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Phase VII Update (1984) Report For The Energy Economic Data Base Program EEDB - VII

Published August 1985

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Prepared for:
U.S. Department of Energy
Assistant Secretary for Nuclear Energy
Office of Support Programs
Plans and Evaluation Division

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ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM
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EXECUTIVE SUMMARY OF THE
ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM
PHASE VII UPDATE (1984) REPORT

DESCRIPTION OF THE ENERGY ECONOMIC DATA BASE PROGRAM

The objective of the Energy Economic Data Base (EEDB) Program is to provide current, representative and consistent power plant technical and cost information to the U.S. Department of Energy (DOE). These data are useful for program planning by the Office of the Assistant Secretary for Nuclear Energy, because they are representative of current U.S. power plant construction cost experience and are developed on a consistent, organized basis.

Historical Basis

This update of the Energy Economic Data Base is the latest in a series of technical and cost studies prepared by United Engineers & Constructors Inc., during the last 20 years. These studies have been sponsored by the U.S. Department of Energy, the U.S. Nuclear Regulatory Commission and their predecessor organizations, the U.S. Energy Research and Development Administration, and the U.S. Atomic Energy Commission. The EEDB and its antecedent studies provide a common and consistent detailed basis for evaluating and comparing the economic viability of a variety of nuclear and alternative power generating stations.

The data base was assembled in 1978 and has been updated annually since then. The purpose of the updates has been to reflect the impact of changing regulations and technology on the costs of electric power generating stations. This Phase VII Update (1984) Report documents the results of a comprehensive update of the technical and capital cost information for the pressurized water reactor nuclear power plant and the 486 MWe high sulfur coal-fired power plant data models. Additionally, large scale prototype breeder reactor technical and cost data models were introduced to the data base. The update provided costs for these nuclear and comparison power plants that are representative of current experience and practice. Costs for the pressurized water reactor nuclear power plant (PWR) are given in terms of both the best and median industry cost experience. Consequently, the Phase VII Update has continued to provide important benchmark information through which technical and capital cost trends may be identified that have occurred since 1978.

Power Plant Cost Trends and The EEDB Program

The EEDB updates regularly report capital cost estimates for selected types of power plants based on technical developments and economic and regulatory conditions current for the reference date of each update. That is, they incorporate current regulatory requirements, design, construction and management practices, labor productivity, and labor/material costs. Capital costs are developed in terms of direct and indirect base construction costs. The direct costs are the costs of commodities, equipment and their installation labor. Indirect costs are the costs of construction services, engineering, construction management, field supervision and testing. Contingency, owner's and inflation related costs are not included.

The Phase VI (1983) and the preceding five EEDB Updates identified a continuing upward trend in light water reactor power plant costs, relative to those of

coal-fired power plants. The principal drivers behind this trend were increases caused by sharp rises in the quantities of commodities, construction (craft) labor manhours, and engineering and construction supervision manhours. Labor (craft, engineering and field supervision) costs became the predominant cost driver in the Phase VI Update. These trends have continued in the Phase VII Update, and are reflected in the median industry experience based PWR data model.

Continuing increases in nuclear power plant base construction costs are not in themselves a new development. Nevertheless, through the use of this cost driver information, the EEDB has become an important tool in identifying those cost elements that have been most susceptible to change, and the factors that have been dominant in causing their change. This kind of information may provide a basis for identifying and developing corrective measures that permit nuclear energy to continue as a competitive source of electric power.

Data Base Content

The data base contains technical and capital (base construction) cost data models for 15 different types of nuclear and comparison power generating stations. The 15 power plant data models included in the data base are listed below. Those data models that were updated or added in the Phase VII Update are marked with a "VII." The remaining data models are marked with a number indicating the year in which they were last updated.

Nuclear Power Generating Stations

- 83 1190 MWe Boiling Water Reactor Plant (BWR)
- 82 858 MWe High Temperature Gas Cooled Reactor Plant - Steam Cycle (HTGR-SC)
- 82 150 MWt High Temperature Gas Cooled Reactor Plant - Process Steam (HTGR-PS)
- VII 1139 MWe Pressurized Water Reactor Plant - Median Cost Experience (PWR•ME)
- VII 1139 MWe Pressurized Water Reactor Plant - Best Cost Experience (PWR•BE)
- 82 1260 MWe Pressurized Heavy Water Reactor Plant (PHWR)
- 83 1457 MWe Liquid Metal Fast Breeder Reactor Plant (LMFBR)
- VII* 1320 MWe Large Scale Prototype Breeder Reactor Plant (LSPB)

Comparison Fossil Power Generating Stations

- 81 1240 MWe High Sulfur Coal Plant (HS12)
- 83 791 MWe High Sulfur Coal Plant (HS8)
- 81 1244 MWe Low Sulfur Coal Plant (LS12)
- 81 795 MWe Low Sulfur Coal Plant (LS8)
- 81 630 MWe Coal Gasification Combined Cycle Plant (CGCC)
- VII 486 MWe High Sulfur Coal Plant (HS5)
- 82 480 MWe Low Sulfur Coal Plant (LS5)
- 82 360 MWe Low Sulfur Coal Plant - District Heating (LS5-D/H)

* New Addition

In the EEDB, the terms "capital cost" and "base construction cost" are used interchangeably. EEDB base construction costs are in constant dollars and contain no arbitrary factors, such as contingency or escalation. In actual practice, total capital costs are the sum of the base construction costs and a number of other factors, such as owner's costs, contingency, escalation and allowance for funds used during construction. Users of the data base may apply these factors to suit their unique scenarios.

Perhaps the most important attribute of any EEDB update is the fact that assumptions and ground rules are clearly identified and are applied uniformly to all cost estimates. Site related factors are normalized by locating each technical data model on a common hypothetical "Middletown" site, for which there is a detailed geological and environmental description. Adjustments may be made to the technical/cost data models to reflect the characteristics of actual sites.

Technical/Cost Data Models

Each capital cost estimate is based upon a detailed technical data model which includes system design descriptions for over 50 major structure/systems and up to 400 subsystems, and a detailed equipment list containing up to 1250 mini-specifications and up to 10,000 data lines of commodity, equipment and labor hour quantities and costs. The technical data models are based on actual current power plant designs and over 50 years of power plant design and construction experience. The data models have sufficient visibility of details and assumptions that the user may have confidence in the consistency, balance and comparability of the various alternatives contained in the data base.

EEDB Program Estimating Approach

The EEDB estimating approach promotes understanding and acceptance of reported costs, because all components of "bottom-line" amounts in the different estimates are readily identified and compared through a uniform accounting system. For example, base construction costs are presented as equipment, labor, and site material costs in a uniform code-of-accounts. Each system, component or commodity that is common to two or more of the technical data models has the same account identifier in every data model. This feature, together with the high level of detail furnished, is the means by which a consistent comparison of commodities, components and manhours is accomplished among diverse alternatives whether they are already incorporated in the data base or an existing data model is modified to represent their unique characteristics.

All estimates are point estimates that generally represent the median of an actual or projected range of cost estimates for each data model for the update year. Yearly variations in the availability and quality of power plant technical and cost data tend to obscure actual year to year cost changes. Consequently, the series of point estimates generated during the seven updates are considered to be more representative of cost trends than of point-to-point variations.

SUMMARY OF THE PHASE VII UPDATE TECHNICAL CHANGES

Major Activities

Selection of technical/cost data models to be updated or added to the data base and related activities for a given update are based on current DOE objectives and availability of resources. During the Phase VII Update, the following major activities were completed:

- Phase VI (1983) PWR•ME, PWR•BE and HS5 technical/cost data models were refined and updated to January 1, 1984 with particular emphasis on improving the technical maturity of the HS5 to a comparable level with that of the PWR.
- The LMFBR was replaced with an EEDB LSPB technical/cost data model based on the EPRI/ CoMO (Consolidated Management Office for the liquid metal fast breeder reactor) LSPB and EEDB Program ground rules.
- The EEDB Technical Reference Book was updated for the PWR and expanded to include complete system design descriptions for the HS5 and LSPB, and building/equipment arrangement drawings and design/construction milestone schedules for the PWR and HS5.

Phase VII Technical Update Process

It was observed during the Phase VII Update that nuclear power plant costs continued to escalate above the general inflation rate, but at a rate of increase that appeared to be slackening. This observation was based on company confidential data that was available during the update. Table ES-1 summarizes this data for large light water reactor power plants and a range of coal-fired power plants, which are under construction and over 45 percent complete. For the nuclear power plants, the predominant cost drivers remained craft labor, engineering and field supervision manhours.

An in-depth review was performed on the PWR•ME, PWR•BE and HS5 to adjust their technical data models against current construction experience, as represented by available field data, other appropriate studies and United Engineers' current experience. Adjustments were made to quantities of commodities, equipment and manhours for each technical data model's structures/systems at the nine-digit code-of-accounts level of detail. After these adjustments were made, the PWR and HS5 technical data models' total quantities of commodities and manhours were found to be representative of current industry experience and practice.

The PWR has been representative of median nuclear power plant cost experience in the EEDB program since 1978. Because of the increasing spread in the nuclear power plant cost range, it has become less representative of better nuclear power plant cost experience. During the Phase VI Update (1983), the PWR•BE was created from the old PWR to support cost estimates that were more

representative of commercially viable systems anticipated for the 1990's. The modified technical data models were based on the current best (but not lowest) industry cost and manhours experience and the assumption that regulatory reforms and improved construction practices would be promulgated and implemented. The older PWR became the PWR•ME and continued to be representative of median industry cost experience. During the Phase VII Update (1984), additional refinements were made to the PWR•BE to improve its representation of best nuclear power plant cost experience.

A variety of technical refinements were made to the PWR•ME, PWR•BE and HS5 during a major design practice review of these technical data models. This effort was supplemented with the development of building/equipment arrangement drawings and licensing/engineering/construction schedules. Reviews of structure/system configuration, parameters and installation manhours were made based on these documents. A technical maturity review was conducted for the HS5 so that the more representative 486 MWe HS5 could replace the HS8 in the Phase VII Update as the lead comparison power plant. New system design descriptions were prepared for the HS5 to supplement the development of the drawings and schedules mentioned above.

A new liquid metal reactor technical data model was incorporated into the EEDB to replace the LMFBR. The new data model was based on the EPRI/CoMO (Consolidated Management Office for the Liquid Metal Fast Breeder Reactor) Large Scale Prototype Breeder (LSPB) nuclear power plant. The EEDB-LSPB was used to prepare a cost estimate based on the EPRI/CoMO LSPB cost estimate and the EEDB ground rules. The substitution of the LSPB for the LMFBR in the EEDB reflected the designation of the LSPB as the base liquid metal reactor concept by the U.S. Department of Energy. It should be noted that the LSPB is a second-of-a-kind, pre-commercial unit, while other EEDB data models represent nth-of-a-kind, commercial units.

The Phase VI Technical Reference Book was updated during the Phase VII Update. The update included refinement of conceptual system design descriptions for the 50 major structures and systems for each of the nuclear and coal-fired power plants updated in Phase VII and the supporting tabulations of key technical parameters, plot plans and summary heat balance diagrams. The newly developed engineering drawings and milestone schedules described above were incorporated into the Phase VII Technical Reference Book.

The adjustments described above comprise a major update to the EEDB technical data models. An important result of the effort is that the EEDB technical features and resulting capital cost estimates are currently reflective of nuclear and coal-fired power plant construction experience. Consequently, the data base is available to serve as a current benchmark for identifying trends in quantities of commodities, equipment and manhours and their related costs for those types of power plants included in the update.

RESULTS OF THE PHASE VII UPDATE COST CHANGES

Summary of the Cost Results

The Phase VI (1983) base construction costs were recalculated during the Phase VII Update based on updated pricing information and the adjusted and revised technical data models described above. Quantities of commodities and equipment were derived from the updated technical data models. Updated equipment prices were obtained from manufacturers of major equipment. Installation rates, and engineering and field supervision manhours were based on available field data and United Engineers' current experience. Commodity unit costs and labor rates were revised, in accordance with national indices and United Engineers' project experience.

A summary of the Phase VII Update base construction cost results is given in Table ES-2. All costs are given in January 1, 1984 constant dollars and include the consequences of safety and environmental regulations in effect on that date. The table illustrates the cost differences between median and best experience nuclear power plants and between nuclear and coal-fired power plants.

The base construction (direct + indirect) or capital costs exclude owner's costs, contingency, fixed charges, escalation and allowance for funds used during construction. The nuclear power plant costs include the effects of design features that resulted from the Three Mile Island incident. The coal-fired power plant costs include costs for enclosed boilers and turbine-generators, electrostatic precipitators, and wet lime flue gas desulfurization systems (scrubbers). Both nuclear and coal-fired power plants include costs for mechanical draft cooling towers, river water makeup, and treatment of waste water discharge. The coal-fired power plant costs include costs for coal storage pile water runoff and seepage control systems.

Summary of Cost Changes

An overview of the EEDB cost changes, that have occurred between the Phase I Update in 1978 and the Phase VII Update in 1984, is given in Table ES-3. All of the values in Table ES-3 are given in 1984 constant dollars to remove the effects of inflation. This table shows that the PWR•ME has experienced a significant real base construction cost increase between 1978 and 1984, relative to that experienced by the HS5. On the other hand, the table shows that the cost increase for the PWR•BE is similar to that experienced by the HS5. The PWR•ME has more than doubled in cost between 1978 and 1984, while the PWR•BE and the HS5 costs have increased by about 25 percent each. Of the increase for the PWR•ME, over 25 percent occurred between the Phase V (1982) and Phase VI (1983) Updates, while the HS5 remained relatively constant in cost between these two updates.

The cost changes for the PWR's from 1978 through 1984 have been driven by increases in commodities and manhours, particularly in the case of the PWR•ME during 1982 and 1983. The cost change for the PWR•ME was primarily caused by the large increase in manhour costs that occurred in the Phase VI Update

(1983). The cost change for the HS5 was primarily caused by the increase in costs for flue gas cleaning, waste water treatment and various technical refinements; however, the major impact was caused by a near tripling of the flue gas cleaning equipment installed costs. The HS5 cost changes largely offset the PWR•BE cost changes between 1978 and 1984 even though they had different aspects. The HS5 cost changes were unable to offset the large labor cost increases in the PWR•ME. In all three cases, however, the major cost increases were related to changes in regulations and their interpretations.

The LSPB was a new cost entry for the Phase VII Update. It is based on a second-of-a-kind replica plant that has a "best experience" class of labor costs, but has not reached the cost maturity of a commercial power plant, particularly in the area of the nuclear steam supply system and its supporting structures/systems. Since the other updated EEDB data models represent nth-of-a-kind commercial costs, comparisons between the LSPB and the PWR or HS5 in Table ES-3 must be made with care.

IMPLICATIONS OF THE RESULTS OF THE PHASE VII UPDATE

Influence of Capital Cost on Nuclear/Coal Cost Comparisons

Historically, light water reactor nuclear power plants have had higher capital costs, but lower fuel cycle costs, than coal-fired power plants. On the average, the much higher fuel costs for the coal-fired power plants have in the past been projected to more than offset the higher capital costs of nuclear power plants. Therefore, nuclear power plants were perceived to produce electricity at a lower cost than many coal-fired power plants over their projected life cycles.

As shown in Tables ES-3 through ES-5, the capital costs for the median cost experience nuclear power plants have been increasing at a much faster rate than for coal-fired power plants. Consequently, these nuclear power plants have become marginally competitive with coal-fired power plants.

Comparison of Nuclear/Coal Cost Ratios

The EEDB PWR and HS5 base construction cost comparison in Table ES-4 for the period between 1978 and 1984 shows a much faster rate of increase for the PWR•ME costs than for either the PWR•BE costs or the HS5 costs. The values in this table are given in 1984 constant dollars to remove the effects of inflation from the comparison. Table ES-4 indicates that during this period the PWR•ME base construction costs increased at a rate of 13 percent per year above general inflation, while the PWR•BE and the HS5 base construction costs have each increased at a rate of four percent per year above general inflation. The table also indicates that the indirect costs for each of the PWR's and the HS5 have increased at a faster rate than the direct costs; however, the PWR•ME increase in indirect costs is much more significant.

Table ES-4 exemplifies the nuclear and coal-fired power plant cost trends implied by the results of the Phase I through Phase VII Updates of the EEDB. The cost trends are most significant when they are used to compare the relative costs of the nuclear option (as represented by the EEDB PWR) and an

alternative (as represented by the EEDB HS5). The nuclear/coal-fired power plant capital cost trends, as identified by the changes in EEDB cost ratios between 1978 and 1984, are given in Table ES-5. On a dollars per kilowatt basis, the PWR•ME costs increased from a one percent differential in 1978 to a 70 percent differential in 1984. On the same basis, the PWR•BE costs maintained the 1978 one percent differential through 1984.

Capital Cost Drivers

As shown in Table ES-4, base construction costs for the EEDB median experience nuclear power plant has increased at a rate above general inflation that is over three times that for the comparable EEDB coal-fired power plant. As shown in Table ES-5, the median experience PWR/HS5 cost ratio has increased by two-thirds between 1978 and 1984. The increases represented in Tables ES-4 and ES-5 have been driven by increases in commodities, equipment and manhours, but more recently the increases have been in craft manhours and indirect costs. Since 1978 labor (craft, engineering and field supervision) costs have increased by 200 percent above general inflation for the PWR•ME, 35 percent for the PWR•BE and 25 percent for the HS5.

The field surveys made concurrently with the Phase V and Phase VI Updates found and verified that both regulatory and construction practices were responsible for the continuing increase in manhours. Engineering and engineering support services, construction crafts and indirect labor associated with temporary facilities and field supervision were primary contributors to this increase. The surveys also showed a correlation between high manhours and high costs as well as low manhours and low costs. If the median to high cost and manhour experience continues, nuclear power plants will become increasingly less competitive with coal-fired power plants and other alternatives. On the other hand, if the best cost and manhour experience were to prevail in the future, nuclear power plants would most likely be at least as competitive with coal-fired power plants as they were in 1978 when the EEDB Phase I Update showed a PWR/HS5 dollars per kilowatt (electrical) capital cost ratio of 1.01.

Effective Date 1/1/84

TABLE ES-1

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE

NUCLEAR^(a) AND COAL-FIRED^(b) POWER PLANT
COST EXPERIENCE

<u>Cost Experience Level</u>	<u>BCC^(c) \$/kWe (1984)</u>			
	<u>Phase VI (1983)^(d)</u>		<u>Phase VII (1984)</u>	
	<u>NPGS</u>	<u>FPGS</u>	<u>NPGS</u>	<u>FPGS</u>
Best	1456	N/AV	1492	603 ^(e)
Median	2259	N/AV	2578	1492
Poorest	3485	N/AV	3215	1755
Average	2393	N/AV	2453	1243 ^(e)

(a) 900 MWe to 1300 MWe, Single or First-on-Site LWR Units Under Construction, but Over 65 Percent Complete.

(b) 250 MWe to 850 MWe, Single or First-on-Site Coal-Fired Units, with Flue Gas Desulfurization Systems, Under Construction, but Mostly Over 45 Percent Complete.

(c) Base Construction Cost: Data in January 1, 1984 Constant Dollars without AFUDC, but Including Contingency and Owners Costs.

(d) Escalated to Account for General Inflation Between 1983 and 1984.

(e) Units in the low end of the cost range are repeat units on a single site or burn low sulfur coal.

N/AV = Data Not Available

Effective Date 1/1/84

TABLE ES-2

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE

SUMMARY OF THE PHASE VII UPDATE (1984) BASE CONSTRUCTION COSTS
(Constant January 1, 1984 Dollars)

<u>Data Model</u>	<u>Nuclear Power Plants</u>			<u>Coal-Fired Power Plants</u>
	<u>PWR•ME(a)</u>	<u>PWR•BE(a)</u>	<u>LSPB(b)(c)</u>	<u>HS5(a)</u>
MWt	3411	3411	3500	1379
MWe	1139	1139	1320	486
Total Base				
Construction Costs (\$ x 10 ⁶)	2130	1272	1943	536
(\$/kWe)	1870	1117	1472	1103

(a) Costs are based on an nth-of-a-kind, commercial unit.

(b) Costs are based on a second-of-a-kind, pre-commercial unit.

(c) Costs do not include the cost of the initial inventory of sodium.

TABLE ES-3

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE

COMPARISON OF PHASE I (1978) AND PHASE VII (1984) UPDATES
BASE CONSTRUCTION COSTS
(Constant January 1, 1984 Dollars)

<u>Data Model</u>	<u>PWR•ME</u>		<u>PWR•BE</u>		<u>LSPB</u>	<u>HS5</u>	
MWt	3411		3411		3500	1379	
MWe	1139		1139		1320	486	
EEDB Program Update Phase	<u>I(a)</u>	<u>VII</u>	<u>I(a)</u>	<u>VII</u>	<u>VII(b)</u>	<u>I(c)</u>	<u>VII</u>
Total Base Construction Costs (\$ x 10 ⁶)	1010	2130	1010	1272	1943	427	536
(\$/kWe)	887	1870	887	1117	1472	878	1103

- (a) The Phase I Update (1978) PWR data model was the antecedent for both the PWR•ME and PWR•BE data models.
 (b) The LSPB has no antecedent for comparison because it is a new data model in the Phase VII Update.
 It is based on a second-of-a-kind, pre-commercial unit, while the PWR•ME, PWR•BE and HS5 are based on
 nth-of-a-kind, commercial units. Costs do not include the cost of the initial inventory of sodium.
 (c) The Phase I Update (1978) 795 MWe HS8 costs have been adjusted to reflect the costs for a 486 MWe HS5.

Effective Date 1/1/84

TABLE ES-4

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE

PHASE I (1978) TO PHASE VII (1984) UPDATE
BASE CONSTRUCTION COST INCREASES FOR THE
PWR•ME, PWR•BE AND HS5
(Constant January 1, 1984 Dollars)

	<u>EEDB Program Update</u>		<u>Average Compound Annual Increase (%)</u>
	<u>Phase I</u>	<u>Phase VII</u>	
<u>PWR•ME</u>			
Direct Costs	711	1061	7
Indirect Costs	<u>299</u>	<u>1069</u>	24
Base Construction Costs	1010	2130	13
<u>PWR•BE</u>			
Direct Costs	711	800	2
Indirect Costs	<u>299</u>	<u>472</u>	8
Base Construction Costs	1010	1272	4
<u>HS5(a)</u>			
Direct Costs	351	433	4
Indirect Costs	<u>76</u>	<u>103</u>	5
Base Construction Costs	427	536	4

(a) The Phase I Update (1978) 795 MWe HS8 costs have been adjusted to reflect the costs for a 486 MWe HS5.

Effective Date 1/1/84

TABLE ES-5

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE

COMPARISON OF PHASE I (1978) AND PHASE VII (1984) UPDATES
PWR/HS5^(a) BASE CONSTRUCTION COST RATIOS

	<u>PWR/HS5 Base Construction Cost^(b) Ratio</u>
Phase I Update (1978)	
PWR	1.01
Phase VII Update (1984)	
PWR•ME	1.70
PWR•BE	1.01

(a) PWR: 1139 MWe
HS5: 486 MWe

(b) Based on Constant Dollars per kWe in the Year of the Estimate. The Phase I Update (1978) 795 MWe HS8 costs have been adjusted to reflect the costs for a 486 MWe HS5.

SECTION 1

1.0 OVERVIEW OF THE PHASE VII UPDATE REPORT

1.1 EEDB PROGRAM BACKGROUND

1.1.1 Purpose and Objective

The Energy Economic Data Base (EEDB) Program provides power plant technical and cost information to the U.S. Department of Energy (DOE) that is representative of current U.S. power plant construction cost experience. These data are used in program planning by the Office of the Assistant Secretary for Nuclear Energy. The internally consistent, technical and cost data models for these large power plants (500 MWe to 1500 MWe) provide detailed design data and cost information as the basis for capital cost estimates.

The objective of the data base is to develop credible cost estimates that clearly indicate what is included in the costs. This objective is achieved through the inclusion of a high level of detail in the technical data models and clear statements of the ground rules and assumptions on which the technical and cost detail is based. Additionally, the data models are periodically aligned with actual power plant technical practice and cost experience. Because of the level of detail and periodic alignments, the data models have a high degree of detail so the user may have confidence in the consistency and comparability of the various alternatives contained in the data base.

1.1.2 Design and Application of the Data Base

The data base is structured to provide point estimates of base construction costs (direct plus indirect costs) for each updated data model in a given update year. The estimates are based on quantities of commodities and equipment, unit costs, unit installation hours and labor rates that are representative of actual design and construction experience for each updated data model for the year of the update. The experience is gleaned from internal sources, field information, other cost reports and national cost indices. The most important and effective source of experience is the field information, which reflects the experiences of the entire power industry.

For any given update, the point estimates provide a valid and reasonably accurate resource for making technical and cost comparisons of alternatives. The details in the technical data models provide a basis for determining cost related design feature differences. Analyses of these differences lead to an understanding and acceptance of the cost relationships among the compared alternatives. Such analyses may also show cost anomalies that identify opportunities for cost effective design improvements. Comparisons may be made among alternatives in the data base, between an actual plant and a data base model, or among two or more actual plants. When actual plants are compared, similar data base models must be reconfigured to represent the actual plants before the comparison is made.

The point estimates generally represent the median of an actual or projected range of cost estimates for a particular data model. The succession of point

estimates, over a period of several years, represents a trend rather than actual point to point variations. This is particularly true of the yearly variations in quantities of commodities, equipment and manhours. Year to year variations reflect differences in the availability and accuracy of the experience resources, differences in the point in time at which the available data has been recorded and differences in the level-of-effort available for a particular update. The variations caused by these differences have exhibited the tendency to become normalized over the seven annual EEDB updates.

1.1.3 Historical Development

The technical data models in the data base have evolved from studies performed by United Engineers & Constructors Inc. over the last 20 years. The data base was assembled in 1978 by formally incorporating and updating the data from the earlier studies. The resultant cost estimates and supporting technical descriptions were published in the EEDB Program - Phase I Update (1978) Report.¹ The EEDB has been updated and new update reports have been issued on an annual basis for the years 1979 through 1983.²⁻⁶ This report for the year 1984 describes the results of the seventh annual update in the EEDB Program.

Capital cost estimates based on updated technical data models received the primary emphasis in the update reports and were used to generate the capital associated component of electric generating cost. In the earlier updates, this component was added to fuel and operating/maintenance costs to predict present and future electricity costs. Beginning with the Phase VI (1983) Update, the effort was focused on estimating the capital (base construction) costs without predicting electricity costs. The Seventh (Phase VII) Update has incorporated 1984 technical and economic data for a cost and regulation date of January 1, 1984. The Phase VII Update of the EEDB Program was authorized under ORNL Sub-contract Number 38X-86004V.

1.1.4 Recent Developments

Each year, various technical and cost data models have been selected to be updated. Plant types and cost areas selected have been dependent on available resources and related objectives of the Department of Energy. Data models for plant types and cost areas not included in an update were retained in the EEDB for possible reactivation in a future update. At the conclusion of the Sixth (Phase VI) Update, the EEDB contained technical and capital, fuel, and operating and maintenance cost data models for fourteen different types of nuclear or fossil power generating stations; however, technical and capital cost data models for only five plant types were updated.

The six updates preceding this Seventh Update focused on a variety of power plant types at varying levels of effort. An historical record of the plant types included in each of these updates is given in Table 1-1. The new and existing data models selected for this update, the PWR•ME, PWR•BE, LSPB and HS5, are defined in Table 1-2.

1.1.5 Resources for Use of the EEDB

The EEDB Program Reference Book⁷ provides the assumptions, reference conditions, and ground rules under which the EEDB technical and cost data models have been developed. The results presented in the EEDB Update Reports are valid only under the described conditions. Therefore, a good understanding of the items included in and excluded from the data models is necessary before the results may be effectively extended to a wider range of conditions and sensitivities. A discussion of what is and is not included in EEDB Program reported costs may be found in the EEDB Program Reference Book and, in part, in Table 5-2.

The Program Reference Book provides important descriptive and tutorial information concerning the structure and use of the EEDB, particularly with respect to the data models' level of detail and the "code-of-accounts" system that provides order and consistency to that detail. It also contains reports of work done to support various aspects of earlier updates, together with significant reference data developed during those updates. The first three sections of the Reference Book describe the EEDB Program, identify the components of the data base and state the ground rules under which costs are developed and updated. Other sections describe the data base components and the technical and cost updating procedures in detail. The user of this Update Report is urged to review the Reference Book before attempting to utilize the data reported herein, in order to derive the maximum benefit from the Update. As a minimum, the user should be familiar with Sections 1 through 3 of the Reference Book.

1.2 THE PHASE VII EEDB PROGRAM OBJECTIVES, GOALS AND SCOPE

1.2.1 Objectives and Goals

The objective of the Phase VII Update of the EEDB was to support ongoing DOE assessment of the long-term economic potential of the nuclear option. The Phase VIII and Phase IX Updates are currently planned to meet this objective by extending and refining the Phase VII work. Consequently, the major goals for the Phase VII Update were to maintain, expand and refine the technical/cost data models, to continue the development (started in the Phase VI Update) of costs representative of the best nuclear power plant construction experience and to lay the groundwork for the Phase VIII and Phase IX work.

1.2.2 Scope

The scope of the Phase VII Update included three major efforts. The first major effort was the technical and cost updates of the PWR•ME and HS5 data models. The PWR•ME is the historic PWR data model with its cost history going back to the Phase I Update (1978). (This data model was referred to as the "PWR for the 1980's" in the Phase VI Update (1983).) It reflects the median cost experience (ME) for nuclear power generating stations currently under construction. The HS5 has been designated as the lead comparison plant data model, replacing the HS8 (791 MWe). This change reflects the current industry trend for selection of lower coal-fired power plant capacities.

The second major effort for the Phase VII Update was the technical and cost update of the PWR•BE data model. The PWR•BE is based on the PWR•ME, but has quantities of commodities, equipment, and installation manhours and indirect costs that reflect the best cost experience (BE) for nuclear power generating stations currently under construction. (This data model was referred to as the "PWR for the 1990's" in the Phase VI Update (1983).) The PWR•BE to HS5 cost comparison provides an interesting and revealing contrast to the PWR•ME to HS5 cost comparison.

The third major effort for the Phase VII Update was the replacement of the LMFBR with a liquid metal reactor data model similar to the Large Scale Prototype Breeder (LSPB). The LSPB has been designated by DOE as the reference plant for evaluation of advanced liquid metal reactors. The EEDB LSPB is based on the concept developed by the Consolidated Management Office for the LMFBR of the Electric Power Research Institute (EPRI/CoMO). It is expected that this effort will be expanded and refined in the Phase VIII and IX Updates.

1.3 SUMMARY OF PHASE VII UPDATE ACTIVITIES

Specifically, the activities pursued to meet the objectives and goals of the Phase VII Update are listed below.

1. The EEDB was updated to include January 1, 1984 regulatory, technical and capital cost data.
2. The PWR•ME and PWR•BE technical data models were updated.
3. The LMFBR was replaced by the EPRI/CoMO LSPB which was modified to EEDB ground rules at the three-digit code-of-accounts level of detail.
4. An extensive and detailed technical review was made of the HS5 for development of the necessary data model maturity required to replace the HS8 as the lead comparison plant.
5. Building and equipment arrangement drawings and engineering/construction milestone schedules were prepared for the PWR•ME/BE and the HS5.
6. Various major system flow diagrams were prepared for the HS5.
7. New system design descriptions were prepared for the LSPB and HS5, based on Items 3, 4 and 6 above.
8. The Technical Reference Book (1983)⁸ was updated for the PWR, LSPB and HS5, based on Items 1 through 7 above and was issued as the Phase VII Update Technical Reference Book (1984).⁹

9. Indirect cost accounts were reviewed and refined for the PWR•ME/BE, LSPB and HS5 relative to craft, engineering and field supervision manhours.
10. This update report was prepared based on Items 1 through 9 above.

The data tables, which make up a large part of this Phase VII Update (1984) Report, were updated to the cost and regulation basis date of January 1, 1984. The data in these tables supersede the corresponding technical and cost information presented in the Phase VI Update (1983) Report.²

1.4 PRESENTATION OF THE EEDB PROGRAM REPORT

For the Seventh Update (1984), the EEDB Program Report is divided into two parts.

This Volume: Energy Economic Data Base Program
Phase VII Update (1984) Report

Companion Volume: Energy Economic Data Base Program
Technical Reference Book, Phase VII
Update (1984)⁹

These volumes are supplemented and amplified by the last four report volumes published.

Energy Economic Data Base Program
Phase VI Update (1983) Report²

Energy Economic Data Base Program
Phase V Update (1982) Report³

Energy Economic Data Base Program
Reference Book (1983)⁷

Energy Economic Data Base Program
Technical Reference Book (1983)⁸

1.4.1 Purpose of the Technical Reference Books

The purpose of the EEDB Technical Reference Book Phase VII Update (1984)⁹ is to provide the current technical design bases for each of the technical data models updated in the Seventh Update (1984). It contains a set of detailed system design descriptions for these technical data models, which are supplemented with engineering drawings and construction schedules. The system design descriptions reflect regulatory and industry practice and experience for nuclear and coal-fired power generating stations that were current on January 1, 1984.

The purpose of the EEDB Technical Reference Book (1983)⁸ is to provide the technical design bases for the BWR and HS8 technical data models which were last updated in the Phase VI Update (1983). It contains detailed system design descriptions for the BWR and HS8, supplemented with engineering drawings. These system design descriptions reflect regulatory and industry practice and experience that were current on January 1, 1983.

The Table of Contents, the List of Tables and the List of Figures for the Phase VII (1984) Technical Reference Book are included for reference in Table 1-3. Sections 1 and 2 discuss the technical data models and the assumptions and ground rules on which they are based. Sections 3 through 5 present the system design descriptions, engineering drawings and construction schedules. It is intended that the Technical Reference Book be periodically updated.

1.4.2 Purpose of the Program Reference Book and the Phase V (1982) and Phase VI (1983) Update Reports

The purpose of the Program Reference Book⁷ and the Phase V (1982) and Phase VI (1983) Update Reports^{2,3} is to provide the historical development of the EEDB through the Phase VI Update. These documents contain important descriptive and tutorial information concerning the structure and use of the EEDB. They also contain reports of work done to support various aspects of the first six updates,¹⁻⁶ together with significant reference data developed during those updates.

1.4.3 Purpose of the Phase VII Update Report

The purpose of the Phase VII Update Report is to present the results of the current update, including a detailed description of technical and cost changes made to the data base following the Phase VI Update. The report includes a detailed description of changes made to the technical data models, and summaries of the updated costs based on these changes. It is intended that a new Update Report be published for each update, using a standard format for easy cross referencing.

1.5 ORGANIZATION OF THE PHASE VII UPDATE REPORT

This overview (Section 1) presents a general introduction to the EEDB Phase VII Update. The remaining sections of the Update Report discuss and present the results of the Phase VII Update at the level of detail necessary to convey the findings of the update.

Section 2 of this report presents a summary of the technical and cost update results.

Section 3 of this report discusses the causes and effects of the Phase VII Update cost changes, relative to the results of previous updates and to nuclear/coal-fired power plant cost trends. The section discusses costs and cost trends for nuclear power plants reflecting the median industry experience and the best industry experience.

Section 4 presents the details of the Phase VII technical changes for each of the updated data models, including key technical parameters and quantities of commodities, equipment and labor manhours.

Section 5 presents the Phase VII capital costs for each of the updated data models. The direct cost changes, relative to the technical changes presented in Section 4, and the major indirect cost changes, relative to the available field information, are also discussed.

Section 6 presents the new EEDB LSPB technical and cost details and provides a comparison between the EEDB LSPB and the EPRI/CoMO LSPB.

Section 7 contains the complete list of references cited in the Phase VII Update Report. Definitions of terms and abbreviations used in this report are also included.

TABLE 1-1

ENERGY ECONOMIC DATA BASE

TECHNICAL DATA MODEL UPDATE HISTORY
NUCLEAR POWER GENERATING STATIONS

Plant Type	Net Cap. (MWe)	EEDB Data Model ^(a) Number by Update						
		1978	1979	1980	1981	1982	1983	1984
Boiling Water Reactor Plant (BWR)	1190	A1	A1	A1	A1	A1	A1(d)	--
High Temperature Gas Cooled Reactor Plant (HTGR)	1330	A2	A2	--	--	--	--	--
High Temperature Gas Cooled Reactor Plant - Steam Cycle (HTGR-SC)	858	--	--	A2(b)	A2	A2(c)	--	--
Pressurized Water Reactor Plant (PWR)	1139	A3	A3	A3	A3	A3	A3(d)	A3(d)
Pressurized Heavy Water Reactor Plant (PHWR)	1162	A4	A4	--	--	--	--	--
Pressurized Heavy Water Reactor Plant (PHWR)	1260	--	--	A4(b)	A4	A4(c)	--	--
Gas Cooled Fast Reactor Plant (GCFR) ^(e)	917	B1	B1	--	--	--	--	--
High Temperature Gas Cooled Reactor Plant - Process Steam (HTGR-PS)	150	--	--	B1(b)	B1	B1	--	--
Liquid Metal Fast Breeder Reactor Plant (LMFBR)	1390	B2	--	--	--	--	--	--
Liquid Metal Fast Breeder Reactor Plant (LMFBR)	1457	--	A5(b)	A5	A5	A5	A5(d)	--
Large Scale Prototype Breeder Reactor Plant (LSPB)	1320	--	--	--	--	--	--	B3(f)

- (a) A = Detailed Data Model, Detailed Level Update
B = Summary Data Model, Summary Level Update
(b) Previous data model replacement
(c) Summary Level Update of Detailed Data Model

- (d) AX*ME (Median Cost Experience) and AX*BE (Best Cost Experience)
(e) GCFR was deleted in the Third Update (1980)
(f) Replicate plant, best cost experience basis

TABLE 1-1

ENERGY ECONOMIC DATA BASE

TECHNICAL DATA MODEL UPDATE HISTORY
COMPARISON POWER GENERATING STATIONS

Plant Type	Net Cap. (MWe)	EEDB Data Model(a) Number by Update						
		1978	1979	1980	1981	1982	1983	1984
Comparison High Sulfur Coal Plant (HS12)	1232	C1	C1	C1	--	--	--	--
	1240	--	--	--	C1	--	--	--
Comparison High Sulfur Coal Plant (HS8)	795	C2	C2	C2	C2	C2	--	--
Comparison High Sulfur Coal Plant (HS8)	791	--	--	--	--	--	C2(b)	--
Comparison Low Sulfur Coal Plant (LS12)	1243	C3	C3	C3(g)	--	--	--	--
	1244	--	--	--	C3	--	--	--
Comparison Low Sulfur Coal Plant (LS8)	802	C4	C4	C4(g)	--	--	--	--
	795	--	--	--	C4	--	--	--
Comparison Coal Gasification Combined Cycle Plant (CGCC)	630	D1	D1	D1	D1	--	--	--
Comparison Low Sulfur Coal Plant (LS5)	480	--	--	--	D2	--	--	--
Comparison High Sulfur Coal Plant (HS5)	480	--	--	--	--	D2(b)	--	--
Comparison High Sulfur Coal Plant (HS5)	486	--	--	--	--	--	C5(b)	C5
Comparison Low Sulfur District Heating Cogeneration Coal Plant (LS5-D/H)	360	--	--	--	D3	--	--	--
Comparison High Sulfur District Heating Cogeneration Coal Plant (HS5-D/H)	360	--	--	--	--	D3(b)	--	--

(a) C = Detailed Data Model, Detailed Level Update
D = Summary Data Model, Summary Level Update

(b) Previous data model replacement
(g) Added flue gas cleaning to technical data model

TABLE 1-2

ENERGY ECONOMIC DATA BASE
 NUCLEAR AND COMPARISON POWER GENERATING STATIONS
 FOR THE PHASE VII UPDATE (1984)

<u>EEDB Model (a) Number</u>	<u>Plant Type</u>	<u>Net Capacity</u>
A3•ME	Pressurized Water Reactor Plant (PWR•ME)(b)	1139 MWe
A3•BE	Pressurized Water Reactor Plant (PWR•BE)(c)	1139 MWe
B3	Large Scale Prototype Breeder Plant (LSPB)(d)	1320 MWe
C5	Comparison High Sulfur Coal Plant	486 MWe

(a) A and C = Detailed Data Model, Detailed Level Update
 B = Summary Data Model, Summary Level Update

(b) ME = Median Industry Cost Experience Basis

(c) BE = Best Industry Cost Experience Basis

(d) This new data model is based on the EPRI/CoMO LSPB Study (Replicate Plant)

TABLE 1-3

EEDB PHASE VII UPDATE (1984) TECHNICAL REFERENCE BOOK

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SECTION 2

2.0 SUMMARY OF THE PHASE VII TECHNICAL/COST UPDATE RESULTS

2.1 TECHNICAL SUMMARY

The status of the technical data models base parameters for the Phase VII Update is summarized in Table 2-1 for the nuclear power plants and Table 2-2 for the comparison power plant. The summaries present listings of important or key parameters that establish the technical envelope for the PWR•ME/BE, LSPB and HS5. The system design descriptions and engineering drawings found in the Phase VII Update Technical Reference Book⁹ supplement and support the key parameters.

2.2 CAPITAL COST SUMMARY

Capital costs have been prepared for the EEDB as "overnight" base construction costs, which are the sum of the direct and indirect costs. Direct costs comprise equipment and commodity costs, the costs of necessary site material and labor for installation of the equipment and commodities. Indirect costs include the costs of construction services, engineering, engineering support, construction management, field supervision, quality assurance, insurance and taxes, and other expenses such as payroll taxes, overhead, and fees. EEDB base construction costs include only those cost elements described in the EEDB Program Reference Book⁷ and in Table 5-2. They specifically exclude owner's costs, contingencies, escalation and allowance for funds used during construction. Direct, indirect and base construction costs are summarized in Table 2-3 for the updated and new power plant data models.

Tables 2-4 and 2-5 also summarize the same data for the updated and new technical/cost data models, except that the capital costs have been normalized to the identical electrical or thermal capacities, respectively. The normalization process is discussed in Section 6 of the Program Reference Book. The net electrical capacity chosen for this process is that of the EEDB PWR, so that capital costs of the other technical data models can be compared to this most frequently chosen industry cost base. The nominal thermal capacity chosen for the normalization process is the maximum licensable nuclear power plant thermal rating of 3800 MWt, so that costs may also be compared on the basis of maximum licensable capacity.

Costs tabulated in Tables 2-3, 2-4 and 2-5 for the PWR•ME, PWR•BE and HS5 are representative of nth-of-a-kind commercial units. The costs for the LSPB, although complying with EEDB Program ground rules and assumptions, are representative of a second-of-a-kind, precommercial unit. Consequently, LSPB costs are expected to decrease relative to the PWR•ME, PWR•BE and HS5 when this data model is evolved to an nth-of-a-kind, commercial unit basis.

All costs in this update report are presented as January 1, 1984 constant dollars.

TABLE 2-1
ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
NUCLEAR POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

2-2

<u>GENERAL</u>	<u>PWR</u>	<u>LSPB*</u>
1. Site	Middletown, USA	Middletown, USA
2. Operation	Base Load	Base Load
3. Technical Data Model Reference Date	January 1, 1984*	January 1, 1984
4. Plant Life (years)	30	40
5. Number of Units	Single	Single
6. Thermal Power (MWt)		
a. Rated (Core)*	3,411*	3,500
b. Nuclear Steam Supply System ^{(1)*}	3,423*	3,542
7. Net Plant Heat Rate (Btu/kWh) ⁽²⁾	10,224	9,050
8. Net Plant Efficiency (%) ⁽²⁾	33.38	37.71
9. Net Power to GSU ⁽³⁾ (MWe)	1139	1320
10. Water Table (Feet above mean river level)	10	10
* Designates change from the Phase VI Update (1983) - Refer to Reference 2; the LSPB data model replaces the LMFBR.		
(1) Includes Reactor Coolant Pumping Power		
(2) Based on Rated Thermal Power		
(3) Generator Step-up Transformer		

TABLE 2-1

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
NUCLEAR POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

	<u>PWR</u>	<u>LSPB*</u>
<u>GENERAL (cont'd)</u>		
11. 100 Year Flood (Feet above mean river level)*	8	8
12. External Missiles	Tornadoes Only	Tornadoes Only
<u>LICENSING</u>		
13. Codes & Standards Reference Date	January 1, 1984*	January 1, 1984
<u>CIVIL/STRUCTURAL</u>		
14.1 *Containment		
a. Type	Reinforced Concrete with Steel Plate Liner	Reinforced Concrete with Steel Plate Liner
b. Overall Height (ft)	219	133.5 (Including Floor and Base Mat)
c. Inside Diameter (ft)	140	N/A
d. Outside Length & Width (ft)*	N/A*	162 x 134
e. Free Volume (10 ⁶ cu ft)	2.8	2.3

* Designates change from the Phase VI Update (1983) - Refer to Reference 2; the LSPB date model replaces the LMFBR.
N/A Not Applicable

TABLE 2-1
ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
NUCLEAR POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

	PWR	LSPB*
<u>CIVIL/STRUCTURAL</u> (cont'd)		
f. Design Pressure (psig)	52	N/A
1. Inerted Cells*	N/A*	10
2. Areas except inerted cells*	N/A*	3
14.2 Confinement Structure(4)*		
a. Type*	N/A*	Steel Structure
b. Height (ft)*	N/A*	95(5)
c. Outside Dimension - Length x Width (ft)*	N/A*	242 x 199
d. Free Volume (10 ⁶ cu ft)*	N/A*	4.6
15. Turbine Building	Enclosed	Enclosed
16. Turbine Pedestal	High Tuned	High Tuned
17. Fuel or Fuel/Blanket Storage (Number of Cores)*	4/3	1.49
18. Flooding Provisions	No Special Provisions	No Special Provisions

* Designates change from the Phase VI Update (1983) - Refer to Reference 2; the LSPB date model replaces the LMFBR.
N/A Not Applicable

- (4) The combination of the Confinement Structure, other confinement buildings (portions of nuclear island structures surrounding the containment designed for this purpose) and the nuclear island HVAC System are designed to limit radioactive release; "other confinement buildings" are not included in these parameters.
(5) This height is the distance above the containment structure "roof."

TABLE 2-1

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
NUCLEAR POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

	<u>PWR</u>	<u>LSPB*</u>
<u>CIVIL/STRUCTURAL</u> (cont'd)		
19. Seismic SSE/OBE (g)	0.25/0.125	0.25/0.125
20. Foundations (Type)		
a. Seismic Category I	Mat	Mat
b. Non-Seismic Category I	Spread Footings	Spread Footings and/or Mats
21. Grade Elevation (Feet above mean river level)	18	18
<u>MECHANICAL</u>		
22. Reactor		
a. Type	Cylindrical Carbon Steel Pressure Vessel with Stainless Steel Cladding, Hemispherical Bottom Head and Removable Hemispherical Upper Head	Cylindrical Stainless Steel Vessel with a Toroidal Knuckle, a Conical Frustum, a Spherical Bottom Cap and a Flat Cover Structure with Rotating Plugs
b. Vessel Inside Diameter/Height (in/in)	173/516	569/739

* Designates change from the Phase VI Update (1983) - Refer to Reference 2; the LSPB data model replaces the LMFBR.

TABLE 2-1

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
NUCLEAR POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

	<u>PWR</u>	<u>LSPB*</u>
<u>MECHANICAL</u> (cont'd)		
c. Number Fuel Assemblies	193	372 (Driver), 175 (Axial Blanket), 90 (Radial Blanket), 432 (Radial Shield), 36 (Control Assy.)/ 6.2 (Pitch)
d. Initial Core	UO ₂	(Pu-U)O ₂
e. Enrichment (%)	3	24.4 (Equilibrium Core)
f. Refueling Method	- Inclined Tube Fuel Transfer System Between Fuel Pool and Reactor Vessel - Rail Mounted Refueling Platform with Tele- scoping Grapple over Fuel Pool	- Rotating Plugs, In-Vessel Refueling and Inclined Tube Fuel Transfer System - "A" - Frame
23. Primary Fluid Type/Wt (10 ⁵ lbs)	Light Water/5.70	Liquid Sodium (Primary and Intermediate)/ 52 (Primary) 32 (Intermediate)
24. Moderator	Light Water	Not Applicable

* Designates change from the Phase VI Update (1983) - Refer to Reference 2; the LSPB data model replaces the LMFBR.

TABLE 2-1

Effective Date 1/1/84
Sheet 6 of 12ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
NUCLEAR POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

	<u>PWR</u>	<u>LSPB*</u>
<u>MECHANICAL</u> (cont'd)		
25. Reactor Coolant Conditions at Reactor Outlet		
a. Temperature (°F)	618	950
b. Pressure (psia)	2,250	Near Atmospheric (6 in-w.g.)
c. Flow (10 ⁶ lb/h)	140.3	141.2
26. Reactor Coolant/Recirculation Loops		
a. Number of Loops/Number of Pumps per Loop	Four/One	Four (Primary)/One Four (Intermediate)/One
b. Drive Type/HP	Electric Motor/7000 (hot) Electric Motor/9000 (cold)	Variable Speed Electric Motor (Primary and Intermediate)/ 14,000 (Primary) 7,000 (Intermediate)
27. Steam Generators		
a. Number per Coolant Loop	1	1
b. Type	Vertical U-Tube with Integral Steam Drums	Benson Cycle Once- through, Combined Evaporator/Superheater

* Designates change from the Phase VI Update (1983) - Refer to Reference 2; the LSPB data model replaces the LMFBR.

TABLE 2-1

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
NUCLEAR POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

	<u>PWR</u>	<u>LSPB*</u>
<u>MECHANICAL</u> (cont'd)		
c. Classification (Section III, ASME B&PVC)	Tube Side - Class 1 Shell Side - Class 2	None (Steam generators are external to the reactor containment building and separated from the safety class portion of the intermediate sodium loop; they are designed to Section VIII of the ASME B&PVC)
d. Total Heat Transfer Surface (SF)*	220,200*	50,900
e. Total Steam Flow at Rated Load* (10 ⁶ lb/h)*	15.1	12.6
f. Outlet Steam Pressure at Rated Load (psia)	1,000	2,290
28. Turbine-Generator		
a. Configuration	Tandem-Compound, 6-Flow	Tandem-Compound, 6-Flow
b. Speed (r/min)	1,800	1,800
c. Last Stage Blade Length (in)	43	44

* Designates change from the Phase VI Update (1983) - Refer to Reference 2; the LSPB data model replaces the LMFBR.

TABLE 2-1

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
NUCLEAR POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

	<u>PWR</u>	<u>LSPB*</u>
<u>MECHANICAL</u> (cont'd)		
29. Main Steam Conditions at High Pressure Turbine Inlet (Rated Load)*		
a. Pressure (psia)	975	2,215
b. Temperature (°F)	544	850
c. Throttle Flow (10 ⁶ lb/hr)	13.7	12.6
30. Gross Turbine-Generator Output at 1.69/2.10/2.71 Inches HgA (MWe)*	1,192	1,426
31. Condensers		
a. Type*	Single-Pressure*	Multi-Pressure
b. Shell/Divisions per Shell	3/1	3/1
c. Arrangement	Transverse	Transverse
d. Number of Passes	Two	One
e. Water Box	Split	Split
f. Pressure (in-HgA)*	2.5*	1.69/2.10/2.71
g. Total Heat Transfer Surface (SF)	1,221,000*	678,066

* Designates change from the Phase VI Update (1983) - Refer to Reference 2; the LSPB data model replaces the LMFBR.

TABLE 2-1
ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
NUCLEAR POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

	<u>PWR</u>	<u>LSPB*</u>
<u>MECHANICAL</u> (cont'd)		
32. Cooling Tower		
a. Type	Round Mechanical Wet Evaporative*	Round Mechanical Wet Evaporative*
b. Number/Total Flow - Normal (gpm)	3/717,000*	3/504,000
33. Cooling Tower Conditions		
a. Approach (°F)	14	8
b. Range (°F)	22	30
c. Wet Bulb (°F)	74	74
34. Ultimate Heat Sink	2-100% Mechanical Wet Evaporative Cooling Towers	2-100% Sodium to Air Heat Exchangers with Electric Motor Driven Fans 1-100% Natural Convec- tion Sodium to Air Heat Exchanger
35. Feedwater Pumps		
a. Main (Number/Drive)	2/Turbine	2/Turbine

* Designates change from the Phase VI Update (1983) - Refer to Reference 2; the LSPB data model replaces the LMFBR.

TABLE 2-1

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
NUCLEAR POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

	<u>PWR</u>	<u>LSPB*</u>
<u>ELECTRICAL</u> (cont'd)		
b. Other (Number/Service/Drive)	1/Emergency/Turbine 1/Emergency/Motor *	1/Startup/Motor
36. Feedwater Heaters		
a. Open Stages (Number)	None	One
b. High Pressure Closed Stages (Number/Number Trains)	1/2	1/2
c. Low Pressure Closed Stages (Number/Number Trains)	4/3, 1/2	3/3
37. Stages of Reheat (Number/Type)	One/Steam	One/Steam
<u>ELECTRICAL</u>		
38. Connection to Off-Site Power (Number/kV)	2/500, 2/230	2/500, 2/230
39. Generator		
a. Rating (MVA)	1,377*	1,667
b. Voltage (kV)	25	22
c. Power Factor	0.9	0.9

* Designates change from the Phase VI Update (1983) - Refer to Reference 2; the LSPB data model replaces the LMFBR.

TABLE 2-1

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
NUCLEAR POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

	PWR	LSPB*
<u>ELECTRICAL</u> (cont'd)		
d. H ₂ Pressure (psig)	75	75
40. Generator Disconnect		
a. Type	Load Break Switch	Load Break Switch
b. Rating (kV)	36	36
41. Auxiliary Power System		
a. Medium Voltage System A (kV)	13.8	13.8
b. Medium Voltage System B (kV)	4.16	4.16
c. Low Voltage System (V)	480	480
d. Direct Current Systems (V)	250/125	250/125
42. Unit Auxiliary Transformer Nameplate Rating ⁽⁶⁾ (MVA)	90	188
43. Reserve Auxiliary Transformer Nameplate Rating ⁽⁶⁾ (MVA)	90	188
44.1 *Diesel-Generator Unit		
a. Type/Number	Medium Speed/2	N/A

* Designates change from the Phase VI Update (1983) - Refer to Reference 2; the LSPB data model replaces the LMFBR.
N/A Not Applicable
(6) Total of all transformers at top class of cooling rating

TABLE 2-1

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
NUCLEAR POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

	PWR	LSPB*
<u>ELECTRICAL</u> (cont'd)		
b. Voltage (kV)	4.16	N/A
c. Rating (kW/PF)	6083/0.8	N/A
44.2 Gas-Turbine Units*		
a. Standby Power Supply (Class 1E)*		
1. Number*	N/A*	2
2. Voltage (kV)*	N/A*	4.16
3. Rating (kW/PF)*	N/A*	3000/0.9
b. Emergency Power Supply (Non-Class 1E)*		
1. Number*	N/A*	1
2. Voltage (V)*	N/A*	480
3. Rating (kW/PF)*	N/A*	1500/0.9
45. Control Room Wiring	Wired Directly to Panels in Control Room	Wired Directly to Panels in Control Room
46. Multiplexing of BOP Cables*	None	Plant Wide
47. Instrumentation	Independent Sensors for Computer Input	Independent Sensors for Computer Input

* Designates change from the Phase VI Update (1983) - Refer to Reference 2; the LSPB data model replaces the LMFBR.
N/A Not Applicable

TABLE 2-2

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
COMPARISON POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

HS5

GENERAL

1. Site	Middletown, USA
2. Operation	Base Load
3. Technical Data Model Reference Date	January 1, 1984*
4. Plant Life (years)	30
5. Number of Units	Single
6. Thermal Power (MWt)	1,379*
7. Net Plant Heat Rate (Btu/kWh)	9,684*
8. Net Plant Efficiency (%)	35.24*
9. Net Power to GSU ⁽¹⁾ (MWe)	486
10. Water Table (Feet above mean river level)	10
11. 100 Year Maximum Water Level (Feet above mean river level)	8

CIVIL/STRUCTURAL

12. Boiler House	Enclosed
13. Turbine Building	Enclosed
14. Turbine Pedestal	High Tuned
15. Flooding Provisions	No Special Provisions
16. Seismic	Uniform Building Code Zone 1
17. Foundations	Spread Footings*

* Designates change from the Phase VI Update (1983) - Refer to Reference 2.
(1) Generator Step-Up Transformer

TABLE 2-2

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
COMPARISON POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

	<u>HS5</u>
<u>MECHANICAL</u>	
18. Grade Elevation (Feet above mean river level)	18
19. Steam Generator Type	Pulverized Coal Balanced Draft Furnace
20. Steam Generator Outlet Conditions	
a. Maximum Continuous Rating (10 ⁶ lb/h/psig/°F)*	3.97/2640/1010*
b. Superheater Outlet at Rated Load* (10 ⁶ lb/h/psig/°F)	3.5/2515/1010*
c. Reheater Outlet at Rated Load* (10 ⁶ lb/h/psig/°F)	3.2/DNA(2)/1005
21. Forced Draft Fan	
a. Number	2
b. Drive	Motor
c. Capacity (acfm @ boiler MCR)*	489,000*
22. Induced Draft Fan	
a. Number	2
b. Drive	Motor
c. Capacity (acfm @ boiler MCR)*	867,000*
23. Fuel Type	<u>Eastern Coal</u>
a. Moisture (% by wt)	11.3

* Designates change from the Phase VI Update (1983) - Refer to Reference 2.
(2) DNA = Data Not Available

TABLE 2-2

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
COMPARISON POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

		HS5
<u>MECHANICAL</u> (cont'd)		
b. Ultimate Analysis (% by dry wt)	Carbon 69.34 Chlorine 0.04 Hydrogen 4.90 Sulfur 3.61 Nitrogen 0.86 Oxygen 9.65	
c. Calorific Value (Btu/lb)	As Received 11,026 Dry 12,432	
d. Ash (% by Dry Wt)	11.6	
24. Coal Delivery	100 Car Unit Train at 5 Hour Nominal Turnaround*	
25. Coal Storage	60 Days at Rated Load, 8 Hours in Silos*	
26. Coal Firing Rate at Rated Load (tons/day)*	5,112*	
27. Coal Handling System	Rotary Car Dumper, Coal Breaker, Stacker/Reclaimer Transfer Tower, Staker/ Reclaimer, Crusher, Boiler House Transfer Tower, Trippers	
28. Number of Pulverizers/Spares	5/1	
29. Stack		
a. Height (ft)*	650*	
b. Gas Velocity (fps)*	40 max.*	
30. SO ₂ Scrubber		
a. Type	Lime (Wet) with Electrostatic Precipitator	
b. Number of Modules/ Number of Spares	4/1	

* Designates change from the Phase VI Update (1983) - Refer to Reference 2.

TABLE 2-2

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
COMPARISON POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

	HS5
<u>MECHANICAL</u> (cont'd)	
31. Sludge Fixation	On-Site
32. Waste Disposal	Trucked Off-Site
33. Turbine-Generator	
a. Configuration	Tandem-Compound, 4-Flow
b. Speed (r/min)	3600
c. Last Stage Blade Length (in)	30
34. Main Steam Conditions at High Pressure Turbine Inlet (Rated Load)*	
a. Pressure, psia	2415
b. Temperature (°F)	1000
c. Throttle Flow (10 ⁶ lb/hr)	3.5
35. Gross Turbine-Generator Output at 2.5 in-HgA (MWe)*	523
36. Condensers	
a. Type*	Single Pressure*
b. Shell/Divisions per Shell	1/1
c. Arrangement	Longitudinal
d. Number of Passes	1
e. Water Box	Split
f. Pressure (in-HgA)	2.5*
g. Total Heat Transfer Surface (SF)	332,600*

* Designates change from the Phase VI Update (1983) - Refer to Reference 2.

TABLE 2-2

ENERGY ECONOMIC DATA BASE
 PHASE VII UPDATE
 COMPARISON POWER GENERATING STATIONS
 TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

HS5

MECHANICAL (cont'd)

37. Cooling Tower

a. Type	Round Mechanical Wet
Evaporative
b. Number/Total Flow - Normal (gpm)	1/239,000*

38. Cooling Tower Conditions

a. Approach (°F)	14
b. Range (°F)	22*
c. Wet Bulb (°F)	74

39. Feedwater Pumps

a. Main (Number/Drive)	2/Turbine
b. Other (Number/Service/Drive)	2/Booster/Motor

40. Feedwater Heaters

a. Open Stages (Number)	One
b. High Pressure Closed Stages
(Number/Number Trains)	2/1
c. Low Pressure Closed Stages
(Number/Number Trains)	3/1, 1/2

41. Stages of Reheat (Number/Type)	One/Boiler
------------------------------------	------------

ELECTRICAL

42. Connection to Offsite Power
(Number/kV)	2/230, 2/115

* Designates change from the Phase VI Update (1983) - Refer to Reference 2.

TABLE 2-2

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
COMPARISON POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

HS5

ELECTRICAL (cont'd)

43. Generator	
a. Rating (MVA)	625*
b. Voltage (kV)	25
c. Power Factor	0.9
d. H ₂ Pressure (psig)	75
44. Generator Disconnect	Bolted Links
45. Auxiliary Power System	
a. Medium Voltage System A (kV)	None
b. Medium Voltage System B (kV)	4.16
c. Low Voltage System (V)	480
d. Direct Current Systems (V)	250/125
46. Unit Auxiliary Transformers Nameplate Rating ⁽³⁾ (MVA)	44
47. Reserve Auxiliary Transformer Nameplate Rating ⁽³⁾ (MVA)	22
48. Diesel-Generator Unit	
a. Type/Number	High Speed/2
b. Voltage (V)	480
c. Rating (kW/PF)	400/0.8
49. Control Room Wiring	Wired Directly to Panels in Control Room

* Designates change from the Phase VI Update (1983) - Refer to Reference 2.
(3) Total of all Transformers at top class of cooling rating

TABLE 2-2

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
COMPARISON POWER GENERATING STATIONS
TECHNICAL DATA MODELS BASE PARAMETER SUMMARY

HS5

ELECTRICAL (cont'd)

50. Multiplexing of Cables

None

51. Instrumentation

Independent Sensors for
Computer Input

TABLE 2-3

ENERGY ECONOMIC DATA BASE
 PHASE VII UPDATE
 CAPITAL COST UPDATE SUMMARY
 (\$1984 X 10⁶)(a)

<u>Model</u>	<u>Nuclear Plant Data Models</u>			<u>Comparison Plant Data Model</u>
	<u>PWR•ME(b)</u>	<u>PWR•BE(b)</u>	<u>LSPB(c)(d)</u>	<u>HS5(b)</u>
MWt	3411	3411	3500	1379
MWe	1139	1139	1320	486
Direct Cost	1061	800	1345	433
Indirect Cost	<u>1069</u>	<u>472</u>	<u>598</u>	<u>103</u>
Base Construction Cost	2130	1272	1943	536
\$/kWe	1870	1117	1472	1103

(a) Data in January 1, 1984 Constant Dollars

(b) Costs are based on an nth-of-a-kind, commercial unit

(c) Costs are based on a second-of-a-kind, pre-commercial unit

(d) Reported costs do not include cost of the initial inventory of sodium

TABLE 2-4

ENERGY ECONOMIC DATA BASE
 PHASE VII UPDATE
 NORMALIZED(a) CAPITAL COST UPDATE SUMMARY
 (\$1984 X 10⁶)(b)

<u>Model</u>	<u>Nuclear Plant Data Models</u>			<u>Comparison Plant Data Model(c)</u>
	<u>PWR•ME(d)</u>	<u>PWR•BE(d)</u>	<u>LSPB(e)(f)</u>	<u>HS5(d)</u>
MWt	3411	3411	3020	3232
MWe	1139	1139	1139	1139
Direct Cost	1061	800	1255	767
Indirect Cost	<u>1069</u>	<u>472</u>	<u>558</u>	<u>182</u>
Base Construction Cost	2130	1272	1813	949
\$/kWe	1870	1117	1592	833
<u>\$/kWe</u> <u>PWR•ME \$/kWe</u>	1.00	0.60	0.85	0.45

- (a) Normalized to a plant size providing 1139 MWe (net)
 (b) Data in January 1, 1984 Constant Dollars
 (c) Normalization of HS5 is subject to greater error than for other models.
 (d) Costs are based on an nth-of-a-kind, commercial unit.
 (e) Costs are based on a second-of-a-kind, pre-commercial unit
 (f) Reported costs do not include cost of the initial inventory of sodium.

TABLE 2-5

ENERGY ECONOMIC DATA BASE
 PHASE VII UPDATE
 NORMALIZED(a) CAPITAL COST UPDATE SUMMARY
 (\$1984 X 10⁶)(b)

<u>Model</u>	<u>Nuclear Plant Data Models</u>			<u>Comparison Plant Data Model(c)</u>
	<u>PWR•ME(d)</u>	<u>PWR•BE(d)</u>	<u>LSPB(e)(f)</u>	<u>HS5(d)</u>
MWt	3800	3800	3800	3800
MWe	1269	1269	1433	1339
Direct Cost	1109	836	1398	878
Indirect Cost	<u>1117</u>	<u>493</u>	<u>622</u>	<u>209</u>
Base Construction Cost	2226	1329	2020	1087
\$/kWe	1754	1047	1416	812
<u>\$/kWe</u> <u>PWR•ME \$/kWe</u>	1.00	0.60	0.81	0.46

(a) Normalized to a plant size of 3800 MWt or its equivalent

(b) Data in January 1, 1984 Constant Dollars

(c) Normalization of HS5 is subject to greater error than for other models.

(d) Costs are based on an nth-of-a-kind, commercial unit.

(e) Costs are based on a second-of-a-kind, pre-commercial unit.

(f) Reported costs do not include cost of the initial inventory of sodium.

SECTION 3

3.0 CAUSES AND EFFECTS OF THE PHASE VII UPDATE CHANGES

3.1 INTRODUCTION

The Phase VII Update of the Energy Economic Data Base has developed base construction (direct plus indirect) costs for nuclear and coal-fired power plants, in terms of January 1, 1984 constant dollars. The EEDB Program provides this updated cost information on a periodic basis for use in other estimates of total generating costs. The updates are also used to indicate trends from which general conclusions may be made about future power costs. The Phase V Update (1982) and the Phase VI Update (1983) were the most comprehensive updates since the Phase I Update (1978). The Phase VII Update (1984) has extended the work of the Phase V and Phase VI Updates; however, the extreme cost increases identified in these earlier updates appear to have moderated prior to the Phase VII Update. The Phase I Update and the Phase V, VI and VII Updates are benchmarks through which significant cost drivers may be identified for the period from 1978 to 1984.

Recently constructed coal-fired power generating stations are smaller in size than those constructed during the early years of the EEDB Program. In recognition of this fact, the 791 MWe High Sulfur Coal-Fired Power Generating Station (HS8) has been replaced with the 486 MWe High Sulfur Coal-Fired Power Generating Station (HS5) in the Phase VII Update as the lead comparison plant data model. This change is significant when comparing cost results on a dollar per kilowatt basis from this report with those of previous update reports.

3.2 PERCEPTION OF NUCLEAR/COAL COST TRENDS

In 1978, the year of the Phase I Update, the cost for electricity was estimated to be significantly less from a nuclear power plant than from a coal-fired power plant of comparable capacity. However, when the Phase V Update was issued in 1982, the estimated cost of electricity from large nuclear and coal-fired power plants were almost the same. Today, median to high cost experience light water reactor power plants are perceived by many to be not competitive with coal-fired power plants. On the other hand, it appears that current best to median cost experience nuclear power plants could be competitive with coal-fired power plants when the necessary government and industry actions are taken to encourage resumption of their deployment.

A significant factor contributing to the decrease in economic advantage for nuclear power plants was their large and continuing capital cost increases between 1978 and 1984 compared with the smaller capital cost increases for coal-fired power plants. As was discussed in the Phase V and VI Update Reports^{2,3}, the rapid rise in nuclear power plant capital costs was due primarily to large increases in the quantities of craft, engineering and field service manhours and to a lesser extent to increases in the quantities of commodities and equipment. These and other factors which are not evaluated in the EEDB analysis (such as mounting interest on funds used during construction, the ability to generate funds needed for construction, licensing delays, and long construction times) have had profound effects on a utility's decision regarding the type of generating station to be constructed.

3.3 RESULTS OF THE PHASE VII UPDATE

3.3.1 EEDB and Actual Power Plant Costs

The Phase VII Update continued to focus on the principal nuclear power plant cost drivers when the overnight base construction costs of nuclear and comparison power plants were estimated for 1984. The base construction cost for the EEDB PWR•ME 1139 MWe data model, representing median light water reactor power plant cost experience, was estimated to be \$1870/kWe. The estimated base construction cost for the EEDB PWR•BE 1139 MWe data model, representing the best light water reactor power plant cost experience, was \$1117/kWe. The base construction cost for the EEDB HS5 486 MWe data model, representing best to median coal-fired power plant experience, was estimated to be \$1103/kWe. Details of the Phase VII technical and cost data model updates are discussed in Sections 4 and 5 respectively.

Current information from company confidential sources for nuclear and coal-fired power plants nearing completion indicate that the estimated nuclear power plant base construction costs in 1984 dollars without AFUDC, but including owner's costs and contingency, ranged from \$1492/kWe to \$3215/kWe. The sources also indicate that base construction costs in 1984 dollars without AFUDC, but including owner's costs and contingency, for coal-fired power plants with flue gas desulfurization ranged from \$603/kWe to \$1755/kWe. Plants at the low end of the cost range, however, were repeat units on an existing site or burned coal with a very low sulfur content. It should also be noted that the range of plant capacities and configurations varied more widely for the coal-fired power plants than for the nuclear power plants.

3.3.2 Comparison of EEDB and Actual Power Plant Costs

The relationship between industry reported costs in January, 1984 dollars and the EEDB estimated nuclear and coal-fired power plant base construction costs are as follows:

<u>EEDB Update</u>	<u>EEDB Estimated Costs</u>				
	<u>Constant \$/kWe (1984)</u>			<u>Ratios</u>	
	<u>PWR•ME</u>	<u>PWR•BE</u>	<u>HS5</u>	<u>PWR•ME /HS5</u>	<u>PWR•BE /HS5</u>
Phase VII Update (1984)	1870	1117	1103	1.70	1.01
Phase I Update (1978)	887	(b)	878(a)	1.01	(b)
Phase VII Update (1984) Adjusted ^(c)	2329	1331	1290	1.81	1.03
Phase I Update (1978) Adjusted ^(c)	1029	(b)	1004(a)	1.02	(b)

(a), (b), (c) Notes are given on page 3-3

<u>EEDB Update Period</u>	<u>Industry Reported Costs^(c)</u>				
	<u>Constant \$/kWe (1984)</u>			<u>Ratios</u>	
	<u>NPGS•ME</u>	<u>NPGS•BE</u>	<u>FPGS•ME</u>	<u>NPGS•ME/ FPGS•ME</u>	<u>NPGS•BE/ FPGS•ME</u>
Phase VII Update (1984)	2578	1492	1405	1.83	1.06
Phase VI Update (1983) ^(d)	2259	1456	1405 ^(e)	1.43	1.04

- (a) The Phase I Update (1978) 795 MWe HS8 costs have been adjusted to reflect the costs for a 486 MWe HS5.
- (b) The Phase I Update PWR was representative of the PWR cost range in 1978 and is the predecessor to the Phase VII PWR•ME and PWR•BE, which are representative of the much wider PWR cost range in 1984.
- (c) Includes Owner's Costs and Contingency.
- (d) Escalated to Account for General Inflation Between 1983 and 1984.
- (e) Phase VII Data Used for Comparison; FPGS Data Not Available for Phase VI Update.

ME = Median Cost Experience

BE = Best Cost Experience

NPGS = Nuclear Power Generating Station

FPGS = Coal-Fired Power Generating Station

A comparison of the Phase VII adjusted EEDB Estimated Costs with the Industry Reported Costs indicate reasonable agreement for both median and best cost experience cases, with the EEDB costs being on the order of 90 percent of the industry reported costs. This difference is within the uncertainty band for EEDB estimates when adjusted to reflect an average owner's cost plus contingency. Therefore, the primary EEDB objective that technical/cost data models remain representative of major nuclear power industry cost trends is met for the Phase VII Update.

In earlier EEDB updates, the PWR data model was more representative of better cost experience than in later updates because the range of nuclear power plant costs was not as wide as in the later updates. Because of the cost range that evolved during recent years, the PWR•BE was developed to reflect the best costs that the industry was experiencing, while the older PWR became the PWR•ME to reflect median industry cost experience. The early comparison plant data models represented best to median cost experience for coal-fired power plants. The HS8 in the Phase VI Update and the HS5 in the Phase VII Update continue to reflect best to median cost experience. The EEDB Estimated Cost Table above indicates PWR/HS5 cost ratios. It is interesting to note that the 1984 PWR•ME/HS5 cost ratio has increased substantially since 1978, when nuclear power plants were considered to be competitive with coal-fired power plants. On the other hand, the PWR•BE/HS5 cost ratio is (coincidentally) identical to the 1978 PWR•ME/HS5 cost ratio. The 1984 EEDB cost ratios are supported by the cost ratios shown in the Industry Reported Costs Table above, within the uncertainty band of the adjusted EEDB estimates.

3.3.3 EEDB and Actual Power Plant Cost Trends

The Phase V and Phase VI Updates^{2,3} and associated field data identified the fact that nuclear power plant costs were rising at twice the rate of inflation and were being driven by rapidly increasing quantities of manhours and commodities. These increases were identified as being caused by a variety of conditions. Among them were proliferation of regulations, codes and standards; owner/designer overreaction to these regulations, codes and standards; rework caused by field interferences, constantly changing designs and inadequate engineering-to-construction lead times; extreme precision in analyses, coupled with inflexible design and construction quality assurance procedures; management preoccupation with regulatory inspection and enforcement personnel site visits; and low worker morale, caused by all of the above. Although these conditions lead to increased commodities and costs, their predominant impact has been to increase craft labor, engineering and field service manhours.

During the Phase VII Update, it was found that this trend seemed to be slackening, as indicated in the table on page 3-3. Between 1983 and 1984, the median experience nuclear power plant cost increased by about 14 percent above general inflation and the best experience nuclear power plant cost increased by about 2.5 percent above general inflation. The average nuclear power plant cost, however, increased by only about three percent above general inflation. The Phase VII Update resulted in an increase of one percent above general inflation for the PWR•ME and one percent less than general inflation for the PWR•BE. No adjustment was made to the updated PWR•ME or PWR•BE costs to compensate for this disagreement in percentage changes, because the numerical amounts were in reasonable agreement with industry experience, as discussed in Section 3.3.2.

3.4 BASE CONSTRUCTION COST TRENDS BETWEEN 1978 AND 1984

3.4.1 Base Construction Cost Components

Base construction costs are controlled by the following five factors:

- quantities of commodities and equipment;
- unit installation manhours for commodities and equipment;
- home office, field supervision and construction service manhours shown as indirect costs;
- unit costs for commodities and equipment; and
- craft labor rates and professional and non-manual salary rates.

Total installation manhours are determined as the product of the first two items. Base construction costs are driven by variations in the first three items: the quantities of commodities, equipment and manhours. The last two items are mainly affected by inflation and amplify the cost levels determined by the first three items.

3.4.2 Base Construction Cost Trends

Figures 3.1, 3.2 and 3.3 show PWR and HS5 base construction cost trends from the Phase I Update (1978) through the Phase VII Update (1984). The costs are normalized on the basis of dollars per kilowatt and are all in terms of 1984 constant dollars. The cost bars display costs for two important cost areas: "factory equipment plus site material" (commodities/equipment) costs and "labor" (craft, engineering and field supervision) costs. The accounting system used for these figures has a commodity/equipment/labor basis rather than the plant account basis reflected in Tables 2-3 through 2-5. For a detailed discussion of these accounts and what they contain, refer to Section 5.5.

In 1978, the PWR point estimate represented the then current narrow range of costs for PWR nuclear power plants. By 1983, that range had widened to the extent that a single point estimate was no longer representative of the range of costs. Consequently, the PWR•ME and PWR•BE estimates were developed to represent the median and best cost experience. Figures 3.1 through 3.3 show the cost trends that have taken place from the 1978 PWR to the 1983/4 PWR•ME and PWR•BE.

Likewise in 1978, the HS8 (791 MWe) represented a medium capacity coal-fired power plant. In 1982, the HS5 (486 MWe) was developed to reflect the trend to construction of smaller medium capacity coal-fired power plants. In 1984, the HS8 was no longer updated because the trend to smaller units persisted. Figures 3.1 through 3.3 show the cost trends that have taken place for an HS5. This was accomplished by making adjustments to the 1978 HS8 costs to reflect an HS5 486 MWe unit in that time frame. The adjustment added \$175/kWe to the base construction costs of the 1978 HS8 in 1984 constant dollars.

Figure 3.1 shows the following:

- Commodities/equipment costs have grown by about 35, 15 and 25 percent above inflation for the PWR•ME, the PWR•BE and the HS5 respectively since 1978.
- Total labor costs (craft, engineering and field supervision) have increased by almost 200 percent above inflation for the PWR•ME between 1978 and 1984.
- Total labor costs have increased by almost 35 percent above inflation for the PWR•BE between 1978 and 1984.
- Total labor costs have increased by about 25 percent above inflation for the HS5 between 1978 and 1984.

Labor costs have become the most predominant of the cost drivers that are investigated in the EEDB analyses. They are causing nuclear power plants to become less and less competitive with coal-fired power plants. Since all labor rates in the figures have been adjusted for inflation, the labor cost increase is real.

This craft labor increase has been caused mostly by decreased productivity and to a lesser extent by rising quantities of commodities and equipment being installed. Craft labor productivity in nuclear power plants has two components. One is controlled by the workman and is related to his competence, thoroughness, organization and incentive to do quality work. The second is outside his control and is related to rework (design changes, interferences, inadequate lead times) and delays (extended schedules, quality assurance, inspections). It is the second component that predominates in the causes for decreased productivity.

It must be emphasized, however, that increases in indirect costs rather than in craft labor are the most significant part of the labor related increase for the PWR•ME data model. The indirect costs include the cost of labor associated with construction services, engineering/services and field nonmanual personnel. In the case of engineering/services, the increases are caused by proliferating regulations, codes and standards, repetitive changes in designs other than those caused by changes in regulations, escalating need for complex analyses and checking/rechecking of analyses, and increasingly rigorous quality assurance programs. In the case of the field non-manual personnel, the increases are caused by increasing interfaces with engineering, increasingly rigorous quality control programs and the rising number of craftsmen to supervise.

3.4.3 Equipment and Material Cost Trends

Figure 3.2 shows the relationships and content of the commodity/equipment part of the cost bars in Figure 3.1. These equipment/material costs are discussed under the following three broad categories.

Items whose costs are primarily associated with manufacturers' prices: NF (nuclear or fossil steam supply system), SR (HS5 SO₂ removal system), T-G (turbine-generator unit), and M (mechanical equipment, such as pumps, heat exchangers, tanks, insulation, and equipment for fire control, HVAC and water purification).

The cost of the nuclear steam supply system increased by over 15 percent above inflation for the PWR data models between 1983 and 1984, primarily because of a change in the manufacturer's scope for the estimating quotation, as discussed in Section 5. The other costs in this group did not change significantly between 1983 and 1984 for the PWR data models or for the HS5 data model.

Between 1978 and 1983, the steam supply system and the turbine-generator costs increased faster than the average inflation rate. During the same period, the SO₂ removal system cost increased greatly because of design changes required to meet the 1977 (became effective in 1979) New Source Performance Standards. (This change applies equally to the HS5 and HS8 data models even though the HS5 data model did not exist in the Phase I Update (1978).)

Items whose costs are primarily associated with quantity: P (piping, including valves and supports), E (electrical equipment, wiring and raceways, instruments, and communication equipment), SS (structural support, which includes concrete

with its formwork, reinforcing and embedded steel, and structural steel), and S (other structural, including non-load bearing interior and exterior walls, elevators, painting, and excavation).

Between 1983 and 1984, these costs changed at essentially the inflation rate for all three data models. A more detailed analysis than may be gained from the figure was also done. The analysis showed that the PWR data model increases were slightly less than the inflation rate, because some items were transferred to the NSSS account, and that the HS5 data model increases were higher than the inflation rate, because of piping cost increases.

Between 1978 and 1983, these costs increased faster than inflation by 29 percent for the PWR•ME, 17 percent for the HS5 and three percent for the PWR•BE. These increases reflect the rising quantities of commodities for the PWR•ME, as discussed in the Phase V and VI Updates^{2,3}, the FGD system changes for the HS5, and the relative constancy of commodity quantities for the PWR•BE.

Items whose costs for construction services are indirect costs: CS (temporary buildings, temporary facilities, and construction tools and equipment).

For the PWR•ME, this account grew at about the inflation rate between 1983 and 1984. The account decreased for the PWR•BE and HS5 data models between 1983 and 1984 because the construction time ground rule for each data model was decreased for the Phase VII Update (1984) (refer to Sections 5.4.3.2 and 5.4.4.2).

Between 1978 and 1983, this account increased at a rate exceeding inflation by about 125, 40 and 20 percent for the PWR•ME, PWR•BE and HS5 respectively. These increases reflect lengthened construction schedules, an increase in temporary buildings for the increased field supervision personnel, an increase in tools and construction equipment to reflect the increase in craft labor, and the need for more temporary services (e.g., electric power).

3.4.4 Labor Cost Trends

Figure 3.3 shows the relationship and breakdown of the labor part of the cost bars in Figure 3.1. This figure emphasizes the extreme increase in labor costs above the inflation rate for the PWR•ME compared to the relatively small increases for the HS5 and PWR•BE between 1978 and 1983.

3.4.4.1 Labor Cost Trends from 1983 to 1984

The increases in labor for all three models were close to the general inflation rate between 1983 and 1984. For the PWR•ME data model, each change was within three percent of the inflation rate. For the PWR•BE and the HS5 data models, only the following items differed by more than three percent from the inflation rate.

CS - Construction service labor costs decreased by 14 percent for the PWR•BE and by 15 percent for the HS5 because of the decreases in the construction time ground rule (refer to Sections 5.4.3.2 and 5.4.4.2).

FS - Field supervision costs decreased by eight percent for the PWR•BE because of the decrease in the site labor manhours caused by the reduced construction time. The decreased construction service labor for the HS5 model was almost balanced by the increased direct labor for other accounts so that this account decreased by only one percent.

I&T - Direct payroll taxes decreased by seven percent for the PWR•BE for the same reasons identified in FS - Field Supervision above.

MC - Mechanical craft labor costs increased by six percent for the HS5, primarily because of increases in piping quantities.

EC - Electrical/I&C craft labor costs increased by seven percent for the HS5, primarily because of increases in lighting and service power for the buildings.

E - Engineering costs increased by 18 percent for the HS5 because of a 15 percent increase in engineering and home office services based on improved field data.

3.4.4.2 Labor Cost Trends from 1978 to 1984

The increases in labor costs above general inflation for the three data models between 1978 and 1984 were 189 percent for the PWR•ME, 39 percent for the PWR•BE and 27 percent for the HS5. The following discussions provide reasons for the increases, particularly the very large increases for the PWR•ME. The comments refer to the PWR•ME, unless noted otherwise.

SC - Structural craft labor costs increased by about 70 percent between 1978 and 1984. This change resulted from an increase in quantities of structural commodities and a decrease in installation labor productivity.

MC - Mechanical craft labor costs increased by about 110 percent between 1978 and 1984, because of mechanical equipment and piping quantity increases and productivity decreases. Mechanical craft labor for the PWR is extensively utilized for the installation of piping, and for the reactor and other mechanical equipment. The HS5 mechanical craft labor increased by about 25 percent primarily because of increases in the FGD system.

EC - Electrical/I&C craft labor costs increased by about 120 percent between 1978 and 1984, because of electrical/I&C equipment and wiring quantity increases coupled with productivity decreases.

CS - Construction services labor costs to install the temporary buildings and facilities plus the other "craft labor" under indirect costs increased by about 425 percent between 1978 and 1984. These increases were partly caused by the conditions identified in the discussion of Item CS in Section 3.4.3 and were partly caused by labor hour categories not previously identified. Similar causes were responsible for increases of about 225 percent for the PWR•BE and about 50 percent for the HS5.

E - Engineering costs, which includes payroll expenses, engineering support costs and other related costs, increased about 140 percent from 1978 to 1984. These increases resulted from the uncertainties caused by regulation and the inefficiencies of current practice (for a complete discussion of these effects refer to Appendix C of the Phase VI Update³). Similar causes were responsible for increasing the PWR•BE by about 30 percent. The HS5 increase of about 40 percent resulted primarily from the availability of new and more complete data.

FS - Field supervision costs, which includes payroll expenses and other related costs, increased by about 850 percent from 1978 to 1984. The dramatic increase in this account resulted from the greater number of craft laborers being supervised and, for the nuclear power plants, from the uncertainties caused by regulation and the inefficiencies of current practice (for a complete discussion of these effects refer to Appendix C of the Phase VI Update³). Similar causes were responsible for increasing the PWR•BE field supervision costs by about 105 percent. The 40 percent increase in the HS5 field supervision costs was related primarily to increased craft laborers to supervise.

The field supervision (FS) plus engineering (E) costs now equal almost half of the total labor dollars required to build a new PWR•ME. If the remaining indirect costs associated with labor (CS, O, and I&T) are added to engineering and field supervision costs, the total 1984 labor related indirect costs equal 220 percent of the craft labor costs. These indirect-costs/craft-labor-cost percentages were 220 percent in 1983 and 112 percent in 1978. For comparison, these indirect costs in 1984 equal 173 percent of the craft labor costs for the PWR•BE and 70 percent of the craft labor costs for the HS5.

O - Other labor costs cover home office and field quality assurance plus plant startup and testing. Although this account grew significantly in terms of \$/kWe from 1978 to 1984, the account still represents less than five percent of the total labor cost for all three data models.

I&T - Insurance and taxes is a direct function of the cost for craft plus construction services labor. Between 1978 and 1984, however, the average percentage of wages required for insurance and taxes increased to the extent that this account increased more rapidly than the direct labor account increased.

3.4.5 Base Construction Cost Trend Recapitulation

In summary, the indirect labor costs have increased much more rapidly for the PWR•ME than for the PWR•BE and the HS5. Consequently, the total indirect costs are 101 percent of the direct costs for the PWR•ME in 1984, versus 59 percent of the direct costs for the PWR•BE and 24 percent of the direct costs for the HS5. The large rise in PWR•ME labor costs may be attributed to continuation of the trends discussed in the previous section and verified by industry experience. This experience includes low cost as well as high cost unit experience. The low cost unit experience coincides with low craft, engineering and field supervision manhours as shown in Figures 3.2 and 3.3.

Therefore, the PWR•BE and the HS5 data models showed similar increases in costs between 1978 and 1984, while the PWR•ME costs increased at a significantly faster rate. This comparison implies that nuclear power is still a viable option (based on the method for calculating electricity costs given in the Phase V Update (1982) Report ³), when the related regulatory reform and construction practice improvements discussed in the Phase V (1982) and Phase VI (1983) Updates^{2,3} are implemented.

FIGURE 3.1
ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM
COMPARISON OF PHASE I (1978), PHASE VI (1983) AND PHASE VII (1984)
PWR AND HS 5 BASE CONSTRUCTION COSTS

JANUARY 1 OF YEAR OF ESTIMATE

FIGURE 3.2
ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM
COMPARISON OF PHASE I (1978), PHASE VI (1983) AND PHASE VII (1984)
PWR AND HS 5 FACTORY EQUIPMENT PLUS SITE MATERIAL COST

LEGEND (EQUIPMENT/MATERIAL)

NF — NSSS OR FSSS*	E — ELECTRICAL/I&C
SR — SO ₂ REMOVAL	SS — STRUCTURAL SUPPORT
T-G — TURBINE-GENERATOR UNIT	S — STRUCTURAL (OTHER)
M — MECHANICAL	CS — CONSTRUCTION SERVICES
P — PIPING	

*NSSS = NUCLEAR STEAM SUPPLY SYSTEM
 FSSS = FOSSIL STEAM SUPPLY SYSTEM
 (COAL-FIRED BOILER)

ME - MEDIAN EXPERIENCE
BE - BEST EXPERIENCE
- BASED ON THE HS8

FIGURE 3.3
ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM
COMPARISON OF PHASE I (1978), PHASE VI (1983) AND PHASE VII (1984)
PWR AND HS 5 LABOR COST

SECTION 4

4.0 TECHNICAL UPDATE FOR SINGLE UNIT NUCLEAR AND COMPARISON POWER PLANTS

The Phase VII Update of the Capital Costs (Base Construction Costs only) in the EEDB has been accomplished in two separate steps, in accordance with the EEDB Capital Cost Update Procedure. The first step was the evaluation and adjustment of the technical data models to assure that they reflected current power plant design practice and construction experience (including quantities of commodities, equipment and manhours), and current regulations, codes and standards. The second step was the adjustment of the capital cost data models to accommodate the technical data model revisions and to reflect equipment and labor cost escalation from the last update. This section of the report presents the results of the detailed changes to the technical data models.

4.1 TECHNICAL DATA MODEL UPDATE PROCEDURE

A specific technical data model update procedure was developed for the EEDB, as a part of the Capital Cost Update Procedure. This procedure is described in Section 6 of the EEDB Program Reference Book⁷. The procedure was utilized for the update of the PWR•ME, PWR•BE and HS5 technical data models listed in Table 1-2 of this report.

The Phase VII Update performed a modified Level 2B (nine-digit code-of-accounts level of detail) Technical Update on these power plant technical data models. The PWR•ME, PWR•BE and HS5 data models had been developed to the nine-digit code-of-accounts level of detail in previous updates. A major task of the Phase VII Update was a detailed review of the HS5 technical data model that would assure the necessary level of maturity required as the lead fossil fired power plant data model.

Normally, a Level 2B technical update examines the major cost drivers; structures, nuclear or fossil steam supply system, turbine-generator unit, piping, electrical/I&C, flue gas cleaning system (coal-fired power plants only) and condenser/cooling towers. In the Phase VII update, many systems/equipment outside of that envelope were evaluated in order to assure current technical credibility for the PWR and HS5. Sections 4.3.2, 4.4.1 and 4.4.2 discuss the results of this evaluation.

Another major task of the Phase VII Update was the incorporation of the LSPB technical data model into the EEDB (refer to Table 1-2). The LSPB is a new data model which was substituted for the LMFBR technical data model previously included in the data base. A discussion of the development of this new liquid metal reactor data model is given in Section 6.

4.2 TECHNICAL SUMMARY

Summaries of the Phase VII Update quantities of commodities and equipment are given for the PWR•ME, PWR•BE, and HS5 in Table 4-1. Comparison summaries of Phase VI Update (1983) data are given in Table 4-2. The installed costs of the commodities/equipment summarized in these tables for the PWR•ME, PWR•BE and HS5 represent approximately 75 percent of the total direct costs.

Summaries of the installed costs per unit of commodity or per item of equipment are given in Tables 4-3, 4-4 and 4-5 for the PWR•ME, PWR•BE and HS-5 respectively. These tables also show the distribution of direct site labor between the various crafts. The data were provided in the same format in the Phase V (1982) and Phase VI (1983) Update Reports^{2,3} for the PWR•ME and in the Phase VI Update Report for the HS5.

The Phase VII Update changes in the quantities of commodities and equipment, as summarized in Tables 4-1 through 4-5, were a direct result of the technical changes described in the following sections.

4.3 TECHNICAL UPDATE RESULTS

The Phase VII technical update supported the EEDB objective of assuring that the technical data models continue to represent current industry design and construction practice at the level established by the Phase VI Update. This objective was achieved by comparing commodity, equipment and manhour quantities for the updated EEDB technical data models with historical project experience, company confidential field data, and complimentary and parallel studies.

4.3.1 Review of Impact of Changing Regulations, Codes and Standards

As a first step in the process of updating the technical data models to January 1, 1984, a review of new and revised regulations was conducted. As in the past two updates, it was found for the Phase VII Update that changes to existing regulations and promulgation of new regulations occurring since the previous update have had a negligible effect on the quantities of commodities and equipment in the technical data models.

For example, of the 150 Division 1 (Power Reactors) Regulatory Guides effective on January 1, 1983, four were revised and one was added during 1983. Three of the revisions were related to ASME Boiler and Pressure Vessel Code Case Acceptability. The fourth gave clarification of requirements for instruments for following the course of an accident. The new regulatory guide endorsed the requirements for instrument sensing lines in an existing ISA standard.

There was considerable activity in 1983 in NRC Inspection and Enforcement Information Notices with 84 being issued during 1983. Generally, these documents promulgated requirements that affected the administration of engineering and construction in nuclear power plants. As such, they contributed to pressures that tend to increase manhours, rather than changes to commodities and equipment.

4.3.2 Review of Commodities and Manhours

In the second step of the update process for the technical data models, detailed reviews were made or initiated against historical project and current field data in the following two areas:

1. An overall technical review of the PWR was completed.
2. A technical maturity review for the HS5 was completed.

The purpose of these reviews was to continue the technical data models' refinement process and to assure that they continue to reflect actual industry experience.

An overall technical review of the PWR was conducted to improve and expand the technical basis for the data model. It should be noted that the PWR•ME and the PWR•BE versions of the PWR are very similar with respect to site, building and system/equipment configuration. The principle differences in the two versions lie in their quantities of commodities, equipment and man-hours. This overall review concentrated on building, system and equipment configuration and associated erection and installation manhours.

During the Phase VII Update, building/equipment arrangement drawings and licensing/engineering/construction milestone schedules were prepared. The arrangement drawings were based on those in the base data studies and reports¹⁰. The schedules were based on historical and current field experience. Using these documents and the system design descriptions prepared during the Phase VI Update², a review of the PWR structure/system configuration, parameters and installation manhours was made.

The review resulted in a variety of refinements in the PWR technical data models. These changes were reflected in the update of the system design descriptions, included in the Phase VII Technical Reference Book⁹, and the commodity/equipment/manhour summaries included in Tables 4-1, 4-3 and 4-4. The differences found in a comparison of Tables 4-1 and 4-2 for the PWR•ME and PWR•BE are primarily a result of these refinements. The specific changes are listed in Section 4.4.1 at the three-digit code-of-accounts level of detail.

The minor reductions in total craft manhours for the PWR•ME and PWR•BE caused by these refinements are considered minor adjustments to achieve higher technical data model credibility. On a manhours per kilowatt basis, the PWR•ME manhours remain closely representative of craft manhours associated with the industry median cost experience. The PWR•BE manhours remain close to the best experience benchmark established during the Phase VI Update (1983). Adequate field information was not available during the Phase VII Update (1984) to determine if this benchmark should be changed.

As a part of the PWR refinement effort, the commodity/equipment/manhour quantity summaries given in Tables 4-1 (1984), 4-2 (1983) and 4-4 (1984) for the PWR•BE were developed for the first time.

A technical maturity review for the HS5 was conducted so that the HS5 could replace the HS8* as the lead comparison power plant. This action was taken

* HS8 = 791 MWe High Sulfur Coal Fossil Power Generating Station

because a 486 MWe capacity was more representative of coal-fired power plant experience in 1984 than was the 791 MWe capacity.

During the Phase VI Update (1983), the level of detail of the HS5 technical data model was extended from the three-digit to the nine-digit code-of-accounts level. This extension was based on the HS8 technical data model which was also updated during the Phase VI Update.

For the Phase VII Update, a thorough technical review was made of the buildings, systems and equipment in the HS5 technical data model. The objective of this review was to extend and improve the HS5 technical data model to a level of maturity similar to that of the HS8. This review included the following features:

- preparation of equipment/building arrangement drawings and licensing/engineering/construction milestone schedules, which were not previously available;
- review and revision of structural commodities, where required by a building/equipment configuration change identified from the newly prepared arrangement drawings;
- expansion of system design descriptions to be independent of the HS8 descriptions, to add necessary design criteria and to enhance clarity;
- review and revision of system configuration with consideration of current practice, recently available data, and general applicability to a 486 MWe coal-fired unit on the Middletown site;
- review and revision of major systems, such as the boiler, coal handling, ash handling, waste water treatment, flue gas desulfurization and heat rejection systems, by manufacturers and engineering system/equipment specialists;
- review and revision of the installation manhours associated with each of the above features; and
- review and revision of the engineering hours, field supervision hours and other elements of the indirect costs.

The review resulted in extension of the technical maturity of the HS5 to a level equal to or exceeding that of the HS8. The maturity refinements were reflected in the HS5 expanded system design descriptions, included in the Phase VII Technical Reference Book⁹, and the commodity/equipment/manhour summaries, included in Tables 4-1 and 4-5. Review of Tables 4-1 and 4-2 indicates the degree to which the maturity refinements changed the HS5 quantities of commodities and equipment. The specific changes made are listed in Section 4.4.2 at the three-digit code-of-accounts level of detail.

The reductions in total craft manhours for the HS5 that were achieved during the technical maturity review were the result of incorporating more detailed information in the HS5 technical data model. Nevertheless, the HS5 craft manhours are slightly higher than the craft manhours associated with actual coal-fired power plant median cost experience. The base construction costs for the HS5, however, are closely representative of low to median coal-fired power plant cost experience, when compared on a dollar per kilowatt basis. It is expected, therefore, that efforts in future updates to develop an HS5 that is more representative of best to median coal-fired power plant cost experience will be in the area of improving the relationship between HS5 craft manhours and those associated with that experience.

4.4 DETAILED TECHNICAL CHANGES

The EEDB Technical Reference Book⁹, prepared during the Phase VII Update, contains the base data for each of the technical data models updated. The base data are in the form of assumptions, ground rules, design criteria, system design descriptions, engineering drawings and milestone schedules.

This section describes the modifications made to the Phase VI technical data models required for the Phase VII Update and preparation of the Technical Reference Book. Commodities, equipment and craft labor manhours and costs resulting from this update are tabulated for each of the three mature (nine-digit code-of-accounts level of detail) technical data models in Tables 4-3 through 4-5 as follows:

<u>Nuclear Plant Models</u>	<u>Table Number</u>	<u>Comparison Plant Model</u>	<u>Table Number</u>
PWR•ME	4-3	HS5	4-5
PWR•BE	4-4		

The following pages discuss the specific technical data model modifications made during the Phase VII Update. The discussions of these modifications are given at the three-digit code-of-accounts level of detail. A parenthetical statement is provided at the end of each modification description to indicate the effect of the modification on the base construction costs. For convenience, the discussion of each technical data model is started at the top of a new page.

4.4.1 EEDB Data Model Number A3•ME, Type PWR•ME, EEDB Phase VII (1984) Update
EEDB Data Model Number A3•BE, Type PWR•BE, EEDB Phase VII (1984) Update

The following technical data model modifications are common to the two PWR power generating stations selected for the Phase VII Update. These modifications take the form of changes in quantities of commodities and equipment and their installation manhours, which are an integral part of the technical data models. In many cases, however, the quantities differ for the PWR•ME and PWR•BE to the extent that median and best industry experience differ. This is particularly true for installation manhours. The changes are based on current designs and construction practice as reflected in the Phase VII technical reviews, ongoing assessments of field data and United Engineers' experience.

ACCOUNT 211 Yardwork

The sanitary sewage treatment system was revised to conform to current design practice. The treatment standard was changed from tertiary to secondary, which is sufficient to meet existing standards. The treatment facility capacity was reduced from 15,000 gallons per day to 10,500 gallons per day based on a reevaluation of need. (Cost Decrease)

ACCOUNT 212 Reactor Containment Building,

ACCOUNT 216 Waste Process Building (including Tank Farm),

ACCOUNT 217 Fuel Storage Building,

ACCOUNT 218B Administration and Service Building,

ACCOUNT 218D Fire Pump House Including Foundations for Two Fire Protection Tanks,

ACCOUNT 218H Non-Essential Switchgear Building,

ACCOUNT 218L Technical Support Center,

ACCOUNT 218T Ultimate Heat Sink Structure, and

ACCOUNT 218V Control Room Emergency Air Intake Structures

Minor increases were made to the structural quantities to more accurately reflect configurations on the new building arrangement drawings prepared during the Phase VII Update (refer to the Phase VII Technical Reference Book⁹). (Cost Increase)

ACCOUNT 218G Electrical Tunnel

Two sump pumps were added to remove seepage or other ingress of water. (Cost Increase)

ACCOUNT 218M Hydrogen Recombiner Structure (Account Deleted)

The hydrogen recombinder was relocated inside the containment and the separate Hydrogen Recombiner Structure was deleted. This change was made to reflect current design practice. (Cost Decrease)

ACCOUNT 218S Waste-Water Treatment Building

The waste-water treatment building (formerly Account 218Z) was combined with the holding basins (which replaced the holding pond) in this account. These revisions were made to improve account consistency and reflect current design practice. (Cost Decrease)

ACCOUNT 218Z Waste-Water Treatment Building (Account Deleted)

This Account was deleted and the waste-water treatment building was moved to Account 218S (refer to Account 218S).

ACCOUNT 221 Reactor Equipment

Reactor part-length control rods were eliminated. The reactor manufacturer advised that part-length rods were no longer included in the reactor design and that older plants which included part-length rods have had them electrically disconnected to make them inoperable (Cost Reduction Absorbed by Escalation of NSSS Price).

ACCOUNT 234 Feedheating System

The start-up feedwater pump was eliminated. A motor driven start-up feedwater pump is included or excluded according to the preference of the individual utility. The EEDB turbine driven feedwater pumps can be driven using auxiliary steam and thus should be suitable for start-up use. (Cost Decrease)

ACCOUNT 235 Other Turbine Plant Equipment

Technical refinements were made to the demineralized water make-up system and the neutralization system for improved consistency with other data models. (No Significant Cost Change)

The demineralized water storage tank dimensions were changed to provide the same volume at lower cost. (Cost Decrease)

ACCOUNT 252 Air, Water and Steam Service Systems

The service water system piping was revised based on an arrangement which eliminated the return run, by combining the service water return flow with the circulating water return flow. (Cost Decrease)

A strainer was added for the fire protection make-up water system to remove any debris which passes through the traveling water screens. (Cost Increase)

The earthen dike around the plant fuel oil storage tank was replaced by a steel dike supported on a concrete ringwall. The tank foundation was changed from compacted sand to clay and a clay liner was added to seal the ground inside the dike. (Cost Decrease)

These changes were made to reflect current design practice.

ACCOUNT 255 Waste Water Treatment Equipment

Technical refinements were made to the non-radioactive waste water treatment system for improved consistency with other data models. (No Significant Cost Change)

ACCOUNT 261 Main Condenser Heat Rejection System - Structures

Structural quantities associated with the make-up water pretreatment building and the cooling tower switchgear building were increased to improve technical data model consistency and reflect current design practice. (Cost Increase)

ACCOUNT 262 Main Condenser Heat Rejection System - Mechanical Equipment

Minor adjustments were made to the circulating water flow and temperatures in order to bring them into better alignment with the design heat balance and also to account for the volume change of the water as it is heated. (Cost Increase)

The circulating water piping sizes and quantities were increased based on a reevaluation of the system arrangement. Related excavation and backfill quantities were revised accordingly. (Cost Increase)

The make-up water system was revised to eliminate clarification of the cooling tower make-up. All make-up water will be strained through 1/32 inch mesh, but only the comparatively small portion to be demineralized or to be used for other purposes requiring cleaner water will be clarified. The clarifier capacity was reduced accordingly. (Cost Decrease)

These changes were made to reflect current design practice.

4.4.2 EEDB Data Model Number C5, Type HS5, EEDB Phase VII (1984) Update

During the Phase VI Update, the HS5 technical data model was expanded from the three-digit to the nine-digit code-of-accounts level of detail, using the HS8 as a basis. For the Phase VII Update, the HS5 has replaced the HS8 as the lead comparison plant data model. Consequently, a detailed review of the complete HS5 technical data model was conducted to bring the HS5 to a level of maturity comparable with that of the HS8. The following technical data model modifications resulted from this review.

ACCOUNT 211 Yardwork

The roads and parking areas were revised to provide better access or new access to various structures. (Cost Increase)

The sanitary sewage treatment facility capacity was reduced from 11,000 gallons per day to 5,500 gallons per day based on a reevaluation of need. The treatment standard was revised from tertiary to secondary which is sufficient to meet existing standards. (Cost Decrease)

The railroad track arrangement was revised based on changes in the coal unloading system, which requires minimal storage of cars on site, and on requirements for additional flexibility of operations. (Cost Increase)

ACCOUNT 218B Administration and Service Building,

ACCOUNT 218I Electrical Switchgear Building,

ACCOUNT 218L Stacker/Reclaimer Transfer Tower,

ACCOUNT 218N Rotary Car Dumper Building and Tunnel,

ACCOUNT 218O Coal Breaker House,

ACCOUNT 218P Coal Crusher House,

ACCOUNT 218R Dead Storage Transfer Tunnel,

ACCOUNT 218T Locomotive Repair Shop and Garage Facilities

ACCOUNT 218U Materials Handling and Service Building

Structural quantities were revised to reflect configurations on the new building arrangement drawings prepared during the Phase VII Update (refer to the Phase VII Technical Reference Book⁹). (Cost Increase)

ACCOUNT 212 Steam Generator Building, and

ACCOUNT 213 Turbine, Heater and Control Building

Building dimensions and structural quantities were increased as a result of preparing new building arrangement drawings during the Phase VII Update. (Cost Increase)

ACCOUNT 218M Coal Car Thaw Shed

The number of heating positions was increased from two to six to provide more effective thawing and to eliminate unloading delays. (Cost Increase)

ACCOUNT 218Q Boiler House Transfer Tower

The transfer tower was completely enclosed and moved to the south end of the heater bay because the new arrangement drawing indicated that all five pulverizers should be in one line along the south side of the boiler house for the best configuration. (Cost Increase)

ACCOUNT 218S Waste-Water Treatment Building

The waste-water treatment building (formerly Account 218V) was moved to this account for consistency with the PWR. (No Significant Cost Change)

The API oil separator was replaced by a type which is not part of the building structure, based on current design practice. (Cost Decrease)

ACCOUNT 218V Waste-Water Treatment Building (Account Deleted)

This account was deleted and the waste-water treatment building was moved to Account 218S. (refer to Account 218S)

ACCOUNT 218W Miscellaneous Coal Handling Structures

The exterior siding and roof were eliminated from the coal conveyor galleries, in accordance with information on current design practice from the coal handling equipment vendor. (Cost Decrease)

The coal pile membrane barrier was changed from a 0.02 inch thick PVC membrane to a compacted clay liner with integral clay lined ditches around the perimeter for collecting runoff and a drainage system underneath the liner to collect and divert groundwater to a sampling basin. This eliminated most of the excavation and backfill, and provided a more complete barrier system to comply with current interpretations of regulations. (Cost Increase)

A concrete runoff collection basin was substituted for the earthen basin previously shown on the plot plan. A concrete basin is more conveniently and permanently sealed and is more suitable to being emptied with pumps. (Cost Increase)

ACCOUNT 219 Stack Structure

The height of the stack was reduced from 750 feet to 650 feet, which is two and one-half times the height of the boiler house. Environmental regulations effective on January 1, 1984 defined this height as "good engineering practice" and did not allow credit (in dispersion modeling) to be taken for any height exceeding two and one-half times the boiler house height. (Cost Decrease)

The inside flue diameter was increased from 20 to 27.5 feet which resulted in a gas velocity of less than 40 feet per second. This velocity was expected to minimize entrainment of condensed liquid droplets into the gas stream. (Cost Increase)

As a result of the diameter and height changes, the foundation mat size was recalculated. The octagonal diameter decreased from 105 feet to 94.5 feet. The mat thickness was set at ten feet so that it could be keyed two feet into the rock under the site. (Cost Decrease)

The lining inside the flue was changed from a "paint" type coating to an asphaltic urethane membrane/adhesive coating and 1-1/2 inch thick borosilicate blocks to provide better protection from acid which condensed from the flue gas. In selecting this lining system, several other flue material/lining systems were considered. These are briefly described below:

1. Carbon steel with a high build "paint" type protective coating. This was the least expensive option considered; however, currently available information indicates that paint type coatings have frequently not provided acceptable service life.
2. Acid resistant brick with target walls and pressurized annulus. This was the least expensive of the acceptable materials, costing about 5-10 percent more than the painted steel and about 20-30 percent less than the selected borosilicate block. The serviceability of acid brick has been amply demonstrated through the years.

Since the acid brick would be somewhat porous, fans would be required for pressurizing the annulus. The fans would have 50-100 hp motors and would operate continuously.

During the last several years, it was discovered that the acid brick used in tall stacks was swelling in the area opposite the breeching and causing a lateral displacement of the top of the flue. It is currently believed that this swelling was caused by absorption of moisture and other material from the impinging flue gas. To protect the flue, sacrificial "target walls" are being installed up to a height of about three diameters. While this should cure the problem, there is valid reason to believe

that the target walls may require demolition and replacement during the operating life of the plant. While certainly less expensive than replacing the entire flue, replacing the target walls would still be a significant expense.

Even though the first cost of the acid brick flue was less than that of the selected borosilicate block, the operating and maintenance costs appeared to be higher.

3. Solid alloy 625 (or similar material). Experience over the past four years with a solid Inconel 625 flue has been excellent, but the expected first cost of 70-75 percent higher than the selected borosilicate block on carbon steel was considered too high.
4. Carbon steel clad with alloy 625 (or similar material). The clad material was significantly less expensive than solid alloy 625, but was estimated to be about 20-30 percent more expensive than the borosilicate block. Its performance might equal that of the solid alloy, but there was some concern that the relatively thin layer of corrosion resistant material may experience pitting or other localized corrosion sufficient to expose the base metal.

The selected borosilicate block on carbon steel was a relatively new material, and as such, data from actual service was limited; however, experience data was encouraging. Based on the current knowledge of its performance and cost, it was believed to be a realistic choice. (Cost Increase)

ACCOUNT 220A Fossil Steam Supply System

The boiler maximum continuous rating was changed from 3.8 million pounds per hour to 3.97 million pounds per hour to provide a margin of approximately three percent above the steam flow at valves wide open and five percent overpressure, which was consistent with the design of the HS8. (Cost Increase)

ACCOUNT 222 Draft System

The forced draft fan, the primary air fan and the induced draft fan capacities were revised based on information from the boiler manufacturer. (Included in the Boiler Price)

The secondary air heaters were added to the equipment list. Their previous omission from the equipment list was an oversight since they were always part of the FSSS package. (No Cost Change)

A mini-specification for the electrostatic precipitator was developed and added to the equipment list. The quantity of precipitator insulation was decreased based on manufacturer information. (Cost Decrease)

ACCOUNT 224 Fuel Handling System

The coal car thaw shed and heating equipment was expanded from two heating positions to six. This change provided more effective thawing and minimized unloading delays. (Cost Increase)

The second live storage pile was eliminated from the plot plan. The sizes of the live and dead storage piles were recalculated and revised on the plot plan to reflect current coal storage practice. (Refer to Account 218W - paragraph on coal pile membrane barrier)

The coal unloading system was revised to permit leased unit train coal delivery. The unit train cars have swivel couplings which do not need to be disconnected for dumping. Empty cars would generally not stay at the site, since the locomotive would stay with and take away the entire train as soon as it was emptied. (Refer to Account 211 - Yardwork - paragraph on railroad track arrangement, and the paragraph on the coal car thaw shed stated above.)

The number and length of conveyors were generally increased based on the new boiler house arrangement drawings. (Cost Increase)

The unloading and stackout rate of 2000 tons per hour (tph) was reviewed and found to be satisfactory with the modified unloading concept. The coal reclaim rate was verified at 550 tph. (No Cost Change)

The existing coal storage silo capacity of eight hours was reviewed and found to be satisfactory with the 550 tph reclaim rate and a conservative assumed daily load profile. (No Cost Change)

ACCOUNT 225 Flue Gas Desulfurization Structures

The absorber island enclosure was transferred to Account 225.5 from Account 226.3 and structural quantities were reduced. (Cost Decrease)

In the Phase VII Update, individual accounts were developed for the buildings in the 225 Account. This change had a significant effect on the craft labor distribution and on the distribution of tabulated quantities of commodities; however, total quantities of commodities and manhours did not change. (No Significant Cost Change)

ACCOUNT 226 Desulfurization Equipment

The piping and ductwork were disaggregated for separate costing in each of the subaccounts. (No Cost Change)

Account 226.3 Sulfur Dioxide Absorber System

Reheating of the scrubbed gases was eliminated. (Cost Decrease)

- a. Previously, the HS5 technical data model contained all of the equipment required to provide stack gas reheat, but was vague about the source of the required steam. When it was determined that the steam should be extracted from the cold reheat steam system, it became apparent that doing so would reduce the generator output by 15-20 MWe. Since this represents a significant economic penalty, a review of the current need for reheat was conducted with the following conclusions:
 - 1) The assumed characteristics of the hypothetical Middletown site include a pre-construction environment characterized by a relatively low level of air pollution (no other new sources which consume a substantial "Prevention of Significant Deterioration" increment) and by relatively flat terrain. From an air quality standpoint, these assumptions define a site considered routinely licensable. (The assumed site characteristics for the nuclear units also define a location which is "routinely licensable" and presents no special site related problems.) For such a site, the governing emission regulation is the New Source Performance Standards (NSPS) which can be satisfied without reheat.
 - 2) It was also determined that reheat may be detrimental from an equipment corrosion standpoint because of the increased temperature.
- b. Recognizing that emission regulations may change, the ability to add reheat in the future has been retained:
 - 1) A capped off steam source connection on the cold reheat pipe, materials believed to be satisfactory with or without reheat, blanked connections on the FGD outlet duct, and space for reheat equipment, piping, wiring, etc.
 - 2) This represents the most likely course a typical prudent utility would take if building a new plant on a "routinely licensable" site.

The absorber island enclosure was transferred to Account 225.5 (Refer to Account 225).

Account 226.4 Waste Slurry Thickening System

Structural quantities were reduced to improve technical data model consistency and reflect current designs. (Cost Decrease)

ACCOUNT 231 Turbine Generator

The mini-specification was revised to improve consistency with the heat balance and the information provided by the vendor. (No Significant Cost Change)

The generator rating was changed from 632 MVA to 625 MVA when recalculated on a basis consistent with other data models. (Cost Decrease)

Lube oil transfer pumps were added to permit oil transfers which could not be handled by the lube oil purifier pumps. (Cost Increase)

ACCOUNT 233 Condensing System

The condenser was modified as part of an overall condenser-cooling tower-circulating water system review. Manufacturer information was obtained and included in the review. (Cost Decrease)

The condensate and condensate booster pump total dynamic heads were modified based on a review of system requirements. (Cost Increase)

The condensate storage tank foundation was changed from a concrete ringwall to compacted clay on grade because there are no Seismic Category I considerations for this tank. (Cost Decrease)

The mechanical vacuum pumps were modified based on manufacturer information. (Cost Increase)

Minor revisions were made to the condensate polishing system and the system description was rewritten for clarity. (No Significant Cost Change)

ACCOUNT 234 Feedheating System

Feedwater heaters were modified based on manufacturer information. (Cost Increase)

The main boiler feed pump total dynamic head was increased based on a revised estimate of system requirements. (Cost Increase)

ACCOUNT 235 Other Turbine Plant Equipment

Main steam, hot reheat steam and cold reheat steam piping quantities were increased based on a reevaluation of system requirements. (Cost Increase)

The demineralized water make-up system capacity was changed from 300,000 gallons per day to 200,000 gallons per day based on a reestimate of plant requirements. (Cost Decrease)

The quantity of small bore stainless steel piping for ammonia and hydrazine systems were increased based on a reestimate of plant requirements. (Cost Increase)

The neutralization system components were modified and the neutralization tanks were replaced by below grade sumps based on current design practice. (Cost Decrease)

ACCOUNT 242 Station Service Equipment

The diesel-generator unit design basis was modified based on manufacturer information. (Cost Decrease)

ACCOUNT 251 Transportation and Lifting Equipment

Two needed front end loaders were added for use in the flue gas desulfurization and coal handling areas. (Cost Increase)

ACCOUNT 252 Air, Water and Steam Service Systems

The two-inch and smaller compressed air piping was changed from schedule 80 to schedule 40. The heavier pipe is not required for this service. (Cost Decrease)

The service water pump capacity was increased to be consistent with the turbine building closed cooling water system heat exchangers; however, higher speed pumps were found suitable. (Cost Decrease)

The quantity of service water piping and valves was increased based on a reevaluation of the system configuration. (Cost Increase)

A strainer was added to the fire protection make-up water system to remove any debris which passes through the traveling water screens. (Cost Increase)

The weight per foot of the fire protection water piping was increased to account for the cement lining. (Cost Increase)

Sprinkler systems were added for the boiler house and the materials handling and service building. (Cost Increase)

The two-inch and smaller size water piping was changed from schedule 80 to schedule 40, which is adequate for the service. (Cost Decrease)

The auxiliary boilers were changed from two at 100,000 lb/hr to one at 125,000 lb/hr based on a revised estimate of steam needs and reliability requirements. (Cost Decrease)

The capacities of the auxiliary boiler feedwater pumps were made consistent with the revised steam capacity. Only two pumps are now provided. The pumps were not included in the auxiliary boiler package and, thus, are priced separately. (Cost Decrease)

The auxiliary boiler deaerator was deleted from the auxiliary boiler package and priced separately. (No Overall Cost Change)

The auxiliary boiler blowdown piping was reevaluated and changed from two-inch schedule 40 to 1-1/2 inch schedule 80. The valve size and insulation were similarly changed. (Cost Decrease)

The auxiliary steam system heater drain tank pumps were changed from two at 50 percent to two at 100 percent to conform to current design practice. (Cost Increase)

The earthen dike around the plant fuel oil storage tank was replaced by a steel dike supported on a concrete ringwall. The tank foundation was changed from compacted sand to clay and a clay liner was added to seal the ground inside the dike. This change was made to reflect current design practice. (Cost Decrease)

ACCOUNT 254 Furnishings and Fixtures

The thermal effluent monitor was deleted because it is not required. (Cost Decrease)

ACCOUNT 255 Waste Water Treatment Equipment

This system was reevaluated and redesigned to reflect cost effective approaches to current regulatory requirements. (Cost Decrease)

ACCOUNT 261 Main Condenser Heat Rejection System - Structures

Structural quantities were revised for the following structures to improve consistency with the PWR and to reflect current design practice:

- Make-up Water Intake Structure
- Circulating Water Pump House
- Make-up Water Pretreatment Building
- Cooling Tower Switchgear Building

In general, these revisions resulted in increased commodity quantities. (Cost Increase)

ACCOUNT 262 Main Condenser Heat Rejection System - Mechanical Equipment

The screen wash piping size was changed from 5-inch to 2-1/2 inch based on vendor information about the required water flow. Pipe weight was correspondingly reduced. Screen wash valves were also changed from 5-inch to 2-1/2 inch size. (Cost Decrease)

Minor adjustments were made to the circulating water flow and temperatures in order to bring them into better alignment with the design heat balance and also to account for the volume change of the water as it is heated. (Cost Increase)

The quantities and sizes of circulating water pipe and valves were increased based on a reevaluation of the system arrangement. Related excavation and backfill quantities were revised accordingly. (Cost Increase)

The sulfuric acid feed equipment was moved to the make-up water system sub-account. (No Overall Cost Change)

The PVC pipe was moved to the chlorination equipment subaccount because it is used for the chlorine solution. (No Overall Cost Change)

The make-up water system was revised to eliminate clarification of the cooling tower make-up. All make-up will be strained through 1/32 inch mesh, but only the comparatively small portion to be demineralized or to be used for other purposes requiring cleaner water will be clarified. The clarifier capacity was reduced accordingly. (Cost Decrease)

The blowdown piping was increased in length and was changed from concrete to FRP because concrete is not readily available in the required size. (Cost Increase)

These changes were made to reflect current design practice.

TABLE 4-1

ENERGY ECONOMIC DATA BASE
 PHASE VII UPDATE (1984)
 DIRECT COMMODITY/EQUIPMENT/LABOR SUMMARY FOR NUCLEAR AND COMPARISON POWER GENERATING STATIONS

<u>Model/Rating (MWe)</u>		<u>PWR•ME/1139</u>	<u>PWR•BE/1139</u>	<u>HS5/486</u>
<u>Commodity/Equipment</u>	<u>Unit(a)</u>	<u>Commodities (Quantity x 10³(b))</u>		
Excavation	CY	645	541	155
Formwork	SF	2,158	1,698	645
Reinforcing, Embedded and Structural Steel	TN	39	30	19
Structural Concrete	CY	168	139	59
BOP Pumps (1000 HP and Up)(c)	HP	66	66	25
Piping(d)	LB	10,781	8,730	3,708
Raceways	LF	725	676	445
Wire and Cable	LF	6,276	5,416	2,661
		<u>Equipment (\$/kWe(e))</u>		
Steam Supply System	LT	154	154	135
Coal and Ash Handling	LT	N/A	N/A	62
Precipitator and Scrubber(f)	LT	N/A	N/A	128
Turbine-Generator	LT	101	101	94
Heat Exchangers(g)	LT	39	38	30
Instrumentation and Control	LT	30	27	17
		<u>Manhours (Quantity x 10³(b))</u>		
Craft Manhours	N/A	29,397	15,572	6,640

(a) CY = Cubic Yards; HP = Horsepower; LB = Pounds; LF = Linear Feet; LT = Lot; SF = Square Feet; TN = Tons

(b) Rounded Off to the Nearest 1,000 Units

(c) Includes Boiler Feed Pumps; Does Not Include NSSS Primary System Pumps

(d) Includes Carbon Steel and Stainless Steel Piping for PWR•ME and PWR•BE, plus Chrome-Moly Piping for HS5.

(e) Installed Costs in January 1, 1984 Constant Dollars

(f) Does Not Include Commodities for Structures, Equipment Foundations, Piping, HVAC, I&C, or Electrical Equipment for Scrubbers

(g) Includes Cooling Towers and Condensers

N/A = Not Applicable

TABLE 4-2

ENERGY ECONOMIC DATA BASE
 PHASE VI UPDATE (1983)
 DIRECT COMMODITY/EQUIPMENT/LABOR SUMMARY FOR NUCLEAR AND COMPARISON POWER GENERATING STATIONS

<u>Model/Rating (MWe)</u>		<u>PWR•ME/1139</u>	<u>PWR•BE/1139</u>	<u>HS5/486</u>
<u>Commodity/Equipment</u>	<u>Unit(a)</u>	<u>Commodities (Quantity x 10³(b))</u>		
Excavation	CY	668	563	233
Formwork	SF	2,123	1,671	604
Reinforcing, Embedded and Structural Steel	TN	40	30	19
Structural Concrete	CY	172	142	63
BOP Pumps (1000 HP and Up)(c)	HP	56	56	23
Piping(d)	LB	10,721	8,683	4,011
Raceways	LF	725	676	445
Wire and Cable	LF	6,275	5,394	2,660
		<u>Equipment (\$/kWe(e))</u>		
Steam Supply System	LT	130	130	128
Coal and Ash Handling	LT	N/A	N/A	50
Precipitator and Scrubber(f)	LT	N/A	N/A	161
Turbine-Generator	LT	98	98	91
Heat Exchangers(g)	LT	38	37	27
Instrumentation and Control	LT	29	27	17
		<u>Manhours (Quantity x 10³(b))</u>		
Craft Manhours	N/A	29,802	16,838	6,717

(a) CY = Cubic Yards; HP = Horsepower; LB = Pounds; LF = Linear Feet; LT = Lot; SF = Square Feet; TN = Tons

(b) Rounded Off to the Nearest 1,000 Units

(c) Includes Boiler Feed Pumps; Does Not Include NSSS Primary System Pumps

(d) Includes Carbon Steel and Stainless Steel Piping for PWR•ME and PWR•BE, plus Chrome-Moly Piping for HS5

(e) Installed Costs in January 1, 1983 Constant Dollars

(f) Does Not Include Commodities for Structures, Equipment Foundations, Piping, HVAC, I&C, or Electrical Equipment for Scrubbers

(g) Includes Cooling Towers and Condensers

N/A = Not Applicable

TABLE 4-3

ENERGY ECONOMIC DATA BASE
 PHASE VII UPDATE
 DIRECT COMMODITY AND CRAFT MANHOUR SUMMARY
 1139 MWe PRESSURIZED WATER REACTOR - MEDIAN EXPERIENCE
 NUCLEAR POWER GENERATING STATION

NUCLEAR PLANT QUANTITIESNUCLEAR PLANT MANHOURS

Commodity	Unit(a)	Quantity	Installed Cost/Unit(b)	Craft	Manhours	Cost x 10 ³ (b)
Excavation (Rock/Earth)	CY	644,590	12.04	Boiler Makers	957,278	20,821.
Fill	CY	382,969	7.50	Bricklayers	295,966	5,390.
Formwork	SF	2,157,503	18.53	Carpenters	1,761,814	35,148.
Reinforcing Steel	TN	26,692	1,865.87	Electricians	3,643,777	76,920.
Structural Concrete	CY	168,346	124.58	Ironworkers	2,439,040	55,049.
Concrete Fill	CY	102,700	79.31	Laborers	2,371,383	37,041.
Embedded Steel	TN	1,922	10,038.89	Millwrights	255,292	5,884.
Structural Steel	TN	10,864	2,660.03	Operating Engineers	1,539,984	30,214.
Special Steel Liners	LT	--	22.66(c)	Painters	772,101	12,747.
Carbon Steel Piping (NS)	LB	2,133,148	18.62	Pipe Fitters	6,455,803	148,354.
Stainless Steel Piping (NS)	LB	729,560	64.35	Sheet Metal Workers	208,034	4,602.
Carbon Steel Piping (NNS)	LB	7,340,360	11.98	Teamsters	333,011	5,028.
Stainless Steel Piping (NNS)	LB	577,757	43.32	All Others	177,917	4,137.
Valves	LT	--	10.62(c)			
Fire Protection	LT	--	6.36(c)	Total Craft Labor(h)	21,211,400	441,335.
BOP Pumps (1000 HP & above)(d)	HP	66,150	119.26			
Heat Exchangers(e)	LT	--	39.20(c)			
Turbine Generator	LT	--	101.26(c)			
Instrumentation and Control	LT	--	29.98(c)			
Heat., Ventilating, & Air Cond.(f)	LT	--	11.41(c)			
Lighting & Service Power	LT	--	6.09(c)			
Duct Runs and Wire Containers	LF	724,600	44.35			
Wire and Cable	LF	6,275,630	5.01			
Electrical Balance of Plant	LT	--	34.70(c)			
Nuclear Steam Supply System	LT	--	154.40(c)			
All Others(g)	LT	--	120.45(c)			

(a) CY = Cubic Yards; HP = Horsepower; LB = Pounds; LF = Linear Feet; LT = Lot; SF = Square Feet; TN = Tons

(b) Data in January 1, 1984 Constant Dollars

(c) Cost per Unit is in Dollars per Kilowatt - Electrical (\$/kWe)

(NNS) = Non-Nuclear Safety Grade

(d) Includes Boiler Feed Pumps; Does Not Include NSSS Pumps

(NS) = Nuclear Safety Grade

(e) Includes Cooling Towers and Condensers

(f) Includes Ductwork and All HVAC Equipment

(g) Does Not Include Indirect Costs

(h) Does Not Include Indirect Manhours

TABLE 4-4

ENERGY ECONOMIC DATA BASE
 PHASE VII UPDATE
 DIRECT COMMODITY AND CRAFT MANHOUR SUMMARY
 1139 MWe PRESSURIZED WATER REACTOR - BEST EXPERIENCE
 NUCLEAR POWER GENERATING STATION

NUCLEAR PLANT QUANTITIESNUCLEAR PLANT MANHOURS

Commodity	Unit(a)	Quantity	Installed Cost/Unit(b)	Craft	Manhours	Cost x 10 ³ (b)
Excavation (Rock/Earth)	CY	541,418	11.80	Boiler Makers	771,830	16,787.
Fill	CY	360,796	3.83	Bricklayers	160,255	2,918.
Formwork	SF	1,698,458	13.94	Carpenters	1,131,414	22,572.
Reinforcing Steel	TN	21,090	1,487.89	Electricians	2,076,506	43,835.
Structural Concrete	CY	138,655	87.19	Ironworkers	1,371,410	30,953.
Concrete Fill	CY	76,794	70.11	Laborers	1,353,298	21,139.
Embedded Steel	TN	1,326	9,307.27	Millwrights	204,921	4,723.
Structural Steel	TN	7,101	2,291.14	Operating Engineers	808,959	15,872.
Special Steel Liners	LT	--	19.41(c)	Painters	302,419	4,993.
Carbon Steel Piping (NS)	LB	1,669,608	9.51	Pipe Fitters	2,838,348	65,225.
Stainless Steel Piping (NS)	LB	604,790	29.09	Sheet Metal Workers	18,552	410.
Carbon Steel Piping (NNS)	LB	5,993,470	7.66	Teamsters	146,591	2,214.
Stainless Steel Piping (NNS)	LB	462,101	23.64	All Others	149,548	3,496.
Valves	LT	--	10.57(c)			
Fire Protection	LT	--	5.66(c)	Total Craft Labor(h)	11,334,051	235,137.
BOP Pumps (1000 HP & above)(d)	HP	66,150	117.49			
Heat Exchangers(e)	LT	--	38.25(c)			
Turbine Generator	LT	--	100.81(c)			
Instrumentation and Control	LT	--	27.24(c)			
Heat., Ventilating, & Air Cond.(f)	LT	--	6.98(c)			
Lighting & Service Power	LT	--	4.14(c)			
Duct Runs and Wire Containers	LF	676,100	22.94			
Wire and Cable	LF	5,415,880	3.43			
Electrical Balance of Plant	LT	--	32.93(c)			
Nuclear Steam Supply System	LT	--	153.86(c)			
All Others(g)	LT	--	91.23(c)			

(a) CY = Cubic Yards; HP = Horsepower; LB = Pounds; LF = Linear Feet; LT = Lot; SF = Square Feet; TN = Tons

(b) Data in January 1, 1984 Constant Dollars

(c) Cost per Unit is in Dollars per Kilowatt - Electrical (\$/kWe)

(NNS) = Non-Nuclear Safety Grade

(d) Includes Boiler Feed Pumps; Does Not Include NSSS Pumps

(NS) = Nuclear Safety Grade

(e) Includes Cooling Towers and Condensers

(f) Includes Ductwork and All HVAC Equipment

(g) Does Not Include Indirect Costs

(h) Does Not Include Indirect Manhours

TABLE 4-5

ENERGY ECONOMIC DATA BASE
 PHASE VII UPDATE
 DIRECT COMMODITY AND CRAFT MANHOUR SUMMARY
 486 MWe HIGH SULFUR COAL-FIRED POWER GENERATING STATION

COMPARISON COAL PLANT QUANTITIESCOMPARISON COAL PLANT MANHOURS

<u>Commodity</u>	<u>Unit(a)</u>	<u>Quantity</u>	<u>Installed Cost/Unit(b)</u>	<u>Craft</u>	<u>Manhours</u>	<u>Cost x 10³(b)</u>
Excavation (Earth/Rock/Dredging)	CY	154,926	6.97	Boiler Makers	637,381	13,863.
Fill (Earth/Clay/Stone)	CY	112,196	20.37	Bricklayers	63,343	1,153.
Formwork	SF	644,587	10.29	Carpenters	321,219	6,408.
Reinforcing Steel	TN	3,846	1,312.40	Electricians	1,029,676	21,736.
Structural Concrete	CY	58,987	80.00	Ironworkers	519,556	11,726.
Concrete Fill	CY	4,000	66.74	Laborers	566,977	8,856.
Embedded Steel	TN	251	6,951.10	Millwrights	158,757	3,659.
Structural Steel	TN	14,923	1,853.34	Operating Engineers	368,982	7,239.
Carbon Steel Piping	LB	2,659,740	7.66	Painters	156,104	2,577.
Stainless Steel Piping	LB	1,560	23.37	Pipe Fitters	1,769,134	40,655.
Chrome-Moly Piping	LB	1,046,400	10.54	Sheet Metal Workers	91,455	2,023.
Valves	LT	—	5.65(c)	Teamsters	74,515	1,125.
Fire Protection	LT	—	5.33(c)	All Others	74,805	1,744.
Pumps (1000 HP & above)(d)	HP	25,000	144.12			
Heat Exchangers(e)	LT	—	30.08(c)	TOTAL CRAFT LABOR(j)	5,831,904	122,764.
Turbine Generator	LT	—	94.00(c)			
Coal Handling(f)	LT	—	50.90(c)			
Electrostatic Precipitator	LT	—	14.31(c)			
SO ₂ Removal(g)	LT	—	113.64(c)			
Ash Handling	LT	—	11.31(c)			
Instrumentation and Control	LT	—	17.48(c)			
Heat., Ventilating, & Air Cond.(h)	LT	—	8.25(c)			
Lighting & Service Power	LT	—	7.82(c)			
Duct Runs & Wire Containers	LF	444,800	20.47			
Wire and Cable	LF	2,661,115	3.47			
Electrical Balance of Plant	LT	—	35.56(c)			
Fossil Steam Supply System	LT	—	135.31(c)			
All Others(i)	LT	—	150.16(c)			

(a) CY = Cubic Yards; HP = Horsepower; LB = Pounds; LF = Linear Feet; LT = Lot; SF = Square Feet; TN = Tons

(b) Data in January 1, 1984 Constant Dollars

(c) Cost per Unit is in Dollars per Kilowatt - Electrical (\$/kWe)

(d) Includes Boiler Feed Pumps

(e) Includes Cooling Towers and Condensers

(f) Does Not Include Ignition Oil System

(g) Does Not Include Commodities for Structures, Equipment Foundations, Piping, HVAC, I&C, or Electrical Equipment

(h) Includes Ductwork and All HVAC Equipment; Excludes Flue Gas Ductwork

(i) Does Not Include Indirect Costs

(j) Does Not Include Indirect Manhours

SECTION 5

5.0 CAPITAL COST UPDATE FOR SINGLE UNIT NUCLEAR AND COMPARISON POWER PLANTS

As stated in Section 4, the Phase VII Update of the Capital Costs (Base Construction Costs only) in the EEDB was accomplished in two separate steps. Section 4 presented the results of the first step, which was the evaluation and adjustment of the technical data models selected for the update. This section of the report presents the results of the second step, which was the adjustment of the capital cost data models to accommodate the technical data model revisions and to reflect the effects of equipment and labor cost escalation since the Phase VI Update (1983).

5.1 CAPITAL COST DATA MODEL UPDATE PROCEDURE

A specific capital cost update procedure was developed for the EEDB during the Phase I Update in 1978, which includes both the technical and capital cost update steps. This procedure is described in Section 6 of the EEDB Program Reference Book.⁷ The Phase VII Update utilized a Level 2 (nine-digit code-of-accounts level of detail) Capital Cost Update for the PWR•ME, PWR•BE and HS5, in conjunction with their Level 2B Technical Updates discussed in Section 4.

In the Phase VII Update, commodity and equipment costs were updated to January 1, 1984, in accordance with the applicable specifications for Level 2 Capital Cost Updates. As discussed in Section 4.1, a Level 2 cost update normally examines the major cost drivers. In the Phase VII Update, costs for many systems/equipment outside of the cost driver envelope were estimated in order to assure current cost credibility for the PWR and HS5. This was particularly true for the HS5, in order to support the technical maturity review discussed in Section 4.3.2. Table 5-1 identifies the major equipment in the PWR and HS5 for which estimating quotations were received. Where quotations included installation, manhours and installation costs were requested to preserve the integrity of the EEDB factory equipment and labor costs. Installation costs were deducted from quoted installed equipment costs prior to inclusion in the data base. Quoted manhours and "Middletown" labor rates were then used to develop the associated EEDB labor cost.

Unit costs were obtained for structural (e.g., concrete, formwork, structural steel) and piping commodities utilizing national indices, United Engineers' power plant experience and field data from company private sources. Labor rates were updated by craft to January 1, 1984. Equipment costs that were not updated by estimating quotations were escalated to January 1, 1984 by standard percentages, based on United Engineers' experience and national indices. The unweighted average increase due to escalation between January 1, 1983 and January 1, 1984 was approximately two percent for equipment and eight percent for labor.

As mentioned in Section 4.1, a major task for the Phase VII Update was the incorporation of the LSPB technical data model into the EEDB. A corresponding cost data model was developed and was incorporated into the data base. A discussion of the development of the LSPB technical/cost data model and presentation of an LSPB cost estimate are given in Section 6.

5.2 CAPITAL COST SUMMARY

Capital costs were prepared for the EEDB as base construction costs, which equal the direct plus indirect costs. EEDB base construction costs include only those cost elements described in the EEDB Program Reference Book. They specifically exclude owner's costs, contingencies, escalation and allowance for funds used during construction. These and other excluded preferential and discretionary items are listed in Table 5-2. Direct, indirect and base construction costs are summarized in Tables 2-3, 2-4 and 2-5.

During the Phase VI Update, a new PWR technical/cost data model was created which was called the "PWR for the 1990's." This data model had reduced quantities of materials, improved labor productivities and reduced indirect costs, which reflected the best cost experience for nuclear power plants then currently under construction. At the same time, the old PWR technical/cost data model, based on median nuclear power plant cost experience, was renamed the "PWR for the 1980's." The designation "PWR for the 1990's" implied that the improved construction practices plus nuclear regulatory and license reforms anticipated during the next decade would result in future plants having average costs that were comparable to the costs for the current best experience plants. Since the terms "PWR for the 1980's" (median cost experience) and "PWR for the 1990's" (best cost experience) led to confusion in interpreting the results of the Phase VI Update, these data models have been redesignated PWR•ME and PWR•BE respectively in the Phase VII Update.

5.3 DETAILED CAPITAL COSTS

Results of the Capital Cost Phase VII Update are presented for each technical data model at the two-digit and three-digit code-of-accounts level of detail in Tables 5-3 through 5-5 as indicated below. The first sheet of each table is a cost and manhours tabulation at the two-digit code-of-accounts (plant account) level of detail. The following four sheets comprise the cost and manhour tabulations at the three-digit code-of-accounts (structure/system account) level of detail. Additional detail for the PWR•ME, PWR•BE and HS5 to the nine-digit code-of-accounts (commodity/component account) level of detail, is available in the EEDB Backup Data File.

<u>Nuclear Plant Models</u>	<u>Table Number</u>	<u>Comparison Plant Model</u>	<u>Table Number</u>
PWR•ME	5-3	HS5	5-5
PWR•BE	5-4		

5.4 CAPITAL COST CHANGES

The Phase VII Update capital costs incorporated the technical changes discussed in Section 4, including the commodity/equipment changes summarized in Tables 4-1 and 4-2. These changes were made to meet the primary objective of the Phase VII Update, which was to refine the EEDB technical/cost data models

to reflect current experience. The following paragraphs focus on the Phase VI to Phase VII cost changes for the PWR and HS5.

As was discussed in Section 4.3.1, "Review of Impact of Changing Regulations, Codes and Standards," none of the regulatory changes that have occurred between January 1, 1983 and January 1, 1984 required significant changes to be made to the quantities of commodities and equipment in the technical data models and, consequently, in the related capital cost data models.

A major emphasis in the Phase VII Update was the detailed technical reviews and resulting technical changes described in Sections 4.3.2 and 4.4. Specific cost changes to the Phase VI (1983) PWR•ME, PWR•BE and HS5 were based on these changes. The PWR•ME and PWR•BE cost changes were generated by the technical refinements resulting from the overall technical review of the PWR. The HS5 cost changes were based on the extensive technical changes created from the technical maturity review of the HS5. Additional cost changes were made to the PWR•ME, PWR•BE and HS5 to reflect the effects of inflation that has occurred between the Phase VI and Phase VII Updates.

5.4.1 Presentation of the PWR and HS5 Cost Changes

Tables 5-6 through 5-8 present the base construction cost changes that have occurred in the PWR•ME, PWR•BE and HS5, between the Phase VI (1983) and Phase VII (1984) Updates. The Phase VI Update costs in these tables were increased by a uniform factor of 4.1 percent, in order to express the Phase VI dollars in terms of Phase VII dollars. The tables present the base construction costs for the Phase VI and Phase VII Updates in terms of 1984 constant dollars, the differences between the Phase VI and Phase VII Update costs, and the cost differences stated as a percentage of the inflated Phase VI costs. In these tables, the direct costs were regrouped from the building/system (Account) orientation of Tables 5-3 through 5-5, to a commodity/equipment orientation for Structural, Mechanical and Electrical/Instrumentation and Control (I&C) items.

The Structural direct costs were the installed costs for structural commodities for the buildings in Accounts 21 and 26 plus the installed costs for equipment foundations and underground encasements for all accounts (Accounts 21 through 26). The Mechanical direct costs were the installed costs for the building service equipment, piping and ducting in Account 21 and for all of the mechanical equipment and piping in Accounts 22 through 26. The Electrical/I&C direct costs were the installed costs for the lighting and service power systems in Account 21, the I&C equipment in Accounts 21 through 26, all of Account 24 (including the diesel-generator units) except foundations and underground encasements, and the communication equipment in Account 25.

For the indirect costs, "Construction Services" included temporary construction facilities, construction tools and equipment, and insurance, taxes and permits. "Engineering and Home Office Services" included home office and field engineering services, home office quality assurance (QA) services (for nuclear power plants only), and home office construction management services. Engineering services included engineering management, engineering and design, planning and

scheduling, cost engineering, and purchasing and expediting. "Field Office Services" included field office expenses, field job supervision, field office quality assurance/quality control (QA/QC) services and startup and testing services.

5.4.2 PWR•ME Cost Changes (Table 5-6)

The base construction costs for the PWR•ME increased between the Phase VI and Phase VII Updates at a rate which was one percent above the general inflation rate. This increase was primarily attributable to inflation and the general technical refinements discussed in Section 4.4. The relationship of this cost change to previous EEDB and actual power plant cost trends is discussed in Section 3.3.3.

5.4.2.1 PWR•ME Direct Costs

The largest cost increase above general inflation was in the account "NSSS + T/G." The turbine-generator unit (T/G) cost was based on a manufacturer's quotation and reflected the depressed state of the power industry. The T/G cost increase was about two percent, which was near the average equipment escalation for 1983. On the other hand, the nuclear steam supply system (NSSS) cost increased about 14 percent above general inflation. This was primarily caused by an adjustment in the EEDB NSSS scope. The change was made to conform to the manufacturer's current standard practice. The following equipment and costs were transferred to the NSSS account:

- the standard NSSS valve package which was included under "Piping - Valves" (Refer to Section 5.5.1) in Phase VI was included in the NSSS scope;
- the fuel storage racks which were included under "Mechanical - Other Equipment" in Phase VI were made part of the NSSS scope;
- the shipping costs for the NSSS equipment were not previously included in the NSSS cost; and
- the fuel handling tools which were included under "Mechanical - Other Equipment" in Phase VI were included in the NSSS scope.

The "Mechanical (w/o NSSS + T/G)" account kept pace with the general rate of inflation. Increases generated by changes in labor rates, which increased at a rate that exceeded the general inflation rate, and the mechanical technical changes described in Section 4.4.1 were offset by small changes in equipment costs, which increased at a rate lower than the general inflation rate, and the transfer of mechanical equipment to the NSSS scope. The "Total Mechanical" account was driven to increase by three percent above inflation by the increase in the NSSS cost described above.

The "Structural" account increased by two percent above general inflation. This was primarily caused by the structural technical changes described in Section 4.4.1. A part of this increase was attributable to the fact that the structural account was highly labor intensive and the average structural labor escalation for the year 1983 was about three percent higher than the general inflation rate.

The "Electrical/I&C" account kept pace with general inflation because there were no significant electrical/I&C technical changes made in this update. Factory equipment plus site material (FE + SM) costs were about equal to installation labor costs in this account. While labor costs increased at a rate higher than general inflation, they were offset by FE + SM costs which increased at a lower rate than general inflation.

5.4.2.2 PWR•ME Indirect Costs

The indirect costs have essentially kept pace with general inflation. Construction Services showed an increase of two percent above general inflation. Since this account was labor intensive, much of the increase was caused by the average construction service labor escalation of ten percent above general inflation for 1983.

The Engineering and Home Office Services account increase of one percent above general inflation was caused by an increase in salaries and expenses that was somewhat higher than the general inflation rate for 1983. The Field Office Services increase, which was slightly less than the 1983 general increase in inflation, was attributable to the small reduction in craft manhours associated with the changes described in Section 4.4.1. Another contributor to this lower than general inflation increase was a reduction in the costs for startup/test personnel.

5.4.3 PWR•BE Cost Changes (Table 5-7)

The base construction costs for the PWR•BE increased between the Phase VI and Phase VII Updates at a rate that was one percent below the general inflation rate. This lower than general inflation increase was primarily attributable to the decrease in the indirect costs that was caused by a reduction of 18 months in the construction schedule developed for the PWR•BE in the Phase VII Update Technical Reference Book⁹. The relationship of this cost change to previous EEDB and actual power plant cost trends is discussed in Section 3.3.3.

5.4.3.1 PWR•BE Direct Costs

The largest cost increase above general inflation was in the account "NSSF + T/G" for generally the same reasons as given for the similar increase in the PWR•ME.

The "Mechanical (w/o NSSF + T/G)" account increased at a rate that was almost four percent less than the general rate of inflation. Unlike the case of the PWR•ME, the increases generated by labor rates, which increased at a rate

that exceeded the general inflation rate, and the mechanical technical changes described in Section 4.4.1 were more than offset for the PWR•BE by small changes in equipment costs, which increased at a rate lower than the general inflation rate, and the transfer of mechanical equipment to the NSSS scope. In particular, the increased labor costs associated with the mechanical technical changes, principally the piping manhours, were not increased enough to have the totally offsetting effect for the PWR•BE that they did for the PWR•ME. This effect occurred because the PWR•BE installation hours were much lower than those of the PWR•ME. For example, the piping installation manhours for the PWR•ME were almost three times those in the PWR•BE. Consequently, the piping increases associated with the mechanical technical changes drove the mechanical cost increase closer to the general inflation rate for the PWR•ME than for the PWR•BE.

The "Structural" account for the PWR•BE increased by two percent above general inflation, to equal the PWR•ME structural increase. The increase was primarily caused by structural technical changes described in Section 4.4.1 that were very similar for both the PWR•ME and PWR•BE. The actual cost increase for the PWR•BE was two-thirds of that for the PWR•ME because the PWR•BE had higher labor productivities than those of the PWR•ME. The percentage increase was the same because the base to which the change was made for the PWR•BE was about two-thirds of that for the PWR•ME.

The "Electrical/I&C" account increased at a rate that was three percent less than that of general inflation. Similar conditions prevailed for the PWR•BE electrical/I&C account as for that of the PWR•ME. In this case, however, the installation labor was only on the order of two-thirds of the FE + SM costs because of the higher PWR•BE labor productivities. Consequently, this account did not keep pace with general inflation, as did the electrical/I&C account for the PWR•ME.

5.4.3.2 PWR•BE Indirect Costs

The indirect costs have shown a decrease in the Phase VII Update of about one percent below their value for the Phase VI Update (1983). Both the Construction Services and Field Office Services accounts showed significant reductions. These savings accrued through the reduction of the construction schedule from 90 to 72 months.

A basic assumption for the PWR•BE cost estimate was that regulatory reform, similar to that suggested by DOE, had occurred as one of the factors necessary to duplicate current best industry cost experience. Implicit in this assumption was the idea that construction may be completed for a PWR in 72 months under such conditions. The 20 percent reduction in schedule significantly impacted both the fixed and variable construction expenses in the Construction Services account. It also permitted more efficient use of construction labor and, therefore, reduced the field supervision required in the Field Office Services accounts.

The Engineering and Home Office Services account increase of two percent above inflation was caused by an increase in salaries and expenses that was somewhat higher than the general inflation rate for 1983. The percentage increase difference between the PWR•BE and the PWR•ME was caused by differences in rounding and in the basic costs.

5.4.4 HS5 Cost Changes (Table 5-8)

The base construction cost for the HS5 increased between the Phase VI and Phase VII Updates at a rate that was two percent above general inflation. This increase was primarily attributable to the upgrade of the HS5 to lead comparison plant data model through the technical maturity review discussed in Sections 4.3.2 and 4.4.2.

5.4.4.1 HS5 Direct Costs

In the direct costs, the major increases were in the "Other Mechanical" and "Structural" accounts. These cost changes were a result of the technical changes made during the technical maturity review, as described in Section 4.4.2. The other direct cost accounts kept pace with general inflation or increased at a slightly higher rate than general inflation. While a number of changes were made to the FGD system during the technical maturity review, the overall cost impact was negligible.

5.4.4.2 HS5 Indirect Costs

The indirect costs have shown a decrease in the Phase VII Update of one percent over their value for the Phase VI (1983) Update. This decrease was primarily attributable to the decrease in construction schedule from 54 to 46 months as developed for the Phase VII Update Technical Reference Book⁹. The reduction in schedule caused a significant decrease in both the Construction Services and Field Office Services accounts.

The schedule reduction was based on an evaluation of historical and current field data. The 17 percent reduction impacted the Construction Services and Field Office Services accounts in the same way as the schedule reduction impacted these accounts for the PWR•BE.

Mostly offsetting the impact of the schedule reduction was an increase in the Engineering and Home Office Services account manhours. This increase was also based on an evaluation of the historical and field data. There was an increase in this account in salaries and expenses that was higher than the general inflation rate for 1983. These two factors were the contributors to the increase of 18 percent above general inflation in the Engineering and Home Office Services account.

5.5 BASIS FOR COST COMPARISONS FOR THE PWR•ME, THE PWR•BE AND THE HS5

Base construction costs for the PWR•ME, PWR•BE and HS5 are compared in Tables 5-9 and 5-10 on both a dollars and a dollars per kilowatt basis. Factory

equipment plus site materials costs are given in Table 5-9, while labor (craft, engineering and field supervision) costs are given in Table 5-10.

Tables 5-9 and 5-10 have the base construction costs grouped in a commodity/equipment and labor orientation for structural, mechanical and electrical items. These tables form the basis for Figures 3.1, 3.2 and 3.3 and for Tables 5-6, 5-7 and 5-8. Following is a listing of what is included in each account:

5.5.1 Factory Equipment plus Site Material Costs (Table 5-9)

- NSSS or FSSS - the price for the nuclear or fossil steam supply system scope of supply plus the cost of site materials required for its installation. When installation manhours are included in a quotation, quantities and costs of the installation manhours are requested. The installation costs are deducted from the quotation and the result is entered in the factory equipment account. The installation manhours are multiplied by Middletown labor rates and the resulting costs are entered in the labor account.
- SO₂ Removal System (Coal-Fired Power Plants only) - the quoted estimating cost of the flue gas desulfurization system and the site materials required for its installation. Costs of associated structural commodities, building or equipment foundations, piping, HVAC, I&C and electrical equipment are included in the appropriate accounts described below.
- T/G Unit - the price for the turbine-generator unit plus the cost of site materials required for its installation.
- Mechanical - the quoted estimating cost or apparatus handbook price of the mechanical equipment listed plus the cost of site materials required for their installation. Installation costs included in system/equipment quotations are deducted and distributed in the labor accounts as described in the "NSSS or FSSS" section. "Other Equipment" includes all other mechanical equipment not listed, such as tanks, filters and HVAC equipment.
- Piping - the cost for all interconnecting piping systems and equipment, except for the NSSS primary piping (included with the NSSS). Piping costs include costs for valves, supports, specialties and the site materials required for their installation.
- Electrical/I&C - the cost for all electrical, instrumentation and control equipment, including interconnecting wiring and its supporting or enclosing raceways. Electrical/I&C

costs include the costs of building lighting, building service power, communications equipment and site materials required for installation.

- Structural Support - the cost of the structural support commodities; structural steel, reinforcing steel, structural concrete, embedded steel and formwork, including fabricated items. These items are mostly site material, but include some fabricated items of factory equipment.
- Structural (Other) - the cost of all other structural and architectural commodities and items, such as roofing, interior and exterior non-load bearing walls, doors, miscellaneous steel, siding, protective coatings, plus structure equipment, such as elevators. These items are mostly site material, but include some fabricated or manufactured items of factory equipment.
- Construction Services - the rental or purchase cost and expenses associated with construction equipment (e.g., earth moving machinery and construction cranes), temporary buildings, small tools and expendable supplies plus field office expenses. These are indirect costs.

5.5.2 Labor Costs (Table 5-10)

- Structural Craft Labor - the installation labor costs for the construction of structures, buildings and other civil works, including equipment foundations.
- Mechanical Craft Labor - the installation labor costs for installing or erecting equipment and piping for the reactor or boiler plant, mechanical plant, miscellaneous plant, building services and heat rejection systems and equipment. All craft labor which is not in the structural or electrical accounts is included here.
- Electrical/I&C Craft Labor - the installation labor costs for the installation of instrumentation, control, and electrical systems and equipment, including emergency engine-driven generators, building lighting, service power and communication systems.
- Construction Services - the costs for labor to construct and maintain temporary buildings and facilities, to store, maintain and repair construction tools and equipment, and to provide security for the area during construction; plus the costs for surveying team support, medical/first aid support, expendable supplies, construction training meetings, and field office equipment. These are indirect costs.

- Salaries - costs for engineering and engineering support, plus costs for non-manual field supervision personnel and services, including quality assurance/quality control, construction management and test/startup personnel and services. These are indirect costs.
- Expenses - expenses associated with the personnel and services listed under salaries. These are indirect costs.
- Insurance/Taxes - costs of payroll insurance and taxes plus builders all risk insurance. These are indirect costs.

5.5.3 Use of Commodity/Equipment/Labor Accounting System

These nine equipment/material and seven labor cost sub-categories identify all of the cost components of the technical data models while segregating those items which have caused major cost differences among nuclear power plant construction projects. Examination of the numerical data in Tables 5-9 and 5-10 can provide many useful insights into the cost relationships of the PWR•ME, PWR•BE and HS5. For example, examination of the piping for these three plants on a dollars per kilowatt (\$/kWe) basis reveals the following relationships:

	1984 \$/kWe		
<u>Piping</u>	<u>PWR•ME</u>	<u>PWR•BE</u>	<u>HS5</u>
FE + SM	1.3	Base	1.1
Labor	2.7	Base	0.9
Total Costs	2.0	Base	1.0

Comparing the PWR•ME and the HS5 to the PWR•BE indicates that the piping installed costs on a \$/kWe basis are nearly equal for the HS5 AND PWR•BE, but about twice as high for the PWR•ME as for the PWR•BE.

PWR•ME Versus PWR•BE

Twice as many labor dollars per FE + SM dollar are spent for the PWR•ME piping as for the PWR•BE piping. Additionally, although the plants are similar in design, the PWR•ME FE + SM piping costs 30 percent more than that of the PWR•BE. The EEDB Phase VI Update (1983)² indicates that median cost experience plants typically have significantly lower labor productivities and higher material quantities than similar best cost experience plants. Consequently, the analysis has affirmed and quantified the expected cost relationships.

HS5 Versus PWR•BE

The \$/kWe similarity in the HS5 and PWR•BE piping FE + SM and labor costs is a result of offsetting cost factors. The lower capacity of the HS5 produces

higher \$/kWe costs than for the high capacity PWR•BE. Additionally, the higher operating pressures and temperatures of the HS5 produce higher unit piping costs than for the PWR•BE. Offsetting these costs, however, are high cost safety-related piping and lower labor productivities for the PWR•BE. Although PWR•BE labor productivities are similar to HS5 productivities for non-safety related piping, productivities for safety-related piping are considerably lower for the HS5. Further analysis is required to quantify these differences; however, the analysis has qualitatively affirmed the expected cost relationships.

TABLE 5-1

ENERGY ECONOMIC DATA BASE
 PHASE VII UPDATE
 MAJOR EQUIPMENT ESTIMATING QUOTATIONS RECEIVED FOR THE PWR AND HS5

<u>Equipment</u>	<u>PWR</u>	<u>HS5</u>
Ash Handling System		X
Boiler (NSSS or FSSS)	X	X
Chimney		X
Circulating Water Piping (Concrete)	X	X
Circulating Water Pumps	X	X
Coal Handling System		X
Condensate Booster Pumps - High Pressure		X
Condensate Booster Pumps - Low Pressure	X	X
Condensate Polishing System	X	X
Condensate Pumps	X	X
Condenser	X	X
Cooling Towers	X	X
Deaerating Heater		X
Electrostatic Precipitators		X
Emergency Diesel-Generator Units		X
Feedwater Heaters	X	X
Feedwater Pumps	X	X
Fuel Storage Racks (New)	X	
Fuel Storage Racks (Spent)	X	
Make-up Demineralizer	X	X
Make-up Water Pretreatment System	X	X
Service Water Pumps	X	X
Soot Blowing Air Compressor		X
Turbine-Generator Unit	X	X
Turbine Room Crane	X	X

TABLE 5-2

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATE
PREFERENTIAL AND DISCRETIONARY ITEMS EXCLUDED FROM EEDB
BASE CONSTRUCTION COSTS

Owner's Cost (Consultants, Site Selection, Land, etc.)

Fees and Permits (Federal, State, Local)

Federal, State and Local Taxes

Allowance for Funds Used During Construction

Escalation

Contingency

Owner's Discretionary Items

Switchyard and Transmission Lines

Generator Step-up Transformer

Waste Disposal Equipment

Spare Parts

Initial Fuel Supply

Nuclear Liability and Other Insurance

Special Coolant Initial Inventory

Effective Date 1/1/84

TABLE 5-3

ENERGY ECONOMIC DATA BASE - PHASE VII UPDATE

1139 MWe PRESSURIZED WATER REACTOR NPGS

MEDIAN EXPERIENCE

CAPITAL COST ESTIMATE

PLANT CODE
148

COST BASIS
01/84

UNITED ENGINEERS & CONSTRUCTORS INC.
EEDB-VII BASE COSTS (MEDIAN EXPERIENCE BASIS)
1139 MWE PRESSURIZED WATER REACTOR

SUMMARY PAGE 1

12/10/84

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*****	*****	*****	*****	*****	*****	*****
21 .	STRUCTURES + IMPROVEMENTS	10,882,819	9046379 MH	179,034,156	92,926,613	282,843,588
22 .	REACTOR PLANT EQUIPMENT	221,460,014	4224696 MH	92,723,313	20,486,946	334,670,273
23 .	TURBINE PLANT EQUIPMENT	158,689,675	3066608 MH	66,820,106	10,762,311	236,272,092
24 .	ELECTRIC PLANT EQUIPMENT	29,494,445	2620099 MH	54,501,033	17,654,311	101,649,789
25 .	MISCELLANEOUS PLANT EQUIPT	16,076,802	1455031 MH	31,878,886	6,157,863	54,113,551
26 .	MAIN COND HEAT REJECT SYS	30,546,510	798587 MH	16,377,227	4,124,128	51,047,865
	TOTAL DIRECT COSTS	467,150,265	21211400 MH	441,334,721	152,112,172	1,060,597,158
91 .	CONSTRUCTION SERVICES	101,183,820	7282040 MH	152,922,760	99,073,870	353,180,450
92 .	HOME OFFICE ENGRG.&SERVICE	343,045,000				343,045,000
93 .	FIELD OFFICE ENGRG&SERVICE	337,331,840	903670 MH	18,977,770	16,477,600	372,787,210
	TOTAL INDIRECT COSTS	781,560,660	8185710 MH	171,900,530	115,551,470	1,069,012,660
	TOTAL BASE COST	1,248,710,925	29397110 MH	613,235,251	267,663,642	2,129,609,818

PLANT CODE
148

COST BASIS
01/84

UNITED ENGINEERS & CONSTRUCTORS INC.
EEDB-VII BASE COSTS (MEDIAN EXPERIENCE BASIS)
1139 MWE PRESSURIZED WATER REACTOR

SUMMARY PAGE 2

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ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*****	*****	*****	*****	*****	*****	*****
211.	YARDWORK	263,059	1009131 MH	17,838,818	11,850,798	29,952,675
212.	REACTOR CONTAINMENT BLDG	2,865,276	3099929 MH	62,283,507	28,715,616	93,864,399
213.	TURBINE ROOM + HEATER BAY	543,983	887696 MH	18,262,374	16,534,224	35,340,581
214.	SECURITY BUILDING	74,978	52788 MH	1,076,462	542,880	1,694,320
215.	PRIM AUX BLDG + TUNNELS	2,898,437	789050 MH	15,688,832	6,242,100	24,829,369
216.	WASTE PROCESS BUILDING	587,355	718114 MH	14,086,581	6,354,286	21,028,222
217.	FUEL STORAGE BLDG	936,385	305211 MH	6,071,008	3,855,487	10,862,880
218A.	CONTROL RM/D-G BUILDING	1,598,532	929404 MH	18,945,417	7,778,976	28,322,925
218B.	ADMINISTRATION+SERVICE BLG	882,450	260119 MH	5,273,212	2,994,754	9,150,416
218D.	FIRE PUMP HOUSE,INC FNDTNS	38,153	14921 MH	299,793	151,062	489,008
218E.	EMERGENCY FEED PUMP BLDG	21,477	126083 MH	2,478,153	952,448	3,452,078
218F.	MANWAY TUNNELS (RCA TUNLS)		47736 MH	903,155	299,917	1,203,072
218G.	ELEC. TUNNELS	10,592	2228 MH	47,668	19,039	77,299
218H.	NON-ESSEN. SWGR BLDG.	21,023	20454 MH	409,278	286,894	717,195
218J.	MN STEAM + FW PIPE ENC.	31,931	394802 MH	7,922,143	3,361,620	11,315,694
218K.	PIPE TUNNELS		18115 MH	336,976	115,807	452,783
218L.	TECHNICAL SUPPORT CENTER	59,982	25148 MH	486,120	252,537	798,639
218P.	CONTAIN EQ HATCH MSLE SHLD		9725 MH	186,325	56,013	242,338
218S.	WASTE WATER TREATMENT	8,000	28885 MH	548,579	286,852	843,431
218T.	ULTIMATE HEAT SINK STRUCT	41,206	302709 MH	5,813,170	2,245,984	8,100,360
218V.	CONTR RM EMG AIR INTK STR		4131 MH	76,585	29,319	105,904
21 .	STRUCTURES + IMPROVEMENTS	10,882,819	9046379 MH	179,034,156	92,926,613	282,843,588

PLANT CODE
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COST BASIS
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UNITED ENGINEERS & CONSTRUCTORS INC.
EEDB-VII BASE COSTS (MEDIAN EXPERIENCE BASIS)
1139 MWE PRESSURIZED WATER REACTOR

SUMMARY PAGE 3

12/10/84

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*****	*****	*****	*****	*****	*****	*****
220A.	NUCLEAR STEAM SUPPLY(NSSS)	164,000,000				164,000,000
220B.	NSSS OPTIONS					
221.	REACTOR EQUIPMENT	795,964	184500 MH	4,009,038	5,900,905	10,705,907
222.	MAIN HEAT XFER XPORT SYS.	3,036,365	639612 MH	14,113,343	1,446,025	18,595,733
223.	SAFEGUARDS SYSTEM	7,579,755	611501 MH	13,501,871	1,584,255	22,665,881
224.	RADWASTE PROCESSING	11,462,704	464039 MH	10,226,558	1,269,595	22,958,857
225.	FUEL HANDLING + STORAGE	2,171,025	78962 MH	1,744,689	185,778	4,101,492
226.	OTHER REACTOR PLANT EQUIP	19,542,072	1627662 MH	35,908,773	6,320,766	61,771,611
227.	RX INSTRUMENTATION+CONTROL	12,872,129	377700 MH	7,861,801	594,269	21,328,199
228.	REACTOR PLANT MISC ITEMS		240720 MH	5,357,240	3,185,353	8,542,593
22 .	REACTOR PLANT EQUIPMENT	221,460,014	4224696 MH	92,723,313	20,486,946	334,670,273
231.	TURBINE GENERATOR	112,540,744	454270 MH	9,716,517	1,678,421	123,935,682
233.	CONDENSING SYSTEMS	16,209,938	596624 MH	13,089,943	1,718,157	31,018,038
234.	FEED HEATING SYSTEM	15,770,747	585115 MH	12,912,212	1,287,479	29,970,438
235.	OTHER TURBINE PLANT EQUIP.	12,365,762	946199 MH	20,861,167	2,229,732	35,456,661
236.	INSTRUMENTATION + CONTROL	1,802,484	230900 MH	4,803,113	410,209	7,015,806
237.	TURBINE PLANT MISC ITEMS		253500 MH	5,437,154	3,438,313	8,875,467
23 .	TURBINE PLANT EQUIPMENT	158,689,675	3066608 MH	66,820,106	10,762,311	236,272,092

PLANT CODE
148

COST BASIS
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UNITED ENGINEERS & CONSTRUCTORS INC.
EEDB-VII BASE COSTS (MEDIAN EXPERIENCE BASIS)
1139 MWE PRESSURIZED WATER REACTOR

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ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*****	*****	*****	*****	*****	*****	*****
241.	SWITCHGEAR	10,033,856	26380 MH	550,614	81,062	10,665,532
242.	STATION SERVICE EQUIPMENT	16,385,899	128036 MH	2,697,202	411,917	19,495,018
243.	SWITCHBOARDS	1,400,993	16340 MH	341,093	128,568	1,870,654
244.	PROTECTIVE EQUIPMENT		132050 MH	2,758,501	1,648,138	4,406,639
245.	ELECT.STRUC +WIRING CONTNR		1435863 MH	29,740,728	5,445,969	35,186,697
246.	POWER & CONTROL WIRING	1,673,697	881430 MH	18,412,895	9,938,657	30,025,249
24 .	ELECTRIC PLANT EQUIPMENT	29,494,445	2620099 MH	54,501,033	17,654,311	101,649,789
251.	TRANSPORTATION & LIFT EQPT	3,019,000	58550 MH	1,287,988	483,944	4,790,932
252.	AIR,WATER+STEAM SERVICE SY	8,315,234	1096371 MH	24,179,065	4,825,061	37,319,360
253.	COMMUNICATIONS EQUIPMENT	1,948,800	192200 MH	4,015,017	601,612	6,565,429
254.	FURNISHINGS + FIXTURES	2,093,768	25910 MH	532,784	60,843	2,687,395
255.	WASTEWATER TREATMENT EQUIP	700,000	82000 MH	1,864,032	186,403	2,750,435
25 .	MISCELLANEOUS PLANT EQUIPT	16,076,802	1455031 MH	31,878,886	6,157,863	54,113,551
261.	STRUCTURES	268,297	147013 MH	2,874,389	1,512,196	4,654,882
262.	MECHANICAL EQUIPMENT	30,278,213	651574 MH	13,502,838	2,611,932	46,392,983
26 .	MAIN COND HEAT REJECT SYS	30,546,510	798587 MH	16,377,227	4,124,128	51,047,865
	TOTAL DIRECT COSTS	467,150,265	21211400 MH	441,334,721	152,112,172	1,060,597,158

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COST BASIS
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UNITED ENGINEERS & CONSTRUCTORS INC.
EEDB-VII BASE COSTS (MEDIAN EXPERIENCE BASIS)
1139 MWE PRESSURIZED WATER REACTOR

SUMMARY PAGE 5

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ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*****	*****	*****	*****	*****	*****	*****
911.	TEMPORARY CONSTRUCTION FAC		6867380 MH	144,214,960	30,742,500	174,957,460
912.	CONSTRUCTION TOOLS & EQUIP		414660 MH	8,707,800	66,203,890	74,911,690
913.	PAYROLL INSURANCE & TAXES	101,183,820				101,183,820
914.	PERMITS,INS. & LOCAL TAXES				2,127,480	2,127,480
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	101,183,820	7282040 MH	152,922,760	99,073,870	353,180,450
921.	HOME OFFICE SERVICES	327,230,630				327,230,630
922.	HOME OFFICE Q/A	11,011,750				11,011,750
923.	HOME OFFICE CONSTRCTN MGMT	4,802,620				4,802,620
92 .	HOME OFFICE ENGRG.&SERVICE	343,045,000				343,045,000
931.	FIELD OFFICE EXPENSES		59240 MH	1,244,070	16,477,600	17,721,670
932.	FIELD JOB SUPERVISION	302,755,330	505050 MH	10,605,970		313,361,300
933.	FIELD QA/QC	19,801,380	339380 MH	7,127,730		26,929,110
934.	PLANT STARTUP & TEST	14,775,130				14,775,130
93 .	FIELD OFFICE ENGRG&SERVICE	337,331,840	903670 MH	18,977,770	16,477,600	372,787,210
	TOTAL INDIRECT COSTS	781,560,660	8185710 MH	171,900,530	115,551,470	1,069,012,660
	TOTAL BASE COST	1,248,710,925	29397110 MH	613,235,251	267,663,642	2,129,609,818

Effective Date 1/1/84

TABLE 5-4

ENERGY ECONOMIC DATA BASE - PHASE VII UPDATE

1139 MWe PRESSURIZED WATER REACTOR NPGS

BEST EXPERIENCE

CAPITAL COST ESTIMATE

PLANT CODE
184

COST BASIS
01/84

UNITED ENGINEERS & CONSTRUCTORS INC.
EEDB-VII BASE COSTS (BEST EXPERIENCE BASIS)
1139 MWE PRESSURIZED WATER REACTOR

SUMMARY PAGE 1

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ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*****	*****	*****	*****	*****	*****	*****
21 .	STRUCTURES + IMPROVEMENTS	10,060,020	5114242 MH	101,489,499	67,299,801	178,849,320
22 .	REACTOR PLANT EQUIPMENT	215,420,082	1921494 MH	41,938,030	15,583,728	272,941,840
23 .	TURBINE PLANT EQUIPMENT	154,392,632	1742611 MH	37,821,446	7,829,457	200,043,535
24 .	ELECTRIC PLANT EQUIPMENT	28,722,302	1275200 MH	26,519,519	13,321,173	68,562,994
25 .	MISCELLANEOUS PLANT EQUIPT	14,996,426	793659 MH	17,319,601	5,088,529	37,404,556
26 .	MAIN COND HEAT REJECT SYS	29,777,316	486845 MH	10,049,335	2,832,953	42,659,604
	TOTAL DIRECT COSTS	453,368,778	11334051 MH	235,137,430	111,955,641	800,461,849
91 .	CONSTRUCTION SERVICES	53,482,210	3835740 MH	80,550,500	56,874,430	190,907,140
92 .	HOME OFFICE ENGRG.&SERVICE	187,222,500				187,222,500
93 .	FIELD OFFICE ENGRG&SERVICE	74,839,090	402450 MH	8,451,500	10,315,910	93,606,500
	TOTAL INDIRECT COSTS	315,543,800	4238190 MH	89,002,000	67,190,340	471,736,140
	TOTAL BASE COST	768,912,578	15572241 MH	324,139,430	179,145,981	1,272,197,989

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COST BASIS
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UNITED ENGINEERS & CONSTRUCTORS INC.
EEDB-VII BASE COSTS (BEST EXPERIENCE BASIS)
1139 MWE PRESSURIZED WATER REACTOR

SUMMARY PAGE 2

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ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*****	*****	*****	*****	*****	*****	*****
211.	YARDWORK	225,000	670229 MH	11,701,359	9,624,424	21,550,783
212.	REACTOR CONTAINMENT BLDG	2,513,396	1745110 MH	35,800,145	22,220,796	60,534,337
213.	TURBINE ROOM + HEATER BAY	535,398	475308 MH	9,807,864	10,641,201	20,984,463
214.	SECURITY BUILDING	50,000	34307 MH	701,774	376,383	1,128,157
215.	PRIM AUX BLDG + TUNNELS	2,814,970	418878 MH	8,345,695	4,196,569	15,357,234
216.	WASTE PROCESS BUILDING	580,804	389982 MH	7,656,841	4,238,429	12,476,074
217.	FUEL STORAGE BLDG	935,231	170435 MH	3,393,289	3,089,222	7,417,742
218A.	CONTROL RM/D-G BUILDING	1,361,690	462759 MH	9,304,696	4,843,795	15,510,181
218B.	ADMINISTRATION+SERVICE BLG	823,413	144927 MH	2,935,637	2,199,682	5,958,732
218D.	FIRE PUMP HOUSE,INC FNDTNS	37,887	10118 MH	204,034	134,029	375,950
218E.	EMERGENCY FEED PUMP BLDG	21,359	72860 MH	1,437,491	701,969	2,160,819
218F.	MANWAY TUNNELS (RCA TUNLS)		24462 MH	477,271	222,889	700,160
218G.	ELEC. TUNNELS	9,264	1728 MH	36,855	14,802	60,921
218H.	NON-ESSEN. SWGR BLDG.	20,904	13667 MH	276,087	221,738	518,729
218J.	MN STEAM + FW PIPE ENC.	31,611	228782 MH	4,603,780	2,313,432	6,948,823
218K.	PIPE TUNNELS		12694 MH	243,248	106,796	350,044
218L.	TECHNICAL SUPPORT CENTER	50,000	18022 MH	349,267	191,738	591,005
218P.	CONTAIN EQ HATCH MSLE SHLD		7640 MH	146,225	48,587	194,812
218S.	WASTE WATER TREATMENT	8,000	20892 MH	400,838	255,447	664,285
218T.	ULTIMATE HEAT SINK STRUCT	41,093	188222 MH	3,607,107	1,631,316	5,279,516
218V.	CONTR RM EMG AIR INTK STR		3220 MH	59,996	26,557	86,553
21 .	STRUCTURES + IMPROVEMENTS	10,060,020	5114242 MH	101,489,499	67,299,801	178,849,320

PLANT CODE 184		COST BASIS 01/84		UNITED ENGINEERS & CONSTRUCTORS INC. EEDB-VII BASE COSTS (BEST EXPERIENCE BASIS) 1139 MWE PRESSURIZED WATER REACTOR			SUMMARY PAGE 3 12/07/84
ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS	
*****	*****	*****	*****	*****	*****	*****	
220A.	NUCLEAR STEAM SUPPLY(NSSS)	164,000,000				164,000,000	
220B.	NSSS OPTIONS						
221.	REACTOR EQUIPMENT	770,964	162200 MH	3,524,471	5,852,448	10,147,883	
222.	MAIN HEAT XFER XPORT SYS.	2,706,150	249446 MH	5,499,426	579,169	8,784,745	
223.	SAFEGUARDS SYSTEM	6,364,262	189585 MH	4,184,323	642,279	11,190,864	
224.	RADWASTE PROCESSING	10,612,482	176049 MH	3,870,440	748,527	15,231,449	
225.	FUEL HANDLING + STORAGE	2,106,345	35301 MH	783,207	98,836	2,988,388	
226.	OTHER REACTOR PLANT EQUIP	16,482,833	612813 MH	13,504,106	4,063,232	34,050,171	
227.	RX INSTRUMENTATION+CONTROL	12,377,046	319600 MH	6,652,542	502,412	19,532,000	
228.	REACTOR PLANT MISC ITEMS		176500 MH	3,919,515	3,096,825	7,016,340	
22 .	REACTOR PLANT EQUIPMENT	215,420,082	1921494 MH	41,938,030	15,583,728	272,941,840	
231.	TURBINE GENERATOR	112,389,700	326745 MH	7,021,534	1,298,011	120,709,245	
233.	CONDENSING SYSTEMS	15,199,121	333818 MH	7,309,764	1,126,600	23,635,485	
234.	FEED HEATING SYSTEM	14,590,339	292374 MH	6,448,795	642,664	21,681,798	
235.	OTHER TURBINE PLANT EQUIP.	10,480,314	401074 MH	8,831,428	1,089,649	20,401,391	
236.	INSTRUMENTATION + CONTROL	1,733,158	190600 MH	3,964,805	340,733	6,038,696	
237.	TURBINE PLANT MISC ITEMS		198000 MH	4,245,120	3,331,800	7,576,920	
23 .	TURBINE PLANT EQUIPMENT	154,392,632	1742611 MH	37,821,446	7,829,457	200,043,535	

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EEDB-VII BASE COSTS (BEST EXPERIENCE BASIS)
1139 MWE PRESSURIZED WATER REACTOR

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ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*****	*****	*****	*****	*****	*****	*****
241.	SWITCHGEAR	10,033,856	24220 MH	505,527	52,034	10,591,417
242.	STATION SERVICE EQUIPMENT	15,732,270	89402 MH	1,866,595	285,930	17,884,795
243.	SWITCHBOARDS	1,382,728	14690 MH	306,650	122,946	1,812,324
244.	PROTECTIVE EQUIPMENT		102650 MH	2,144,341	1,648,138	3,792,479
245.	ELECT.STRUC +WIRING CONTNR		662790 MH	13,728,042	3,468,326	17,196,368
246.	POWER & CONTROL WIRING	1,573,448	381448 MH	7,968,364	7,743,799	17,285,611
24 .	ELECTRIC PLANT EQUIPMENT	28,722,302	1275200 MH	26,519,519	13,321,173	68,562,994
251.	TRANSPORTATION & LIFT EQPT	3,003,980	38900 MH	855,729	456,976	4,316,685
252.	AIR,WATER+STEAM SERVICE SY	7,308,210	498399 MH	10,977,957	4,031,168	22,317,335
253.	COMMUNICATIONS EQUIPMENT	1,948,800	159500 MH	3,331,923	547,298	5,828,021
254.	FURNISHINGS + FIXTURES	2,035,436	21860 MH	449,084	53,087	2,537,607
255.	WASTE WATER TREATMENT EQ	700,000	75000 MH	1,704,908		2,404,908
25 .	MISCELLANEOUS PLANT EQUIPT	14,996,426	793659 MH	17,319,601	5,088,529	37,404,556
261.	STRUCTURES	256,867	95344 MH	1,861,783	1,161,139	3,279,789
262.	MECHANICAL EQUIPMENT	29,520,449	391501 MH	8,187,552	1,671,814	39,379,815
26 .	MAIN COND HEAT REJECT SYS	29,777,316	486845 MH	10,049,335	2,832,953	42,659,604
	TOTAL DIRECT COSTS	453,368,778	11334051 MH	235,137,430	111,955,641	800,461,849

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UNITED ENGINEERS & CONSTRUCTORS INC.
EEDB-VII BASE COSTS (BEST EXPERIENCE BASIS)
1139 MWE PRESSURIZED WATER REACTOR

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ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*****	*****	*****	*****	*****	*****	*****
911.	TEMPORARY CONSTRUCTION FAC		3506410 MH	73,634,610	17,569,380	91,203,990
912.	CONSTRUCTION TOOLS & EQUIP		329330 MH	6,915,890	38,034,140	44,950,030
913.	PAYROLL INSURANCE & TAXES	53,482,210				53,482,210
914.	PERMITS,INS. & LOCAL TAXES				1,270,910	1,270,910
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	53,482,210	3835740 MH	80,550,500	56,874,430	190,907,140
921.	HOME OFFICE SERVICES	176,775,490				176,775,490
922.	HOME OFFICE Q/A	6,346,840				6,346,840
923.	HOME OFFICE CONSTRCTN MGMT	4,100,170				4,100,170
92 .	HOME OFFICE ENGRG.&SERVICE	187,222,500				187,222,500
931.	FIELD OFFICE EXPENSES		25910 MH	544,090	10,315,910	10,860,000
932.	FIELD JOB SUPERVISION	60,447,540	285870 MH	6,003,330		66,450,870
933.	FIELD QA/QC	5,051,640	90670 MH	1,904,080		6,955,720
934.	PLANT STARTUP & TEST	9,339,910				9,339,910
93 .	FIELD OFFICE ENGRG&SERVICE	74,839,090	402450 MH	8,451,500	10,315,910	93,606,500
	TOTAL INDIRECT COSTS	315,543,800	4238190 MH	89,002,000	67,190,340	471,736,140
	TOTAL BASE COST	768,912,578	15572241 MH	324,139,430	179,145,981	1,272,197,989

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TABLE 5-5

ENERGY ECONOMIC DATA BASE - PHASE VII UPDATE

486 MWe HIGH SULFUR COAL FPGS

CAPITAL COST ESTIMATE

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

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ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*****	*****	*****	*****	*****	*****	*****
21 .	STRUCTURES + IMPROVEMENTS	2,446,841	1344038 MH	25,949,618	36,745,372	65,141,831
22 .	BOILER PLANT EQUIPMENT	142,238,906	2306544 MH	50,205,519	14,956,727	207,401,152
23 .	TURBINE PLANT EQUIPMENT	65,084,970	791793 MH	17,143,795	4,314,736	86,543,501
24 .	ELECTRIC PLANT EQUIPMENT	12,531,896	677389 MH	14,077,168	9,001,099	35,610,163
25 .	MISCELLANEOUS PLANT EQUIPT	8,482,657	484475 MH	10,695,206	1,963,622	21,141,485
26 .	MAIN COND HEAT REJECT SYS	10,581,512	227665 MH	4,692,271	2,084,467	17,358,250
	TOTAL DIRECT COSTS	241,366,782	5831904 MH	122,763,577	69,066,023	433,196,382
91 .	CONSTRUCTION SERVICES	23,056,160	808130 MH	16,970,750	19,123,830	59,150,740
92 .	HOME OFFICE ENGRG.&SERVICE	25,905,000				25,905,000
93 .	FIELD OFFICE ENGRG&SERVICE	17,031,690			1,303,330	18,335,020
	TOTAL INDIRECT COSTS	65,992,850	808130 MH	16,970,750	20,427,160	103,390,760
	TOTAL BASE COST	307,359,632	6640034 MH	139,734,327	89,493,183	536,587,142

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ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*****	*****	*****	*****	*****	*****	*****
211.	YARDWORK	50,000	277685 MH	4,706,322	4,572,539	9,328,861
212.	STEAM GENERATOR BUILDING	754,347	357337 MH	7,334,434	14,125,251	22,214,032
213.	TURBINE,HEATER,CONTROL BLD	469,926	255138 MH	5,224,925	8,428,461	14,123,312
218B.	ADMINISTRATION+SERVICE BLD	460,112	64536 MH	1,334,197	1,359,766	3,154,075
218I.	ELECTRICAL SWITCHGR BLDGS	11,896	2081 MH	42,117	17,425	71,438
218L.	STACK/RECLAIM TRANSFR TWR	5,606	9123 MH	188,496	242,204	436,306
218M.	COAL CAR THAW SHED		6164 MH	117,881	49,714	167,595
218N.	ROTARY CAR DUMP BLDG+TUNNL	5,718	22426 MH	425,943	269,159	700,820
218O.	COAL BREAKER HOUSE	99,149	20837 MH	431,545	609,141	1,139,835
218P.	COAL CRUSHER HOUSE	120,200	13378 MH	278,971	318,804	717,975
218Q.	BOILER HOUSE TRANSFR TOWER	2,367	5256 MH	111,800	163,291	277,458
218R.	DEAD STRG TRANSFER TUNNEL		18685 MH	359,814	190,802	550,616
218S.	WASTE WATER TREATMENT BLDG	14,000	28516 MH	548,709	438,317	1,001,026
218T.	LOCOMOTIVE REPAIR GARAGE	18,984	8935 MH	184,837	221,181	425,002
218U.	MATERIAL HANDL+SERVICE BLD	22,536	9457 MH	189,558	211,773	423,867
218W.	MISC COAL HANDLING STRUCT	272,000	130374 MH	2,300,425	1,866,553	4,438,978
219.	STACK STRUCTURE	140,000	114110 MH	2,169,644	3,660,991	5,970,635
21 .	STRUCTURES + IMPROVEMENTS	2,446,841	1344038 MH	25,949,618	36,745,372	65,141,831

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ENERGY ECONOMIC DATA BASE (EEDB) PHASE VII
486 MWE HIGH SULFUR COAL

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ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*****	*****	*****	*****	*****	*****	*****
220A.	FOSSIL STEAM SUPPLY SYSTEM	52,600,000	550000 MH	11,962,500	1,196,250	65,758,750
221.	STEAM GENERATING SYSTEM	1,029,003	16896 MH	374,357	42,419	1,445,779
222.	DRAFT SYSTEM	7,322,026	166608 MH	3,653,456	2,028,416	13,003,898
223.	ASH + DUST HANDLING SYSTEM	5,114,340	112297 MH	2,465,724	282,765	7,862,829
224.	FUEL HANDLING SYSTEMS	18,962,809	216967 MH	4,770,518	873,486	24,606,813
225.	FLUE GAS DESULFUR STRUCT	2,313,408	258823 MH	5,251,987	6,451,566	14,016,961
226.	DESULFURIZATION EQUIPMENT	50,314,766	839770 MH	18,808,498	2,637,350	71,760,614
227.	INSTRUMENTATION + CONTROL	4,333,581	77758 MH	1,617,507	114,844	6,065,932
228.	BOILER PLANT MISC ITEMS	248,973	67425 MH	1,300,972	1,329,631	2,879,576
22 .	BOILER PLANT EQUIPMENT	142,238,906	2306544 MH	50,205,519	14,956,727	207,401,152
231.	TURBINE GENERATOR	43,065,538	204784 MH	4,357,995	1,114,853	48,538,386
233.	CONDENSING SYSTEMS	5,789,599	77394 MH	1,692,301	402,309	7,884,209
234.	FEED HEATING SYSTEM	7,649,399	134163 MH	2,962,652	298,348	10,910,399
235.	OTHER TURBINE PLANT EQUIP.	8,445,827	309316 MH	6,822,212	786,760	16,054,799
236.	INSTRUMENTATION + CONTROL	134,607	692 MH	14,382	719	149,708
237.	TURBINE PLANT MISC ITEMS		65444 MH	1,294,253	1,711,747	3,006,000
23 .	TURBINE PLANT EQUIPMENT	65,084,970	791793 MH	17,143,795	4,314,736	86,543,501

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

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ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*****	*****	*****	*****	*****	*****	*****
241.	SWITCHGEAR	6,610,861	16210 MH	338,344	33,835	6,983,040
242.	STATION SERVICE EQUIPMENT	4,554,591	28552 MH	585,522	135,645	5,275,758
243.	SWITCHBOARDS	769,919	8830 MH	184,323	94,135	1,048,377
244.	PROTECTIVE EQUIPMENT		81030 MH	1,698,781	1,264,920	2,963,701
245.	ELECT.STRUC +WIRING CONTNR		364470 MH	7,545,610	2,628,750	10,174,360
246.	POWER & CONTROL WIRING	596,525	178297 MH	3,724,588	4,843,814	9,164,927
24 .	ELECTRIC PLANT EQUIPMENT	12,531,896	677389 MH	14,077,168	9,001,099	35,610,163
251.	TRANSPORTATION & LIFT EQPT	1,906,397	7610 MH	165,980	97,799	2,170,176
252.	AIR,WATER+STEAM SERVICE SY	4,448,643	278149 MH	6,133,834	1,229,656	11,812,133
253.	COMMUNICATIONS EQUIPMENT	191,260	48500 MH	1,013,155	268,802	1,473,217
254.	FURNISHINGS + FIXTURES	827,368	10130 MH	207,838	30,358	1,065,564
255.	WASTE WATER TREATMENT EQPT	1,108,989	140086 MH	3,174,399	337,007	4,620,395
25 .	MISCELLANEOUS PLANT EQUIPT	8,482,657	484475 MH	10,695,206	1,963,622	21,141,485
261.	STRUCTURES	143,370	81315 MH	1,592,676	1,309,061	3,045,107
262.	MECHANICAL EQUIPMENT	10,438,142	146350 MH	3,099,595	775,406	14,313,143
26 .	MAIN COND HEAT REJECT SYS	10,581,512	227665 MH	4,692,271	2,084,467	17,358,250
	TOTAL DIRECT COSTS	241,366,782	5831904 MH	122,763,577	69,066,023	433,196,382

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

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ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*****	*****	*****	*****	*****	*****	*****
911.	TEMPORARY CONSTRUCTION FAC		686990 MH	14,426,800	6,005,100	20,431,900
912.	CONSTRUCTION TOOLS & EQUIP		121140 MH	2,543,950	12,582,680	15,126,630
913.	PAYROLL INSURANCE & TAXES	23,056,160				23,056,160
914.	PERMITS,INS. & LOCAL TAXES				536,050	536,050
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	23,056,160	808130 MH	16,970,750	19,123,830	59,150,740
921.	HOME OFFICE SERVICES	23,809,280				23,809,280
922.	HOME OFFICE Q/A					
923.	HOME OFFICE CONSTRCTN MGMT	2,095,720				2,095,720
92 .	HOME OFFICE ENGRG.&SERVICE	25,905,000				25,905,000
931.	FIELD OFFICE EXPENSES				1,303,330	1,303,330
932.	FIELD JOB SUPERVISION	15,916,110				15,916,110
933.	FIELD QA/QC	436,020				436,020
934.	PLANT STARTUP & TEST	679,560				679,560
93 .	FIELD OFFICE ENGRG&SERVICE	17,031,690			1,303,330	18,335,020
	TOTAL INDIRECT COSTS	65,992,850	808130 MH	16,970,750	20,427,160	103,390,760
	TOTAL BASE COST	307,359,632	6640034 MH	139,734,327	89,493,183	536,587,142

TABLE 5-6

ENERGY ECONOMIC DATA BASE
 PHASE VII UPDATE
 PHASE VI TO PHASE VII UPDATE BASE CONSTRUCTION COST INCREASES FOR THE
 PRESSURIZED WATER REACTOR NUCLEAR POWER GENERATING STATION (PWR•ME)
 MEDIAN EXPERIENCE

<u>Commodity/Equipment/Service</u>	<u>Installed Costs (\$1984 x 10⁶)(a)</u>			<u>Delta as a % of Phase VI</u>
	<u>Phase VI (1983)</u>	<u>Phase VII (1984)</u>	<u>Delta</u>	
NSSS + T/G(b)	270	288	18	7
Mechanical (w/o NSSS + T/G)	<u>355</u>	<u>355</u>	<u>0</u>	0
<u>Sub-Total Mechanical</u>	625	643	18	3
Structural	267	273	6	2
Electrical/I&C	<u>145</u>	<u>145</u>	<u>0</u>	0
<u>Total Direct Costs (TDC)</u>	1037	1061	24	2
Construction Services	347	353	6	2
Eng. and Home Office Services	339	343	4	1
Field Office Services	<u>376</u>	<u>373</u>	<u>(3)</u>	(*)
<u>Total Indirect Costs (TIC)</u>	<u>1062</u>	<u>1069</u>	<u>7</u>	*
TOTAL BASE CONSTRUCTION COSTS (TDC + TIC)	2099	2130	31	1

(a) Data in Constant \$1984

(b) Nuclear Steam Supply System plus Turbine-Generator Unit

* Less than One Percent

TABLE 5-7

ENERGY ECONOMIC DATA BASE
 PHASE VII UPDATE
 PHASE VI TO PHASE VII UPDATE BASE CONSTRUCTION COST INCREASES FOR THE
 PRESSURIZED WATER REACTOR NUCLEAR POWER GENERATING STATION (PWR•BE)
 BEST EXPERIENCE

<u>Commodity/Equipment/Service</u>	<u>Installed Costs (\$1984 x 10⁶)(a)</u>			<u>Delta as a % of Phase VI</u>
	<u>Phase VI (1983)</u>	<u>Phase VII (1984)</u>	<u>Delta</u>	
NSSS + T/G(b)	267	285	18	7
Mechanical (w/o NSSS + T/G)	<u>239</u>	<u>230</u>	<u>(9)</u>	(4)
<u>Sub-Total Mechanical</u>	506	515	9	2
Structural	174	178	4	2
Electrical/I&C	<u>110</u>	<u>107</u>	<u>(3)</u>	(3)
<u>Total Direct Costs (TDC)</u>	790	800	10	1
Construction Services	213	191	(22)	(10)
Eng. and Home Office Services	184	187	3	2
Field Office Services	<u>102</u>	<u>94</u>	<u>(8)</u>	(8)
<u>Total Indirect Costs (TIC)</u>	<u>499</u>	<u>472</u>	<u>(27)</u>	(5)
TOTAL BASE CONSTRUCTION COSTS (TDC + TIC)	1289	1272	(17)	(1)

(a) Data in Constant \$1984

(b) Nuclear Steam Supply System plus Turbine-Generator Unit

TABLE 5-8

ENERGY ECONOMIC DATA BASE
 PHASE VII UPDATE
 PHASE VI TO PHASE VII UPDATE BASE CONSTRUCTION COST INCREASES FOR THE
 486 MWe HIGH SULFUR COAL-FIRED POWER GENERATING STATION (HS5)

<u>Commodity/Equipment/Service</u>	<u>Installed Costs (\$1984 x 10⁶)(a)</u>			<u>Delta as a % of Phase VI</u>
	<u>Phase VI (1983)</u>	<u>Phase VII (1984)</u>	<u>Delta</u>	
FGD System(b)	55	55	0	0
FSSS + T/G(c)	113	114	1	1
Other Mechanical	<u>127</u>	<u>133</u>	<u>6</u>	5
<u>Sub-Total Mechanical</u>	295	302	7	2
Structural	80	83	3	4
Electrical/I&C	<u>48</u>	<u>48</u>	<u>0</u>	0
<u>Total Direct Costs (TDC)</u>	423	433	10	2
Construction Services	63	59	(4)	(6)
Eng. and Home Office Services	22	26	4	18
Field Office Services	<u>19</u>	<u>18</u>	<u>(1)</u>	(5)
<u>Total Indirect Costs (TIC)</u>	<u>104</u>	<u>103</u>	<u>(1)</u>	(1)
TOTAL BASE CONSTRUCTION COSTS (TDC + TIC)	527	536	9	2

(a) Data in Constant \$1984

(b) Flue Gas Desulfurization System: Does Not Include Commodities for Structures, Equipment Foundations, Piping, HVAC, I&C or Electrical Equipment

(c) Fossil Steam Supply System plus Turbine-Generator Unit

TABLE 5-9

Effective Date 1/1/84

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATECOMPARISON OF THE PWR•ME, PWR•BE, AND HS5
FACTORY EQUIPMENT PLUS SITE MATERIAL COSTS

		January 1, 1984 Constant Dollars					
		PWR•ME(a)		PWR•BE(a)		HS5(b)	
		\$ x 10 ⁶	\$/kWe	\$ x 10 ⁶	\$/kWe	\$ x 10 ⁶	\$/kWe
NSSS or FSSS:		171	150	171	150	54	111
SO ₂ Removal System:(c)		-	-	-	-	42	86
T/G Unit:		111	97	111	97	43	88
Mechanical:	Coal & Ash Handling	-	-	-	-	24	50
	Electrostatic Precipitators	-	-	-	-	5	12
	Other Equipment	28	25	26	23	15	30
	Cooling Towers	22	19	22	19	7	14
	Condensers/Heat Exchangers	16	14	16	14	6	12
	Pumps	11	10	11	10	5	10
	Special Process Equipment	6	5	6	5	1	2
	Water Treatment	3	3	3	3	1	2
	Sub-Total - Mechanical	86	76	84	74	64	132
Piping:	Pipe	59	52	41	36	23	48
	Valves	12	11	12	11	3	6
	Supports/Specialties	8	7	6	5	3	6
	Sub-Total - Piping	79	70	59	52	29	60
Electrical/I&C:	Equipment	33	29	31	27	15	31
	I&C	20	18	19	17	6	12
	Wire/Cable	13	11	11	10	6	12
	Raceway	5	4	3	3	2	5
	Sub-Total - E/I&C	71	62	64	57	29	60
Structural Support:	Structural Steel	21	18	14	12	25	52
	Reinforcing Steel	20	18	14	12	3	6
	Concrete/Embedded Steel	21	18	16	14	5	10
	Formwork	6	5	3	3	3	6
	Sub-Total - Struc. Support	68	59	47	41	36	74
Structural (Other):		33	29	29	25	14	29
Construction Serv:(d)	Major Equipment	39	35	26	23	8	17
	Temp. Bldgs./Facilities	31	27	18	16	6	12
	Field Office Expense	17	15	10	9	1	2
	Small Tools	10	9	5	4	2	4
	Expendable Supplies/Safety	16	14	7	6	2	4
	Sub-Total - Const. Serv.	113	100	66	58	19	39
TOTAL EQUIPMENT PLUS MATERIAL COSTS		732	643	631	554	330	679

(a) 1139 MWe (b) 486 MWe (d) Indirect Costs

(c) Includes lime handling, slurry preparation, SO₂ absorption, waste slurry thickening, waste stabilization, and miscellaneous equipment; does not include commodities for structures or building and equipment foundations, piping, HVAC, I&C or electrical equipment.

Effective Date 1/1/84

TABLE 5-10

ENERGY ECONOMIC DATA BASE
PHASE VII UPDATECOMPARISON OF THE PWR•ME, PWR•BE, AND HS5
LABOR COSTS

		January 1, 1984 Constant Dollars					
		PWR•ME(a)		PWR•BE(a)		HS5(b)	
		\$ x 10 ⁶	\$/kWe	\$ x 10 ⁶	\$/kWe	\$ x 10 ⁶	\$/kWe
Craft Labor:	Structural - Concrete Work	110	97	64	56	12	25
	- Other	63	55	38	33	21	43
	Sub-Total - Structural	173	152	102	89	33	68
	Mechanical - Piping	146	128	54	48	21	43
	- FGD/Coal/Ash	-	-	-	-	19	39
	- Other	50	44	36	32	31	64
	Sub-Total - Mechanical	196	172	90	80	71	146
	Electrical/I&C - Cable	18	15	8	7	4	8
	- Raceway	28	25	13	11	7	14
	- Other	28	25	22	20	8	17
	Sub-Total - Electrical/I&C	74	65	43	38	19	39
	Construction Services(c)	172	151	89	78	17	34
	Sub-Total - Craft Labor	615	540	324	285	140	287
Salaries:(c)	Engineering	132	116	71	63	9	18
	Field Job Supervision	175	154	34	30	9	18
	Other	25	22	12	10	2	5
	Sub-Total - Salaries	332	292	117	103	20	41
Expenses:(c)(d)	Engineering	195	171	106	93	14	29
	Field Job Supervision	128	112	26	23	7	14
	Other	25	22	13	11	2	5
	Sub-Total - Expenses	348	305	145	127	23	48
Insurance/Taxes:(c)	Sub-Total - Insurance/Taxes	103	90	55	48	23	48
TOTAL LABOR COSTS		1398	1227	641	563	206	424
TOTAL EQUIPMENT PLUS MATERIAL COSTS (FROM TABLE 5-9)		732	643	631	554	330	679
TOTAL BASE CONSTRUCTION COSTS		2130	1870	1272	1117	536	1103

(a) 1139 MWe (b) 486 MWe (c) Indirect costs

(d) Includes payroll expenses, overhead loading, fees, outside consultants, and relocation and other expenses.

SECTION 6

6.0 REPLACEMENT OF THE EEDB LMFBR WITH AN LMR BASED ON THE EPRI/CoMO LSPB

6.1 INTRODUCTION

During the Phase VII Update, the LMFBR technical/cost data model was replaced by a Large Scale Prototype Breeder Reactor Nuclear Power Plant (LSPB) technical/cost data model. This substitution was in response to the designation of the LSPB as the base liquid metal reactor (LMR) concept by the U.S. Department of Energy.

The design and related costs for a base and replica plant LSPB were recently developed by the Electric Power Research Institute/Consolidated Management Office for the Liquid Metal Fast Breeder Reactor (EPRI/CoMO). Adjustments were made to the CoMO LSPB designs and costs to develop an LSPB technical/cost data model that approached complete compatibility with EEDB ground rules and assumptions. For the Phase VII Update, the EEDB LSPB entered the data base at the three-digit code-of-accounts level of detail.

Consistency with EEDB ground rules and assumptions was a major goal for incorporation of the LSPB into the data base. Because of a limitation on resources allocated for this activity and a lack of necessary detail in some of the CoMO LSPB data, complete consistency could not be achieved during the Phase VII Update. It is expected that expansion of the EEDB LSPB to a greater level of detail in future updates will fully achieve this goal.

The major inconsistency lies in the fact that the CoMO LSPB used as a basis for the EEDB LSPB was a "replicate" or second-of-a-kind, development type concept. Technical/cost data models in the EEDB are developed as nth-of-a-kind, commercial type facilities. They are characterized, for example, by nuclear steam supply system components that have technical and cost features representative of the 25th to 100th item manufactured. Consequently, component/equipment costs for the nth-of-a-kind data models tend to be lower than those of a second-of-a-kind data model because the designs are based on more mature application and manufacturing experience.

The following sections discuss the technical and cost features of the EEDB LSPB and its technical/cost differences with the CoMO LSPB that are caused by conforming to the EEDB Program ground rules and assumptions.

6.2 THE EEDB LSPB TECHNICAL FEATURES

6.2.1 Technical Design Basis

The EEDB LSPB technical data model was based on the technical design of the CoMO LSPB as represented in the system design descriptions and engineering drawings contained in CDS 400-8, 9/84, Rev. 4: "LSPB Large Scale Prototype Breeder Design Description" - Volumes 1, 2 and 3, and the documents listed in Table 6-1. A tabulation of key technical parameters for the EEDB LSPB is given in Table 2-1.

An initial review of the CoMO LSPB design was conducted in order to identify those modifications necessary for its incorporation into the EEDB. The CoMO LSPB loop design was developed and documented with particular emphasis on those technologies and features specific to the liquid metal fast breeder reactor. Details of some common design features, in areas of long established power plant practice, were not covered in the LSPB design to a level of detail consistent with EEDB Program practice. Consequently, it was necessary to provide additional details of auxiliary buildings and equipment beyond that contained in the CoMO LSPB design. Where this was necessary, the additional details were made consistent with accepted power plant practice.

In addition, the CoMO LSPB design was not optimized for conditions at the EEDB Program hypothetical "Middletown" site, or for other program ground rules. In order to assure compatibility with the Middletown site and comparability with other EEDB technical and cost data models, some minor revisions to the CoMO LSPB design were necessary. In this regard, the most visible change was the addition of a third cooling tower to accommodate the higher design wet bulb temperature of the Middletown site. It should be noted that although this may not be the most cost effective way of accommodating this site condition, it accomplished EEDB comparability within the limitations of available resources, while having a negligible impact on EEDB-LSPB base construction cost and power output. It is expected that this design will be optimized in future updates.

These additional details and modifications were reflected in the preparation of a set of EEDB LSPB system design descriptions and a site plan which were included in the Phase VII Technical Reference Book⁹. The specific technical changes are listed and described in Section 6.2.4.

Since the Phase VII EEDB LSPB was developed at the three-digit code-of-accounts level, detailed commodity/manhour summaries are not available. For comparison purposes, however, Table 6-2 includes a summary of significant quantities for the CoMO LSPB. It should be noted that Table 6-2 and Table 4-2 should only be compared with consideration of the limitations discussed above.

6.2.2 EPRI/CoMO LSPB Technical Design Features

A number of interesting design features were incorporated in the CoMO LSPB power plant design. These design features have been retained without change in the EEDB LSPB technical data model. Features of particular interest are described below.

Major safety related and sodium bearing components and equipment are housed in a Seismic Category I, reinforced concrete nuclear island structure. The nuclear island is composed of a control building, a reactor service building, four steam generator buildings and three auxiliary buildings arranged around a rectangular containment structure. These buildings are integrated and founded on a common nuclear island base mat located at grade. An enclosed Seismic Category I steel frame confinement structure is located atop the concrete nuclear island structure. The confinement structure, together with

the buildings surrounding the rectangular containment structure and a negative pressure ventilating system provide complete confinement for the reactor containment.

The loop type primary reactor system is configured to provide close coupling of major components, thereby minimizing lengths of primary and intermediate sodium piping. Guard vessels are eliminated for the intermediate heat exchangers and primary sodium circulation pumps through incorporation of siphon breakers. Check valves in each primary sodium loop mitigate thermal transients on primary heat transport system loop components/piping resulting from the large reverse flows that follow an individual pump failure. They also provide the capability to operate the reactor with one loop out of service.

A redundant, passive, decay heat removal system is provided that is separate and independent from the primary and intermediate loops. The steam generators are Benson cycle type and are designed as non-nuclear safety (NNS) class. Radwaste facilities are minimized by providing for outside contractors to periodically process and dispose of solid and intermediate level liquid radioactive wastes. Gas-turbine-generators are utilized as on-site standby (safety-related) and emergency (non-safety related) power supplies. On-site sodium storage is accomplished in underground storage facilities.

Distributed multiplexing and fiber optics are utilized to minimize quantities of instrumentation and control wiring and raceways. Some of the temporary construction facilities are designed to be utilized as permanent structures after their construction purpose is fulfilled.

6.2.3 Quantities of Craft Manhours

Significant differences may be noted between the commodity/equipment installation (craft) manhours developed for the EEDB LSPB and those reported for the CoMO LSPB. Craft manhours are a function of the quantities of commodities and equipment to be installed and the unit installation rates (e.g., manhours per cubic yard of concrete) for those commodities or equipment. The EEDB LSPB craft manhours were based on CoMO LSPB quantities of commodities/equipment and EEDB Program unit installation rates. The use of the CoMO LSPB quantities preserved the integrity of the CoMO design, while the use of the EEDB installation rates assured craft manhour consistency with other EEDB data models.

Although the CoMO LSPB commodity/equipment quantities were available, associated unit installation rates were not provided. A comparison of the EEDB LSPB and CoMO LSPB craft manhours indicated that the EEDB direct labor was on the order of three-fourths as productive as that used for the CoMO LSPB. Nevertheless, the EEDB unit installation rates were compatible with those used for the EEDB PWR•BE data model when it was updated for the Phase VII Update.

6.2.4 Detailed Technical Modifications

The EEDB Technical Reference Book⁹, prepared for the Phase VII Update, contains

the base data for the EEDB LSPB technical data model. The base data are in the form of assumptions, ground rules, design criteria, system design descriptions and an overall site plan. This section describes the specific modifications made to the CoMO LSPB technical design during the development of the EEDB LSPB technical data model.

EEDB Data Model Number B3, Type LSPB, EEDB Phase VII (1984) Update

The EEDB LSPB is a new technical data model that replaces the EEDB LMFBR. During the Phase VII Update, this data model was developed to the three-digit code-of-accounts level of detail.

The EEDB LSPB data model is based on the LSPB developed for DOE by EPRI/CoMO. Some of the CoMO LSPB design features have been modified in the EEDB LSPB to obtain conformance with the EEDB Program assumptions and ground rules. The discussion of these modifications is given below at the three-digit code-of-accounts level of detail. A parenthetical statement is provided at the end of each modification description to indicate the effect of the modification on the base construction costs.

ACCOUNT 211 Yardwork

This account was detailed for the EEDB Middletown site, particularly with respect to rock excavation. (Cost Increase)

ACCOUNT 213 Turbine Room and Heater/Auxiliary Bay

Quantities of commodities were revised, in accordance with EEDB Program ground rules and EPRI/CoMO consultation. (Cost Decrease)

ACCOUNT 218D Fire Pump House Including Foundations For Fire Protection Tanks

ACCOUNT 218K Pipe Tunnels

ACCOUNT 218R Auxiliary Boiler Building

ACCOUNT 218S Waste-Water Treatment Building

Designs, including quantities of commodities and installation manhours, were developed for these structures, based on similar structures in other EEDB technical data models and EEDB Program ground rules. (Cost Increase)

ACCOUNT 233 Condensing System

Quantities of equipment and installation manhours were developed for the condensate polishing system. (Cost Increase)

ACCOUNT 235 Other Turbine Plant Equipment

A neutralization system was added for compatibility with other EEDB data models. (Cost Increase)

ACCOUNT 236 Instrumentation and Control

Quantities of equipment and installation manhours were developed for the turbine plant instrumentation and control to supplement quantities transferred from other accounts. (Cost Increase)

ACCOUNT 241 Switchgear

ACCOUNT 242 Station Service Equipment

ACCOUNT 243 Switchboards

ACCOUNT 244 Protective Equipment

ACCOUNT 246 Power and Control Wiring

ACCOUNT 252 Air, Water and Steam Systems

Designs, including derivation of quantities of commodities and installation manhours, were revised as required for these systems, based on similar systems in other EEDB technical data models and EEDB Program ground rules. (Cost Decrease)

Waste-water treatment equipment was transferred from Account 252 to Account 255. (Cost Decrease)

ACCOUNT 254 Furnishings and Fixtures

Quantities of equipment and installation manhours were developed for this account, based on similar equipment for other EEDB technical data models and EEDB Program ground rules. (Cost Increase)

ACCOUNT 255 Waste-Water Treatment Equipment

Waste-water treatment equipment was transferred to Account 255 from Account 252. (Cost Increase)

Quantities of installation manhours were developed for this equipment, based on similar equipment for other EEDB technical data models and EEDB Program ground rules. (Cost Increase)

ACCOUNT 261 Main Condenser Heat Rejection System - Structures

A make-up water intake structure for withdrawing make-up water from the North River on the Middletown site replaced the well water pump house. (Cost Increase)

Designs, including quantities of commodities and installation manhours, were developed for a make-up water pretreatment building, a circulating water pump house and a cooling tower switchgear building, based on similar structures in

other EEDB technical data models and EEDB Program ground rules. (Cost Increase)

ACCOUNT 262 Main Condenser Heat Rejection System - Mechanical Equipment

A third cooling tower and basin were added to accommodate the higher wet bulb temperature of the Middletown site. (Cost Increase)

Well water equipment was replaced by plant make-up water and cooling tower blowdown equipment in order to utilize the North River on the Middletown site, based on similar equipment for other EEDB technical data models and EEDB Program ground rules. (Cost Decrease)

6.3 THE EEDB LSPB CAPITAL COSTS

6.3.1 Capital Cost Summary

The EEDB LSPB cost data model was based on the EEDB LSPB technical data model, the CoMO LSPB cost estimate given in CDS 400-5 ("Plant Cost Estimate Report" - refer to Table 6-1), and EEDB Program ground rules and assumptions. Capital costs were prepared as base construction costs, as discussed in the first paragraph of Section 5.2 and Table 5-2. Direct, indirect and base construction costs are summarized in Tables 2-3, 2-4 and 2-5.

During the Phase VII Update, two versions of the PWR were updated; the PWR•ME and the PWR•BE. Their corresponding cost estimates were based on median (ME) or best (BE) industry technical and cost experience. In general, the PWR•BE had significantly lower craft labor, engineering and field supervision costs than the PWR•ME. The EEDB LSPB cost data model has been developed to be representative of this best industry experience and, consequently, reflects the PWR•BE labor cost basis.

6.3.2 Detailed Capital Costs

Results of the EEDB LSPB cost estimate are presented in Table 6-3 at the two-digit and three-digit code-of-accounts level of detail. The first sheet of Table 6-3 is a cost and manhours tabulation at the two-digit code-of-accounts (plant account) level of detail. The following three sheets comprise the cost and manhour tabulations at the three-digit code-of-accounts (structure/system account) level of detail.

The CoMO LSPB cost estimate was developed in a work breakdown structure (WBS) format. When this development was completed, the estimate was restructured into an EEDB type code-of-accounts format, as given in Table 6-7 of CDS 400-5. For purposes of comparison, the CoMO LSPB cost estimate in the EEDB code-of-accounts format is repeated in Table 6-4 of this report.

The reader is cautioned that assignment of the WBS costs to the various EEDB accounts by EPRI/CoMO was sometimes done on a different basis than that normally utilized in the EEDB Program. These and other differences are discussed in Section 6.4. It should also be noted that some of the structures

in Table 6-4 have different account numbers than those in the CoMO estimate (CDS 400-5, Table 6-7). The following account cross index relates the EEDB and CoMO LSPB Structures and Improvements accounts.

Structures and Improvements Account Cross-Index

<u>EEDB-VII</u> <u>Table</u> <u>6-4</u>	<u>CoMO</u> <u>Table</u> <u>6-7</u>	<u>EEDB-VII</u> <u>Table</u> <u>6-4</u>	<u>CoMO</u> <u>Table</u> <u>6-7</u>
211	211	218C	219A
212	212	218D	218D
213	213	218E	218E
214	219E	218H	219M
215	215	218K	218K
216	219F	218N	218N
218A	219B	218R	218R
218B	219C	219G	219G

Costs for Accounts 218I and 218T are included in Account 218E in both cases. Accounts 217, 218F, G, J, L, M, O, P, Q, S, U, V, W, X, Y and Z, and all of 219 except 219G are not utilized in Table 6-4.

6.3.3 Engineering and Field Supervision Costs

Engineering and engineering support costs were significantly different in content in the EEDB LSPB and CoMO LSPB cost estimates. In the CoMO LSPB estimate, a large number of engineering/engineering support costs were attributed to reactor manufacturer activities that were related to home office engineering and manufacturer concept development. These costs were either transferred to home office engineering (Account 921) where appropriate, or omitted in accordance with EEDB ground rules and assumptions.

One of the established EEDB Program procedures was that NSSS price rather than cost is included in the cost estimates. The EEDB procedure was based on the assumption that development costs, such as the CoMO LSPB reactor manufacturer development engineering costs, were written off by the concept developer over some period of commercial activity. The extent to which this write-off was to be recovered from each commercial activity was then included in the NSSS price. Two other important reactor manufacturer engineering costs to be considered were the cost of concept modifications for a particular application and the costs of licensing, plant design and construction support. For the EEDB Program, the assumption was made that these costs were also included in the NSSS price.

Consequently, each of these three engineering costs were reflected in the NSSS factory equipment price on a proportional basis (Account 220A-Factory Equipment) rather than as engineering costs (Account 921-Factory Equipment). A similar situation existed for field supervision costs, except that the EEDB-CoMO differences were much smaller.

6.3.4 Commodity Costs

Significant differences occurred between site material costs developed for the EEDB LSPB and those reported for the CoMO LSPB, particularly in Account 21 (Structures and Improvements). Costs for commodities, such as concrete, piping and wiring, are a function of the quantities of the commodities and the unit costs for these commodities. The EEDB LSPB commodity costs were based on CoMO LSPB quantities of commodities and EEDB Program commodity unit costs. The use of the CoMO LSPB quantities preserved the integrity of the CoMO design, while the use of EEDB unit costs assured consistency with other EEDB data models. Other factors discussed below tended to mask or offset these absolute differences when EEDB and CoMO LSPB site material costs were compared.

6.3.5 EEDB LSPB Cost Account Format

The EEDB LSPB cost estimate in Table 6-3 had one format inconsistency with the PWR and HS5 cost estimates (refer to Tables 5-3 through 5-5) at the two- and three-digit code-of-accounts level of detail. At the three-digit code-of-accounts level of detail, there were two additional format inconsistencies. These inconsistencies were a result of the CoMO accounting methodologies employed for the costs of large/small bore piping, heating, ventilating and air conditioning (HVAC), and lighting and service power (LSP).

In the EEDB Program accounting system, large bore piping (2-1/2 inches and larger) costs were considered a factory equipment cost, while small bore piping (2 inches and smaller) costs were considered a site material cost. Additionally, HVAC and LSP costs were estimated for and included with the building services costs for each building/structure. In the CoMo LSPB estimate, both large and small bore piping were considered as a site material cost, HVAC costs were estimated as a lump sum and included as a miscellaneous plant (Account 25) cost, and LSP costs were included as electric plant (Account 24) costs.

Since insufficient detail was available to separate these costs per the EEDB Program approach, the following three ground rules were utilized for the EEDB LSPB estimate. All piping costs were accepted as site material costs and two separate structural accounts (218X and 218Y) were created for the HVAC and LSP costs respectively. Creation of these two new accounts permitted the costs for HVAC and LSP to be included in the two-digit structures account (Account 21), even though these costs could not be distributed at the three-digit code-of-accounts level.

Because of the first ground rule, EEDB LSPB factory equipment or site material costs, for each two-digit or three-digit account involving large bore piping, were not consistent with factory equipment or site material costs in corresponding accounts of other EEDB Program cost estimates. The degree of inconsistency was related to the quantity of large bore piping in the account of interest. On the other hand, the factory-equipment-plus-site-material costs for each two-digit or three-digit account was totally consistent with the factory-equipment-plus-site-material costs in corresponding accounts in the other EEDB Program cost estimates. Because of the second and third ground

rules, three-digit structural accounts were not consistent with similar accounts in other EEDB Program cost estimates. The two-digit structural account, however, was totally consistent with the two-digit structural accounts in other EEDB Program cost estimates.

6.4 COMPARISON OF THE EEDB LSPB COST ESTIMATE WITH THE EPRI/CoMO LSPB COST ESTIMATE

6.4.1 Base Construction Costs

The estimated base construction costs (BCC) for the EEDB LSPB and CoMO LSPB are summarized from Tables 6-3 and 6-4 in the following table:

	LSPB BCC (\$1984 x 10 ⁶)		
	<u>EEDB(E)</u>	<u>CoMO(C)</u>	<u>E/C</u>
Direct Costs (DC)	1345	1285	1.05
Indirect Costs (IC)	598	710	0.84
Total BCC	1943	1995	0.97
IC/DC	0.44	0.55	--

Note: Costs are based on a second-of-a-kind, pre-commercial unit.

The differences in the total base construction costs were negligible; however, the differences in the distribution of direct and indirect costs bear examination. These differences were primarily attributable to differences in the accounting practices followed by EPRI/CoMo and the EEDB Program, the levels of craft labor productivity utilized and the degree to which reactor manufacturer development engineering costs were included. The following sections discuss these differences in detail. The analysis presented was developed with the knowledge of and in consultation with the EPRI/CoMO team that prepared the CoMO LSPB cost estimate.

6.4.2 Direct Cost Differences

The EEDB LSPB direct costs are 105 percent of those for the CoMO LSPB. Review of Tables 6-3 and 6-4 shows the following percentage differentials between the direct cost accounts in the EEDB LSPB and the CoMO LSPB cost estimates:

<u>Account Number</u>	<u>EEDB LSPB/CoMO LSPB Direct Cost Percentage Differentials</u>				
	<u>Factory Equipment Costs</u>	<u>Site Labor Hours</u>	<u>Site Labor Costs</u>	<u>Site Material Costs</u>	<u>Total Costs</u>
21	213	38	59	(16)	18
22	5	22	9	(10)	5
23	2	50	38	2	6
24	(13)	20	8	1	(4)
25	(19)	(20)	28	(67)	(32)
26	45	(2)	5	(47)	15
2 (Total)	4	26	34	(22)	5

Numbers in parentheses in the table are negative percentages. That is, (13%) is equivalent to an EEDB to CoMO cost ratio of 0.87; similarly, 213% is equivalent to an EEDB to CoMO cost ratio of 3.13.

The differences in the rows (plant accounts) and columns (cost accounts) result from combinations of effects. In particular, row accounts for Structures and Improvements (21), Miscellaneous Plant (25), and Main Condenser Heat Rejection System (26), and column accounts for Site Labor Costs and Site Material Costs show significant differences. Reactor Plant (22), Turbine Plant (23), Electric Plant (24) and Factory Equipment Costs show related but less significant differences.

6.4.2.1 Major Cost Differences

The causes for the three major cost differences in the above table were as follows:

1. The row increases in Account 21 and the row decreases in Accounts 24 and 25 were primarily caused by transferring the HVAC costs from Account 25 and the LSP costs from Account 24 to Account 21, in accordance with EEDB Program ground rules.
2. The column increases in Site Labor Hours were generally caused by the application of the higher EEDB Program installation rates (lower productivity) to the CoMO LSPB commodity/ equipment quantities. The decreases in the Site Labor Hours were caused by the combination of this effect with offsetting effects discussed in Section 6.4.2.2.
3. The column decreases in Site Material Costs were generally caused by deleting subcontract labor costs. In the CoMO LSPB estimate, craft labor was costed on a two-tier basis, one for force account labor and one for subcontract labor. The costs for the subcontract labor were included with the Site Material Costs, while the hours for this labor were recorded under Site Labor Hours. Consequently, the Site Labor Costs to Site Labor Hours ratios in Table 6-4 (apparent labor costs) are lower than the labor rates actually used. For the EEDB Program, the ground rule was followed that all craft labor must be costed on a force account or single tier basis. Therefore, all subcontract craft labor hours and dollars were recorded under Site Labor Hours and Site Labor Costs respectively (refer to Section 5.5.1 - "NSSS or FSSS").

6.4.2.2 Detailed Cost Differences

Detailed discussions of the effect of the major cost differences, the other cost differences, and their combinations are given below at the two-digit code-of-accounts level.

ACCOUNT 21 - Structures and Improvements

Factory Equipment Costs (FEC) were increased by the transfer of HVAC and LSP costs from Accounts 25 and 24 respectively, and other minor adjustments.

Site Labor Hours (SLH) were increased by the HVAC and LSP SLH transfer, by the changes described in Section 6.2.4 and by using the higher EEDB Program installation rates.

Site Labor Costs (SLC) were increased by the increase in SLH; however, this increase was amplified by apparent CoMO LSPB labor rates (Refer to Section 6.4.2.1, paragraph 3) that were lower than those of the EEDB LSPB.

Site Material Costs (SMC) were decreased by removal of subcontract labor costs, and by using the lower EEDB Program commodity unit costs, as discussed in Section 6.3.4; however, this decrease was partly offset by the site material portion of the HVAC cost transfer, and by increased costs from the changes described in Section 6.2.4.

ACCOUNT 22 - Reactor Plant Equipment

FEC were increased by an allowance for reactor manufacturer engineering costs in the NSSS sub-account (220A), as discussed in Section 6.3.3; however, the increase was partly offset by deletion of costs for sodium and spare control rods and drives, in accordance with EEDB Program ground rules (Refer to Table 5-2).

In the EEDB, the amount entered for the NSSS is the price for the entire NSSS scope. The decreases in FEC for sub-accounts 221, 222, 223, 225 and 226 and the increase in FEC for sub-account 220A (NSSS) were caused by the transfer of costs for NSSS scope equipment/components in these accounts to the NSSS FEC account. It is also the EEDB practice to enter labor hours, labor costs and site material costs for these NSSS items under the other reactor plant sub-accounts. For the EEDB LSPB estimate, these manhour and site material costs were redistributed among the appropriate sub-accounts and under the SLH, SLC and SMC columns.

SLH were increased by using the higher EEDB Program installation rates and by making SLH adjustments in accordance with EEDB Program ground rules and EPRI/CoMO recommendations.

SLC were increased by the increase in SLH; however, this increase was partly offset by apparent CoMO LSPB labor rates that were generally higher than those of the EEDB LSPB.

SMC were decreased by removal of subcontract labor costs and by using lower EEDB Program commodity unit costs; however, this decrease was partly offset by the addition of SMC in support of installation activities per EEDB Program ground rules.

ACCOUNT 23 - Turbine Plant Equipment

Within Account 23, the "Deaerator Storage Tank" costs were transferred from sub-account 233 to sub-account 234 "Feedheating System," in accordance with EEDB Program ground rules.

FEC were increased by the changes described in Section 6.2.4, and by conformance of other equipment costs to those of similar equipment in other EEDB data models.

SLH were increased by the changes described in Section 6.2.4, and by using the higher EEDB Program installation rates.

SLC were increased by the increase in SLH; however, this increase was partly offset by apparent CoMO LSPB labor rates that were higher than those of the EEDB LSPB.

SMC were decreased by removal of subcontract labor costs and by using lower EEDB Program commodity unit costs; however, this decrease was more than offset by the changes discussed in Section 6.2.4.

ACCOUNT 24 - Electric Plant Equipment

Within Account 24, "Motor Control Centers" and "Gas Turbine Sequencers" costs were transferred from sub-account 242 to sub-account 241 "Switchgear," "D.C. Switchgear" costs were transferred from sub-account 242 to sub-account 243 "Switchboards," and miscellaneous "Cable Tray" and "Conduit" costs were transferred from sub-account 246 to sub-account 245 "Electric Structures and Wiring Containers," in accordance with the EEDB Program ground rules.

FEC were decreased by deletion of switchyard and generator step-up transformer costs, in accordance with EEDB Program ground rules, by transfer of LSP costs to Account 21, and by the changes described in Section 6.2.4.

SLH were increased by using the higher EEDB Program installation rates; however, this increase was modified by the deletion of the switchyard and generator step-up transformer SLH, by the transfer of the LSP SLH to Account 21, and by the changes described in Section 6.2.4.

SLC were increased by the increase in SLH; however, this increase was partly offset by apparent CoMO LSPB labor rates that were higher than those of the EEDB LSPB.

SMC were increased by the use of higher EEDB site material unit prices; however, this increase was mostly offset by the deletion of switchyard and generator step-up transformer costs and by the changes described in Section 6.2.4.

ACCOUNT 25 - Miscellaneous Plant Equipment

Within Account 25, sub-account 256 "Industrial Security and Safeguards" costs were transferred to sub-account 253 "Communications Systems," in accordance with EEDB Program ground rules.

FEC were decreased through the transfer of HVAC costs to Account 21, in accordance with EEDB Program ground rules, and by the changes to the air, water and steam system described in Section 6.2.4; however, this decrease was partly offset by the addition of other equipment as described in Section 6.2.4.

SLH were increased by using the higher EEDB Program installation rates and by the addition of manhours and other equipment, as described in Section 6.2.4; however, this increase was more than offset by the HVAC transfer and by the air, water and steam system changes described in Section 6.2.4.

SLC were decreased by the decrease in SLH; however, this decrease was more than offset by apparent CoMO LSPB labor rates that were much lower than those for other CoMO LSPB accounts and also much lower than those for the EEDB LSPB.

SMC were decreased by removal of subcontract labor costs, by the HVAC transfer and by the air, water and steam system changes described in Section 6.2.4; however, this decrease was slightly offset by the addition of furnishings and fixtures, as described in Section 6.2.4.

ACCOUNT 26 - Main Condenser Heat Rejection System

FEC received a net increase from the addition of structures and mechanical equipment as described in Section 6.2.4.

SLH were increased by using the higher EEDB Program installation rates; however, this increase was more than offset by a decrease in structural quantities and associated manhours related to the design modifications described in Section 6.2.4.

SLC were decreased by the decrease in SLH; however, this decrease was more than offset by apparent CoMO LSPB labor rates that were lower than those of the EEDB LSPB.

SMC were decreased by removal of subcontract labor costs and by a reduction of structural quantities caused by the design modifications described in Section 6.2.4.

6.4.3 Indirect Cost Differences

The EEDB LSPB indirect costs are 84 percent of those for the CoMO LSPB. The following percentage differentials between the indirect cost accounts in the EEDB and CoMO LSPB cost estimates may be obtained from Tables 6-3 and 6-4:

<u>EEDB LSPB/CoMO LSPB Indirect Cost Percentage Differentials</u>					
<u>Account Number</u>	<u>Factory Equipment Costs</u>	<u>Site Labor Hours</u>	<u>Site Labor Costs</u>	<u>Site Material Costs</u>	<u>Total Costs</u>
91	120	79	58	(27)	22
92	(3)	0	0	0	(3)
93	(33)	(92)	(90)	561	(50)
9 (Total)	(6)	(59)	(49)	(11)	(16)

6.4.3.1 Major Cost Differences

The very large differences that occurred between the EEDB LSPB and CoMO LSPB indirect costs were primarily caused by different accounting practices and by combining architect-engineer (A/E) and reactor manufacturer engineering costs in the CoMO LSPB estimate. The major difference was caused by recording non-manual (field supervision and quality assurance) manhours and costs under the site labor hours and costs respectively. Another significant difference was caused by the inclusion of engineering manhours in several different indirect cost accounts in the CoMO LSPB estimate.

The existing EEDB Program ground rules separated manual (craft labor) and non-manual manhours. Manual manhours were recorded under site labor hours and extended to site labor costs through the application of appropriate labor rates. Nonmanual manhour costs were calculated from manhour estimates and salary rates and entered under factory equipment costs. Additionally, all engineering costs were included under Account 92, Engineering and Home Office Services. Reactor manufacturer engineering was included in the NSSS price, as discussed in Sections 6.3.3 and 6.4.3.1 (Account 22).

6.4.3.2 Detailed Cost Differences

The following paragraphs describe the differences discussed above as they relate to each of the indirect cost accounts. It should be noted that in the EEDB accounting system, the FEC column is the only column where professional and non-manual salaries, associated expenses, payroll insurance and taxes for craft labor, and fees are entered.

ACCOUNT 91 - Construction Services

FEC were increased because a lower factor was applied to total site labor costs to obtain Payroll, Insurance and Taxes in the CoMO LSPB than in the EEDB LSPB.

SLH were increased by a transfer of craft labor from Account 93, in accordance with EEDB Program ground rules.

SLC were increased by the increase in SLH; however, this increase was partly offset by apparent CoMO LSPB labor rates (Refer to Section 6.4.2.1, paragraph 3) that were higher than those of the the EEDB LSPB.

SMC were decreased by the removal of subcontract labor costs; however, this decrease was partly offset by a transfer of some site material costs from Account 93.

ACCOUNT 92 - Engineering and Home Office Services

FEC were slightly decreased by a recalculation of engineering and engineering support costs. Reactor manufacturer engineering costs allocated to sub-account 921 in the CoMO LSPB cost estimate were reviewed and only those costs for reactor manufacturer engineering that would normally be done by an A/E on a commercial project were included in the EEDB LSPB sub-account 921. This decrease was mostly offset by a substantial transfer of "921 A/E" costs from sub-account 932. Within Account 92, a smaller transfer of project direction costs was made from sub-account 923 to sub-Account 921.

SLH, SLC and SMC were not applicable for Account 92 under EEDB Program ground rules. Consequently, these costs were zero in both the EEDB and CoMO LSPB cost estimates.

ACCOUNT 93 - Field Office Services

FEC were decreased by the transfer of "921 A/E" and other engineering costs to Account 92; however, this decrease was partly offset by the use of a slightly lower salary rate for the CoMO LSPB estimate than for the EEDB LSPB estimate.

SLH were completely restructured to transfer non-manual hours to the appropriate 92 and 93 sub-accounts under the FEC column, re-stated as non-manual manhour costs. Most of the hours listed under SLH in the CoMO LSPB estimate were non-manual hours. Therefore, the transfer made a very substantial decrease in the SLH for the EEDB LSPB. The manhours that remained were mostly for survey party personnel and craftsmen training activities. These manhours were allocated in Account 93, in accordance with EEDB Program ground rules.

SLC were recalculated based on the manual SLH discussed above and EEDB Program labor rates.

SMC were applicable for field office expenses only in accordance with EEDB Program practice. This amount was recalculated, based on EEDB Program ground rules and discussions with EPRI/CoMO.

6.4.4 Validity of the EEDB LSPB Cost Estimate

Examination of Tables 6-3 and 6-4 has shown substantial differences on an account-by-account basis for both dollars and manhours between the EEDB LSPB and the CoMO LSPB cost estimates. Although these differences existed at the direct and indirect cost levels, the total base cost was very similar for the two estimates.

Application of the EEDB Program cost estimating methodology is straightforward, but requires attention to detail. The detail is necessary to provide confidence that an estimate fully characterizes a concept and may be compared with alternatives in the data base on a consistent basis. The organization of the methodology also provides the means to optimize concept costs by clearly identifying the significant drivers of those costs, particularly with respect to alternatives. Because of the degree of detail in the EEDB Program accounting system, interpretations may be made that are not consistent with the practices evolved around the EEDB ground rules and assumptions. This is especially true where the work breakdown structure (WBS) is used to prepare the initial estimate.

The discussions given in Sections 6.4.2 and 6.4.3 indicate that the differences in the EEDB and CoMO cost estimates were principally caused by procedural rather than technical differences. Additionally, the discussions show that the LSPB has been properly and successfully recast to reflect the CoMO LSPB technical details in a cost estimate compiled in accordance with EEDB Program ground rules and assumptions. Therefore, the EEDB LSPB may be used to make a representative comparison between the PWR or other EEDB technical/cost data models and the LSPB on a consistent basis.

TABLE 6-1

ENERGY ECONOMIC DATA BASE
 PHASE VII UPDATE
 TABULATION OF EPRI/CoMO LSPB REFERENCE DOCUMENTS

<u>Document Number</u>	<u>Date</u>	<u>Revision Number</u>	<u>Document Title</u>
CDS 100-2	2/84	Rev. 7	Overall Plant Design Specification
CDS 200-11	1/15/84	Rev. 2	Power Transmission System
CDS 200-12	1/13/84	Rev. 4	Building Electrical Power System
CDS 200-15	1/13/84	Rev. 3	Communication System
CDS 200-18	1/13/84	Rev. 3	Industrial Security and Safeguards System
CDS 200-20	4/13/84	Rev. 4	BOP Buildings and Structures
CDS 200-21A	3/15/84	Rev. 3	Reactor Support Buildings
CDS 200-21B	4/15/84	Rev. 3	Steam Generator and Auxiliary Buildings
CDS 200-22	1/15/84	Rev. 3	Compressed Gas System
CDS 200-23	1/15/84	Rev. 4/5	Chilled Water System
CDS 200-24	1/13/84	Rev. 3	Radioactive Waste System
CDS 200-25A	1/14/84	Rev. 3	Nuclear Island Heating, Ventilating, and Air Conditioning Systems
CDS 200-25B	1/15/84	Rev. 3	Balance of Plant and Nuclear Island Maintenance Building Heating, Ventilating, and Air Conditioning
CDS 200-25C	4/15/84	Rev. 2	Steam Generator and Auxiliary Buildings Heating, Ventilating, and Air Conditioning Systems
CDS 200-26	1/14/84	Rev. 3	Fire Protection System
CDS 200-27	3/15/84	Rev. 3	Reactor Containment System
CDS 200-28	3/15/84	Rev. 3	Recirculating Gas Cooling System
CDS 200-31	2/15/84	Rev. 0	Reactor System
CDS 200-32	2/15/84	Rev. 3	Reactor Enclosure System
CDS 200-41	12/15/83	Rev. 3	Reactor Refueling
CDS 200-51A	3/15/84	Rev. 3	Primary Heat Transport System
CDS 200-51B	4/15/84	Rev. 3	Intermediate Heat Transport System
CDS 200-52	3/15/84	Rev. 0	Direct Reactor Auxiliary Cooling System (DRACS)
CDS 200-53	4/15/84	Rev. 3	Steam Generation System
CDS 200-56	3/15/84	Rev. 3	Heat Transport Instrumentation System
CDS 200-66	3/15/84	Rev. 3	Leak Detection System
CDS 200-68	3/15/84	Rev. 3	Sodium Piping and Equipment Heating
CDS 200-71	3/15/84	Rev. 3	Feedwater and Condensate System
CDS 200-72	1/15/84	Rev. 4	Main and Auxiliary Steam System
CDS 200-73	1/15/84	Rev. 3	Heat Rejection System
CDS 200-75A	1/15/84	Rev. 4	Plant Service Water System
CDS 200-75B	1/15/84	Rev. 1/3	Treated Water System
CDS 200-76	1/15/84	Rev. 1	Waste Water Treatment System
CDS 200-81	3/15/84	Rev. 3	Liquid Metals Auxiliaries System
CDS 200-82	3/15/84	Rev. 3	Inert Gas Receiving and Processing System
CDS 200-85	3/15/84	Rev. 3	Impurity Monitoring and Analysis System
CDS 200-90	6/15/84	Rev. 0	Plant Control System

TABLE 6-1

ENERGY ECONOMIC DATA BASE
 PHASE VII UPDATE
 TABULATION OF EPRI/CoMO LSPB REFERENCE DOCUMENTS

<u>Document Number</u>	<u>Date</u>	<u>Revision Number</u>	<u>Document Title</u>
CDS 200-91	6/15/84	Rev. 3	Data Handling and Transmission System
CDS 200-92	2/14/84	Rev. 3	Reactor Instrumentation System
CDS 200-94	2/14/84	Rev. 3	Failed Element Detection and Location System
CDS 200-95	2/14/84	Rev. 3	Flux Monitoring System
CDS 200-96	1/15/84	Rev. 3	Radiation Monitoring System Design Description
CDS 200-99	6/15/84	Rev. 3	Plant Protection System
CDS 400-5	9/84	Rev. 5	Plant Cost Estimate Report
CDS 500-2	8/83	Rev. 2	Plant Ground Rules and Requirements
CDS 500-29	6/83	Rev. 0	Nuclear Utility Services (NUS) Code of Accounts Dictionary

TABLE 6-2

ENERGY ECONOMIC DATA BASE
 PHASE VII UPDATE
 DIRECT COMMODITY/EQUIPMENT/LABOR SUMMARY FOR THE 1320 MWe EPRI/CoMO LSPB

<u>Commodity/Equipment</u>	<u>Unit(a)</u>	<u>Commodities (Quantity x 10³(b))</u>
Excavation	CY	522
Formwork	SF	1,764
Reinforcing, Embedded and Structural Steel	TN	40
Structural Concrete	CY	199
BOP Pumps(c) (1000 HP and Up)	HP	123
Large Bore Piping(d)	LF	179
Raceways	LF	520
Wire and Cable	LF	4,675
		<u>Equipment (\$/kWe(e))</u>
Steam Supply System	LT	434
Turbine-Generator	LT	93
		<u>Craft Labor</u>
Total Manhours (x 10 ³)		11,532
Manhours/kWe		9

(a) CY = Cubic Yards; HP = Horsepower; LF = Linear Feet; LT = Lot;
 SF = Square Feet; TN = Tons

(b) Rounded Off to the Nearest 1,000 Units

(c) Includes Boiler Feed Pumps and NSSS Pumps

(d) Carbon Steel, Stainless Steel and Chrome-Moly Large Bore (2-1/2" & larger) Piping Only

(e) Data in January 1, 1984 Constant Dollars

Effective Date 1/1/84

TABLE 6-3

ENERGY ECONOMIC DATA BASE - PHASE VII UPDATE
1320 MWe LARGE SCALE PROTOTYPE BREEDER REACTOR NPGS (EEDB LSPB)
BEST EXPERIENCE BASIS - PLANT CODE 410L
CAPITAL COST ESTIMATE

6/21/85

UNITED ENGINEERS & CONSTRUCTORS, INC.
 EEDB VII BASE COSTS (BEST EXPERIENCE BASIS)
 1320 MWe EEDB LARGE SCALE PROTOTYPE BREEDER REACTOR
 Plant Code 410L Cost Basis 1/1/84 (\$ x 1000)

Acct. No.	Account Name	Factory Equipment Cost	Site Labor Hours	Site Labor Cost	Site Material Cost	Total Costs
21	STRUCTURES & IMPROVEMENTS	12,223	7,236	145,378	112,009	269,610
22	REACTOR PLANT EQUIPMENT	593,183	2,264	49,368	11,251	653,802
23	TURBINE PLANT EQUIPMENT	159,751	1,718	37,217	30,060	227,028
24	ELECTRIC PLANT EQUIPMENT	38,637	1,632	33,873	14,766	87,275
25	MISC PLANT EQUIPMENT	20,772	1,054	22,927	13,032	56,732
26	MAIN COND HEAT REJECT SYS	33,401	584	12,038	5,179	50,618

2	TOTAL DIRECT COSTS	857,967	14,488	300,801	186,297	1,345,065
	\$ or Manhours Per net KWe	650	11	228	141	1,019
91	CONSTRUCTION SERVICES	62,366	3,164	65,811	65,034	193,211
92	ENG & HOME OFFICE SERVICES	266,439	0	0	0	266,439
93	FIELD OFFICE SERVICES	110,611	546	11,363	16,365	138,339

9	TOTAL INDIRECT COSTS	439,416	3,710	77,174	81,399	597,989
	\$ or Manhours Per net KWe	333	3	58	62	453
=====						
	TOTAL BASE COST (2+9)	1,297,383	18,198	377,976	267,696	1,943,055
	\$ or Manhours Per net KWe	983	14	286	203	1,472

This estimate represents a second-of-a-kind, pre-commercial unit.
 It does not include owner's costs, contingency, AFUDC, EDC, or costs for
 first core, switchyard, generator step up transformers, spare parts and
 other preferential items.

6/21/85

UNITED ENGINEERS & CONSTRUCTORS, INC.
 EEDB VII BASE COSTS (BEST EXPERIENCE BASIS)
 1320 MWe EEDB LARGE SCALE PROTOTYPE BREEDER REACTOR
 Plant Code 410L Cost Basis 1/1/84 (\$ x 1000)

Acct. No.	Account Name	Factory Equipment Cost	Site Labor Hours	Site Labor Cost	Site Material Cost	Total Costs
211	Yardwork	0	551	9,797	10,107	19,904
212	Reactor Contain/Confine Bldg	3,350	2,723	55,468	49,582	108,400
213	Turbine Room & Heater/Aux Bay	97	435	8,791	9,890	18,778
214	Gate House	0	7	138	109	247
215	Reactor Service Building	0	1,265	25,022	12,205	37,227
216	NI Maintenance Building	103	299	5,914	4,003	10,020
218A	Control Building	0	180	3,551	2,165	5,716
218B	Plant Service (Admin) Building	95	75	1,448	890	2,433
218C	Gas-Turbine Building	0	74	1,460	744	2,204
218D	Fire Pump House incl Foundatn	0	4	80	67	147
218E	Steam Generator Buildings	190 *	525 *	10,411 *	5,985 *	16,586 *
218H	Electrical Equipment Building	95	15	300	348	743
218K	Pipe Tunnels	0	50	962	1,165	2,127
218N	Maintenance Shop & Warehouse	0	66	1,302	1,209	2,511
218R	Auxiliary Boiler Building	0	99	1,979	2,030	4,009
218S	Waste Water Treatment Bldg	8	21	454	255	717
218X	Structures HVAC	7,312	749	16,253	11,218	34,783
218Y	Structures Lighting	973	98	2,049	37	3,059
219G	Off-Site Technical Building	----- Not Included -----				-----
21	STRUCTURES & IMPROVEMENTS	12,223	7,236	145,378	112,009	269,610
	\$ or Manhours Per net KWe	9	5	110	85	204
* Includes costs for 218I Aux Builds and 218T Intermed Sodium Storage Vault.						
220A	Nuclear Steam Supply (NSSS)	572,187	0	0	0	572,187
221	Reactor Equipment	150	89	1,927	321	2,398
222	Main Heat Xfer & Xport System	3,862	329	7,212	721	11,795
223	Safeguards System	2	23	504	15	521
224	Radwaste Processing System	1,000	10	219	440	1,659
225	Fuel Handling & Storage System	100	139	3,040	300	3,440
226	Other Reactor Plant Equipment	4,282	853	18,493	6,478	29,253
227	RX Instrumentation & Control	11,440	397	8,524	110	20,074
228	Reactor Plant Misc Items	160	424	9,451	2,866	12,477
22	REACTOR PLANT EQUIPMENT	593,183	2,264	49,368	11,251	653,802
	\$ or Manhours Per net KWe	449	2	37	9	495

6/21/85

UNITED ENGINEERS & CONSTRUCTORS, INC.
 EEDB VII BASE COSTS (BEST EXPERIENCE BASIS)
 1320 MWe EEDB LARGE SCALE PROTOTYPE BREEDER REACTOR
 Plant Code 410L Cost Basis 1/1/84 (\$ x 1000)

Acct. No.	Account Name	Factory Equipment Cost	Site Labor Hours	Site Labor Cost	Site Material Cost	Total Costs
231	Turbine Generator	122,149	377	8,113	1,540	131,802
233	Condensing System	15,301	416	9,085	7,622	32,008
234	Feed Heating System	12,025	253	5,553	12,591	30,169
235	Other Turbine Plant Equip	8,824	320	7,014	7,205	23,043
236	Instrumentation & Control	1,452	165	3,529	353	5,334
237	Turbine Plant Misc Items	0	187	3,921	749	4,670
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23	TURBINE PLANT EQUIPMENT	159,751	1,718	37,217	30,060	227,028
	\$ or Manhours Per net KWe	121	1	28	23	172
241	Switchgear	6,786	27	561	56	7,403
242	Station Service Equipment	19,473	166	3,430	696	23,599
243	Switchboards	5,716	96	1,996	200	7,911
244	Protective Equipment	0	85	1,771	1,182	2,953
245	Elect Struc & Wiring Contr	0	755	15,598	3,950	19,548
246	Power and Control Wiring	6,662	503	10,518	8,682	25,862
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24	ELECTRIC PLANT EQUIPMENT	38,637	1,632	33,873	14,766	87,275
	\$ or Manhours Per net KWe	29	1	26	11	66
251	Transportation & Lift Equip	5,058	28	614	61	5,734
252	Air, Water & Steam Service Sys	6,827	711	15,514	12,741	35,082
253	Communications Systems	3,173	208	4,474	170	7,817
254	Furnishings & Fixtures	4,134	32	680	60	4,874
255	Waste Water Treatment Equip	1,580	75	1,645	0	3,225
256	Industrial Security & Safeguards	-----	Included in Account	253	-----	-----
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25	MISC PLANT EQUIPMENT	20,772	1,054	22,927	13,032	56,732
	\$ or Manhours Per net KWe	16	1	17	10	43
261	Heat Rej Sys Structures	193	94	1,836	1,500	3,529
262	Heat Rej Sys Mech Equip	33,208	490	10,202	3,679	47,089
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26	MAIN COND HEAT REJECT SYS	33,401	584	12,038	5,179	50,618
	\$ or Manhours Per net KWe	25	0	9	4	38
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2	TOTAL DIRECT COSTS	857,967	14,488	300,801	186,297	1,345,065
	\$ or Manhours Per net KWe	650	11	228	141	1,019

6/21/85

UNITED ENGINEERS & CONSTRUCTORS, INC.
 EEDB VII BASE COSTS (BEST EXPERIENCE BASIS)
 1320 MWe EEDB LARGE SCALE PROTOTYPE BREEDER REACTOR
 Plant Code 410L Cost Basis 1/1/84 (\$ x 1000)

Acct. No.	Account Name	Factory Equipment Cost	Site Labor Hours	Site Labor Cost	Site Material Cost	Total Costs
911	Temporary Construction Fac.	0	2,760	57,408	19,872	77,280
912	Construction Tools & Equip	0	404	8,403	43,268	51,671
913	Payroll Insurance & Taxes	62,366	0	0	0	62,366
914	Permits, Ins. & Local Taxes	0	0	0	1,894	1,894
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91	CONSTRUCTION SERVICES	62,366	3,164	65,811	65,034	193,211
	\$ or Manhours Per net KWe	47	2	50	49	146
921	Home Office Services	254,228	0	0	0	254,228
922	Home Office QA	8,007	0	0	0	8,007
923	Home Office Constrtn Mgmt	4,204	0	0	0	4,204
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92	ENG & HOME OFFICE SERVICES	266,439	0	0	0	266,439
	\$ or Manhours Per net KWe	202	0	0	0	202
931	Field Office Expenses	0	28	589	16,365	16,954
932	Field Job Supervision	90,909	393	8,174	0	99,083
933	Field QA/QC	6,885	125	2,600	0	9,485
934	Plant Startup & Test	12,817	0	0	0	12,817
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93	FIELD OFFICE SERVICES	110,611	546	11,363	16,365	138,339
	\$ or Manhours Per net KWe	84	0	9	12	105
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9	TOTAL INDIRECT COSTS	439,416	3,710	77,174	81,399	597,989
	\$ or Manhours Per net KWe	333	3	58	62	453
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TABLE 6-4

ENERGY ECONOMIC DATA BASE - PHASE VII UPDATE
1320 MWe EPRI/CoMO LARGE SCALE PROTOTYPE BREEDER
REACTOR NPGS (CoMO LSPB)

CAPITAL COST ESTIMATE

(Reference: CDS 400-5, Table 6-7)

9/84

UNITED ENGINEERS & CONSTRUCTORS, INC.
 EEDB VII BASE COSTS (BEST EXPERIENCE BASIS)
 1320 MWe EPRI/CoMO LARGE SCALE PROTOTYPE BREEDER REACTOR
 Cost Basis 1/1/84 (\$ x 1000)

Acct. No.	Account Name	Factory Equipment Cost	Site Labor Hours	Site Labor Cost	Site Material Cost	Total Costs
21	STRUCTURES & IMPROVEMENTS	3,900	5,257	91,332	132,977	228,209
22	REACTOR PLANT EQUIPMENT	567,386	1,853	45,476	12,487	625,349
23	TURBINE PLANT EQUIPMENT	157,069	1,149	27,030	29,343	213,442
24	ELECTRIC PLANT EQUIPMENT	44,650	1,365	31,409	14,593	90,652
25	MISC PLANT EQUIPMENT	25,698	1,314	17,859	39,702	83,259
26	MAIN COND HEAT REJECT SYS	23,020	594	11,417	9,720	44,157
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2	TOTAL DIRECT COSTS	821,723	11,532	224,523	238,822	1,285,068
	\$ or Manhours Per net KWe	623	9	170	181	974
91	CONSTRUCTION SERVICES	28,354	1,764	41,660	88,524	158,538
92	ENG & HOME OFFICE SERVICES	273,388	0	0	0	273,388
93	FIELD OFFICE SERVICES	166,244	7,249 *	108,959	2,474	277,677
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9	TOTAL INDIRECT COSTS	467,986	9,013 *	150,619	90,998	709,603
	\$ or Manhours Per net KWe	355	7 *	114	69	538
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	TOTAL BASE COST (2+9)	1,289,709	20,545 *	375,142	329,820	1,994,671
	\$ or Manhours Per net KWe	977	16 *	284	250	1,511

This estimate represents a second-of-a-kind, pre-commercial unit.
 It does not include owner's costs, contingency, AFUDC, EDC, or costs for
 first core, spare parts and other preferential items.

* Includes both manual (craft labor) and non-manual (field supervision)
 manhours

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UNITED ENGINEERS & CONSTRUCTORS, INC.
 EEDB VII BASE COSTS (BEST EXPERIENCE BASIS)
 1320 MWe EPRI/CoMO LARGE SCALE PROTOTYPE BREEDER REACTOR
 Cost Basis 1/1/84 (\$ x 1000)

Acct. No.	Account Name	Factory Equipment Cost	Site Labor Hours	Site Labor Cost	Site Material Cost	Total Costs
211	Yardwork	160	366	7,082	10,984	18,226
212	Reactor Containment Building	3,350	1,956	34,723	54,070	92,143
213	Turbine Generator Building	97	504	4,005	30,372	34,474
214	Gate House	0	7	131	109	240
215	Reactor Service Building	0	963	17,545	16,790	34,335
216	NI Maintenance Building	103	299	5,343	5,090	10,536
218A	Control Building	0	246	4,827	2,447	7,274
218B	Plant Service Building	95	75	1,435	890	2,420
218C	Gas-Turbine Building (correctn)	0	84	1,659	744	2,403
218D	Fire Pump House	0	4	53	98	151
218E	Steam Generator Building	95	514	10,086	5,745	15,926
218H	Electrical Equipment Building	0	11	220	348	568
218K	Pipe Tunnels	0	50	887	1,338	2,225
218N	Maintenance Shop	0	66	1,306	1,209	2,515
218R	Auxiliary Boiler Building	0	99	1,775	2,376	4,151
218S	Waste Water Treatment Bldg	0	0	0	0	0
218X	Structures HVAC	-----See Account 255-----				
218Y	Structures Lighting	0	0	0	0	0
219G	Off-Site Technical Building	0	13	255	367	622

21	STRUCTURES & IMPROVEMENTS	3,900	5,257	91,332	132,977	228,209
	\$ or Manhours Per net KWe	3	4	69	101	173
220A	Nuclear Steam Supply (NSSS)	410,494	175	3,817	321	414,632
221	Reactor Equipment	92,063	31	1,621	0	93,684
222	Main Heat Transport System	21,677	289	7,877	1,992	31,546
223	Safeguards System	8,071	21	502	0	8,573
224	Radwaste Processing System	1,000	10	221	440	1,661
225	Fuel Handling	9,118	0	0	0	9,118
226	Other Reactor Plant Equipment	13,400	853	17,016	9,624	40,040
227	RX Instrumentation & Control	11,440	117	4,741	110	16,291
228	Reactor Plant Misc Items	0	357	9,681	0	9,681
2291	Unspecified	123	0	0	0	123

22	REACTOR PLANT EQUIPMENT	567,386	1,853 *	45,476	12,487	625,349
	\$ or Manhours Per net KWe	430	1	34	9	474

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UNITED ENGINEERS & CONSTRUCTORS, INC.
 EEDB VII BASE COSTS (BEST EXPERIENCE BASIS)
 1320 MWe EPRI/CoMO LARGE SCALE PROTOTYPE BREEDER REACTOR
 Cost Basis 1/1/84 (\$ x 1000)

Acct. No.	Account Name	Factory Equipment Cost	Site Labor Hours	Site Labor Cost	Site Material Cost	Total Costs
231	Turbine Generator	122,149	301	8,325	2,182	132,656
233	Condensing System	14,592	269	5,957	5,950	26,499
234	Feed Heating System	12,218	258	5,314	13,508	31,040
235	Other Turbine Plant Equip	8,110	318	7,373	7,503	22,986
236	Instrumentation & Control	0	0	0	0	0
237	Turbine Plant Misc Items	0	3	61	200	261
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23	TURBINE PLANT EQUIPMENT	157,069	1,149	27,030	29,343	213,442
	\$ or Manhours Per net KWe	119	1	20	22	162
241	Switchgear	4,241	6	150	0	4,391
242	Station Service Equipment	28,748	175	3,893	380	33,021
243	Switchboards	7,843	45	1,025	0	8,868
244	Protective Equipment	0	54	1,259	1,004	2,263
245	Elect Struc & Wiring Contr	0	553	12,792	5,863	18,655
246	Power and Control Wiring	3,818	532	12,290	7,346	23,454
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24	ELECTRIC PLANT EQUIPMENT	44,650	1,365	31,409	14,593	90,652
	\$ or Manhours Per net KWe	34	1	24	11	69
251	Transportation & Lift Equip	5,058	28	572	0	5,630
252	Air, Water & Steam Service Sys	8,857	496	10,312	15,096	34,265
253	Communications Equipment	855	11	263	83	1,201
254	Furnishings & Fixtures	1,748	8	174	0	1,922
255	HVAC Systems	7,312	749	6,026	24,518	37,856
256	Industri Security & Safeguards	1,868	22	512	5	2,385
<hr/>						
25	MISC PLANT EQUIPMENT	25,698	1,314	17,859	39,702	83,259
	\$ or Manhours Per net KWe	19	1	14	30	63
261	Structures	0	110	1,670	3,178	4,848
262	Mechanical Equipment	23,020	484	9,747	6,542	39,309
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26	MAIN COND HEAT REJECT SYS	23,020	594	11,417	9,720	44,157
	Per net KWe	17	0	9	7	33
<hr/>						
2	TOTAL DIRECT COSTS	821,723	11,532	224,523	238,822	1,285,068
	\$ or Manhours Per net KWe	623	9	170	181	974

UNITED ENGINEERS & CONSTRUCTORS, INC.
EEDB VII BASE COSTS (BEST EXPERIENCE BASIS)
1320 MWe EPRI/CoMO LARGE SCALE PROTOTYPE BREEDER REACTOR
Cost Basis 1/1/84 (\$ x 1000)

This estimate represents a second-of-a-kind, pre-commercial unit. It does not include owner's costs, contingency, AFUDC, EDC, or costs for first core, spare parts and other preferential items.

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SECTION 7

7.0 REFERENCES, DEFINITIONS AND GLOSSARY

7.1 REFERENCES AND BIBLIOGRAPHY

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10. "Commercial Electric Power Cost Studies," United Engineers & Constructors Inc., 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: Low and High Sulfur Coal Plants - 800 MWe (Nominal)" Volumes 1, 2 and 3, NUREG-0244, COO-2477-8, June, 1977.

7.2 DEFINITIONS

The following commonly used terms are specifically defined as they are used in the Energy Economic Data Base Program.

7.2.1 Rated Load (Unit or Equipment)

The operating condition that exists when the unit steam turbine-generator is operating at that load for which the turbine-generator performance is guaranteed by the manufacturer.

7.2.2 Rated Thermal Power (Nuclear Power Generating Stations)

The rated load heat input to the reactor coolant from the reactor core expressed as thermal megawatts (MWt).

7.2.3 Rated Thermal Power (Fossil Power Generating Stations)

The rated load heat input to the boiler in the form of fuel, expressed as thermal megawatts (MWt).

7.2.4 Net Power to GSU (Generator Step-up Transformer)

The generator output at rated load and voltage reduced by the plant auxiliary power load at these conditions, expressed as electric megawatts (MWe).

7.2.5 Net Plant Heat Rate

The figure of merit obtained by dividing the product of the "Thermal Power" and the constant 3412.9 (British thermal units per hour per electric kilowatt) by the "Net Power to GSU," expressed as British thermal units/kilowatt-hour (Btu/kWh).

7.2.6 Net Plant Efficiency

The figure of merit obtained by dividing the "Net Power to GSU" by the "Thermal Power," expressed as a percentage.

7.2.7 Maximum Continuous Rating (Fossil Boiler)

The boiler design condition which corresponds to a main and reheat steam pressure of five percent above that for rated load conditions, and a flow rate in excess of that predicted by the turbine manufacturer at the valves wide open, five percent overpressure condition.

7.2.8 Valves Wide Open, Five Percent Overpressure Condition (VWO, 5% OP)

The operating condition that exists when the turbine is operated with the main throttle valve(s) fully opened and the main steam pressure at the throttle valve inlet five percent greater than that at rated load. Typically, this is

the maximum load condition for which the turbine manufacturer predicts (but does not guarantee) performance.

7.2.9 Base Construction Cost

The base construction cost is the overnight plant capital cost for the direct and indirect costs only. It does not include contingency, owner's cost, allowance for funds used during construction, initial supply of fuel nor other costs related to utility preference or specific utility system requirements (Refer to Table 5-2).

7.2.10 Constant Dollars

Constant dollar cost is the cost which would be paid for an item or a service in the future if there were no inflation between the time that the cost is estimated and the time the cost is incurred.

7.2.11 Site Materials

Site materials are field purchased or bulk commodity items. Piping two inches in diameter and smaller nominal pipe size is site material. All galvanized pipe, storm, roof and floor drainage piping and sanitary piping is also site material. Wire/cable and raceways, including those in building service lighting and power systems, are site material.

7.2.12 Factory Equipment

Factory equipment is manufactured or factory fabricated items. Piping 2.5 inches and larger is factory equipment, with the exception of galvanized pipe, storm, roof and floor drainage piping and sanitary piping.

7.2.13 Force Account

Force account refers to the direct hiring and supervision of craftsmen by a prime contractor to perform a construction task.

7.2.14 Subcontract Account

Subcontract account refers to the hiring of a subcontractor by a prime contractor to perform a construction task in accordance with appropriate specifications.

7.3 GLOSSARY OF ACRONYMS AND ABBREVIATIONS

This glossary contains acronyms and abbreviations that are applicable to the EEDB Program Update Reports and Technical Reference Books.

7.3.1 Governmental Organizations

AEC	- Atomic Energy Commission, Predecessor to ERDA and NRC
ANL	- Argonne National Laboratory
DOE (DoE)	- Department of Energy (Successor to ERDA and AEC)
EPA	- Environmental Protection Agency
ERDA	- Energy Research and Development Administration, (Predecessor to DOE)
NRC	- Nuclear Regulatory Commission (Successor to AEC)
ORNL	- Oak Ridge National Laboratory
US	- United States

7.3.2 Other Organizations

AIChE	- American Institute of Chemical Engineers
ANS	- American Nuclear Society
API	- American Petroleum Institute
ASCE	- American Society of Civil Engineers
ASME	- American Society of Mechanical Engineers
CE	- Combustion Engineering, Inc.
EPRI/CoMO	- Electric Power Research Institute/Consolidated Management Office for the Liquid Metal Fast Breeder Reactor
GE	- General Electric Company
ICEA	- Insulated Cable Engineers Association, Inc.
IEEE	- Institute of Electrical and Electronics Engineers

7.3.2 (Cont'd)

ISA	- Instrument Society of America
NFPA	- National Fire Protection Association
UE&C	- United Engineers & Constructors Inc. (A Raytheon Subsidiary)
UL	- Underwriters' Laboratories, Inc.
WE	- Westinghouse Electric Corporation
WEC	

7.3.3 Technical/Cost Identification and Programs

A	- Amperes
ac	- Alternating Current
acfm	- Actual Cubic Feet per Minute
A/E	- Architect-Engineer
AFUDC	- Allowance for Funds Used During Construction
ASME B&PVC	- ASME Boiler and Pressure Vessel Code
BCC	- Base Construction Costs
BE	- Best (Industry Cost) Experience
BOP	- Balance of Plant (other than NSSS and BORP)
BORP	- Balance of Reactor Plant (other than NSSS)
BRS	- Boron Recycle System
BTG	- Boiler Turbine-Generator
BTU, Btu	- British Thermal Unit = 1055 Joules
Btu/kWh	- British Thermal Units per Kilowatt-hour (electrical)
BWR	- Boiling Water Reactor
C	- Temperature - Degrees Celsius (sometimes Centigrade)

7.3.3 (Cont'd)

CF, cu ft	- Cubic Feet - ft ³
cfm	- Cubic Feet per Minute
CFR	- Code of Federal Regulations (usually preceded by a Title number and followed by a Part number as 10CFR50)
CGC	- Combustible Gas Control (System)
CGCC	- Coal Gasification Combined Cycle Plant
CO	- Carbon Monoxide
CRT	- Cathode Ray Tube
CSS	- Containment Spray System
CuNi	- Copper Nickle
CVCS	- Chemical and Volume Control System
CY, cu yd	- Cubic Yard - yd ³
DBA	- Design Basis Accident
DC	- Direct Costs
dc	- Direct Current
DF	- Decontamination Factor
\$/kWe	- Dollars per kilowatt-electrical
DNA	- Data Not Available
EDC	- Escalation During Construction
EEDB	- Energy Economic Data Base
EHC	- Electrohydraulic Control
EIS	- Environmental Impact Statement
EM	- Electromagnetic
EPA	- Environmental Protection Agency
EVST	- Ex-Vessel Storage Tank

7.3.3 (Cont'd)

F	- Temperature - Degrees Fahrenheit
FEC	- Factory Equipment Costs
FGD	- Flue Gas Desulfurization
FPGS	- Fossil Power (Electric) Generating Station
FT, ft	- Feet
ft/sec	- Feet per Second
GESSAR	- General Electric Standard Safety Analysis Report
g	- Acceleration Due to Gravity = 32.16 ft/sec^2 = 9.8 Metres/sec^2
gpm	- Gallons per Minute
GSU	- Generator Step-Up (Transformer)
H ₂	- Hydrogen
HEPA	- High Energy Particulate Air (Filter)
HP, hp	- Horsepower
hr	- Hour
HS	- High Sulfur
HSC	- High Sulfur Coal
HS8	- 800 MWe (Nominal) High Sulfur Coal-Fired Power Generating Station
HS5	- 500 MWe (Nominal) High Sulfur Coal-Fired Power Generating Station
HVAC	- Heating, Ventilating and Air-Conditioning
Hz	- Hertz (cycles per second)
I&C	- Instrumentation and Control
IC	- Indirect Costs

7.3.3 (Cont'd)

In, in	- inches
in-Hg	- Inches of Mercury (1 in-Hg = 25.4 Torr)
in-HgA	- Inches of Mercury - Absolute
k_{eff}	- Effective Multiplication Factor (The requirement for criticality in a finite system is $k_{eff} = 1$)
kV	- Volts $\times 10^3$ - Kilovolts
kVA	- Volt-Amperes $\times 10^3$ - Kilovolt-Amperes
kW	- Watts $\times 10^3$ - Kilowatt = 3412.9 Btu/hr
kWh	- Kilowatt-Hour - 3412.9 Btu
LB, lb	- Pound or Pounds (depending on context)
lb/hr	- Pounds per Hour
LF	- Linear Feet
LMFBR	- Liquid Metal Fast Breeder Reactor
LMR	- Liquid Metal Reactor
LOCA	- Loss-of-Coolant-Accident
LSPB	- Large Scale Prototype Breeder Reactor
LT	- Lot
LWR	- Light Water Reactor (includes BWR and PWR)
MCR	- Maximum Continuous Rating (Fossil Boilers)
ME	- Median (Industry Cost) Experience
min	- Minute
mph	- Miles per Hour
mr/hr	- Millirems per Hour (rem is radiation equivalent-man)
MSLB	- Main Steam Line Break

7.3.3 (Cont'd)

MVA	- Volt-amperes x 10 ⁶ - Megavolt-amperes
MW	- Watts x 10 ⁶ - Megawatt
MWe	- Megawatts - Electrical
MWt	- Megawatts - Thermal
N/A	- Not Applicable
N/Av	- Not Available
Na	- Element No. 11 - Sodium - Liquid Metal Coolant
NaK	- A low melting point mixture of Sodium and Potassium
NEPA	- National Environmental Policy Act
NNS	- American Nuclear Society Non-Nuclear Safety Class
NO _x	- Oxides of Nitrogen (general)
NPDES	- National Pollution Discharge Elimination System
NPGS	- Nuclear Power (Electric) Generating Station
NPSH	- Net Positive Suction Head
NS	- Nuclear Safety
NSPS	- New Source Performance Standards
NSSS	- Nuclear Steam Supply System
NSW	- Nuclear Service Water (System)
OBE	- Operating Basis Earthquake
OP	- Overpressure
Pb	- Element No. 82 - Lead
PCCW	- Primary Component Cooling Water (System)
PF	- Power Factor

7.3.3 (Cont'd)

ppm	- Parts per Million
psf	- Pounds per Square Foot
PSD	- Prevention of Significant Deterioration
PSI, psi	- Pounds per Square Inch (1 psi = 51.7 Torr)
PSIA, psia	- Pounds Per Square Inch - Absolute
PSIG, psig	- Pounds Per Square Inch - Gauge (14.7 psia = 0 psig)
PuO ₂	- Plutonium Dioxide
PWR	- Pressurized Water Reactor
QA	- Quality Assurance
r, rev	- Revolutions
R.C.A.	- Radiological Controlled Access
RESAR	- Westinghouse Reference Safety Analysis Report
RHR	- Residual Heat Removal (System)
RPM r/min	- Revolutions per Minute
SC1, SC2, SC3	- American Nuclear Society Safety Class 1, 2, 3
SCF	- Standard Cubic Feet - one cubic foot of gas at 0°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°C
sec	- Second
SF, sq ft	- Square Feet - ft ²
SIS	- Safety Injection System
SLC	- Site Labor Costs

7.3.3 (Cont'd)

SLH	- Site Labor Hours
SMC	- Site Material Costs
SO ₂	- Sulfur Dioxide
SPDES	- State Pollution Discharge Elimination System
SS	- Stainless Steel
SSE	- Safe Shutdown Earthquake
SSU	- Seconds Saybolt Universal (a measure of kinematic viscosity)
TDC	- Total Direct Costs
TDH	- Total Dynamic Head (discharge head minus suction head for centrifugal pumps)
TIC	- Total Indirect Costs
tph	- Tons per Hour
UO ₂	- Uranium Dioxide
V	- Volts
VWO	- Valves Wide Open
WBS	- Work Breakdown Structure
We	- Watts - Electrical
w.g.	- Water Gage (usually inches of water, 1 in. W.G. = 1.87 Torr)
Wt	- Watts - Thermal or Weight (depending on context)
Y yr	- year = 8760 Hours = 3.154×10^7 Seconds