north-south orientation of the North River. It is estimated that winds within the river valley blow approximately parallel to the valley orientation in excess of 50 percent of the time.

A1.6.3 Atmospheric Diffusion Properties

The transport and dilution of radioactive materials in the form of aerosols, vapors or gases released into the atmosphere from the Middletown nuclear power station are a function of the state of the atmosphere along the plume path, the topography of the region, and the characteristics of the effluents themselves. For a routine airborne release, the concentration of radioactive materials in the surrounding region depends on the amount of effluent released, the height of the release, the wind speed, atmospheric stability, and airflow patterns of the site, and various effluent removal mechanisms. Geographic features such as hills and valleys influence diffusion and airflow patterns.

Of the diffusion models that have been developed, the straight-line trajectory model is utilized to calculate the atmospheric diffusion from the Middletown site.

The straight-line trajectory model assumes that the airflow transports and diffuses effluents along a straight line through the entire region of interest in the airflow direction at the release point. The version of this model which is used is the Gaussian straight-line trajectory model. In this model, the wind speed and atmospheric stability at the release point are assumed to determine the atmospheric diffusion characteristics in the direction of airflow.

A long-term continuous release is assumed whose effluent is distributed evenly across a 22-1/2 degree sector. The model treats elevated-only, ground-level only, or mixed elevated-ground level releases, as determined by the interaction of plant characteristics and wind speeds.

For elevated releases, the basic equation, modified from Turner (1970), is:

$$\frac{\bar{X}}{Q}(x,k) = \frac{2.032 \cdot RF_k(x)}{x} \sum_{ij} \frac{DEPL_{ijk}(x) \cdot DEC_i(x) \cdot f_{ijk} \exp \cdot \left(\frac{1}{2} \frac{h_e^2}{\sigma^2_{zj}(x)} \right)}{\bar{u}_i \, \sigma_{zj}(x)} \qquad (1)$$

where

$\frac{\bar{X}}{Q}(x,k)$ = average effluent concentration normalized by source strength at distance x and direction k;

$\bar{u}_i$ = mid-point values of the ith wind speed class;

$\sigma_{zj}(x)$ = vertical (z) spread of effluent at distance x for the jth stability class;

f_{ijk} = joint probability of the ith wind speed class, jth stability class, and kth wind direction;

x = downwind distance from release point or building;

h_e = effective plume height;

$DEC_i(x)$ = reduction factor due to radioactive decay at distance x for the ith wind speed class;

$DEPL_{ijk}(x)$ = reduction factor due to plume depletion at distance x for the ith wind speed class, jth stability class, and kth wind direction; and

$RF_k(x)$ = correction factor for air recirculation and stagnation at distance x and kth wind direction.

Ground release concentrations are calculated using the following two equations modified from Turner (1970):

$$\frac{\bar{X}}{Q}(x,k) = \frac{2.032}{x} RF_k(x) \sum_{ij} DEPL_{ijk}(x) \cdot DEC_i(x) \cdot f_{ijk} \left[\bar{u}_i \left(\sigma_{zj}^2(x) + D_z^2/\pi \right)^{1/2} \right]^{-1} \quad (2)$$

$$\frac{\bar{X}}{Q}(x,k) = \frac{2.032}{x} RF_k(x) \sum_{ij} DEPL_{ijk}(x) \cdot DEC_i(x) \cdot f_{ijk} \left(\sqrt{3}\, \bar{u}_i\, \sigma_{zj}(x) \right)^{-1} \quad (3)$$

Where D_z is the building height which is used to describe the dilution due to the building wake, from Yanskey, et al (1966). Equation 3 represents the maximum building wake dilution allowed; the higher value of $\overline{X/Q}$ calculated from Equations 2 and 3 is utilized.

Values of $\frac{\bar{X}}{Q}(x,k)$ are calculated at 22 downwind distances between 0.25 and 50 miles. Each of the 16 directional sectors are divided into 10 downwind segments and an average value is determined for each sector as follows:

$$(X/Q)_{seg} = \frac{R_1 (X/Q)_{R_1} + r_1 (X/Q)_{r_1} + \cdots + r_n (X/Q)_{r_n} + R_2 (X/Q)_{R_2}}{R_1 + r_1 + \cdots + r_n + R_2} \quad (4)$$

where

$\overline{(X/Q)}_{seg}$ = average value of $\overline{X/Q}$ for the segment;

$\overline{(X/Q)}_r$ = $\frac{\overline{X}}{Q}(x = r, k)$ calculated at distance r;

R_1, R_2 = the downwind distance of the segment boundaries; and

$r_1 \cdots r_2$ = selected radii between R_1 and R_2.

The effluent plume is depleted via dry deposition using Figures 2 through 5 of Regulatory Guide 1.111, Rev. 1 (1977). These depletion factors are adjusted for changes in topography.

From Slade (1968) the reduction factor due to radioactive decay is:

$$DEC = EXP(-.693 t_i / T) \quad (5)$$

where

$$t_i = x/(86400 \bar{u}_i), \quad (6)$$

such that DEC = reduction factor due to radioactive decay;

T = half life, in days, of the radioactive material;

t_i = travel time, in days;

x = travel distance, in meters; and

$\bar{u}_i$ = midpoint of the windspeed class, in meters/second.

Finally, for the Middletown site, the $\overline{X/Q}$ values are amended so that they are not substantially underestimated due to the effects of the regional recirculation and stagnation of the air. For downvalley airflow, the relative concentrations are multiplied by five for distances less than 20 miles. For upvalley airflow, the concentrations are multiplied by 1.5 for all distances.

The relative deposition per unit area, $\overline{D/Q}$, is calculated by sector for 22 downwind distances and 10 downwind segments between 0.25 and 50 miles. Elevated-only, ground-level only, or mixed elevated-ground level release are utilized depending on the ratio of the effluent exit velocity to the exit level windspeed.

For a 22-1/2 degree sector, the basic equation to calculate the average D/Q for a specified downwind distance is:

$$\frac{\overline{D}}{Q}(x,k) = \frac{RF_k(x) \cdot \sum_{ij} D_{ij} f_{ijk}}{(2\pi/16)x} \qquad (7)$$

where

$\frac{\overline{D}}{Q}(x,k)$ = average relative deposition per unit area at a downwind distance x and direction k, in meters^{-2};

D_{ij} = the relative deposition rate from Figures 6 through 9 of Regulatory Guide 1.111 for the ith wind speed class (since plume height is dependent on windspeed) and jth stability class, in meters^{-1};

f_{ijk} = joint probability of the ith windspeed class, jth stability class, and kth wind direction;

x = downwind distance, in meters; and

$RF_k(x)$ = correction factor for air recirculation and stagnation at distance x and kth wind direction.

Equation 4 is used to calculate average values of D/Q for the downwind segments, with D replacing X in the equation.

A1.6.4 Severe Meteorological Phenomena

A maximum instantaneous wind velocity of 100 mph has been recorded at the site. During the past 50 years, three tropical storms, all of them in the final dissipation stages, have passed within 50 miles of the site. Some heavy precipitation and winds in excess of 40 miles per hour were recorded, but no significant damage other than to crops resulted.

The area near the site experiences an average of 35 thunderstorms a year, with maximum frequency in early summer. High winds near 60 mph, heavy precipitation, and hail are recorded about once every four years.

In forty years of record keeping, there have been twenty tornadoes reported within fifty miles of the site. This moderately high frequency of tornado activity indicates a need to design Seismic Category I structures at the site for the possibility of an on-site tornado occurrence. Maximum tornado frequency occurs in May and June.

During the past forty years, there have been ten storms in which freezing rain has caused power transmission line disruptions. Most of these storms have occurred in early December.

A1.6.5 Potential Accident Release Meteorology

In the event of an accidental release of fission products to the atmosphere, transport and diffusion is determined by the meteorological conditions at the site for the duration of the accident, which is assumed to be 30 days.

The methodology required to calculate radiation dosages from accidental releases involves a series of procedures. The dosages are based upon a ground level release only. Each directional sector from the plant requires a separate X/Q value for the EAB (Exclusion Area Boundary) and the LPZ (Low Population Zone) distances. To evaluate the accident dosages, both the short-term (≤ 2 hrs) and the annual X/Q values are calculated. The annual X/Q value methodology is taken from Regulatory Guide 1.111, Section C.1.c with the effective height defined as:

$$h_e = h_s - h_t$$

where

h_s = stack height

h_t = terrain height

The short-term X/Q values are derived from the conditional equations

$$X/Q = 1/(\bar{u}_{10}\, \pi\, \Sigma_y\, \sigma_z) \qquad (1)$$

$$X/Q = 1/\left[\bar{u}_{10}(\pi\, \sigma_y\, \sigma_z + A/2)\right] \qquad (2)$$

$$X/Q = 1/(\bar{u}_{10}(3\pi\, \sigma_y\, \sigma_z)) \qquad (3)$$

with

$\bar{u}_{10}$ = wind speed at ten meters above ground level,

σ_y, σ_z = horizontal and vertical dispersion coefficients,

A = minimum cross-sectional area of building from which effluent is released,

Σ_y = lateral plume spread; a function of atmospheric stability, wind speed and downwind distance.

For distances greater than 800 meters, $\Sigma_y = (M-1)\sigma_{y_{800\,m}} + \sigma_y$.

M is a function of atmospheric stability and wind speed, as presented in Regulatory Guide 1.145 (1979), Figure 1. For distances less than 800 meters, $\Sigma_y = M\sigma_y$.

The choice of the proper equation determining short-term χ/Q values depends upon the procedure below:

1. The higher χ/Q value is chosen between equations (2) and (3).
2. If the wind speed is less than 6m/sec and the stability class is greater than or equal to D (i.e.; D, E, F or G stabilities), then the lower χ/Q value given by equation (1) or by the higher value of equation (2) or (3) is chosen.

In other words, the values computed from equations (2) and (3) are compared and the higher value is selected. Then, if the meteorological conditions given in Item 2 above are true, the selected value computed from equation (2) o. (3) is compared with the value from equation (1), and the lower of these two values is chosen.

The χ/Q value selected as the accident dosage is a function of the effective probability level P_e given by

$$P_e = \frac{P(N/n)}{S} \qquad (4)$$

where

P = probability level which is mandated as five percent for a conservative estimate and 50 percent for realistic.

N = total number of valid observations.

n = total number of valid observations within a given sector.

S = number of sectors.

The short-term χ/Q values for each meteorological condition during a given time period are tallied in a cumulative distribution table and normalized to 100 percent. The χ/Q distributions for each direction are plotted on cumulative probability paper. The conservative and realistic average short-term χ/Q values are selected from the graph using the effective probability values. Logarithmic interpolation is performed between the graph-selected χ/Q values and the annual average χ/Q values at time intervals of eight hours, 16 hours, three days and 26 days for each sector and distance of interest. For each distance, the χ/Q accident values for the 16 directions are compared and the highest value is selected.

A1.7 HYDROLOGY

The North River provides an adequate source of raw make-up water for the station. The average maximum temperature is 75°F, and the average minimum is 39°F. The mean annual temperature is 57°F.

U.S. Army Corps of Engineers' studies indicate that the 100 year maximum flood level rose to eight feet above the mean river level. There are no dams near the site whose failure could cause the river to rise above the eight foot level.

A1.8 GEOLOGY AND SEISMOLOGY

A1.8.1 Soil Profiles and Load Bearing Characteristics

Soil profiles for the site show alluvial soil and rock fill to a depth of eight feet; Brassfield limestone to a depth of 30 ft; blue weathered shale and fossiliferous Richmond limestone to a depth of 50 ft; and bedrock over a depth of 50 ft. Allowable soil bearing is 6,000 psf and rock bearing characteristics are 18,000 psf and 15,000 psf for Brassfield and Richmond strata, respectively. No underground cavities exist in the limestone.

A1.8.2 Seismology

The site is located in a generally seismically inactive region. Historical records show three earthquakes have occurred in the region between 1870 and 1975. A safe shutdown earthquake (SSE) with a horizontal ground acceleration of 0.25 g provides conservative design margin. For design purposes, the horizontal and vertical component Design Response Spectra given in NRC Regulatory Guide 1.60, Rev. 1, December 1973, are linearly scaled to a horizontal ground acceleration of 0.25 g.

A1.9 SEWAGE AND RADIOACTIVE WASTE DISPOSAL

A1.9.1 Sewage

All sewage receive primary and secondary treatment prior to discharge into the North River.

A1.9.2 Gaseous and Liquid Radioactive Wastes

The gaseous and liquid effluent releases from this plant comply with 10 CFR Part 20 and the intent of Appendix I of 10 CFR Part 50.

A1.9.3 Solid Radioactive Wastes

Storage on site for decay is permissible but no ultimate disposal on site is planned.

References

Briggs, G. A., Plume Rise, AEC Critical Review Series, TID-25075, 1969, Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia.

Turner, D. B., Workbook of Atmospheric Dispersion Estimates, 1970, Office of Air Programs Publication No. AP-26, Environmental Protection Agency, Research Triangle Park, North Carolina.

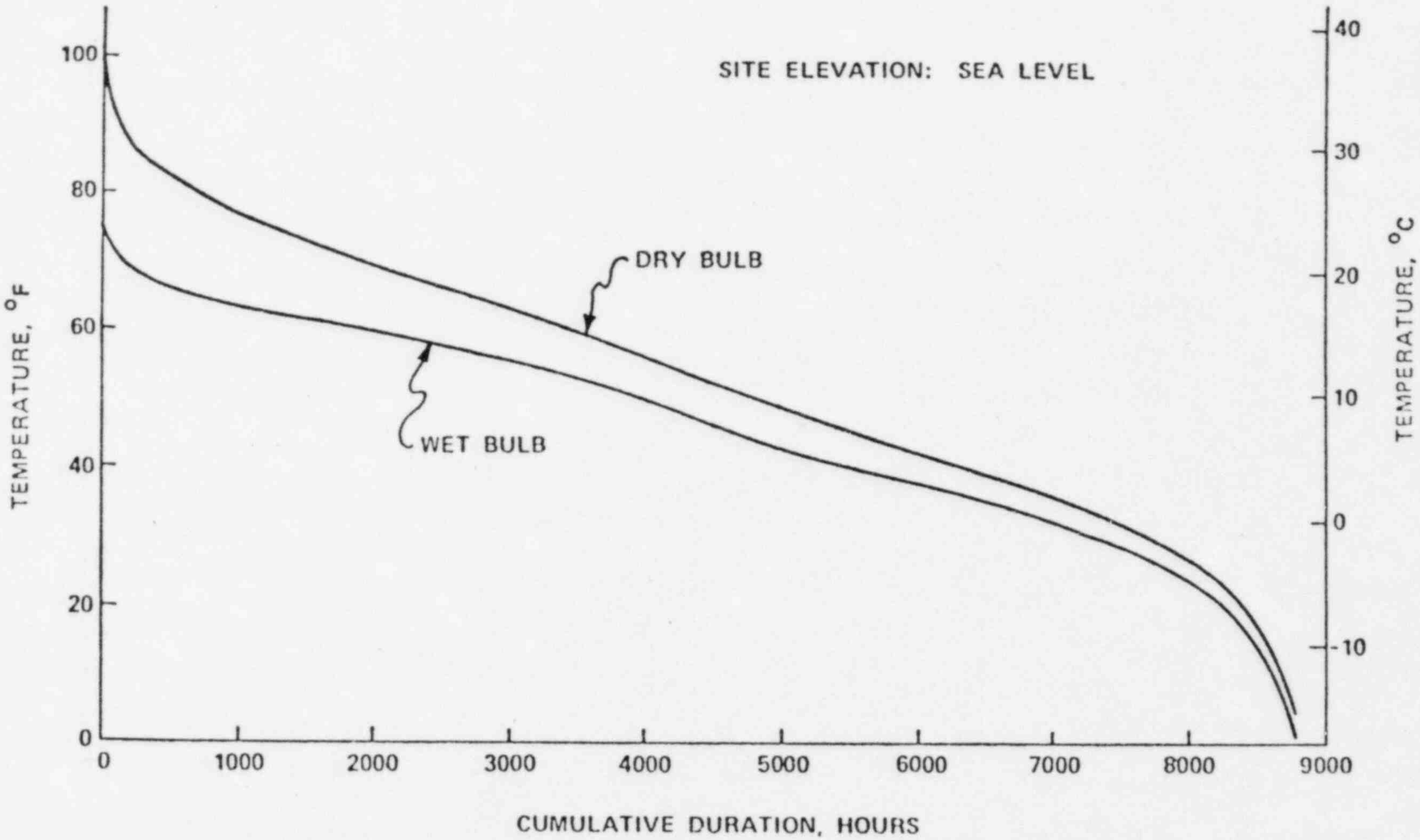
U.S. Nuclear Regulatory Commission, Regulatory Guide 1.111, Revision 1, Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors, 1977, USNRC Office of Standards Development, Washington, D. C.

Yanskey, G. R., Markee, E. H., Jr., and Richter, A. P., Climatography of the National Reactor Testing Station, 1960, Idaho Operations Office, USAEC, IDO-12048, Idaho Falls, Idaho.

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.145, Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants, July 1979, USNRC Office of Standards Development, Washington, D.C.

FIGURE A1.1

TEMPERATURE DURATION CURVES; MIDDLETOWN, U.S.A.



APPENDIX - A2

ʒE IV FINAL REPORT AND FOURTH UPDATE OF THE
ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

APPENDIX A-2

DESCRIPTION OF STANDARD HYPOTHETICAL MIDDLETOWN SITE FOR COAL-FIRED POWER PLANTS

SITE DESCRIPTION

A2.1 GENERAL

This site description provides the site and environmental data as derived from Appendix A of "Guide for Economic Evaluation of Nuclear Reactor Plant Designs", USAEC Report NUS-531, and modified to reflect coal plant siting. These data form the bases of the criteria used for designing the facility and for evaluating the release of liquids and gases to the environment.

A2.2 TOPOGRAPHY AND GENERAL SITE CHARACTERISTICS

The site is located on the east bank of the North River at a distance of approximately twenty-five miles south of Middletown, the nearest large city. The North River flows from north to south and is one-half mile (2600 ft) wide adjacent to the plant site. A flood plain extends from both river banks an average distance of one-half mile, ending with hilltops generally 150 to 250 ft above the river level. Beyond this area, the topography is gently rolling, with no major critical topographical features. The plant site itself extends from river level to elevations of 50 ft above river level. The primary structures and the switchyard are located on level ground at an elevation of 18 ft above the mean river level. This elevation is ten feet above the 100 year maximum river level, according to U.S. Army Corps of Engineers' studies of the area.

In order to optimize land area requirements for the coal fueled plant site, maximum use of the river location is employed. The primary structure is located 1200 ft from the east bank of the river. The site land area is approximately 500 acres. An additional 2,000 acres, approximately six miles from the plant site, are available for solid waste disposal.

A2.3 SITE ACCESS

Highway access is provided to the hypothetical site by five miles of secondary road connecting to a State highway. This road is in good condition and needs no additional improvements. Railroad access is provided by constructing a railroad spur which intersects the B&M Railroad. The length of the required spur from the main line to the plant site is assumed to be five miles in length. The North River is navigable throughout the year with a 40 ft wide by 12 ft deep channel. The distance from the shoreline to the center of the ship channel is 2,000 ft. All plant shipments are assumed to be made overland except that heavy equipment may be transported by barge. The Middletown Municipal Airport is located three miles west of the State highway, 15 miles south of Middletown, and ten miles north of the site.

A2.4 POPULATION DENSITY AND LAND USE

The hypothetical site is near a large city (Middletown, of 250,000 population) but in an area of low population density. Variation in population with distance from the site boundary is:

Miles	Cumulative Population
0.5	0
1.0	310
2.0	1,370
5.0	5,020
10.0	28,600
20.0	133,000
30.0	1,010,000

There are five industrial manufacturing plants within 15 miles of the hypothetical site. Four are small plants employing less than 100 people each. The fifth, near the airport, employs 2,500 people. Closely populated areas are found only in the centers of the small towns, so the total land area used for housing is small. The remaining land, including that across the river, is used as forest or cultivated crop land, except for railroads and highways.

A2.5 NEARBY FACILITIES

Utilities are available as follows:

- Natural gas service is available two miles from the site boundary on the same side of the river.
- Communication lines will be furnished to the project boundaries at no cost.
- Power and water for construction activities are available at the southwest corner of the side boundary.
- Two connections to the utility grid (one at 500 kV for the generator connection and one at 230 kV for the reserve auxiliary transformer connection) are available at the switchyard.

A2.6 METEOROLOGY AND CLIMATOLOGY

A2.6.1 Ambient Temperatures

The winters in the Middletown area are moderately cold, with average temperatures in the low 30s. The summers are fairly humid with average temperatures in the low 70s, and with high temperatures averaging around 82°F. The historic maximum wet bulb and dry bulb temperatures are 78°F and 99°F respectively.

The year-round temperature duration curves for the dry bulb temperatures and coincident wet bulb temperatures are shown in Figure A2.1.

A2.6.2 Prevailing Wind

According to Weather Bureau records at the Middletown Airport, located ten miles North of the site on a low plateau just east of the North River, surface winds are predominantly southwesterly 4-10 knots during the warm months of th. year, and westerly 6-13 knots during the cool months.

There are no large diurnal variations in wind speed or direction. Observations of wind velocities at altitudes indicate a gradual increase in mean velocity and a gradual veering of the prevailing wind direction from southwest and west near the surface to westerly and northwesterly aloft.

In addition to the above, studies of the area indicate that there is a significant channeling of the winds below the surrounding hills into the north-south orientation of the North River. It is estimated that these winds within the river valley blow approximately parallel to the valley orientation in excess of 50 percent of the time.

A2.6.3 Atmospheric Diffusion Properties

The transport and dilution of materials in the form of aerosols, vapors, or gases released into the atmosphere from the Middletown coal power station are a function of the state of the atmosphere along the plume path, the topography of the region, and the characteristics of the effluents themselves. For a routine airborne release, the concentration of materials in the surrounding region depends on the amount of effluent released, the height of the release, the windspeed, atmospheric stability, and airflow patterns of the site, and various effluent removal mechanisms. Geographic features such as hills and valleys influence diffusion and airflow patterns.

Of the diffusion models that have been developed, the straight line trajectory model is utilized to calculate the atmospheric diffusion from the Middletown site.

The straight-line trajectory model assumes that the airflow transports and diffuses effluents along a straight line through the entire region of interest in the airflow direction at the release point. The version of this model which is used is the Gaussian straight-line trajectory model. In this model, the windspeed and atmospheric stability at the release point are assumed to determine the atmospheric diffusion characteristics in the direction of airflow.

A2.6.4 Severe Meteorological Phenomena

A maximum instantaneous wind velocity of 100 mph has been recorded at the site. During the past 50 years, three tropical storms, all of them in the final dissipation stages, have passed within 50 miles of the site. Some heavy precipitation and winds in excess of 40 miles/h were recorded, but no significant damage other than to crops resulted.

The area near the site experiences an average of 35 thunderstorms a year, with maximum frequency in early summer. High winds near 60 mph, heavy precipitation, and hail are recorded about once every four years.

In forty years of record, there have been twenty tornadoes reported within fifty miles of the site. Maximum tornado frequency occurs during the months of May and June.

During the past forty years, there have been ten storms in which freezing rain has caused power transmission line disruptions. Most of these storms have occurred early in December.

A2.6.5 Ambient Background Concentrations

Background concentrations of SO_2, NO_x and particulates are typical of a rural area approximately 30 miles from a major industrial metropolitan center. They are considered when determining the plant's adherence to the guidelines.

A2.6.6 Air Quality Estimation

Ambient pollutant levels are estimated through the application of atmospheric diffusion models. The estimates are based primarily upon the pollutant emissions, meteorology, topography, and background concentration as previously described. Modeling techniques described in the Turner Atmospheric Dispersion Workbook are used for concentration estimates.*

A2.7 HYDROLOGY

The North River provides an adequate source of raw makeup water for the station. The average maximum temperature is 75°F and the average minimum is 39°F. The mean annual temperature is 57°F.

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* Turner, D. B., "Workbook of Atmospheric Dispersion Estimates", Public Health Service Publication No. 999-AP-26, U.S. Department of Health, Education, and Welfare, Public Health Service, Consumer Protection and Environmental Health Service, National Air Pollution Control Administration, Cincinnati, Ohio, Revised 1969.

U.S. Army Corps of Engineers' studies indicate that the 100 year maximum flood level rose to eight feet above the mean river level. There are no dams near the site whose failure could cause the river to rise above the eight foot level.

A2.8 GEOLOGY AND SEISMOLOGY

A2.8.1 Soil Profiles and Load Bearing Characteristics

Soil profiles for the site show alluvial soil and rock fill to a depth of eight feet; Brassfield limestone to a depth of 30 ft; blue weathered shale and fossiliferous Richmond limestone to a depth of 50 ft; and bedrock over a depth of 50 ft. Allowable soil bearing is 6,000 psf and rock bearing characteristics are 18,000 psf and 15,000 psf for Brassfield and Richmond strata, respectively. No underground cavities exist in the limestone.

A2.8.2 Seismology

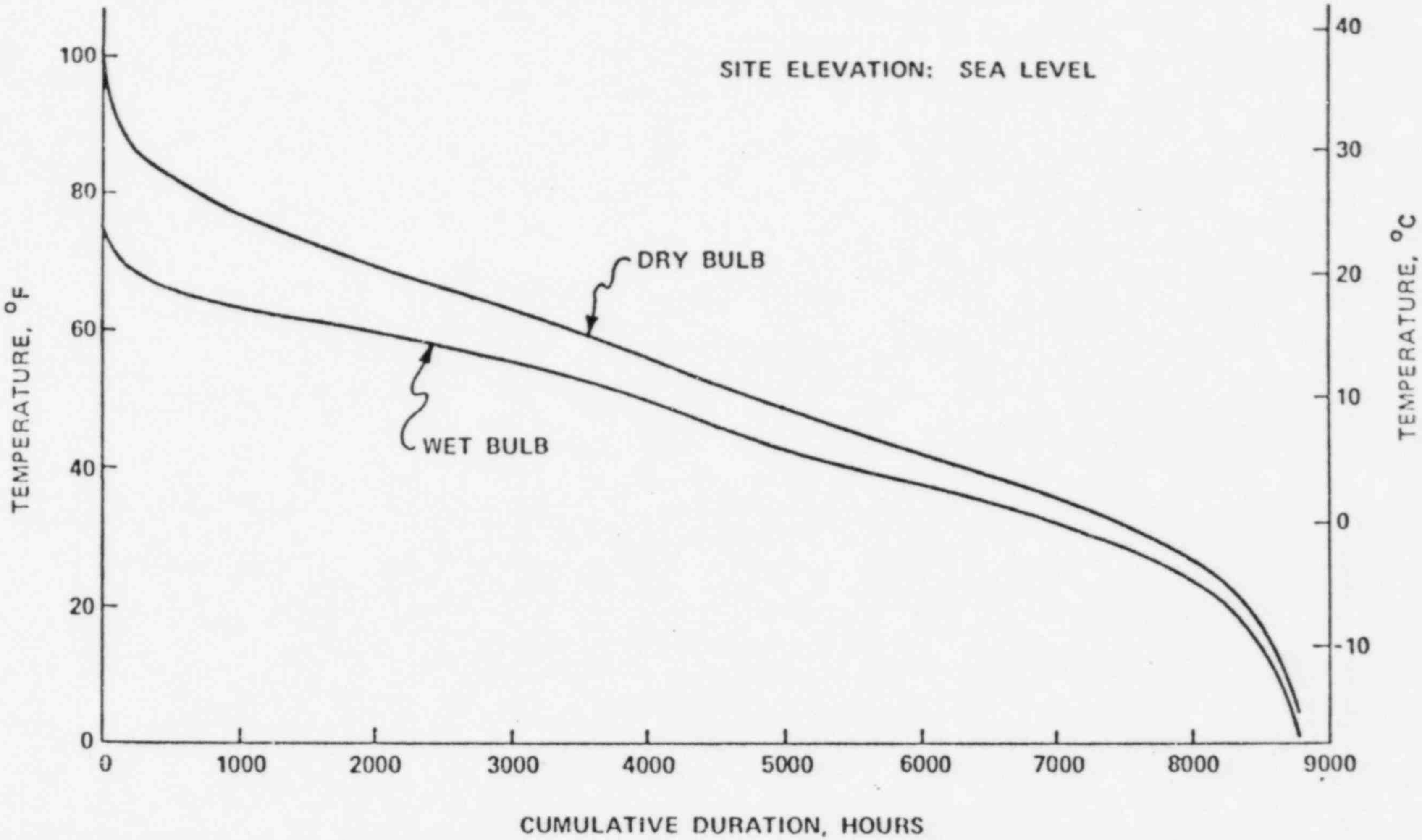
The site is located in a generally seismically inactive region. Historical records show three earthquakes have occurred in the region between 1870 and 1975.

A2.9 SEWAGE AND LIQUID EFFLUENTS

All sewage receives primary and secondary treatment prior to discharge into the North River. Other wastewater is discharged in compliance with EPA effluent standards as promulgated in 40 CFR 423.

FIGURE A2.1

TEMPERATURE DURATION CURVES; MIDDLETOWN, U.S.A.



APPENDIX - B

PHASE IV FINAL REPORT AND FOURTH UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

APPENDIX B

FIXED CHARGE RATES
(without Inflation)

B.1 GENERAL

Fixed charges consist of many components which vary markedly with such factors as charter and financial structure of electric utilities, local conditions, accounting methods, etc. Therefore, although in generalized studies an "average" fixed charge rate may be used, in practice that average will probably not apply to any individual company. The following discussion introduces the concepts involved and addresses methods of calculation of fixed charges applicable to investor-owned utilities.

For every investment made in a capital asset, the owner company commits itself to a program of payments over the life of that asset. These payments, or charges against income which the company expects to realize from its investment, are generally fixed in nature, related only to the actual initial investment, and independent of the actual usage of the asset. These payments are commonly called fixed charges (also referred to as annual or carrying charges) and represent the absolute minimum revenue requirements which the investment must command.

Because the investment in plant is recovered over its life by periodic depreciation or amortization charges, the net investment declines and consequently the fixed charges, as a percent of initial investment, vary from year to year. Therefore, it is convenient to know a "levelized" fixed charge value, which will incorporate not only the actual year by year values of fixed charges, but also the time variance in payments. This levelized annual value (or uniform annual equivalent) permits the engineer

The fixed charges on investment plus operating and maintenance expenses represent the total revenue requirements needed to support the project, and can, therefore, be used for economic comparisons of alternative investment plans. The plan having the smallest revenue requirement yields the lowest costs to the consumer or, where income is fixed, the greatest net return for the company.

Fixed charges include the following basic items:

1. Return on investment - and/or - cost of borrowed money.
2. Depreciation - or - amortization - or - repayment of principal.
3. Taxes on income.
4. State and local taxes
5. Insurance
6. Interim replacements.

Since the components of fixed charges are all related only to the initial investment, it is usually more convenient to work with fixed charge rates rather than actual dollars. The levelized annual rate, consisting of the summation of individual rates in the above areas and levelized by present-worth methods, can then be applied to the alternative investments to yield the uniform annual equivalent total fixed charges in dollars.

The concept of capital recovery encompasses the first two components of fixed charges tabulated above, namely return on investment (rate of return) and depreciation, commonly referred to as interest and principal respectively. The capital recovery rate is a levelized annual charge and is a function of the weighted rate of return and the life of the asset (book life for accounting purposes).

It is calculated from the expression $\frac{R\ (1 + R)^n}{(1 + R)^n - 1}$ where "R" is the rate of return expressed as a decimal and "n" is the life of the asset in years. Capital recovery factors are tabulated in many interest tables. The factor gives that annual charge which would pay all cost of money and fully recover the invested capital over the life of the asset in equal payments. Again using the money pool concept, any schedule of payments which accomplishes the same results over the same period will have the same present-worth as the uniform annual payment schedule. For instance, the capital recovery factor for 3.50 percent and 30 years is 0.0544. This means that a payment of $5.44 per $100 of investment, made each year for 30 years, would fully support return plus depreciation.

Now for the same case, consider paying interest on the full investment each year, and putting an amount into the interest-bearing money pool such that at the end of 30 years we could withdraw $100 to retire the principal. That annual deposit can be calculated from the expression $\frac{R}{(1 + R)^n - 1}$ which is called a sinking fund factor. For our example, it comes out to be 0.0194 or $1.94 per $100 of investment. Therefore, the total $5.44 annual capital recovery can be considered to consist of:

$3.50 (3.50%)	return
+ 1.94	sinking fund depreciation
$5.44	annual capital recovery

On the other hand, we may choose to retire the $100 principal in 30 equal annual installments of $3.33, which represents a straight line depreciation rate of 3.33 percent ($\frac{1}{n} = \frac{1}{30}$ = 0.033). It is now necessary to pay interest or return on only the net investment (outstanding balance). The interest payments therefore decrease annually as shown below:

Year	Net Investment	Interest at 3.50%
1	$100.00	$3.50
10	70.00	2.45
20	36.67	1.28
30	3.33	0.12

If we compute the present-worth of all interest payments over the full 30 years, and then the uniform annual interest, the levelized payment is $2.11. Therefore, the $5.44 annual capital recovery can be considered to consist of:

$2.11 (2.11%)	levelized return
+ 3.33	straight line depreciation
$5.44	annual capital recovery

However, the more common presentation is in the former format, i.e., return plus sinking fund depreciation.

In summary, it can be demonstrated that any pay-back schedule results in the same levelized annual total for return plus depreciation which is readily found by using the capital recovery factor.

The various components of fixed charges as they apply to private (investor owned) utilities, are discussed in Section B.2.

B.2 INVESTOR-OWNED UTILITIES

B.2.1 Return

The weighted rate of return is the average cost of money to the utility and is a composite of interest on debt and earnings for equity. Debt money comes from bondholders, while equity money is supplied by the stockholder. For a particular project, the economic analysis must be based on the average capital structure of the company, since in actual operation the investment under study will become just a part of total investment in the business.

For investor-owned utilities a 50/50 debt-equity ratio is not uncommon, and the range of 40/60 to 60/40 probably includes most companies. Most indentures of trust limit the debt to not more than 2/3 of added property. In some states, the percentage of total capital raised by debt is limited by law. State and Federal Regulatory Commissions also have some control.

Having established the debt-equity ratio, the interest or earnings on each component must be determined. Here the bond interest rate, to be used in studies, must be that which would have to be paid for new bonds, not an average of all outstanding debt, which might be considerably lower. The interest rate must also be commensurate with risk, i.e., a company with traditionally high debt financing will require the bondholders to incur higher risk, and they in turn will command higher rates. Equity earnings must also reflect the risk involved, and must be in proper perspective to debt interest. The weighted rate of return, illustrated in the example below, must also be checked for its reasonableness. In practice, return of the regulated electric utility industry is controlled within rather close limits.

EXAMPLE OF WEIGHTED RATE OF RETURN
(Without Inflation)

Capitalization Ratios[(2)] (Average 1955-1978)	Calculated Required Yields[(3)] Without Inflation (Average 1955-1978)	Weighted Rate Of Return (Average 1955-1978)	
52.6% Bonds	2.5%	0.013	Debt
10.9% Preferred Stock	2.7%	0.003	Equity
36.5% Common Stock	5.1%	0.019	Equity
	Total:	0.035 or 3.5%	

(2) Capitalization Ratios

Ratios were obtained from DOE/EIA-0044, "Statistics of Privately Owned Electric Utilities in the United States - 1978 and earlier editions," for the years 1955-1978 and averaged.

(3) Calculated Required Yields Without Inflation

Required yields without inflation were calculated for each year over the period 1955-1978 and averaged, for bonds, preferred stock and common stock. The sources of the data, and the procedure used for calculating the yields without inflation are as follows:

a) Bond and Preferred Stock Yields (With Inflation)

Yields with inflation were obtained from "Moody's Public Utility Manual -1979;" Table entitled "The Market For New Utility Capital" page a3 for the year 1955-1978.

b) Common Stock Yields (With Inflation)

Total yields with inflation were calculated from the following expression for the years 1955-1978:

$$\text{Total Yield With Inflation} = \frac{D}{P} + g$$

where: $\frac{D}{P}$ is the dividend divided by market price per share

g is the expected growth in dividend per year, which equals (Retained Earnings) ÷ (Book Value)

The data necessary for calculations, such as Market Prices, Earnings, Dividends, Payout Ratios and Book Values were obtained from "Moody's Public Utility Manual - 1979," Tables entitled "Utility Common Stocks - End-of-Month Averages," page a10, and "Selected Statistics On Moody's 24 Electric Utilities," pages a12 and a13.

c) <u>Calculating Yields Without Inflation</u>

The above Bond, Preferred Stock and Common Stock yields with inflation were converted to yields without inflation by the following expression:

Yield Without Inflation = $(1 + d)/(1 + i) - 1$

where: d is the yield with inflation

i is the annual rate of general inflation as measured by the implicit price deflator (IPD) for gross national product, obtained from "Business Statistics," 1979 edition, U.S. Department of Commerce/Bureau of Economic Analysis, for years 1955-1978.

B.2.2 Depreciation

Depreciation or amortization represents retirement of principal. For book purposes (plant valuation), property is depreciated lineraly over its book life. This straight line method can be represented by an annual charge at the rate of $\frac{1}{n}$, as discussed earlier, or in levelized form by the appropriate sinking fund factor. The life selected should be the best estimate of life expectancy considering both physical deterioration and economic obsolescence factors. Commonly used lives of fossil-fired and nuclear plants are approximately 30 years. In comparison, hydroelectric installations are often assigned lives of 40 to 50 years or more.

Some components of the total investment cost of a generating plant are for non-depreciable property, the prime example of which is land. In some very detailed economic studies the cost of land and other non-depreciable components of capital investment, such as materials and supplies and working capital, are segregated and are handled by a different fixed charge rate, which does not include depreciation and hence does not decline over the years. However, in many economic studies this distinction is not made, because the resulting error is not significant unless land is responsible for an unusually high percentage of the total capital cost.

B.2.3 Taxes on Income

Of the revenue required to cover fixed charges, all components, except equity earnings, are expense items which are deductible from gross income for income tax purposes. However, to any requirement of revenue for equity earnings must also be added the necessary revenue to pay the income tax. For example, at the present corporate federal income tax rate of 46 percent, it would take

$100 in gross revenue to net $54 of equity return. Each year federal income tax liability declines with net investment. The levelized annual income tax rate can be calculated from the levelized equity earnings, as shown below in an example using previously cited sample data:

$$\bar{t} = \frac{T}{(1 - T)} \left(CRF - \frac{1}{n}\right) \left(\frac{R - bi}{R}\right)$$

where T = federal income tax rate, here 0.46

and where $\left(CRF - \frac{1}{n}\right)$ = levelized return, computed previously as the difference between capital recovery factor and straight line depreciation rate, here 5.44 - 3.33 = 2.11 for 3.50 percent return and 30 year life.

and where $\left(\frac{R - bi}{R}\right)$ = the fraction of levelized return which is equity earnings.
R = overall return, here 0.035
b = bond ratio, here 0.526
i = bond interest, here 0.025

Levelized income tax $\bar{t} = \left(\frac{0.46}{0.54}\right) (0.0211) \left(\frac{0.035 - 0.0132}{0.035}\right) = 0.0112$ or 1.12%

State income taxes, where applicable, can generally be handled in a similar fashion, as can any other taxes on income. Calculations often can be simplified by working with a composite tax rate which is the sum of federal plus state plus other income tax rates. In this study, however, "Taxes on Income" are restricted to federal taxes only.

While the industry almost universally uses the straight-line method for book depreciation, liberalized or accelerated depreciation methods are commonly used for tax purposes. These methods do not reduce the total tax dollars paid over the life of the asset, but they do lead to reduction of the levelized annual tax charge by deferring some of the taxes in the early years to later payments. There are two commonly used methods of calculating accelerated tax depreciation. They are sum-of-years-digits (SYD) and double rate declining balance (DRDB or DDB).

With SYD, the annual tax depreciation rate is a fraction whose denominator is the summation of all the numbers from one to plant life in years. The numerators decrease from plant life in years down to one. For 30 years, $\Sigma_1^{30} n = 465$. Therefore, the first year depreciation rate is $\frac{30}{465}$ second year $\frac{29}{465}$ ...down to $\frac{1}{465}$ in the last year. It is obvious that

$$\frac{30}{465} + \frac{29}{465} + \frac{28}{465} + \cdots + \frac{3}{465} + \frac{2}{465} + \frac{1}{465} = 100\%$$

Double declining balance tax depreciation is calculated each year as twice the straight line rate times net investment. For example, for 30 years life, the normal straight line rate is $\frac{1}{30}$ = 3.33 percent and the DDB rate is 6.67 percent. The computation procedure is as follows:

Year	Net Investment - %	DDB Depreciation - %
1	100.00	6.67
2	93.33	6.23
3	87.10	5.81
4	81.29	5.42

If this computation were continued for 30 years, the summation of annual depreciation entries in the DDB column will not yield 1.00 or 100 percent. It is therefore necessary to switch to the straight line method about halfway through plant life.

There are rather complex formulae for computing the levelized annual value of accelerated depreciation. These are presented in the sample calculations at the end of this discussion in Section B.3. Also given is a formula, which is used to levelize income tax using previously calculated levelized accelerated depreciation. The tax formula reflects the fact that the tax saving attributable to accelerated depreciation is $\frac{T}{1 - T}$ times the difference between straight line and the levelized annual tax depreciation.

The federal investment tax credit (10 percent of qualified investment deductible from income tax in the first year only) also produces a slight reduction in the levelized income tax charge. This reduction is calculated as the annual capital recovery of the present worth of the 10 percent credit in year one, and is calculated to be 0.0039 or 0.39 percent as shown in Section B.3.4.

Calculation of fixed charges on a flow-through basis (benefits passed on to consumers), incorporating liberalized tax depreciation and the 10 percent credit as used by most companies, yields minimum revenue requirements since the income tax component is reduced.

B.2.4 State and Local Taxes

There are a variety of other types of taxation which are encountered in the investor-owned utilities industry. The more important ones are property, franchise and gross revenue taxes. Property taxes are levied by the local community, and the rate is applied to the original (undepreciated) value of the asset.

In several of the states where the franchise tax is paid, the levy is on net income. Therefore, it is treated as a state income tax, which has been discussed previously.

The gross revenue or gross receipts tax, on the other hand, is levied on all revenue which the utility collects without deductions or exemptions. The tax then is a revenue requirement in itself, and when used must be added to the subtotal of all other fixed charges. It must be noted that unlike other types of taxation, the gross receipts tax revenue requirement must also be added to operation, maintenance and fuel expenses in economic studies. However, since in comparison of alternatives, the effect of a gross revenue tax is to increase the differential costs between plans by the tax rate percentage, it is sometimes handled just that way, instead of carrying it through individual plan fixed charge rate and operating expense calculations.

The fixed charge rate of 2.56 percent for state and local taxes, shown in Section B.2.7, is based upon information reported in DOE/EIA-044(78), "Statistics of Privately Owned Electric Utilities In The United States - 1978." It is an average for the years 1972 through 1978 (the last seven years of published data), and does not reflect the effects of general inflation over the life of the plant.

B.2.5 Insurance

Insurance coverage for power plants include both property damage and public liability. Liability coverage is not directly related to plant investment and is therefore included in O&M costs.. The fixed charge rate of 0.06 percent for property damage, shown in Section B.2.7, is based upon data reported in DOE/EIA-0044(78). It is an average of the ratios of the property insurance paid by privately-owned utilities to their total investment in plant and equipment, for the years 1972 through 1978.

In total, annual charges for insurance usually amount to less than one percent of the capital investment, and in some cases are even considered negligible in developing the total fixed charge rate.

B.2.6 Interim Replacements

Some utilities include a rate for interim replacements in their fixed charges. The charges represent large expenditures for replacing major equipment components of the asset during its life, where failure of such components would impair the integrity of the asset. Interim replacement charges, as used here, do not include normal maintenance costs or cost of additions made after the original construction. When used, the most commonly applied rate is 0.35 percent annually, which is based upon fossil-fueled power station experience. Long term experience upon which to base the value of this allowance for nuclear plants is lacking. However, it is believed that the 0.35 percent value is conservative for them, since safety-related nuclear components are subject to more stringent design specifications and quality control inspections.

The fixed charge rate of 0.35 percent for interim replacements, shown in Section B.2.7, does not reflect the effects of general inflation over the life of the plant.

B.2.7 Typical Fixed Charges for Investor-Owned Utility Nuclear and Fossil Power Generating Stations

While it has been stated that there is in essence no such thing as an "average" fixed charge rate, it is nevertheless recognized that such a value is often desired. In this case, an inflation-free value of 8.67 percent, subject to additions and adjustments based upon the particular area or project under consideration, is suggested for a privately-owned utility. The levelized 8.67 percent rate (without inflation) is made up as follows:

Return:	52.6% Bonds	@ 2.5% =	1.3
	10.9% Preferred Stock	@ 2.7% =	0.3
	36.5% Common Stock	@ 5.1% =	1.9
	Weighted Rate of Return		3.5 percent
	Depreciation (30 year sinking fund)		1.94
	Federal Income Tax (including 10% credit and based on SYD depreciation)		0.26
	State and Local Taxes		2.56
	Insurance		0.06
	Interim Replacements		0.35
			8.67 percent

B.3 FORMULAE AND SAMPLE CALCULATIONS FOR LEVELIZED VALUE OF ACCELERATED TAX DEPRECIATION

Note: All sample calculations are based on the following parameters:

3.5% Weighted Rate of Return	(R = .035)
52.6/47.4 Debt/Equity Ratio	(b = .526) (Debt/Capital Structure Ratio)
2.5% Bond Interest	(i = .025)
30 Year Life	(n = 30)

B.3.1 Double Declining Balance (DDB) Depreciation

$$\bar{D} = SFF \left[\frac{\frac{2}{n}(CAF) + R \left(1 - \frac{2}{n}\right)^{n}}{R + \frac{2}{n}} \right]$$

Where: $\bar{D}$ = Levelized annual depreciation

SFF = Sinking fund factor (SFF = .194 from interest tables for 30 year life and 3.5 percent return)

n = Life (n = 30)

CAF = Single payment compound amount factor (CAF = 2.81 from tables)

R = Rate of Return (R = .035)

Sample calculation:

$$\bar{D} = .0194 \left[\frac{\frac{2}{30}(2.81) + .035 \left(1 - \frac{2}{30}\right)^{30}}{.035 + \frac{2}{30}} \right] = .0366 \text{ or } 3.66\%$$

B.3.2 Sum of Years Digits (SYD) Depreciation

$$\overline{D} = \frac{2\left(CRF - \frac{1}{n}\right)}{R\ (N + 1)}$$

Where: $\overline{D}$ = Levelized annual depreciation

CRF = Capital recovery factor (CRF = .0544) from interest tables for 30 year life and 3.5 percent return

n = Life (n = 30)

R = Weighted Rate Of Return (R = .035)

Sample calculation:

$$\overline{D} = \frac{2\left(.0544 - \frac{1}{30}\right)}{.035\ (30 + 1)} = .0388 \text{ or } 3.88$$

B.3.3 Federal Income Tax

$$\overline{t} = \frac{T}{1 - T}\left[R - d - \frac{bi}{R}\ (R - d_o)\right]$$

Where: $\overline{t}$ = Levelized annual federal income tax

T = Federal income tax rate (T = .46) currently 46 percent

R = Rate of return (R = .035)

d = $\overline{D}$ - SFF or Difference between levelized depreciation for a particular method and sinking fund depreciation

b = Bond ratio (b = .526)

i = Bond interest rate (i = .025)

d_o = $\frac{1}{n}$ - SFF or Difference between straight line and sinking fund depreciation

Sample calculations:

A. With straight line tax depreciation (not accelerated)

$$d = d_o = \frac{1}{n} - SFF = \frac{1}{30} - .0194 = 0139$$

$$\bar{t} = \frac{.46}{1 - .46}\left[.035 - .0139 - \frac{(.526)(.025)}{.035}(.035 - .0139)\right] = .0112 \text{ or } 1.12\%$$

B. With double declining balance tax depreciation

$$d = \bar{D} - SFF = .0366 - .0194 = .0172$$

$$d_o = \frac{1}{n} - SFF = .0139 \text{ as above}$$

$$\bar{t} = \frac{.46}{1 - .46}\left[.035 - .0172 - \frac{(.526)(.025)}{.035}(.035 - .0139)\right] = .0084 \text{ or } 0.84\%$$

C. With SYD tax depreciation

$$d = \bar{D} - SFF = .0388 - .0194 = .0194$$

$$d_o = \frac{1}{n} - SFF = .0139 \text{ as above}$$

$$\bar{t} = \frac{.46}{1 - .46}\left[.035 - .0194 - \frac{(.526)(.025)}{.035}(.035 - .0139)\right] = .0065 \text{ or } 0.65\%$$

B.3.4 Levelized Effect of 10 Percent Investment Tax Credit in First Year

$$\bar{t}_c^{(4)} = .10\ (PWF_1)\ (CRF)\ (.75)$$

Where: $\bar{t}_c$ = Levelized effect of 10 percent tax credit in year one

PWF_1 = Single payment present-worth factor for year one

CRF = Capital recovery factor

.75 = Portion of investment qualified for investment tax credit

$$\bar{t}_c = .10\ \frac{1}{1.035}\ (.0544)(.75) = .0039 = 0.39\%$$

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(4) At times a before tax investment tax credit is utilized to offset the levelized annual federal income tax component of the fixed charge rate. This has the effect of slightly reducing the fixed charge rate.

B.3.5 Summary of Sample Calculations

Tax Depreciation Method	Levelized Annual Depreciation in Percent	Levelized Annual Federal Income Tax in Percent		
		Tax	10% Credit in Year 1-Levelized	Net Tax
	$\bar{D}$	$\bar{t}$	$\bar{t}_c$	$\bar{t} - \bar{t}_c$
Straight Line	3.33	1.12	0.39	0.73
Double Declining Balance	3.66	0.84	0.39	0.45
Sum of Years Digits	3.88	0.65	0.39	0.26

APPENDIX - C1

PHASE IV FINAL REPORT AND FOURTH UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

APPENDIX C1

TECHNICAL MODEL INITIAL UPDATE

This appendix contains Sections 5.4.1 through 5.4.9 (pages 5-4 through 5-23) of the "Final Report and Initial Update of the Energy Economic Data Base (EEDB) Program-Phase I", UE&C-DOE-790930. The purpose of including this material in the "Phase IV Final Report and Fourth Update of the Energy Economic Data Base (EEDB) Program" is to provide a convenient reference to the changes made to the Base Data Studies and Reports during the Initial Update (1978). Appendices C2 and C3 contain similar material for the Second and Third Updates respectively.

5.4.1 EEDB Model Number A1, Model Type BWR, EEDB Initial Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - Boiling Water Reactor Plant (NUREG-0242, COO-2477-6)

ACCOUNT 214 Security Building

Plant security is revised to meet the requirements of Regulatory Guide 1.17, "Protection of Nuclear Plants Against Industrial Sabotage" (Revision 1, 6/73). The security building and upgraded security system are added to meet plant physical security requirements as currently interpreted by UE&C. The building provides a controlled means of access to the plant to prevent industrial sabotage or the theft of nuclear materials. It is a reinforced concrete, Seismic Category I, structure located at grade. The building is 53 feet wide, 63 feet long and one story or 20 feet high, with a volume of approximately 66,800 cubic feet.

The upgraded security system costs are included in Account 253.22.

ACCOUNT 218A Control Room/Diesel-Generator Building

The control building and electrical tunnels are modified to meet the requirements of Regulatory Guide 1.120, "Fire Protection Guidelines for Nuclear Power Plants" (Revision 1, 11/77). The control building is modified by adding a fourth floor above the control room for cable spreading. This modification provides over and under cable spreading areas for the control room which allows each electrical channel to have its own spreading area separated by three-hour rated fire walls. The electrical tunnels are also modified to separate each channel with three-hour rated fire walls.

ACCOUNT 218T Ultimate Heat Sink Structure

The ultimate heat sink basin capacity is increased from 7 to 30 days storage to meet the requirements of Regulatory Guide 1.27, "Ultimate Heat Sinks for Nuclear Power Plants" (Revision 2, 1/76). No change is made to the superstructure which includes the north and south bays and cooling towers.

ACCOUNT 224 Radwaste Processing

The liquid, gaseous and solid waste systems are upgraded to improve system performance and operability.

ACCOUNT 225 Fuel Handling and Storage

The spent fuel pool cooling system is changed from one loop with redundant components to two separate redundant loops. This revision is made to preclude the loss of spent fuel pool cooling in the event of a pipe or valve failure in a single loop.

ACCOUNT 226 Other Reactor Equipment

The boron recycle system is upgraded, consistent with changes made to the liquid radwaste system (see Account 224 above), to improve system performance and operability.

ACCOUNT 234 Feed Heating System

The two turbine driven boiler feed-water pumps are increased from 57 percent capacity to 80 percent capacity each to prevent reactor trip from the loss of one pump.

ACCOUNT 252 Air, Water and Steam Service System

The plant fire protection system is modified to meet the requirements of the additional floor in the control building and additional separation in the electrical tunnels (see Account 218A above).

ACCOUNT 253 Communications Equipment

The communications system is modified to meet the requirements of the additional floor in the control building and additional separation in the electrical tunnels (see Account 218A above). The security system is revised to meet the requirements of Regulatory Guide 1.17 (see Account 214 above).

5.4.2 EEDB Model Number A2, Model Type HTGR, EEDB Initial Update

Base Data Study: 3360 MWt HTGR-Steam Cycle Reference Plant Design (General Atomic Company-SC 558623)

ACCOUNT 211 Yardwork

The Yardwork account is modified to adjust for the "Middletown" site conditions described in Appendix A-1 and a single unit design versus the first of two units design of the Base Data Study. Excavation quantities are changed to reflect a rock site from the firm soil site of the Base Data Study.

ACCOUNT 214 Security Building

Same as subsection 5.4.1, BWR, Account 214 modification.

ACCOUNT 215 Reactor Service Building, ACCOUNT 217 Fuel Storage Building ACCOUNT 218E Helium Storage Area, ACCOUNT 218I Access Building, ACCOUNT 218S Holding Pond, ACCOUNT 261.1 Makeup Water Intake and Discharge Structures

These structures are reduced in size to reflect a single unit design. Fuel storage is set at 0.3 core in containerized fuel modules.

ACCOUNT 224 Radwaste Processing, ACCOUNT 225 Nuclear Fuel Handling and Storage

These systems and components are reduced in size and/or number to reflect a single unit design.

ACCOUNT 226 Other Reactor Plant Equipment

The helium storage and transfer system is reduced in size to reflect a single unit design. The nuclear service water cross connection between Units 1 and 2 is deleted.

ACCOUNT 233 Condensing System

The bulk chemical storage tanks for the condensate polishing system are reduced in capacity to reflect a single unit design.

ACCOUNT 24 Electric Plant Equipment

Offsite power connections are changed from 345 kV and 115 kV to 500 kV and 230 kV respectively.

ACCOUNT 252 Auxiliary Water and Steam Service System

The auxiliary steam system interconnecting piping between Units 1 and 2 is deleted.

5.4.3 EEDB Model Number A3, Model Type PWR, EEDB Initial Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - Pressurized Water Reactor Plant (NUREG-0241, COO-2477-5)

ACCOUNT 214 Security Building

Same as subsection 5.4.1, BWR, Account 214 modification.

ACCOUNT 218A Control Room/Diesel-Generator Building

Same as subsection 5.4.1, BWR, Account 218A modification.

ACCOUNT 218T Ultimate Heat Sink Structure

Same as subsection 5.4.1, BWR, Account 218T modification.

ACCOUNT 224 Radwaste Processing

Same as subsection 5.4.1, BWR, Account 224 modification. Additionally, a flash tank and pumps are added to the steam generator blowdown system to balance steam flow rates from the steam generators.

ACCOUNT 225 Fuel Handling and Storage

Same as subsection 5.4.1, BWR, Account 225 modification.

ACCOUNT 226 Other Reactor Plant Equipment

Same as subsection 5.4.1, BWR, Account 226 modification.

ACCOUNT 234 Feed-Heating System

Same as subsection 5.4.1, BWR, Account 234 modification.

ACCOUNT 252 Air, Water and Steam Service System

Same as subsection 5.4.1, BWR, Account 252 modification.

ACCOUNT 253 Communications Equipment

Same as subsection 5.4.1, BWR, Account 253 modification.

5.4.4 EEDB Model Number A4, Model Type PHWR, EEDB Initial Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - Pressurized Heavy Water Reactor Plant (COO-2477-13)

ACCOUNT 211 Yardwork

Excavation quantities are reduced to reflect replacement of PWR scaled buildings with unique PHWR design buildings.

ACCOUNT 212 Reactor Containment Building, ACCOUNT 215 Reactor Service and Fuel Handling Building

Material quantities are revised to reflect replacement of PWR scaled buildings with unique PHWR design buildings.

ACCOUNT 214 Security Building

Same as subsection 5.4.1. BWR, Account 214 modification.

ACCOUNT 218A Control Room/Diesel-Generator Building

Same as subsection 5.4.1. BWR, Account 218A modification.

ACCOUNT 218T Ultimate Heat Sink Structure

Same as subsection 5.4.1. BWR, Account 218T modification.

ACCOUNT 23 Turbine Plant Equipment, ACCOUNT 24 Electric Plant Equipment, ACCOUNT 25 Miscellaneous Plant Equipment, ACCOUNT 26 Main Condenser Heat Rejection System

System design is revised to reflect replacement of PWR designs with unique PHWR designs based on ongoing DOE studies.

5.4.5 EEDB Model Number B1, Model Type GCFR, EEDB Initial Update

Base Data Study: Capital Cost - Gas Cooled Fast Reactor Plant (COO-2477-16)

ACCOUNT 212 Reactor Containment Building

Design of secondary containment is modified to improve constructibility and decrease cost.

ACCOUNT 214 Security Building

Same as subsection 5.4.1, BWR, Account 214 modification.

ACCOUNT 222 Main Heat Transfer System

Estimate for manhours to install steam generators is improved.

ACCOUNT 223 Safeguards Cooling System

Design conservatism is reduced to reflect current practice by replacing two 100 percent pumps in each of two loops of the Core Auxiliary Cooling Water (CACW) system with one 50 percent pump per loop.

ACCOUNT 226 Other Reactor Plant Equipment

Design of Reactor Plant Cooling Water (RPCW) system is improved to reflect current practice by adding one RPCW heat exchanger.

ACCOUNT 227 Instrumentation and Control

Instrumentation and Control quantities are revised to reflect current practice for reactor plant diagnostic and instrumentation tubing.

ACCOUNT 233 Condensing System

Instrumentation and Control material and labor manhours for the condensate polishing system are reduced to reflect current practice.

ACCOUNT 234 Feed Heating System

Design conservatism is reduced to reflect current practice by deleting one of four emergency feed-water pumps and drives. Labor manhours for installation of a booster pump is increased to provide technical model consistency.

ACCOUNT 237 Turbine Plant Miscellaneous Items

Pipe Insulation, Account 237.31, is deleted to provide technical model consistency and eliminate double accounting. Pipe insulation is included in the individual piping system accounts.

5.4.6 EEDB Model Number B2, Model Type LMFBR, EEDB Initial Update

Base Data Study: Technical Comparison of Prototype Large Breeder Reactor (PLBR) Phase II Competing Designs (31-109-38-3547)

In the case of the LMFBR, the Base Data Studies could not be used directly as for the other Nuclear Plant Models for the following reasons:

1. PLBR Phase II Competing Designs were not structured in a uniform code-of-accounts for either technical or cost tabulation.
2. PLBR Phase II Competing Designs varied widely and were, therefore, difficult to compare or consolidate.
3. Quantities, commodities and costs varied widely and appeared to be overly conservative for an nth-of-a-kind plant when compared at the component level with other reactor types.

For the purposes of the EEDB Initial Update, it was desirable to include an LMFBR NPGS based on target costs of a commercially viable reactor, deployed in a time frame when the target goals have a high probability of being realized.

LMFBR NPGS Target Economics Philosophy

For the LMFBR NPGS to become an economically viable concept, certain cost criteria need to be met. Namely, the sum of the three cost factors contributing to energy cost (Capital, Fuel Cycle, and O&M) must combine to provide an energy cost equal to or less than competing forms of energy production.

The Light Water Reactor Nuclear Power Generating Station as represented by the PWR NPGS is chosen as the present competition for the LMFBR NPGS. The current EEDB goal is to eliminate cost over-conservatism and cost uncertainties which have prevailed over the past few years by developing a commercial cost estimate for a LMFBR NPGS, based upon an nth-of-a-kind unit, designed to commercial type nuclear standards and regulations. The year 2001 is selected as the target date when the LMFBR NPGS should become competitive. This date takes into account the present research and development requirements of the concept, as well as allowing for the predicted increase in the cost of uranium to a minimum value of \$62 per pound (in constant \$1978), where a break-even point is more likely.

A review of Tables 4-6 and 5-3 provides insight into the required relative target cost of the LMFBR vs. the PWR to achieve a m/kWh break-even energy cost. A goal of LMFBR NPGS capital cost equal to about 1.25 times the PWR cost is established. This ratio equates to a maximum delta of approximately 135 \$/kWe (in \$1978) by which the Base Construction Cost of a 3800 MWt LMFBR NPGS can exceed that of a PWR NPGS of the same thermal capacity.

To achieve these goals a set of target costs is established which, if met, would create a competitive LMFBR. The largest legally licensable plant (3800 MWt) is selected since the economy of scale will have a positive effect in achieving the goal. Basic ground-rules to govern the cost estimating are also established to ensure that the costs reflect a realistic commercial concept within the bounds of current regulations.

The method utilized to evaluate and control the costs is to compare the LMFBR cost estimates on a commodity basis, such as $\$/Ft^2$, \$/HP, etc., with that of the PWR. When a significant difference is noted without reasonable technical justification, additional attention is focused to bring the cost to a reasonable value. In this manner, costs estimated on an overly-pessimistic basis can be improved.

In future work, an effort should be made to define concept improvements, which although not necessarily licensable at the present time, can reasonably be assumed to be licensable by the year 2000. Items such as expansion joints instead of expansion loops in sodium piping and new cost saving materials need to be evaluated for further cost improvements.

LMFBR NPGS Cost Basis

To implement the Target Economics philosophy, a 1390 MWe, loop type, LMFBR central station power plant is selected for the study. Using the experience gained from the Base Data Studies, UE&C designed the Balance of Plant systems, and retained Combustion Engineering, Inc. to develop a Nuclear Steam Supply System, in accordance with the above philosophy.

The plant design incorporates a 3800 MWt (1390 MWe), 850°F, 2200 psig LMFBR Nuclear Steam Supply System, which is described in Combustion Engineering, Inc. Report CE-FBR-78-532, "NSSS Capital Costs for a Mature LMFBR Industry." A copy of this report may be found in Appendix D-1.

Further discussion of the Target Economics Philosophy for the LMFBR NPGS is included in Appendix D-2.

A plant size of 3800 MWt is selected to achieve the maximum benefit of economy of scale within the current regulatory limit. Other design features to minimize costs that are incorporated, within the limits of current regulatory requirements, are as follows:

- o The safety related NSSS buildings are clustered around the containment building and share a common base mat founded on rock.

- The reactor plant incorporates four primary and four secondary loops with four intermediate heat exchangers and four primary and four secondary pumps. Four primary loop check valves are located within the reactor vessel.

- The steam generation system is of the Benson Cycle type, utilizing two single wall tube steam generators for each of the four loops.

- The turbine plant consists of a cross-compound turbine with four double flow low pressure stages. The inlet conditions to the high pressure turbine are 850°F @ 2200 psia.

- The safety related decay heat removal function is fulfilled by two 100 percent Auxiliary Heat Transfer Systems which cool the primary sodium directly from the reactor vessel without requiring the primary loops to be operating.

- The secondary loops provide no emergency function and are classified non-nuclear downstream of the external isolation valves at the containment.

- The steam generators are classified as non-nuclear, and the steam generator buildings are non-Seismic Category I.

- Fuel handling is of the "under-the-head" type with 1/3 core storage inside the containment structure, isolated from the primary containment volume to permit fuel transfer during normal reactor operations.

- Guard vessels for the primary system have been eliminated by the utilization of filler block around the reactor vessel, and siphon breaker lines.

For the EEDB Initial Update sodium, NaK and Dowtherm inventories are not included.

<u>Results</u>

The LMFBR/PWR capital cost ($/kW basis) ratio goal of 1.25 is not realized during this first attempt at target economics. However, a cost ratio of 1.32 (refer to Table 5-3) is achieved. This ratio achieves a slightly lower than break-even cost for the LMFBR vs. the PWR, because a uranium cost of approximately $62 per pound (constant $1978) is used in the fuel cycle study for the year 2001. (Refer to Table 4-7)

5.4.7 EEDB Model Number C1, Model Type HS12, EEDB Initial Update
EEDB Model Number C3, Model Type LS12, EEDB Initial Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - High and Low Sulfur Coal Plants - 1200 MWe (Nominal) (NUREG-0243, COO-2477-7)

ACCOUNT 219 Stack Structure

The stack height is increased from 600 feet to 750 feet to meet the requirements of the Clean Air Act Amendments of 1977. The stack structure is changed from a brick to steel liner due to the increase in height.

ACCOUNT 223 Ash and Dust Handling System

The ash and dust handling systems are upgraded to improve system performance and operability.

ACCOUNT 233 Condensing Systems

The condenser design is upgraded to improve system heat rate.

Licensability

As discussed in subsection 4.5.1, these coal-fired power plants are not designed to meet the proposed revisions to the emission standards current on January 1, 1978. However, cost adders are given in subsection 4.5.1 to permit the adjustment of the EEDB Initial Update capital costs, to reflect the impact of including these proposed changes.

It should be pointed out, there is some doubt that coal-fired power plants designed to meet emission standards requirements current for January 1, 1978, can be sited where desired in all cases. The most desirable location may be a lightly to heavily industrialized area. For such sites, where topographical features are not optimum, there is a probability that additional capital expenditures may be required for the plant to remain in compliance continuously. Appendix D-3 addresses this subject in greater detail. No attempt has been made, during this initial update, to predict levels of potential additional capital expenditure requirements, because the emission standards are currently in a state of change.

5.4.8 EEDB Model Number C2, Model Type HS8, EEDB Initial Update
EEDB Model Number C4, Model Type LS8, EEDB Initial Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - Low and High Sulfur Coal Plants - 800 MWe (Nominal) (NUREG-0244, COO-2477-8)

ACCOUNT 219 Stack Structures

Same as subsection 5.4.7, HS12/LS12, Account 219 modification.

ACCOUNT 223 Ash and Dust Handling System

Same as subsection 5.4.7, HS12/LS12, Account 223 modification.

ACCOUNT 233 Condensing System

Same as subsection 5.4.7, HS12/LS12, Account 233 modification.

Licensability

Same as subsection 5.4.7, HS12/LS12, Licensability.

5.4.9 EEDB Model Number D1, Model Type CGCC, EEDB Initial Update

Base Data Study: Study of Electric Plant Applications for Low Btu Gasification of Coal for Electric Power Generation (FE-1545-59)

The technical description and cost estimate for the coal gasification power plant are based on a conceptual balance-of-plant study performed by UE&C for Combustion Engineering, Inc. This study has been extended to a complete plant under the Energy Economic Data Base program. Combustion Engineering provided costs and design data for several systems.

Combustion Engineering has been developing this concept since 1970, supported in part by the Department of Energy and the Electric Power Research Institute. A process demonstration unit is now operating, and demonstration plant preliminary designs are being prepared.

Except for the gasification process unit and the gas turbines, all plant components are readily available commercial equipment which are commonly used in power plants or natural gas processing facilities. The gasifier itself is very similar to pulverized coal-fired boilers. The gas turbines utilize current technology but are not now on the market. Because the plant produces elemental sulfur as a by-product, the environmental effects are significantly less than direct coal-fired plants with SO_2 scrubbers.

Technical Description

This plant is a combined cycle electric power plant which is fired by gasified coal. The coal is gasified in an air-blown, entrained bed gasifier. The resulting gas, which has a low heating value, is cleaned and the sulfur is removed using the Stretford process. The clean gas is compressed and burned in gas turbines, which generate a total of 283 MWe. The exhaust gas from the gas turbines passes through waste heat boilers to produce steam, which drives a 372 MWe steam turbine-generator. The net plant output is 630 MWe.

The net station heat rate is 8250 Btu/kWh. Plant thermal efficiency is about 41 percent.

Coal Handling System

The coal handling system is standard for a power plant of this size. Railroad cars dump to a hopper-type unloader. The coal is stacked out, reclaimed by lowering wells, crushed, and pulverized. Thaw sheds, car shakers, and distribution and sampling systems are included. Coal storage space holds a 90-day reserve.

The plant uses 195 tons per hour of Pittsburgh Steam coal (13,480 Btu/lb-Dry, 2.6 percent sulfur, 2.4 percent moisture). However, the entrained bed gasifier can handle most types of coal.

Ash Handling System

The ash handling system is a standard system handling 18 tons per hour of molten slag.

Gasifier

The two gasifiers are air-blown, entrained bed gasifiers. They are similar to standard water-wall boilers and have superheater and reheater sections. The gasifier provides about one-half of the steam produced in the plant.

The gasifier produces 2.3 million pounds per hour of fuel gas, a mixture of carbon monoxide, carbon dioxide, methane, hydrogen, and nitrogen. Sulfur in the gas is 90 percent H_2S and 10 percent carbonyl sulfide (COS). The heating value of the gas is assumed to be about 110 Btu/SCF, although recent pilot plant data has been reported in the 120 to 140 Btu/SCF range.

Gas Clean-up System

Cyclones remove most of the particulates in the raw gas, which are recycled into the gasifier. Fine cleaning is accomplished with a wet scrubber, with wastes recycled to the gasifier. The H_2S is then removed by the Stretford process. About 90 tons per day of elemental sulfur are produced, with a small waste stream, which is also recycled to the gasifier.

In this plant, the COS is burned with the fuel gas, producing SO_2 which is released. Because only 10 percent of the sulfur occurs as COS, the plant will comply with regulations requiring 90 percent sulfur removal. If this level of SO_2 removal violates future regulations, the COS can be shifted to H_2S before Stretford processing.

Gas Turbine-Generators

Four gas turbine-generator units compress and burn the fuel gas, with a net output of 70.8 MWe each. The gas turbines are rated at an inlet temperature of 2200°F, which is somewhat higher than currently available turbines. Reducing the inlet temperature would cause a reduction in plant efficiency.

Waste Heat Boilers

Four waste heat boilers convert the exhaust heat to steam. Primary steam production is about 500,000 lb/hr at 2600 psig and 1000°F. Reheat to 1000°F is included, and low pressure steam is produced in another section.

Steam Turbine-Generator

The standard steam turbine-generator system produces 372 MWe. The design steam flow is 1.99 million pounds per hour, with a back pressure of 2.0 inches of mercury. The generator is rated at 410 MVA.

Cooling System

The main cooling system utilizes a wet, natural draft, hyperbolic cooling tower, approximately 300 feet in diameter and 400 feet high.

Waste Treatment

The waste treatment system handles the relatively small quantity of waste from the cooling and ash handling systems. The system includes filtration, neutralizing, and a sediment basin.

Economic Description

The costs estimated for the coal gasification combined cycle power plant are an extension of studies performed for DOE and EPRI by Combustion Engineering, Inc. United Engineers & Constructors Inc. estimated balance-of-plant costs for C-E.

The cost design basis is not entirely consistent with the other plants estimated for the EEDB Initial Update; however, the differences are considered to be negligible.

APPENDIX - C2

PHASE IV FINAL REPORT AND FOURTH UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

APPENDIX C2

TECHNICAL MODEL SECOND UPDATE

This appendix contains Sections 5.4.2.1, 5.4.2.2, 5.4.2, and 5.4.3 (pages 5-5 through 5-7 of the Phase II Final Report and Second Update of Energy Economic Data Base (EEDB) Program", UE&C/DOE-810430. The purpose of including this material in the "Phase IV Final Report and Fourth Update of the Energy Economic Data Base (EEDB) Program" is to provide a convenient reference to the changes made to the Base Data Studies and Reports and Initial Update (1978) modifications during the Second Update (1979). Appendices C1 and C3 contain similar material for the Initial and Third Updates respectively.

5.4.2 Specific Modifications

5.4.2.1 EEDB Model Number A5, Model Type LMFBR, EEDB Second Update

Base Data Study: NSSS Capital Costs for a Mature LMFBR Industry (Combustion Engineering, Inc. CE-FBR-78-532)

The NSSS for the Initial Update is based on the cost estimate provided by the Base Data Study. Due to limited time and funding, the Balance of Plant (BOP) for the Initial Update cost estimate is based on numerous assumptions and scaling of structure and system costs of other EEDB models.

The 1978 cost included 1/3 core fuel storage, and a scaled fossil plant type cross-compound turbine generator based on an estimated plant efficiency of 36.6%. Total net output was 1390 MWe.

For the EEDB Second Update, the entire plant was reviewed and a conceptual design prepared sufficient for detailed costing basis. Structures were designed where necessary, and commodities of all structures were determined. BOP systems were designed, as necessary, in sufficient detail for detailed cost estimates and mini-specification development.

The NSSS for 1979 was based on the Base Data Study, escalated to 1979 dollars. This also included a 1/3 core storage. The BOP was based on a steam cycle proposed by Brown Boveri. This steam cycle included a two stage steam reheat with a large tandem-compound turbine-generator with a plant efficiency of 38.3%. This increased the net electric output from 1390 MWe reported in the Initial Update cost estimate to 1457 MWe for the Second Update.

During the Second Update, a Topical Report was prepared on a new approach to the LMFBR Demonstration Program. The report discusses the feasibility of building a 1500 MWe demonstration LMFBR NPGS, utilizing a nominal 750 MWe conceptual design as an intermediate step. This report is presented in Appendix E.

The basic Target Economic philosophy, described in Appendix C, remains as the basis for the LMFBR NPGS cost estimate. The principle result of the effort described above is to expand the detail for the LMFBR Technical and Cost Models to the ninth-digit level of detail. This expansion provides a more detailed equipment list with mini-specifications, a more detailed cost breakdown and sufficient detail to provide a material and commodity tabulation.

5.4.2.2 EEDB Model Number D2, Model Type CLIQ, EEDB and Second Update

Base Data Study: Recycle SRC Processing for Liquid and Solid Fuels, Gulf Mineral Resources Company

This Model has been deleted from the EEDB because adequate data for an update is not available.

5.4.3 Ongoing Modifications

During the course of preparing the Second Update of the EEDB, it became apparent that modiciations were required for some of the Technical Models that would take more effort than could be allotted to the resources available for a single update. Consequently, these efforts are spread over Second and Third Updates but, although they are initiated in the Second

Update, the results will not be reported until the Third Update is completed

Among these efforts are the following:

- Replacement of the 3360 MWe HTGR NPGS (Model A2) with a smaller sized unit, consistent with the current thinking and emphasis of General Atomic Company and Gas Cooled Reactor Associates (a Utility Sponsored HTGR NPGS Development Group).

- Replacement of the 1162 MWe PHWR NPGS (Model A4) based on the Canadian CANDU design with a large PHWR NPGS based on a U.S. design.

- Continued upgrading of the LMFBR NPGS (Model A5) to reflect information contained in current commercialization studies, within the framework of the Target Economic approach, and to incorporate under-the-head refueling and one-and-one-third core storage.

- Evaluation of the Flue Gas Desulfurization system design for the High Sulfur Coal FPGS (Models C1 and C2), with respect to the revised New Source Performance Standards.

- Addition of the Flue Gas Desulfurization Systems to the Low Sulfur Coal FPGS (Models C3 and C4), to meet the revised New Source Performance Standards.

- Reevaluation of the major cost drivers which comprise 85% of the plant cost; specifically Structures, Nuclear Steam Supply Systems, Turbine-Generator Units, Piping Systems, and Electric and Instrumentation and Control Systems.

- Evaluation of installation labor hours to reflect the growing realization in the industry that these hours may be understated for NPGS.

APPENDIX - C3

PHASE IV FINAL REPORT AND FOURTH UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

APPENDIX C3

TECHNICAL MODEL THIRD UPDATE

This appendix contains Sections 5.4.2.1 through 5.4.2.11 (pages 5-6 through 5-28) of the "Phase III Final Report and Third Update of the Energy Economic Data Base (EEDB) Program", UE&C-DOE-810731. The purpose of including this material in the "Phase IV Final Report and Fourth Update of the Energy Economic Data Base (EEDB) Program" is to provide a convenient reference to the changes made to the Base Data Studies and Reports and the Initial and following updates during the Third Update. Appendices C1 and C2 contain similar material for the Initial and Second Update respectively.

5.4.2.1 EEDB Model Number A1, Model Type BWR, EEDB Third (1980) Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - Boiling Water Reactor Plant (NUREG-0242, COO-2477-6)

ACCOUNT 220A Nuclear Steam Supply System (NSSS)

The nuclear steam supply package is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 231 Turbine-Generator

The turbine-generator is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 233 Condensing Systems

The main condenser tube material is changed from 90-10 copper-nickel to stainless steel to reflect the current trend in BWR plant design.

ACCOUNT 241 Switchgear
ACCOUNT 242 Station Service Equipment
ACCOUNT 245 Electric Structures and Wiring Containers
ACCOUNT 246 Power and Control Wiring

The electrical distribution system is modified to support the changes to the main cooling towers (refer to Account 262).

ACCOUNT 262 Main Condenser Heat Rejection System/Mechanical Equipment

The design of the main cooling towers is changed to reflect current vendor capabilities and practice. The quantity and diameter of the towers are changed from three and 260 feet to two and 285 feet, respectively. The number of fans per tower is changed from 12 to 16.

5.4.2.2 EEDB Model Number A2, Model Type HTGR-SC, EEDB Third (1980) Update

The six loop, 3360 MWt, 1330 MWe HTGR NPGS is replaced in the Third Update with a four loop, 2240 MWt, 858 MW HTGR-SC (Steam Cycle) NPGS.

Considerable work has been performed during the last several years to improve the commercial viability of the HTGR concept. This work has been done by Gas Cooled Reactor Associates (GCRA), an electric utility consortium, in conjunction with General Atomic Company (GAC), and with the assistance of USDOE funding.

The decision to replace the six loop plant with the four loop plant in the EEDB is based on two facts. First, the ongoing GCRA work has rendered the EEDB six-loop model obsolete. Second, GCRA and GAC are currently concentrating their efforts on the smaller plant as the preferred concept. The basis for the EEDB four loop plant is the following study.

Base Data Study: The HTGR for Electric Power Generation - Design and Cost Evaluation (GCRA/AE/78-1)

The conceptual design and cost estimates described in this base data study are directly compatible with the EEDB Program. Therefore, the study results are directly incorporated into the EEDB with the following modifications to meet the EEDB groundrules and the revisions incorporated in the Third Update:

1. Minor modifications are made to transfer the conceptual design from an Eastern Pennsylvania site to the "Middletown" site.

2. Minor modifications are made to obtain conformance to the EEDB Code-of-Accounts.

5.4.2.3 EEDB Model Number A3, Model Type PWR, EEDB Third (1980) Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - Pressurized Water Reactor Plant (NUREG-0241, COO-2477-5)

ACCOUNT 220A Nuclear Steam Supply System (NSSS)

The nuclear steam supply package is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 231 Turbine-Generator

The turbine-generator is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 241 Switchgear
ACCOUNT 242 Station Service Equipment
ACCOUNT 245 Electric Structures and Wiring Containers
ACCOUNT 246 Power and Control Wiring

The electrical distribution system is modified to support the changes to the main cooling towers (refer to Account 262).

ACCOUNT 262 Main Condenser Heat Rejection System/Mechanical Equipment

The design of the main cooling towers is changed to reflect current vendor capabilities and practice. The quantity and diameter of the towers are changed from three and 250 feet to two and 285 feet, respectively. The number of fans per tower is changed from 12 to 16.

5.4.2.4 EEDB Model Number A4, Model Type PHWR, EEDB Third (1980) Update

The three loop, 3800 MWt, 1162 MWe CANDU type PHWR NPGS is replaced in the Third Update with a two loop 3800 MWt, 1260 MWe PHWR NPGS, specifically designed for U.S. siting.

This replacement is made to accommodate the desire of USDOE to meet the EEDB objective with alternatives based on U.S. designs sited in the contiguous United States. The study selected as the basis for this change is the following joint Combustion Engineering/United Engineers study, funded by USDOE.

Base Data Study: Conceptual Design of a Large HWR for U.S. Siting (Combustion Engineering, Inc. CEND-379)

The conceptual design and cost estimates described in this base data study are directly compatible with the EEDB Program. Therefore, the study results are directly incorporated into the EEDB with the following modifications to meet the EEDB groundrules and the revisions incorporated in the Third Update:

1. Modifications are made to replace refrigeration systems, used for primary, moderator and reactor plant service cooling, with conventional water systems.
2. Modifications are made in the Structural, Electric Plant and Miscellaneous Plant accounts to support the replacement of the refrigeration systems used for primary, moderator and reactor plant service cooling.
3. Modifications are made to increase the construction site labor manhours to approximately 17 manhours per kilowatt (Refer to Section 5.5.1)
4. The design of the main cooling towers is modified to reflect current vendor capabilities and practice.

5.4.2.5A EEDB Model Number B1, Model Type GCFR, EEDB Third (1980) Update - Deleted

Base Data Study: Capital Cost - Gas Cooled Fast Reactor Plant (COO-2477-16)

The Gas Cooled Fast Breeder Reactor NPGS is deleted from the data base in the Third Update.

The decision to make this deletion is based on two facts. First, the ongoing GCRA/GAC work on the HTGR, described in Section 5.4.2.2, has been incorporated into the GAC GCFR NPGS development, rendering the EEDB conceptual design obsolete. Second, the extensive revisions required to update the GCFR NPGS cannot be currently accommodated by the priorities set and the resources available for the EEDB Program.

5.4.2.5B <u>EEDB Model Number B1, Model Type HTGR-PS, EEDB Third (1980) Update</u>

An 1170 MWt, 150 MWe HTGR-PS (Process Steam Cogeneration) NPGS is added to the data base in the Third Update.

The decision to add the HTGR-PS NPGS is based upon the need to expand the data base into the area of nuclear cogeneration in general and process steam from HTGRs in particular. The basis for this additon is the following USDOE sponsored study.

Base Data Study: 1170 MWt HTGR Steamer Cogeneration Plant - Design and Cost Study (UE&C/DOE-800716)

The conceptual design and cost estimates described in this base data study are directly compatible with the EEDB Program. Therefore, the study results are directly incorporated into the EEDB with the following modifications to meet the EEDB groundrules and the revisions incorporated in the Third Update:

1. Minor modifications are made to transfer the conceptual design from an Eastern Pennsylvania site to the "Middletown" site.

2. Minor modifications are made to obtain conformance to the EEDB Code-of-Accounts.

3. Modifications are made to increase the construction site labor manhours to approximately 17 manhours per kilowatt (Refer to Section 5.5.1).

4. The design of the main cooling towers is changed to reflect current vendor capabilities and practice.

5.4.2.6 EEDB Model Number A5, Model Type LMFBR, EEDB Third (1980) Update

Base Data Study: NSSS Capital Costs for a Mature LMFBR Industry and Addendum (Combustion Engineering Inc. - CE-FBR-78-532 & CE-ADD-80-310)

ACCOUNT 211 Yardwork

The excavation for the nuclear island buildings is increased. The increase is the result of revisions to the nuclear island building plan and location of the base mat, 24 feet deeper in the ground (refer to Account 212).

ACCOUNT 212 Reactor Containment Building

The containment building is increased in overall height by 24 feet to provide additional space for miscellaneous equipment and the containment cell gas cooling systems (refer to Account 220A). In addition, the internal structure is revised to accommodate a larger reactor vessel, a reactor guard vessel, revised fuel handling, and the removal of the ex-vessel fuel storage tank (refer to Account 220A). The cylindrical portion of the containment has an inside diameter of 187 feet. It measures 227 feet from the top of the foundation mat to the springline of the dome. The inside height from the top of the mat to the dome is 274.5 feet. The gross volume of the containment is 7,100,000 cubic feet.

ACCOUNT 215 Reactor Service Building

The reactor service building is revised to accommodate an increased fuel handling requirement which includes the housing of a larger (1-1/3 core capacity) ex-vessel storage tank (refer to Account 220A). This building is increased in height to maintain compatibility with the containment building and to provide additional equipment space.

The major portion of the reactor service building is 146 feet high, abuts the containment and has one straight side of 131 feet, and the other side is 145 feet. The overall volume is 2,280 x 10^3 cubic feet.

ACCOUNT 218E Steam Generator Buildings

The steam generator buildings are revised to adjust the structures to account for an additional 24 feet of below-grade design. Overall height of the buildings remains unchanged (refer to Account 212).

ACCOUNT 218W Auxiliary Heat Transport System Bays

The bay adjacent to the reactor service building is revised to be compatible with the floor plans of the new reactor service building (refer to Account 215).

ACCOUNT 220A Nuclear Steam Supply System (NSSS)

This account is revised based on Combustion Engineering Report CE-ADD-80-310, "NSSS Capital Costs for a Mature LMFBR Industry - Addendum." A copy of this report is included in Appendix E. This revision includes a larger reactor vessel with internal downcomers and a reactor vessel guard-vessel. Also incorporated in this addendum is a revised fuel handling system with a 1-1/3 core fuel storage capability. The larger fuel storage vessel and guard-vessel are located in the reactor service building and replace the 1/3 core fuel storage vessel located in the reactor containment building in EEDB Phases I & II Conceptual design.

The primary sodium loop isolation valves are eliminated in the Third Update.

ACCOUNT 222 Main Heat Transfer Transport System

This account is revised to reflect the decrease in primary sodium loop piping which results from the increase in reactor vessel diameter (refer to Account 220A).

ACCOUNT 225 Fuel Handling

The fuel handling system installation is revised to reflect the changes in NSSS fuel handling equipment (refer to Account 220A). The ex-vessel storage tank (EVST) cooling system capacity is increased to accommodate the need to remove 1-1/3 core spent fuel decay heat.

ACCOUNT 226 Other Reactor Plant Equipment

The cell cooling systems are revised to conform to the latest NSSS configuration (refer to Account 220A). Two systems, the reactor head, and the machinery dome cooling systems are deleted. A system to cool the cell that contains the EVST sodium cooling system is added.

ACCOUNT 241 Switchgear
ACCOUNT 242 Station Service Equipment
ACCOUNT 245 Electric Structures and Wiring Containers
ACCOUNT 246 Power and Control Wiring

The electrical distribution system is modified to support the changes to the Nuclear Steam Supply System and the main cooling towers (refer to Accounts 220A and 262).

ACCOUNT 252 Air, Water And Steam Service System

The passive sodium fire protection systems are revised to reflect current technology.

ACCOUNT 262 Mechanical Equipment

The design of the main cooling towers is changed to reflect current vendor capabilities and practice. The number of cooling towers is changed from 3 to 2. The new towers are 285 feet in diameter and 35 feet to the fan deck. Each tower uses 16 - 33 foot diameter fans per tower.

5.4.2.7 EEDB ' 1 Number C1, Model Type HS12, EEDB Third (1980) Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - High and Low Sulfur Coal Plants - 1200 MWe (Nominal) (NUREG-0243, COO-2477-7)

ACCOUNT 220A Fossil Steam Supply Steam

The fossil steam supply system package is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 222 Draft System

The electrostatic precipitators (which are part of the draft system account) are upgraded to meet the 1979 New Source Performance Standards (NSPS) particulate limit of 0.03 pounds per million Btu heat input.

ACCOUNT 225 Flue Gas Desulfurization Structures

The flue gas desulfurization structures are modified to accommodate the upgraded flue gas desulfurization system (refer to Account 226).

ACCOUNT 226 Desulfurization Equipment

The flue gas desulfurization system is upgraded to meet the 1979 New Source Performance Standards sulfur dioxide (SO_2) limit of 0.60 pounds per million Btu heat input with SO_2 removal between 70% and 90%.

ACCOUNT 231 Turbine-Generator

The turbine-generator is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 241 Switchgear
ACCOUNT 242 Station Service Equipment
ACCOUNT 245 Electric Structures and Wiring Containers
ACCOUNT 246 Power and Control Wiring

The electrical distribution system is modified to support the changes to the precipitator, flue gas desulfurization system, and main cooling towers (refer to Accounts 222, 226 and 262).

ACCOUNT 262 Main Condenser Heat Rejection System/Mechanical Equipment

The design of the main cooling towers is modified to reflect current vendor capabilities and practice.

5.4.2.8 EEDB Model Number C2, Model Type HS8, EEDB Third (1980) Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - Low and High Sulfur Coal Plants - 800 MWe (Nominal) (NUREG-0244, COO-2477-8)

ACCOUNT 220A Fossil Steam Supply System

The fossil steam supply system package is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 222 Draft System

The electrostatic precipitators (which are part of the draft system account) are upgraded to meet the 1979 New Source Performance Standards (NSPS) particulate limit of 0.03 pounds per million Btu heat input.

ACCOUNT 225 Flue Gas Desulfurization Structures

The flue gas desulfurization structures are modified to accommodate the upgraded flue gas desulfurization system (refer to Account 226).

ACCOUNT 226 Desulfurization Equipment

The flue gas desulfurization system is upgraded to meet the 1979 New Source Performance Standards (NSPS) sulfur dioxide (SO_2) limit of 0.06 pounds per million Btu heat input with SO_2 removal between 70% and 90%.

ACCOUNT 231 Turbine-Generator

The turbine-generator is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 241 Switchgear
ACCOUNT 242 Station Service Equipment
ACCOUNT 245 Electric Structures and Wiring Containers
ACCOUNT 246 Power and Control Wiring

The electrical distribution system is modified to support the changes to the precipitator, flue gas desulfurization system, and main cooling towers (refer to Accounts 222, 226 and 262).

ACCOUNT 262 Main Condenser Heat Rejection System/Mechanical Equipment

The design of the main cooling towers is modified to reflect current vendor capabilities and practice.

5.4.2.9 EEDB Model Number C3, Model Type LS12, EEDB Third (1980) Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - High and Low Sulfur Coal Plants - 1200 MWe (Nominal) (NUREG-0243, COO-2477-7)

ACCOUNT 220A Fossil Steam Supply System

The fossil steam supply system package is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 222 Draft System

The flue gas ductwork arrangement is modified and the induced draft (I.D.) fan is upgraded to accommodate the addition of the baghouse and dry flue gas desulfurization system (refer to Account 226).

ACCOUNT 223 Ash and Dust Handling System

The fly ash system is modified to accommodate the increased number of pick-up points and dust loading associated with the dry flue gas desulfurization system (refer to Account 226).

ACCOUNT 225 Flue Gas Desulfurization Structures

The following structures associated with the baghouse and dry flue gas desulfurization system are added (refer to Account 226):

- Lime unloading building
- Lime preparation building
- Spray dryer supports and enclosures
- Baghouse supports and enclosures
- Waste product disposal and recycling structures.

ACCOUNT 226 Flue Gas Desulfurization System

A flue gas desulfurization system is added to comply with the 1979 New Source Performance Standards (NSPS) sulfur dioxide (SO_2) limit of 0.06 pounds per million Btu heat input with SO_2 removal between 70% and 90%.

The system is designed on the dry absorption principle, where lime slurry is injected into spray dryer absorbers. The SO_2 in the flue gas is absorbed by the lime slurry forming a powdery waste material which falls into the bottom of the spray dryer.

Fly ash and other particulates carried over are collected in a baghouse which provides particulate removal in compliance with the 1979 New Source Performance Standards (NSPS) limit of 0.03 pounds per million Btu heat input. (The baghouse replaces the electrostatic precipitator previously used.) Part of the SO_2 removal process also takes place in the baghouse.

The flue gas desulfurization system consists of the following major subsystems:

- Dry Lime Handling

  Pebble lime is received from bottom-dump rail cars into receiving hoppers. From the hoppers, it is conveyed to the storage silos and eventually to the lime preparation building. All transfer areas are equipped with fabric filters to collect fugitive dust.

- Lime Slaking

  Pebble lime is slaked in the lime preparation buildings in closed loop ball mill spiral classifier circuits. Lime is fed by weigh belt feeders into the ball mills which are supplied with the required amount of water for slaking. The slurry is latter transferred to the slurry feed tanks that supply the spray dryer absorbers.

- Spray Dryer Absorbing

  The flue gas is introduced into each spray dryer absorber through a roof and a central gas disperser. A rotary atomizer placed in the center of the roof gas dispenser atomizes the lime slurry into fine droplets, providing an extremely large surface area for reaction with the incoming flue gas.

- Particle Collection

  A portion of the fly ash and the reacted and unreacted reagent is collected in the bottom of the spray dryer absorbers. The main particulate control, however, is provided by the fabric filter baghouse. The fabric filter is properly sectionalized in order to assure suitable isolation capability.

- Ash Handling

  Fly ash from the baghouse hoppers is collected by a pneumatic conveying system and transferred into the ash disposal silos. A portion of the fly ash is transferred into the surge bin at the slaking/slurry preparation area for recycling.

- Waste Disposal

  The waste product from the ash disposal silo is conveyed to the waste surge silo, which is located in a designated on-site area. The material is metered from the waste surge silo into a mixer. Water is then added to the mixer in proportion to the solids to achieve a damp, dustless blend. The mixer then discharges to a truck for the haul to the disposal area.

ACCOUNT 241 Switchgear
ACCOUNT 242 Station Service Equipment
ACCOUNT 245 Electric Structures and Wiring Containers
ACCOUNT 246 Power and Control Wiring

The electrical distribution system is modified to support the addition of the baghouse and the dry flue gas desulfurization system, the elimination of the precipitator, and the changes to the main cooling towers (refer to Accounts 222, 226 and 262).

ACCOUNT 262 Main Condenser Heat Rejection System/Mechanical Equipment

The design of the main cooling towers is modified to reflect current vendor capabilities and practice.

5.4.2.10 EEDB Model Number C4, Model Type LS8, EEDB Third (1980) Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - Low and High Sulfur Coal Plants - 800 MWe (Nominal) (NUREG-0244, COO-2477-8)

ACCOUNT 220A Fossil Steam Supply System

The fossil steam supply system package is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 222 Draft System

The flue gas ductwork arrangement is modified and the induced draft (I.D.) fan is upgraded to accommodate the addition of the baghouse and dry flue gas desulfurization system (refer to Account 226).

ACCOUNT 223 Ash and Dust Handling System

The fly ash system is modified to accommodate the increased number of pick-up points and dust loading associated with the dry flue gas desulfurization system (refer to Account 226).

ACCOUNT 225 Flue Gas Desulfurization Structures

The following structures associated with the baghouse and dry flue gas desulfurization system are added (refer to Account 226):

- Lime unloading building
- Lime preparation building
- Spray dryer supports and enclosures
- Baghouse supports and enclosures
- Waste product disposal and recycling structures.

ACCOUNT 226 Flue Gas Desulfurization System

A flue gas desulfurization system is added to comply with the 1979 New Source Performance Standards (NSPS) sulfur dioxide (SO_2) limit of 0.06 pounds per million Btu heat input with SO_2 removal between 70% and 90%.

The system is designed on the dry absorption principle, where lime slurry is injected into spray dryer absorbers. The SO_2 in the flue gas is absorbed by the lime slurry forming a powdery waste material which falls into the bottom of the spray dryer.

Fly ash and other particulates carried over are collected in a baghouse which provides particulate removal in compliance with the 1979 New Source Performance Standards (NSPS) limit of 0.03 pounds per million Btu heat input. (The baghouse replaces the electrostatic precipitator previously used.) Part of the SO_2 removal process also takes place in the baghouse.

The flue gas desulfurization system consists of the following major subsystems:

- Dry Lime Handling

  Pebble lime is received from bottom-dump rail cars into receiving hoppers. From the hoppers, it is conveyed to the storage silos and eventually to the lime preparation building. All transfer areas are equipped with fabric filters to collect fugitive dust.

- Lime Slaking

  Pebble lime is slaked in the lime preparation buildings in closed loop ball mill spiral classifier circuits. Lime is fed by weigh belt feeders into the ball mills which are supplied with the required amount of water for slaking. The slurry is later transferred to the slurry feed tanks that supply the spray dryer absorbers.

- Spray Dryer Abosrbing

  The flue gas is introduced into each spray dryer absorber through a roof and a central gas disperser. A rotary atomizer placed in the center of the roof gas dispenser atomizes the lime slurry into fine droplets, providing an extremely large surface area for reaction with the incoming flue gas.

- Particle Collection

  A portion of the fly ash and the reacted and unreacted reagent is collected in the bottom of the spray dryer abosrbers. The main particulate control, however, is provided by the fabric filter baghouse. The fabric filter is properly sectionalized in order to assure suitable isolation capability.

- Ash Handling

  Fly ash from the baghouse hoppers is collected by a pneumatic conveying system and transferred into the ash disposal silos. A portion of the fly ash is transferred into the ash disposal silos. A portion of the fly ash is transferred into the surge bin at the slaking/slurry preparation area for recycling.

- Waste Disposal

  The waste product from the ash disposal silo is conveyed to the waste surge silo, which is located in a designated on-site area. The material is metered from the waste surge silo into a mixer. Water is then added to the mixer in proportion to the solids to achieve a damp, dustless blend. The mixer then discharges to a truck for the haul to the disposal area.

ACCOUNT 241 Switchgear
ACCOUNT 242 Station Service Equipment
ACCOUNT 245 Electric Structures and Wiring Container
ACCOUNT 246 Power and Control Wiring

The electrical distribution system is modified to support the addition of the baghouse and the dry flue gas desulfurization system, the elimination of the precipitator, and the changes to the main cooling towers (refer to Accounts 222, 226 and 262).

ACCOUNT 262 Main Condenser Heat Rejection System/Mechanical Equipment

The design of the main cooling towers is modified to reflect current vendor capabilities and practice.

5.4.2.11 EEDB Model Number D1, Model Type CGCC, EEDB Third (1980) Update

Base Data Study: Study of Electric Plant Applications For Low Btu Gasification of Coal For Electric Power Generation (FE-1545-59)

Minor modifications are made in the Third Update to bring the CGCC in closer conformance to the EEDB Groundrules.

APPENDIX - D

PHASE IV FINAL REPORT AND FOURTH UPDATE OF THE
ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

Effective Date - 1/1/81

APPENDIX D

U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY GUIDE REVIEW

This list shows the revision of Regulatory Guides in effect on January 1976, January 1980, and January 1981. Each guide is noted as follows:

0	- revision 0, or original issue
1, 2 or N	- revision in effect
NI	- not issued.

A column entitled, "Relates To," shows:

D	- related to design and/or licensing
C	- related to construction
O	- related to operation
NA	- not applicable to nuclear power reactors
CI	- Regulatory Guide revision has a significant cost impact.

REGULATORY GUIDES

Division 1 Regulatory Guides
Power Reactors

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
1.1	Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal System Pumps	0	0	0	D
1.2	Thermal Shock to Reactor Pressure Vessels	0	0	0	D
1.3	Assumptions Used for Evaluating the Potential Radiological Consequence of a Loss of Coolant Accident for Boiling Water Reactors	2	2	2	D
1.4	Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors	2	2	2	D
1.5	Assumptions Used for Evaluating the Potential Radiological Consequences of a Steam Line Break Accident for Boiling Water Reactors	0	0	0	D
1.6	Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems	0	0	0	D
1.7	Control of Combustible Gas Concentrations in Containment Following a Loss of Coolant Accident	0	2	2	D
	Supplement to Safety Guide 7, Backfitting Considerations	0	0	0	D
1.8	Personnel Selection and Training	1	1	1	O
1.9	Selection of Diesel Generator Set Capacity for Standby Power Supplies	0	2	2	D
1.10	Mechanical (Cadweld) Splices in Reinforcing Bars of Category I Concrete Structures	1	1	1	D
1.11	Instrument Lines Penetrating Primary Reactor Containment	0	0	0	D
	Supplement to Safety Guide 11, Backfitting Considerations	0	0	0	D

*Refer to page D-1

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
1.12	Instrumentation for Earthquakes	1	1	1	D
1.13	Spent Fuel Storage Facility Design Basis	1	1	1	D
1.14	Reactor Coolant Pump Flywheel Integrity	1	1	1	D
1.15	Testing of Reinforcing Bars for Category I Concrete Structures	1	1	1	C
1.16	Reporting of Operating Information - Appendix A Technical Specifications	4	4	4	O
1.17	Protection of Nuclear Plants Against Industrial Sabotage	1	1	1	D, O (CI)
1.18	Structural Acceptance Test for Concrete Primary Reactor Containments	1	1	1	C
1.19	Nondestructive Examination of Primary Containment Liner Welds	1	1	1	C
1.20	Comprehensive Vibration Assessment Program for Reactor Internals During Preoperational and Initial Startup Testing	1	2	2	O
1.21	Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactivity in Liquid and Gaseous Effluents from Light Water Nuclear Power Plants	1	1	1	O
1.22	Periodic Testing of Protection System Actuation Functions	0	0	0	O
1.23	Onsite Meteorological Programs	0	0	0	O
1.24	Assumptions Used for Evaluating the Potential Radiological Consequences of a Pressurized Water Reactor Gas Storage Tank Failure	0	0	0	D
1.25	Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors	0	0	0	D

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
1.26	Quality Group Classifications and Standards for Water-, Steam- and Radio-Waste-Containing Components of Nuclear Power Plants	2	3	3	D
1.27	Ultimate Heat Sink for Nuclear Power Plants	1	2	2	D
1.28	Quality Assurance Program Requirements (Design and Construction)	0	2	2	D, C
1.29	Seismic Design Classification	1	3	3	D
1.30	Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electric Equipment	0	0	0	C
1.31	Control of Ferrite Content in Stainless Steel Weld Metal	1	3	3	C
1.32	Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants	1	2	2	D
1.33	Quality Assurance Program Requirements (Operation)	0	2	2	O
1.34	Control of Electroslag Weld Properties	0	0	0	C
1.35	Inservice Inspection of Ungrouted Tendons in Prestressed Concrete Containment Structures	2	2	2	C
1.36	Nonmetallic Thermal Insulation for Austenitic Stainless Steel	0	0	0	D
1.37	Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants	0	0	0	C
1.38	Quality Assurance Requirements for Packaging, Shipping, Receiving, Storage, and Handling of Items for Water-Cooled Nuclear Power Plants	1	2	2	C
1.39	Housekeeping Requirements for Water-Cooled Nuclear Power Plants	1	2	2	C, O

Number	Title	Revision in Effect			Relates* to
		1/76	1/80	1/81	
1.40	Qualification Tests of Continuous-Duty Motors Installed Inside the Containment of Water-Cooled Nuclear Power Plants	0	0	0	D
1.41	Preoperational Testing of Redundant Onsite Electric Power Systems to Verify Proper Load Group Assignments	0	0	0	C
1.42	Interim Licensing Policy on As-Low-As-Practicable for Gaseous Radio-Iodine Releases from Light-Water-Cooled Nuclear Power Reactors	0	(Withdrawn 3/22/76)	-	-
1.43	Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components	0	0	0	C
1.44	Control of the Use of Sensitized Stainless Steel	0	0	0	C
1.45	Reactor Coolant Pressure Boundary Leakage Detection Systems	0	0	0	D
1.46	Protection Against Pipe Whip Inside Containment	0	0	0	D
1.47	Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems	0	0	0	D, O
1.48	Design Limits and Loading Combinations for Seismic Category I Fluid System Components	0	0	0	D
1.49	Power Levels of Nuclear Power Plants	1	1	1	D
1.50	Control of Preheat Temperature for Welding of Low-Alloy Steel	0	0	0	C
1.51	Inservice Inspection of ASME Code Class 2 and 3 Nuclear Power Plant Components	(Withdrawn 7/21/75)		-	-
1.52	Design, Testing, and Maintenance Criteria for Engineered-Safety-Feature Atmosphere Cleanup System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants	NI	2	2	D, O
1.53	Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems	0	0	0	D

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
1.54	Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants	0	0	0	D, C
1.55	Concrete Placement in Category I Structures	0	0	0	C
1.56	Maintenance of Water Purity in Boiling Water Reactors	0	1	1	O
1.57	Design Limits and Loading Combinations for Metal Primary Reactor Containment System Components	0	0	0	D
1.58	Qualification of Nuclear Power Plant Inspection, Examination, and Testing Personnel	0	0	1	C
1.59	Design Basis Floods for Nuclear Power Plants	1	2	2#	D
1.60	Design Response Spectra for Seismic Design of Nuclear Power Plants	1	1	1	D
1.61	Damping Values for Seismic Design of Nuclear Power Plants	0	0	0	D
1.62	Manual Initiation of Protective Actions	0	0	0	D, O
1.63	Electric Penetration Assembles in Containment Structures for Light-Water-Cooled Nuclear Power Plants	0	2	2	D
1.64	Quality Assurance Requirements for the Design of Nuclear Power Plants	1	2	2	D
1.65	Materials and Inspection for Reactor Vessel Closure Studs	0	0	0	D, C, O
1.66	Nondestructive Examination of Tubular Products	0	(Withdrawn - 10/6/77)		-
1.67	Installation of Overpressure Protective Devices	0	0	0	D, C
1.68	Initial Test Programs for Water-Cooled Reactor Power Plants	0	2	2	C, O
1.68.1	Preoperational and Initial Startup Testing of Feedwater and Condensate Systems for Boiling Water Reactor Power Plants	NI	1	1	C, O

Errata Issued

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
1.68.2	Initial Startup Test Program to Demonstrate Remote Shutdown Capability for Water-Cooled Nuclear Power Plants	NI	1	1	C, O
1.69	Concrete Radiation Shields for Nuclear Power Plants	0	0	0	D
1.70	Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants-LWR Edition	2	3	3	D
1.71	Welder Qualification for Areas of Limited Accessibility	0	0	0	C
1.72	Spray Pond Piping Made from Fiberglass-Reinforced Thermosetting Resin	0	2	2	D
1.73	Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants	0	0	0	C
1.74	Quality Assurance Terms and Definitions	0	0	0	D, C, O
1.75	Physical Independence of Electric Systems	1	2	2	D
1.76	Design Basis Tornado for Nuclear Power Plants	0	0	0	D
1.77	Assumptions Used for Evaluating a Control Rod Ejection Accident for Pressurized Water Reactors	0	0	0	D
1.78	Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release	0	0	0	D
1.79	Preoperational Testing of Emergency Core Cooling Systems for Pressurized Water Reactors	1	1	1	C, O
1.80	Preoperational Testing of Instrument Air Systems	0	0	0	C, O
1.81	Shared Emergency and Shutdown Electric Systems for Multi-Unit Plants	1	1	1	D
1.82	Sumps for Emergency Core Cooling and Containment Spray Systems	0	0	0	D

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
1.83	Inservice Inspection of Pressurized Water Reactor Steam Generator Tubes	1	1	1	O
1.84	Code Case Acceptability - ASME Section III Design and Fabrication	8	16	17	D, C, O
1.85	Code Case Acceptability - ASME Section III Materials	8	16	17	D, C, O
1.86	Termination of Operating Licenses for Nuclear Reactors	0	0	0	O
1.87	Guidance for Construction of Class 1 Components in Elevated-Temperature Reactors (Supplement to ASME Section III Code Classes 1592, 1593, 1594, 1595 and 1596)	1	1	1	D
1.88	Collection, Storage, and Maintenance of Nuclear Power Plant Quality Assurance Records	1	2	2	D, C, O
1.89	Qualification of Class 1E Equipment for Nuclear Power Plants	0	0	0	D, C
1.90	Inservice Inspection of Prestressed Concrete Containment Structures with Grouted Tendons	0	1	1	D, C, O
1.91	Evaluation of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plant Sites	0	1	1	D
1.92	Combining Modal Responses and Spatial Components in Seismic Response Analysis	0	1	1	D
1.93	Availability of Electric Power Sources	0	0	0	D
1.94	Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants	0	1	1	C
1.95	Protection of Nuclear Power Plant Control Room Operators Against an Accidental Chlorine Release	0	1	1	D

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
1.96	Design of Main Steam Isolation Valve Leakage Control Systems for Boiling Water Reactor Nuclear Power Plants	0	1	1	D
1.97	Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant Conditions During and Following an Accident	0	1	2	D, O
1.98	Assumptions Used for Evaluating the Potential Radiological Consequences of a Radioactive Offgas System Failure in a Boiling Water Reactor	NI	0	0	D
1.99	Effects of Residual Elements on Predicted Radiation Damage to Reactor Vessel Materials	0	1	1	D
1.100	Seismic Qualification of Electric Equipment for Nuclear Power Plants	0	1	1	D, C
1.101	Emergency Planning for Nuclear Power Plants	0	1	(Withdrawn 9/24/80)	-
1.102	Flood Protection for Nuclear Power Plants	0	1	1	D
1.103	Post-Tensioned Prestressing Systems for Concrete Reactor Vessels and Containments	0	1	1	D
1.104	Overhead Crane Handling Systems for Nuclear Power Plants	NI	(Withdrawn - 8/16/79)		-
1.105	Instrument Setpoints	0	1	1	D, O
1.106	Thermal Overload Protection for Electric Motors on Motor-Operated Valves	0	1	1	D
1.107	Qualifications for Cement Grouting for Prestressing Tendons in Containment Structures	0	1	1	C
1.108	Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants	0	1	1	O
1.109	Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I	NI	1	1	D

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
1.110	Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors	NI	0	0	D
1.111	Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors	NI	1	1	D, O
1.112	Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors	NI	0	0	D, O
1.113	Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I	NI	1	1	D, O
1.114	Guidance on Being Operator at the Controls of a Nuclear Power Plant	NI	1	1	O
1.115	Protection Against Low-Trajectory Turbine Missiles	NI	1	1	D
1.116	Quality Assurance Requirements for Installation, Inspection, and Testing of Mechanical Equipment and Systems	NI	0	0	C
1.117	Tornado Design Classification	NI	1	1	D
1.118	Periodic Testing of Electric Power and Protective Systems	NI	2	2	O
1.119	Surveillance Program for New Fuel Assembly Designs	NI	(Withdrawn - 6/20/77)		-
1.120	Fire Protection Guidelines for Nuclear Power Plants	NI	1	1	D(CI)
1.121	Bases for Plugging Degraded PWR Steam Generator Tubes	NI	0	0	C
1.122	Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components	NI	1	1	D
1.123	Quality Assurance Requirements for Control of Procurement of Items and Services for Nuclear Power Plants	NI	1	1	D, C

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
1.124	Service Limits and Loading Combinations for Class 1 Linear Type Component Supports	NI	1	1	D
1.125	Physical Models for Design and Operation of Hydraulic Structures and Systems for Nuclear Power Plants	NI	1	1	D
1.126	An Acceptable Model and Related Statistical Methods for the Analysis of Fuel Densification	NI	1	1	O
1.127	Inspection of Water Control Structures Associated with Nuclear Power Plants	NI	1	1	C, O
1.128	Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants	NI	1	1	D, C(CI)
1.129	Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants	NI	1	1	O
1.130	Design Limits and Loading Combinations for Class 1 Plate-and-Shell-Type Component Supports	NI	1	1	D
1.131	Qualification Tests of Electric Cables, Field Splices, and Connections for Light-Water-Cooled Nuclear Power Plants	NI	0	0	C
1.132	Site Investigations for Foundations of Nuclear Power Plants	NI	1	1	D
1.133	Loose-Part Detection Program for the Primary System of Light-Water-Cooled Reactors	NI	0	0	D, C, O
1.134	Medical Certification and Monitoring of Personnel Requiring Operator Licenses	NI	1	1	O
1.135	Normal Water Level and Discharge at Nuclear Power Plants	NI	0	0	O
1.136	Material for Concrete Containments	NI	1	1	C
1.137	Fuel-Oil Systems for Standby Diesel Generators	NI	1	1	D

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
1.138	Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants	NI	0	0	D
1.139	Guidance for Residual Heat Removal	NI	0	0	D
1.140	Design, Testing and Maintenance Criteria for Normal Ventilation Exhaust System, Air Filtration and Absorption Units of Light-Water-Cooled Nuclear Power Plants	NI	1	1	D
1.141	Containment Isolation Provisions for Fluid Systems	NI	0	0	D
1.142	Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)	NI	0	0	D
1.143	Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants	NI	1	1	D
1.144	Auditing of Quality Assurance Programs for Nuclear Power Plants	NI	0	1	D
1.145	Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants	NI	0	0	D
1.146	Qualification of Quality Assurance Program Audit Personnel for Nuclear Power Plants	NI	NI	0	D

REGULATORY GUIDES

Division 2 Regulatory Guides
Research and Test Reactors

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
2.1	Shield Test Program for Evaluation of Installed Biological Shielding in Research and Training Reactors	0	0	0	NA
2.2	Development of Technical Specifications for Experiments in Research Reactors	0	0	0	NA
2.3	Quality Verification for Plate-Type Uranium-Aluminum Fuel Elements for Use in Research Reactors	0	1	1	NA
2.4	Review of Experiments for Research Reactors	NI	0	0	NA
2.5	Quality Assurance Program Requirements for Research Reactors	NI	0	0	NA
2.6	Emergency Planning for Research Reactors	NI	0	0	NA

*Refer to page D-1

REGULATORY GUIDES

Division 3 Regulatory Guides
Fuels and Materials Facilities

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
3.1	Use of Borosilicate-Class Rashig Rings as a Neutron Absorber in Solutions of Fissile Material	0	0	0	NA
3.2	Efficiency Testing of Air-Cleaning Systems Containing Devices for Removal of Particles	0	0	0	NA
3.3	Quality Assurance Program Requirements for Fuel Reprocessing Plants and for Plutonium Processing and Fuel Fabrication Plants	1	1	1	NA
3.4	Nuclear Criticality in Safety Operations with Fissionable Materials Outside Reactors	0	1	1	NA
3.5	Standard Format and Content of License Applications for Uranium Mills	0	1	1	NA
3.6	Guide to Content of Technical Specifications for Fuel Reprocessing Plants	0	0	0	NA
3.7	Monitoring of Combustible Gases and Vapors in Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.8	Preparation of Environmental Reports for Uranium Mills	0	1	1	NA
3.9	Concrete Radiation Shields	0	0	0	NA
3.10	Liquid Waste Treatment System Design Guide for Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.11	Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills	1	2	2	NA
3.12	General Design Guide for Ventilation Systems of Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.13	Guide for Acceptable Waste Storage Methods at UF_6 Production Plants	0	0	0	NA

*Refer to page D-1

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates * to
3.14	Seismic Design Classification for Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.15	Standard Format and Content of License Applications for Storage Only of Unirradiated Reactor Fuel and Associated Radioactive Material	0	0	0	NA
3.16	General Fire Protection Guide for Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.17	Earthquake Instrumentation for Fuel Reprocessing Plants	0	0	0	NA
3.18	Confinement Barriers and Systems for Fuel Reprocessing Plants	0	0	0	NA
3.19	Reporting of Operating Information for Fuel Reprocessing Plants	0	0	0	NA
3.20	Process Offgas Systems for Fuel Reprocessing Plants	0	0	0	NA
3.21	Quality Assurance Requirements for Protective Coatings Applied to Fuel Reprocessing Plants and to Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.22	Periodic Testing of Fuel Reprocessing Plant Protection System Actuation Functions	0	0	(Withdrawn 10/21/80)	-
3.23	Stabilization of Uranium-Thorium Milling Waste Retention Systems	0	0	0	NA
3.24	Guidance on the License Application, Siting, Design, and Plant Protection for an Independent Spent Fuel Storage Installation	0	0	0	NA
3.25	Standard Format and Content of Safety Analysis Reports for Uranium Enrichment Facilities	0	0	0	NA
3.26	Standard Format and Content of Safety Analysis Reports for Fuel Reprocessing Plants	0	0	0	NA

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
3.27	Nondestructive Examination of Welds in the Liners of Concrete Barriers in Fuel Reprocessing Plants	0	1	1	NA
3.28	Welder Qualification for Welding in Areas of Limited Accessibility in Fuel Reprocessing Plants in Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.29	Preheat and Interpass Temperature Control for the Welding of Low-Alloy Steel for Use in Fuel Reprocessing Plants and in Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.30	Selection, Application, and Inspection of Protective Coatings (Paints) for Fuel Reprocessing Plants	0	0	0	NA
3.31	Emergency Water Supply Systems for Fuel Reprocessing Plants	0	0	0	NA
3.32	General Design Guide for Ventilation Systems for Fuel Reprocessing Plants	0	0	0	NA
3.33	Assumptions Used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Fuel Reprocessing Plant	NI	0	0	NA
3.34	Assumptions Used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Uranium Fuel Fabrication Plant	NI	1	1	NA
3.35	Assumptions Used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Plutonium Processing and Fuel Fabrication Plant	NI	1	1	NA
3.36	Nondestructive Examination of Tubular Products for Use in Fuel Reprocessing Plants and in Plutonium Processing and Fuel Fabrication Plants	0	(Withdrawn - 1/24/79)		-
3.37	Guidance for Avoiding Intergranular Corrosion and Stress Corrosion in Austenitic Stainless Steel Components of Fuel Reprocessing Plants	0	0	0	NA

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
3.38	General File Protection Guide for Fuel Reprocessing Plants	NI	0	0	NA
3.39	Standard Format and Content of License Applications for Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.40	Design Basis Floods for Fuel Reprocessing Plants and for Plutonium Processing and Fuel Fabrication Plants	NI	1	1	NA
3.41	Validation of Calculational Methods for Nuclear Criticality Safety	NI	1	1	NA
3.42	Emergency Planning for Fuel Cycle Facilities and Plants Licensed Under 10 CFR Parts 50 and 70	NI	1	1	NA
3.43	Nuclear Criticality Safety in the Storage of Fissile Materials	NI	1	1	NA
3.44	Standard Format and Content for the Safety Analysis Report to be Included in a License Application for the Storage of Spent Fuel	NI	1	1	NA
3.45	Nuclear Criticality Safety for Pipe Intersections Containing Aqueous Solutions of Enriched Uranyl Nitrate	NI	NI	0	NA

REGULATORY GUIDES

Division 4 Regulatory Guides
Environmental and Siting Guides

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
4.1	Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants	0	1	1	O
4.2	Preparation of Environmental Reports for Nuclear Power Stations	1	2	2	D
4.3	Measurements of Radionuclides in the Environment-Analysis of I-131 in Milk	0 (Withdrawn 12/9/76)		-	-
4.4	Reporting Procedures for Mathematical Models Selected to Predict Heated Effluent Dispersion in Natural Water Bodies	0	0	0	O
4.5	Measurements of Radionuclides in the Environment-Sampling and Analysis of Plutonium in Soil	0	0	0	O
4.6	Measurements of Radionuclides in the Environment-Strontium-89 and Strontium-90 Analysis	0	0	0	O
4.7	General Site Suitability Criteria for Nuclear Power Stations	1	1	1	D
4.8	Environmental Technical Specifications for Nuclear Power Plants	0	0	0	O
4.9	Preparation of Environmental Reports for Commercial Uranium Enrichment Facilities	1	1	1	NA
4.10	Irreversible and Irretrievable Commitments of Material Resources	0 (Withdrawn 11/17/77)		-	-
4.11	Terrestrial Environmental Studies for Nuclear Power Stations	0	1	1	D
4.13	Performance, Testing, and Procedural Specifications for Thermoluminescence Dosimetry: Environmental Applications	NI	1	1	O
4.14	Measuring, Evaluating, and Reporting Radioactivity in Releases of Radioactive Materials in Liquids and Airborne Effluents from Uranium Mills	NI	0	1	O

*Refer to page D-1

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
4.15	Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment	NI	1	1	O
4.16	Measuring, Evaluating and Reporting Radioactivity in Releases of Radioactive Materials in Liquid and Airborne Effluents from Nuclear Fuel Processing and Fabrication Plants	NI	0	0	O

REGULATORY GUIDES

Division 5 Regulatory Guides
Materials and Plant Protection

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
5.1	Serial Numbering of Light-Water-Power Reactor Fuel Assemblies	0	0	0	O
5.2	Classification of Unirradiated Plutonium and Uranium Scrap	0	(Withdrawn - 9/26/79)		-
5.3	Statistical Terminology and Notation for Special Nuclear Materials Control Accountability	0	0	0	O
5.4	Standard Analytical Methods for the Measurement of Uranium Tetrafluoride (UF_4) and Uranium Hexafluoride (UF_6)	0	0	0	NA
5.5	Standard Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Uranium Dioxide Powders and Pellets	0	0	0	NA
5.6	Standard Methods for Chemical, Mass Spectrochemical Analysis of Nuclear-Grade Plutonium Dioxide Powders and Pellets and Nuclear Grade Mixed Oxides (U, Pu, O_2)	0	0	0	NA
5.7	Control of Personnel Access to Protected Areas, Vital Areas, and Material	0	0	0	D, C, O(CI)
5.8	Design Considerations for Minimizing Residual Holdup of Special Nuclear Material in Drying and Fluidized Bed Operations	1	1	1	NA
5.9	Specifications of Ge(Li) Spectroscopy Systems for Material Protection Measurements - Part I: Data Acquisition	1	1	1	NA
5.10	Selection and Use of Pressure-Sensitive Seals on Containers for Onsite Storage of Special Nuclear Materials	0	0	0	O
5.11	Nondestructive Assay of Special Nuclear Material Contained in Scrap and Waste	0	0	0	NA

*Refer to page D-1

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
5.12	General Use of Locks in the Protection and Control of Facilities and Special Nuclear Materials	0	0	0	D, O
5.13	Conduct of Nuclear Material Physical Inventories	0	0	0	O
5.14	Visual Surveillance of Individuals in Material Access Areas	0	0	1	O
5.15	Security Seals for the Protection and Control of Special Nuclear Material	0	0	0	O
5.16	Standard Methods for Chemical, Mass Spectrometric, Spectrochemical, Nuclear and Radiochemical Analysis of Nuclear-Grade Plutonium Nitrate Solutions and Plutonium Metal	1	1	1	NA
5.17	Truck Identification Markings	0	0	0	O
5.18	Limit of Error Concepts and Principles of Calculation in Nuclear Materials Control	0	0	0	NA
5.19	Methods for the Accountability of Plutonium Nitrate Solutions	0	0	0	NA
5.20	Training, Equipping, and Qualifying of Guards and Watchmen	0	0	0	O
5.21	Nondestructive Uranium-235 Enrichment Assay by Gamma-Ray Spectrometry	0	0	0	NA
5.22	Assessment of the Assumption of Normality (Employing Individual Observed Values)	0	0	0	NA
5.23	In-Situ Assay of Plutonium Residual Holdup	0	0	0	NA
5.24	Analysis and Use of Process Data for the Protection of Special Nuclear Material in Equipment for Wet Process Operations	0	0	0	NA
5.25	Design Considerations for Minimizing Residual Holdup of Special Nuclear Material in Equipment for Wet Process Operations	0	0	0	NA
5.26	Selection of Material Balance Areas and Item Control Areas	1	1	1	NA

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
5.27	SNM Doorway Monitors	0	0	0	D, O
5.28	Evaluation of Shipper-Receiver Differences in the Transfer of Special Nuclear Material	0	0	0	O
5.29	Nuclear Material Control Systems for Nuclear Power Plants	1	1	1	D, O
5.30	Materials Protection Contingency Measures for Uranium and Plutonium Fuel Manufacturing Plants	0	0	0	NA
5.31	Specially Designed Vehicle with Armed Guards for Road Shipments of Special Nuclear Material	1	1	1	O
5.32	Communication with Transport Vehicles	1	1	1	O
5.33	Statistical Evaluation of Material Unaccounted For	0	0	0	O
5.34	Nondestructive Assay of Plutonium in Scrap by Spontaneous Fission Detection	0	0	0	NA
5.35	Calorimetric Assay for Plutonium	0	(Withdrawn 8/18/77)	-	-
5.36	Recommended Practice for Dealing With Outlying Observations	0	0	0	NA
5.37	In-Situ Assay of Enriched Uranium Residual Holdup	0	0	0	NA
5.38	Nondestructive Assay of High-Enrichment Uranium Fuel Plates by Gamma-Ray Spectrometry	0	0	0	NA
5.39	General Methods for the Analysis of Uranyl Nitrate Solutions for Assay, Isotopic Distribution, and Impurity Determinations	0	0	0	NA
5.40	Methods for the Accountability of Plutonium Dioxide Powder	0	0	0	NA
5.42	Design Considerations for Minimizing Residual Holdup of Special Nuclear Material in Equipment for Dry Process Operations	0	0	0	NA

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
5.43	Plant Security Force Duties	0	0	0	0
5.44	Perimeter Intrusion Alarm Systems	0	1	2	D, O
5.45	Standard Format and Content for the Special Nuclear Material Control and Accounting Section of a Special Nuclear Material License Application	0	0	0	O
5.47	Control and Accountability of Plutonium in Waste Material	0	0	0	NA
5.48	Design Considerations - Systems for Measuring the Mass of Liquids	0	0	0	NA
5.49	Internal Transfers of Special Nuclear Material	0	0	0	O
5.51	Management Review of Nuclear Material Control and Accounting Systems	0	0	0	O
5.52	Standard Format and Content for the Physical Protection Section of a License Application (for Facilities Other than Nuclear Power Plants)	NI	1	2	NA
5.53	Qualification, Calibration, and Error Estimation Methods for Nondestructive Assay	0	0	0	NA
5.54	Standard Format and Content of Safeguards Contingency Plans for Nuclear Power Plants	NI	0	0	O
5.55	Standard Format and Content of Safeguards Contingency Plans for Fuel Cycle Facilities	NI	0	0	NA
5.56	Standard Format and Content of Safeguards Contingency Plans for Transportation	NI	0	0	NA
5.57	Shipping and Receiving Control of Special Nuclear Material	NI	0	1	O
5.58	Considerations for Establishing Traceability of Special Nuclear Materials Accounting Measurements	NI	0	1	O

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
5.59	Standard Format and Content for a Licensee Physical Security Plan for the Protection of Special Nuclear Material of Moderate or Low Strategic Significance	NI	NI	0	D, O
5.60	Standard Format and Content of a Licensee Physical Protection Plan for Strategic Special Nuclear Material in Transit	NI	NI	0	0
5.61	Intent and Scope of the Physical Protection Upgrade Rule Requirements for Fixed Sites	NI	NI	0	0

REGULATORY GUIDES

Division 6 Regulatory Guides
Products

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
6.1	Leak Testing Radioactive Brachytherapy Sources	1	1	1	NA
6.2	Integrity and Test Specifications for Selected Brachytherapy Sources	1	1	1	NA
6.3	Design, Construction, and Use of Radioisotopic Power Generators for Certain Land and Sea Applications	0	0	0	NA
6.4	Classification of Containment Properties of Sealed Radioactive Sources Contained in Certain Devices to be Distributed for Use Under General License	1	1	2	NA
6.5	General Safety Standard for Installations Using Nonmedical Sealed Gamma-Ray Sources	0	0	0	NA
6.6	Acceptance Sampling Procedures for Exempted and Generally Licensed Items Containing Byproduct Material	0	0	0	NA
6.7	Preparation to an Environmental Report to Support a Rule Making Petition Seeking an Exemption for a Radionuclide-Containing Product	0	1	1	NA
6.8	Identification Plaque for Irretrievable Well-Logging Sources	NI	0	0	NA

*Refer to page D-1

REGULATORY GUIDES

Division 7 Regulatory Guides
Transportation

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
7.1	Administrative Guide for Packaging and Transporting Radioactive Material	0	0	0	O
7.2	Packaging and Transportation of Radioactively Contaminated Biological Materials	0	0	0	NA
7.3	Procedures for Picking Up and Receiving Packages of Radioactive Materials	0	0	0	O
7.4	Leakage Tests on Packages for Shipment of Radioactive Materials	0	0	0	O
7.5	Administrative Guide for Obtaining Exemptions from Certain NRC Requirements over Radioactive Material Shipments	0	0	0	O
7.6	Stress Allowables for the Design of Shipping Cask Containment Vessels	NI	1	1	D
7.7	Administrative Guide for Verifying Compliance with Packaging Requirements for Shipments of Radioactive Materials	NI	0	0	O
7.8	Load Combinations for the Structural Analysis of Shipping Casks	NI	0	0	D
7.9	Standard Format and Content of Part 71 Applications for Approval of Packaging of Type B, Large Quantity, and Fissile Radioactive Material	NI	0	1	O

*Refer to page D-1

REGULATORY GUIDES

Division 8 Regulatory Guides
Occupational Health

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
8.1	Radiation Symbol	0	0	0	0
8.2	Administrative Practices in Radiation Monitoring	0	0	0	0
8.3	Film Badge Performance Criteria	0	0	0	0
8.4	Direct-Reading and Indirect-Reading Pocket Dosimeters	0	0	0	0
8.5	Immediate Evacuation Signal	0	0	0	0
8.6	Standard Test Procedure for Geiger-Muller Counters	0	0	0	0
8.7	Occupational Radiation Exposure Records Systems	0	0	0	0
8.8	Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be as Low as is Reasonably Achievable	1	3	3	D, 0
8.9	Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program	0	0	0	0
8.10	Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as is Reasonably Achievable (Nuclear Power Reactors)	1	1	1	0
8.11	Application of Bioassay for Uranium	0	0	0	0
8.12	Criticality Accident Alarm Systems	0	0	0	0
8.13	Instruction Concerning Prenatal Radiation Exposure	1	1	1	0
8.14	Personnel Neutron Dosimeters	0	1	1	0
8.15	Acceptable Programs for Respiratory Protection	NI	0	0	0

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Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
8.18	Information Relevant to Ensuring that Occupational Radiation Exposures at Medical Institutions will be as Low as Reasonably Achievable	NI	0	0	NA
8.19	Occupational Radiation Dose Assessment in Light-Water Reactor Power Plants Design Stage Man-Rem Estimates	NI	1	1	D, O
8.20	Application of Bioassay for I-125 and I-131	NI	1	1	O
8.21	Health Physics Surveys for By-Product Material at NRC-Licensed Processing and Manufacturing Plants	NI	1	1	O
8.22	Bioassay at Uranium Mills	NI	0	0	NA
8.24	Health Physics Surveys During Enriched Uranium-235 Processing and Fuel Fabrication	NI	1	1	NA
8.25	Calibration and Error Limit of Air Sampling Instruments for Total Volume of Air Sampled	NI	NI	0	O
8.26	Application of Bioassay for Fission and Activation Products	NI	NI	0	O

REGULATORY GUIDES

Division 9 Regulatory Guides
Antitrust Review

Number	Title	Revision in Effect 1/76	1/80	1/81	Relates* to
9.1	Regulatory Staff Position Statement on Antitrust Matters	0	0	0	D
9.2	Information Needed by the NRC Staff in Connection with its Antitrust Review of Construction Permit Applications for Nuclear Power Plants	0	1	1	D
9.3	Information Needed by the NRC Staff in Connection with its Antitrust Review of Operating License Applications for Nuclear Power Plants	0	0	0	D
9.4	Suggested Format for Cash Flow Statements Submitted as Guarantees of Payment of Retrospective Payments	NI	0	0	O

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REGULATORY GUIDES

Division 10 Regulatory Guides
General Guides

Number	Title	Revision in Effect 1/76	Revision in Effect 1/80	Revision in Effect 1/81	Relates* to
10.1	Compilation of Reporting Requirements for Persons Subject to NRC Regulations	1	3	3	O
10.2	Guidance to Academic Institutions Applying for Specific Byproduct Material Licenses of Limited Scope	0	1	1	NA
10.3	Guide for the Preparation of Applications for Special Nuclear Material Licenses of Less than Critical Mass Quantities	0	1	1	O
10.4	Guide for the Preparation of Applications for Licenses to Process Source Material	0	1	1	O
10.5	Guide for the Preparation of Applications for Type A Licenses of Broad Scope for Byproduct Material	NI	0	0	O
10.6	Guide for the Preparation of Applications for the Use of Sealed Sources and Devices for the Performance of Industrial Radiography	NI	0	0	C
10.7	Guide for the Preparation of Applications for Licenses for Laboratory Use of Small Quantities of Byproduct Material	NI	1	1	NA
10.8	Guide for the Preparation of Applications for Medical Programs	NI	0	1	NA
10.9	Guide for the Preparation of Applications for Licenses	NI	NI	0	NA

*Refer to page D-1

APPENDIX - E

PHASE IV FINAL REPORT AND FOURTH UPDATE OF THE
ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

APPENDIX E

DESCRIPTION OF REACTOR TYPES AND THEIR FUEL CYCLES

In the course of the NUS Corporation study, performed for the fuel cycle evaluation in the EEDB Initial Update, the economics for the fuel cycles of a number of reactor types and their options were reviewed. The material presented here covers only those reactor types and options previously defined for the establishment of the EEDB, and are summarized in Table E-1. Table E-2 gives a brief summary of the basic features of the baseline reactor types and their fuel cycle. A determination is made that differences between the two LWR types, the Boiling Water Reactor (BWR) and the Pressurized Water Reactor (PWR), have a relatively insignificant effect on the overall fuel cycle costs. Consequently, in performing the fuel cycle cost study, NUS Corporation, with the concurrence of USDOE and United Engineers, agreed that data developed for the PWR cases also apply to the BWR.

The fuel cycle cost calculations are based on the NASAP reactor design data. The rated powers of the nuclear systems studied in EEDB differ in some cases from the nominal thermal powers listed for the NASAP systems in Table E-1. However, the mass flow relationships remain unchanged for a determinate reactor type over a relatively large range of output power. Thus, although the total mass of fuel used (200 MTU vs. 150 MTU) is different for two PWRs of different thermal power, the level of initial enrichment ($\sim 3\%$), the average burnup (30,000 MWd/T) and the heat rate (10,200 Btu/kWh) are approximately the same. Therefore, the total cost of fuel is different, but the specific costs in \$/MBtu or mills/kWh, are the same for the same portions of the nuclear fuel cycle. Consequently, the differences between the EEDB nuclear systems rated power and the nominal NASAP rated power do not affect the calculated costs of the nuclear fuel cycle for the reactor types studied. As noted in the preceding paragraph, the real differences between the PWR and the BWR are insufficient to change the calculated costs for LWRs by a significant amount.

E.1 LIGHT WATER REACTORS

Light water reactors, operating primarily on the thermal neutron spectrum, include the Boiling Water Reactor (BWR), and the Pressurized Water Reactor (PWR). The differences between the two reactor types with respect to the fuel cycle are relatively minor. In general, the BWR carries the burnup of its fuel, in terms of megawatt-days-per-ton, to a lower final level than the PWR. Related to this, are the differences in initial enrichment for the two reactor types, with the BWR having enrichments around 2.7 to 2.8 weight percent and the PWR having enrichments between 3.0 and 3.3 weight percent of fissile U-235.

A summary of a typical PWR design and a schematic of the PWR fuel cycle for both the disposal case and for the fuel reprocessing case are shown in Table E-3 and Figure E.1. A summary of a typical BWR design and a schematic of the BWR fuel cycle for both the disposal case and the fuel reprocessing case are shown in Table E-4 and Figure E.1.

The calculation of fuel cycle costs is based on equilibrium operation. The equilibrium operation assumes approximately uniform exposure of each batch of nuclear fuel. A batch is a quantity of reactor fuel which is some substantial fraction (0.25 - 0.33) of the total reactor core load. At initial plant start-up, a fully loaded core is in place. After about one year of operation, a fraction of the core is replaced with fresh fuel. At intervals of about one year thereafter, additional equal core fractions are removed and replaced with fresh fuel, until the entire initial core has been replaced. Assuming that the core fraction removed/replaced is approximately one-third of the full core loading and that the reload interval is one year, the first segment of the initial core receives an exposure of one year and the last segment is exposed for three years. Subsequently, each batch is operational for about three years prior to replacement.

Data for the PWR were obtained from Combustion Engineering, Inc. for the system designed by them. Data for the BWR system were obtained from General Electric Company. The sources of data for the LWRs and the remaining reactor fuel cycles, discussed in this appendix, are given in Table E-5.

E.2 THE HIGH TEMPERATURE GAS COOLED REACTOR - HTGR

The plant design of the HTGR, as well as the fuel block configuration, permits a variety of fuel loadings in various configurations within the reactor core without changes in the plant design. The initial charge for the HTGR uses enriched uranium at an enrichment level of approximately 19.8 weight percent U-235. The balance of the fuel in these fuel rods is U-238. The chemical form of the fuel, unlike that used in the LWR, is uranium carbide. In addition to the uranium carbide fuel, other fuel elements can be made containing various mixtures of fissile or fertile materials. In the ideal case for the HTGR, the fertile material is thorium oxide. Neutron capture in the abundant (approximately 100 percent in nature) Th-232, produces a small number of fissions but results primarily in captures leading to Th-233. Upon beta decay, Th-233 becomes Pa-233, which also undergoes beta decay to become U-233. U-233 is a thermally fissile material suitable for use in thermal reactors as a direct substitute for U-235, the only thermally fissile material occurring naturally. Since the overall abundance of thorium in the earth's crust is believed to be about ten times that of uranium, the potential for converting significant portions of this material to U-233 is important. The mass flow characteristics for the HTGR are given in Table E-6. A schematic of the "throw-away" cycle and the U-233 recycle are shown in Figure E.2. Only one full scale version of this reactor type has been operated in the United States. This is the Fort St. Vrain reactor in Colorado, which embodies a number of technological innovations, as well as the use of the HTGR fuel cycle. Information on the HTGR was provided by General Atomic Company.

E.3 THE PRESSURIZED HEAVY WATER REACTOR (PHWR)

The PHWR, in the Initial Update of the EEDB, is also referred to as the CANDU Heavy Water Reactor. (The acronym CANDU is derived from Canada Deuterium Uranium). It is based upon the concept of using natural uranium in a heavy water environment, which serves as the moderator, with very low neutron absorption. Reactors of this type have been designed and built by Atomic Energy of Canada Limited. In the CANDU reactor, the fuel elements are contained within pressure tubes along with their coolant. The pressure tubes are submerged in the heavy water moderator which totally separates the internal, pressurized water from the moderator. The initial concept of the CANDU/PHWR envisioned a reactor using natural uranium fuel, which is uranium with the natural content of U-235, approximately 0.711 weight percent. More recent concepts have been investigated which use low enrichments, up to a level of about 1.2 weight percent U-235, in the reactor fuel. The low level of enrichment does not permit high burnup, but the reactor does achieve good utilization of the slightly enriched uranium. Consequently, the slightly enriched concept may yield a significant reduction in fuel cycle costs, compared to a natural uranium cycle.

As shown in the fuel cycle schematic, Figure E.3, as well as the design characteristics, Table E-7, the PHWR/CANDU is operated without intentional recycle (i.e., without recovery of the U-238 or any bred plutonium which may be present in the spent fuel at the end of its cycle through the reactor). A batch of fuel remains in the PHWR/CANDU reactor for approximately one cycle of 3-1/4 years before being replaced by a fresh batch. No reactors of the PHWR/CANDU type have yet been built in the United States. Data for the PHWR were provided by Combustion Engineering, Inc.

E.4 THE LIQUID METAL FAST BREEDER REACTOR - LMFBR

As the name of the reactor indicates, the LMFBR utilizes liquid metal coolant in the current design and fission is produced by neutrons having a fast spectrum, nominally in excess of 0.1 MeV. The fuel for the LMFBR is primarily fissile plutonium, mixed with depleted uranium U-238, having a content of fissile U-235 of 0.2 weight percent or less. In addition to the fissile fuel elements in the reactor core, blankets of fertile material are placed both top and bottom and around the periphery of the active core. These fertile blankets can contain additional depleted U-238 or natural thorium Th-232. The term breeder for this reactor type arises from its ability to produce more fissile material than is consumed. This yields a net gain of fissile material from previously non-fissile material with each refueling.

The breeder thus permits the utilization of the much more abundant non-fissile isotope U-238, by converting it to fissile plutonium and converting the non-fissile Th-232 to the fissile U-233. This augmentation of the fissile fuel resources extends the potential for producing power from fissile reactions, significantly beyond the time range of any alternative power source now envisioned, except that of the sun or power from the fusion of the hydrogen isotopes.

The function of the LMFBR is twofold:

a. To produce electric power through conversion of fission heat energy to steam and, subsequently through a steam turbine, to electricity; and

b. to produce more fissile material than is consumed in the operation of the reactor.

For this second reason, the LMFBR is intrinsically committed to reprocessing of both fuel and blanket materials, since the recovery of fissile material from these sources is required for continuing operation of existing reactors. The data for two of the principal options of the LMFBR type are given in Table E-8. A schematic flow diagram of these two options is given in Figure E.4.

The LMFBR fuel cycle permits a number of options, including:

- The fertile U-238 in the blankets can consist of uranium depleted in U-235 to levels produced as "tails" from the enrichment plants or as uranium recovered from reprocessing of LWR spent fuels.

- In addition, thorium can be used as a fertile blanket material (as noted in the preceding paragraphs). This is usually fresh, unirradiated material, but at least in theory, the irradiated Th can be recovered and recycled. However, a cooling period of about 10 years is needed to insure that some of the more objectionable induced activities have decayed. There is presently no firm plan to use U-233 bred from Th-232 in the LMFBR. The neutronic behavior of Pu (FIS) with fast neutrons, is significantly better in the LMFBR than that of U-233. Conversely, the neutronic behavior of U-233 with thermal neutrons is superior to all other fissile nuclides and insures its use in thermal reactors rather than in breeders.

- The LMFBR operates on a fast neutron spectrum and its efficiency is not compromised by the ingrowth of fission products of high cross-section, but it is not now clear how the fuel reprocessing and separation will be handled. The recovery of plutonium from the core and from the fertile blanket can be carried through to the point where essentially pure plutonium is obtained. There is concern that unadulterated plutonium or other fissile material will somehow find its way into the hands of terrorists or other antisocial groups. There are options in which Pu can be mixed again with the fertile blanket and fission products can be retained rather than removed, thus making the finished fuel elements far more difficult to fabricate and significantly reducing the risk of diversion by sub-national groups for use in nuclear weapons.

The fabrication of fuel using the unspiked mixed oxides of uranium and plutonium is significantly more expensive than for uranium oxide fuel. The deliberate addition of fission products ("spiking") will further increase costs. Similarly, the reprocessing of spent fuels is complicated if the fission products are not initially removed, as high level waste, from the uranium and plutonium. The option to retain some level of fission product activity in the reprocessing plant product, also requires the use of properly shielded equipment at all points in the processing line. This is compared to a reprocessing flow sheet which removes the high level fission product wastes and delivers essentially clean uranium and plutonium either intermixed or separated from each other.

These options make it difficult to present a consistent figure for:

- the cost of fuel fabrication for plutonium fuels,
- the cost of fuel reprocessing which may include co-processing and spiking, and
- the cost of shipping mixed oxide and spiked fuels.

The technical data, mass flows, and schematic flow diagrams for the LMFBR were provided by Argonne National Laboratory, the Hanford Engineering Development Laboratory and the U.S. Department of Energy.

E.5 THE GAS COOLED FAST BREEDER REACTOR - GCFR

The Gas Cooled Fast Breeder Reactor incorporates features which are common to the HTGR (see paragraph E.2) and to the LMFBR (see paragraph E.2). The coolant for the GCFR is helium gas at high pressure. The fission reaction depends primarily on fast neutrons. The fuel, which is superficially similar to LMFBR fuel, is designed to be plutonium with blankets of either uranium or thorium. The design characteristics of the GCFR are summarized in Table E-9. The flow diagram for the GCFR is the same as for the LMFBR and is shown in Figure E.4. The design data for the GCFR and for its flow sheet were provided by General Atomic Company.

TABLE E-1

ENERGY ECONOMIC DATA BASE

REACTOR TYPES, CYCLE, RATING, AND START-UP DATE

REACTOR TYPE AND CYCLE	NASAP (1) CYCLE DESIGNATION	NOMINAL (2) THERMAL RATING (MWt)	START-UP DATE 1 JANUARY + YEAR
LWR (Throwaway)	U5(LE)/U-T	3800	1987
LWR (Pu Recycle)	U5(LE) + Pu(RE)/U	3800	1991
HTGR (Throwaway)	U5/U/Th-20%-T	3360	1995
HTGR (^{233}U Recycle)	U5(DE)/U/Th-20%	3360	1995
PHWR (Throwaway) (CANDU - NAT. U)	U5(NAT)/U-T	3990	1995
PHWR (Throwaway) (CANDU - Slightly Enriched - 1.2%)	U5(SE)/U-T	3990	1995
LMFBR (U Blanket)	Pu/U/U/U-HT	3318	2001
LMFBR (Th Blanket)	Pu/U/Th/Th-HT	3411	2001
GCFR (U Blanket)	Pu/U/U/U	3290	2001
GCFR (Th Blanket)	Pu/U/Th/Th	3290	2001

(1) Nonproliferation Alternate Systems Assessment Program.

(2) The nominal thermal ratings may not agree with the actual thermal ratings selected for the EEDB.

TABLE E-2

ENERGY ECONOMIC DATA BASE

BASIC FEATURES OF BASELINE REACTOR/FUEL CYCLE SYSTEMS

System Designation	Reactor Type	Fuel Type	Fuel Cycle Alternative	Reactor Thermal Output (MWt)	Reactor Start Date
PWR-U5(LE)/U-T	LWR(PWR)	low-enriched uranium (UO_2)	throwaway	3800	Jan. 1, 1987
PWR-U5(LE)+ Pu(RE)/U	LWR(PWR)	low-enriched uranium and plutonium oxide (UO_2 - PuO_2)	recycle of plutonium and uranium (self-generated)	3800	Jan. 1, 1991
HTGR-U5/U/Th-20%-T	HTGR	medium-enriched uranium (20%) and thorium (UC_2-ThO_2)	throwaway	3360	Jan. 1, 1995
HTGR-U5(DE)/U/Th-20%	HTGR	medium-enriched uranium (denatured 20%) and thorium (UC_2-ThO_2)	recycle of U-233 (self-generated)	3360	Jan. 1, 1995
PHWR-U5(NAT)/U-T (CANDU)	PHWR	natural uranium (UO_2)	throwaway	3990	Jan. 1, 1995
PHWR-U5(SE)/U-T (CANDU)	PHWR	slightly-enriched (1.2%) uranium (UO_2)	throwaway	3990	Jan. 1, 1995
LMFBR-Pu/U/U/U-HT	LMFBR	Pu/depleted uranium-core, and depleted uranium-blankets (PuO_2-UO_2/UO_2/UO_2)	recycle of plutonium in breeders	3318	Jan. 1, 2001
LMFBR-Pu/U/Th/Th-HT	LMFBR	Pu/depleted uranium-core, and thorium blankets (PuO_2-UO_2/ThO_2/ThO_2)	recycle of plutonium in breeders, recycle of U-233 in converters	3411	Jan. 1, 2001
GCFR-Pu/U/U/U	GCFR	Pu/depleted uranium-core, and depleted uranium blankets (PuO_2-UO_2/UO_2/UO_2)	recycle of plutonium in breeders	3290	Jan. 1, 2001
GCFR-Pu/U/Th/Th	GCFR	Pu/depleted uranium-core, and thorium-blankets (PuO_2-UO_2/ThO_2/ThO_2)	recycle of plutonium in breeders, recycle of U-233 in converters	3290	Jan. 1, 2001

TABLE E-3

ENERGY ECONOMIC DATA BASE

DESIGN CHARACTERISTICS OF PWR

	PWR-U5(LE)/U-T Disposal	PWR-U5(LE)+Pu(RE)/U Recycle
Reactor Thermal Output	3,800 MWt	3,800 MWt
Number of Fuel Assemblies	241	241
Fuel Type	Oxide Fuel (UO_2)	Oxide Fuel (UO_2/PuO_2-UO_2)
Approximate Fraction of Core Replaced at Each Refueling	1/3	1/3
Start of Plutonium Recycle	N/A	Cycle 4
Initial Core (Average)		
Discharge Burnup	21,082 MWD/MTU	21,077 MWD/MTU
Core Loading	99.313 MTU	99.313 MTU
Fresh Fuel Enrichment	2.22 w/o U-235	2.22 w/o U-235
Spent Fuel Enrichment	0.73 w/o U-235	0.73 w/o U-235
Fissile Plutonium Discharged	5.427 Kg/MTU_i	5.246 Kg/MTU_i
Replacement Loadings		
Discharge Burnup	30,360 MWD/MTU	30,360 MWD/MTH
Core Loading	102.783 MTU	102.782 MTH
Fresh Fuel Enrichment	3.01 w/o U-235	3.30 w/o(*)
Fissile Plutonium Charged	---	9.807 Kg/MTH_i
Spent Fuel Enrichment	0.85 w/o U-235	0.76 w/o U-235(**)
Fissile Plutonium Discharged	6.596 Kg/MTU_i	10.887 Kg/MTH_i

(*) Mixture of 3.20 w/o U-235 (22319 Kg), natural uranium (11387 Kg), and 336 Kg of fissile plutonium, per batch.

(**) Mixture of 0.95 w/o U-235 (21627 Kg) and 0.39 w/o U-235 (11154 Kg), per batch.

TABLE E-4

ENERGY ECONOMIC DATA BASE

DESIGN CHARACTERISTICS OF BWR(1)

	Disposal	Recycle
Reactor Thermal Output	3,579 MWt	3,579 MWt
Number of Fuel Assemblies	748	752
Fuel Type	Oxide Fuel (UO_2)	Mixed Oxide Fuel (UO_2+PuO_2)
Approximate Fraction of Core Replaced at Each Refueling	0.25	0.25
Start of Plutonium Recycle	N/A	Cycle 5
Initial Core (Average)		
Discharge Burnup	17,500 MWD/MTU	21,211 MWD/MTHM
Core Loading	136.136 MTU	136.907 MTHM
Fresh Fuel Enrichment	1.9 w/o ^{235}U	2.16 w/o ^{235}U
Fissile Plutonium Loaded	N/A	0.35 w/o ^{FIS}Pu (485 Kg)
Spent Fuel Enrichment	0.7 w/o ^{235}U	0.85 w/o ^{235}U
Fissile Plutonium Discharged	4.745 Kg/MTU_i	7.178 $Kg/MTHM_i$
Replacement Loadings		
Discharge Burnup	28,400 MWD/MTU	28,010 MWD/MTHM
Core Loading	136.136 MTU	156.032 MTHM
Fresh Fuel Enrichment	2.8 w/o ^{235}U	1.84 w/o ^{235}U
Fissile Plutonium Loaded	N/A	1.29 w/o ^{FIS}Pu (2016 Kg)
Spent Fuel Enrichment	0.8 w/o ^{235}U	0.66 w/o ^{235}U
Fissile Plutonium Discharged	8.242 Kg/MTU_i	11.818 $Kg/MTHM_i$

(1) Data not available for fuel cycle cost calculations; included for comparison only.

TABLE E-5

ENERGY ECONOMIC DATA BASE

FUEL CYCLE DATA SOURCE BY REACTOR TYPE

REACTOR TYPE	SYSTEM DESIGNED BY	DATA PROVIDED BY
PWR	Combustion Engineering	Combustion Engineering
BWR	General Electric	General Electric **
HTGR	General Atomic	General Atomic
PHWR	Combustion Engineering	Combustion Engineering
LMFBR	Argonne National Lab. & Hanford Engineering Development Lab.	Department of Energy
GCFR	General Atomic	General Atomic

*Mass flow information provided by source indicated through NASAP.

**BWR data not available for fuel cycle costs; PWR data used for BWR (Model A1).

TABLE E-6

ENERGY ECONOMIC DATA BASE

DESIGN CHARACTERISTICS OF HTGR

	HTGR-U5/U/Th-20%-T	HTGR-U5(DE)/U/Th-20%
Reactor Thermal Output	3,360 MWt	3,360 MWt
Number of Fuel Blocks	5,288	5,288
Approximate Fraction of Core Replaced at Each Refueling	1/4	1/4
Start of U-233 Recycle	---	Cycle 3
Initial Core (Average)		
Discharge Burnup	52,900 MWD/MTH	52,925 MWD/MTH
Core Loading	41.130 MTH	41.130 MTH
C/Th Ratio	350	350
Thorium Charged	31.802 MT	31.798 MT
Enrichment of Uranium Charged	19.8 w/o U-235	19.8 w/o U-235
Enrichment of Uranium Discharged	12.8 w/o*	12.8 w/o*
U-233 Discharged	75.5 Kg/MTU_f	75.5 Kg/MTU_f
Fissile Plutonium Discharged	12.071 Kg/MTU_f	12.014 Kg/MTU_f
Replacement Loadings		
Discharge Burnup	133,100 MWD/MTH	132,500 MWD/MTH
Core Loading	29.504 MTH	29.648 MTH
C/Th Ratio	850	850
Thorium Charged	446 Kg/MTH_i	444 Kg/MTH_i
Enrichment of Uranium Charged	19.8 w/o U-235	19.0 w/o***
Recycled U-233 Charged	---	11.927 Kg/MTH_i
Enrichment of Uranium Discharged	4.9 w/o**	4.7 w/o
U-233 Discharged	27.5 Kg/MTU_f	28.9 Kg/MTU_f
Fissile Plutonium Discharged	13.702 Kg/MTU_f	13.630 Kg/MTU_f

* Mixture of 625.1 Kg of U-233 and 434.7 Kg of U-235 in total uranium of 8275.9 Kg discharged.

** Mixture of 88.3 Kg of U-233 and 69.0 Kg of U-235 in total uranium of 3211.1 Kg discharged.

*** Mixture of U-235 makeup (696.5 Kg) and U-233 recycled (88.4 Kg) in total uranium loaded (4122.7 Kg).

TABLE E-7

ENERGY ECONOMIC DATA BASE

DESIGN CHARACTERISTICS OF PHWR

	PHWR-U5(NAT)/U	PHWR-U5(SE)/U
Reactor Thermal Output	3,990 MWt	3,990 MWt
Number of Coolant Channels	380	380
Number of Fuel Bundles per Channel	12	12
Fuel Type	Oxide Fuel	Oxide Fuel
Initial Core (Average)		
Discharge Burnup	4,759 MWD/MTU	6,556 MWD/MTU
Core Loading	148.388 MTU	148.388 MTU
Fresh Fuel Enrichment	0.711 w/o U-235	0.711 w/o U-235
Replacement Loadings		
Discharge Burnup	6,100 MWD/MTU	19,749 MWD/MTU
Annual Requirement	179.059 MTU	55.304 MTU
Fresh Fuel Enrichment	0.711 w/o U-235	1.2 w/o U-235

TABLE E-8

ENERGY ECONOMIC DATA BASE

DESIGN CHARACTERISTICS OF LMFBR

	LMFBR-Pu/U/U/U	LMFBR-Pu/U/Th/Th
Reactor Thermal Output	3,318 MWt	3,411 MWt
Number of Elements		
Core Fuel	678	432
Axial Blanket	678	432
Radial Blanket	420	252
Fuel Type	Oxide Fuel	Oxide Fuel
Breeding Ratio	1.1417	N/A
Initial Core (Average)		
Discharge Burnup	45,983 MWD/MTHM	34,650 MWD/MTHM
Core Loading	22.668 MTHM	34.370 MTHM
Fissile Plutonium Loaded	154.314 Kg/MTH$_i$	121.559 Kg/MTH$_i$
Fissile Plutonium Discharged	136.713 Kg/MTH$_i$	117.457 Kg/MTH$_i$
Initial Uranium Enrichment	0.20 w/o U-235	0.20 w/o U-235
Final Uranium Enrichment	0.13 w/o U-235	0.15 w/o U-235
Replacement Core Loadings		
Discharge Burnup	67,590 MWD/MTHM	53,150 MWD/MTHM
Core Loading	23.316 MTHM	32.994 MTHM
Fissile Plutonium Charged	154.315 Kg/MTH$_i$	121.537 Kg/MTH$_i$
Fissile Plutonium Discharged	134.243 Kg/MTH$_i$	116.142 Kg/MTH$_i$
Initial Uranium Enrichment	0.20 w/o U-235	0.20 w/o U-235
Final Uranium Enrichment	0.13 w/o U-235	0.13 w/o U-235

TABLE E-8 (Cont.)

ENERGY ECONOMIC DATA BASE
DESIGN CHARACTERISTICS OF LMFBR

	LMFBR-Pu/U/U/U	LMFBR-Pu/U/Th/Th
Axial Blanket		
Loading	19.038 MTHM	22.470 MTHM
Fissile Plutonium Discharged	22.691 Kg/MTH_i	---
U-233 Discharged	---	18.069 Kg/MTH_i
Initial Uranium Enrichment	0.20 w/o U-235	---
Final Uranium Enrichment	0.16 w/o U-235	---
Radial Blanket		
Loading	44.796 MTHM	42.815 MTHM
Fissile Plutonium Discharged	20.895 Kg/MTH_i	---
U-233 Discharged	---	16.466 Kg/MTH_i
Initial Uranium Enrichment	0.2 w/o U-235	---
Final Uranium Enrichment	0.i8 w/o U-235	---

TABLE E-9

ENERGY ECONOMIC DATA BASE

DESIGN CHARACTERISTICS OF GCFR

	GCFR-Pu/U/U/U	GCFR-Pu/U/Th/Th
Reactor Thermal Output	3,290 MWt	3,290 MWt
Number of Elements		
Core Fuel	253	253
Axial Blanket	253	253
Radial Blanket	198	198
Fuel Type	Oxide Fuel	Oxide Fuel
Conversion Ratio	1.51	1.48
Initial Core (Average)		
Discharge Burnup	50,332 MWD/MTH	50,356 MWD/MTH
Core Loading	28.620 MTH	28.982 MTH
Fissile Plutonium Loaded	138.539 Kg/MTHi	142.330 Kg/MTHi
Fissile Plutonium Discharged	127.079 Kg/MTHi	128.921 Kg/MTHi
Fresh Uranium Enrichment	0.25 w/o U-235	0.25 w/o U-235
Spent Uranium Enrichment	0.17 w/o U-235	0.17 w/o U-235
Replacement Core Loadings		
Discharge Burnup	75,576 MWD/MTH	75,574 MWD/MTH
Core Loading	28.981 MTH	28.981 MTH
Fissile Plutonium Charged	144.885 Kg/MTHi	151.875 Kg/MTHi
Fissile Plutonium Discharged	124.471 Kg/MTH i	127.829 Kg/MTHi
Fresh Uranium Enrichment	0.25 w/o U-235	0.25 w/o U-235
Spent Uranium Enrichment	0.14 w/o U-235	0.14 w/o U-235

TABLE E-9 (Cont.)

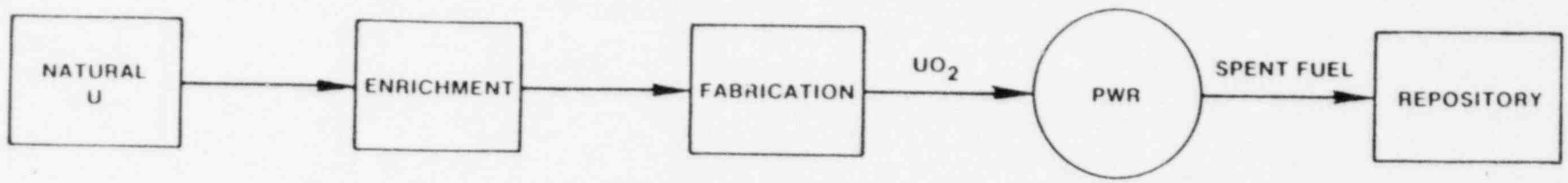
ENERGY ECONOMIC DATA BASE

DESIGN CHARACTERISTICS OF GCFR

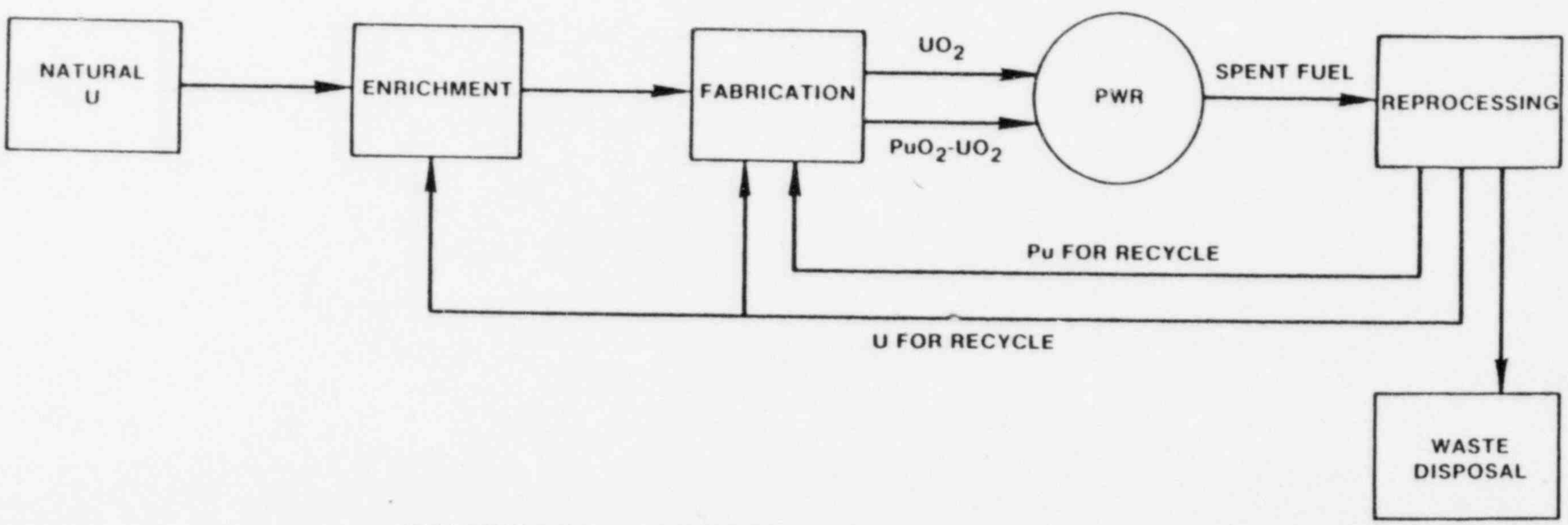
	GCFR-Pu/U/U/U	GCFR-Pu/U/Th/Th
Axial Blanket		
Loading	33.01 MTH	28.493 MTH
Fissile Plutonium Discharged	28.356 Kg/MTH_i	---
Fissile U-233 Discharged	---	31.787 Kg/MTH_i
Fresh Uranium Enrichment	0.25 w/o U-235	---
Spent Uranium Enrichment	0.20 w/o U-235	---
Radial Blanket		
Loading	99.305	85.938 MTH
Fissile Plutonium Discharged	15.591 Kg/MTH_i	---
Fissile U-233 Discharged	---	16.868 Kg/MTH_i
Fresh Uranium Enrichment	0.25 w/o U-235	---
Spent Uranium Enrichment	0.22 w/o U-235	---

FIGURE E-1

LWR FUEL CYCLE



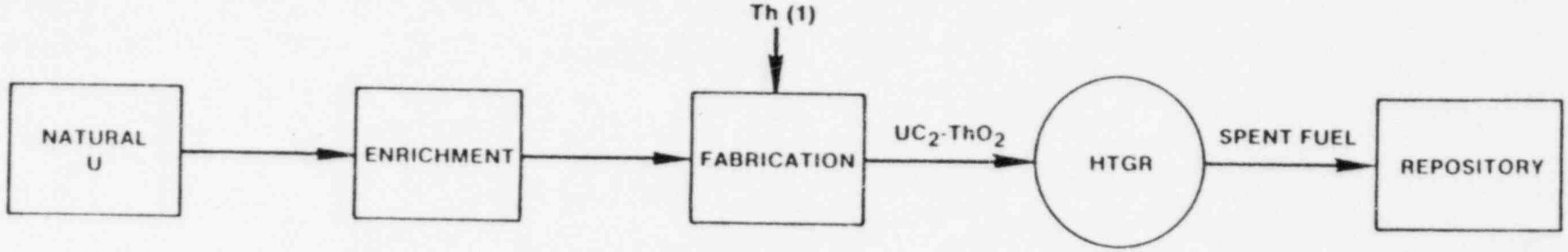
(A) THROW-AWAY CYCLE (PWR-U5(LE)/U-T)



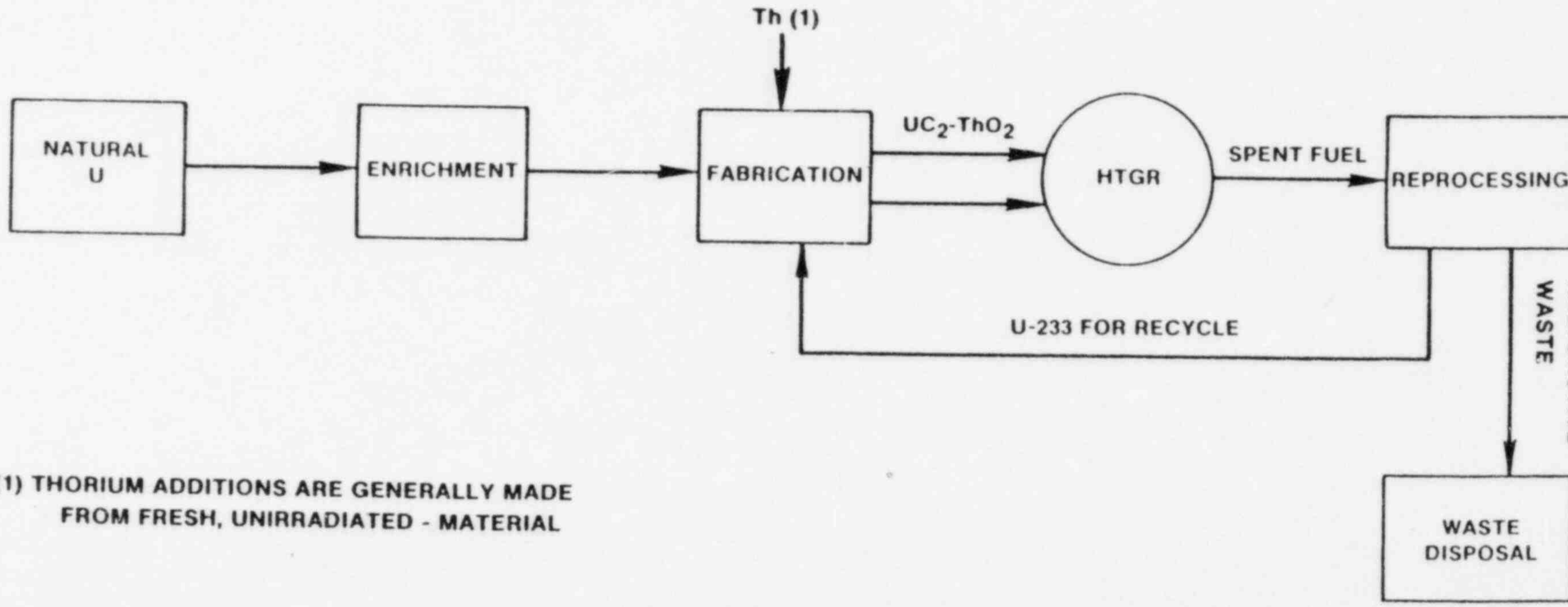
(B) PLUTONIUM AND URANIUM RECYCLE (PWR-U5(LE) + Pu(RE)/U)

FIGURE E-2

HTGR FUEL CYCLE



(A) THROW-AWAY CYCLE (HTGR-U5/U/Th-20%-T)

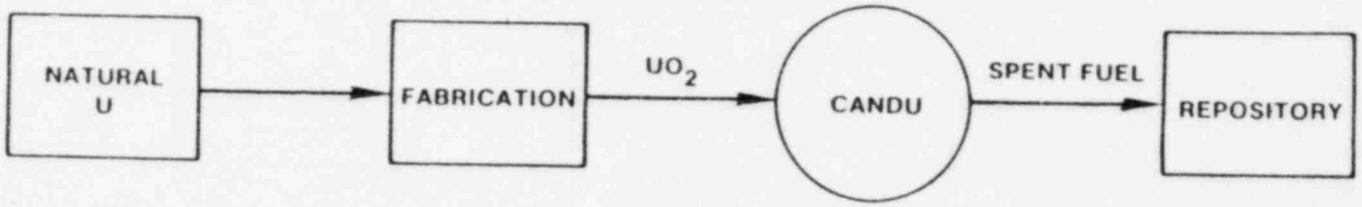


(1) THORIUM ADDITIONS ARE GENERALLY MADE FROM FRESH, UNIRRADIATED - MATERIAL

(B) U-233 RECYCLE (HTGR-U5 (DE)/U/Th-20%)

FIGURE E-3

PHWR (CANDU) FUEL CYCLE

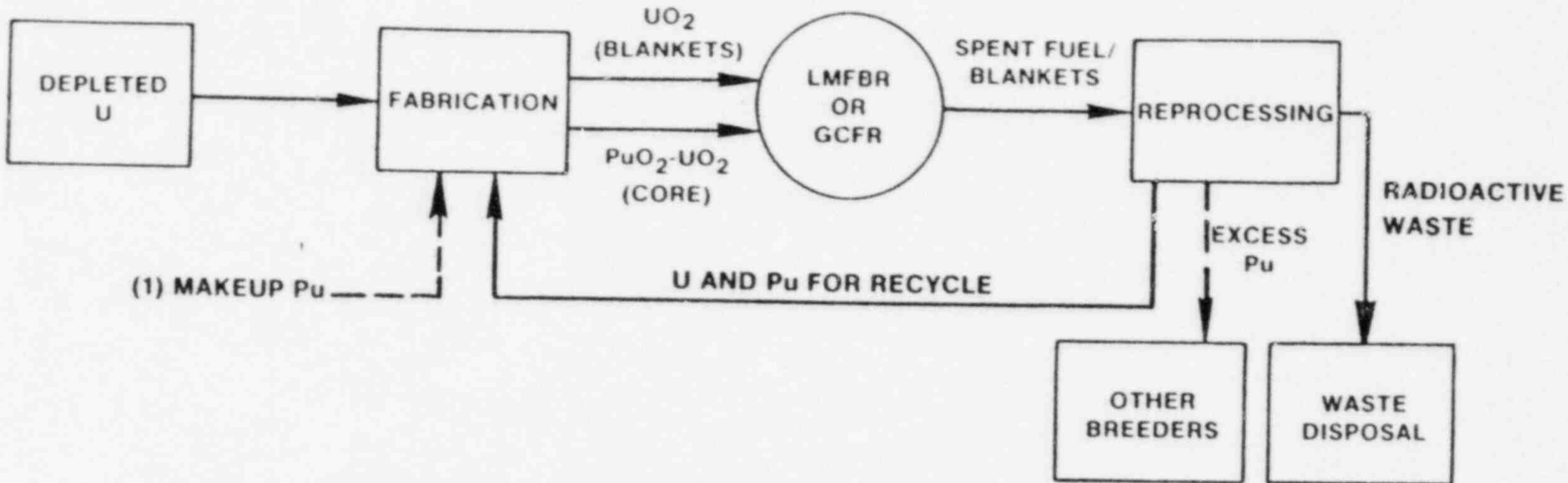


(A) NATURAL URANIUM THROW AWAY CYCLE (CANDU-U5(NAT)/U-T)

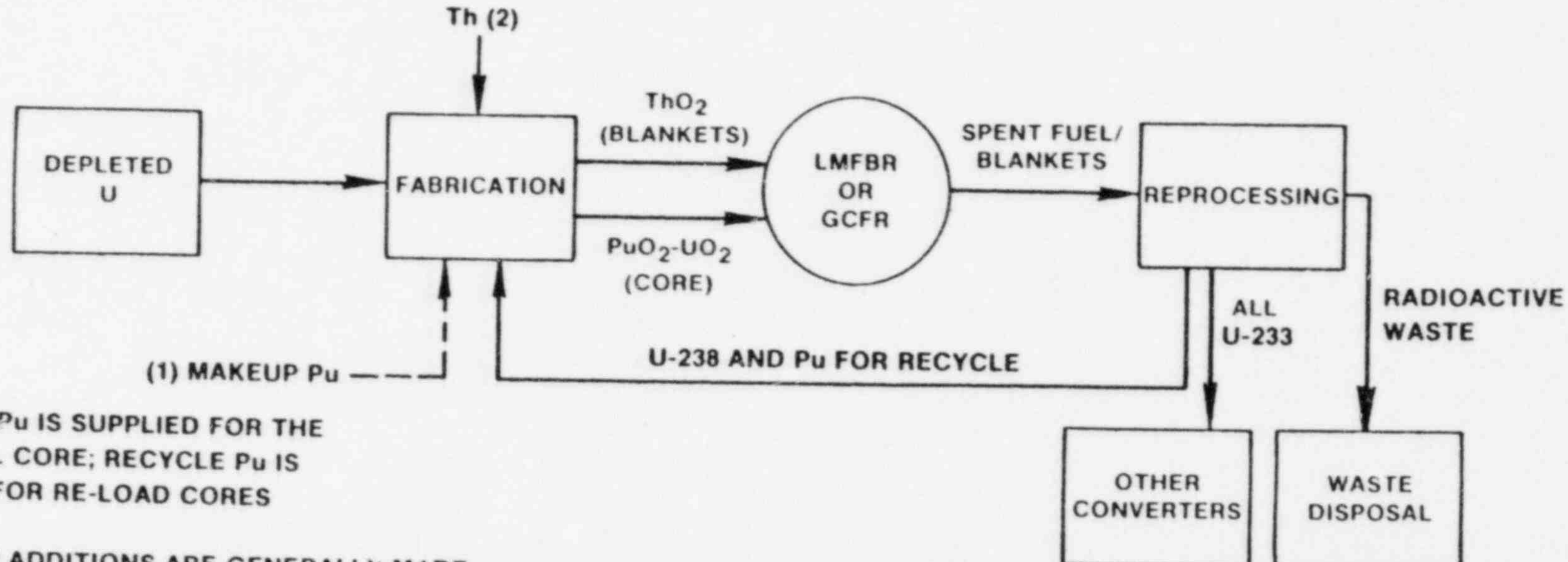
(B) SLIGHTLY ENRICHED URANIUM THROW AWAY CYCLE (CANDU-U5(SE)/U-T)

FIGURE E-4

LMFBR/GCFR FUEL CYCLE



(A) URANIUM BLANKETS (LMFBR-Pu/U/U/U-HT OR GCFR-Pu/U/U/U)



(1) MAKEUP Pu IS SUPPLIED FOR THE INITIAL CORE; RECYCLE Pu IS USED FOR RE-LOAD CORES

(2) THORIUM ADDITIONS ARE GENERALLY MADE FROM FRESH, UNIRRADIATED MATERIAL

(B) THORIUM BLANKETS (LMFBR-Pu/U/Th/Th/ OR GCFR-Pu/U/Th/Th)