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OAK RIDGE
NATIONAL
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Cost Estimate Guidelines for Advanced Nuclear Power Technologies

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COST ESTIMATE GUIDELINES FOR ADVANCED NUCLEAR POWER TECHNOLOGIES

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This document contains information of a preliminary nature. It is subject to revision or correction and therefore does not represent a final report.

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COST ESTIMATE GUIDELINES FOR ADVANCED NUCLEAR POWER TECHNOLOGIES

ABSTRACT

To make comparative assessments of competing technologies, consistent ground rules must be applied when developing cost estimates. This document provides a uniform set of assumptions, ground rules, and requirements that can be used in developing cost estimates for advanced nuclear power technologies.

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1. INTRODUCTION

Several advanced power plant concepts are currently under development. These include the Modular High Temperature Gas Cooled Reactors (MHTGR), the Advanced Liquid Metal Reactor (ALMR) and the Advanced Light Water Reactors (ALWR). One measure of the attractiveness of a new concept is its cost. Invariably, the cost of a new type of power plant will be compared with other alternative forms of electrical generation. This report provides a common starting point, whereby the cost estimates for the various power plants to be considered are developed with common assumptions and ground rules. Comparisons can then be made on a consistent basis.

This is the second update of these cost estimate guidelines.[1,2] Changes have been made to make the guidelines more current (January 1, 1992) and in response to suggestions made as a result of the use of the previous report.[2] The principal changes are that the reference site has been changed from a generic Northeast (Middletown) site to a more central site (EPRI's East/West Central site) and that reference bulk commodity prices and labor productivity rates have been added.

This report is designed to provide a framework for the preparation and reporting of costs. The cost estimates will consist of the overnight construction cost, the total plant capital cost, the operation and maintenance (O&M) costs, the fuel costs, decommissioning costs and the power production or busbar generation cost. While providing a generic set of assumptions and ground rules, this document does not provide scenarios or assumptions specific to the individual concepts, nor does it provide reporting requirements. Thus, these guidelines may be used in a variety of studies when supplemented with concept specific data.

Power plant capital costs in this report will be developed using the U.S. Department of Energy (DOE) Energy Economic Data Base[3] (EEDB) Program Code of Accounts that has evolved from the NUS Corporation Code of Accounts[4] through modification and expansion over two decades.

The utilization of the EEDB Code of Accounts will allow for comparisons between the advanced concept cost estimate and costs of other plants reported in the EEDB format. The levelized busbar generation costs will be developed using the methodology presented in the U.S. DOE *Nuclear Energy Cost Data Base* (NECDB).[5] All costs will be developed using the methods and tax provisions in the Tax Reform Act of 1986.

These ground rules will be updated as necessary to provide and maintain a common and consistent cost basis. The DOE Office of Nuclear Energy (NE) is responsible for approving changes to this document. Requested changes should be made in writing to Department of Energy Assistant Secretary for Nuclear Energy, Office of Advanced Reactor Programs, Washington, D.C. 20545.

1.1 OBJECTIVE

Cost estimates for the development, design, construction and operation costs of future power plants involve a great deal of uncertainty. In order to manage the cost estimating task for the advanced nuclear power plant concepts, a number of simplifying assumptions should be made. These include:

- Nuclear plant licensing reform, recently enacted, allows one-step licensing and certification of a standard plant design.
- The Nth-of-a-kind (NOAK) plant is assumed to be built by the same vendor/architect-engineer team as the first commercial plant and is identical to the first commercial plant. The plants will be deployed on separate sites.
- An adequate site exists to build a plant (See Appendix F.)
- Adequate project financing is available for all phases of the development, design, construction and operation of the subject plant.
- No provision should be made for acts of God, war, or labor strikes.

The cost estimate Guidelines are intended to provide a consistent comparison between the advanced reactor technologies. The cost estimates are intended to be reasonable estimates rather than to envelope the ultimate cost in an uncertain environment. The total capital cost estimate should represent the median cost, based on the guideline assumptions where there is an equal probability of the ultimate cost being higher or lower than that cost.

1.2 DEFINITION OF TERMS

The following definition of terms will provide the background necessary for understanding and interpreting the present guidelines.

Base construction cost. The base construction cost is the most likely plant capital cost based on the direct and indirect costs only. This cost is lower than the total capital cost because cost elements such as contingency, interest, and escalation are NOT included. The specific cost items omitted are listed in Table 1.1.

Table 1.1. Preferential and discretionary items excluded from base construction costs

Allowance for funds used during construction
Escalation
Contingency (including allowance for indeterminates)
Owner's discretionary items
Switchyard and transmission costs
Generator step-up transformer
Initial fuel supply

The direct costs are those costs directly associated on an item-by-item basis with the equipment and structures that comprise the complete power plant. The indirect costs are expenses for services applicable to all portions of the physical plant, such as Architect Engineer (AE) home office engineering and design, AE field office engineering and services, construction management (CM), and taxes. Reactor manufacturer (RM) home office engineering and services are also included in a separate account (see Sect. 2.3, Item 16).

Building block. A building block is a combination of one or more reactor modules and associated electrical generation equipment and structures that represent the smallest unit for commercial electrical generation. Building blocks may be duplicated for capacity expansion.

Busbar costs. Total levelized power generation costs for electricity produced by a power plant. It includes costs associated with the capital investment, operation and maintenance of the power plant, fuel costs, and the cost of decommissioning the plant at the end of life.

Common plant facilities. Common plant facilities are those systems, structures, and components that are required to support the operation of a first building block at a new plant site and include such facilities as administration building, provisions for refueling, general warehouse, water supply, general fire systems, etc. These common plant facilities may be sized sufficiently so as to be shared by other building blocks added subsequently.

Constant dollars. Constant dollar cost is defined as the cost for an item measured in dollars that have a general purchasing power as of some reference date. As inflation is generally associated with the erosion of the general purchasing power of the dollar, constant dollar analysis factors out inflation.

Construction Module. A construction module is a free standing, transportable preassembly of a portion of the plant. A construction module may be a preassembly of a single system or portion thereof or may contain elements of all the systems that exist in a given location in the plant. A construction module may contain parts of the building structure. A construction module would typically be assembled in a factory, shipped to the plant site and installed in the plant.

Contingency Allowance. The contingency allowance is an adder to the base construction cost to obtain a median cost estimate (see Appendix H). Contingency provides an allowance for cost uncertainties. It includes an allowance for indeterminents and should be related to the level of design, degree of technological advance, and the quality/reliability level of given components (see Sect. 3.1). Contingency cost does not include any allowance for potential changes from external factors such as changing government regulations, major design changes, catastrophic events, labor strikes, extreme weather conditions, varying site conditions, or project funding (financial) limitations.

Escalation rate. The rate of change of a cost. This rate can be greater or less than the general inflation rate as measured by the Gross Domestic Product Implicit Price Deflator.

Equipment. Generally, equipment includes all manufactured items ordered by RM or AE. Such items may be procured on a design and build contract from qualified vendors, wherein design responsibility belongs to the seller (vendor) or is maintained by the buyer (RM or AE) on a "build-to-print" basis. All piping 2-1/2-in. and larger nominal pipe size is an equipment item with the exception of galvanized pipe; storm, roof, and floor drainage; and sanitary piping, which are site material.

Equipment module. An equipment module is a skid-mounted, factory assembled package which includes (but is not limited to) equipment, piping, instrumentation, controls, structural components, and electrical items. Module types include Box Modules, Equipment Modules, Structural Modules, Connection Modules, Electrical Modules, Control System Modules and Dressed Equipment Modules. These Modules are applicable to both the Nuclear Island and Balance of Plant.

Factory (manufacturing facility) FOAK costs. These first of a kind (FOAK) costs include the development of manufacturing specifications, factory equipment, facilities, startup, tooling and setup of factories that are used for manufacturing specific equipment for the concept. These costs may be minimized if existing facilities are used for module production, which might not be dedicated or even its primary use application (e.g. a shipyard or other factory which builds modules for other industries).

First commercial plant costs. The first commercial plant is the first plant of that type that is sold to an entity for the purpose of commercial production of electricity. The costs include all engineering, equipment, construction, testing, tooling, project management, and any other costs that are repetitive in nature. Any costs unique to the first commercial plant which will not be incurred for subsequent plants of the identical design will be identified and broken out separately as FOAK plant costs. The learning for this first plant will reflect its first commercial plant status and not be the average over a larger number of plants.

FOAK plant costs. First-of-a-kind costs necessary to put a first commercial plant in place which will not be reproduced for subsequent plants. Such costs include R&D, standard plant design, NRC certification of standard design and any prototype and other such FOAK costs.

Force account. Force account involves the direct hiring and supervision of craftsmen to perform a construction activity by a prime contractor as opposed to the prime contractor hiring a subcontractor to perform these functions.

Industrial grade construction. Industrial grade construction means construction practices which conform to generally accepted commercial requirements such as those required for fossil-fired plant construction.

Inflation rate. The rate of change in the general price level as measured by the Gross Domestic Product Implicit Price Deflator.

Large monolithic plant. A large monolithic plant is defined as a power plant consisting of a single, large nuclear steam supply system (NSSS) having a power output at least two and possibly four times as large as a typical modular building block. In some instances, a plant of this size is referred to as an integrated plant.

Materials. Basically, materials include field-purchased (site material) and/or bulk items such as lumber, concrete, structural steel, and plumbing items. Prefabricated pipe is an equipment item. All other piping, less than 2-1/2-in. nominal pipe size, is a materials item with the exception of pipe for cryogenic fluids, which is an equipment item. Also all wire and cable and raceways are material items, including those in building service power systems.

Multi-block plant. A power plant consisting of multiple building blocks is referred to as a multi-block plant.

Nominal dollars. Nominal dollar cost is defined as the cost for an item measured in as-spent dollars and includes inflation. Nominal dollars are sometimes referred to as "current" dollars, "year of expenditure" dollars, or "as spent" dollars in the literature.

Nominal cost of money. The nominal cost of money is the percentage rate used in calculations involving the time value of money containing an inflation component. It explicitly provides for part of the return on an investment to be solely for the purpose of keeping up with inflation.

Nth-of-a-kind (NOAK) plant costs. The NOAK plant is the nth-of-a-kind or equilibrium commercial plant of identical design to the first commercial plant. NOAK plant costs include all engineering, equipment, construction, testing, tooling, project management, and any other costs that are repetitive in nature and would be incurred if an identical plant were built. The NOAK plant also reflects the experience of prior plants leading to the NOAK plant (see Sect. 2.3, Item 6).

Nuclear safety grade. Nuclear-safety grade construction means construction practices which satisfy the requirments of 10CFR50, Appendix B.

Prototype facility and test costs. Costs specific to any prototype plant required. These include prototype-specific design, development, licensing, construction, testing, and operation of the prototype to support the standard plant design certification.

R&D costs. Costs associated with material, component, system, process and fuel development and testing performed specifically for the particular advanced concept.

Reactor module. A reactor module is a single reactor and that portion of the nuclear island which is duplicated with the addition of each reactor, able to generate thermal heat as an integral part of a building block of power production.

Real cost of money. The real cost of money is the percentage rate used in calculations involving the time value of money when the inflation component has been removed. Calculations using the real cost of money assume that the dollar maintains a constant value in terms of purchasing power, and, thus, no return on an investment is needed for inflation.

Single-block plant. A stand-alone commercial power plant consisting of a single building block and all necessary common plant facilities is referred to as a single-block plant. This is the smallest unit of capacity normally sold to a customer.

Standard plant design costs. Costs associated with the engineering and engineering support functions for the design of the standard plant.

Standard plant NRC certification costs. Costs associated with licensing related activities performed to establish the design or licensability of the standard plant, including the design and analysis of prototype tests necessary for certification, coordination with NRC and preparation of documents required to obtain NRC certification of the standard plant design.

Standard fuel facility design costs. These costs include the design and engineering of facility and equipment, proof testing of equipment and licensing for any concept. Standard fuel facilities may be either integral to the power plant, central or both.

Technology development costs. See R&D costs.

Transition period. The period starting with the first commercial plant and extending to the NOAK plant.

Transition period plant-specific capital costs. The capital costs for the transition plants. These costs exclude any FOAK costs and include costs for manufacturing of factory equipment, site construction, site-specific engineering, and home office construction support. The transition in costs from the first to NOAK commercial plant and the effects of serial manufacturing and construction should be documented.

Total capital cost. The total capital cost is an all inclusive plant capital cost developed for the purpose of calculating the plant busbar electricity cost. This cost is the base construction cost plus contingency, escalation, and interest-related costs.

Total overnight cost. The total overnight cost is the base construction cost plus applicable contingency costs. It is referred to as an overnight cost in the sense that time value costs (interest during construction and escalation) are not included. Total overnight cost is expressed as a constant dollar amount in reference year dollars.

2. BASE CONSTRUCTION CAPITAL COST GROUND RULES

2.1 COST CATEGORIES

The estimated costs will be reported in eight independent categories as defined in Sect. 1. These are:

1. Technology Development (R&D) costs
2. Standard plant design costs
3. Prototype facility and test costs
4. Standard plant NRC certification costs
5. Standard fuel facility R&D, design, test and certification costs
6. Factory FOAK costs
7. First commercial plant costs
8. NOAK plant costs

If desired, the costs for plants in the transition from the first commercial to the NOAK plant can be given also. In any event, the transition in costs from the first commercial to NOAK commercial plant and the effects of serial manufacturing and construction should be documented.

Costs are to be expressed in constant reference year dollars. All Technology Development (R&D), standard plant design, and NRC certification, prototype and other one-time costs necessary before the first commercial plant can be built, and any one-time costs for the first commercial plant are included in categories 1—6. All categories may not be applicable for a given concept (e.g. a prototype plant may not be needed for all advanced concepts). A sample listing of these first plant tasks is given in Appendix D. All costs in categories 1—6 should be reported in only one category and should not be amortized into the first commercial or subsequent plants except as reflected in site-delivered equipment costs from a dedicated factory (see Sect. 2.2, Item 8). The timing of all expenditures should be identified. Fuel cycle facility construction and operating costs are discussed in Sect. 4.4.

The specification of the costs into categories 1—7 and their time distributions allows these estimates to be combined as appropriate and allows the total expenditures for a concept up through the first commercial plant to be shown as a function of time. If the transition plant costs and NOAK plant costs are included, the costs and time distributions may be combined as appropriate for a given plan of commercialization and allows the total expenditures for a concept to be shown as a function of time.

Distributions of costs in each category are to be presented in a way which is consistent with the way they were estimated. Power plant capital costs must be given in the EEDB format.

All values in the eight categories are defined as costs to the buyer and include supplier profit margins. Representative margins (markup) of 15% for NSSS equipment suppliers and 7% for BOP suppliers are to be used. Vendor prices are to be based on quotations or margins consistent with the economic parameters for industrial organizations given later in the guidelines.

2.2 GENERAL GROUND RULES

This section describes the ground rules to be followed in developing the base construction capital cost for the advanced concepts.

1. The EEDB Code of Accounts will be the structure used for cost estimates and cost accumulation. The EEDB Code of Accounts is an evolutionary expansion and modification of the NUS 531 Code of Accounts. Sample EEDB Code of Accounts for the advanced liquid metal reactor (ALMR), the modular high-temperature gas-cooled reactor (MHTGR), and a light water reactor are given in Appendices A, B, and C, respectively.
2. Detailed cost estimates will be reported in constant January 1 dollars for the year specified by DOE-NE. Current studies should be reported in constant January 1, 1992 dollars.
3. The cost estimates will reflect the plant requirements and design as detailed in the Design Requirements, System Design Descriptions (SDDs), and other formal design documentation. Individual system boundaries will be as defined in the SDDs.
4. The base construction cost estimates will be developed so that they are the most likely cost for a particular EEDB cost entry without any allowance for funds used during construction (AFUDC) (interest), escalation, or contingency allowance as defined in Sect. 3. The cost estimates shall be based on quantities of commodities/materials and

equipment together with unit costs (see Table 2.2). The installation costs shall be based on quantitites, installation rates (see Table 2.3) and labor rates (see Table 2.1).

5. Assumed use of any government-owned or -operated facility shall be costed at full cost recovery, including all direct costs, related indirect costs, depreciation, and any other related general and administrative costs. Inquiries regarding prices and charges to be assumed for specific materials and services shall be made to the Office of Advanced Reactor Programs, DOE-NE.
6. All construction and installation costs may reflect a separated construction concept whereby nuclear-safety grade and Seismic Category 1 construction are separated from conventional industrial (nonnuclear-safety) construction. All costs of equipment, materials, storage, quality assurance (Q/A), quality control (Q/C) and labor productivity for the non-nuclear safety areas will reflect conventional industrial practice. The portions or fractions of the plant constructed under each construction grade shall be documented.
7. As an aid in establishing system-to-system boundaries for costing purposes, the following general guidelines are set forth:
    a. The cost estimate for a system, equipment, facility, or structure shall include those costs associated with fabricating, installing, and/or constructing the particular item described in the SDDs or Building and Structures Design Descriptions (BSDDs).
    b. For costing purposes, the boundaries of a system, facility, or structure are as defined in the SDDs or BSDDs and in the piping and instrumentation diagrams (P&IDs).
    c. The cost for all electrical power terminations, including connectors, shall be borne by the electrical power system. For the trace heating system, the interface with the electrical power system is the individual heater controllers. For building service power and lighting systems, the interface with the electrical power system is the individual power lighting panel.
    d. The expense for terminating instrumentation and control cabling and wiring with the exception of control system fiber optic cabling shall also be included in the electrical power system. This includes terminations with individual sensors as well as providing electrical interconnections between panels, cabinets, consoles, data processing units, controllers, etc. The expense for terminating the control system fiber optics shall be included with the control system.

e. Costs for routing and laying or pulling wire and cable in ducts, conduits, and trays shall be included in the electrical power system.

f. The costs for attachments to structures (e.g., anchor bolts and auxiliary steel) shall be borne by the equipment item requiring the support. Embedments are included in the costs of structures.

8. If the NOAK plant utilizes a dedicated factory for producing construction modules for the NSSS and/or balance of plant (BOP), the amortization of the factory cost over the production life must be included in the NOAK plant cost. The bases for site-delivered cost assumptions should be reported and should include factory construction cash flow, capitalization and amortization assumptions (e.g., number of units assumed for factory capital cost recovery).

2.3 SPECIFIC COST-ESTIMATING ASSUMPTIONS

The following assumptions will be used in developing the base construction cost estimates.

1. Assumptions on the organizational structure to be used in developing the cost estimate are as follows:
   a. Overall project management will be provided by a utility or other entity engaged in the direct production of commercial electricity.
   b. A single RM and a single AE contractor will be employed to design NSSS and other plant equipment, to design plant buildings and structures, to prepare all technical documentation and reports, and to support construction activities.
   c. A single construction manager (CM), which may also be the AE contractor, will be responsible for construction activities.
   d. These assumptions do not exclude a single vendor/supplier entity that would supply and construct commercial facilities.
2. The following assumptions apply to costing the first commercial plant:
   a. The costs for this plant should not include any of the costs included in category 1-6 given in Sect. 2.1 except as reflected in site-delivered equipment costs from a dedicated factory. If there are exceptions to this, these are to be clearly identified.

b. Any learning included in the costing of the plant should reflect that the plant is a first plant. An average learning or cost for a series of plants is not acceptable for the first commercial plant cost estimate.

c. The cost estimate will include the cost for all site-specific licensing or prelicensed sites. A generic plant design approval should be assumed.

d. Plant costs include all engineering, equipment, construction, testing, tooling, project management costs, and any other costs that are repetitive in nature and would be incurred in building an identical plant. A sample listing of repetitive engineering and management tasks is presented in Appendix E.

3. The following assumptions apply to costing the NOAK plant:

a. Design is identical to the first commercial plant.

b. The plant site is enveloped by the reference site conditions.

c. No product improvements are incorporated; that is, the first commercial plant design is frozen.

d. Equipment manufacture and plant construction are performed by the same contractors as for the first plant.

e. There are no changes in NRC regulations or major codes and standards subsequent to the first plant time frame.

f. The cost estimate will include the cost for all site-specific licensing or prelicensed sites. A generic plant design approval should be assumed.

g. Plant costs include all engineering, equipment, construction, testing, tooling, project management costs, and any other costs that are repetitive in nature and would be incurred in building an identical plant. A sample listing of repetitive engineering and management tasks is presented in Appendix E.

4. Labor rates for craftsmen employed to assemble equipment at any on-site fabrication shop will be the same as construction crew rates.

5. All plant construction will be accomplished by force account with exception of those tasks subcontracted by the AE. Costs for all tasks, including subcontracted tasks, must be reported as equipment cost, material cost, and labor hours and cost.

6. Reductions in factory equipment costs due to learning effects may be recognized. Unless a different value is substantiated and documented, the estimator shall use a 94% unit

learning curve (percentage for each item doubling) for estimating individual factory equipment items. The 94% unit learning curve is a composite curve and includes both labor learning and material cost discounts (see item 18). For costing equipment items for the NOAK plant, all concepts must assume that the NOAK plant is that unit whose manufacturing first places the cumulative net production of that type of plant at or in excess of 4500 MW(e). The base or starting point for cost reduction due to learning will be equipment items for the first unit of equipment manufactured for the first commercial power plant. The cost for a given equipment item for the NOAK plant should reflect the cumulative production history for that item as determined by the cumulative item requirements necessary to satisfy the NOAK unit definition above. The learning curve reductions shall apply only to items which are not commercially available, off-the-shelf items. Unless a different value is substantiated and documented, the estimator shall use 97% learning curve for field labor on the same site and 98% from site to site.

7. It will be assumed for the estimates that all engineering information, including specifications and drawings, will be released for construction in time for efficient planning and performance of the work and further that all equipment, material, and labor resources are available as required.
8. It will be assumed that the baseline construction requires no premium time (overtime) work to recover from schedule delays. Costs for possible schedule recovery overtime will be reflected in the contingency cost (see Sect. 3.1). The use of premium time for normal baseline construction over and above a 40-h week should be identified.
9. It will be assumed that funding is available as required to support uninterrupted design, testing, construction, installation, checkout, and plant startup.
10. The industrial non-nuclear-safety portion of each plant is designed and erected to the same standards as a conventional fossil-fuel power plant. Only the nuclear-safety-grade structures and equipment require the more elaborate procedures, documentation, and Q/A—Q/C overview. Any on-site fuel manufacturing, handling, and reprocessing facilities will be assumed to be nuclear-safety-grade.
11. Site conditions for each plant are similar to those at a hypothetical East/West Central site as described in Appendix F:

a. An adequate pool of qualified craft labor is available.

b. There are no unique nuclear or conventional licensing restrictions that would affect plant design, construction, or operation.

c. Estimates cover work within the plant security fence and include the water intake systems and structures.

d. Soil and subsurface conditions are such that no unusual problems are associated with soil-bearing capacity or rock removal, major cut and fill operations, and dewatering.

12. Site land (Account 20) shall be based on the estimated site area, including any buffer zones (500 acre minimum) and a cost of $10,000/acre. It is to be assumed that the total land cost is incurred at the same time as the decision is made to build a plant.

13. Cost items to be excluded from the base construction cost estimate were listed in Table 1.1.

14. The assumptions to be used for the estimates of the Engineering and Home Office Services for all plants are defined in Appendices D and E.

15. Engineering and Home Office Services includes the AE costs for design, engineering, procurement, cost engineering, Q/A—Q/C, reproduction services, etc. (Account 92). Any module fabricator costs for engineering, Q/A etc should be separately shown.

16. Nonrecurring engineering and home office services costs of the RM are assumed to be zero for the first commercial and NOAK plant. Any applicable recurring RM engineering costs should be identified.

17. Composite wage rates (base rate plus fringes) to be used for the site in 1992 dollars are given in Table 2.1 and the cost of major materials is given in Table 2.2.

18. There should be no reduction in field material prices based on quantity discounts. For factory produced modules, an equipment learning curve of 94% was specified (see item 6). The 94% factor includes provision for volume discounts on materials. If labor and material learning is estimated separately, the material price discounts for high volume items should be limited to 10% for NOAK plants. There should be no such discounts for first commercial plants.

Table 2.1. 1992 composite labor crews and rates
Effective date: January 1, 1992

COMPOSITE CREWS

Craft	Wage rate $/h	Concrete		Structural		Earthwork		Mechanical equipment		Piping		Instrumentation		Electrical	
		Formwork, rebar, embeds, concrete		Str. steel, misc. iron and architectural		Clearing, excava., backfill		Installation		Installation		Installation		Installation	
		%	Contr.	%	Contr.	%	Contr.	%	Contr.	%	Contr.	%	Contr.	%	Contr.
Boiler maker	24.55							15	3.68						
Carpenter	24.01	40	9.60	5	1.20									2	0.48
Electrician	27.09											70	18.96	96	26.01
Iron Worker	27.48	20	5.50	75	20.61			10	2.75						
Laborer	20.94	30	6.28	5	1.05	60	12.56							1	0.21
Millwright	22.47							25	5.62						
Operating Engr.	25.49	5	1.27	15	3.82	35	8.92	12	3.06	15	3.82	2	0.51	1	0.25
Pipefitter	25.48							35	8.92	80	20.38	28	7.14		
Teamster	16.15					5	0.81	3	0.48	5	0.81				
Others	22.81	5	1.14												
		100	23.80	100	26.68	100	22.30	100	24.51	100	25.02	100	26.61	100	26.95

Table 2.2. Cost of Major Materials - Bulk

Effective Date: January 1, 1992

Commodity	Unit of measure	Nuclear $	Non-nuclear $
STRUCTURAL COMMODITIES			
Formwork	SF	2.00	1.85
Decking	SF	5.00	3.00
Reinforcing steel	TN	700.00	450.00
Embedded metal	LB	2.50	1.50
Concrete	CY	90.00	60.00
Structural steel	TN	3,100.00	1,400.00
Miscellaneous steel	TN	6,000.00	3,000.00
PIPING COMMODITIES			
2 in. and under screwed pipe	LF	26.00	21.00
2 in and under CS welded pipe	LF	36.00	26.00
2 in. and under CM welded pipe	LF	50.00	38.00
2 in. and under SS welded pipe	LF	50.00	38.00
4 in. CS sch 40 (0.237 in.) spooled pipe	LF	88.00	38.00
4 in. CM sch 40 (0.237 in.) spooled pipe	LF	175.00	100.00
4 in. SS sch 40 (0.237 in.) spooled pipe	LF	210.00	125.00
12 in. CS sch 80 (0.688 in.) spooled pipe	LF	400.00	360.00
12 in. CM sch 80 (0.688 in.) spooled pipe	LF	810.00	750.00
12 in. SS sch 80 (0.688 in.) spooled pipe	LF	1,260.00	1,210.00
20 in. CS sch 120 (1.50 in.) spooled pipe	LF	1,100.00	1,040.00
ELECTRICAL COMMODITIES			
2 in. dia. rigid steel exposed conduit	LF	7.50	5.00
4 in. dia. non-metallic duct bank conduit	LF	3.60	2.90
24 in. × 3 in. aluminum cable tray	LF	16.20	10.80
600 volt power and control cable (Avg. 5 C, #12)	LF	2.10	1.70
600 volt instrumentation cable (Avg. 2 Pr., Shld, #18)	LF	1.10	0.90
5-15 kV power cable (Avg. 3 C, #250)	LF	5.50	4.40
600 volt connections	EA	2.00	1.00
5-15 kV connections	EA	95.00	65.00

Table 2.3. Bulk Commodity Unit Hour Installation Rates
(man hours/unit)

Commodity	Unit of measure	Nuclear	Non-nuclear
STRUCTURAL COMMODITIES			
Formwork - substructure	SF	0.64	0.48
Formwork - superstructure	SF	1.12	0.84
Decking	SF	0.16	0.12
Reinforcing steel - substructure	TN	32.00	24.00
Reinforcing steel - superstructure	TN	40.00	30.00
Embedded metal	LB	0.11	0.08
Concrete - substructure	CY	2.00	1.50
Concrete - superstructure	CY	4.00	3.00
Structural steel	TN	64.00	14.40
Miscellaneous steel	TN	120.00	72.00
PIPING COMMODITIES			
2 in. and under screwed pipe	LF	3.46	1.30
2 in. and under CS welded pipe	LF	5.18	1.94
2 in. and under CM welded pipe	LF	8.06	3.02
2 in. and under SS welded pipe	LF	10.37	3.89
4 in. CS sch 40 (0.237 in.) spooled pipe	LF	5.70	2.14
4 in. CM sch 40 (0.237 in.) spooled pipe	LF	13.71	5.14
4 in. SS sch 40 (0.237 in.) spooled pipe	LF	11.40	4.28
12 in. CS sch 80 (0.688 in.) spooled pipe	LF	13.41	5.03
12 in. CM sch 80 (0.688 in.) spooled pipe	LF	29.02	10.88
12 in. SS sch 80 (0.688 in.) spooled pipe	LF	26.82	10.06
20 in. CS sch 120 (1.50 in.) spooled pipe	LF	42.62	15.98
ELECTRICAL COMMODITIES			
2 in. dia. rigid steel exposed conduit	LF	1.26	0.58
4 in. dia. non-metallic duct bank conduit	LF	0.35	0.16
24 in. × 3 in. aluminum cable tray	LF	2.88	1.32
600 volt power and control cable	LF	0.13	0.06

Table 2.3. (continued)

Commodity	Unit of measure	Nuclear	Non-nuclear
600 volt instrumentation cable	LF	0.11	0.05
5-15 kV power cable	LF	0.54	0.25
600 volt connections	EA	0.88	0.41
5-15 kV connections	EA	20.80	9.40
INSTRUMENTATION			
Control panel	LF	96.00	36.00
Field-mounted instrument	EA	12.80	4.80
Instrument tube	LF	0.96	0.72

Table 2.4. Commodity definitions

Description	Commodity content
FORMWORK	Supply, preparation, assembly, installation, removal and disposal of forming material. Commodity starting point assumes that forms are wooden and reused.
DECKING	Supply, preparation, and installation of metal decking used to form concrete slabs. Decking is assumed to be galvanized steel, and remains in place after concrete is set. Area take-off is exact, and material cost includes overlap, and waste, corrugated filler, spotwelding, and other installation aids as needed.
REINFORCING STEEL	Supply of straight bars or vendor-bent bars of reinforcing steel, including necessary materials for supports and field joints. Weight take-off or estimate is for rebar only. Material cost includes supports, joints and related additional material.
EMBEDDED METAL	Supply, preparation and installation of embedments, including nelson studs or other weldments as needed.
CONCRETE	Supply, delivery and placement within the site of mixed structural concrete, with nominal 3000 psi compressive strength. Assumed mixed in a dedicated on-site batch plant. Values include heat control or ice addition, patch and sack, curing mixes, hardeners, expansion and construction or seismic joint materials, if needed.
STRUCTURAL STEEL	Supply, preparation, installation, alignment, and bolting or welding of prefabricated painted steel shapes and structures. Includes column base plates, grouting, touch-up painting, etc.
MISCELLANEOUS STEEL	Supply, preparation, installation, alignment, and bolting or welding of prefabricated painted steel shapes, structures, and components. This commodity includes stairs, platforms, hand railings, toe plate, door and opening frames, grating, checker plate, etc.
PIPING COMMODITIES	Piping commodities include pipe, fittings, hangers and supports, installation, alignment and tack-welding (when appropriate), welding, and post-weld heat treatment if necessary. Installation includes non-destructive testing, flushing, and hydrotesting. Piping excludes the material cost of valves, but includes the installation labor for valves. Separate commodities are used for insulation, vacuum jacketing, heat tracing, and painting. Piping 2 in. and smaller is predominantly supplied as straight run material and field fabricated or on-site pre-fabricated. Larger piping is predominantly shop prefabricated and supplied to the field as spoolpieces. Only joints needed to allow shipping and installation are installed in the field.
ELECTRICAL CONDUIT	Supply and installation of electrical conduit, including hinges, supports, attachments, fittings including installation devices such as pull boxes.
CABLE TRAY	Supply and installation of electrical cable tray, including hangers, supports, connecting pieces, barriers, covers, etc.
ELECTRICAL AND INSTRUMENT CABLE	Supply and installation of electrical conductors, including tray ties and other installation aids. Excludes conduit, tray, and terminations. Electrical terminations include cable end preparation and supply and installation of connectors, lugs, boots, taps, ferrules, clamps, etc.

19. Bulk commodity unit hour installation rates are given in Table 2.3 for nuclear and non-nuclear construction practices. Bulk commodity definitions are given in Table 2.4. The data in Tables 2.2-2.4 were obtained from actual architect/engineer cost experience.[6] Material unit rates were obtained from an aggregate of current commodity vendor data. Labor installation rates were developed by applying a productivity factor to estimating standard rates. Nuclear productivity factors were developed from a set of early nuclear projects, which did not undergo the upset and turmoil of the post-TMI backfitting experience. Non-nuclear installation rates were developed from current fossil power project experience. While these data values may not be the absolute best that can be achieved under the licensing and construction environment described by these groundrules, they represent a data set sufficient for the preparation of consistent conceptual cost estimates. The bulk commodity unit costs (Table 2.2) and installation rates (Table 2.3) do not comprise the complete set of such information needed to cost a plant design. Any exception to the labor rates, commodity prices and installation manhours shown on Tables 2.1, 2.2, and 2.3 shall be justified.

20. Capital costs shall be separated into two categories related to whether the equipment/construction is nuclear-safety-grade or industrial non-nuclear-safety-grade. The plant design contractor (RM's and AE's) shall determine the boundaries of the nuclear-safety-grade and industrial non-nuclear-safety grade areas. Costs within each category will be reported in EEDB format as illustrated in Appendices A, B, and C.

21. Although included and reported in the overall plant estimate, costs of common plant facilities will, in addition, be identified at the two digit account level and listed separately in EEDB format as discussed above.

22. In cases where equipment items or piping are combined with structural members to produce a factory-assembled equipment module, a work sheet documenting each module should be prepared. The work sheet will identify by three-digit EEDB account the applicable items and costs that comprise the module. For each three-digit account, the work sheet will provide the equipment and material costs, shop and field labor hours and costs, factory overhead and profit, freight, and total module cost. In addition, the text must describe the approach used to estimate each of the cost items. In regard to the total plant cost estimate, three-digit level costs for items that are part of a factory

module must remain in the EEDB account that represents that particular item i.e., costs for structural portions of a module should be reported in Account 21 and equipment/ piping costs should be reported in the relevant system account (Accounts 22-26).[3] The total factory cost, including shop labor and materials, should be recorded as factory equipment costs in the EEDB cost estimate format. Field labor to install a module should be recorded as site labor in the EEDB estimate format. Labor costs to produce and/or install a module may be prorated among the related three-digit EEDB accounts, if necessary. The basis for cost-related assumptions regarding the module factory must be documented. Such assumptions include factory location, factory labor rates, labor unit productivity, factory overhead, and module shipping cost assumptions. The wage rates for factory craft workers should be based on the field craft labor data for the factory site. Any adjustments to the labor rates to reflect the factory environment must be fully supported in the cost estimate report.

23. For large equipment items and modules, the site delivered transportation costs are to be identified as a line item.

24. For large factory equipment items such as the reactor vessel and internals, steam generators, heat exchangers, etc., supporting cost data by component must be available for review. The supporting data will include factory material cost, material weights, factory man-hours, recurring cost, and total cost for each equipment item.

25. The heat rejection system will be designed for the site conditions as described in Appendix F such that the turbine exhaust pressure will be at or below the design value 91% of the time.

26. The estimator will use cost information relevant to the reference date (January 1, 1992 for current studies) where possible. If such information is not available, costs in terms of another reference year may be adjusted, where applicable, using appropriate cost indices. Examples of such adjustment factors using both the Gross Domestic Product Implicit price deflator[7] and the Handy-Whitman cost index[8] for Nuclear Production Plant Electric Utility construction costs (North Central region) are given in Table 2.5.

Table 2.5. Escalation adjustment factors[a]

Initial year[b]	Implicit price deflation[c]	Nuclear plant cost adjustment factors[d]					
		EEDB account number					
		21	22	23	24	25	Total
1987	1.203	1.120	1.197	1.162	1.277	1.167	1.178
1988	1.165	1.072	1.108	1.106	1.242	1.119	1.111
1989	1.118	1.050	1.072	1.056	1.073	1.074	1.066
1990	1.073	1.020	1.031	1.067	1.059	1.039	1.028
1991	1.030	1.004	1.014	1.010	1.022	1.013	1.010
1992	1.0	1.0	1.0	1.0	1.0	1.0	1.0

[a]Cost escalation factors from initial year to January 1, 1992.

[b]January 1 of dates shown.

[c]Increase from 4th quarter of previous year until 4th quarter of 1991, Source: Ref. 7.

[d]Source: Ref. 8. Nuclear Production plant Electric Utility construction cost index for North Central region.

2.4 EEDB COST ACCOUNT DEFINITIONS

2.4.1 Direct Cost Accounts

Direct costs include those construction and installation costs directly associated with the operating plant structures, systems, and components. At the two digit level of detail, the direct cost accounts include: land and land rights (20), structures and improvements (21), reactor plant equipment (22), turbine plant equipment (23), electric plant equipment (24), miscellaneous plant equipment (25), and the main condenser heat reject system (26). Each account is divided into equipment, site labor and site material costs as described below.

2.4.1.1 Equipment Costs

Equipment costs include the costs for all design, analysis, fabrication, documentation preparation, predelivery testing, and follow-up engineering performed by equipment vendors; materials for all plant equipment; equipment; transportation and insurance expenses; provision of shipping fixtures and skids; warranties; preparation of maintenance and operations manuals and handling instructions; delivery of startup and acceptance test equipment; on-site unloading and receiving inspection expenses; and overhead expenses.

All plant equipment items, whether directly associated with the power generation systems or the facility systems, such as heating and ventilation, are included in this category.

For the equipment fabricated and/or assembled at an on-site fabrication facility, all the associated costs are included as equipment costs, including the fabrication and/or assembly costs and the costs to move the equipment within the facility to its on-site receiving or storage point. The on-site labor related to installation of shop fabricated modules should be included in the field labor and not as factory equipment. Field labor rates should be used for any on-site fabrication facility.

2.4.1.2 Site Labor Cost

The site labor portion of the construction and equipment installation costs includes all on-site activities related to permanent plant structures, systems, and equipment required for all aspects of power plant operation.

The direct costs of all work crews and foremen to excavate, backfill, erect, and finish structures and to place and install equipment, piping, wiring, modules, etc. are included.

Labor rates for this work include base rates, fringe benefits, and any travel or subsistence allowances.

All direct construction and installation costs are on a force account basis (see Sect. 1.2).

For this estimate, the costs associated with installing equipment items for both NSSS and BOP systems include the labor to transport the equipment from on-site storage or the on-site fabrication facility to the final resting place as well as the labor to align the equipment, physically attach it to the supporting structure and test it. In addition, the labor costs for providing mechanical hookups and electrical connections between interfacing systems will be included.

2.4.1.3 Site Materials Cost

Site materials include all materials purchased in the field and/or bulk items such as paint, concrete, rebar, welding rod, formwork, etc. All piping, less than 2-1/2-in. nominal pipe size, is a materials item with the exception of pipe for cryogenic fluids. Also all wire, cable, and raceways except the control system fiber optic cabling are material items, including those in building service power systems. The control system fiber optic cabling shall be included with the control system equipment.

2.4.2 Indirect Cost Accounts

The indirect cost accounts include those construction support activities required to design and build the structures and systems described in the direct cost accounts. At the two-digit account level of detail, the indirect cost accounts collect the costs for construction services, home office engineering and services, field office engineering and services and owner's cost. A bottoms up estimate for indirect costs is recommended. The cost estimate procedure should be fully documented by the estimator.

The following subsections provide a description of the indirect costs by three-digit EEDB accounts.

2.4.2.1 Construction Services Costs (Account 91)

Construction services (Account 91) includes costs for CM-related activities associated with construction as indicated below:

Temporary construction facilities (Account 911). This subaccount includes temporary structures and facilities, janitorial services, maintenance of temporary facilities, guards and security, roads, parking lots, laydown areas, and temporary electrical, heat, air, steam and water systems, general cleanup, etc.

Construction tools and equipment (Account 912). Construction tools and equipment include rental and/or purchase of construction equipment, small tools and consumables (fuel, lubricants, etc.), as well as maintenance of construction equipment.

Payroll insurance and taxes (Account 913). These expenses include insurance and taxes related to craft labor (direct and indirect including guards and janitors), such as social security taxes and state unemployment taxes, workmen's compensation insurance, and public liability and property damage insurance.

Permits, insurance and local taxes (Account 914). Consistent with other EEDB-type estimates, builders all-risk insurance will be the only cost included in Account 914. Payments to federal, state, and local governments for taxes, fees, and permits are to be included in Account 942 because they are plant specific.

2.4.2.2 Engineering and Home Office Services Costs (Account 92)

Engineering and home office services are site specific and include all AE management, engineering design, licensing and associated support activities. The costs for these services include salaries, direct payroll-related costs (DPC), overhead loading expenses, and fees for these services. This cost element includes activities as given below.

Reactor Module Engineering and Services (Account 920). These costs include site specific reactor module engineering and licensing (both field and home office), procurement and expediting activities, estimating and cost control, engineering planning and scheduling, reproduction services, and expenses associated with the above functions. These costs may be included in the cost of the NSSS package but should be broken out separately.

AE Engineering and home office expenses (Account 921). These costs include AE engineering and design (both field and home office), procurement and expediting activities, estimating and cost control, engineering planning and scheduling, reproduction services, and expenses associated with performance of the above functions (i.e., telephone, postage, computer use, travel, etc.).

AE Home office quality assurance (Account 922). This account includes the services of home office QA engineers and staff personnel engaged in work on the project. Services include reviews, audits, vendor surveillance, etc. as required for design and construction of the nuclear safety-related portion of the facility.

AE Home office project management (Account 923). These services include those of the construction manager and his assistants. Services of construction planning and scheduling, construction methods, labor relations, safety, and security personnel are utilized as required.

2.4.2.3 Field Supervision and Field Office Services Costs (Account 93)

Field Supervision and Field Office Services (Account 93) includes costs for CM-related activities associated with on-site management of construction, site Q/A, startup and test, and the supporting costs for these functions as indicated below. Costs of these services include salaries, DPC, overhead loading, relocation costs of key personnel, and fees.

Field office expenses (Account 931). These expenses include costs associated with purchase and/or rental of furniture and equipment (including reproduction), communication charges, postage, stationery, other office supplies, first aid, and medical expenses.

Field job supervision (Account 932). This management function includes the resident construction superintendent and his assistants; craft labor supervisors; field accounting, payroll, and administrative personnel; field construction schedulers; field purchasing personnel; warehousemen; survey parties; stenographers; and clerical personnel.

Field QA/QC (Account 933). These services include those of personnel located at the job site engaged in equipment inspection, required documentation of safety-related equipment, inspection of construction activities, and construction training meetings.

Plant startup and test (Account 934). These services are associated with preparation of startup and plant operation manuals and test procedures, direction and supervision of testing of equipment and systems as the plant nears completion, and direction of startup of the facility. Costs of any craft labor required for startup and testing activities are included in the appropriate direct-cost line items.

2.4.2.4 Owners' Cost (Account 94)

Owners' cost (Account 94) includes the costs of the owner for activities associated with the overall management and integration of the project and other costs not included in the direct capital costs incurred prior to start of commercial operations as follows:

Management, engineering, integration, and QA/QC (Account 941). These expenses include cost of owner's staff for project management, engineering, integration, licensing, control, and QA/QC. It also includes supporting home office services such as estimating, planning and scheduling, and purchasing, as well as payment for outside supporting service directly associated with siting, building and startup of the plant.

Taxes and insurance (Account 942). These expenses cover all owner's nuclear and other insurance premiums, state and local taxes and sales taxes on purchased materials and equipment incurred during the course of the project, and permits, licenses, and fees. Builder's all risk insurance is included in Account 914.

Spare parts and initial supplies (Account 943). This account includes the initial stock of supplies, consumables and spare parts needed for testing and startup operations and the plant inventories of fluids (water, lub oils), fuels (excluding nuclear fuel) and chemicals. Office furniture, communication equipment, transportation vehicles, laboratory equipment, house keeping gear, and other utility specific equipment are also part of this account. A good Reliability Centered Maintenance (RCM) program should be assumed and spare parts costs should reflect standard plants and modular plants and use of spare parts pools as applicable. Special coolants are not included here but in account 946.

Staff Training and Startup (Account 944). The costs of the initial staffing and training of maintenance, operating, supervisory and administrative personnel are included in this account. This includes the preparation of all training materials and instruction costs, the salaries of the operating and the maintenance staff assigned to the plant prior to the plant acceptance, and their associated material and service expenses.

General and Administrative (G&A) (Account 945). This includes administrative and general salaries plus related expenses, labor and certain regulatory expenses, outside services not applicable to other owner accounts, and public relation activities.

Capital equipment (Account 946). This item includes costs for any special coolants such as sodium, helium or heavy water for the initial loading of the plant systems.

It is preferred that owner's cost be estimated directly by consideration of the contents of each subaccount. If such an estimate is not possible, it is recommended that total owner's cost (Account 94) be estimated as 15% of the sum of the total direct and other indirect costs plus the cost of any special coolants.

2.4.2.5 RM Home Office Engineering and Services (Account 95)

This account includes all the costs of RM services and support that are over and above the normal charges included in the cost of an NSSS package (EEDB Account 220A).

2.5 BASE CONSTRUCTION CAPITAL COST DOCUMENTATION

Specific reporting requirements will be determined by DOE Program Management. The following documentation guidelines represent possible reporting requirements.

2.5.1 Cost Reports

As determined by DOE, separate cost estimates for the first commercial and NOAK plant may be required. Each separate cost set will be documented, separating the nuclear island costs from the balance of plant costs, using the EEDB tabular format and Code of Accounts according to the format in Table 2.6. Typical Code of Accounts for the ALMR, MHTGR and LWRs are provided in Appendices A—C. In addition to tabular cost data, a complete text description of the methods and assumptions used in developing the costs shall be submitted with the cost data. As discussed in Sect. 2.3, documentation on factory-produced equipment modules should include a work sheet for each different module. Examples of how the factory module costs fit into the EEDB code of accounts should be given. A suggested work sheet format is provided in Table 2.7.

2.5.2 Plant Bulk Commodities Data

To make commodity comparisons with competing plant concepts, the commodities listed below shall be reported as indicated at the two-digit EEDB level. Additional account detailed breakdowns should be retained by the proponent for review by DOE.

- Formwork [square feet (SF)] — Both wooden and metal forms are included.
- Structural steel [tons (TN)] — All structural steel is included regardless of whether it is used in modules or is field erected for both safety or nonsafety class structures.
- Reinforcing steel [tons (TN)] — The quantities for cadwelds and wire fabric are not included.
- Embedded steel [tons (TN)] — All embedded steel is included regardless of whether it is used in safety or nonsafety class structures.
- Structural concrete [cubic yards (CY)] — The costs for removable concrete plugs and for curbs and walks are not included. All structural concrete is included regardless of whether it is used in safety-class or non-safety-class structures, whether it is in internal or external walls, or whether it is in floor or elevated slabs.
- Concrete fill [cubic yards (CY)] — All fill concrete is included regardless of its location or purpose except when included as part of a module.
- Piping [linear ft (LF)] — The following subcategories are required:

  CS, SC, <2 1/2-in. pipe
  SS, SC, <2 1/2-in. pipe
  CS, SC, ≥2 1/2-in. pipe
  SS, SC, ≥2 1/2-in. pipe
  CM, SC, ≥2 1/2-in. pipe
  CS, NNS, <2 1/2-in. pipe
  SS, NNS, <2 1/2-in. pipe
  CS, NNS, ≥2 1/2-in. pipe
  SS, NNS, ≥2 1/2-in. pipe
  CM, NNS, ≥2 1/2-in. pipe

Table 2.6. Plant base construction cost estimate
(Costs in millions of 1992$)
(Manhours in thousands)

Account No.	Account description	Nuclear Island (NI)					Balance of Plant (BOP)				
		Factory equipment	Site labor hours	Site labor cost	Site material	Total NI	Factory equipment	Site labor hours	Site labor cost	Site material	Total BOP
20	Land and land rights										
21	Structures and improvements										
22	Reactor plant equipment										
23	Turbine plant equipment										
24	Electric plant equipment										
25	Miscellaneous plant equipment										
26	Heat rejection system										
2	Total direct costs										
	Total direct manhours										
91	Construction services										
92	Home office engineering & services										
93	Field office and services										
94	Owner's cost										
9	Total indirects										
	Total base construction costs										
	Total base construction manhours										

Table 2.7. Factory module cost work sheet
Module ________________

	Factory cost							Field cost	
EEDB account	Equipment	MH	Labor	Matl.	Overhead and profit	Freight	Total	MH	Labor

where

CS = carbon steel,

SS = stainless steel,

CM = chrome moly steel,

SC = safety class,

NNS = non-nuclear-safety class.

These ten categories of piping do not include the following:

1. concrete, copper, cast iron, and galvanized pipe;
2. roof and floor drains piping;
3. sprinkler systems piping; and
4. sanitary facilities piping.

- Power cable [linear feet (LF)]

  This category should exclude lighting, cathodic protection, communication and heat tracing cable.
- Control cable and instrumentation cable.
- Wire and cable duct runs and containers [linear feet (LF)]—This account includes:

  1. underground and above ground,
  2. metallic and nonmetallic ducts, conduit, and
  3. cable trays.

  This category should exclude lighting, cathodic protection, communication and heat tracing cable.

Bulk commodities should be reported by EEDB Code of Accounts as shown in Table 2.8.

2.5.3 Plant Labor Requirements Data

Craft and engineering labor requirements will be summarized by two-digit direct and indirect cost accounts as well as by total plant. Three-digit detail should be retained by the

Table 2.8. Plant bulk commodities

Bulk Commodity	Units	Account 21		Account 22		Account 23		Account 24		Account 25		Account 26		Total		Total Plant
		Nuclear	Non-nuclear	Nuclear	Non-nuclear	Nuclear	Non-nuclear	Nuclear	Non-nuclear	Nuclear	Non-nuclear	Nuclear	Non-nuclear	Nuclear	Non-nuclear	
Formwork	SF															
Structural Steel	TN															
Reinforcing Steel	TN															
Embedded Steel	TN															
Structural Concrete	CY															
Concrete Fill	CY															
CS<2.5 inch Pipe	LF															
SS<2.5 inch Pipe	LF															
CS ≥ 2.5 inch Pipe	LF															
SS ≥ 2.5 inch Pipe	LF															
CM ≥ 2.5 inch Pipe	LF															
Wire and Cable	LF															
Wire and Cable Tray	LF															

Note: Material items used on the nuclear island are nuclear safety grade and those in the energy conversion area are non-nuclear safety grade per Tables 2.2 and 2.3.

proponent for review by DOE. Specific, individual, manhour data will be provided for the following workers if utilized: boilermakers, bricklayers, carpenters, electricians, ironworkers, laborers, millwrights, operating engineers, painters, pipefitters, sheet metal workers, teamsters, other craft labor, engineering, and other noncraft home and field office labor. An example format is shown in Table 2.9.

Table 2.9. Plant labor requirments (manhours)

	Account Number										
	21	22	23	24	25	26	91	92	93	94	Total
Labor type	(h)	(h)	(h)	(h)	(h)	(h)	(h)	(h)	(h)	(h)	(h)
Boilermaker											
Carpenter											
Electrician											
Iron worker											
Laborer											
Millwright											
Operating engineer											
Pipefitter											
Teamster											
Other craft labor											
Engineering											
Other Non-craft labor											
Total hours											

2.6 DEVELOPMENT AND PROTOTYPE COST DOCUMENTATION

The expected technology, design, prototype and certification costs (cost categories 1-6 in Sect. 2.1) will be itemized and expressed in constant dollars as defined in Sect. 2.2 (Item 2). These include all costs necessary to bring a concept to commercialization. Both a 50/50 and 90/10 confidence level estimate is desired. The timing of each cost item (at 50% confidence level) shall be identified. The cash flows for these items may be provided on an annual basis. The report format is given in Table 2.10. The prototype construction cost should be reported at the two digit level. In addition to tabular cost data, a complete text description of the methods and assumptions used in developing the costs shall be submitted with the cost data.

Table 2.10. Development/prototype costs
(thousands of January 199_ dollar)

Technology (R&D) Costs	
Standard Plant Design	
Preliminary Design	
Detailed Design	
Prototype/Demonstration Module	
Design	
Construction	
Direct Cost	
Indirect Cost	
Fuel	
Testing and Operation	
Standard Plant NRC Certification	
Fuel Facility Design and Certification	
Factory FOAK Costs	

3. TOTAL CAPITAL COST

This section provides the ground rules for preparing an esti[illegible]e total capital cost of a power plant. The base construction capital cost as described in the previous section is the starting point for costs developed in this section. The total capital cost shall be calculated in nominal dollars (including inflation) to the operation date and then adjusted to the reference years dollars.

3.1 CONTINGENCY

Contingency is a judgement adder to the base construction cost estimate to obtain a median cost estimate where there is equal probability that the true cost will be higher or lower than that cost (see Appendix H). It includes an allowance for indeterminates and shall be calculated as a percentage of base construction cost. However, different percentages should be used for different systems or components in a plant because the amount of the contingency cost should be related to the stage or current level of design, the degree of technological advance represented by the design, and the quality/reliability level of the given system/component. As an example, it should be possible to estimate the cost for a standard mechanical draft cooling tower system more accurately (therefore requiring less contingency) than the cost for a new, innovative NSSS. To obtain consistency between various cost estimates, the percentages and requirements for their use are defined as follows.

A contingency cost of 25% of the applicable base cost shall be calculated for those systems that are innovative, that represent a substantial departure from previously built designs, or that require a high assurance of quality in construction and operation (e.g., nuclear-safety grade systems). For systems or components that are standard, current, off-the-shelf technology items that are being applied in a normal, industrial non-nuclear-safety grade application, a contingency cost of 15% of the applicable base cost shall be calculated.

In cases where the scope and level of design provide for accurate quantity takeoffs and material and labor pricing, a lower contingency may be justified. Where design margins are substantial (for example, if a turbine-generator has a capability far higher than design output), a lower contingency may also be justified. In other cases where design definition is limited and prices are uncertain, a higher contingency value may be justified. The estimators may assess individual contingency amounts at the detailed account level. In those cases that the estimator departs from the basic 15% and 25% contingency rates, the details and reasons for the deviation shall be shown. The total contingency cost to be reported will be the sum of the contributions from each system or component category, and will include the expected value of cost items not explicitly covered in the detailed estimate (allowance for indeterminates). Contingency amounts for indirect base costs shall be calculated as above, based on an estimation of the proportion of the contingency reflected in that particular indirect cost. The assumptions used in classifying the direct and indirect base costs according to the two categories must be fully documented by the estimator in detail.

The contingency estimate will be expressed in the same year's dollars as the base construction costs.

3.2 CASH FLOW

The cash flow requirements during the design and construction period will be determined on a quarterly basis for the prototype, first commercial and NOAK plants as required. The cash flow should be expressed in the same year's dollars as the overnight costs and should indicate whether contingency costs are included. Contingency costs must be explicitly included in the cash flow data if it is not assumed that contingency cash flow is proportional to base cost cash flow. Time effects such as escalation/inflation and interest should not be included in this cash flow data. As a result of the exclusion of escalation, the dates of cash flow may be expressed as either a relative or absolute date with respect to commercial operation. In addition, cash flows may be provided which include inflation.

3.3 ESCALATION

It is to be assumed that escalation during the design and construction period is occurring at the same rate as inflation; that is, there is no real escalation during this period. Costs will escalate between the reference year given in Sect. 2.2 (item 2) and the time the money is spent. It will be assumed that the money spent during any quarterly period will be paid at the beginning of the period. Total escalation during construction may be computed using the following formula

$$\text{Allowance for escalation} = \sum_{j=1}^{J} C_j (1 + i)^{t_j - t_o} - \sum_{j=1}^{J} C_j$$

where

j = quarterly cash flow period

J = total number of cash flow periods

C_j = quarterly cash flow (base year dollars) during period j assumed paid at beginning of period.

i = inflation rate, fraction

t_j = date at beginning of quarterly period (i.e., 2001.25)

t_o = reference date from Sect. 2.1 (i.e., 1992.0).

When the total cost is expressed in constant dollars for the year given in Sect. 2.2, escalation will be zero when expressed in constant dollars.

3.4 INTEREST DURING CONSTRUCTION

Once money is raised and the construction payment is made, a return must be paid on it until first operation. This return is sometimes referred to as the allowance for funds used during construction (AFUDC) or, more simply, the interest during construction (IDC). The IDC rate is the average cost of money (X) and includes both equity and debt capital used to finance a project. The financial parameters for utility ownership given in Table 3.1 are those from the DOE NECDB[5] and are to be used in determining IDC costs. It should be noted that the Tax Reform Act of 1986 no longer allows bond interest to be expensed (allowed as a tax deduction) during construction, but requires that it be fully capitalized. Thus, the average and not the tax-adjusted cost of money must be used in calculating interest during construction.

Table 3.1. Financial parameters

Parameters	Utility	Industrial[a]	High leverage[b]
Capitalization, %			
Debt	50	30	70
Preferred stock	10	-	-
Common equity	40	70	30
Return on capitalization, %/year			
Debt interest	9.7	9.7	13.0
Preferred dividend	9.0	-	-
Common equity return	14.0	17	22.0
Average cost of money, %/year	11.35	14.81	15.7
Ratio of cost of debt/average cost of money	0.427	0.196	0.580
Inflation rate, %/year	5.0	5.0	5.0
Real (inflation-adjusted) average cost of money, %/year	6.05	9.34	10.19

[a]Typically financed industrial company or conservatively financed independent power producer.

[b]Highly leveraged independent power producer or similar organization.

In addition to financial parameters for utility ownership, parameters for typically financed industrial ownership and for a more highly leveraged industrial ownership are also given. These latter two financial structures should cover the range for an independent power producers (IPP). An organization which is too highly leveraged (high debt ratio with debt of "Junk bond" quality) may not have the stability acceptable for operation of a nuclear plant. Costs are to be provided assuming utility ownership of the power plant. Any on-site fuel cycle facilities which are integral to the reactor plant are assumed to be utility owned and subject to utility financial assumptions. Off-site facilities, such as a central fuel cycle facility, and any module factories are to be assumed to be industrial owned and subject to the typical industrial parameters. Non-integral on-site fuel cycle facilities are also subject to industrial financial parameters. Nominal dollar interest will be calculated using the cash flow summaries developed in Sect. 3.2, and the inflation/escalation rates and average cost of money shown in Table 3.1. All interest costs will be capitalized up to the commercial operation date using the following method.

$$IDC_N = \sum_{j=1}^{J} C_j \, (1 + i)^{t_j - t_o} \left[(1 + X)^{t_{op} - t_j} - 1\right]$$

where

IDC_N = nominal dollar IDC cost

t_{op} = year of commercial operation

X = nominal dollar average cost of money.

The cash flows (C_j) reflect quarterly, beginning-of-period borrowing. Although the IDC should be calculated in nominal dollars in order to correctly determine the fraction of the initial investment which may be depreciated for tax purposes, capital costs and interest costs should be expressed in constant dollars of the reference year given in Sect. 2.2. This IDC cost is given by

$$IDC_o = \sum_{j=1}^{J} C_j \left[(1 + X_o)^{t_{op} - t_j} - 1\right].$$

The real average cost of money, X_o, may be computed from the nominal dollar average cost of money, X and the inflation rate, i, using the expression

$$X_o = (1 + X)/(1 + i) - 1 .$$

If the cash flow data developed in Sect. 3.2 does not explicitly contain contingency costs, then the interest calculated using the cash flow summaries must be adjusted by the ratio of the total overnight cost to base construction cost as follows:

$$IDC_{total} = \frac{\text{base cost + contingency}}{\text{base cost}} \times IDC_{\text{base cost}} .$$

3.5 TOTAL CAPITAL COST

Total capital cost (TCC) will consist of the base construction cost as developed in Sect. 2, contingency, escalation, and interest during construction. All costs will be expressed in constant dollars in the year defined in Sect. 2.2 and separated into nuclear-safety grade, nonnuclear-safety grade, and total cost. Table 3.2 provides the format to be used in reporting total capital cost. In addition to constant dollars, costs may be expressed in nominal dollars. The total capital cost in nominal dollars differs from that in constant dollars by the total inflation between the reference year and year of startup,

$$TCC_N = TCC_o(1 + i)^{t_s - t_o}$$

where

TCC_N = nominal dollar total capital cost

TCC_o = constant dollar total capital cost

i = inflation rate.

Table 3.2. Plant total capital cost estimate
(thousands of January 199_ dollars)

EEDB Account No.	Account description	Nuclear-safety grade cost	Non-nuclear-safety grade cost	Total cost
20	Land and land rights			
21	Structures and improvements			
22	Reactor plant equipment			
23	Turbine plant equipment			
24	Electric plant equipment			
25	Miscellaneous plant equipment			
26	Main condenser heat rejection system	______	______	______
	Total direct cost			
91	Construction services			
92	AE home office engineering and services			
93	Field office supervision and services			
94	Owner's expenses			
95	RM home office engineering and services	______	______	______
	Total indirect costs			
	BASE CONSTRUCTION COST - Total $ - $/kW(e)			
	CONTINGENCY			
	TOTAL OVERNIGHT COST - Total $ - $/kW(e)			
	ESCALATION			
	INTEREST DURING CONSTRUCTION			
	TOTAL CAPITAL COST - Total $ - $/kW(e)			

4. BUSBAR GENERATION COST

This section provides guidance for developing the total levelized generation or busbar cost for a power plant consisting of one or more building blocks. The method is equally applicable to a large monolithic plant.

4.1 GENERAL ASSUMPTIONS AND METHODOLOGY

A total plant energy generation cost or busbar cost includes the capital, nonfuel operation and maintenance (O&M), fuel and decommissioning costs and is generally expressed as a cost per unit energy. The general methodology to be followed in computing these levelized power generation costs can be found in the U.S. DOE document NECDB.[5] The methodology uses year-by-year revenue requirements procedures together with levelization over the economic life of the plant. The levelized costs can either be expressed in dollars indexed to a reference year's buying power (constant dollar levelized cost) or in terms of a levelized cost which remains constant over the life of the plant (nominal dollar levelized cost). In the constant dollar levelized approach, the year-by-year unit cost of electricity is assumed to rise in nominal dollar terms at the rate of inflation. The method used to determine this unit cost is to calculate the present value of all the plant revenue requirements (costs) and divide that amount by the present value of the energy generated over the life of the plant. Although either constant dollar or nominal dollar levelized costs will give an accurate comparison using the NECDB methodology, baseline results will be expressed in constant dollars of the reference year given in Sect. 2.2. Since the effect of taxes on the levelized cost depends on the inflation rate, the actual calculation should be done in nominal dollars including the projected inflation, and then adjusted to constant dollars.

Constant and nominal dollar levelized costs as defined with the NECDB methodology are directly related by the relation,

$$LC_o = LC_N \times CNCF$$

where

CNCF = Constant from Nominal cost factor

$$= [1/(1 + i)^{L}] \times \frac{CRF(d_o,30)}{CRF(d,30)} \times \frac{\sum_{j=1}^{B} 1/(1+d)^{t_j - t_1}}{\sum_{j=1}^{B} 1/(1+d_o)^{t_j - t_1}}$$

LC_o = constant dollar levelized costs

LC_N = nominal dollar levelized cost

i = inflation rate

L = time between first block startup (t_{op}) and reference year (t_o)

B = number of blocks

CRF(a,b) = capital recovery factor at interest rate a for period b.

$$= \frac{a}{[1 - (1 + a)^{-b}]}$$

d_o = constant dollar discount rate (real cost of money)

d = nominal dollar discount rate (effective cost of money)

30 = economic life (30 years).

The last ratio accounts for the lag time of subsequent blocks in a multiblock plant. This ratio becomes unity if all capacity is placed on line at the same time. Tabulations of the CNCF factor for utility, industrial, and IPP (high risk) financial factors are given in Appendix G for various values of L, number of blocks and time increments between block startup.

The nominal dollar levelized cost as used in the above equation is that as defined in the NECDB and includes inflation. An alternate approach is to perform the analysis with inflation (in nominal dollars) but remove the inflation between the reference year and first block startup, or

$$LC_D = \frac{LC_N}{(1 + i)^L} .$$

This "deflated nominal dollar" approach is simple and may promote better acceptance in some sectors than either the pure nominal dollar or constant dollar figures.

Following some general requirements below, the treatment of each cost component will be discussed, and in Chap. 5, examples of the method with alternative plants will be given.

1. The power plant will be assumed to be utility owned and operated. Other applications may be shown in addition.
2. The levelized busbar cost will be expressed in constant dollars in the year defined in Sect. 2.2, Item 2. Nominal dollar or deflated nominal dollar levelized cost may also be shown.
3. The economic operating life of each unit (block) is assumed to be 30-years for cost-estimating purposes. It is realized that plant lives of greater than 30-years are probable and that these longer plant lives will be of potential economic benefit. However, the ability to predict costs as well as technological changes into the distant future is questionable. An economic life of 30-years is consistent with the maturity of long-term bonds.
4. The default capacity factor to be assumed is 80%. A concept-specific capacity factor may be used if it is properly substantiated.
5. The present-worth discount rates using the financial parameters given in Table 3.1 are 9.57%/yr (nominal) and 4.35%/yr (real) for utility applications (see Table 4.1). Discount rates for typical industrial ownership are 13.74%/yr nominal and 8.32%/yr real. Discount rates for the more risky, highly leveraged IPP are 12.37%/yr nominal and 7.02%/yr real. These latter rates are less than those for the typical industrial ownership because of the large interest expense tax deduction received in the more highly leveraged IPP case. The general inflation rate is 5%/yr.
6. Assumed use of any government-owned or -operated facility shall be costed at full cost recovery, including all direct costs, related indirect costs, depreciation, and any other related general and administrative costs. Inquiries regarding prices and charges to be assumed for specific materials and services shall be made to the Office of Advanced Reactor Programs, DOE-NE.
7. Costs will be calculated in a manner consistent with the Tax Reform Act of 1986.

Table 4.1. Fixed charge rate input parameters

Parameters	Utility	Industrial[a]	IPP[b]
Effective (tax-adjusted) cost of money, %/yr	9.57	13.74	12.37
Real cost of money, %/yr	4.35	8.32	7.02
Inflation rate, %/yr	5		
Federal income tax rate, %/yr	34		
State income tax rate, %/yr	4		
Combined state and federal tax rate, %	36.64		
Property tax rate, % of capital investment/yr	2		
Interim replacement rate, % of investment/yr	0.5		
Book/analysis life, yr	30		
Tax depreciation duration, yr	15		
Tax depreciation method[c]	150% declining balance		
Accounting method	Normalized		

[a]Typically financed industrial company or conservatively financed Independent Power Producer.

[b]Highly leveraged independent power producer or similar organization.

[c]See Table 2.5, p. 21 of Ref. 5 for details.

4.2 CAPITAL COST

Under the assumption of equal annual energy generation, the equation for calculating the nominal dollar levelized capital cost can be expressed as

$$LCC = \frac{FCR \times \sum_j CAP_j/(1 + d)^{t_j - t_1}}{E \times \sum_j 1/(1 + d)^{t_j - t_1}}$$

where

LCC = levelized capital cost in nominal dollars,

FCR = nominal dollar fixed charge rate,

CAP_j = total capital cost for unit j in nominal dollars as determined in Sect. 3,

t_1 = commercial operation date for unit 1,

t_j = commercial operation date for unit j,

E = annual energy generation for single unit.

For a single-unit (block) plant, the previous equation reduces to

$$LCC = (FCR \times CAP)/E \, .$$

A fixed charge rate is used to properly account for return on capital, depreciation, interim replacements, property tax, and income tax effects. The fixed charge rate is discussed in detail in Sect. 3.3 and Appendix B of Ref. 5. The fixed charge rate is dependent upon the fraction of the total plant investment that is eligible for tax depreciation (tax depreciation may not be taken on equity financing costs). The fixed charge rate can be calculated using the NECDB methodology as implemented in an IBM type PC code.[9] However, if this code is not available the relationships given below can be used to determine the applicable fixed charge rate for utility and industrial applications (see Tables 3.1 and 4.1 for financial structure). The fixed charge rate varies depending on the ratio of total interest during construction (including equity financing) to total capital cost (all expressed in nominal dollar terms) as follows,

Utility: $FCR = 0.01795 \times (IDC/TCC) + 0.15862$

Industrial: $FCR = 0.02783 \times (IDC/TCC) + 0.21460$

IPP: $FCR = 0.01416 \times (IDC/TCC) + 0.019548$

where

IDC = nominal dollar interest during construction,

TCC = nominal dollar total capital cost.

The input parameters given in Table 4.1 were used to develop the above relationship.

Constant dollar fixed charge rates may be determined from the nominal dollar rates by multiplying by the ratio of the constant to nominal dollar capital recovery factors (0.590 for utilities, 0.652 for industrials, and 0.633 for IPPs).

$$FCR_o = \frac{CRF(d_o,30)}{CRF(d,30)} \times FCR$$

where

FCR_o = constant dollar fixed charge rate.

The capital recovery factor ratio is given in Appendix G (Table G.10) for various nominal dollar discount rates and inflation rates.

4.3 O&M COSTS

This section provides guidance on the development of the nonfuel O&M costs. The O&M costs are incurred from commercial operation and throughout the operating life of the plant. For these studies only the first 30 years of operation will be considered.

Certain O&M costs, such as those for materials and supplies, can be at least partially dependent upon the amount of energy generated by the plant. These variable costs should be added to the fixed costs, which are independent of generation, to arrive at a total annual O&M cost.

The O&M cost estimate should provide, as a minimum, the detail shown in Tables 4.2 and 4.3 for fixed, variable, and total O&M costs as applicable. Site staff requirements data should also be reported as shown in Table 4.4. For multi-block plants, the annual O&M costs and staffing requirements are to be specified by block as well as for the total plant.

The O&M cost estimate should be the expected costs and expressed in constant dollars for the year defined in Sect. 2.2. It is to be assumed that the escalation rate for O&M costs is equal to the rate of inflation, such that there is no real escalation for O&M costs. Certain O&M cost factors are design independent and/or owner related. Data for these factors are provided below and should be used in the development of the annual O&M costs.

Table 4.2. Nonfuel O&M expense accounts

Account	Description
On-site staff	Includes all personnel assigned to the plant site. See Table 4.4 for typical categories.
Maintenance materials	Can be either variable or fixed costs. Consist of noncapitalized hardware used in normal maintenance activities.
Supplies and expenses	Can be either variable or fixed costs. Consist of consumable materials and other unrecoverable items such as make-up fluids, chemicals, gases, lubricants, office and personnel supplies and monitoring and record supplies; costs for on-site radioactive and non-radioactive waste management activities; costs for disposal of absorbers and other replacable reflector/shield assemblies.
Off-site technical support	Activities by personnel not assigned full time to the plant site; examples are safety reviews, off-site training, environmental monitoring, meteorological surveys, power planning, fuel studies, and other owner home office activities directly supporting the plant.
Pensions and benefits	Costs of pensions and benefits, including worker's compensation insurance, provided for the on-site and off-site staff.
Regulatory fees	NRC annual fees and review costs as well as other routine safety, environmental, and health physics inspections.
Insurance premiums	Costs for commercial and government liability insurance, property damage insurance, and replacement power insurance.
Other A&G	Administrative and general salaries and related expenses.

Table 4.3. Annual O&M cost format

Item	1992 $k/yr		
	1 block	2 blocks	Etc.
Direct power generation			
On-site staff			
Maintenance materials			
Fixed			
Variable			
Supplies and expenses			
Fixed			
Variable			
Off-site technical support			
Administrative and general			
Pensions and benefits			
Nuclear regulatory fees			
Nuclear insurance premiums			
Other administrative and general expenses			
Total annual O&M costs			

Table 4.4. On-site staff requirements

Category	Salary[a] 1992 $/yr	Number of persons		
		1 Block	2 Blocks	Etc.
Plant manager	122,000			
Administrative Division:				
Manager	85,000			
Environmental control	54,000			
Emergency plant public relations	54,000			
Training	59,000			
Safety and fire protection	50,000			
Administrative services	32,400			
Health services	32,400			
Security	29,100			
Subtotal				
Operations Division:				
Manager	85,000			
Shift supervision	62,600			
Shift operators	52,500			
Results engineering	52,500			
Subtotal				
Maintenance Division:				
Manager	85,000			
Supervision	58,100			
Diagnostic engineering	52,500			
Crafts (Mech., Elect., I&C, ISI)	41,300			
Annualized peak maintenance	41,300			
Annualized refueling	44,700			
Radwaste	41,300			
Quality Assurance	44,700			
Planning	44,700			
Grounds and housekeeping	29,500			
Warehouse	38,000			
Subtotal				
Technical Division:				
Manager	85,000			
Reactor engineering	62,600			
Radioachem and water chem	58,100			
Licensing and regulatory assurance	53,600			
Engineering	53,600			
Technicians	43,600			
Health physics	44,800			
Subtotal				
Total staff				

[a]Add 10% to salaries for social security and unemployment insurance premiums.

Annual on-site staff salaries to be assumed are shown in Table 4.4 with an additional 10% to be added for social security tax and unemployment insurance premiums. For off-site technical support, an average annual salary of $62,000/person (1992$) should be assumed with an additional 70% added to the total (10% for social security tax and unemployment insurance and a 60% overhead allowance for office space, utilities and miscellaneous expenses). The pension and benefits account which includes workman's compensation insurance should be calculated as 25% of the sum of on-site and off-site direct salaries (excluding off-site over-head). Annual nuclear regulatory fees should be assumed to be $2.8 million (1992$) per block (unit) for the first commercial plants and $1.4 million for the NOAK plants. Estimates of annual premiums for nuclear plant insurance for medium-sized [350-700 MW(e)] advanced nuclear plants are provided in Table 4.5. Finally, other administrative and general expenses should be calculated as 15% of the direct power generation accounts (i.e., 15% of the sum of on-site staff, maintenance materials, supplies and expenses, and off-site technical support costs).

Table 4.5. Annual premiums for nuclear power plant insurance for medium-size [350-700 MW(e)] advanced nuclear plants

(January 1992 dollars)

	Number of blocks per site			
	1	2	3	4
Public liability				
Commercial ($200 million)	$ 600,000	$ 900,000	$1,200,000	$1,500,000
Self insurance	-0-	-0-	-0-	-0-
Plant property damage				
Primary ($500 million)	2,380,000	3,640,000	4,900,000	6,160,000
Secondary ($600 million)	1,200,000	1,400,000	1,600,000	1,800,000
Total	$4,180,000	$5,940,000	$7,700,000	$9,460,000

To obtain the nominal dollar levelized cost for O&M, the present worth of the annual plant O&M costs must be determined by discounting, at the nominal cost of money, the annual O&M cost back to the commercial operation date of the first unit (block). In equation form

$$PWOM = \sum_{n} \frac{OM_n}{(1 + d)^n},$$

where

PWOM = present worth of O&M costs,

OM_n = annual total plant O&M costs (in nominal dollars)

n = time index relative to plant startup.

If the O&M costs are escalating at the inflation rate, then

$$OM_n = (1 + i)^L (1 + i)^n OM_{o,n}$$

where

L = time between reference year and startup of first block,

$OM_{o,n}$ = O&M cost in year n in Reference years dollar.

So

$$PWOM = (1 + i)^L \sum_{n} \frac{OM_{o,n}}{(1 + d_o)^n}$$

where

d_o = constant dollar (real) discount rate.

This present-worth cost is then divided by the present worth of the total energy generation as shown below to arrive at the levelized cost.

$$LCOM = \frac{CRF(d,30) \times PWOM}{E \times \sum_{j} 1/(1 + d)^{t_j - t_1}},$$

where

LCOM = levelized O&M cost in nominal dollars,

PWOM = present worth of annual O&M costs,

CRF = capital recovery factor

Examples using this methodology are presented in Sect. 5.

4.4 FUEL COSTS

The expected fuel cycle costs for the first 30 years of a power plant's operation shall be estimated. The fuel cycle will be subdivided into its components, such as uranium, thorium or plutonium purchase, conversion, enrichment, fabrication, reprocessing, and waste disposal. Costs and quantities will be reported for each component over the assumed operating period. All assumptions, such as unit costs, processing losses, mass balance data, and lead and lag times for costs, shall be reported. A complete description of the fuel cycle cost analysis shall be prepared. Additional requirements are listed below.

1. Fuel management plans including mass flows and their timing into and out of the reactor must be provided for all fuel, blanket, and absorber elements.
2. The capital and O&M costs for the initial and subsequent fuel cycle facilities assumed to support the operation of the first commercial through NOAK plants, must be estimated following the procedures given in Sects. 3 and 4 of this document. This includes, but is not limited to, documenting the direct and indirect costs, the contingency cost, cash flow, and interest during construction in the capital cost of the fuel cycle facilities. Such fuel cycle facilities include fuel reprocessing plants and fuel fabrication plants which are not currently commercially available. The AFUDC and fixed charge rate for non-government owned facilities should be calculated using industrial rates. If the facility is an on-site facility and is utility owned and a physical part of the power plant (part of utility rate-base), utility financial rates may be used. An allowance for equipment replacement will be included if the equipment has a design life of less than the 30-year facility operating life.
3. A deployment plan for the fuel cycle facilities should be developed and coordinated with fuel delivery requirements of the plants to be supplied by the facility. Capital and operating cash flows during the deployment period should be developed.

4. The economic lifetime of any co-located, integral fuel recycle facility shall not be in the excess of the time necessary to service fuel from a specific power plant site over its assumed economic life. (It is to be assumed that each power block has a 30 year economic operating life.)
5. The costs for absorber and other replaceable reflector/shield elements must be included in the fuel cycle cost estimates.
6. The levelized cost for an equilibrium cycle fuel, blanket, shield, and absorber assembly shall be reported in \$/assembly and \$/kg HM if applicable. The costs must be further subdivided into components related to fissile material procurement, facility capital amortization, fuel facility O&M costs, hardware costs, fresh heavy metal and transportation, as applicable.
7. It shall be assumed that spent fuel leaving the reactor (including the final core discharge) has no economic value in that state. The value of any fissile plutonium or uranium-233 from spent fuel is to be based on the cost of its recovery. The cost basis/purchase price for recycled fissile material shall be a levelized average cost based on the cost to reprocess (including related facility capital amortization) and the total fissile output of the fuel cycle facility.
8. The source, availability, and cost of the reactor fuel needs to be documented if a fuel other than U-235 used. For example, if fissile plutonium is the reactor fuel, then the method and cost of obtaining this fuel needs to be shown. If the NOAK plant is to use excess fissile material from other plants of its type for its start-up fuel, then the time and extent of this recycle fuel availability needs to be shown for representative scenarios.
9. Consistent with the 1986 Tax Reform Act, no investment tax credits may be taken.
10. The cost of each batch of fuel will be capitalized and depreciated for tax purposes by either a 200% declining balance method over five years using the IRS half-year convention (see Table 2.6, page 21, Ref. 5) or a units-of-production (energy proration) basis.
11. The combined federal and state tax rate to be assumed is 36.64%.

The following unit costs should be assumed in developing fuel cycle costs:

1. Uranium ore price shall be \$25.00/1b (1992 \$). This price is assumed to escalate at the

1. Uranium ore price shall be $25.00/1b (1992 $). This price is assumed to escalate at the rate of inflation (no real escalation) over the economic life of the plant.
2. Uranium conversion price shall be $10.00/kg U (1992 $) with escalation equal to inflation (i.e., no real escalation).
3. Enrichment price shall be $125/kg SWU (1992 $) for uranium enrichments up to 10.5%. The incremental enrichment price above 10.5% enrichment shall be $925/kg SWU. The price escalation shall be equal to inflation (i.e., no real escalation).
4. Fuel fabrication price for extended burnup LWR fuel in 2005 is $260/kg HM (1992 dollars) with escalation equal to inflation (i.e., no real escalation).
5. The spent fuel or waste disposal fee is 1 mill/kWh (1992 $) with no real escalation.
6. Escalation will be at the rate of inflation for all other fuel cycle components (i.e., no real escalation).

Additional or revised cost assumptions may be provided by DOE.

Capital cost and amortization assumptions for all fuel cycle facilities (e.g., MHTGR fuel fabrication or ALMR fuel reprocessing/recycle/fabrication facilities) shall be fully documented.

As each batch of fuel is capitalized for tax purposes, the fuel cycle analysis must be performed in nominal rather than constant dollar terms to properly reflect tax depreciation. Finally, all fuel cycle costs for the power plant should be present-worthed to plant startup for use in developing the total busbar cost. The methodology to obtain the present worth of the fuel costs is provided in Sect. 3 of the NECDB.[5] A computer code such as the PC version[9] of the REFC0-83 code[10] may be used to help calculate the fuel cycle costs.

Similar to the calculation of levelized O&M costs, the nominal dollar levelized fuel cost can be expressed as

$$LCFC = \frac{CRF(d,30) \times PWFC}{E \times \sum_{j} 1/(1 + d)^{t_j - t_1}} ,$$

where

LCFC = levelized fuel cost in nominal dollars,

PWFC = present worth of annual fuel costs.

4.5 DECOMMISSIONING

The cost for plant decommissioning should be estimated and included in the busbar cost. A separate analysis is desirable, however, in the absence of a specific decommissioning estimate, a default cost that is a function of block (unit) size may be used. The default values are based on the NRC minimum prescribed decommissioning costs developed by PNL. Separate costs as a function of unit thermal output were prescribed for PWRs and BWRs. In the previous cost guidelines,[2] these costs, were increased by inflation and also by the estimated cost of dismantlement. For these guidelines, the previous relations were increased by about 1/3 to account for cost increases since 1989. For reactor types other than BWRs or PWRs an average value should be used. The cost equations are

PWR: Cost (million $) = 145 + 0.020 (P-1200)

BWR: Cost (million $) = 185 + 0.020 (P-1200)

Other: Cost (million $) = 165 + 0.020 (P-1200)

where P = block thermal power MWt. Costs are constant at the 1200 MWt and 3400 MWt values for block power levels below 1200 MWth and above 3400 MWt. These costs are assumed to increase at the rate of inflation.

It should be assumed that an external sinking fund consisting of high grade tax-free municipal bonds yielding 7.0%/yr nominally will be established to accumulate the funds necessary for decommissioning. Although the plant will probably have a life exceeding the 30-year analysis life, it will be assumed that the funds necessary for decommissioning the plant will be accumulated over the 30-year analysis life. The present worth of this decommissioning fund in nominal dollars can be calculated using the expression

$$PWDC = \frac{DO_o \times (1 + i)^L \times SFF(7.0,30) \times \sum_j 1/(1 + d_o)^{t_j - t_s}}{(1+d_o)^{30} \times SFF(d,30)}$$

where

PWDC = present worth of total decommissioning costs;

DC_o = decommissioning cost in reference year's dollars for one block;

SFF(r,t) = sinking fund factor at rate r for t years, that is, $r/[(1+r)^t - 1]$.

Following the treatment used for O&M and fuel costs, the levelized cost of decommissioning can be expressed as

$$LCDC = \frac{CRF\ (d,30) \times PWDC}{E \times \sum_j 1/(1 + d)^{t_j - t_1}} ,$$

where

LCDC = levelized decommissioning cost in nominal dollars.

An example of this calculation is given in Sect. 5.

4.6 TOTAL BUSBAR COST

The levelized total busbar cost is simply the sum of the levelized costs for capital, O&M, fuel, and decommissioning as determined previously,

$$LC = LCC + LCOM + LCFC + LCDC .$$

The above procedure calculates nominal dollar levelized costs. Constant dollar levelized costs are needed for DOE reporting purposes since these costs are indexed to reference year cost levels. The nominal dollar costs may be converted to constant dollar values using the equation defined in Sect. 4.1.

LC_o = LC × CNCF

$LCOM_o$ = LCOM × CNCF

etc.

where

$$CNCF = (1 + i)^{-L}\ \frac{CRF(d_o,30)}{CRF(d,30)} \times \frac{\sum_j 1/(1 + d)^{t_j - t_1}}{\sum_j 1/(1 + d_o)^{t_j - t_1}} .$$

This factor is tabulated in Appendix G for utility and industrial applications. Deflated nominal dollar levelized costs may be calculated from nominal dollar costs using the expression

$$LC_D = (1 + i)^{-L} \times LC .$$

Examples of the development of total busbar costs for alternative plants are provided in the next chapter.

5. EXAMPLE CALCULATIONS

This chapter provides examples of the method used to estimate the busbar costs for alternative power plant configurations. Costs are provided for fossil-fired generation and are for reference purposes only. Comparisons of advanced reactor concept costs with those for alternatives are not required. To further understand how the levelized costs are obtained, a description of the calculational procedure is provided below for example configurations. Other configurations can be determined in a similar manner. The alternative plants used for the example calculations are for coal- and gas-fired generation starting commercial operation in the year 2010. The plants include a pulverized coal-fired (PC) plant, and a combined cycle combustion turbine (CCCT) plant:

600-MW(e) PC plant
500-MW(e) CCCT plant
2 × 600-MW(e) PC plant

The following general assumptions apply to the development of the levelized busbar generation costs for the alternative power plants:

1. The levelized busbar cost will be expressed in constant 1992 dollars. In addition, costs may be expressed in nominal dollars or deflated nominal dollars.
2. The capacity factor for all alternative plants is assumed to be 80%.
3. The operating life of each unit is assumed to be 30 years for cost estimating purposes.
4. The present-worth discount rate is the utility ownership rates of 9.57%/yr (nominal) and 4.35%/yr (real). The general inflation rate is 5%/yr.

5.1 COST DATA

The capital and operating costs for these plants were taken from a recent USCEA study.[11] The basis for these costs may not be consistent with the groundrules presented in these guidelines. The levelized costs calculated in this section therefore may not be directly comparable to costs estimated using these groundrules and absolute comparisons with these plants should be avoided.

5.1.1 Capital Cost

The capital cost estimates for the example power plants listed previously are given in Table 5.1. The overnight cost data and total construction times for these plant were taken from the USCEA study. The AFUDC (interest during construction) shown Table 5.1 was calculated using the procedures recommended in these groundrules and assuming a chopped cosine cash flow distribution where 5% of the fossil plant cost was expended during the pre-concrete pour period. This period is assumed to be 12 months for the first PC coal and 6 months for the CCCT plant and second PC coal unit and are included in the construction times shown. The final capitalized cost differs somewhat from those reported in the USCEA study due to differences in the cost of money and cash flow assumptions. The second unit of the PC coal-fired plant is assumed to come on line 1 year after the first unit.

Table 5.1. Example power plant capital cost data

Plant type	Overnight capital cost (1992$/kWe)	Construction period (months)	Total capital cost[a] (1992$/kWe)
1-600 MW(e) PC plant	1268	42	1394
Second 600 MW(e) PC unit	1074	36	1180
Combined 2-unit PC plant	1171	48	1287
500 MW(e) CCCT plant	532	24	565

[a]Nominal dollar cost for startup in any year, Y, calculated by adjusting for inflation between 1992 and year Y. For reference inflation rate of 5%:

$$\text{Cost }(Y) = \text{cost}(1992) \times 1.05^{(Y-1992)}$$
$$= 2.407 \times \text{cost}(1992) \text{ for 2010 startup.}$$

The pulverized coal-fired plant has precipitators and wet limestone scrubbers. All plants have mechanical draft cooling towers.

5.1.2 O&M Cost

O&M cost estimates are needed for estimating the alternative plant configurations under consideration. The O&M cost estimates are again based on the USCEA study[11] and are given in Table 5.2. The procedure using the data in Table 5.2 to produce a cost estimate for an alternative plant is discussed in Sect. 5.6.

Table 5.2. Alternative power plant O&M cost data[a]

Plant type	Annual O&M cost[b] (millions 1992$)
1-600 MW(e) PC plant	38.1[c]
2-600 MW(e) PC plant	70.8
1-500 MW(e) CCCT plant	7.8

[a]At 80% capacity factor.

[b]Based on Ref. 11.

[c]Includes a $500/ton sulfur tax.

5.1.3 Fuel Costs

The price assumptions for fossil fuels are shown in Table 5.3. The 1992 prices are near current (1992) price levels. The real price escalation rates are from the supplement to the EIA 1992 Annual Energy Outlook.[12] These rates are the average rates for the 1990-2040 period.

Table 5.3. Fossil fuel price assumptions (1992 $)

Fuel	1992 Price ($/MBtu)	Real escalation rate (%/year)
Coal	1.45	1.0
Natural gas	2.33	2.2

5.1.4 Decommissioning

The decommissioning cost for a 600-MW(e) coal-fired unit is estimated to be $15 million in 1992 dollars. Decommissioning costs are assumed to escalate at the rate of inflation. A sinking fund similar to that described in Sect. 4.5 will be used to accumulate the necessary funds during the operation of the plant.

5.2 COST CALCULATION FOR A 600-MW(e) PULVERIZED COAL (PC) PLANT

This section will discuss the calculation of the levelized cost for a single-unit 600 MW(e) pulverized coal-fired plant starting commercial operation in the year 2010. Levelized costs for each cost component will be determined and then summed to obtain the total levelized busbar generation cost.

5.2.1 Capital Cost

As given in Sect. 4.2, the levelized capital cost for a single-unit plant is found by multiplying the total capital cost by the fixed charge rate and dividing by the annual energy generation. The total capital cost for this plant is shown in Table 5.1 to be $1394 $/kWe in 1992 dollars which is equivalent to a nominal dollar cost of $2013 million for startup in 2010. The nominal dollar fixed charge rate for a coal plant with a 42 month construction schedule is 0.1655. This fixed charge rate is determined using the methodology presented in the NECDB.[5] This study assumes a constant annual energy generation at 80% capacity factor. For the 600-MW(e) plant, this corresponds to generation of 4.2048 million MWh/yr.

Substituting in values, the equation from Sect. 4.2 becomes

$$\begin{aligned} LCC &= \frac{(0.1655)\ (2013)}{4.2048}\ . \\ &= 79.2 \text{ mills/kWhe} \end{aligned}$$

The constant dollar levelized cost is obtained by multiplying the nominal dollar cost by the nominal to constant cost factor from Table G.1

$$
\begin{aligned}
LCC_o &= 0.2451 \times LCC \\
&= 19.4 \text{ mills/kWhe.}
\end{aligned}
$$

The deflated nominal dollar cost is found by discounting the nominal dollar cost by the inflation between 1992 and 2010.

$$
\begin{aligned}
LCC_D &= (1.05)^{-18} \times 79.2 \\
&= (0.4155) \times 79.2 \\
&= 32.9 \text{ mills/kWhe.}
\end{aligned}
$$

5.2.2 O&M Cost

The present worth of the O&M cost is given by the equation in Sect. 4.3 as

$$PWOM = (1 + i)^L \sum_{n=1}^{30} \frac{OM_{o,n}}{(1 + d_o)^n} .$$

The annual O&M cost is given in Table 5.2 as \$38.1 million. The real cost of money (d_o) is 4.35% and the PWOM for this single unit PC plant becomes

$$
\begin{aligned}
PWOM &= (1.05)^{18} \times 38.1/CRF\ (4.35,30) \\
&= \frac{2.4066 \times 38.1}{0.06031} \\
&= \$1520 \text{ million .}
\end{aligned}
$$

The nominal dollar levelized cost is

$$LCOM = \frac{CRF(9.57,30) \times 1520}{4.2048}$$

$$= \frac{(0.1023) \times 1520}{4.2048}$$

$$= 37.0 \text{ mills/kWhe} .$$

The constant dollar levelized cost is

$$LCOM_o = 37.0 \times 0.2451 = 9.1 \text{ mills/kWhe} ,$$

and the deflated nominal dollar levelized cost is

$$LCOM_D = 37.0 \times 0.4155 = 15.4 \text{ mills/kWe} .$$

5.2.3 Fuel Cost

The basic procedure for obtaining the levelized fuel cost is described in Sect. 4.4. For a single unit plant, the present worth of the fuel costs is given by

$$PWFC = \frac{(1 + g)^L \times FC}{CRF(Z,30)}$$

where

g = nominal rate of increase in coal price

Z = combined escalation, discount rate

= $(1+d)/(1+g) - 1$, where d = nominal dollar discount rate

FC = annual cost of fuel in reference year.

Using a coal price of $1.45/MBtu (1992$), a plant heat rate of 9700 Btu/kWh, and an annual generation of 4.2048×10^9 kWh,

$FC = 1.45 \times 9.7 \times 4.2048$

= $59.1 million/yr (1992$).

The price of coal is assumed to escalate at a real rate of 1%/yr (nominal rate (g) = 6.05%/yr including 5%/yr inflation rate), so

$$Z = \frac{1.0957}{1.0605} - 1 = 0.0332 \text{ or } 3.32\% \ .$$

Substituting for the present worth of the fuel costs,

$$PWFC = \frac{(2.8787)\ (59.1)}{0.05315}$$
$$= \$3201 \text{ million} \ .$$

The nominal dollar levelized cost is

$$LCFC = \frac{(0.1023)\ (3201)}{4.2048}$$
$$= 77.9 \text{ mills/kWhe} \ .$$

The constant dollar levelized fuel cost is

$$LCFC_o = (0.2451)\ (77.9) = 19.1 \text{ mills/kWhe} \ ,$$

and the deflated nominal dollar levelized fuel cost is

$$LCFC_D = (0.4155)\ (77.9) = 32.4 \text{ mills/kWhe} \ .$$

5.2.4 Decommissioning Cost

Following the NECDB, a 600 MW(e) coal-fired unit will have a decommissioning (dismantalment) cost of $15 million. Substituting into the equation in Sect. 4.5, the present value of the decommissioning cost becomes

$$PWDC = \frac{(15)\ (2.407)\ (0.01059)}{(3.5873)\ (0.006593)}$$
$$= \$16.2 \text{ million} .$$

The nominal dollar levelized cost is

$$LCDC = \frac{(0.1023)\ (16.2)}{4.2048} = 0.39 \text{ mills/kWhe} .$$

The constant dollar levelized cost is

$$LCDC_o = (0.2451)\ (0.39) = 0.10 \text{ mills/kWhe} .$$

The deflated nominal dollar cost is

$$LCDC_D = (0.4155)\ (0.39) = 0.16 \text{ mills/kWhe} .$$

5.2.5 Busbar Costs

The levelized busbar costs are the sum of the component costs

LC = 194.5 mills/kWhe (nominal dollars)

LC_o = 47.7 mills/kWhe (constant 1992$)

LC_D = 80.9 mills/kWhe (deflated nominal dollars).

5.3 COST CALCULATION FOR TWO UNIT 500 MW(e) COMBINED CYCLE COMBUSTION TURBINE PLANT

This section will discuss the calculation of the levelized cost for a 500-W(e) Combined cycle combustion turbine plant with both units starting commercial operation in the year 2010. Levelized costs for each cost component will be determined and then summed to obtain the total busbar generation levelized cost.

5.3.1 Capital Cost

The total capital cost for this plant was shown in Table 5.1 to be 565 \$/kWe in 1992 dollars. This is equivalent to a nominal dollar cost of \$679 million for startup in 2010.

The nominal dollar fixed charge rate for this plant is 0.1646 using the methodology in the NECDB.[5] The annual energy generation for this plant at 80% capacity factor is 3.504 million MWh/year.

Substituting in the values, the equation from Sect. 4.2 becomes

$$LCC = \frac{(0.1646)\ (679)}{3.504}$$

$$LCC = 31.9 \text{ mills/kWhe} .$$

The constant dollar levelized cost is obtained by multiplying the nominal dollar cost by the constant to nominal cost factor from Table G.1.

$$LCC_o = 0.2451 \times LCC$$
$$= 7.8 \text{ mills/kWhe} .$$

The deflated nominal dollar cost is found by discounting the nominal dollar cost by the inflation between 1992 and 2010

$$LCC_D = (1.05)^{-18} \times 31.9$$
$$= 13.3 \text{ mills/kWhe} .$$

5.3.2 O&M Cost

The present worth of the O&M cost is

$$PWOM = (1 + i)^L \sum_n \frac{OM_{o,n}}{(1 + d_o)^n} .$$

The annual O&M cost is given in Table 5.2 as $7.8 million. The present worth of the O&M cost is:

$$PWOM = (1.05)^{18} \frac{7.8}{0.06031}$$
$$= \$311 \text{ million} .$$

The nominal dollar levelized cost is

$$LCOM = \frac{CRF(9.57,30) \times (311)}{3.504}$$
$$= \frac{(0.1023) \times (311)}{3.504}$$
$$= 9.1 \text{ mills/kWhe} .$$

In constant dollars:

$$LCOM_o = (0.2451)(9.1) = 2.2 \text{ mills/kWhe} .$$

In deflated nominal dollars:

$$LCOM_D = (0.4155)(9.1) = 3.8 \text{ mills/kWhe} .$$

5.3.3 Fuel Cost

Using the reference natural gas price of $2.33/MBtu (1992$), a CCCT plant heat rate of 7514, and the annual generation of 3.504×10^9 kWh, the annual fuel cost (FC) in the reference year is

$$FC = (2.33)(7.514)(3.504)$$
$$= \$61.3 \text{ million} .$$

The price of natural gas is assumed to escalate at 2.2%/yr above inflation (7.31%/yr nominal rate), so the nominal price increase prior to startup is,

$$(1.0731)^{18} = 3.561$$

The effective discount factor for the capital recovery factor is,

$$Z = \frac{1.0957}{1.0731} - 1 = 0.0211 \text{ or } 2.11\%$$

and

$$CRF(2.11,30) = 0.04530$$

Substituting for the present Worth of the fuel costs,

$$PWFC = \frac{(3.561)(61.3)}{0.04530}$$
$$= \$4,418 \text{ million} .$$

The nominal dollar levelized fuel cost is

$$LCFC = \frac{(0.1023)(4418)}{3.504}$$
$$= 140.7 \text{ mills/kWhe} .$$

The constant dollar levelized cost is

$$LCFC_o = (0.2451)(140.7) = 34.5 \text{ mills/kWhe} .$$

The deflated nominal dollar fuel cost is

$$LCFC_D = (0.4155)(140.7) = 58.4 \text{ mills/kWhe} .$$

5.3.4 Decommissioning Cost

The decommissioning cost for the CCCT is assumed to be negligable.

5.3.5 Busbar Cost

The levelized busbar cost is the sum of the component costs,

LC = 181.7 Mills/kWhe (nominal dollars)

LC_0 = 44.5 mills/kWhe (constant 1992 $)

LC_D = 75.5 mills/KWhe (deflated nominal dollars).

5.4 COST CALCULATION FOR A TWO UNIT 600-MWe PC PLANT

This section will discuss the calculation of the levelized cost for a plant with two 600 MW(e) PC units where the second unit follows the first on line by one year. The first unit startup is in 2010.

5.4.1 Capital Cost

The 1992 dollar total capital costs are shown in Table 5.1. The total capitalized cost for the first unit in nominal dollars at startup in 2010 is.

$$(600 \times 10^3)(1394)(1.05)^{18}$$
$$= \$2,013 \text{ million} .$$

The second unit, starting up in 2011 will have a nominal dollar cost of

$$(600 \times 10^3)(1180)(1.05)^{19}$$
$$= \$1,789 \text{ million} .$$

The fixed charge rate is 0.1655 and the annual energy production, per unit at 80% capacity factor is 4.2048 million MWh.

$$LCC = \frac{(0.1655)\ [2013 + 1789(1.0957)^{-1}]}{(4.2048)[1 + (1.0957)^{-1}]}$$
$$= 75.0 \text{ mills/kWh} .$$

The constant dollar cost is

$$LCC_o = (0.2451)(75.0) = 18.4 \text{ mills/kWhe}$$

and the deflated nominal dollar cost is

$$LCC_D = (0.4155)\ (75.0) = 31.2 \text{ mills/kWhe} .$$

5.4.2 O&M Cost

The annual O&M cost for year 1 and 31 (2010, 2041) in 1992 dollars is $38.1 million and $70.8 million for years 2 through 30. The present worth (to plant startup) is $2,818 million.

The nominal dollar levelized cost is

$$LCOM = \frac{(0.1023)(2818)}{4.2048\ [1 + (1.0957)^{-1}]} = 35.8 \text{ mills/kWhe} .$$

The constant dollar levelized cost is obtained by multiplying the nominal dollar cost by the constant to nominal cost factor from Table G.1. (Note that this factor is different for the 2-unit plant than for a single unit plant.)

$$LCOM_o = (0.2394)\ (35.8) = 8.6 \text{ mills/kWe} .$$

In deflated nominal dollars

$$LCOM_D = (0.4155)\ (35.8) = 14.9 \text{ mills/kWhe} .$$

5.4.3 Fuel Cost

Using the reference coal price of $1.45/MBtu (1992), plant heat rate of 9700 Btu/kWh and an annual generation of 4.2048×10^9 kWh per unit, the annual cost of fuel (FC) in the reference year is $59.1 million for each unit. The present worth to plant startup of the fuel cost, in nominal dollars is given by

$$PWFC = \frac{(1+g)^L \times FC \times \sum_j 1/(1+Z)^{t_j - t_1}}{CRF(Z,30)}$$

where the final term in the numerator accounts for the timing delay of the multiple units. Substituting,

$$PWFC = \frac{(2.8787)(59.1)(1.9679)}{0.05315}$$

$$= 6{,}299 \text{ million.}$$

The nominal dollar levelized fuel cost is

$$LCFC = \frac{(0.1023)\ (6.299)}{8.0423}$$

$$= 80.1 \text{ mills/kWhe.}$$

The constant dollar levelized cost is

$$LCFC_o = (0.2394)(80.1) = 19.2 \text{ mills/kWhe.}$$

The deflated nominal dollar fuel cost is

$$LCFC_D = (0.4155)(80.1) = 33.3 \text{ mills/kWhe}$$

5.4.4 Decommissioning Cost

The decommissioning cost was calculated previously in Sect. 5.2.4.

The nominal dollar levelized cost = 0.39 mills/kWhe.

The constant, 1992$ levelized cost = 0.10 mill/kWhe.

The deflated nominal dollars levelized cost = 0.16 mills/kWhe.

5.4.5 Busbar Costs

The levelized busbar costs are the sum of the cost components. For the 2-unit 600 MW(e) PC Plant these are

LC = 191.3 mills/kWhe (nominal dollars)

LC_o = 46.3 mills/kWhe (constant 1992 dollars)

LC_D = 79.6 mills/kWhe (deflated nominal dollars).

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ABBREVIATIONS AND ACRONYMS

AE	architect engineer
AFUDC	allowance for funds used during construction
ALMR	advanced liquid metal reactor
ALWR	advanced light water reactor
BOP	balance of plant
CCCT	combined cycle combustion turbine
CM	construction manager
CM	chrome moly steel
CONCEPT	name of capital cost computer code
CRF	capital recovery factor
CS	carbon steel
CY	cubic yards
DOE	Department of Energy
DPC	direct payroll related costs
EEDB	Energy Economic Data Base
EIA	DOE Energy Information Administration
EPRI	Electric Power Research Institute
FBC	Fluidized Bed Combustion
FCR	fixed charge rate
FOAK	First-of-a-Kind
FSAR	final safety analysis report
G&A	General and Administrative costs
HM	heavy metal
IDC	interest during construction
IPP	Independent Power Producer
LB	pounds
LF	linear feet
LWR	Light Water Reactor
MHTGR	Modular High Temperature Gas-cooled Reactor

MRB	materials review board
NE	Nuclear Energy
NNS	non-nuclear-safety class
NOAK	Nth-of-a-Kind
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
O&M	operation and maintenance
OMCOST	name of operation and maintenance cost computer code
PC	personal computer or pulverized coal
P&ID	piping and instrumentation diagram
PSAR	preliminary safety analysis report
PWR	pressurized water reactor
Q/C	quality control
Q/A	quality assurance
R&D	Research and Development
REFCO	name of nuclear fuel cycle cost code
RCM	Reliability Centered Maintenance
RM	reactor manufacturer
SAR	safety analysis report
SC	safety class
SDD	system design description
SF	square feet
SFF	sinking fund factor
SS	stainless steel
TN	tons
USCEA	U.S. Council for Energy Awareness

LIST OF SYMBOLS

CAP_j	capital cost (nominal dollars) of block j
C_j	cash flow during period j
CNCF	factor for converting nominal dollar levelized costs to constant dollar levelized costs
CRF(a,b)	capital recovery factor at rate, a, and period, b
d	nominal dollar discount rate
DC_o	decommissioning cost in reference years dollars
d_o	constant dollar discount rate
E	annual energy generation
FC	fuel costs
FCR	nominal dollar fixed charge rate
FCR_o	constant dollar fixed charge rate
g	escalation rate/year
i	inflation rate, /year
IDC	interest during construction in nominal dollars
IDC_o	interest during construction in constant dollars
J	total number of periods or blocks
j	index denoting period or block of capacity
L	years between reference year and year of commercial operation
LC	levelized cost in nominal dollars
LC_D	levelized cost in deflated nominal dollars
LC_o	levelized cost in constant dollars
LCC	levelized cost of capital (nominal dollars)
LCDC	levelized cost of decommissioning (nominal dollars)
LCFC	levelized fuel cycle cost (nominal dollars)
LCOM	levelized O&M cost (nominal dollars)
n	period index relative to time of commercial operation
$OM_{n,j}$	O&M costs for block j in period n
$OM_{o,n}$	O&M costs in reference year dollars in period n

P	block thermal power
PWDC	present worth of decommissioning cost
PWFC	present worth of fuel cycle costs
PWOM	present worth of O&M costs
PWR	pressurized water reactor
SFF(a,b)	sinking fund factor at rate, a, for period, b
t_1	time first block put in operation
TCC	Total capital cost in nominal dollars
TCC_o	total capital cost in constant dollars
t_j	date at beginning of period j or date block j starts operation
t_o	reference date (year given in sect. 2.2)
t_{op}	year of commercial operation
X	average cost of money in nominal dollars
X_o	average cost of money in constant dollars
Z	combined escalation/discount rate

Appendix A

EEDB CODE OF ACCOUNTS FOR ADVANCED LIQUID-METAL REACTOR (ALMR) CONCEPT

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
20	LAND & LAND RIGHTS					
21	STRUCTURES & IMPROVEMENTS					
22	REACTOR PLANT EQUIPMENT					
23	TURBINE PLANT EQUIPMENT					
24	ELECTRIC PLANT EQUIPMENT					
25	MISCELLANEOUS PLANT EQUIPMENT					
26	MAIN COND. HEAT REJECT. SYSTEM					
	TOTAL DIRECT COSTS					
91	CONSTRUCTION SERVICES					
92	AE HOME OFFICE ENGR. & SERVICE					
93	FIELD OFFICE SUPV. & SERVICE					
94	OWNERS' EXPENSES					
95	RM HOME OFFICE ENGINEERING & SERVICE					
	TOTAL INDIRECT COSTS					
	TOTAL COST					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
211	YARDWORK					
212	REACTOR FACILITIES					
213	TURBINE GENERATOR BUILDING					
214	SECURITY BUILDING AND GATE HOUSE					
215	REACTOR SERVICE BUILDING					
216	RADWASTE BUILDING					
217	FUEL SERVICE BUILDING					
218A	CONTROL BUILDING					
218B	ADMINISTRATION BUILDING					
218C	OPERATION AND MAINTENANCE CENTER					
218E	STEAM GENERATOR BUILDINGS					
218K	PIPE TUNNELS					
218L	ELECTRICAL TUNNEL					
218N	MAINTENANCE SHOP					
218P	REACTOR STORAGE SILO					
218Q	MISC TANK FOUNDATION					
218R	BOP SERVICE BUILDING					
218S	WASTEWATER TREATMENT BUILDING					
218T	GAS TURBINE BUILDING					
218V	PERSONNEL SERVICE BLDGS.					
218W	WAREHOUSE					
218Y	REACTOR MODULE SERVICE ROADWAY					
218Z	REACTOR RECEIVING AND ASSEMBLY BLDG.					
219A	TRAINING CENTER					
219K	SODIUM UNLOADING FACILITY					
21	STRUCTURES & IMPROVEMENTS					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
220A	NUCLEAR STEAM SUPPLY (NSSS)					
220B	NSSS OPTIONS					
221	REACTOR EQUIPMENT					
222	MAIN HEAT TRANSPORT SYSTEM					
223	SAFEGUARDS SYSTEM					
224	RADWASTE PROCESSING					
225	FUEL HANDLING					
226	OTHER REACTOR PLANT EQUIPMENT					
227	RX INSTRUMENTATION & CONTROL					
228	REACTOR PLANT MISC. ITEMS					
22	REACTOR PLANT EQUIPMENT					
231	TURBINE GENERATOR					
233	CONDENSING SYSTEM					
234	FEED HEATING SYSTEM					
235	OTHER TURBINE PLANT EQUIP.					
236	INSTRUMENTATION & CONTROL					
237	TURBINE PLANT MISC. ITEMS					
23	TURBINE PLANT EQUIPMENT					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
241	SWITCHGEAR					
242	STATION SERVICE EQUIPMENT					
243	SWITCHBOARDS					
244	PROTECTIVE EQUIPMENT					
245	ELECT. STRUC. & WIRING CONTNR.					
246	POWER & CONTROL WIRING					
24	ELECTRIC PLANT EQUIPMENT					
251	TRANSPORTATION & LIFT EQUIPMENT					
252	AIR, WATER, & STEAM SERVICE SYS.					
253	COMMUNICATIONS EQUIPMENT					
254	FURNISHINGS & FIXTURES					
255	WASTEWATER TREATMENT EQUIP.					
25	MISCELLANEOUS PLANT EQUIP.					
261	STRUCTURES					
262	MECHANICAL EQUIPMENT					
26	MAIN COND. HEAT REJECT SYS.					
	TOTAL DIRECT COSTS					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
911	TEMPORARY CONSTRUCTION FAC.					
912	CONSTRUCTION TOOLS & EQUIP.					
913	PAYROLL INSURANCE & TAXES					
914	PERMITS, INS., & LOCAL TAXES					
915	FACILITY MODULE TRANSPORTATION					
91	CONSTRUCTION SERVICES					
921	ENGR. & HOME OFFICE EXPENSES					
922	ENGR. & HOME OFFICE QA					
923	ENGR. & HOME OFFICE CONSTRCTN. MGMT.					
92	ENGR. & HOME OFFICE SERVICES					
931	FIELD OFFICE EXPENSES					
932	FIELD JOB SUPERVISION					
933	FIELD QA/QC					
934	PLANT STARTUP & TEST					
93	FIELD OFFICE & SERVICES					
941	MGMT., ENGR., & QA					
942	TAXES & INSURANCE					
943	SPARE PARTS					
944	TRAINING					
945	G&A					
946	CAPITAL EQUIPMENT					
94	OWNERS' COSTS					
951	HOME OFFICE SERVICES					
952	HOME OFFICE QA					
95	RM HOME OFFICE ENGR. & SERVICES					
	TOTAL INDIRECT COSTS					
	TOTAL COST					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
21	STRUCTURES & IMPROVEMENTS					
211	YARDWORK					
211.1	GENERAL YARDWORK					
211.4	RAILROADS					
211.7	STRUCTURAL ASSOC. YARDWORK					
	211 YARDWORK					
212	REACTOR FACILITIES					
212.1	BUILDING STRUCTURE					
212.2	BUILDING SERVICES					
	212 REACTOR FACILITIES					
213	TURBINE GENERATOR BUILDING					
213.1	BUILDING STRUCTURE					
213.2	BUILDING SERVICES					
	213 TURBINE GENERATOR BLDG.					
214	SECURITY BUILDING AND GATEHOUSE					
214.1	BUILDING STRUCTURE					
214.2	BUILDING SERVICE					
	214 SECURITY BUILDING AND GATEHOUSE					
215	REACTOR SERVICE BUILDING					
215.1	BUILDING STRUCTURE					
215.2	BUILDING SERVICES					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
216	RADWASTE BUILDING					
216.1	BUILDING STRUCTURE					
216.2	BUILDING SERVICES					
	216 RADWASTE BUILDING					
217	FUEL SERVICE BUILDING					
217.1	BUILDING STRUCTURE					
217.2	BUILDING SERVICES					
	217 FUEL SERVICE BUILDING					
218A	CONTROL BUILDING					
218A.1	BUILDING STRUCTURE					
218A.2	BUILDING SERVICES					
	218A CONTROL BUILDING					
218B	ADMINISTRATION BUILDING					
218B.1	BUILDING STRUCTURE					
218B.2	BUILDING SERVICES					
	218B ADMINISTRATION BLDG.					
218C	OPERATION AND MAINTENANCE CENTER					
218C.1	BUILDING STRUCTURE					
218C.2	BUILDING SERVICES					
	218C OPERATION AND MAINTENANCE CENTER					
218E	STEAM GENERATOR BUILDINGS					
218E.1	BUILDING STRUCTURE					
218E.2	BUILDING SERVICES					
	218E STEAM GENERATOR BUILDINGS					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
218H	PIPE TUNNELS					
218H.1	TUNNEL STRUCTURE					
218H.2	TUNNEL SERVICES					
	218H PIPE TUNNELS					
218L	ELECTRICAL TUNNEL					
218L.1	TUNNEL STRUCTURE					
218L.2	TUNNEL SERVICES					
	218L ELECTRICAL TUNNEL					
218N	MAINTENANCE SHOP					
218N.1	SHOP STRUCTURE					
218N.2	SHOP SERVICES					
	218N MAINTENANCE SHOP					
218P	REACTOR STORAGE SILO					
218P.1	STRUCTURE					
	218P REACTOR STORAGE SILO					
218Q	MISC. TANK FOUNDATIONS					
218Q.1	STRUCTURE					
	218Q MISC. TANK FOUNDATIONS					
218R	BOP SERVICE BLDG.					
218R.1	BUILDING STRUCTURE					
218R.2	BUILDING SERVICES					
	218R BOP SERVICE BLDG.					
218S	WASTE WATER TREATMENT BLDG.					
218S.1	BUILDING STRUCTURE					
218S.2	BUILDING SERVICES					
	218S WASTE WATER TREATMENT BLDG.					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
218T	GAS TURBINE BUILDING					
218T.1	BUILDING STRUCTURE					
218T.2	BUILDING SERVICES					
	218T GAS TURBINE BUILDING					
218V	PERSONAL SERVICE BUILDING					
218V.1	BUILDING STRUCTURE					
218V.2	BUILDING SERVICES					
	218V PERSONAL SERVICE BUILDING					
218W	WAREHOUSE					
218W.1	BUILDING STRUCTURE					
218W.2	BUILDING SERVICES					
	218W WAREHOUSE					
218Y	REACTOR MODULE SERVICE ROADWAY					
218Y.1	STRUCTURE					
	218Y REACTOR MODULE SERVICE ROADWAY					
218Z	REACT. REC. AND ASS. BLDG					
218Z.1	BUILDING STRUCTURE					
218Z.2	BUILDING SERVICES					
	218Z REACT. REC. AND ASS. BLDG.					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
219A	TRAINING CENTER					
219A.1	BUILDING STRUCTURE					
219A.2	BUILDING SERVICES					
	219A TRAINING CENTER					
219K	SODIUM UNLOADING FACILITY					
219K.1	STRUCTURE					
219K.2	SERVICES					
	219K SODIUM UNLOADING FACILITY					
	21 STRUCTURES & IMPROVEMENTS					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
22	REACTOR PLANT EQUIPMENT					
220A	NSSS					
220A.1	QUOTED NSSS PRICE					
220A.2	DISTRIBUTED NSSS COST					
220A.21	REACTOR EQUIPMENT					
220A.211	REACTOR VESSELS					
220A.212	REACTOR VESSEL INTERNALS					
220A.213	CONTROL ROD SYSTEMS					
220A.22	HEAT TRANSPORT SYSTEM					
220A.221	PRIMARY HEAT TRANSPORT SYSTEM					
220A.222	INTERM. HEAT TRANSPORT SYSTEM					
220A.223	STEAM GENERATOR SYSTEM					
220A.23	SAFEGUARDS SYSTEMS					
220A.231	BACKUP HEAT REMOVAL SYSTEMS					
220A.25	FUEL HANDLING & STORAGE					

Table A.1. *ALMR plant cost estimate by EEDB cost account*
(thousands of Jan. 199_ dollars without *contingency*)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
220A.26	OTHER EQUIPMENT					
220A.261	INERT GAS RECEIVING & PROCESSING					
220A.262	SPECIAL HEATING SYSTEM					
220A.264	SODIUM STORAGE, RELIF. MAKEUP					
220A.265	SODIUM PURIFICATION SYSTEM					
220A.266	Na LEAK DETECTION SYSTEM					
220A.267	AUXILIARIES COOLING SYSTEM					
220A.268	MAINTENANCE EQUIPMENT					
220A.27	INSTRUMENTATION & CONTROL					
220A.3	UNDISTRIBUTED NSSS COST					
	220A NSSS					
220B	NSSS OPTIONS					
221	REACTOR EQUIPMENT					
221.1	REACTOR VESSEL & ACCESSORY					
221.11	REACTOR & GUARD VESSEL SUPPORT					
221.12	VESSEL & GUARD VESSEL STRUCTURE					
221.13	VESSEL INTERNALS					
221.2	REACTOR CONTROL DEVICES					
221.21	CONTROL ROD SYSTEM					
	221 REACTOR EQUIPMENT					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
222	MAIN HEAT TRANSPORT SYSTEM					
222.1	PRIMARY HEAT TRANSPORT SYSTEM					
222.11	FLUID CIRCULATION DRIVE SYSTEM					
222.12	REACTOR COOLANT PIPING SYSTEM					
222.13	INTERM. HEAT EXCHANGER EQUIPMENT					
222.15	PRIMARY COOLANT PIPE WHIP RESTRNT.					
222.2	INTERM. HEAT TRANSPORT SYSTEM					
222.21	FLUID CIRCULATION DRIVE SYSTEM					
222.22	INTERM. COOLANT PIPING SYSTEM					
222.23	EXPANSION TANK					
222.24	COOLANT PIPE WHIP RESTRNT.					
222.25	Na/H20 REACTION PROTECTION SYS.					
222.253	TANKS					
222.255	PIPING					
222.257	PIPING - MISCELLANEOUS ITEMS					
222.258	INSTRUMENTATION & CONTROL					
222.259	FOUNDATIONS					
222.3	STEAM GENERATION SYSTEM					
222.31	FLUID CIRCULATION DRIVE SYSTEM					
222.33	STEAM GENERATOR EQUIPMENT					
	222 MAIN HEAT TRANSPORT SYSTEM					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
223	SAFEGUARDS SYSTEM					
223.1	AUXILIARY HEAT TRANSPORT SYSTEM					
223.11	ROTATING EQUIPMENT					
223.12	HEAT TRANSFER EQUIPMENT					
223.13	TANK & PRESSURE VESSEL					
223.15	PIPING					
223.16	VALVES					
223.17	PIPING - MISCELLANEOUS ITEMS					
223.18	INSTRUMENTATION & CONTROL					
223.19	FOUNDATIONS					
	223 SAFEGUARDS SYS.					
224	RADWASTE PROCESSING					
224.1	LIQUID WASTE PROCESSING					
224.2	GAS DISTRIBUTION & PROCESS SYSTEM					
224.3	SOLID WASTE SYSTEM					
	224 RADWASTE PROCESSING					
225	FUEL HANDLING					
225.1	FUEL HANDLING MECHANISMS					
225.2	FUEL HANDLING EQUIPMENT					
225.3	INSPECTION EQUIPMENT					
225.4	CORE COMPONENT STORAGE					
	225 FUEL HANDLING					
226	OTHER REACTOR PLANT EQUIPMENT					
226.1	INERT GAS SYSTEM					
226.2	SPECIAL HEATING SYSTEM					
226.3	LM REC. STORAGE & PROC. SYSTEM					
226.7	AUXILIARY COOLING SYSTEM					
226.8	MAINTENANCE EQUIPMENT					
226.9	SAMPLING EQUIPMENT					
	226 OTHER REACTOR PLANT EQUIPMENT					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
227	RX INSTRUMENTATION & CONTROL					
227.1	BENCHBOARD, PANELS & RACKS, ETC.					
227.2	PROCESS COMPUTERS					
227.3	MONITORING SYSTEMS					
227.4	PLANT CONTROL & PROTECTION SYSTEM					
	227 RX INSTR. & CONTROL					
228	REACTOR PLANT MISCELLANEOUS ITEMS					
228.1	FIELD PAINTING					
228.2	QUALIFICATION OF WELDERS					
228.3	STANDARD NSSS VALVE PACKAGE					
228.4	REACTOR PLANT INSULATION					
	228 REACTOR PLANT MISC. ITEMS					
	22 REACTOR PLANT EQUIPMENT					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
23	TURBINE PLANT EQUIPMENT					
231	TURBINE GENERATOR					
231.1	TURBINE GENERATOR & ACCESSORY					
231.2	FOUNDATIONS					
231.4	LUBRICATING OIL SYSTEM					
231.5	GAS SYSTEMS					
231.6	MSTR. SEPRTR./REHTR. DRAIN SYSTEM					
	231 TURBINE GENERATOR					
233	CONDENSING SYSTEMS					
233.1	CONDENSER EQUIPMENT					
233.12	HEAT TRANSFER EQUIPMENT					
233.2	CONDENSATE SYSTEM					
233.21	ROTATING EQUIPMENT					
233.23	TANKS & PRESSURE VESSELS					
233.25	PIPING					
233.26	VALVES					
233.27	PIPING - MISCELLANEOUS ITEMS					
233.28	INSTRUMENTATION & CONTROL					
233.29	FOUNDATIONS					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
233.3	GAS REMOVAL SYSTEM					
233.4	TURBINE BYPASS SYSTEM					
233.5	CONDENSATE POLISHING					
	233 CONDENSING SYSTEMS					
234	FEED HEATING SYSTEM					
234.1	FEEDWATER HEATERS					
234.12	HEAT TRANSFER EQUIPMENT					
234.2	FEEDWATER SYSTEM					
234.21	ROTATING MACHINERY					
234.25	PIPING					
234.26	VALVES					
234.27	PIPING - MISCELLANEOUS ITEMS					
234.28	INSTRUMENTATION & CONTROL					
234.29	FOUNDATIONS					
234.3	EXTRACTION SYSTEM					
234.4	FWH VENT & DRAIN SYSTEM					
	234 FEED HEATING SYSTEM					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
235	OTHER TURBINE PLANT EQUIPMENT					
235.1	MAIN VAPOR PIPING SYSTEM					
235.2	TURBINE AUXILIARIES					
235.3	TB CLOSED COOLING WATER SYSTEM					
235.4	DEMIN. WATER MAKEUP SYSTEM					
235.5	CHEMICAL TREATMENT SYSTEM					
235.6	NEUTRALIZATION SYSTEM					
	235 OTHER TURBINE PLANT EQUIP.					
236	INSTRUMENTATION & CONTROL					
236.1	PROCESS INSTR. & CONTROL EQUIPMENT					
236.2	PROCESS COMPUTER					
236.3	TURBINE PLANT INSTR. & CONTROL TUBING					
	236 INSTRUMENTATION & CONTROL					
237	TURBINE PLANT MISCELLANEOUS ITEMS					
237.1	FIELD PAINTING					
237.2	QUALIFICATION OF WELDERS					
237.3	TURBINE PLANT INSULATION					
	237 TURBINE PLANT MISC. ITEMS					
	23 TURBINE PLANT EQUIPMENT					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
24	ELECTRICAL PLANT EQUIPMENT					
241	SWITCHGEAR					
241.1	GENERATOR EQUIPMENT SWITCHGEAR					
241.2	STATION SERVICE SWITCHGEAR					
	241 SWITCHGEAR					
242	STATION SERVICE EQUIPMENT					
242.1	*STATION SERVICE & STARTUP EQUIP.*					
242.2	UNIT SUBSTATIONS					
242.3	AUXILIARY POWER SOURCES					
	242 STATION SERV. EQUIPMENT					
243	SWITCHBOARDS					
243.1	CONTROL PANELS					
242.2	AUXILIARY POWER & SIGNAL BOARDS					
	243 SWITCHBOARDS					
244	PROTECTIVE EQUIPMENT					
244.1	GENERAL STATION GROUND SYSTEM					
244.2	FIRE DETECTION & SUPPRESSION					
244.3	LIGHTNING PROTECTION					
244.4	CATHODIC PROTECTION					
244.5	HEAT TRACING & FREEZE PROT.					
	244 PROTECTIVE EQUIPMENT					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
245	ELECT. STRUCTURE & WIRING CONTAINERS					
245.1	UNDERGROUND DUCT RUNS					
245.2	CABLE TRAYS					
245.3	CONDUITS					
	245 ELECT. STRUCT. & WIRING					
246	POWER & CONTROL WIRING					
246.1	GENERATOR CIRCUITS WIRING					
246.2	STATION SERVICE POWER WIRING					
246.3	CONTROL CABLE					
246.4	INSTRUMENT WIRE					
246.5	CONTAINMENT PENETRATIONS					
	246 POWER & CONTROL WIRING					
	24 ELECTRICAL POWER EQUIPMENT					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
25	MISCELLANEOUS PLANT EQUIPMENT					
251	TRANSPORTATION & LIFT EQUIPMENT					
251.1	CRANES & HOISTS					
	251 TRANSPORTATION & LIFT					
252	AIR, WATER, & STEAM SERV. SYSTEM					
252.1	AIR SYSTEMS					
252.2	WATER SYSTEMS					
252.21	PLANT SERVICE WATER SYSTEM					
252.22	NORMAL FIRE PROTECTION SYSTEM					
252.23	PROCESS CHILLED WATER SYSTEM					
252.24	POTABLE WATER SYSTEM					
252.3	AUXILIARY STEAM SYSTEM					
252.4	PLANT FUEL OIL SYSTEM					
252.5	SODIUM FIRE PROTECTION SYSTEM					
	252 AIR, WATER, & STEAM SERV. SYS.					
253	COMMUNICATIONS EQUIPMENT					
253.1	LOCAL COMMUNICATIONS SYSTEMS					
253.2	SIGNAL SYSTEMS					
253.3	SECURITY SYSTEMS					
	253 COMMUNICATIONS EQUIPMENT					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
254	FURNISHING & FIXTURES					
254.1	SAFETY EQUIPMENT					
254.2	CHEMICAL LAB & INSTR. SHOP					
254.3	OFFICE EQUIPMENT & FURNISHINGS					
254.4	CHANGE ROOM EQUIPMENT					
254.5	ENVIRONMENTAL MONITORING EQUIPMENT					
254.6	DINING FACILITIES					
254.7	MAINTENANCE SHOP EQUIPMENT					
	254 FURNISHINGS & FIXTURES					
255	WASTEWATER TREATMENT SYSTEM					
	25 MISCELLANEOUS PLANT EQUIPMENT					
26	MAIN COND. HEAT REJECTION SYSTEM					
261	STRUCTURES					
261.1	MAKEUP WATER & DISCH. STR.					
261.2	CIRC. WATER PUMP HOUSE					
261.3	MAKEUP WATER PRETREATMENT BUILDING					
261.4	COOLING TOWER SWITCHGEAR BUILDING					
	261 STRUCTURES					
262	MECHANICAL EQUIPMENT					
262.1	HEAT REJECTION SYSTEM					
	262 MECHANICAL EQUIPMENT					
	26 MAIN COND. HEAT REJECT. SYS.					

Table A.1. ALMR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
91	CONSTRUCTION SERVICES					
911	TEMPORARY CONSTRUCTION FACILITIES					
911.1	TEMPORARY BUILDINGS					
911.2	TEMPORARY FACILITIES					
	911 TEMP. CONSTRUCTN. FACILITIES					
912	CONSTRUCTION TOOLS & EQUIPMENT					
912.1	MAJOR EQUIPMENT					
912.2	MISCELLANEOUS VEHICLES					
912.3	PURCHASE OF SMALL TOOLS					
912.4	EXPENDABLE SUPPLIES					
912.5	SAFETY EQUIPMENT & INSPECTION					
	912 CONSTRCTN. TOOLS & EQUIPMENT					
913	PAYROLL INSURANCE & TAXES					
914	PERMITS, INSURANCE, & LOCAL TAXES					
915	FACILITY MODULE TRANSPORTATION					
	91 CONSTRUCTION SERVICES					

Table A.1. *ALMR plant cost estimate by EEDB cost account*
(thousands of Jan. 199_ dollars without *contingency*)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
92	ENGR. & HOME OFFICE SERVICES					
921	HOME OFFICE EXPENSES					
922	HOME OFFICE QA					
923	HOME OFFICE CONSTRCTN. MGMT.					
	92 ENGR. & HOME OFFICE SERVICES					
93	FIELD OFFICE & SERVICE					
931	FIELD OFFICE EXPENSES					
932	FIELD JOB SUPERVISION					
933	FIELD OFFICE QA/QC					
934	PLANT STARTUP & TESTING					
	93 FLD. SUPERVISION & FLD. OFFICE SERV.					
94	OWNER'S COSTS					
941	MANAGEMENT, ENGINEERING, & QA					
942	TAXES AND INSURANCE					
943	SPARE PARTS					
944	STAFF TRAINING AND STARTUP					
945	(G&A) GENERAL AND ADMINISTRATIVE					
946	CAPITAL EQUIPMENT					
	94 OWNER'S COSTS					
95	RM HOME OFFICE ENGINEERING AND SERVICES					
951	HOME OFFICE SERVICES					
952	HOME OFFICE QA					
	95 RM HOME OFFICE ENGINEERING AND SERVICES					

Appendix B

EEDB CODE OF ACCOUNTS FOR MODULAR HIGH-TEMPERATURE GAS-COOLED REACTOR (MHTGR) CONCEPT

Table B.1. MHTGR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
20	LAND & LAND RIGHTS					
21	STRUCTURES & IMPROVEMENTS					
22	REACTOR PLANT EQUIPMENT					
23	TURBINE PLANT EQUIPMENT					
24	ELECTRIC PLANT EQUIPMENT					
25	MISCELLANEOUS PLANT EQUIPMENT					
26	HEAT REJECT. SYSTEM					
	TOTAL DIRECT COSTS					
91	CONSTRUCTION SERVICES					
92	HOME OFFICE ENGR. & SERVICE					
93	FIELD OFFICE SUPV. & SERVICE					
94	OWNERS' COST					
95	RM HOME OFFICE ENGINEERING & SERVICE					
	TOTAL INDIRECT COSTS					
	TOTAL COST					

Table B.1. MHTGR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
211	YARDWORK					
212	REACTOR BUILDING					
213	TURBINE BUILDING					
214	OPERATION CENTER					
215	REACTOR SERVICE BUILDING					
216	RADIOACTIVE WASTE MANAGEMENT BUILDING					
218A	PERSONNEL SERVICES BUILDING					
218C	MAKEUP WATER TREATMENT & AUXILIARY BOILER BUILDING					
218D	FIRE PUMP HOUSE					
218E	HELIUM STORAGE BUILDING					
218G	HYDROGEN STORAGE AREA					
218H	GUARD HOUSE					
218I	NUCLEAR ISLAND WAREHOUSE					
218J	ECA WAREHOUSE					
218K	MAINTENANCE BUILDING					
218U	STANDBY POWER BUILDING					
218X	NUCLEAR ISLAND COOLING WATER BUILDING					
218Z	REACTOR AUXILIARY BUILDING					
21	STRUCTURES & IMPROVEMENTS					

Table B.1. MHTGR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
221	REACTOR SYSTEMS					
222	VESSEL SYSTEM					
223	HEAT TRANSPORT SYSTEM					
224	SHUTDOWN COOLING SYSTEM					
225	SHUTDOWN COOLING WATER SYSTEM					
226	REACTOR CAVITY COOLING SYSTEM					
227	REACTOR SERVICE SYSTEMS					
228	PLANT CONTROL, DATA AND INSTRUMENTATION SYSTEM					
229	REACTOR PLANT MISCELLANEOUS ITEMS					
22	REACTOR PLANT EQUIPMENT					
231	TURBINE GENERATOR & AUXILIARIES SYSTEM					
233	MAIN & AUXILIARY STEAM SYSTEM					
234	FEEDWATER & CONDENSATE SYSTEM					
235	STARTUP & SHUTDOWN SYSTEM					
236	TURBINE PLANT SAMPLING					
237	CONTROL, DATA & INSTRUMENTATION SYSTEMS					
23	TURBINE PLANT EQUIPMENT					

Table B.1. MHTGR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
241	SWITCHGEAR					
242	STATION SERVICE EQUIPMENT					
243	SWITCHBOARDS					
244	PROTECTIVE EQUIPMENT					
245	ELECT. STRUC. & WIRING CONTAINERS					
246	POWER & CONTROL WIRING					
24	ELECTRIC PLANT EQUIPMENT					
251	TRANSPORTATION & LIFT EQUIPMENT					
252	AIR, WATER, & STEAM SERVICE SYSTEMS					
253	COMMUNICATIONS EQUIPMENT					
254	FURNISHINGS & FIXTURES					
25	MISCELLANEOUS PLANT EQUIPMENT					
261	CIRCULATING & SERVICE WATER PUMP HOUSE					
262	ECA COOLING WATER SYSTEM					
26	CIRCULATING & SERVICE WATER SYSTEM					
	TOTAL DIRECT COSTS					

Table B.1. MHTGR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
911	TEMPORARY CONSTRUCTION FACILITIES					
912	CONSTRUCTION TOOLS & EQUIPMENT					
913	PAYROLL INSURANCE & TAXES					
914	PERMITS, INS., & LOCAL TAXES					
91	CONSTRUCTION SERVICES					
920	REACTOR MODULE ENGINEERING & SERVICES					
921	AE PLANT ENGINEERING AND SERVICES					
922	AE HOME OFFICE QA					
923	AE HOME OFFICE PROJECT & CONSTRUCTION MANAGEMENT					
92	ENGR. & HOME OFFICE SERVICES					
931	FIELD OFFICE EXPENSES					
932	FIELD JOB SUPERVISION					
933	FIELD QA/QC					
934	PLANT STARTUP & TEST					
93	FIELD OFFICE & SERVICES					
941	MGMT., ENGR., & QA					
942	FEES, TAXES & INSURANCE					
943	SPARE PARTS					
944	TRAINING					
945	G&A					
946	CAPITAL EQUIPMENT					
94	OWNERS' COSTS					
951	HOME OFFICE SERVICES					
952	HOME OFFICE QA					
95	RM HOME OFFICE ENGR. & SERVICES					

Appendix C

EEDB CODE OF ACCOUNTS FOR THE REFERENCE PRESSURIZED WATER REACTOR (PWR)

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
20	LAND & LAND RIGHTS					
21	STRUCTURES & IMPROVEMENTS					
22	REACTOR PLANT EQUIPMENT					
23	TURBINE PLANT EQUIPMENT					
24	ELECTRIC PLANT EQUIPMENT					
25	MISCELLANEOUS PLANT EQUIPMENT					
26	MAIN COND. HEAT REJECT. SYSTEM					
	TOTAL DIRECT COSTS					
91	CONSTRUCTION SERVICES					
92	AE HOME OFFICE ENGR. & SERVICE					
93	FIELD OFFICE SUPV. & SERVICE					
94	OWNERS' EXPENSES					
95	RM HOME OFFICE ENGINEERING & SERVICE					
	TOTAL INDIRECT COSTS					
	TOTAL COST					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
211	YARDWORK					
212	REACTOR FACILITIES					
213	TURBINE ROOM AND HEATER BAY					
214	SECURITY BUILDINGS					
215	PRIM AUX. BLDG. AND TUNNELS					
216	RADWASTE BUILDING					
217	FUEL SERVICE BUILDING					
218A	CONTROL BUILDING					
218B	ADMINISTRATION BUILDING					
218D	FIRE PUMP HOUSE					
218E	EMERGENCY FEED PUMP BLDG.					
218F	MANWAY TUNNELS (RCA TUNLS)					
218G	ELECTRICAL TUNNELS					
218J	MN STEAM & FW PIPE ENC.					
218K	PIPE TUNNELS					
218L	TECHNICAL SUPPORT CENTER					
218P	CONTAIN EQ HATCH MSLE SHLD.					
218S	WASTEWATER TREATMENT					
218T	ULTIMATE HEAT SINK STRUCTURE					
218V	PERSONNEL SERVICE BLDGS.					
21	STRUCTURES & IMPROVEMENTS					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
220A	NUCLEAR STEAM SUPPLY (NSSS)					
220B	NSSS OPTIONS					
221	REACTOR EQUIPMENT					
222	MAIN HEAT TRANSPORT SYSTEM					
223	SAFEGUARDS SYSTEM					
224	RADWASTE PROCESSING					
225	FUEL HANDLING AND STORAGE					
226	OTHER REACTOR PLANT EQUIPMENT					
227	RX INSTRUMENTATION & CONTROL					
228	REACTOR PLANT MISC. ITEMS					
22	REACTOR PLANT EQUIPMENT					
231	TURBINE GENERATOR					
233	CONDENSING SYSTEM					
234	FEED HEATING SYSTEM					
235	OTHER TURBINE PLANT EQUIP.					
236	INSTRUMENTATION & CONTROL					
237	TURBINE PLANT MISC. ITEMS					
23	TURBINE PLANT EQUIPMENT					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
241	SWITCHGEAR					
242	STATION SERVICE EQUIPMENT					
243	SWITCHBOARDS					
244	PROTECTIVE EQUIPMENT					
245	ELECT. STRUC. & WIRING CONTNR.					
246	POWER & CONTROL WIRING					
24	ELECTRIC PLANT EQUIPMENT					
251	TRANSPORTATION & LIFT EQUIPMENT					
252	AIR, WATER, & STEAM SERVICE SYS.					
253	COMMUNICATIONS EQUIPMENT					
254	FURNISHINGS & FIXTURES					
255	WASTEWATER TREATMENT EQUIP.					
25	MISCELLANEOUS PLANT EQUIP.					
261	STRUCTURES					
262	MECHANICAL EQUIPMENT					
26	MAIN COND. HEAT REJECT SYS.					
	TOTAL DIRECT COSTS					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
911	TEMPORARY CONSTRUCTION FAC.					
912	CONSTRUCTION TOOLS & EQUIP.					
913	PAYROLL INSURANCE & TAXES					
914	PERMITS, INS., & LOCAL TAXES					
915	FACILITY MODULE TRANSPORTATION					
91	CONSTRUCTION SERVICES					
921	ENGR. & HOME OFFICE EXPENSES					
922	ENGR. & HOME OFFICE QA					
923	ENGR. & HOME OFFICE CONSTRCTN. MGMT.					
92	ENGR. & HOME OFFICE SERVICES					
931	FIELD OFFICE EXPENSES					
932	FIELD JOB SUPERVISION					
933	FIELD QA/QC					
934	PLANT STARTUP & TEST					
93	FIELD OFFICE & SERVICES					
941	MGMT., ENGR., & QA					
942	TAXES & INSURANCE					
943	SPARE PARTS					
944	TRAINING					
945	G&A					
946	CAPITAL EQUIPMENT					
94	OWNERS' COSTS					
951	HOME OFFICE SERVICES					
952	HOME OFFICE QA					
95	RM HOME OFFICE ENGR. & SERVICES					
	TOTAL INDIRECT COSTS					
	TOTAL COST					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
21	STRUCTURES & IMPROVEMENTS					
211	YARDWORK					
211.1	GENERAL YARDWORK					
211.4	RAILROADS					
211.7	STRUCTURAL ASSOC. YARDWORK					
	211 YARDWORK					
212	REACTOR FACILITIES					
212.1	BUILDING STRUCTURE					
212.2	BUILDING SERVICES					
	212 REACTOR FACILITIES					
213	TURBINE GENERATOR BUILDING					
213.1	BUILDING STRUCTURE					
213.2	BUILDING SERVICES					
	213 TURBINE GENERATOR BLDG.					
214	SECURITY BUILDING					
214.1	BUILDING STRUCTURE					
214.2	BUILDING SERVICE					
	214 SECURITY BUILDING AND GATEHOUSE					
215	REACTOR SERVICE BUILDING					
215.1	BUILDING STRUCTURE					
215.2	BUILDING SERVICES					
	215 REACTOR SERVICE BUILDING					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	*Factory* equipment	*Site labor* hours	*Site* labor	*Site* material	Total $
216	RADWASTE BUILDING					
216.1	BUILDING STRUCTURE					
216.2	BUILDING SERVICES					
	216 RADWASTE BUILDING					
217	FUEL SERVICE BUILDING					
217.1	BUILDING STRUCTURE					
217.2	BUILDING SERVICES					
	217 FUEL SERVICE BUILDING					
218A	CONTROL BUILDING					
218A.1	BUILDING STRUCTURE					
218A.2	BUILDING SERVICES					
	218A CONTROL BUILDING					
218B	ADMINISTRATION BUILDING					
218B.1	BUILDING STRUCTURE					
218B.2	BUILDING SERVICES					
	218B ADMINISTRATION BLDG.					
218C	OPERATION AND MAINTENANCE CENTER					
218C.1	BUILDING STRUCTURE					
218C.2	BUILDING SERVICES					
	218C OPERATION AND MAINTENANCE CENTER					
218E	EMERGENCY FEED PUMP BUILDING					
218E.1	BUILDING STRUCTURE					
218E.2	BUILDING SERVICES					
	218E EMERGENCY FEED PUMP BLDG.					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
218F	MANWAY TUNNELS					
218F.1	BUILDING STRUCTURE					
218F.2	BUILDING SERVICES					
	218F MANWAY TUNNELS					
218G	ELECTRICAL TUNNELS					
218G.1	BLDG STRUCTURE (INCL. ACCT 218E)					
218G.2	BUILDING SERVICES					
	218G ELECTRICAL TUNNELS					
218H	NONESSENTIAL SWGR BUILDING					
218H.1	BUILDING STRUCTURE					
218H.2	BUILDING SERVICES					
	218H NONESSENTIAL SWGR BUILDING					
218J	MAIN STEAM & FW PIPE ENC					
218J.1	BUILDING STRUCTURE					
218J.2	BUILDING SERVICES					
	218J MN STEAM & FW PIPE ENC					
218K	PIPE TUNNELS					
218K.1	BUILDING STRUCTURE					
218K.2	BUILDING SERVICES					
	218K PIPE TUNNELS					
218L	TECHNICAL SUPPORT CENTER					
218L.1	BUILDING STRUCTURE					
218.2	BUILDING SERVICES					
	218L TECH. SUPPORT CENTER					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
218P	CONTAIN EQ HATCH MSLE SHLD					
218P.1	SHIELD STRUCTURE					
	218P CONT. EQ HATCH MSLE SHLD					
218S	WASTE WATER TREATMENT					
218S.1	BUILDING STRUCTURE					
218S.2	W. WATER HOLDING BASIN					
	218S WASTE WATER TREATMENT					
218T	ULTIMATE HEAT SINK STRT.					
218T.1	BUILDING STRUCTURE					
218T.2	BUILDING SERVICES					
	218T ULTRIMATE HEAT SINK STRT.					
218V	CONTR RM EMG AIR INTK STR					
218V.1	BUILDING STRUCTURE					
218V.2	BUILDING SERVICES					
	218T CONTR RM EMG AIR INTK STR					
	21 STRUCTURES & IMPROVEMENTS					

Table C.1. PWR plant cost estimate by EEDB cost account (thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
22	REACTOR PLANT EQUIPMENT					
220A	NSSS					
220A.1	QUOTED NSSS PRICE					
220A.2	DISTRIBUTED NSSS COST					
220A.21	REACTOR EQUIPMENT					
220A.211	REACTOR VESSELS					
220A.212	REACTOR VESSEL INTERNALS					
220A.213	CONTROL ROD SYSTEMS					
220A.22	HEAT TRANSPORT SYSTEM					
220A.221	MAIN COOLANT PUMPS					
220A.222	REACTOR COOLANT PIPING					
220A.223	STEAM GENERATORS					
220A.224	PRESSURIZER					
220A.225	PRESSURIZER RELIEF TANK					
220A.23	SAFEGUARDS SYSTEMS					
220A.231	BACKUP HEAT REMOVAL SYSTEMS					
220A.232	SAFETY INJECTION SYSTEM					
220A.25	FUEL HANDLING & STORAGE					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
220A.26	OTHER EQUIPMENT					
220A.261	COOLANT TREATMENT AND RECOVERY					
220A.262	MAINTENANCE EQUIPMENT					
220A.27	INSTRUMENTATION & CONTROL					
220A.3	UNDISTRIBUTED NSSS COST					
	220A NSSS					
220B	NSSS OPTIONS					
221	REACTOR EQUIPMENT					
221.1	REACTOR VESSEL & ACCESSORY					
221.11	REACTOR SUPPORT					
221.12	VESSEL STRUCTURE					
221.13	VESSEL INTERNALS					
221.14	TRANSPORT TO SITE					
221.2	REACTOR CONTROL DEVICES					
221.21	CONTROL ROD SYSTEM					
	221 REACTOR EQUIPMENT					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
222	MAIN HEAT TRANSPORT SYSTEM					
222.1	REACTOR CORE COOLANT SYSTEM					
222.11	FLUID CIRCULATION DRIVE SYSTEM					
222.12	REACTOR COOLANT PIPING SYSTEM					
222.13	STEAM GENERATOR EQUIPMENT					
222.15	PRESSURIZING SYSTEM					
	222 MAIN HEAT TRANSPORT SYSTEM					
223.3	SAFEGUARDS SYSTEM					
223.1	RESIDUAL HEAT REMOVAL SYSTEM					
223.11	ROTATING EQUIPMENT					
223.12	HEAT TRANSFER EQUIPMENT					
223.15	PIPING					
223.16	VALVES					
223.17	PIPING - MISCELLANEOUS ITEMS					
223.18	INSTRUMENTATION & CONTROL					
223.3	SAFETY INJECTION SYSTEM					
223.4	CONTAINMENT SPRAY SYSTEM					
223.5	COMBUSTIBLE GAS CONTROL SYST.					
	223 SAFEGUARDS SYS.					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
224	RADWASTE PROCESSING					
224.1	LIQUID WASTE PROCESSING					
224.2	GAS DISTRIBUTION & PROCESS SYSTEM					
224.3	SOLID WASTE SYSTEM					
	224 RADWASTE PROCESSING					
225	FUEL HANDLING AND STORAGE					
225.1	FUEL HANDLING TOOLS AND EQUIP					
225.3	SERVICE PLATFORMS					
225.4	FUEL STOR CLNG & INSP. EQ					
	225 FUEL HANDLING					
226	OTHER REACTOR PLANT EQUIPMENT					
226.1	INERT GAS SYSTEM					
226.3	REALTOR MAKEUPWATER SYST.					
226.4	COOLANT TREATMENT AND RECYCLE					
226.7	AUXILIARY COOLING SYSTEM					
226.8	MAINTENANCE EQUIPMENT					
226.9	SAMPLING EQUIPMENT					
	226 OTHER REACTOR PLANT EQUIPMENT					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
227	RX INSTRUMENTATION & CONTROL					
227.1	BENCHBOARD, PANELS & RACKS, ETC.					
227.2	PROCESS COMPUTERS					
227.3	MONITORING SYSTEMS					
227.4	PLANT CONTROL & PROTECTION SYSTEM					
227.5	RX PLANT I&C TUBING & FITTINGS					
227.9	TM INSTRUMENTATION					
	227 RX INSTR. & CONTROL					
228	REACTOR PLANT MISCELLANEOUS ITEMS					
228.1	FIELD PAINTING					
228.2	QUALIFICATION OF WELDERS					
228.4	REACTOR PLANT INSULATION					
	228 REACTOR PLANT MISC. ITEMS					
	22 REACTOR PLANT EQUIPMENT					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
23	TURBINE PLANT EQUIPMENT					
231	TURBINE GENERATOR					
231.1	TURBINE GENERATOR & ACCESSORY					
231.2	FOUNDATIONS					
231.4	LUBRICATING OIL SYSTEM					
231.5	GAS SYSTEMS					
231.6	MSTR. SEPRTR./REHTR. DRAIN SYSTEM					
	231 TURBINE GENERATOR					
233	CONDENSING SYSTEMS					
233.1	CONDENSER EQUIPMENT					
233.2	CONDENSATE SYSTEM					
233.3	GAS REMOVAL SYSTEM					
233.4	TURBINE BYPASS SYSTEM					
233.5	CONDENSATE POLISHING					
	233 CONDENSING SYSTEMS					
234	FEED HEATING SYSTEM					
234.1	FEEDWATER HEATERS					
234.2	FEEDWATER SYSTEM					
234.3	EXTRACTION STEAM SYSTEM					
234.4	FWH VENT & DRAIN SYSTEM					
	234 FEED HEATING SYSTEM					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
235	OTHER TURBINE PLANT EQUIPMENT					
235.1	MAIN VAPOR PIPING SYSTEM					
235.2	TURBINE AUXILIARIES					
235.3	TB CLOSED COOLING WATER SYSTEM					
235.4	DEMIN. WATER MAKEUP SYSTEM					
235.5	CHEMICAL TREATMENT SYSTEM					
235.6	NEUTRALIZATION SYSTEM					
	235 OTHER TURBINE PLANT EQUIP.					
236	INSTRUMENTATION & CONTROL					
236.1	PROCESS INSTR. & CONTROL EQUIPMENT					
236.2	PROCESS COMPUTER					
236.3	TURBINE PLANT INSTR. & CONTROL TUBING					
	236 INSTRUMENTATION & CONTROL					
237	TURBINE PLANT MISCELLANEOUS ITEMS					
237.1	FIELD PAINTING					
237.2	QUALIFICATION OF WELDERS					
237.3	TURBINE PLANT INSULATION					
	237 TURBINE PLANT MISC. ITEMS					
	23 TURBINE PLANT EQUIPMENT					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
24	ELECTRICAL PLANT EQUIPMENT					
241	SWITCHGEAR					
241.1	GENERATOR EQUIPMENT SWITCHGEAR					
241.2	STATION SERVICE SWITCHGEAR					
	241 SWITCHGEAR					
242	STATION SERVICE EQUIPMENT					
242.1	STATION SERVICE & STARTUP EQUIP.					
242.2	UNIT SUBSTATIONS					
242.3	AUXILIARY POWER SOURCES					
	242 STATION SERV. EQUIPMENT					
243	SWITCHBOARDS					
243.1	CONTROL PANELS					
242.2	AUXILIARY POWER & SIGNAL BOARDS					
	243 SWITCHBOARDS					
244	PROTECTIVE EQUIPMENT					
244.1	GENERAL STATION GROUND SYSTEM					
244.2	FIRE DETECTION & SUPPRESSION					
244.3	LIGHTNING PROTECTION					
244.4	CATHODIC PROTECTION					
244.5	HEAT TRACING & FREEZE PROT.					
	244 PROTECTIVE EQUIPMENT					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
25	MISCELLANEOUS PLANT EQUIPMENT					
251	TRANSPORTATION & LIFT EQUIPMENT					
251.1	CRANES & HOISTS					
	251 TRANSPORTATION & LIFT					
252	AIR, WATER, & STEAM SERV. SYSTEM					
252.1	AIR SYSTEMS					
252.2	WATER SYSTEMS					
252.3	AUXILIARY STEAM SYSTEM					
252.4	PLANT FUEL OIL SYSTEM					
	252 AIR, WATER, & STEAM SERV. SYS.					
253	COMMUNICATIONS EQUIPMENT					
253.1	LOCAL COMMUNICATIONS SYSTEMS					
253.2	SIGNAL SYSTEMS					
253.3	SECURITY SYSTEMS					
	253 COMMUNICATIONS EQUIPMENT					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
254	FURNISHING & FIXTURES					
254.1	SAFETY EQUIPMENT					
254.2	CHEMICAL LAB & INSTR. SHOP					
254.3	OFFICE EQUIPMENT & FURNISHINGS					
254.4	CHANGE ROOM EQUIPMENT					
254.5	ENVIRONMENTAL MONITORING EQUIPMENT					
254.6	DINING FACILITIES					
	254 FURNISHINGS & FIXTURES					
255	WASTEWATER TREATMENT SYSTEM					
255.1	ROTATING EQUIPMENT					
255.3	TANKS & PRESSURE VESSELS					
255.4	PURIFICATION & FILTER EQUIP					
	255 WASTEWATER TREATMENT SYSTEM					
	25 MISCELLANEOUS PLANT EQUIPMENT					
26	MAIN COND. HEAT REJECTION SYSTEM					
261	STRUCTURES					
261.1	MAKEUP WATER & INTAKE					
261.2	CIRC. WATER PUMP HOUSE					
261.3	MAKEUP WATER PRETREATMENT BUILDING					
	261 STRUCTURES					
262	MECHANICAL EQUIPMENT					
262.1	HEAT REJECTION SYSTEM					
	262 MECHANICAL EQUIPMENT					
	26 MAIN COND. HEAT REJECT. SYS.					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
91	CONSTRUCTION SERVICES					
911	TEMPORARY CONSTRUCTION FACILITIES					
911.1	TEMPORARY BUILDINGS					
911.2	TEMPORARY FACILITIES					
	911 TEMP. CONSTRUCTN. FACILITIES					
912	CONSTRUCTION TOOLS & EQUIPMENT					
912.1	MAJOR EQUIPMENT					
912.2	MISCELLANEOUS VEHICLES					
912.3	SMALL TOOLS					
912.4	EXPENDABLE SUPPLIES					
912.5	SAFETY EQUIPMENT & INSPECTION					
	912 CONSTRCTN. TOOLS & EQUIPMENT					
913	PAYROLL INSURANCE & TAXES					
914	PERMITS, INSURANCE, & LOCAL TAXES					
915	FACILITY MODULE TRANSPORTATION					
	91 CONSTRUCTION SERVICES					

Table C.1. PWR plant cost estimate by EEDB cost account
(thousands of Jan. 199_ dollars without contingency)

Account No.	Account description	Factory equipment	Site labor hours	Site labor	Site material	Total $
92	ENGR. & HOME OFFICE SERVICES					
921	HOME OFFICE EXPENSES					
922	HOME OFFICE QA					
923	HOME OFFICE CONSTRCTN. MGMT.					
	92 ENGR. & HOME OFFICE SERVICES					
93	FIELD OFFICE & SERVICE					
931	FIELD OFFICE EXPENSES					
932	FIELD JOB SUPERVISION					
933	FIELD OFFICE QA/QC					
934	PLANT STARTUP & TESTING					
	93 FLD. SUPERVISION & FLD. OFFICE SERV.					
94	OWNER'S COSTS					
941	MANAGEMENT, ENGINEERING, & QA					
942	TAXES AND INSURANCE					
943	SPARE PARTS					
944	STAFF TRAINING AND STARTUP					
945	(G&A) GENERAL AND ADMINISTRATIVE					
946	CAPITAL EQUIPMENT					
	94 OWNER'S COSTS					
95	RM HOME OFFICE ENGINEERING AND SERVICES					
951	HOME OFFICE SERVICES					
952	HOME OFFICE QA					
	95 RM HOME OFFICE ENGINEERING AND SERVICES					

Appendix D

LISTING OF SAMPLE FOAK TASKS

D.1 ENGINEERING AND MANAGEMENT

- Prepare engineering specifications and drawings using generic site parameters as needed for design certification (layouts, design, manufacturing, installation, and interface control drawings).
- Prepare overall plant technical documents and maintenance and operating manuals.
- Prepare management plans, directives, and procedures.
- Prepare test plans, specifications, and procedures including definition of startup systems and turnover plans and procedures.
- Conduct analyses (stress, thermal, reliability, maintainability, availability, thermal hydraulics, loads, seismic failure mode analysis, and safety).
- Conduct design review meetings.
- Prepare verification and validation plans and conduct verification tests and analyses.
- Develop computer programs.
- Prepare vendor bid packages, including preparation of RFPs, bid evaluations, owner interface activities, and award of contract.
- Prepare plant construction model.
- Prepare modularization plan including Modular Fabrication/Acquisition strategies
- Obtain NRC certification for standard design.

D.2 EQUIPMENT MANUFACTURER

- Develop tooling and fixtures for fabrication and assembly of components.
- Fabricate or purchase special component shipping fixtures and conditioning equipment.
- Conduct component development tests.
- Fabricate special test fixtures.
- Purchase or fabricate special test equipment.
- Fabricate or purchase any special component/material handling or transportation equipment used for equipment fabrication.

D.3 CONSTRUCTION

- Prepare construction planning documentation.
- Fabricate any special forms or scaffolding required for construction of the first plant.
- Fabricate or purchase any special component and/or material handling or transportation equipment used on the first construction site.

Appendix E

SITE-RELATED ENGINEERING AND MANAGEMENT TASKS*

(Applicable to all plants including prototype,
first commercial, transitional, and NOAK plants)

- Prepare site-related engineering specifications and drawings (layouts, design, manufacturing, installation, and interface control drawings).
- Identify and retab nonsite drawings (design, manufacturing, installation, and interface control drawings), technical documents, specifications, and manuals to show applicability to the Target Plant.
- Update and maintain technical work packages.
- Provide support at vendor's plant to witness factory acceptance testing.
- Support the constructor during plant construction and acceptance testing.
- Provide support to the Materials Review Board (MRB).
- Provide support as specifically requested to SAR (including emergency response) to show that the plant is identical in design.
- Support vendor bid evaluations and negotiations as requested by Procurement.
- Support the Constructor in the resolution of any field problems.
- Prepare site-specific licensing documents, such as ER and SAR.
- Repeat plant planning and scheduling and administrative, quality assurance, procurement, and industrial and public relations activities.
- Provide modularization schedule/sequencing plan.
- Provide engineering necessary to excavate and lay out the site for construction. This includes excavation drawings; dewatering calculations and analyses; and design and layout of access roads, parking lots, utilities, etc.
- Provide project management associated with the above tasks.

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*All FOAK expenditures are separately listed in Appendix D.

Appendix F

DESCRIPTION OF EPRI STANDARD HYPOTHETICAL EAST/WEST CENTRAL SITE FOR NUCLEAR POWER PLANTS

F.1 GENERAL

This site description provides the site and environmental data, derived from the EPRI standard site description for their East/West Central site. These data form the site-related bases of the criteria used in the EPRI requirements document for the siting of advanced nuclear plants including evaluation of the routine and accidental release of radioactive and other liquids and gases to the environment.

F.2 SITE-RELATED CRITERIA

The site location is the EPRI Kenosha, Wisconsin site. This site is typical of power generation facilities located in middle America and having access to water and rail transportation. The site is assumed to be clear and level with no special problems: however, pile foundations may be required.

Site-related criteria are summarized below:

• Elevation	600 feet above mean sea level
• Seismic zone	1
• Road	1-mile road required
• Access to water - shipping	Lake Michigan; no docking facilities available
• Sources of water - makeup	Lake Michigan (Standard Lake Michigan water analysis)
• Limestone proximity	Available locally by truck <50 miles or by rail
• Electric power	Available from the grid during startup; 1-mile transmission line required

F.3 METEOROLOGICAL DATA

Annual average ambient air conditions for material balances, thermal efficiencies, and equipment sizing are:

• Dry bulb temperature	60°F
• Wet bulb temperature	52°F
• Atmospheric prsesure	14.4 psia
• Maximum dry bulb temperature	95°F
• Maximum wet bulb temperature	75°F

Other meteorological data include:

• Minimum temperature (low ambient performance)	20°F
• Minimum temperature (freeze protection)	-20°F
• Design conditions for rated output:	
- Rainfall	31 in./yr
- Wind velocity	10 mph
- Wind direction	Southwest (summer conditions)

Weatherization criteria include the following:

- All exposed piping subject to freezing is electrically heat traced.
- Final coal and sorbent preparation, gas turbine, steam turbine, and water treatment facilities are located indoors.

Meteorlogical maximum data are given in Table F.1

F.4 TECHNICAL DATA

- Raw water is from Lake Michigan: analysis is shown in Table F.2.
- Equipment sizing and sparing are based on achieving the target equivalent availability.

F.5 PLANT SERVICES

Plant services requirements include standards for power voltages, alternative power sources, compressed air, and cooling water.

- Power Voltages

- To line	230 kV
- To yard	13.8 kV
- Motors <250 hp	480 V
- Motors 250-3,000 hp	4160 V
- Motors >3000 hp	7,200 V

Table F.1. Envelope of Advanced Nuclear Plant Design Parameters

Maximum Ground Water Level	2 feet below grade
Maximum flood level[a]	1 foot below plant grade
Precipitation for roof design:	
• Maximum rainfall[b]	19.4 in./h (6.2 in./5 min)
• Maximum snow load	50 lb/sq ft
Ambient Design Temperatures,	
• 1% Exceedance Values	
Maximum:	100°F dry bulb/ 77°F coincident wet bulb 80°F wet bulb (non-coincident)
Minimum:	-10°F
• 0% Exceedance Values (historic limit, excluding peaks <2 hrs)	
Maximum:	115°F dry bulb/ 80°F coincident wet bulb 81°F wet bulb (non-coincident)
Minimum:	-40°F
Extreme Wind:	
Basic wind speed[c]	110 mph
Importance factors	1.0[d]/1.11[e]
Tornado[f]	
• Maximum Tornado wind speed	260 mph
• Translational velocity	57 mph
• Radius	453 ft
• Rate of pressure change	0.27 psi/sec
• Missile Spectra	spectrum 1 of SRP 3.5.1.4
• Missile velocity	35% of Maximum Horiztonal Windspeed
• Missile Attitude	30 ft above grade for large missiles; all evaluations for small missiles

Table F.1 Continued

Soil Properties[g]					
• Minimum Bearing Capacity demand		≥15 ksf			
• Minimum shear wave velocity		≥1000 fps			
• Liquefaction potential		none			
Seismology					
• SSE PGA[h]		0.30 g[i]			
• SSE Design Response Spectra		per Reg. Guide 1.6			
• SSE Time History		Envelope SSE Response spectra			
Atmospheric Dispersion (Chi/Q)[j]					
Downwind Distance	0-2 h	2-8 h	8-24 h	1-4 day	4-30 day
0.5 miles	1.0×10^{-3}				
2.0 miles		1.35×10^{-4}	1.0×10^{-4}	5.4×10^{-5}	2.2×10^{-5}

[a]Probable maximum flood level as defined in ANSI/ANS 2.8-1983. Minimum value to be basis of standard plant design with previsions for accomodiation of flood levels up to maximum level.

[b]Maximum value for 1 hour, 1 square mile probable maximum precipitation (PMP) with ratio of 5 minutes to 1 hour PMP of 0.32.

[c]50 year recurrence level.

[d]Importance factor to be used for non-safety-related structures as defined in ANSI A5811-1982.

[e]Importance factor to be used for safety-related structures as defined in ANSI A58.1-1982.

[f]One million year tornado recurrence interval with associated parameters based on ANSI/ANS 2.3-1983.

[g]Values of bearing capabity and shear wave velocity are included to assure wide application of standard mat-type foundation design. Design must be evaluated against ranges of possible soil properties to verify wide application.

[h]PGA = Peak Ground Acceleration.

[i]Free-field at plant grade elevation. Envelopes all present U.S. nuclear sites except those on California coastline.

[j]The Chi/Q values are to be used for the 10 CFR 100 dose evaluation.

Table F.2. Raw water analysis
(Lake Michigan)

Compound	Analysis (ppmw)
Silica (SiO_2)	1.8
Iron (Fe)	0.09
Manganese (Mn)	0.0
Calcium (Ca)	39.0
Magnesium (Mg)	10.0
Sodium (Na)	3.3
Potassium (K)	0.7
Carbonate (CO_3)	0.0
Bicarbonate (HCO_3)	132.0
Sulfate (SO_4)	23.0
Chloride (Cl)	7.2
Fluoride (F)	0.1
Nitrate (NO_3)	0.0
Hardness as $CaCO_3$ equivalents:	
Total	168
Noncarbonate	30
Total suspended solids	10
Total dissolved solids	215
Color	1 unit
pH	7.9
Turbidity	0
Specific conductance @ 25°C (micrombos)	275

- <u>Alternative Power Sources</u>
  - 250 V dc system with static inverters with normal feed via no break system for uninterruptible ac power for programmable logics, relay protections, operating circuits, and dc motors
  - 125 V dc system for dc controls, instruments, emergency lighting, and annunicators
- <u>Compressed Air</u>
  - Instrument air supplied at 80 to 100 psig and 100°F (maximum), filtered and dried to -40°F dew point
  - Service air supplied at 80 to 100 psig and 100°F (maximum)

- Cooling Water
  - Mechanical draft cooling towers
  - Design based on summer conditions (75°F wet bulb)
  - Projected temperatures:

Description	Maximum (°F)	Base (°F)
Ambient	95	60
Wet bulb	75	52
Temperature approach	10	19
Cold water	85	71
Temperature rise	20	*a*
Return temperature	105	*a*

[a]To be established by maintaining the same cooling water circulation rate set by maximum ambient case.

F.6 ENVIRONMENTAL REQUIREMENTS

Sewage - Sewage generated on-site must receive primary and secondary treatment before discharge. Nonradioactive wastewater must be discharged in compliance with Environmental Protection Agency (EPA) effluent guidelines and standards as promulgated in 40 CFR 423.

Gaseous and Liquid Radioactive Wastes. Gaseous and liquid effluent releases at the site must comply with 10 CFR 20 and the intent of Appendix I of 10 CFR 50.

Solid Radioactive Wastes. On-site storage of solid radioactive wastes to permit radioactive decay is permissible, but ultimate disposal on-site is not planned.

Noise Limitations. In-plant noise levels must not exceed 90 dBA for an 8-h exposure. Plant perimeter noise levels must not exceed 65 dBA during the day and 55 dBA during the night.

Appendix G

CONVERSION FROM NOMINAL TO CONSTANT DOLLARS

Factors for converting nominal dollar levelized costs to constant dollars levelized costs are given in Tables G.1-G.9. These factors were calculated using the formula

$$LC_o/LC = (1+i)^{-L_1} \frac{CRF(d_o,30)}{CRF(d,30)} \times \frac{\sum_j 1/(1+d)^{t_j-t_1}}{\sum_j 1/(1+d_o)^{t_j-t_1}}$$

where

LC_o	= constant dollar levelized cost
LC	= nominal dollar levelized cost
i	= inflation rate
L	= time between reference year and start-up of first block
CRF (a,b)	= capital recovery factor at rate a for period b
d_o	= constant dollar discount rate
d	= nominal dollar discount rate
j	= index denoting block
t_j	= operation date for block j.

The cost factors are shown for a range of spacing between blocks and time between the reference years and the startup of the first block. Information is included for 1 to 4 block plants and for reference utility, industrial and IPP (high risk industrial) financing ground rules.

The ratio of the constant to nominal dollar capital recovery factors by itself is given in Table G.10 for a range of inflation rates and nominal costs of money.

Table G.1. Levelized cost ratios[a]
Utility economics, 2-Block plant

Time until startup years[b]	Spacing between blocks, yr						
	0.0[c]	0.5	1.0	1.5	2.0	2.5	3.0
0.00	0.5898	0.5827	0.5760	0.5696	0.5635	0.5577	0.5522
1.00	0.5617	0.5550	0.5486	0.5425	0.5367	0.5312	0.5259
2.00	0.5349	0.5286	0.5225	0.5167	0.5111	0.5059	0.5008
3.00	0.5095	0.5034	0.4976	0.4921	0.4868	0.4818	0.4770
4.00	0.4852	0.4794	0.4739	0.4686	0.4636	0.4588	0.4543
5.00	0.4621	0.4566	0.4513	0.4463	0.4415	0.4370	0.4326
6.00	0.4401	0.4349	0.4298	0.4251	0.4205	0.4162	0.4120
7.00	0.4191	0.4141	0.4094	0.4048	0.4005	0.3964	0.3924
8.00	0.3992	0.3944	0.3899	0.3855	0.3814	0.3775	0.3737
9.00	0.3802	0.3756	0.3713	0.3672	0.3633	0.3595	0.3559
10.00	0.3621	0.3578	0.3536	0.3497	0.3460	0.3424	0.3390
11.00	0.3448	0.3407	0.3368	0.3330	0.3295	0.3261	0.3228
12.00	0.3284	0.3245	0.3208	0.3172	0.3138	0.3106	0.3075
13.00	0.3128	0.3090	0.3055	0.3021	0.2988	0.2958	0.2928
14.00	0.2979	0.2943	0.2909	0.2877	0.2846	0.2817	0.2789
15.00	0.2837	0.2803	0.2771	0.2740	0.2711	0.2683	0.2625
16.00	0.2702	0.2670	0.2639	0.2610	0.2582	0.2555	0.2530
17.00	0.2573	0.2542	0.2513	0.2485	0.2459	0.2433	0.2409
18.00	0.2451	0.2421	0.2394	0.2367	0.2342	0.2317	0.2294
19.00	0.2334	0.2306	0.2280	0.2254	0.2230	0.2207	0.2185
20.00	0.2223	5.2196	0.2171	0.2147	0.2124	0.2102	0.2081
21.00	0.2117	0.2092	0.2068	0.2045	0.2023	0.2002	0.1982
22.00	0.2016	0.1992	0.1969	0.1947	0.1926	0.1907	0.1888
23.00	0.1920	0.1897	0.1875	0.1855	0.1835	2.1816	0.1798
24.00	0.1829	0.1807	0.1786	0.1766	0.1747	0.1729	0.1712
25.00	0.1742	0.1721	0.1701	0.1682	0.1664	0.1647	0.1631
26.00	0.1659	0.1639	0.1620	0.1602	0.1585	0.1569	0.1553
27.00	0.1580	0.1561	0.1543	0.1526	0.1509	0.1494	0.1479
28.00	0.1504	0.1487	0.1469	0.1453	0.1438	0.1423	0.1409
29.00	0.1433	0.1416	0.1399	0.1384	0.1369	0.1355	0.1342
30.00	0.1365	0.1348	0.1333	0.1318	0.1304	0.1290	0.1278

[a]Ratio of constant to nominal dollar levelized costs.

[b]Time between reference year and year of commercial operation of first block.

[c]Single block plant ratio is the same as zero lag time.

Table G.2. Levelized cost ratios[a]
Utility economics, 3-Block plant

Time until startup years[b]	Spacing between blocks, yr						
	0.0[c]	0.5	1.0	1.5	2.0	2.5	3.0
0.00	0.5898	0.5759	0.5629	0.5508	0.5396	0.5292	0.5195
1.00	0.5617	0.5485	0.5361	0.5246	0.1539	0.5040	0.4947
2.00	0.5349	0.5223	0.5106	0.4996	0.4894	0.4800	0.4712
3.00	0.5095	0.4975	0.4863	0.4758	0.4661	0.4571	0.4487
4.00	0.4852	0.4738	0.4631	0.4532	0.4439	0.4353	0.4274
5.00	0.4621	0.4512	0.4411	0.4316	0.4228	0.4146	0.4070
6.00	0.4401	0.4297	0.4201	0.4110	0.4027	0.3949	0.3876
7.00	0.4191	0.4093	0.4001	0.3915	0.3835	0.3761	0.3692
8.00	0.3992	0.3898	0.3810	0.3728	0.3652	0.3582	0.3516
9.00	0.3802	0.3712	0.2629	0.3551	0.3478	0.3411	0.3349
10.00	0.3621	0.3535	0.3456	0.3382	0.3313	0.3249	0.3189
11.00	0.3448	0.3367	0.3291	0.3221	0.3155	0.3094	0.3037
12.00	0.3284	0.3207	0.3135	0.3067	0.3005	0.2947	0.2893
13.00	0.3128	0.3054	0.2985	0.2921	0.2862	0.2806	0.2755
14.00	0.2979	0.2909	0.2843	0.2782	0.2725	0.2673	0.2624
15.00	0.2837	0.2770	0.2708	0.2650	0.2596	0.2545	0.2499
16.00	0.2702	0.2638	0.2579	0.2523	0.2472	0.2424	0.2380
17.00	0.2573	0.2513	0.2456	0.2403	0.2354	0.2309	0.2266
18.00	0.2451	0.2393	0.2339	0.2289	0.2242	0.2199	0.2159
19.00	0.2334	0.2279	0.2228	0.2180	0.2135	0.2094	0.2056
20.00	0.2223	0.2170	0.2122	0.2076	0.2034	0.1994	0.1958
21.00	0.2117	0.2067	0.2021	0.1977	0.1937	0.1899	0.1865
22.00	0.2016	0.1969	0.1924	0.1883	0.1845	0.1809	0.1776
23.00	0.1920	0.1875	0.1833	0.1793	0.1757	0.1723	0.1691
24.00	0.1829	0.1786	0.1745	0.1708	0.1673	0.1641	0.1611
25.00	0.1742	0.1701	0.1662	0.1627	0.1593	0.1563	0.1534
26.00	0.1659	0.1620	0.1583	0.1549	0.1518	0.1488	0.1461
27.00	0.1580	0.1542	0.1508	0.1475	0.1445	0.1417	0.1391
28.00	0.1504	0.1469	0.1436	0.1405	0.1377	0.1350	0.1325
29.00	0.1433	0.1399	0.1368	0.1338	0.1311	0.1286	0.1262
30.00	0.1365	0.1332	0.1302	0.1275	0.1249	0.1224	0.1202

[a]Ratio of constant to nominal dollar levelized costs.

[b]Time between reference year and year of commercial operation of first block.

[c]Single block plant ratio is the same as zero lag time.

Table G.3. Levelized cost ratios[a]
Utility economics, 4-Block plant

Time until startup years[b]	Spacing between blocks, yr						
	0.0[c]	0.5	1.0	1.5	2.0	2.5	3.0
0.00	0.5898	0.5827	0.5760	0.5696	0.5635	0.5577	0.5522
1.00	0.5617	0.5550	0.5486	0.5425	0.5367	0.5312	0.5259
2.00	0.5349	0.5286	0.5225	0.5167	0.5111	0.5059	0.5008
3.00	0.5095	0.5034	0.4976	0.4921	0.4868	0.4818	0.4770
4.00	0.4852	0.4794	0.4739	0.4686	0.4636	0.4588	0.4543
5.00	0.4621	0.4566	0.4513	0.4463	0.4415	0.4370	0.4326
6.00	0.4401	0.4349	0.4298	0.4251	0.4205	0.4162	0.4120
7.00	0.4191	0.4141	0.4094	0.4048	0.4005	0.3964	0.3924
8.00	0.3992	0.3944	0.3899	0.3855	0.3814	0.3775	0.3737
9.00	0.3802	0.3756	0.3713	0.3672	0.3633	0.3595	0.3559
10.00	0.3621	0.3578	0.3536	0.3497	0.3460	0.3424	0.3390
11.00	0.3448	0.3407	0.3368	0.3330	0.3295	0.3261	0.3228
12.00	0.3284	0.3245	0.3208	0.3172	0.3138	0.3106	0.3075
13.00	0.3128	0.3090	0.3055	0.3021	0.2988	0.2958	0.2928
14.00	0.2979	0.2943	0.2909	0.2877	0.2846	0.2817	0.2789
15.00	0.2837	0.2803	0.2771	0.2740	0.2711	0.2683	0.2625
16.00	0.2702	0.2670	0.2639	0.2610	0.2582	0.2555	0.2530
17.00	0.2573	0.2542	0.2513	0.2485	0.2459	0.2433	0.2409
18.00	0.2451	0.2421	0.2394	0.2367	0.2342	0.2317	0.2294
19.00	0.2334	0.2306	0.2280	0.2254	0.2230	0.2207	0.2185
20.00	0.2223	5.2196	0.2171	0.2147	0.2124	0.2102	0.2081
21.00	0.2117	0.2092	0.2068	0.2045	0.2023	0.2002	0.1982
22.00	0.2016	0.1992	0.1969	0.1947	0.1926	0.1907	0.1888
23.00	0.1920	0.1897	0.1875	0.1855	0.1835	2.1816	0.1798
24.00	0.1829	0.1807	0.1786	0.1766	0.1747	0.1729	0.1712
25.00	0.1742	0.1721	0.1701	0.1682	0.1664	0.1647	0.1631
26.00	0.1659	0.1639	0.1620	0.1602	0.1585	0.1569	0.1553
27.00	0.1580	0.1561	0.1543	0.1526	0.1509	0.1494	0.1479
28.00	0.1504	0.1487	0.1469	0.1453	0.1438	0.1423	0.1409
29.00	0.1433	0.1416	0.1399	0.1384	0.1369	0.1355	0.1342
30.00	0.1365	0.1348	0.1333	0.1318	0.1304	0.1290	0.1278

[a]Ratio of constant to nominal dollar levelized costs.

[b]Time between reference year and year of commercial operation of first block.

[c]Single block plant ratio is the same as zero lag time.

Table G.4. Levelized cost ratios[a]
Industrial economics, 2-Block plant

Time until startup years[b]	Spacing between blocks, yr						
	0.0[c]	0.5	1.0	1.5	2.0	2.5	3.0
0.00	0.6523	0.6446	0.6374	0.6307	0.6244	0.6186	0.6132
1.00	0.6213	0.6139	0.6071	0.6007	0.5947	0.5892	0.5840
2.00	0.5917	0.5847	0.5782	0.5721	0.5664	0.5611	0.5562
3.00	0.5635	0.5569	0.5506	0.5448	0.5394	0.5344	0.5297
4.00	0.5367	0.5303	0.5244	0.5189	0.5137	0.5089	0.5045
5.00	0.5111	0.5051	0.4994	0.4942	0.4893	0.4847	0.4805
6.00	0.4868	0.4810	0.4757	0.4706	0.4660	0.4616	0.4576
7.00	0.4636	0.4581	0.4530	0.4482	0.4438	0.4396	0.4358
8.00	0.4415	0.4363	0.4314	0.4269	0.4226	0.4187	0.4151
9.00	0.4205	0.4155	0.4109	0.4066	0.4025	0.3988	0.3953
10.00	0.4005	0.3957	0.3913	0.3872	0.3833	0.3798	0.3765
11.00	0.3814	0.3769	0.3727	0.3688	0.3651	0.3617	0.3585
12.00	0.3632	0.3590	0.3549	0.3512	0.3477	0.3445	0.3415
13.00	0.3459	0.3419	0.3380	0.3345	0.3311	0.3281	0.3252
14.00	0.3295	0.3256	0.3219	0.3185	0.3154	0.3124	0.3097
15.00	0.3138	0.3101	0.3066	0.3034	0.3004	0.2976	0.2950
16.00	0.2988	0.2953	0.2920	0.2889	0.2861	0.2834	0.2809
17.00	0.2846	0.2813	0.2781	0.2752	0.2724	0.2699	0.2675
18.00	0.2711	0.2679	0.2649	0.2621	0.2595	0.2570	0.2548
19.00	0.2582	0.2551	0.2523	0.2496	0.4271	0.2448	0.2427
20.00	0.2459	0.2430	0.2402	0.2377	0.2353	0.2331	0.2311
21.00	0.2342	0.2314	0.2288	0.2264	0.2241	0.2220	0.2201
22.00	0.2230	0.2204	0.2179	0.2156	0.2135	0.2115	0.2096
23.00	0.2124	0.2099	0.2075	0.2053	0.2033	0.2014	0.1996
24.00	0.2023	0.1999	0.1976	0.1956	0.1936	0.1918	0.1901
25.00	0.1926	0.1904	0.1882	0.1862	0.1844	0.1827	0.1811
26.00	0.1835	0.1813	0.1793	0.1774	0.1756	0.1740	0.1725
27.00	0.1747	0.1727	0.1707	0.1689	0.1673	0.1657	0.1643
28.00	0.1664	0.1644	0.1626	0.1609	0.1593	0.1578	0.1564
29.00	0.1585	0.1566	0.1549	0.1532	0.1517	0.1503	0.1490
30.00	0.1509	0.1492	0.1475	0.1459	0.1445	0.1431	0.1419

[a]Ratio of constant to nominal dollar levelized costs.

[b]Time between reference year and year of commercial operation of first block.

[c]Single block plant ratio is the same as zero lag time.

Table G.5. Levelized cost ratios[a]
Industrial economics, 3-Block plant

Time until startup years[b]	Spacing between blocks, yr						
	0.0[c]	0.5	1.0	1.5	2.0	2.5	3.0
0.00	0.0523	0.6372	0.6234	0.6109	0.5997	0.5897	0.5807
1.00	0.6213	0.6068	0.5937	0.5818	0.5712	0.5616	0.5530
2.00	0.5917	0.5779	0.5654	0.5541	0.5440	0.5348	0.5267
3.00	0.5635	0.5504	0.5385	0.5277	0.5181	0.5094	0.5016
4.00	0.5367	0.5242	0.5129	0.5026	0.4934	0.4851	0.4777
5.00	0.5111	0.4992	0.4884	0.4787	0.4699	0.4620	0.4550
6.00	0.4868	0.4755	0.4652	0.4559	0.4475	0.4400	0.4333
7.00	0.4636	0.4528	0.4430	0.4342	0.4262	0.4191	0.4127
8.00	0.4415	0.4313	0.4219	0.4135	0.4059	0.3991	0.3930
9.00	0.4205	0.4107	0.4018	0.3938	0.3866	0.3801	0.3743
10.00	0.4005	0.3912	0.3827	0.3751	0.3682	0.3620	0.3565
11.00	0.3814	0.3725	0.3645	0.3572	0.3506	0.3448	0.3395
12.00	0.3632	0.3548	0.3471	0.3402	0.3339	0.3283	0.3234
13.00	0.3459	0.3379	0.3306	0.3240	0.3180	0.3127	0.3080
14.00	0.3295	0.3218	0.3148	0.3086	0.3029	0.2978	0.2933
15.00	0.3138	0.3065	0.2999	0.2939	0.2885	0.2836	0.2793
16.00	0.2988	0.2919	0.2856	0.2799	0.2747	0.2701	0.2660
17.00	0.2846	0.2780	0.2720	0.2665	0.2617	0.2573	0.2534
18.00	0.2711	0.2648	0.2590	0.2539	0.2492	0.2450	0.2413
19.00	0.2582	0.2521	0.2467	0.2418	0.2373	0.2333	0.2298
20.00	0.2459	0.2401	0.2349	0.2303	0.2260	0.2222	0.2189
21.00	0.2342	0.2287	0.2238	0.2193	0.2153	0.2117	0.2084
22.00	0.2230	0.2178	0.2131	0.2088	0.2050	0.2016	0.1985
23.00	0.2124	0.2074	0.2030	0.1989	0.1952	0.1920	0.1891
24.00	0.2023	0.1976	0.1933	0.1894	0.1860	0.1828	0.1801
25.00	0.1926	0.1882	0.1841	0.1804	0.1771	0.1741	0.1715
26.00	0.1835	0.1792	0.1753	0.1718	0.1687	0.1658	0.1633
27.00	0.1747	0.1707	0.1670	0.1636	0.1606	0.1579	0.1555
28.00	0.1664	0.1625	0.1590	0.1558	0.1530	0.1504	0.1481
29.00	0.1585	0.1548	0.1514	0.1484	0.1457	0.1433	0.1411
30.00	0.1509	0.1474	0.1442	0.1414	0.1388	0.1364	0.1344

[a]Ratio of constant to nominal dollar levelized costs.

[b]Time between reference year and year of commercial operation of first block.

[c]Single block plant ratio is the same as zero lag time.

Table G.6. Levelized cost ratios[a]
Industrial economics, 4-Block plant

Time until startup years[b]	Spacing between blocks, yr						
	0.0[c]	0.5	1.0	1.5	2.0	2.5	3.0
0.00	0.6523	0.6299	0.6102	0.5929	0.5779	0.5649	0.5537
1.00	0.6213	0.5999	0.5811	0.5646	0.5503	0.5380	0.5274
2.00	0.5917	0.5713	0.5534	0.5378	0.5241	0.5123	0.5022
3.00	0.5635	0.5441	0.5271	0.5122	0.4992	0.4880	0.4783
4.00	0.5367	0.5182	0.5020	0.4878	0.4754	0.4647	0.4556
5.00	0.5111	0.4935	0.4781	0.4645	0.4528	0.4426	0.4439
6.00	0.4858	0.4700	0.4553	0.4424	0.4312	0.4215	0.4132
7.00	0.4636	0.4477	0.4336	0.4214	0.4107	0.4014	0.3935
8.00	0.4415	0.4263	0.4130	0.4013	0.3911	0.3823	0.3748
9.00	0.4205	0.4060	0.3933	0.3822	0.3725	0.3641	0.3569
10.00	0.4005	0.3867	0.3746	0.3640	0.3548	0.3468	0.3399
11.00	0.3814	0.3683	0.3567	0.3466	0.3379	0.3303	0.3238
12.00	0.3632	0.3507	0.3398	0.3301	0.3218	0.3145	0.3083
13.00	0.3459	0.3340	0.3236	0.3144	0.3064	0.2996	0.2937
14.00	0.3295	0.3181	0.3082	0.2994	0.2919	0.2853	0.2797
15.00	0.3138	0.3030	0.2935	0.2852	0.2780	0.2717	0.2664
16.00	0.2988	0.2886	0.2795	0.2716	0.2647	0.2588	0.2537
17.00	0.2846	0.2748	0.2662	0.587	0.2521	0.2464	0.2416
18.00	0.2711	0.2617	0.2535	0.2464	0.2401	0.2347	0.2301
19.00	0.2582	0.2493	0.2415	0.2346	0.2287	0.2235	0.2191
20.00	0.2459	0.2374	0.2300	0.2235	0.2178	0.2129	0.2087
21.00	0.2342	0.2261	0.2190	0.2128	0.2074	0.2028	0.1988
22.00	0.2230	0.2153	0.2086	0.2027	0.1975	0.1931	0.1893
23.00	0.2124	0.2051	0.1986	0.1930	0.1881	0.1839	0.1803
24.00	0.2023	0.1953	0.1892	0.1838	0.1792	0.1751	0.1717
25.00	0.1926	0.1860	0.1802	0.175	0.176	0.1668	0.1635
26.00	0.1835	0.1772	0.1716	0.1667	0.1625	0.1589	0.1557
27.00	0.1747	0.1687	0.1634	0.1588	0.1548	0.1513	0.1483
28.00	0.1665	0.1607	0.1556	0.1512	0.1474	0.1441	0.1413
29.00	0.1585	0.1530	0.1482	0.1440	0.1404	0.1372	0.1345
30.00	0.1509	0.1457	0.1412	0.1372	0.1337	0.1307	0.1281

[a]Ratio of constant to nominal dollar levelized costs.

[b]Time between reference year and year of commercial operation of first block.

[c]Single block plant ratio is the same as zero lag time.

Table G.7. Levelized cost ratios[a]
IPP economics, 2-Block plant

Time until startup years[b]	Spacing between blocks, yr						
	0.0[c]	0.5	1.0	1.5	2.0	2.5	3.0
0.00	0.6330	0.6255	0.6184	0.6118	0.6055	0.5997	0.5943
1.00	0.6028	0.5957	0.5890	0.5826	0.5767	0.5712	0.5660
2.00	0.5741	0.5673	0.5609	0.5549	0.5493	0.5440	0.5390
3.00	0.5468	0.5403	0.5342	0.5285	0.5231	0.5181	0.5133
4.00	0.5208	0.5146	0.5088	0.5033	0.4982	0.4934	0.4889
5.00	0.4960	0.4901	0.4845	0.4793	0.4745	0.4699	0.4656
6.00	0.4723	0.4667	0.4615	0.4565	0.4519	0.4475	0.4434
7.00	0.4498	0.4445	0.4395	0.4348	0.4304	0.4262	0.4223
8.00	0.4284	0.4234	0.4186	0.4141	0.4099	0.4059	0.4022
9.00	0.4080	0.4032	0.3986	0.3944	0.3903	0.3866	0.3831
10.00	0.3886	0.3840	0.3797	0.3756	0.3718	0.3682	0.3648
11.00	0.3701	0.3657	0.3616	0.3577	0.3541	0.3506	0.3474
12.00	0.3525	0.3483	0.3444	0.3407	0.3372	0.3339	0.3309
13.00	0.3357	0.3317	0.3280	0.3233	0.3211	0.3180	0.3151
14.00	0.3197	0.3159	0.3123	0.3090	0.3058	0.3029	0.3001
15.00	0.3045	0.3009	0.2975	0.2943	0.2913	0.2885	0.2858
16.00	0.2900	0.2865	0.2833	0.2803	0.2774	0.2747	0.2722
17.00	0.2762	0.2729	0.2698	0.2669	0.2642	0.2617	0.2593
18.00	0.2630	0.2599	0.2570	0.2542	0.2516	0.2492	0.2469
19.00	0.2505	0.2475	0.2447	0.2421	0.2396	0.2373	0.2352
20.00	0.2386	0.2357	0.2331	0.2306	0.2282	0.2260	0.2240
21.00	0.2272	0.2245	0.22220	0.2196	0.2174	0.2153	0.2133
22.00	0.2164	0.2138	0.2114	0.2091	0.2070	0.2050	0.2031
23.00	0.2061	0.2036	0.2013	0.1992	0.1971	0.1952	0.1935
24.00	0.1963	0.1939	0.1918	0.1897	0.1878	0.1860	0.1843
25.00	0.1869	0.1847	0.1826	0.1807	0.1788	0.1771	0.1755
26.00	0.1780	0.1759	0.1739	0.1721	0.1703	0.1687	0.1671
27.00	0.1695	0.1675	0.1656	0.1639	0.1622	0.1606	0.1592
28.00	0.1615	0.1596	0.1578	0.1561	0.1545	0.1530	0.1516
29.00	0.1538	0.1520	0.1502	0.1486	0.1471	0.1457	0.1444
30.00	0.1465	0.1447	0.1431	0.1416	0.1401	0.1388	0.1375

[a]Ratio of constant to nominal dollar levelized costs.

[b]Time between reference year and year of commercial operation of first block.

[c]Single block plant ratio is the same as zero lag time.

Table G.8. Levelized cost ratios[a]
IPP economics, 3-Block plant

Time until startup years[b]	Spacing between blocks, yr						
	0.0[c]	0.5	1.0	1.5	2.0	2.5	3.0
0.00	0.6330	0.6182	0.6046	0.5923	0.5810	0.5708	0.5616
1.00	0.6028	0.5888	0.5759	0.5641	0.5534	0.5436	0.5348
2.00	0.5741	0.4607	0.5484	0.5372	0.5270	0.5177	0.5093
3.00	0.5468	0.5340	0.5223	0.5116	0.65019	0.4931	0.4851
4.00	0.5208	0.5086	0.4974	0.4873	0.4780	0.4696	0.4620
5.00	0.4960	0.4844	0.4738	0.4641	0.4552	0.4472	0.440
6.00	0.4723	0.4613	0.4512	0.4420	0.4336	0.4259	0.4190
7.00	0.4498	0.4393	0.4297	0.4209	0.4129	0.4057	0.3991
8.00	0.4284	0.4184	0.4092	0.4009	0.3933	0.3863	0.3801
9.00	0.4080	0.3985	0.3898	0.3818	0.3745	0.3679	0.3620
10.00	0.3886	0.3795	0.3712	0.3636	0.3567	0.3504	0.3447
11.00	0.3701	0.3614	0.3535	0.3463	0.3397	0.3337	0.3283
12.00	0.3525	0.3442	0.3367	0.3298	0.3235	0.3178	0.3127
13.00	0.3357	0.3278	0.3207	0.3141	0.3081	0.3027	0.2978
14.00	0.3197	0.3122	0.3054	0.2991	0.2935	0.2883	0.2836
15.00	0.3045	0.2974	0.2908	0.2849	0.2795	0.2746	0.2701
16.00	0.2900	0.2832	0.2770	0.2713	0.2662	0.2615	0.2573
17.00	0.2762	0.2697	0.2638	0.2584	0.2535	0.2490	0.2450
18.00	0.2630	0.2569	0.2512	0.2461	0.2414	0.2372	0.2333
19.00	0.2505	0.2446	0.2393	0.2344	0.2299	0.2259	0.2222
20.00	0.2386	0.2330	0.2279	0.2232	0.2190	0.2151	0.2116
21.00	0.2272	0.2219	0.2170	0.2126	0.2086	0.2049	0.2016
22.00	0.2164	0.2113	0.2067	0.2025	0.1986	0.1951	0.1920
23.00	0.2061	0.2013	0.1969	0.1928	0.1892	0.1858	0.1828
24.00	0.1963	0.1917	0.1875	0.1836	0.1802	0.1770	0.1741
25.00	0.1869	0.1826	0.1786	0.1749	0.1716	0.1686	0.1658
26.00	0.1780	0.1739	0.1701	0.1666	0.1634	0.1605	0.1579
27.00	0.1695	0.1656	0.1620	0.1586	0.1556	0.1529	0.1504
28.00	0.1615	0.1577	0.1542	0.1511	0.1482	0.1456	0.1432
29.00	0.1538	0.1502	0.1469	0.1439	0.1412	0.1387	0.1364
30.00	0.1465	0.1430	0.1399	0.1370	0.1344	0.1321	0.1299

[a]Ratio of constant to nominal dollar levelized costs.

[b]Time between reference year and year of commercial operation of first block.

[c]Single block plant ratio is the same as zero lag time.

Table G.9. Levelized cost ratios[a]
IPP economics, 4-Block plant

Time until startup years[b]	Spacing between blocks, yr						
	0.0[c]	0.5	1.0	1.5	2.0	2.5	3.0
0.0	0.6330	0.6111	0.5916	0.5744	0.5591	0.5457	0.5340
1.00	0.6028	0.5820	0.5634	0.5470	0.5325	0.5197	0.5086
2.00	0.5741	0.5543	0.5366	0.5210	0.5071	0.4950	0.4843
3.00	0.5468	0.5279	0.5111	0.4961	0.4830	0.4714	0.4613
4.00	0.5208	0.5027	0.4867	0.4725	0.4600	0.4490	0.4393
5.00	0.4960	0.4788	0.4635	0.4500	0.4381	0.4276	0.4184
6.00	0.4723	0.4560	0.4415	0.4286	0.4172	0.4072	0.3985
7.00	0.4498	0.4343	0.4205	0.4082	0.3973	0.3878	0.3795
8.00	0.4284	0.4136	0.4004	0.3887	0.3784	0.3694	0.3614
9.00	0.4080	0.3939	0.3814	0.3702	0.3604	0.3518	0.3442
10.00	0.3886	0.3752	0.3632	0.3526	0.3432	0.3350	0.3278
11.00	0.3701	0.3573	0.3459	0.3358	0.3269	0.3191	0.3122
12.00	0.3525	0.3403	0.3294	0.3198	0.3113	0.309	0.2973
13.00	0.3357	0.3241	0.3137	0.3046	0.2965	0.2894	0.2832
14.00	0.3197	0.3086	0.2988	0.2901	0.2824	0.2756	0.2697
15.00	0.3045	0.2939	0.2846	0.2763	02689	0.2625	0.2569
16.00	0.2900	0.2799	0.2710	0.2631	0.2561	0.2500	0.2446
17.00	0.2762	0.2666	0.2581	0.2506	0.2439	0.2381	0.2330
18.00	0.2630	0.2539	0.2458	0.2387	0.2323	0.2268	0.2219
19.00	0.2505	0.2418	0.2341	0.2273	0.2213	0.2160	0.2113
20.00	0.2386	0.2303	0.2230	0.2165	0.2107	0.2057	0.2013
21.00	0.2272	0.2193	0.2124	0.2062	0.2007	0.1959	0.1917
22.00	0.2165	0.2089	0.2002	0.1963	0.1911	0.1865	0.1825
23.00	0.2061	0.1990	0.1926	0.187	0.1820	0.1777	0.1739
24.00	0.1963	0.1895	0.1834	0.1781	0.1734	0.1692	0.1656
25.00	0.1869	0.1805	0.1747	0.1696	0.1651	0.1611	0.1577
26.00	0.1780	0.1719	0.166	0.1615	0.1572	0.1535	0.1502
27.00	0.1695	0.1637	0.1585	0.1538	0.1498	0.1462	0.1430
28.00	0.1615	0.1559	0.1509	0.1465	0.1426	0.1392	0.1362
29.00	0.1538	0.1485	0.1437	0.1395	0.1358	0.1326	0.1297
30.00	0.1465	0.1414	0.1369	0.1329	0.1294	0.1263	0.1236

[a]Ratio of constant to nominal dollar levelized costs.

[b]Time between reference year and year of commercial operation of first block.

[c]Single block plant ratio is the same as zero lag time.

Table G.10. Levelized cost ratios[a]
Utility economics, 2-Block plant

Nominal discount rate, %/year	Inflation rate, %/yr								
	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
5.00	0.681	0.635	0.592	0.551	0.512	0.476	0.441	0.408	0.377
5.50	0.688	0.643	0.600	0.560	0.521	0.484	0.450	0.147	0.386
6.00	0.694	0.650	0.608	0.568	0.530	0.493	0.459	0.426	0.395
6.50	0.701	0.657	0.616	0.576	0.538	0.502	0.468	0.435	0.404
7.00	0.707	0.665	0.624	0.584	0.547	0.511	0.477	0.444	0.413
7.50	0.714	0.672	0.631	0.592	0.555	0.520	0.486	0.453	0.423
8.00	0.720	0.679	0.639	0.601	0.564	0.528	0.495	0.463	0.432
8.50	0.726	0.686	0.646	0.608	0.572	0.537	0.504	0.472	0.441
9.00	0.732	0.692	0.654	0.616	0.580	0.546	0.513	0.481	0.450
9.50	0.738	0.699	0.661	0.624	0.589	0.554	0.521	0.490	0.460
10.00	0.744	0.705	0.668	0.632	0.597	0.563	0.530	0.499	0.469
10.50	0.750	0.712	0.675	0.639	0.605	0.571	0.539	0.508	0.478
11.00	0.755	0.718	0.682	0.646	0.612	0.579	0.547	0.517	0.487
11.50	0.761	0.724	0.688	0.654	0.620	0.587	0.556	0.525	0.496
12.00	0.766	0.730	0.695	0.661	0.627	0.595	0.564	0.634	0.505
12.50	0.771	0.736	0.701	0.668	0.635	0.603	0.572	0.542	0.513
13.00	0.776	0.741	0.707	0.674	0.642	0.611	0.580	0.551	0.522
13.50	0.781	0.747	0.713	0.681	0.649	0.618	0.588	0.559	0.530
14.00	0.785	0.752	0.719	0.687	0.656	0.625	0.596	0.567	0.539
14.50	0.790	0.757	0.725	0.693	0.662	0.632	0.603	0.574	0.547
15.00	0.794	0.762	0.730	0.699	0.669	0.639	0.610	0.582	0.555
15.50	0.798	0.767	0.736	0.705	0.675	0.646	0.618	0.590	0.562
16.00	0.802	0.771	0.741	0.711	0.681	0.653	0.624	0.597	0.570
16.50	0.806	0.776	0.746	0.716	0.687	0.659	0.631	0.604	0.578
17.00	0.810	0.780	0.751	0.722	0.693	0.665	0.638	0.611	0.585
17.50	0.814	0.784	0.755	0.727	0.699	0.671	0.644	0.618	0.592
18.00	0.817	0.788	0.760	0.732	0.704	0.677	0.651	0.624	0.599
18.50	0.821	0.792	0.764	0.737	0.709	0.683	0.657	0.631	0.606
19.00	0.824	0.796	0.768	0.741	0.715	0.688	0.663	0.637	0.612
19.50	0.827	0.800	0.773	0.746	0.720	0.694	0.668	0.643	0.619
20.00	0.830	0.803	0.777	0.750	0.724	0.699	0.674	0.649	0.625

[a]Ratio of constant dollar capital recovery factor to nominal dollar capital recovery factor.

APPENDIX H

MOST LIKELY, EXPECTED, AND CONTINGENCY COSTS*

Base construction cost is defined in Sect. 1.2 to be the "most likely" plant capital cost based on the direct and indirect costs only. Contingency, defined in Sect. 3, is a percentage of base construction cost when added results in the median cost estimate. The relevance of these terms and their interrelationship is described in this Appendix. The overall contingency factor will include an allowance for indeterminates.

H.1 MOST LIKELY COST

If there were several cost estimates for a given item, where the item has uncertainties and complexities associated with it, experience indicates that the distribution of the estimated costs would be typically like that shown in Fig. H.1 with a characteristically skewed to-the-right shape. The highest point on the distribution corresponds to the estimate value for which there are the largest number of estimates. This value, known in statistics as the mode, is the most likely value (i.e., the most probable value or value with the highest probability).

For estimates determined in accordance with these guidelines, the base construction cost estimates are to represent the most likely cost value.

H.2 EXPECTED COST AND CONTINGENCY

Referring again to Fig. H.1, the median estimate value (estimate where there is an equal probability of actual costs being higher or lower) is greater than the most likely value. For the skewed distribution such as that shown in Fig. H.1, the median is where the area under the curve on both sides of the point is equal. The median is shown in Fig. H.2 to be the point were the cumulative probability is 50%. For a normal distribution of costs (not skewed) the median cost = the mode cost and a "0%" contingency for that item would be assigned.

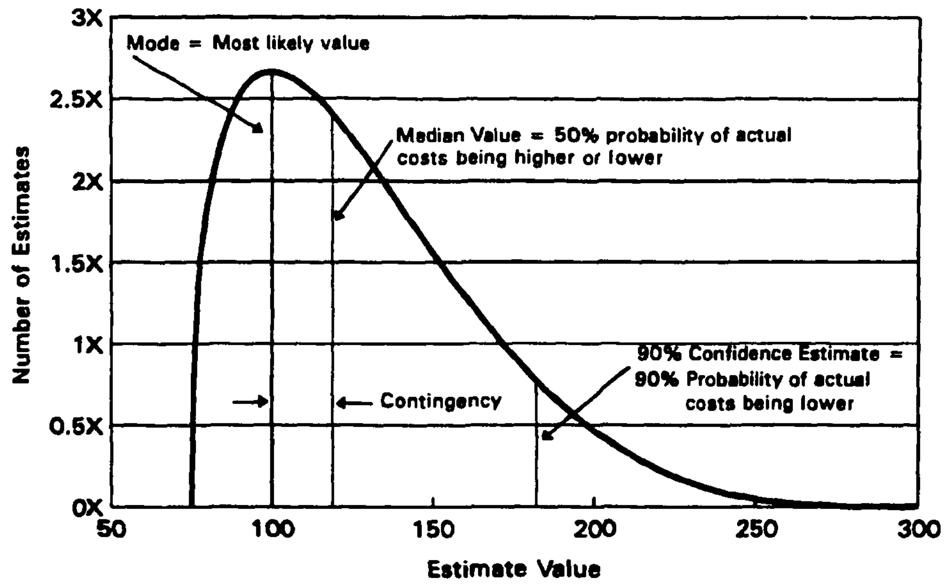
*Based on Ref. 13.

The total contingency cost for a power plant is the sum of the contributions for each system or component category and will also include the expected value of cost items not explicitly covered in the detailed estimate (allowance for indeterminates).

Thus, base cost plus contingency is intended to be a projected cost for which there is an equal probability of the actual cost being higher or lower. The greater the uncertainty, the higher the contingency assigned to develop a 50% confidence level estimate. Obviously, if a 90% confidence level estimate is desired (90% probability that the actual cost will be lower), a much higher contingency factor will be required to be applied to the "most likely" cost (1.85 vs. 1.2 in the Figs. H.1 and H.2 example).

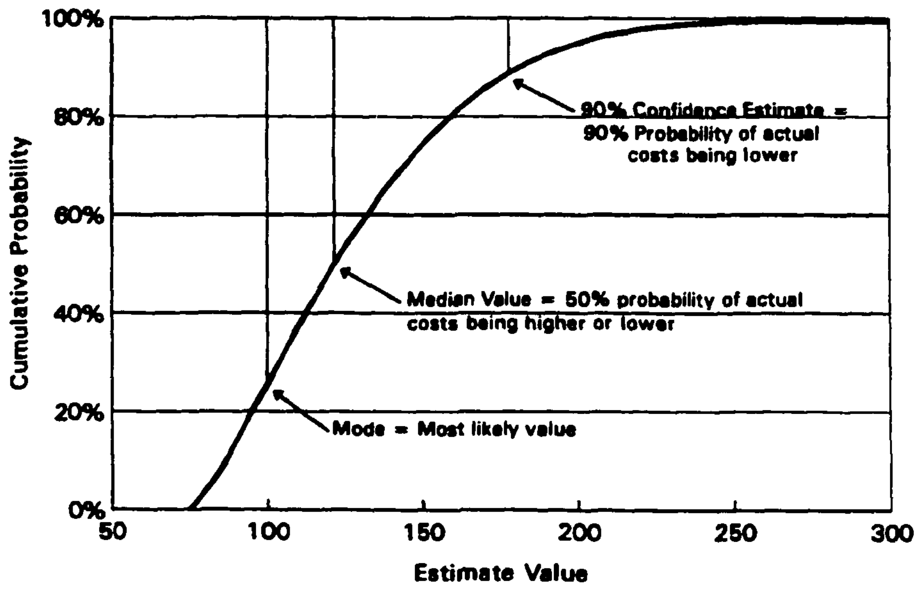
Figures H.1 and H.2 were generated using a simple beta function with a "most likely" estimate of 100, an optimistic estimate of 50, and a pessimistic estimate of 270. This data set results in an median value of 120 and a 20% contingency.

Fig. H.1. Typical Capital Cost of Estimate Distribution (in presence of uncertainites).



GCRA1

Fig. H.2. Typical Cost Estimate Cumulative Distribution (in presence of uncertainties).



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84-152. Given distribution as shown in DOE/OSTI-4500-R75 under category UC-520 (General Reactor Technology)