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A Procedure for Estimating Nonfuel Operation and Maintenance Costs for Large Steam-Electric Power Plants

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NOTICE: 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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A PROCEDURE FOR ESTIMATING NONFUEL OPERATION AND MAINTENANCE COSTS FOR LARGE STEAM-ELECTRIC POWER PLANTS

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ABSTRACT

Revised guidelines are presented for estimating annual nonfuel operation and maintenance costs for large steam-electric power plants, specifically light-water-reactor plants and coal-fired plants. Previous guidelines were published in October 1975 in ERDA 76-37, *A Procedure for Estimating Nonfuel Operating and Maintenance Costs for Large Steam-Electric Power Plants*. Estimates for coal-fired plants include he option of limestone slurry scrubbing for flue gas desulfurization. A computer program, OMCOST, is also presented which covers all plant options.

Keywords: operation and maintenance costs, power plant economics, economic evaluations, LWR, coal plants, steam-electric plants, limestone slurry scrubbing.

1. INTRODUCTION

This report delineates a procedure for estimating annual nonfuel operation and maintenance (O&M) costs for large steam-electric power plants. Since October 1975, when the original estimation procedure was presented in ERDA 76-37,[1] a number of developments have affected certain parts of the procedure significantly. The only near-term candidates for new base-load steam-electric power plants are the light-water-reactor (LWR) plants and the coal-fired plants. Light-water-reactor plants incorporate the concepts of both the boiling-water reactor (BWR) and the pressurized-water reactor (PWR). Each of these fuel types is treated in unit sizes from 400 to 1300 MW(e) and in arrangements of one to four units per plant site. Another significant development has been the increase in the costs of managing physical security, wastewater treatment, and solid wastes. In addition, plant operators have concentrated their efforts on maintaining high availability of equipment under restricted outage schedules. The result is that the use of labor and materials is more difficult to optimize since replacement power during downtime greatly exceeds the value of labor and materials.

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Our cost estimating procedure involves the application of empirical functions that represent historical experience plus new factors arising from regulatory and economic considerations. A digital computer program, OMCOST, has been adapted to suit the new procedure for generating O&M cost estimates and to extrapolate the data.

Cost functions in Sect. 4 are those for hypothetical plants and are given in terms of early 1978 dollars. Although the intent was not to reflect specific operating philosophy or experience, data from published and private sources were examined to insure that the reference plants were realistic. There is necessarily a good deal of subjective judgment in allocating costs to the various expense accounts because all factors affecting performance and O&M costs are not readily quantified. Factors considered in formulating guidelines were plant design, staff training, personnel motivation, outage planning, regulatory provisions, operating load, hours of service, and number of outages and start-ups. In this study only a few of the newer plants were applicable. The utility companies contacted replied to specific requests concerning the procedure output and certain phases of their operation. The parties contacted are, by request, not identified.

The procedures for determining O&M costs are incorporated in the OMCOST computer program, which is designed to assist in examining average trends in costs, determining sensitivity to technical and economic factors, and providing cost projections. By running a series of cases, data can be produced for plotting the trend in unit operating costs for different plant types, number of units per plant, capacity factor, and year of operation. Such a plot is illustrated in Fig. 1.1. The discontinuities in the curves at 700 MW(e) are due to differences in staff requirements for unit sizes of 400 to 700 MW(e) and 700 to 1300 MW(e). These procedures are not substitutes for detailed analyses of specific power plant projects but do permit rapid evaluations using various sets of economic and technical ground rules. The computer program is written in FORTRAN IV for the IBM 360/370 series of digital computers and requires about 52K of core. Execution time for a dozen cases is less than 1/2 sec on the IBM 360/91. The program will be available from the Argonne Code Center, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439.

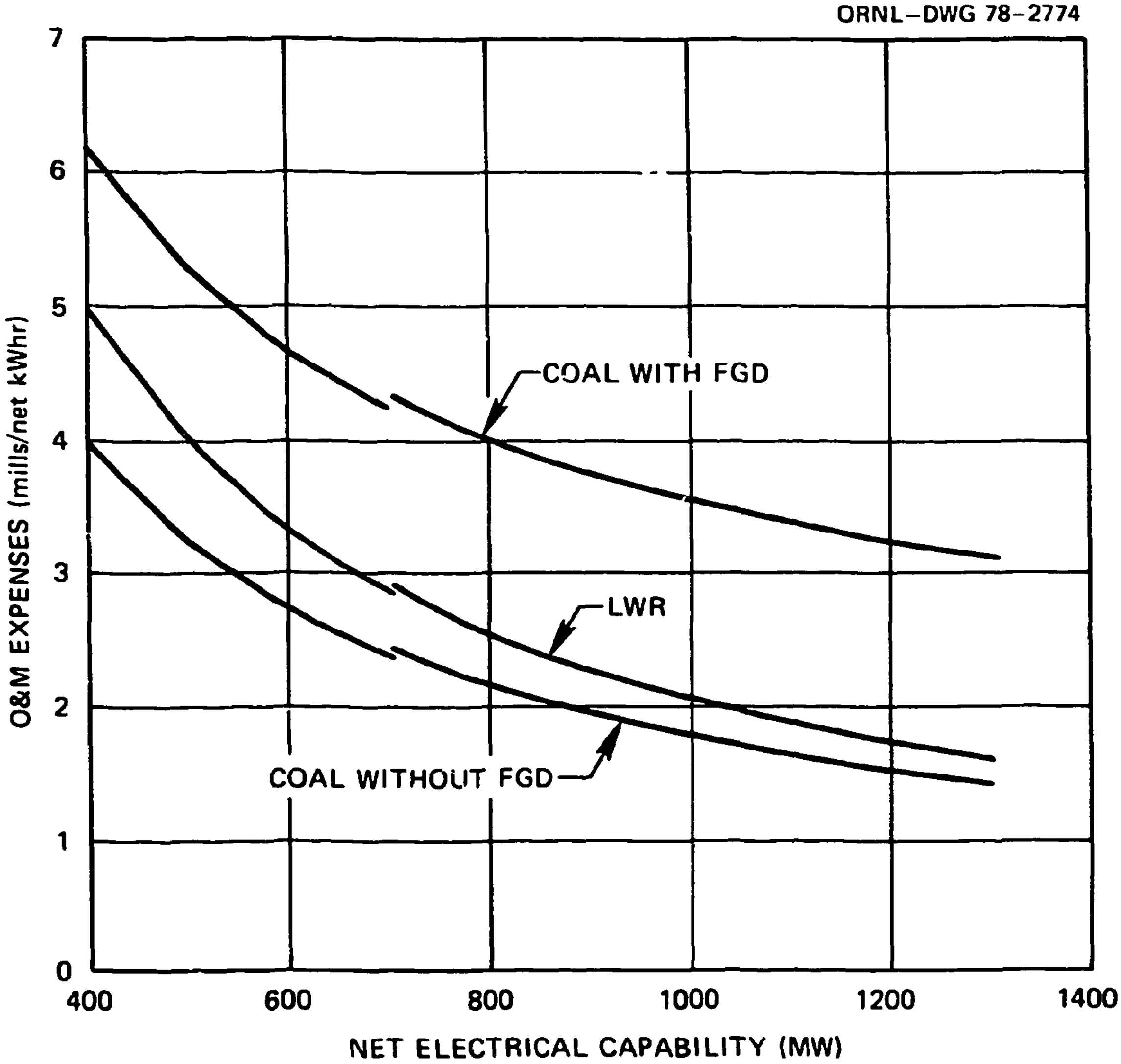

Fig. 1.1. Estimates of O&M expenses in 1978 dollars for single-unit coal-fired and LWR plants at 65% capacity factor as a function of unit size.

2. FACTORS AND TRENDS AFFECTING O&M EXPENSES

2.1 General Factors

Many factors and trends affecting annual costs are common to all plant concepts, whereas others are related to the fuel and to the plant site. Environmental and social influences, along with changing philosophies of management and operations, are not adequately reflected in the historical data now available publicly. Therefore, data from previous experience are not always applicable and must be developed in those areas that are changing. Although gross dollars expended for overall operations may be available from the field operations, segregation of these dollars into the major cost categories either is not sufficiently detailed to identify expenditures or is considered company confidential. Because this breakdown with which to make projections was lacking, a method was developed to estimate the revenue requirements, according to major cost accounts, for several arrangements of plants, two major near-term fuels, and a range of capacity factors. The estimates derived by this method are generally based on inputs of labor, materials, and supplies and on relationships judged appropriate. Assumptions of equipment and personnel performance were required in some cases to keep the computations of the several accounts on a comparable level.

2.1.1 Plant size and number of units

In practice, selecting unit size, fuel, and number of units is complex. Three important components considered in the evaluation of busbar energy costs are the fixed charges on the plant capital investment, operation and maintenance (O&M) expense, and fuel expense. These components are illustrated in Fig. 2.1 for selected plants.[2] Although O&M costs are the least, the differences in the O&M totals make this component as important as the other components, especially when O&M costs are adjusted to reflect recent trends and operating requirements. Although gas and oil are no longer considered as fuels for new plants, the reported average data often present strange patterns such as this

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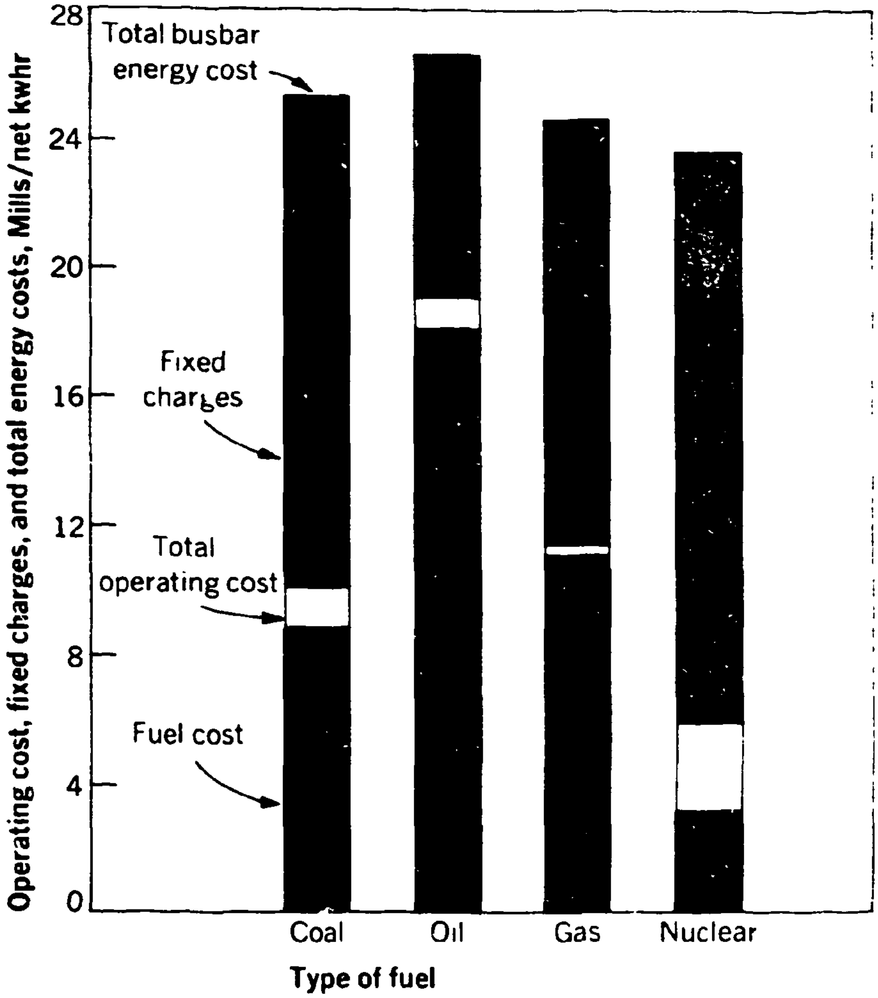

Fig. 2.1. Busbar electrical energy costs. Adapted from G. D. Friedlander, "20th Steam Station Cost Survey," *Electr. World* 188(10): 43–58 (1977).

survey shows. For the gas case in Fig. 2.1, fixed charges are almost twice those of oil, whereas O&M costs are only one-third of those of oil.

Plotting the largest nuclear and fossil-fueled unit sizes by year of order (Fig. 2.2) indicates that new nuclear plants level out at 1200 MW(e), whereas fossil-fueled units hold at or near 800 MW(e). Thus the evaluation of new plants may involve units of different sizes — for example, three 800-MW(e) coal-fired units would be compared with two 1200-MW(e) light-water-reactor (LWR) units.

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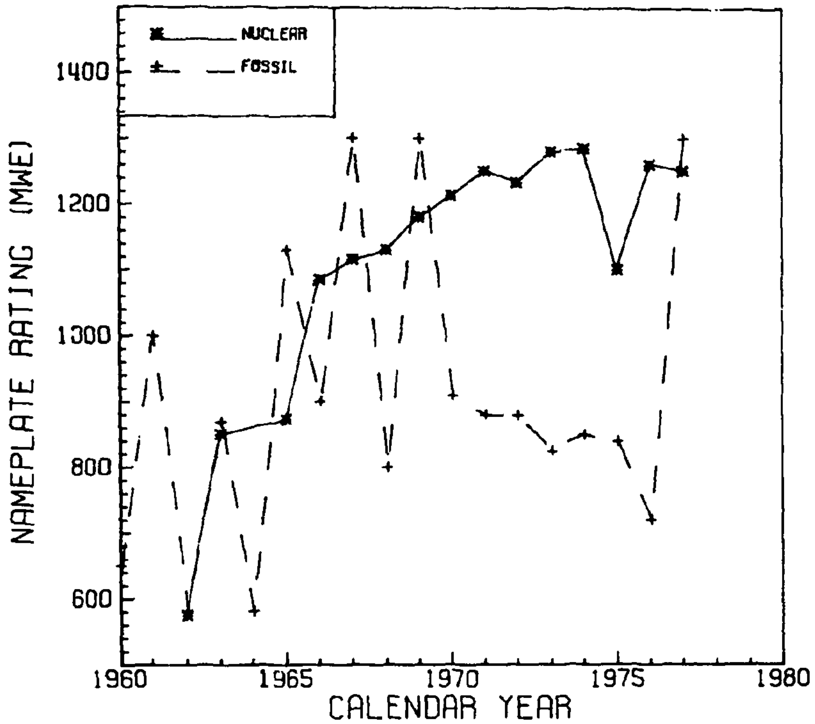

Fig. 2.2. Largest nuclear and fossil-fueled units ordered by year of steam supply system order.

Figures 2.3 and 2.4 show Federal Energy Regulatory Commission (FERC) data for the size distribution of coal-fired and LWR units larger than 200 MW(e), respectively, that are in operation or on order in the contiguous United States through 1976. The question of selecting the steam cycle for the coal case is rarely consistent from one situation to the next. The variables affecting design selection, including O&M considerations, make the decision process complex. For example, the higher pressure cycles have better theoretical heat rates, and variations in load may make steam control of the 3500-psi cycle unsuitable for a utility that occasionally operates below 50% load. One manufacturer has recently offered the supercritical-cycle steam generator for cycling service, but existing plants generally do not provide this capability.

The selection of unit size includes the evaluation of daily and weekly loadings, fuel costs, availability, amortization rates, and other

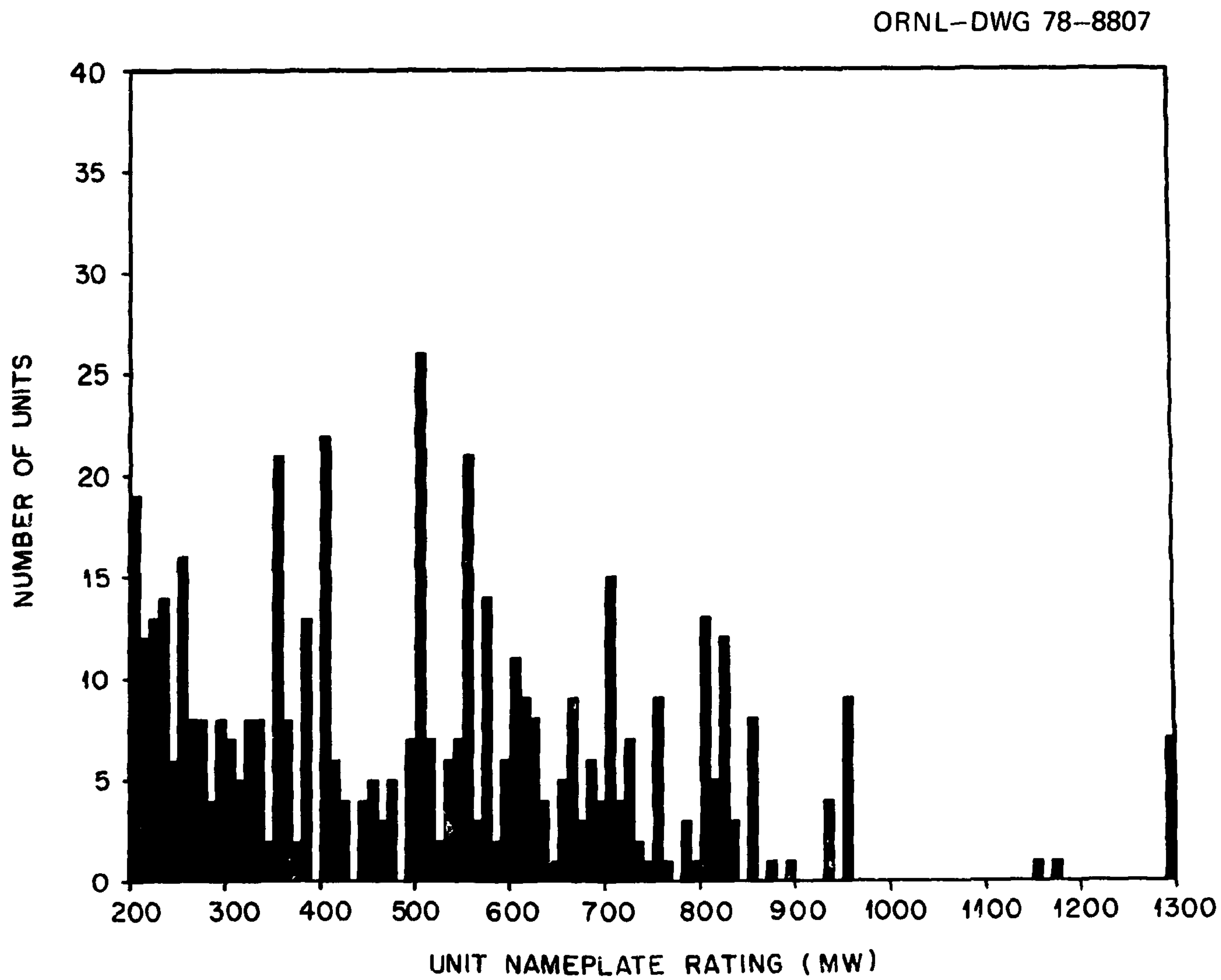

Fig. 2.3. Size distribution of coal-fired units in operation and on order in the United States through 1976. Source: Federal Power Commission Statistical Data.

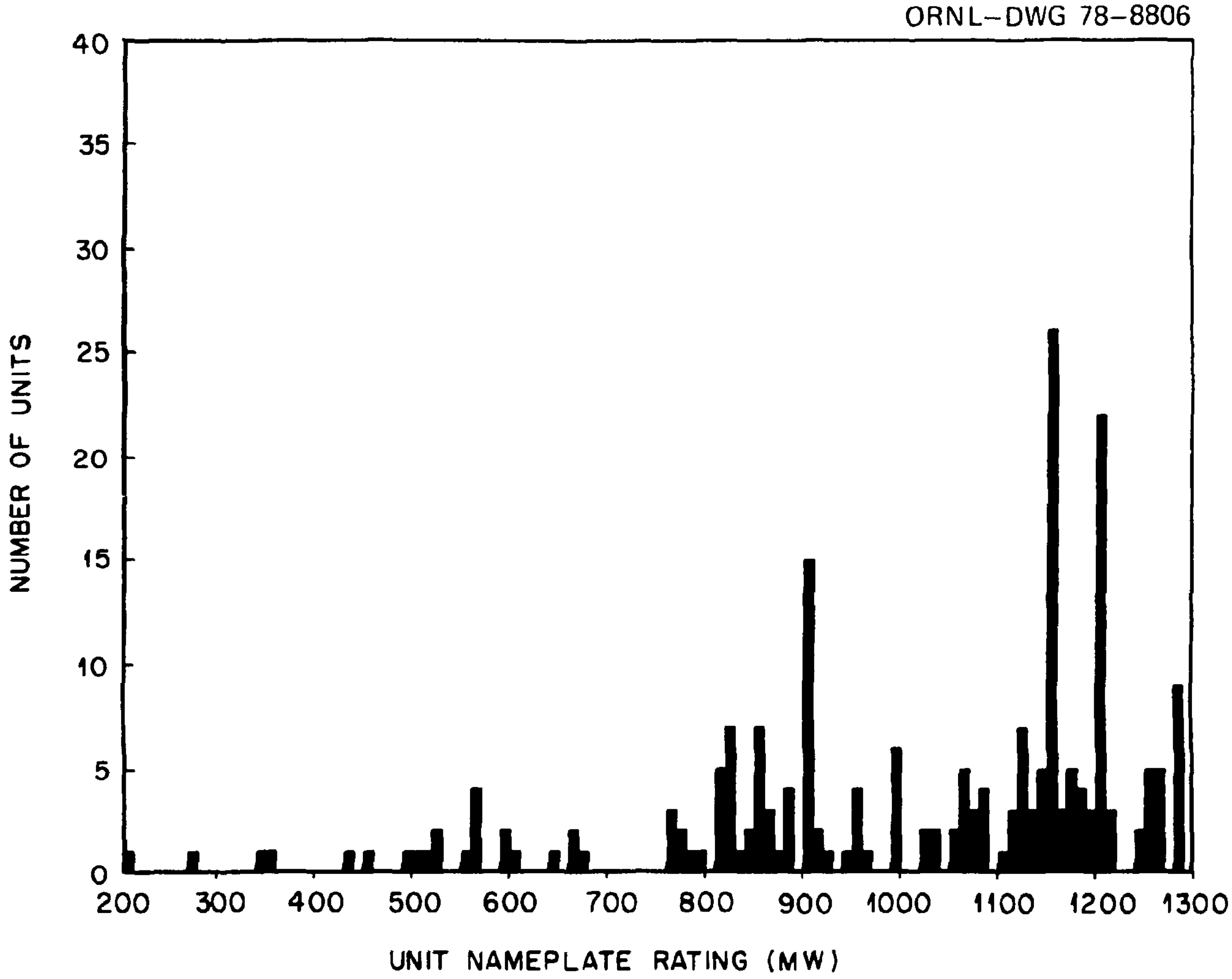

Fig. 2.4. Size distribution of nuclear units in operation and on order in the United States through 1976. Source: Federal Power Commission Statistical Data.

features. The weight given to each item differs from case to case, and the apparent result is an inconsistent pattern in size and cycle selection.

Generally, larger capacity equipment provides cheaper power, and there are plants that consistently show this experience. However, a large unit such as the 1300-MW(e) one could prove unwieldy for a small utility and uneconomical when the full capacity is not used.

Maintenance functions for the smaller 500-MW(e) units are generally more labor intensive [labor hours/MW(e)] than are those for the 1300-MW(e) units. However, the materials to labor cost ratio is not considered to require adjusting for units above 400 MW(e). Because both maintenance labor and material requirements for the smaller units are expected to be more manageable, the smaller units will not be strongly influenced until the basic design parameters of the plant are altered.

For the coal-fired cases in the lower range, an offsetting factor may be the heat rate used in computing coal burned. Detailed plant studies are expected to incorporate an expected heat rate schedule for loading over the plant life. Typical net heat rates for a steam-electric unit are displayed in Table 2.1 for selected load levels. These guidelines for estimating O&M costs were developed for base-load operation, which excludes a varying loading schedule. Between 100% load and 50% load, the variation of about 5% in the heat rate is not significant. The trend is toward reduction of the differential between 1200- and 400-MW(e) units.

2.1.2 Backfitting

Examples of outstanding backfitting requirements for nuclear plants include reactor safety systems, radioactive waste systems, and heat rejection systems. Also, after commercial operation begins, the cooling systems, flue-gas cleaning provisions, and wastewater management systems of coal-fired plants may undergo major design modifications. Expenses for these alterations are primarily of a capital cost nature, although, in practice, the charges may appear in the annual O&M cost. In this report such expenses are assumed to be capitalized.

Table 2.1. Typical net heat rates for a steam-electric unit

Plant type and fuel	Unit rating [MW(e)]	Output (Btu/kWhr) for percent-rated load levels					
		100	80	75	60	50	40
LWR		10,400		10,442		10,951	
Coal without FGD[a]							
Eastern coal[b]	400	9,000	9,045		9,252		9,783
Eastern coal[b]	800–1,200	8,750	8,803		9,048		9,625
Western coal[c]	800	9,816					
Western coal[c]	1,200	9,461					
Coal with FGD[a]							
Eastern coal[c]	800	9,489					
Eastern coal[c]	1,200	9,138					

[a]Flue gas desulfurization.

[b]Electric Power Research Institute, *Synthetic Electric Utility Systems for Evaluating Advanced Technologies*, EPRI EM-285, Palo Alto, California (February 1977).

[c]A. J. Karalis, UE&C, letter to M. L. Myers, ORNL; subject: Heat Balances in NUREG-0243 and NUREG-0244, Feb. 3, 1978.

2.1.3 Plant outages

Nuclear plants are subject to planned shutdowns for routine refueling and required inspection procedures; these shutdowns permit some plant maintenance that may not be similarly afforded to fossil-fueled plants. On the other hand, nuclear plants are also subject to unplanned inspection outages as a result of faults found in similar reactors at other plants. These shutdowns are often brief (three to six days), but, by their frequency, add up to unexpected maintenance expenses.

Estimated plant availability factors for different types of outages are given in Table 2.2. This comparison illustrates a synthetic industry average and not best-plant experience. A few utilities had much better performance consistently, whereas others and the industry average were lower. In the near term, average performance for the industry will be affected by the operation of new systems — a factor that does not tend to improve availability.

2.1.4 Plant physical security

Operators of nuclear plants are required to prepare and implement security plans that meet the approval of the Nuclear Regulatory Commission (NRC). Currently, security at fossil-fueled plants is minimal, and some plants have reduced their security staff. However, considering the many recent occurrences of damage to both public and private property, it is expected that plant security will be upgraded for all types of plants. Personnel staffing assumed for this report meets only the resource guard requirement of 10 CFR Part 73.55. This staff is outlined in Table 2.3 and tabulated in Sect. 4, along with security personnel for fossil-fueled plants. The data for specific plants will probably vary from the values shown.

2.1.5 Housekeeping

Industry-wide, housekeeping now involves a greater number of people than that estimated when nuclear plants first entered commercial service.

Table 2.2. Estimated and reported availability of bulk power concepts in the United States

Plant type	Estimated data [weeks per year (percentage rate)]			Estimated availability percentage rate	Reported data[a,b]		
	Forced outages	Scheduled outages	Other outages		Year	Availability percentage rate	Forced outage percentage rate
Coal	6 (11.5)	6 (11.5)	1 (1.9)	75	1973	77	12
					1974	76	13
					1975	79	11
					1976	76	11
					1977	77	13
Coal with FGD	6 (11.5)	6 (11.5)	3 (5.8)	71	No comparable data		
LWR	6 (11.5)	8 (15)	2 (1.7)	72	1973	78	10
					1974	68	18
					1975	74	14
					1976	72	14
					1977	77	11

[a]Reported data for 1973–1974 are from Edison Electric Institue, *Report on Equipment Availability for the Ten-Year Period 1966–1975*, EEI Publ. No. 76-85 (December 1976).

[b]Reported data for 1975–1977 are from Atomic Industrial Forum Survey, *Nuclear Generating Costs Stabilized at 1976 Level*, p. 4, INFO 117 (April 1978).

Table 2.3. Assumed physical security force for nuclear and coal-fired plants[a]

Number of units	Captains	Lieutenants	Officers	Clerks	Total
		Nuclear			
1 to 3	1	5	49	1	56
4	1	5	59	1	66
		Coal-fired			
1 or 2		1	5	1	7
3		1	7	1	9
4		1	12	1	14

[a]Staffing for nuclear plants is for cost assessment only; the actual arrangement will probably differ for each plant to meet the requirements of 10 CFR Part 73.55. Data regarding staffing for security for specific plants is not available for public review.

This work also requires close supervision in nuclear plants. In coal-fired plants, housekeeping is principally related to outage periods, when cleanup is directed toward aesthetics and pride in operation.

2.1.6 Training and licensing

The NRC requires routine relicensing of reactor operators. To maintain in-plant training, a training department is often formed, and an extra shift of operators may be required to permit relief for training purposes. Large fossil-fueled plants are also using sophisticated operating techniques and are being provided new processes such as flue gas desulfurization (FGD). Training facilities for both nuclear and fossil-fueled plants are now available in some of the larger utility companies. Personnel may be trained for both types of operation.

2.1.7 Spare parts

Quality assurance procedures are the most stringent for purchasing, shipping, storage, and handling of spare parts in nuclear plants.

Inventory requirements are higher for both nuclear and fossil-fueled plants because of the longer lead times now required for delivery of critical items. The exchange of parts between utility companies for emergency repairs is an important factor in reducing outage times.

2.1.8 Environmental considerations

Compliance with the guidelines of the Environmental Protection Agency (EPA) and other agencies regulating discharges to the environment requires onsite utility company personnel or the equivalent in contract or offsite personnel.

2.1.9 Personnel

Personnel costs are increasing because of trends toward higher staffing for each unit, increasing turnover in nuclear plants,[3] lack of interest in overtime and shift work, and changes in both operating and maintenance philosophy. Both onsite and offsite costs for personnel services are affected.

2.1.10 Occupational Safety and Health Administration (OSHA) regulations

The regulations set forth by OSHA are primarily directed toward personnel safety. Design of equipment and systems must conform to these guidelines. It is expected that these measures will increase the time required to perform O&M functions.

2.1.11 Fuel waste disposal

The O&M costs associated with reducing radioactive waste releases from nuclear plants depend on equipment requirements. These requirements have been determined from a cost-benefit analysis of additional radioactive waste systems and equipment designed to reduce the radiation dose to the population reasonably expected to reside within 80 km (50 miles) of the reactor.[4] For fossil-fueled plants, limited data are available on the cost to meet regulations involving flue gas emissions.

2.2 Unique Plant Features

Each plant type has unique features that affect the nonfuel O&M costs. Some important items are listed for each type so that cost differences between the designs may be viewed in a broader perspective. Maintenance procedures and the related inspection and regulatory approvals peculiar to nuclear plants are common to both pressurized-water-reactor (PWR) and boiling-water-reactor (BWR) plants.

2.2.1 PWR plants

- Boron shim control is required to supplement control rod regulation of reactivity.
- Heavy-wall pressure vessels are difficult to open for servicing and refueling in existing plants. New designs should result in improved handling times.
- Redundant auxiliary safety systems are required for emergency core cooling.
- The primary-system pressurizer operates at high pressure (about 2000 psi).
- Large heat exchangers are required for steam generation in a secondary system and are located inside primary containment compartments.
- The turbine operates on saturated steam. Some designs use once-through steam generators that produce a low degree of superheated steam. Turbine blade erosion is accelerated at low loading.
- Saturated-steam designs may incorporate full-flow demineralization of returned condensate.
- Radioactive waste systems employ special handling of steam generator blowdown (saturated-steam cases only).
- Large heat exchangers are required to reheat high-pressure turbine exhaust steam prior to passage through the low-pressure sections.

2.2.2 BWR plants

- The primary system supplies steam directly to the turbine at about 1000 psi.
- A reactor vessel larger than that for the PWR plant is required.
- The steam supply system has fewer components but uses jet pumps and circulating pumps inside and outside the pressure vessel.
- The direct cycle entails greater risks from radioactive leaks and contamination. An off-gas system is required to handle the condenser ejector discharge.
- Redundant auxiliary safety systems are required for emergency core cooling.
- The turbine operates on saturated steam.
- Large heat exchangers are required to reheat high-pressure turbine exhaust steam prior to passage through the low-pressure sections.
- The staff assigned to BWR plants is reported to be 10 to 20% larger than that for PWR plants, according to surveys of operating plants.[5] Peak maintenance personnel appears to be excluded from these surveys.

2.2.3 Coal-fired plants

- Supercritical steam cycles and pressurized furnaces pose unique problems during start-up and low loading.
- Coal burning creates a severe environment for tube surfaces, especially when equipment is operated at overload and on start-up and shutdown.
- Low-quality coal increases wear and tear on plant coal- and ash-handling systems.
- Flue gas desulfurization introduces operations similar to those practiced by the chemical industry.
- Turbine operation at 3600 rpm and 538°C (1000°F) may be more severe on materials life.
- Access for maintenance presents factors important to worker safety and to the expediting of maintenance, that is, poor working conditions inside and outside the steam generator.

3. COST ACCOUNTS

3.1 Annual Power Production Expense Accounts

This report contains estimates of operation and maintenance (O&M) expenses, exclusive of fuel. Table 3.1 shows the makeup of the annual cost of power as given in a Federal Power Commission (FPC) publication[6] and emphasizes the place of nonfuel O&M expense accounts in the calculation of energy costs.

The format previously used by the FPC and now by the Energy Information Administration (EIA) to report annual power production expenses is displayed in Table 3.2.[7] The various production expense accounts are

Table 3.1. Example showing makeup of annual cost of power

I. Plant investment, excluding step-up transformer ($/net kWe)

II. Annual capacity cost ($/net kWe)

- A. Fixed charges
  1. Cost of money
  2. Depreciation
  3. Interim replacements
  4. Insurance, excluding nuclear insurance
  5. Taxes — federal income, federal miscellaneous, state, and local
- B. Annual carrying cost of fuel inventory
- C. Annual fixed operating costs
  1. No-load fuel
  2. *Operation and maintenance*[a]
  3. *Administrative and general*
- D. Total annual capacity cost (IIA + IIB + IIC)

III. Energy — variable operating costs (mills/net kWhr)

- A. Energy fuel
- B. *Operation and maintenance*
- C. Total energy cost (IIIA + IIIB)

[a]Includes nuclear insurance for nuclear power plants.

Source: Federal Power Commission, *Hydroelectric Power Evaluation*, FPC P-35 (March 1968).

Table 3.2. Annual power production expenses reported by the EIA for nuclear and fossil-fueled steam-electric plants

Line number	Production expenses[a]
20	Operation supervision and engineering
21	Fuel
22	Coolants and water (nuclear plants only)
23	Steam expenses
24	Steam from other sources
25	Steam transferred (credit)
26	Electric expenses
27	Miscellaneous steam (or nuclear) power expenses
28	Rents
29	Maintenance supervision and engineering
30	Maintenance of structures
31	Maintenance of boiler (or reactor) plant
32	Maintenance of electric plant
33	Maintenance of miscellaneous steam (or nuclear) plant

[a]See Appendix A for definitions.

Sources:

1. Department of Energy, *Steam-Electric Plant Construction Cost and Annual Production Expenses — Twenty Eighth Annual Supplement, 1975*, DOE/EIA-0033/1 (January 1978).

2. Federal Power Commission, *Uniform System of Accounts Prescribed for Public Utilities and Licenses*, FPC A-118 (April 1, 1973).

defined in the excerpt from the FPC Uniform System of Accounts[8] reproduced in Appendix A.

3.2 Annual Nonfuel O&M Expense Accounts

Internal operating records of utility companies may consist of hundreds of entries. From these entries, which are unique to the utilities' bookkeeping needs, an annual summary is prepared for the regulating agency. The detailed data from these annual summaries are not available for public inspection; however, the data provided on form 1, the cost-summary document submitted to EIA by a given utility company, are available for public inspection at the public document room of the Federal Energy Regulatory Commission [FERC (formerly FPC)]. Table 3.3 illustrates the actual nonfuel O&M costs for a two-unit nuclear plant discussed in these annual summaries. Although individual plant accounts may vary considerably from year to year, the cost per kilowatt-hour at the busbar for this plant is almost level with time.

Two examples of utility company summary breakdowns of nonfuel O&M costs are given in Table 3.4. These and the breakdowns in Tables 3.1 and 3.2 illustrate some of the differences in reporting that make evaluation of individual cost accounts difficult.

For this report, an accounting breakdown has been devised that includes the major cost areas but does not define separate expenses for the reactor or boiler plant and the turbine plant. This breakdown, shown in Table 3.5, is designed to facilitate the derivation of certain costs related to expenditures for personnel. Variable costs are accounted for in two subaccounts — variable maintenance materials and variable supplies and expenses. All other accounts are fixed expenses, that is, constant with plant output. Section 4 gives recommendations for estimating costs for each of these nonfuel O&M expense accounts.

3.3 Working Capital and Decommissioning Costs

Working capital and decommissioning costs are not included in the nonfuel O&M expenses. Working capital for meeting the staff payroll and for the materials and supplies inventory is a nondepreciating investment, and its cost can be evaluated as a portion of the annual fixed charges on capital investment. Decommissioning costs at the end of plant life can be expressed as the present worth of such expenditures and evaluated as an initial capital investment.

Table 3.3. Actual nonfuel O&M expenses for a two-unit nuclear plant [500 MW(e) each]

Administrative and general (A&G) expenses are excluded

	FPC account	Year 1974	1975	1976	1977[a]
		Operation			
Supervision and engineering	517	$ 465,770	$ 176,901	$ 417,602	$ 445,620
Coolants and water	519	166,946	396,658	275,376	279,288
Steam expenses	520	997,533	1,230,266	1,582,330	2,211,512
Electric expenses	523	99,462	101,441	110,388	130,354
Miscellaneous expenses	524	986,253	1,726,230	1,609,282	1,697,330
		Maintenance			
Supervision and engineering	528	67,394	73,493	71,160	142,320
Structures	529	161,296	199,743	85,344	126,086
Reactor plant equipment	530	966,232	1,429,738	1,280,780	1,277,302
Electric plant	531	1,243,081	722,661	1,054,088	1,600,910
Miscellaneous	532	63,426	118,366	100,566	201,132
Total nonfuel O&M costs		$5,217,393	$6,175,497	$6,586,916	$6,372,528
Cost, mills/kWhr		0.8	0.9	0.9	1.1

[a]Average number of plant employees reported on FPC form 1 is 121 excluding peak maintenance.

Source: Federal Power Commission, FPC form 1 (FERC Public Document Room), Washington, D.C., 1977.

Table 3.4. Example formats for internal reporting of nonfuel O&M expenses for a large fossil-fueled steam system

	Cost (mills/kWhr)
July 1977 cost for utility system	
Supervision and engineering labor	0.07
Operating labor	0.40
Maintenance labor	0.49
Materials and supplies	0.55
Other	0.09
Total, exclusive of fuel	1.60
July 1977 cost for best unit	
Supervision and engineering labor	0.08
Operating labor	0.29
Maintenance labor	0.27
Materials and supplies	0.14
Other	0.08
Total, exclusive of fuel	0.86

Table 3.5. Nonfuel O&M expense accounts used in this report

Staff
Maintenance materials
Fixed
Variable
Supplies and expenses
Fixed
Variable
Nuclear plant liability insurance and annual inspection fees
Administrative and general

4. ANNUAL O&M COST ESTIMATING GUIDELINES

4.1 Staff

4.1.1 Organization

To quantify staff requirements, staff for both nuclear and fossil-fueled plants were organized according to function. The typical organization chart shown in Fig. 4.1 is based on unpublished personnel staffing data from operating plants. The nuclear plant organization chart is a modification of a U.S. Atomic Energy Commission representative organization chart[9] and incorporates present practices and projected trends. Fossil-fueled plants, although their organization is similar to that of nuclear plants with regard to plant operation functions, differ in personnel allotment and job classifications; in addition, they do not require staffing for quality assurance or health physics.

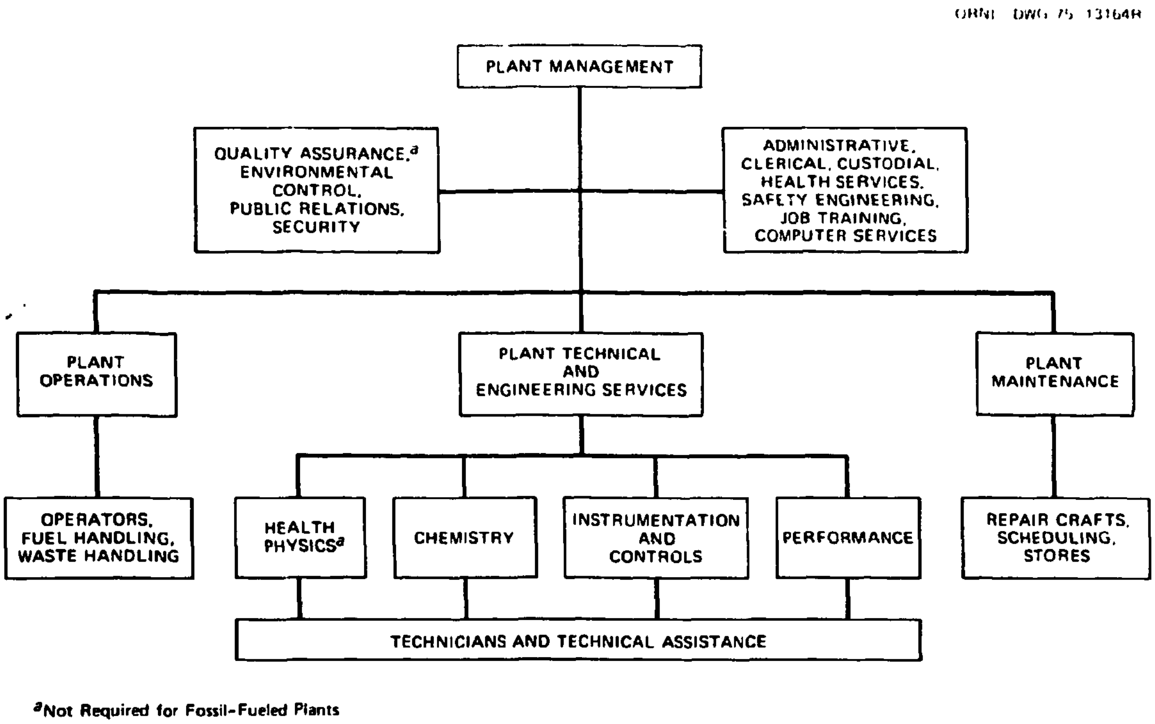

Fig. 4.1. Typical functional organization chart for steam-electric power plant staff.

The total staffing used in this study for the two size ranges of nuclear and fossil-fueled plants is shown in Tables 4.1, 4.2, and 4.3. The staffing totals are detailed in accordance with the organization chart shown in Fig. 4.1.

Examination of Tables 4.2 and 4.3 shows about a 40% increase in O&M staff requirements for fossil-fueled plants equipped with limestone-

Table 4.1. Staff requirement for LWR plants

	400–700 MW(e) unit				701–1300 MW(e) unit			
	Units per site				Units per site			
	1	2	3	4	1	2	3	4
Plant manager's office								
Manager	1	1	1	1	1	1	1	1
Assistant	1	2	3	4	1	2	3	4
Quality assurance	3	4	5	6	3	4	5	6
Environmental control	1	1	1	1	1	1	1	1
Public relations	1	1	1	1	1	1	1	1
Training	1	1	2	2	1	1	2	2
Safety	1	1	1	1	1	1	1	1
Administrative services	13	15	17	19	13	15	17	19
Health services	1	1	1	2	1	1	1	2
Security	56	56	56	105	56	56	56	112
Subtotal	79	83	88	142	79	83	88	149
Operations								
Supervision (excluding shift)	2	2	4	4	2	2	4	4
Shifts	28	48	68	88	33	58	83	108
Subtotal	30	50	72	92	35	60	87	112
Maintenance								
Supervision	8	8	10	12	8	8	10	12
Crafts	14	22	30	38	16	26	36	46
Peak maintenance annualized	55	110	165	220	55	110	165	220
Subtotal	77	140	205	270	79	144	211	278
Technical and engineering								
Reactor	1	2	3	4	1	2	3	4
Radiochemical	2	2	3	4	2	2	3	4
Instrumentation and controls	2	2	3	4	2	2	3	4
Performance, reports, and technicians	17	21	25	29	17	21	25	29
Subtotal	22	27	34	41	22	27	34	41
Total	208	300	399	545	215	314	420	580
Less security	152	244	343	440	159	258	364	468
Less security and peak maintenance	97	134	178	220	104	148	199	248

Table 4.2. Staff requirement for coal-fired plants without FGD systems

	400–700 MW(e) unit				701–1300 MW(e) unit			
	Units per site				Units per site			
	1	2	3	4	1	2	3	4
Plant manager's office								
Manager	1	1	1	1	1	1	1	1
Assistant	1	2	3	4	1	2	3	4
Environmental control	1	1	1	1	1	1	1	1
Public relations	1	1	1	1	1	1	1	1
Training	1	1	1	1	1	1	1	1
Safety	1	1	1	1	1	1	1	1
Administrative services	12	13	14	15	12	13	14	15
Health services	1	1	1	2	1	1	1	2
Security	7	7	9	14	7	7	9	14
Subtotal	26	28	32	40	26	28	32	40
Operations								
Supervision (excluding shift)	2	2	4	4	2	2	4	4
Shifts	45	50	60	65	45	50	60	65
Fuel handling	12	12	12	18	12	12	12	18
Subtotal	59	64	76	87	59	64	76	87
Maintenance								
Supervision	6	6	8	10	6	6	8	10
Crafts	75	90	100	110	80	95	105	115
Peak maintenance annualized	32	64	96	128	32	64	96	128
Subtotal	113	160	204	248	118	165	209	253
Technical and engineering								
Radiochemical	2	2	3	4	2	2	3	4
Instrumentation and controls	2	2	3	4	2	2	3	4
Performance, reports, and technicians	12	15	18	21	15	18	21	24
Subtotal	16	19	24	29	19	22	27	32
Total	214	271	336	404	222	279	344	412

slurry-scrubbing SO_2 removal systems. The SO_2 removal process parallels some chemical industry operations and appears to require special attention in both operation and maintenance compared with other equipment and systems in general use by electric utility systems.[10]

In the long term, staff requirements will vary from year to year over the plant lifetime. To approximate this effect, a four-year cycle of peak forces, which include contract and offsite personnel, was developed; it is presented in Table 4.4. This labor has been included, on

Table 4.3. Staff requirement for coal-fired plants with FGD systems

	400-700 MW(e) unit				701-1300 MW(e) unit			
	Units per site				Units per site			
	1	2	3	4	1	2	3	4
Plant manager's office								
Manager	1	1	1	1	1	1	1	1
Assistant	1	2	3	4	1	2	3	4
Environmental control	1	1	1	1	1	1	1	1
Public relations	1	1	1	1	1	1	1	1
Training	1	1	1	1	1	1	1	1
Safety	1	1	1	1	1	1	1	1
Administrative services	13	14	15	16	13	14	15	16
Health services	1	1	1	2	1	1	1	2
Security	7	7	9	14	7	7	9	14
Subtotal	27	29	33	41	27	29	33	41
Operations								
Supervision (excluding shift)	3	3	5	5	3	3	5	5
Shifts	45	50	60	65	45	50	60	65
Fuel and limestone handling	12	12	12	18	12	12	12	18
Waste systems	15	30	45	60	15	30	45	60
Subtotal	75	95	122	148	75	95	122	148
Maintenance								
Supervision	8	8	10	12	8	8	10	12
Crafts	90	115	135	155	95	120	140	160
Peak maintenance annualized	33	66	99	132	35	70	105	140
Subtotal	131	189	244	299	138	198	255	312
Technical and engineering								
Waste	1	2	3	4	1	2	3	4
Radiochemical	2	2	3	4	2	2	3	4
Instrumentation and controls	2	2	3	4	2	2	3	4
Performance, reports, and technicians	14	17	21	24	14	17	21	24
Subtotal	19	23	30	36	19	23	30	36
Total	252	336	429	524	259	345	440	537

Table 4.4. Peak forces for extended outages and overhauls

Year of time cycle	Personnel/outage weeks for:		
	LWR	Coal	Coal with FGD
1	300/6	275/6	300/6
2	300/6	275/6	300/6
3	300/6	275/6	300/6
4	1200/8	275/6	300/6

an annualized basis, in the plant maintenance totals of Tables 4.1, 4.2, and 4.3. The cycle includes all types of labor expended beyond the onsite maintenance staff.

4.1.2 Payroll expense

Although licensed reactor operators may receive a 5 to 10% bonus, fossil-fueled and nuclear plant personnel have been assigned the same hourly rates. Licensed LWR operators make up one-third of the total plant staff. Nonlicensed jobs in fossil and nuclear work are not significantly different in function. However, considerably more preparation and training may be required to learn nuclear plant procedures for repairs and inspections. The utility must also control personnel exposure to radioactivity.

The basic wage rate in this study was determined by the average hourly earnings of nonsupervisory workers in transportation and public utilities.[11] This basic rate of $7.25/hr in early 1978 was increased by 35% for fringe benefits plus 15% for supervisory and technical support for LWR plants and 10% for coal-fired plants. The resultant average annual salaries for 1978 are about $23,000 and $22,000, respectively, for LWR plants and coal-fired plants.

Wage rates agreed to in 1977 by the utilities and linemen ranged from a high of $9.81/hr on the West Coast to $7.31/hr in the Northeast.[12] Average increases for the same time varied from 7.6 to 6.6%. Fringe benefit increases for the same period are not available. The average hourly rate for the mix of the plant staff will be less than that for the crafts cited.

4.2 Maintenance Materials

The amount of the various major replacement items, expendable materials, and services used to maintain the power plant is variable throughout the plant life. To date, historical data on new plant designs are not extensive enough to provide direct relationships for large plants. In addition, utilities do not list this expense explicitly so that cost can readily be distinguished. Therefore, the relationship of materials to maintenance labor was estimated for 80% plant capacity (maximum cost) (Table 4.5), after which the results were discussed with operating personnel. This approach is convenient to use at the conceptual estimate level to distinguish operations differing in complexity.

Table 4.5. Maintenance materials cost factors as a percentage of maintenance labor cost[a]

	Fixed	Variable	Total
LWR	100	0	100
Coal	50	17	67
Coal with FGD	53	29	82

[a]Estimated at 80% plant capacity factor.

4.2.1 LWR plants

Major backfitting of plant systems or modifications involving capital cost are not considered in these cost procedures. Such expenses may appear in the O&M costs reported annually on form 1 to the Energy Information Administration (EIA) and need to be considered when examining reported data. Examples of such work are radioactive-waste-system alterations, safety-system additions, and cooling-water-system modifications. Specific plants will report costs that may vary widely from year to year because of deferral of major work or because of unanticipated problems.

4.2.2 Coal-fired plants

Operation and maintenance of coal-fired plants tend to be more labor intensive than that of LWR plants because of the routine maintenance involved with burning coal and the effect of high operating temperatures on the equipment. Quality assurance documentation and related administrative controls are not required for regulatory purposes but are necessary for establishing reliable performance.

Maintenance costs are estimated for operation at base-load conditions near 100% capability. The number of starts and stops, for whatever reason, has an important effect on equipment. For coal-fired plants, loading effects may appear as tube erosion, slagging, overheated tubes, furnace overloading by slag and ash, and accelerated wear of fuel- and air-handling components. At low loading, possible effects are increased corrosion at the air preheater, turbine blade erosion, condenser tube wastage, and valve deterioration. Both fossil-fueled and nuclear plant turbines may experience accelerated erosion and overheating at low loading. Turbine start-ups are expected to exceed steam supply system start-ups over an extended period such as a year.

Typical loading cycles and total firing modes derived from data collected by Combustion Engineering, Inc., are shown in Table 4.6. Comparison with specific field data may show base load cycle operation low. This may be due to peaking service or load-following operations which exist for some large units which are classified as base load service.

Table 4.6. Lifetime loading cycles and starts for fossil-fueled units

	Conventional base load	Conventional peaking load	Cycling load
Cold starts	1200	1600	1600
Hot starts	1600	7800	1600
Total	2800	9400	3200

Source: R. D. Brown and D. A. Harris, Combustion Engineering, Inc., "Large Coal-fired Cycling Units," presented at the ASME-IEEE-ASCE Joint Power Generation Conference, Portland, Ore., Sept. 28-Oct. 2, 1975.

Variable maintenance costs are not reported on form 1. For these procedures it was judged that 25% of the total maintenance is subject to change with load between 50 and 80% capacity factor. This judgment is based on factors known to influence incremental costs for coal pulverizers, fuel handling, heat transfer surfaces, and certain nonfuel supplies sensitive to load. An alternative approach, which could not be done with the operating data available, is to show a relationship between annual O&M costs and annual generation. If a linear relationship is assumed, this procedure would establish a no-load intercept at the fixed cost level.

4.2.3 Limestone-slurry scrubbing systems

To maintain performance, scrubbing and sludge-handling systems are expected to require careful attention to both operation and maintenance. Although modular components may be serviced during reduced steam generator loads, some system maintenance will require a boiler outage. The cost of materials for this work is judged to be about twice that of the associated labor. This relationship is shown in Table 4.5 as part of the total plant maintenance. Variable costs, which are also combined with other plant maintenance, are assumed to be twice the fixed costs for FGD systems.

As of 1977, commercial applications of the lime-slurry and limestone-slurry scrubbing processes had been applied to the majority of utility installations.[13] The nonregenerative limestone-slurry scrubbing process was selected for this report to show a process with high sulfur removal and with economics intermediate among the various systems available (including energy requirements and performance capability). This does not mean that acceptance of this process is optimum or that it is recommended.

Sludge-handling and sludge-fixation costs are cost factors in waste management that vary with site and fuel characteristics. These effects and other important features of sludge disposal are examined in an Electric Power Research Institute (EPRI) state-of-the-art paper issued in January 1978.[14] The EPRI paper notes that field and literature data do not separate fixation costs.[15] Therefore, cost estimates are prepared for a hypothetical plant and a set of hypothetical ground rules. With fixation, annual revenue requirement is reported to be in the range of $12 per ton of dry solids for the first year.[16]

4.2.4 Cooling systems

The O&M costs for cooling the main turbine condenser water and other plant heat exchangers have been considered for evaporative cooling towers only. The comparison shown in Table 4.7 for mechanical-draft and natural-draft tower operation shows a higher operating cost for the mechanical-draft case due to maintaining fans, motors, and drive trains. Both designs employ various chemicals to control growths and deposits affecting heat transfer surfaces and the life of system materials. A review of plant experience did not show significant differences in the annual costs of chemicals and materials for the two types of cooling tower designs. Estimates ranged from $25,000 to less than $100,000 annually. Because the effect of capacity factor on cost could not be shown to be significant, costs were not computed for various capacity factors, which simplifies the O&M cost procedure without influencing the results. Penalties for auxiliary power requirements do not appear in O&M costs but are included in an adjusted plant rating.

Table 4.7. Estimate of annual maintenance material costs for evaporative cooling systems

	LWR	Coal
Fixed costs (dollars)		
Natural-draft evaporative cooling towers, per tower	25,000	25,000
Mechanical-draft evaporative cooling towers, per generating unit	50,000	50,000
Variable costs (mills/kWhr)		
Natural-draft evaporative cooling towers, per tower	0.003	0.003
Mechanical-draft evaporative cooling towers, per generating unit	0.005	0.004

4.2.5 Wastewater systems

The Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500) require that the best practicable control technology for cooling steam-electric generating plants be in effect by 1977.[17] By 1983 the best technology economically available is required. The U.S. Environmental Protection Agency (EPA) was also required to publish standards for toxic pollutants. These standards have been challenged in the courts. Guidelines for specific pollutants are to be finalized in March 1979. Pretreatment requirements for discharging into publicly owned treatment works, as promulgated in the October 1974 guideline, have been ruled inadequate by the court. Further amendments require that EPA guidelines be revised at yearly intervals, where appropriate. Regulations covering court rulings regarding priority pollutants must be proposed publicly by EPA no later than September 28, 1978. Whether this compliance document can be adequately reviewed for implementation by industry in the time allowed has been questioned.[18] Therefore, wastewater management cost procedures have been developed on a broad basis. A total flow rate and unit treatment costs were established and converted to incremental (variable) power cost. Continuous processing and/or ponding are the schemes considered for reuse of water. Brine concentration for zero discharge is excluded. A typical flow diagram is shown in Fig. 4.2. Nuclear plants are provided controls for area runoff and cooling tower blowdown only. Light-water-reactor liquid wastes are processed through the radioactive waste treatment system from which discharge is regulated to control thermal, radioactive, and chemical characteristics.

Wastewater flow may vary widely even at the same plant. Estimated volumes for a typical coal-fired plant are given in Table 4.8. The intent in managing these several water streams is to minimize offsite discharges.

For this report, an average unit cost of $0.30 per 1000 gal of water released offsite is used, which amounts to about $500 per day for a 1000-MW(e) unit. Environmental Protection Agency guidelines to be defined in 1978 may increase this value considerably.

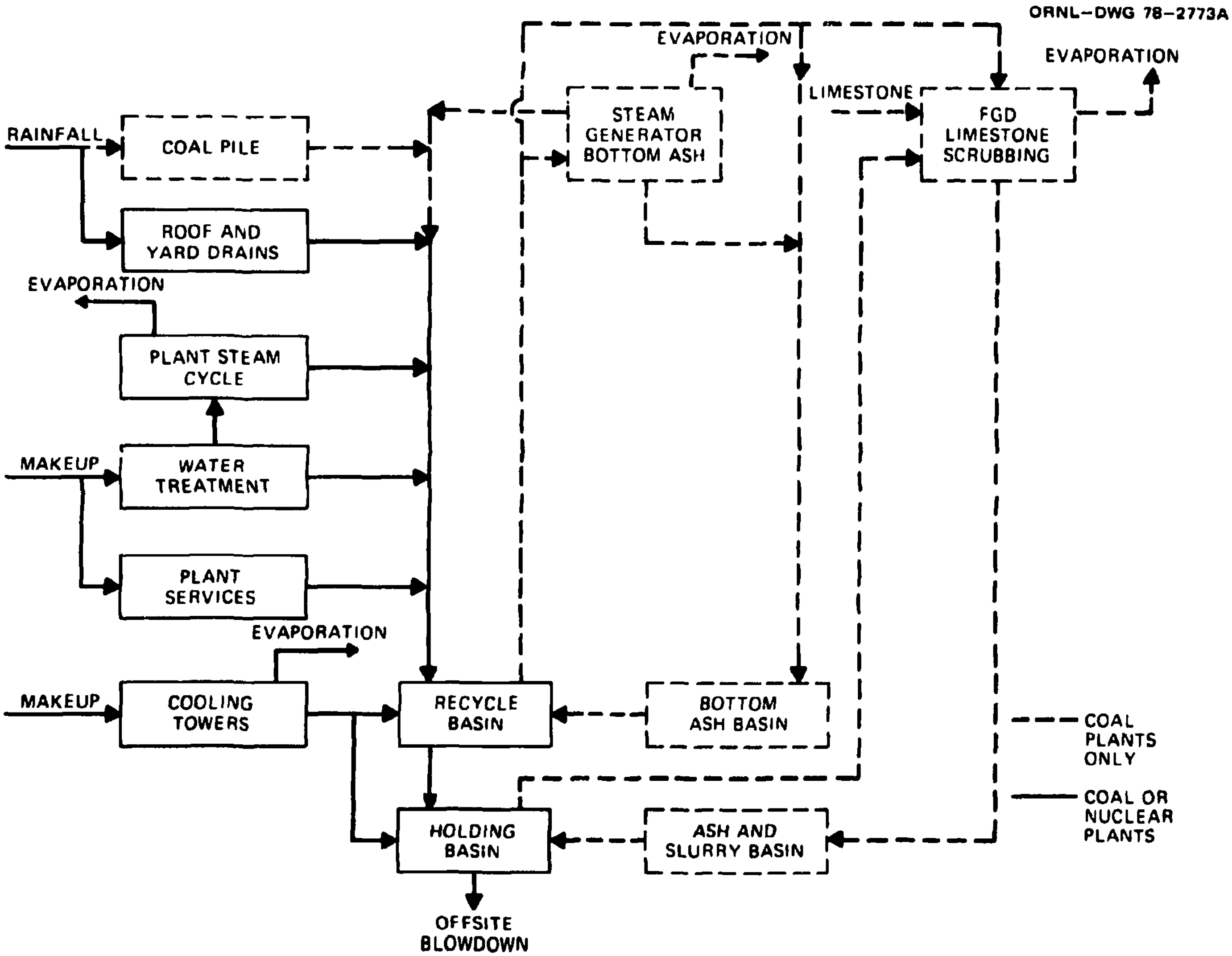

Fig. 4.2. Wastewater management diagram. Source: U.S. Environmental Protection Agency, *Supplement for Pretreatment to the Development Document for the Steam Electric Power Generating Point Source Category*, EPA 440/1-77/084 (April 1977), p. 138.

Table 4.8. Estimated wastewater volumes for a typical coal-fired power plant

	Volume [gpd/MW(e)]
Air pollution control wastes	80
Ion exchange regenerant waste	240
Miscellaneous low-volume waste[a]	80
Area runoff (average 10-year maximum rainfall)[a]	50
Ash pond discharge	40
Boiler blowdown[b]	Reused
Cooling tower blowdown	1000
Total	1490

[a]These flows include miscellaneous low-volume waste and area runoff and are not sensitive to electrical generation.

[b]Control by boiler water analysis — probably about 55 gpd/MW(e) for general guide. This flow is now generally monitored.

Source: Adapted from data in U.S. Environmental Protection Agency, *Supplement for Pretreatment to the Development Document for the Steam Electric Power Generating Point Source Category*, EPA 440/1-77/084 (April 1977), p. 138.

Both LWR and coal-fired plants are assumed to treat 1500 gpd per MW(e) of installed capacity. The higher cooling tower blowdown for nuclear plants tends to balance the several waste streams peculiar to coal-fired plants. Designs to permit high reuse of water are required.

4.3 Supplies and Expenses

Supplies and expenses include certain consumable materials and expenses that are unrecoverable after use in O&M activities. These include makeup fluids, chemicals, gases, lubricants, office and personnel supplies, monitoring and record supplies, and offsite contract services. Costs of limestone and offsite sludge disposal associated with the limestone-slurry scrubbing process for FGD are also included. Although consumptive use of water, such as that lost by evaporation from condenser cooling water systems, is significant [about 15,000,000 gpd for a 1000-MW(e) unit], no cost allowance is included for water not returned to the river system or aquifer from which it was withdrawn. This is treated as a social cost in cost-benefit analyses because no money exchanges hands. Water rights in some parts of the United States, however, are highly, sometimes totally, appropriated, and siting of power plants with evaporative cooling may require the purchase of existing water rights. The actual form and amount of such payments, which may be made annually, are not part of these procedures.

Guidelines for estimating costs of supplies and expenses are summarized in Table 4.9. The variation with plant load is slight for the items listed over the range of operation covered in this report. The category of chemicals covers an allowance for cooling water treatment, and the category of variable costs includes an allowance for consumables and waste management variation with plant output.

All services rendered for the plant by other than the normal plant staff are classified as offsite contract services. In utility company practice, these services can be provided by outside contractors or by

Table 4.9. Guidelines for estimating the cost of supplies and expenses

	LWR	Coal	Coal with FGD
Fixed costs, $\$10^6$/unit year			
Chemicals, gases, lubricants, auxiliary fuel, office, security, and miscellaneous items	2.4	1.1	1.1
Contract services	0.9	0.1	0.1
Radioactive waste management	0.8		
Nonradioactive waste management[a]	0.1	0.1	0.2
Total fixed costs	4.2	1.3	1.4
Variable costs, mills/kWhr[b]	0.06	0.04	0.05

[a]Nonradioactive wastes are primarily from water sources.

[b]See Table 4.12 for coal-related waste management supplies.

central organizations providing specialized s s for all plants in a system. Costs of these services may vary wi ording to staffing policies, type of plant and rating, design of nts and systems, and, to a small degree, the amount of electri generated.

Fuel oil for standby and emergency diesel-engine generators and for auxiliary steam for building heating and evaporator operation is not precisely an O&M expense but is defined by the Federal Power Commission (FPC) as belonging in the fuel account for both nuclear and fossil-fueled plants.[8] In most evaluations, however, this expense is overlooked in the fuel charges; it has been included here. The allowance for a 1000-MW(e) LWR unit included in Table 4.9 is 2×10^6 gal of No. 2 fuel oil at about 40¢/gal. The major portion of fuel oil requirements is for use in auxiliary steam boilers that are operated during start-up and shutdown periods. Standby diesel-engine generators normally use little fuel because they operate only a few hours each month.

The costs of handling LWR radioactive wastes requiring long-term storage are summarized in Tables 4.10 and 4.11. Operating labor is not included in these data. The expenses included are those for resins;

Table 4.10. Radioactive waste system performance and estimated economic data

	BWR	PWR
LWR wastes [3400 MW(t)][a]	55,000 ft^3	40,000 ft^3
Resins		
Evaporator sludge		
Filters		
Compressible wastes		
Incompressible wastes		
Design waste volume, ft^3/MW(t)-year[b]	11 to 16	
Annual waste management cost, $/year	750,000 to 900,000	

[a]From design documents for new reactors, T. B. Mullarhey et al., "A Survey and Evaluation of Handling and Disposing of Solid Low-Level Nuclear Fuel Cycle Wastes," Atomic Industrial Forum, Inc. (October 1976).

[b]Although activity variation is related to reactor rating, volume variation is more related to system design and plant management practices.

Table 4.11. Radioactive waste handling cost example for 1000 drums and 1000 miles round trip

	Approximate cost ($)
1,000 drums at $15/drum	15,000
Binder, 450 lb of cement per drum at 2¢/lb	9,000
Transportation costs	
400 drums at 120 mR/hr and 40 drums per load	10,000
600 drums at 16 drums per load	37,000
Shielded van costs	2,000
Burial costs, average cost per 1,000 drums	27,000
40% at 200 mR/hr 40% at 2–5 R/hr 40% at 5–10 R/hr	
Total	100,000

filters and filter agents; materials for processing evaporator concentrates; and disposal, which depends on the costs of shielded containers, transportation, and burial. Section II.D of Appendix I to 10 CFR Part 50 requires that radioactive waste systems be designed to effect reductions in dose to the population within 80 km (50 miles) of the reactor to meet the as-low-as-reasonably-achievable (ALARA) criterion. Therefore, significant departures from the values in Tables 4.10 and 4.11 can be expected because of differences in designs for site location, fuel performance, and operating procedures.

A cost example for limestone and offsite sludge disposal is shown in Table 4.12. The principal supply is limestone, which varies directly with the sulfur content of the fuel and with the ratio of limestone to sulfur required in the scrubbing operation. If prior ash removal at a precipitator is assumed, the quantity of dry sludge is the sum of the sulfur and limestone, and it is assumed that spent slurry from the scrubber is dried to 40 to 50% moisture for offsite disposal.

A cost example for ash disposal is shown in Table 4.13. The allowance of $4/ton for ash disposal includes transportation and other costs associated with offsite disposal of ash.

Table 4.12. Limestone and sludge-handling cost example

Fuel, tons per year	3,000,000
Sulfur in fuel, wt %	3.5
Sulfur in fuel, tons per year	105,000
Tons of limestone required per ton of sulfur in fuel	4
Limestone, tons per year	420,000
Dry solids, tons per year[a]	420,000
Wet sludge, tons per year[b]	1,050,000
Cost of limestone at $10/ton, $/year	4,200,000
Cost of offsite sludge disposal at $10/ton, $/year[c]	4,200,000
Cost of limestone and sludge disposal, $/year	8,400,000
Cost of sulfur control, dollars per ton of coal	2.80

[a]One ton of sulfur in coal gives about four tons of dry solids.

[b]Four tons of dry solids give ten tons of wet sludge.

[c]Excludes capitalized investment cost and plant labor costs.

Table 4.13. Ash disposal cost example

Fuel, tons per year	3,000,000
Ash in fuel, wt %	10
Ash, tons per year	300,000
Cost of ash disposal at $4/ton, $/year	1,200,000

4.4 Nuclear Liability Insurance and Regulatory Inspection Expenses

4.4.1 Nuclear liability insurance

Operators of nuclear power plants are required to maintain financial protection to a total limit of $560 million.[19] In 1977 the maximum coverage of $140 million was available from commercial insurance pools, American Nuclear Insurance, and Mutual Atomic Energy Liability Underwriters. Recent Price-Anderson Act amendments, which were effective August 1, 1977, introduced an intermediate level of liability between the private insurance limit and the government indemnity limit. This level is called a "retrospective premium," which the utility industry assumes equal to $5 million for each licensed operating reactor. With 68 operating reactors as of June 1978, this premium rate produces $340 million ($5 million × 68) and will automatically continue to increase as additional reactors become operational. This will eventually phase out the government indemnity when the combination of private insurance and retrospective premium equals $560 million. Thereafter, the total limit will float upward above $560 million. The government indemnity fees have been revised to reflect the reduced amount of indemnity limit. Because this limit is now $80 million, the new fee is $6/MW(t) up to 3000 MW(t) in lieu of the previous $30/MW(t).

In summary, the $560 million limit is divided as of June 1978 as follows:

	$\$10^6$
Private insurance	140
Retrospective premium	340
Government indemnity	80
Total	560

The variation in insurance premiums for reactors of comparable power is negligible if plants are sited in areas of similar population density and property considerations. The typical values appearing in Table 4.14 were prepared for use in this study as of June 1978.

In commercial coverage, experience has shown that after ten years a large portion of the premium is refunded. Potential premium refunds (or credits) are not credited to the O&M costs in this report.

Table 4.14. Estimated annual premiums for nuclear insurance for land-based LWRs[a]

	Number of units			
	1	2	3	4
Commercial coverage ($140 million)				
First $1 million	$ 32,000	$ 56,000	$ 80,000	$104,000
Next $4 million	64,000	102,000	140,000	178,000
Next $5 million	32,000	45,000	58,000	71,000
Next $10 million	32,000	40,000	48,000	56,000
Next $20 million	32,000	40,000	48,000	56,000
Next $60 million	60,000	75,000	90,000	105,000
Next $40 million	32,000	40,000	48,000	56,000
Total	$284,000	$398,200	$512,400	$626,600
Retrospective premium	$ 6,000	$ 12,000	$ 18,000	$ 24,000
Government coverage ($80 million)	$6/MW(t) for up to 3000 MW(t) for each reactor unit			

[a]Premiums are the minimum expected. Specific sites must be stated before firm rates are applicable.

4.4.2 Facility routine inspection fees

Safety, environmental, and health physics inspections are routinely performed at specified frequencies for purposes of reviewing a licensed program to assure the NRC that the authorized activities are being conducted in accordance with the Atomic Energy Act of 1954 as amended, NRC regulations, and the terms and conditions of the license. These inspections involve, as necessary, direct observations of operations, personnel interviews, independent measurements and evaluations, and selective record and procedure examination. They do not include safeguard inspections of special nuclear material. The frequency of inspections depends on the type of licensed activities and facilities, the quantities of material used or processed, and the inherent potential safety hazards. Problems experienced by the plant or previous inspection findings may alter the frequency. Estimates of costs associated with facility inspections are summarized in Table 4.15.

Table 4.15. Estimated annual costs for nuclear facility inspections

	First unit	Each additional unit[a]
NRC fee[b]	$ 76,000	$60,000
Owner's inspection-related costs[c]	25,000	20,000
Total	$101,000	$80,000

[a]At same time as first unit.

[b]*Federal Register* 42(84), 28163 (May 2, 1977).

[c]Allowance for special costs.

4.5 Administrative and General Expenses

This expense category includes the owner's offsite salaries and expenses directly allocable to a specific power production facility. Utility wide overhead type expenses which cannot be charged to a specific plant are not included (FPC expense accounts 920 to 932). In this report the magnitude of the A&G expenses has been related to the fixed O&M costs, minus insurance and operating fees. Values of 10 and 15% of the total fixed costs of staff, maintenance materials, and supplies and expenses have been used to estimate A&G costs for fossil-fueled and nuclear plants respectively.

5. DESCRIPTION OF THE OMCOST COMPUTER PROGRAM

5.1 General Description

The OMCOST computer program offers two basic operation and maintenance (O&M) cost models for steam-electric power plants, one coal fired and the other a light-water reactor (LWR). The coal-fired-plant model may be specified with or without flue gas desulfurization (FGD), and both options use evaporative cooling towers.

The cost models are based on early 1978 costs. Escalation rates are included for wages, materials and supplies, government and commercial liability insurance, operating fees, sludge disposal, and limestone cost.

Variables are assigned default values within the program to permit the calculation of an example LWR case. This affords the new user an opportunity to run the program with an incomplete set of input data.

The user may elect to change any of the default conditions as detailed in Sect. 5.4. The options available include the following: a general escalation rate to replace the separate escalation rates, the number of units per plant (up to four), wage rates, operator fringe benefits, plant supervision expenses, heating value of coal, sulfur content, tons of limestone per ton of sulfur, and unit costs of purchased limestone and sludge disposal.

The OMCOST computer program consists of a main program and four subroutines written in IBM FORTRAN IV and two assembly language subroutines. The program is written for the IBM 360/370 series of digital computers. Execution of the program requires about 58K of core. Execution time for three cases is generally less than 1 sec on the IBM 360/91.

OMCOST uses two nonstandard assembly language subroutines, IDAY and TIME, which are available at the Oak Ridge National Laboratory but not necessarily available at other installations. IDAY returns the date as eight EBCDIC characters consisting of the month, day, and year separated by minus signs. TIME returns the time of day as eight EBCDIC characters consisting of the hours, minutes, and seconds separated by periods. Assembly language decks of each will be distributed with the code.

5.2 MAIN Program

Figure 5.1 shows the general flow of calculations in the OMCOST MAIN program. The computer code follows this procedure closely; however, the illustration is not a detailed computer program flow chart. Appendix B contains a detailed computer-produced program flow chart and a FORTRAN listing of the OMCOST code. Nomenclature for MAIN and all subroutines is included in the FORTRAN listing of MAIN.

A series of variables is initialized through DATA statements. With two exceptions, all variables contained in NAMELIST NAME1 that have not been initialized through DATA statements are initialized with ARITHMETIC statements. The exceptions are MWT, thermal input to a single unit, and ISOX, a flag variable indicating the absence (=0) or presence (=1) of an FGD system. ARITHMETIC statements up to this point are addressed only once regardless of the number of cases submitted. Beyond this point in the program, calculations are repeated once for each case submitted. MWT and ISOX are set through ARITHMETIC statements. Because all NAME1 variables have been initialized, a default case may be run with no input data other than a card containing the words &NAME1 and &END with one blank before &NAME1 and at least one blank between &NAME1 and &END.

The default values of NAMELIST NAME1 variables are printed out before any other output, even if the user failed to include any data input cards.

NAMELIST NAME1 is now read. The complete list of variables that may be input through NAMELIST NAME1 is included in Sect. 5.4. There are two coal heating values stored in MAIN. The first value is selected as the default heating value for coal-fired plants without FGD systems. The second value is selected as the default heating value if FGD is specified. If a heating value of coal unequal to the appropriate stored value is input, the input value is used for that case. In addition, the input value is stored for any further use in the appropriate storage locations (first location, no FGD; second location, FGD). Two values of percentage of ash in coal are stored in MAIN in a similar manner. Either or both may be overridden.

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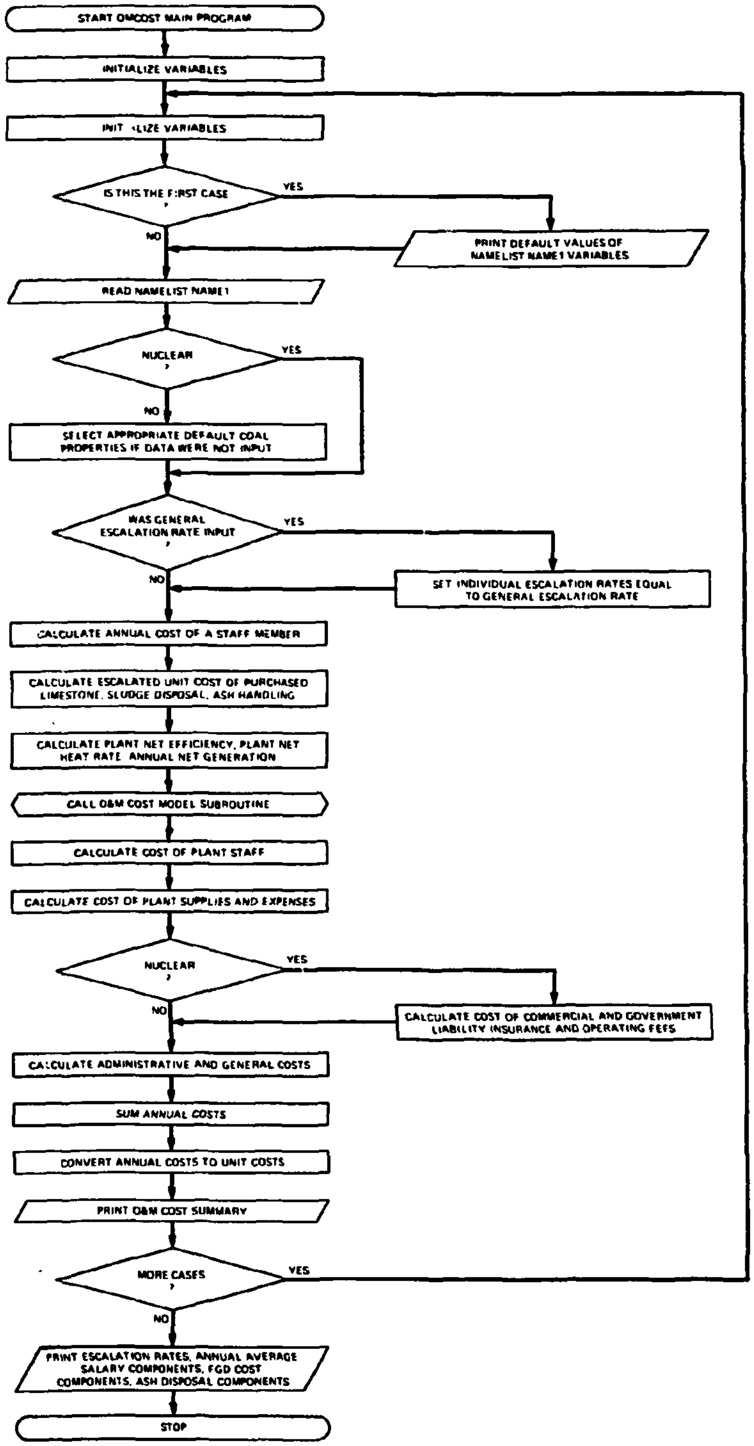


Fig. 5.1. OMCOST MAIN program.

The general escalation rate, ESCGEN, is compared with -99.0 to determine whether a value for the general escalation rate has been input. Seven individual escalation rates, as listed in Sect. 5.1, are set equal to the general escalation rate if a value other than -99.0 is input.

A plant type is classified as either nuclear or coal fired for later use in calling the appropriate cost-model subroutine.

A test is made to ensure that the number of units per plant, UNITS, is in the range of one through four. If it is out of range, a message is printed and the next set of data cards is read.

There are two values of SUPER (plant supervision and engineering as a percentage of base cost of a staff member) stored in MAIN. A value of 15% is assumed for all LWR cases and one of 10% for coal-fired cases. If the SUPER value is overridden for any case, the new input value will be used for all subsequent cases, nuclear or coal fired, until another new value is input.

The average annual cost of a plant staff member, MANCOS, is then calculated using a basic hourly rate with adjustments for fringe benefits and for supervisory and technical support expenses. Staff costs are escalated from a base year, BASEYR, to the year of operation, YEAR, using escalation rate ESWAGE.

The base-year unit costs of sludge disposal (SLURY), purchased limestone (COSLM) for FGD, and ash handling ($ASH) are escalated to the year of operation and stored for later use, using escalation rates ESSLUR for sludge and ash disposal cost and ESLIME for cost of purchased limestone.

If the thermal input to the plant, MWT, and the net plant electrical output, MWN, have both been input through NAMELIST NAME1, OMCOST calculates the plant net efficiency, ETANET, as MWN/MWT. If the net electrical output per unit has been input through NAMELIST NAME1 but no thermal input has been included, the code calculates plant net efficiency for the specified plant type with a correction for FGD systems for coal-fired plants. The plant net efficiencies stored in the code are 32.34% for LWR, 35.97% for coal with FGD, and 34.77% for coal without FGD.

Thermal input to the plant and net heat rate are calculated using these efficiencies.

If net unit electrical capacity is outside the range of 400 to 1300 MW(e), the message "NET UNIT ELECTRICAL OUTPUT OUT OF RANGE..." is printed, and a new data card is read. Each plant is then assigned to an appropriate size category for staff calculations, and the annual net generation, ANNGEN, in millions of kilowatt-hours, is calculated.

The index of plant type, ITYPE, is compared to the values 1 and 2. A light-water-reactor plant is indicated by 1; 2 indicates a coal-fired plant. If ITYPE is equal to 2, the FGD index, ISOX, is compared with 0 and 1. If ISOX is equal to 0, subroutine $COALS is called. $COALS is the cost-model subroutine for coal-fired plants with FGD. If the input plant type does not match one of the list of available plant types, the message "NO COMPARISON OF PLANT TYPE" is printed, and a new data card is read. The cost-model subroutines are described in Sect. 5.3.

After return from the cost-model subroutine, the annual cost of plant staff, COSTAF, is calculated using the average annual cost of a plant staff member, MANCOS, and the total number on the plant staff, STAFF, which was returned from the cost-model subroutine. Next, the code calculates variable cost of supplies and expenses exclusive of limestone, sludge disposal, and ash disposal costs. For coal-fired plants, coal consumption, TONCOL, is calculated using plant annual net electrical generation, plant net heat rate, and the heating value of coal, BTU.

For coal-fired plants with FGD, the costs of purchased limestone and sludge disposal must be included in variable supplies and expenses. The tons of original sulfur in the coal, TONSUL, are calculated using the coal consumption and the sulfur content of the coal, PCTSUL. Limestone requirements, TONLIM, are calculated using the tons of original sulfur in the coal and the limestone to sulfur ratio, XLIMS. Annual limestone cost is the limestone requirement multiplied by the escalated cost per ton of limestone, COSLIM. Annual cost of sludge disposal is the product of original sulfur (TONSUL), the dry sludge to sulfur ratio (SLUSUL), and the escalated unit cost of sludge disposal (SLURY).

For all coal-fired plants, with or without FGD, ash disposal cost must be included. Ash disposal cost, SUPAD2, is the product of coal consumption, fraction of ash, and the escalated cost of ash disposal, $$ASH. Total variable cost of supplies and expenses is determined by adding the ash disposal cost to the basic variable cost of supplies and expenses and by adding sludge disposal and limestone costs, if applicable.

The fixed per unit cost of supplies and expenses is returned from the appropriate cost-model subroutine as SUPEXF. Cost per unit is multiplied by the number of units per plant, escalated at the wage escalation rate, ESWAGE, and added to the variable supplies and expenses, VARSE, to obtain total annual cost of supplies and expenses, SUPEXP.

Commercial and government nuclear liability insurance costs and facility routine inspection fees are determined for LWR plants. Inspection fees and expenses, OPFEES, and retrospective premium, RETRO, vary directly with the number of operating units licensed. Commercial nuclear liability insurance, COMINS, varies linearly with the number of units. Government nuclear liability insurance, GOVINS, varies with the number of units and the thermal rating of each unit up to a maximum of 3000 MW(t). The rates used to escalate to the specified year of operation are ESFEES for inspection fees, ESCINS for commercial insurance and retrospective premium, and ESGINS for government insurance.

Administrative and general costs, ADMGEN, are assumed to be a fixed percentage of the subtotal of staff costs, fixed maintenance costs, and fixed supplies and expenses.

Annual fixed and variable costs are summed to determine total annual costs, and total annual costs are divided by the annual net electrical generation to determine unit O&M costs in mills per kilowatt-hour.

Finally, a summary of O&M costs is printed out, and a check is made to see if more cases are to be run. OMCOST will continue to run cases and print out O&M cost summaries until there are no further NAMELIST NAME1 data cards. At the end of the data set, transfer is made to a series of WRITE statements that print out escalation rates, annual average salary components, FGD cost components, and ash disposal cost components as they were left after the last case.

5.3 O&M Cost-Model Subroutines

A flow chart typical of all O&M cost-model subroutines is shown in Fig. 5.2. The cost-model subroutines for LWRs ($LWR), coal-fired plants without FGD ($COAL), and coal-fired plants with FGD ($COALS) differ only in alphanumeric data and array sizes. The logic for all subroutines is identical.

Each cost-model subroutine passes its arguments to and from MAIN through a COMMON statement. DATA initialization statements contain information on staff complement in accordance with Tables 4.1 through 4.3, factors defining maintenance materials costs in accordance with Table 4.5, and factors defining supplies and expenses costs in accordance with Table 4.8.

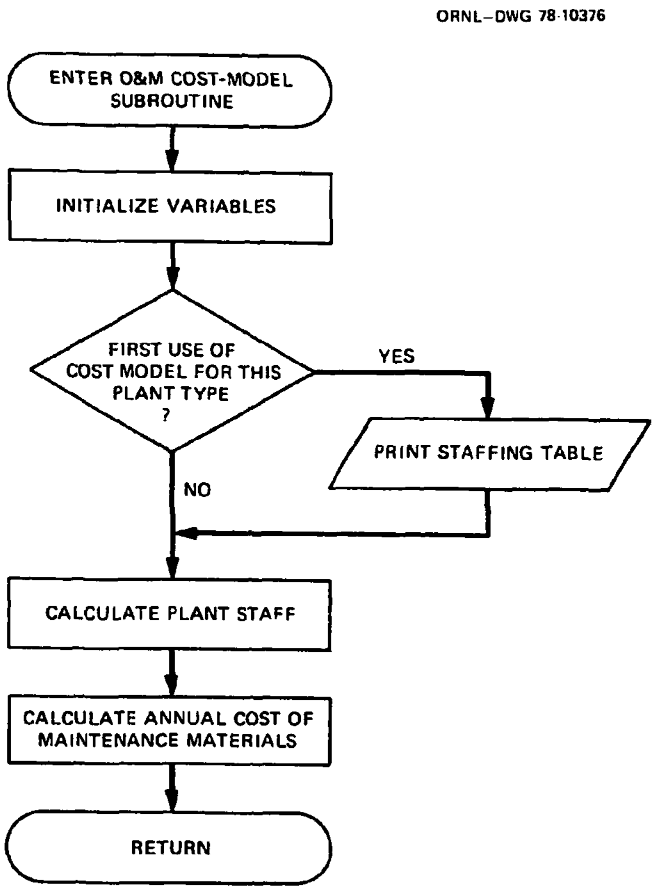


Fig. 5.2. Subroutines $LWR, $COAL, and $COALS.

Staff requirements for each of two size ranges and one through four units per plant are totaled to produce a table for the first call to any cost-model subroutine. Fixed costs of supplies and expenses for a single unit are set through an ARITHMETIC assignment statement. Similarly, unit variable supplies and expenses are set. The appropriate staff total persons is selected from the table. Maintenance material cost is determined as a function of a material component of direct maintenance constant, maintenance staff subtotal, material and wage escalation rates, and cost of a staff member. Maintenance material costs are broken into fixed and variable components, and the variable component is adjusted for plant factor. Control is then returned to the MAIN program.

5.4 Data Input Description

All input data are read through a NAMELIST statement, NAME1, which must be read for each case. With two exceptions, a data variable changed through a NAMELIST read will retain its new value for all the following cases in a given run unless it is changed again by another NAMELIST read. These two variables are MWT (unit thermal input) and ISOX (flag for FGD).

The makeup of data cards is as follows:

Columns	Description
2–7	&NAME1 identifies the following as a NAMELIST called NAME1 that contains optional data.
9–80	The remainder of the card starting in column 9 is used to enter data items separated by commas. The end of the data set is signaled by &END. The form of the data is variable name = constant or variable name = 'alphabetic characters.'

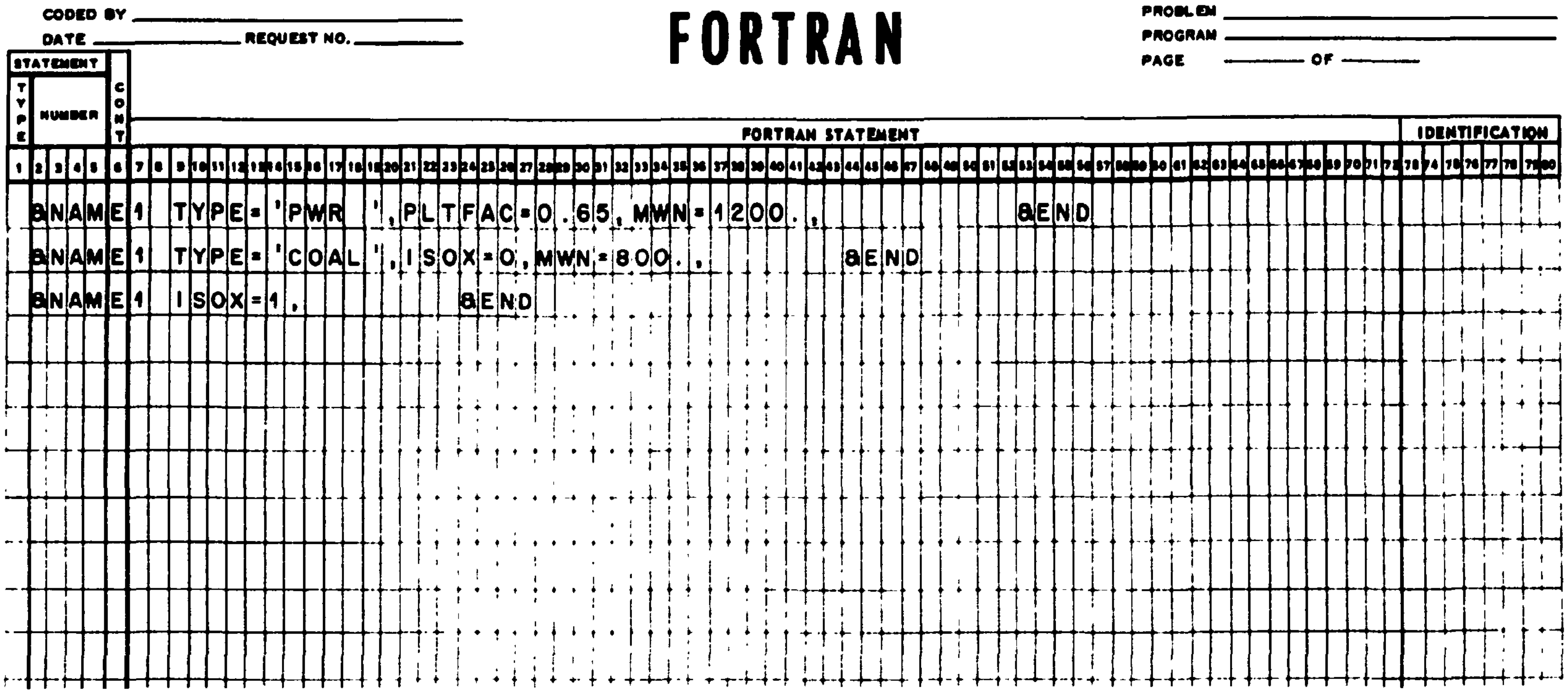
If required, columns 2 through 80 of additional cards can be used. In this case, data items would be separated by commas, and the total data set would be followed by &END. A list and a description of the variables and the default values for NAME1 are given in Table 5.1. Examples of the use of the NAMELIST feature are illustrated in Sect. 5.5.

Table 5.1 NAME1 input data variables and default values

Variable name	Definition	Default value
YEAR	Year of operation	1978.0
TYPE	Plant type (LWR, COAL, COALS)	PWR
PLTFAC	Plant capacity factor	0.80
MWT	Thermal input to plant (single unit), MW	3092.
MWN	Net plant electrical output (single unit), MW	1000.
ISOX	= 0, FGD not specified, = 1, FGD specified	0
UNITS	Number of units per station	1
WAGERT	Wage rate before adders (base year), $/year	7.25
FRINGE	Operator fringe benefits as percentage of wage rate	35.
SUPER	Plant supervision as percentage of wages plus fringe benefits	15.
BTUCOL	Heating value of coal, Btu/lb	8164.
XLIMS	Tons of limestone per ton of sulfur	4.00
$ASH	Ash handling cost (base year), $/ton	4.00
ASHPCT	Ash in coal, %	7.30
PCTSUL	Sulfur in coal, %	3.50
SLURY	Cost of sludge disposal (base year), $/ton	12.00
COSLM	Cost of limestone (base year), $/ton	10.00
ESWAGE	Escalation rate of wages, %/year	7.0
ESSLUR	Escalation rate of cost of sludge disposal, %/year	6.0
ESLIME	Escalation rate of cost of limestone, %/year	6.0
ESCINS	Escalation rate of cost of commercial liability insurance, %/year	5.0
ESGINS	Escalation rate of cost of government liability insurance, %/year	5.0
ESFEES	Escalation rate of cost of operating fees, %/year	3.0
ESMATL	Escalation rate of cost of materials and supplies and expenses, %/year	6.0
ESCGEN	General escalation rate	-99.0

5.5 Example Problems

To illustrate the use of OMCOST, three sample problems together with computer output listings are included in this section. The preparation of input data is illustrated in Fig. 5.3, and the output listings follow. All problems use the default input data defined in Table 5.1, ORNL-DWG 78-20011



FORTRAN

```
&NAME1  TYPE='PWR  ',PLTFAC=0.65,MWN=1200.,         &END
&NAME1  TYPE='COAL  ',ISOX=0,MWN=800.,        &END
&NAME1  ISOX=1,        &END
```

Fig. 5.3. Input data for sample problems.

except where new data are read in via the NAMELIST NAME1. Because these three example problems were run consecutively, input data for each problem carry over to succeeding problems, unless changes in a succeeding NAMELIST. Two exceptions, ISOX and MWT, do not carry over.

In problem 1, a 1200-MW(e) PWR operating with a plant capacity factor of 0.65 was specified. Problem 2 calls for an 800-MW(e) coal-fired plant without FGD. Problem 3 calls for a rerun of problem 2 with FGD. Note that the plant capacity factor specified in example problem 1 was carried over to problems 2 and 3. The plant type and rating were also carried over from problem 2 to problem 3.

DEFAULT VALUES OF NAMELIST NAME1 VARIABLES

YEAR	1978.0
TYPE	PWR
PLTFAC	0.80
MWT	3092.
MWN	1000.
ISOX	0
UNITS	1
WAGERT	7.25
FRINGE	35.
SUPER	15.
BTUCOL	8164.
XLIMS	4.00
$ASH	4.00
ASHPCT	7.30
PCTSUL	3.50
SLURY	12.00
COSLM	10.00
ESWAGE	7.0
ESSLUR	6.0
ESLIME	6.0
ESCINS	5.0
ESGINS	5.0
ESFEES	3.0
ESMATL	6.0
ESCGEN	-99.0

ESCALATION RATES, PERCENT/YEAR

WAGES	7.0
SLUDGE DISPOSAL COST	6.0
LIMESTONE COST	6.0
COML. LIAB. INS. COST	5.0
GOVT. LIAB. INS. COST	5.0
INSPECTION FEES & EXP.	3.0
MATERIAL	6.0
GENERAL ESCALATION	-99.0

ANNUAL AVERAGE SALARY COMPONENTS

WAGE RATE BEFORE ADDERS (BASE YEAR), $/HR	7.25
OPERATOR FRINGE BENEFITS, PCT.	35.
PLANT SUPERVISION & TECHNICAL, PCT.	10.

FGD COST COMPONENTS AT BASE YEAR 1978.0

COST OF LIMESTONE, $/TON	10.00
COST OF SLUDGE DISPOSAL, $/DRY TON	12.00

ASH DISPOSAL COST COMPONENTS AT BASE YEAR

COST OF ASH DISPOSAL, $/TON	4.00
PERCENT ASH IN LOW SULFUR COAL	7.30
PERCENT ASH IN HIGH SULFUR COAL	11.60

PROBLEM 1

STAFF REQUIREMENT FOR LWR POWER PLANTS

	UNIT SIZE RANGE MW(E) 400-700				701-1300			
	NO. UNITS PER SITE				NO. UNITS PER SITE			
	1	2	3	4	1	2	3	4
PLANT MANAGER'S OFFICE								
MANAGER	1	1	1	1	1	1	1	1
ASSISTANT	1	2	3	4	1	2	3	4
QUALITY ASSURANCE	3	4	5	6	3	4	5	6
ENVIRONMENTAL CONTROL	1	1	1	1	1	1	1	1
PUBLIC RELATIONS	1	1	1	1	1	1	1	1
TRAINING	1	1	2	2	1	1	2	2
SAFETY	1	1	1	1	1	1	1	1
ADMIN. & SERVICES	13	15	17	19	13	15	17	19
HEALTH SERVICES	1	1	1	2	1	1	1	2
SECURITY	56	56	56	105	56	56	56	112
SUBTOTAL	79	83	88	142	79	83	88	149
OPERATIONS								
SUPERVISION (EXC. SHIFT)	2	2	4	4	2	2	4	4
SHIFTS	28	48	68	88	33	58	83	108
SUBTOTAL	30	50	72	92	35	60	87	112
MAINTENANCE								
SUPERVISION	8	8	10	12	8	8	10	12
CRAFTS	14	22	30	38	16	26	36	46
PEAK MAINT. ANNUALIZED	55	110	165	220	55	110	165	220
SUBTOTAL	77	140	205	270	79	144	211	278
TECHNICAL AND ENGINEERING								
REACTOR	1	2	3	4	1	2	3	4
RADIO-CHEMICAL	2	2	3	4	2	2	3	4
I & C	2	2	3	4	2	2	3	4
PERFORM., REPORTS, TECH.	17	21	25	29	17	21	25	29
SUBTOTAL	22	27	34	41	22	27	34	41
TOTAL	208	300	399	545	215	314	420	580
LESS SECURITY	152	244	343	440	159	258	364	468
LESS SEC., PEAK MAINT	97	134	178	220	104	148	199	248

PROBLEM 1 (continued)

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1978.0

PLANT TYPE IS PWR
WITH EVAPORATIVE COOLING TOWERS
NUMBER OF UNITS PER STATION 1
THERMAL INPUT PER UNIT IS 3711. MWT
PLANT NET HEAT RATE 10551.
PLANT NET EFFICIENCY, PERCENT 32.34
EACH UNIT IS 1200. MWE NET RATING
ANNUAL NET GENERATION, MILLION KWH 6837.
WITH A PLANT FACTOR OF 0.65

STAFF, $1000/YR	5034. (215 PERSONS AT $23412.)		
MAINTENANCE MATERIAL, $1000/YR	1850.		
FIXED		1850.	
VARIABLE		0.	
SUPPLIES AND EXPENSES, $1000/YR	4610.		
FIXED - PLANT		4200.	
VAR. - PLANT		410.	
INSURANCE AND FEES, $1000/YR	408.		
COMM. LIAB. INS.		284.	
GOV. LIAB. INS.		18.	
RETROSPECTIVE PREMIUM		6.	
INSPECTION FEES & EXPENSES		100.	
ADMIN. AND GENERAL, $1000/YR	1662.		
TOTAL FIXED COSTS, $1000/YR			13153.
TOTAL VARIABLE COSTS, $1000/YR			410.
TOTAL ANNUAL O & M COSTS, $1000/YR			13564.
FIXED UNIT O & M COSTS, MILLS/KWH(E)			1.92
VARIABLE UNIT O & M COSTS, MILLS/KWH(E)			0.06
TOTAL UNIT O & M COSTS, MILLS/KWH(E)			1.98

PROBLEM 2

STAFF REQUIREMENT FOR COAL-FIRED POWER PLANTS
WITHOUT FGD SYSTEMS

	UNIT SIZE RANGE MW(E) 400-700 NO. UNITS PER SITE 1	2	3	4	701-1300 NO. UNITS PER SITE 1	2	3	4
PLANT MANAGER'S OFFICE								
MANAGER	1	1	1	1	1	1	1	1
ASSISTANT	1	2	3	4	1	2	3	4
ENVIRONMENTAL CONTROL	1	1	1	1	1	1	1	1
PUBLIC RELATIONS	1	1	1	1	1	1	1	1
TRAINING	1	1	1	1	1	1	1	1
SAFETY	1	1	1	1	1	1	1	1
ADMIN. & SERVICES	12	13	14	15	12	13	14	15
HEALTH SERVICES	1	1	1	2	1	1	1	2
SECURITY	7	7	9	14	7	7	9	14
SUBTOTAL	26	28	32	40	26	28	32	40
OPERATIONS								
SUPERVISION (EXC. SHIFT)	2	2	4	4	2	2	4	4
SHIFTS	45	50	60	65	45	50	60	65
FUEL HANDLING	12	12	12	18	12	12	12	18
SUBTOTAL	59	64	76	87	59	64	76	87
MAINTENANCE								
SUPERVISION	6	6	8	10	6	6	8	10
CRAFTS	75	90	100	110	80	95	105	115
PEAK MAINT. ANNUALIZED	32	64	96	128	32	64	96	128
SUBTOTAL	113	160	204	248	118	165	209	253
TECHNICAL AND ENGINEERING								
RADIO-CHEMICAL	2	2	3	4	2	2	3	4
I & C	2	2	3	4	2	2	3	4
PERFORM., REPORTS, TECH.	12	15	18	21	15	18	21	24
SUBTOTAL	16	19	24	29	19	22	27	32
TOTAL	214	271	336	404	222	279	344	412

PROBLEM 2 (continued)

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1978.0

PLANT TYPE IS COAL
WITH EVAPORATIVE COOLING TOWERS
NUMBER OF UNITS PER STATION 1
WITHOUT FGD SYSTEMS
THERMAL INPUT PER UNIT IS 2301. MWT
PLANT NET HEAT RATE 9813.
PLANT NET EFFICIENCY, PERCENT 34.77
EACH UNIT IS 800. MWE NET RATING
ANNUAL NET GENERATION, MILLION KWH 4558.
WITH A PLANT FACTOR OF 0.65

STAFF, $1000/YR	4971. (222 PERSONS AT $22394.)		
MAINTENANCE MATERIAL, $1000/YR	1679.		
FIXED		1321.	
VARIABLE		358.	
SUPPLIES AND EXPENSES, $1000/YR	2282.		
FIXED - PLANT		1300.	
VAR. - PLANT		182.	
- ASH DISPOSAL		800.	
ADMIN. AND GENERAL, $1000/YR	759.		
TOTAL FIXED COSTS, $1000/YR			8352.
TOTAL VARIABLE COSTS, $1000/YR			1340.
TOTAL ANNUAL O & M COSTS, $1000/YR			9692.
FIXED UNIT O & M COSTS, MILLS/KWH(E)			1.83
VARIABLE UNIT O & M COSTS, MILLS/KWH(E)			0.29
TOTAL UNIT O & M COSTS, MILLS/KWH(E)			2.13

HEATING VALUE OF COAL, BTU/LB	8164.
COAL BURNED, TONS/YEAR	2739640.
PERCENT ASH	7.30
COST OF ASH DISPOSAL, $/TON	4.00

PROBLEM 3

STAFF REQUIREMENT FOR COAL-FIRED POWER PLANTS WITH FGD SYSTEMS

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

PROBLEM 3 (continued)

```
SUMMARY OF ANNUAL NCNFUEL OPERATION AND MAINTENANCE COSTS
   FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1978.0

      PLANT TYPE IS COAL
      WITH EVAPORATIVE COOLING TOWERS
      NUMBER OF UNITS PER STATION 1
      WITH FGD SYSTEMS
      THERMAL INPUT PER UNIT IS 2224. MWT
      PLANT NET HEAT RATE   9486.
      PLANT NET EFFICIENCY, PERCENT   35.97
      EACH UNIT IS  800. MWE NET RATING
      ANNUAL NET GENERATION, MILLION KWH  4558.
      WITH A PLANT FACTOR OF 0.65

      STAFF, $1000/YR                       5800. (259 PERSONS AT $22394.)

      MAINTENANCE MATERIAL, $1000/YR        2410.
                FIXED                            1896.
                VARIABLE                          514.

      SUPPLIES AND EXPENSES, $1000/YR       8577.
                FIXED - PLANT                    1400.
                VAR.  - PLANT                     228.
                      - ASH & FGD SLUDGE         6949.

      ADMIN. AND GENERAL, $1000/YR           910.

      TOTAL FIXED COSTS, $1000/YR                       10006.
      TOTAL VARIABLE COSTS, $1000/YR                     7691.
      TOTAL ANNUAL O & M COSTS, $1000/YR                17697.

      FIXED UNIT O & M COSTS, MILLS/KWH(E)               2.20
      VARIABLE UNIT O & M COSTS, MILLS/KWH(E)            1.69
      TOTAL UNIT O & M COSTS, MILLS/KWH(E)               3.88
```

HEATING VALUE OF COAL, BTU/LB	11026.
COAL BURNED, TONS/YEAR	1960869.
PERCENT ASH	11.60
COST OF ASH DISPOSAL, $/TON	4.00
PERCENT SULFUR	3.50
SULFUR (ORIGINAL),TONS/YR	68630.
TONS LIMESTONE PER TON SULFUR	4.00
TONS/YEAR LIMESTONE	274522.
COST OF LIMESTONE, $/TON	10.00
COST OF SLUDGE DISPOSAL, $/DRY TON	12.00

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APPENDICES

Appendix A

EXCERPT FROM FEDERAL POWER COMMISSION UNIFORM SYSTEM OF ACCOUNTS

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OPERATION AND MAINTENANCE EXPENSE ACCOUNTS

1. POWER PRODUCTION EXPENSES

A. STEAM POWER GENERATION

Operation

500 Operation supervision and engineering.

This account shall include the cost of labor and expenses incurred in the general supervision and direction of the operation of steam power generating stations. Direct supervision of specific activities, such as fuel handling, boiler-room operations, generator operations, etc., shall be charged to the appropriate account. (See operating expense instruction 1.)

501 Fuel.

A. This account shall include the cost of fuel used in the production of steam for the generation of electricity, including expenses in unloading fuel from the shipping media and handling thereof up to the point where the fuel enters the first boiler plant bunker, hopper, bucket, tank or holder of the boiler-house structure. Records shall be maintained to show the quantity, B.t.u. content and cost of each type of fuel used.

B. The cost of fuel shall be charged initially to account 151, Fuel Stock, and cleared to this account on the basis of the fuel used. Fuel handling expenses may be charged to this account as incurred or charged initially to account 152, Fuel Stock Expenses Undistributed. In the latter event, they shall be cleared to this account on the basis of the fuel used. Respective amounts of fuel stock and fuel stock expenses shall be readily available.

ITEMS

Labor:

1. Supervising purchasing and handling of fuel.
2. All routine fuel analyses.
3. Unloading from shipping facility and putting in storage.
4. Moving of fuel in storage and transferring fuel from one station to another.
5. Handling from storage or shipping facility to first bunker, hopper, bucket, tank or holder of boiler-house structure.
6. Operation of mechanical equipment, such as locomotives, trucks, cars, boats, barges, cranes, etc.

Materials and Expenses:

7. Operating, maintenance and depreciation expenses and ad valorem taxes on utility-owned transportation equipment used to transport fuel from the point of acquisition to the unloading point.
8. Lease or rental costs of transportation equipment used to transport fuel from the point of acquisition to the unloading point.
9. Cost of fuel including freight, switching, demurrage and other transportation charges.
10. Excise taxes, insurance, purchasing commissions and similar items.
11. Stores expenses to extent applicable to fuel.
12. Transportation and other expenses in moving fuel in storage.
13. Tools, lubricants and other supplies.
14. Operating supplies for mechanical equipment.
15. Residual disposal expenses less any proceeds from sale of residuals.

NOTE: Abnormal fuel handling expenses occasioned by emergency conditions shall be charged to expense as incurred.

502 Steam expenses.

This account shall include the cost of labor, materials used and expenses incurred in production of steam for electric generation. This includes all expenses of handling and preparing fuel beginning at the point where the fuel enters the first boiler plant bunker, hopper, tank or holder of the boiler-house structure.

ITEMS

Labor:

1. Supervising steam production.
2. Operating fuel conveying, storage, weighing and processing equipment within boiler plant.
3. Operating boiler and boiler auxiliary equipment.
4. Operating boiler feed water purification and treatment equipment.
5. Operating ash-collecting and disposal equipment located inside the plant.
6. Operating boiler plant electrical equipment.
7. Keeping boiler plant log and records and preparing reports on boiler plant operation.
8. Testing boiler water.
9. Testing, checking, and adjusting meters gauges, and other instruments and equipment in boiler plant.
10. Cleaning boiler plant equipment when not incidental to maintenance work.
11. Repacking glands and replacing gauge glasses where the work involved is of a minor nature and is performed by regular operating crews. Where the work is of a major character, such as that performed on high-pressure boilers, the item should be considered as maintenance.

Materials and Expenses:

12. Chemicals and boiler inspection fees.

13. Lubricants.
14. Boiler feed water purchased and pumping supplies.

503 Steam from other sources.

This account shall include the cost of steam purchased, or transferred from another department of the utility or from others under a joint facility operating arrangement, for use in prime movers devoted to the production of electricity.

NOTE: The records shall be so kept as to show separately for each company from which steam is purchased, the point of delivery, the quantity, the price, and the total charge. When steam is transferred from another department or from others under a joint operating arrangement, the utility shall be prepared to show full details of the cost of producing such steam, the basis of the charge to electric generation and the extent and manner of use by each department or party involved.

504 Steam transferred—Credit.

A. This account shall include credits for expenses of producing steam which are charged to others or to other utility departments under a joint operating arrangement. Include also credits for steam expenses chargeable to other electric accounts outside of the steam generation group. Full details of the basis of determination of the cost of steam transferred shall be maintained.

B. If the charges to others or to other departments of the utility include an amount for depreciation, taxes and return on the joint steam facilities, such portion of the charge shall be credited, in the case of others, to account 454, Rent from Electric Property, and in the case of other departments of the utility, to account 455, Interdepartmental Rents.

505 Electric expenses.

This account shall include the cost of labor, materials used and expenses incurred in operating prime movers, generators, and their auxiliary apparatus, switch gear and other electric equipment to the points where electricity leaves for conversion for transmission or distribution.

ITEMS

Labor:
1. Supervising electric production.
2. Operating turbines, engines, generators and exciters.
3. Operating condensers, circulating water systems and other auxiliary apparatus.
4. Operating generator cooling system.
5. Operating lubrication and oil control system, including oil purification.
6. Operating switchboards, switch gear and electric control and protective equipment.
7. Keeping electric plant log and records and preparing reports on electric plant operations.
8. Testing, checking and adjusting meters, gauges, and other instruments, relays, controls and other equipment in the electric plant.
9. Cleaning electric plant equipment when not incidental to maintenance work.
10. Repacking glands and replacing gauge glasses.

Materials and Expenses:
11. Lubricants and control system oils.
12. Generator cooling gases.
13. Circulating water purification supplies
14. Cooling water purchased.
15. Motor and generator brushes.

506 Miscellaneous steam power expenses.

This account shall include the cost of labor, materials used and expenses incurred which are not specifically provided for or are not readily assignable to other steam generation operation expense accounts.

ITEMS

Labor:
1. General clerical and stenographic work.
2. Guarding and patrolling plant and yard.
3. Building service.
4. Care of grounds including snow removal, cutting grass, etc.
5. Miscellaneous labor.

Materials and Expenses:
6. General operating supplies, such as tools, gaskets, packing waste, gauge glasses, hose, indicating lamps, record and report forms, etc.
7. First-aid supplies and safety equipment.
8. Employees' service facilities expenses.
9. Building service supplies.
10. Communication service.
11. Miscellaneous office supplies and expenses, printing and stationery.
12. Transportation expenses.
13. Meals, traveling and incidental expenses.
14. Research and development expenses.

507 Rents.

This account shall include all rents of property of others used, occupied or operated in connection with steam power generation. (See operating expense instruction 3.)

Maintenance

510 Maintenance supervision and engineering.

This account shall include the cost of labor and expenses incurred in the general supervision and direction of maintenance of steam generation facilities. Direct field supervision of specific jobs shall be charged to the appropriate maintenance account. (See operating expense instruction 1.)

511 Maintenance of structures.

This account shall include the cost of labor, materials used and expenses incurred in the maintenance of steam structures, the book cost of which is includible in account 311, Structures and Improvements. (See operating expense instruction 2.)

512 Maintenance of boiler plant.

A. This account shall include the cost of labor, materials used and expenses incurred in the maintenance of steam plant, the book cost of which is includible in account 312, Boiler Plant Equipment. (See operating expense instruction 2.)

B. For the purpose of making charges hereto and to account 513, Maintenance of Electric Plant, the point at which steam plant is distinguished from electric plant is defined as follows:

a. Inlet flange of throttle valve on prime mover.

b. Flange of all steam extraction lines on prime mover.

c. Hotwell pump outlet on condensate lines.

d. Inlet flange of all turbine-room auxiliaries.

e. Connection to line side of motor starter for all boiler-plant equipment.

513 Maintenance of electric plant.

This account shall include the cost of labor, materials used and expenses incurred in the maintenance of electric plant, the book cost of which is includible in account 313, Engines and Engine-Driven Generators, account 314, Turbogenerator Units, and account 315, Accessory Electric Equipment. (See operating expense instruction 2 and paragraph B of account 512.)

514 Maintenance of miscellaneous steam plant.

This account shall include the cost of labor, materials used and expenses incurred in maintenance of miscellaneous steam generation plant, the book cost of which is includible in account 316, Miscellaneous Power Plant Equipment. (See operating expense instruction 2.)

B. NUCLEAR POWER GENERATION

Operation

517 Operation supervision and engineering.

This account shall include the cost of labor and expenses incurred in the general supervision and direction of the operation of nuclear power generating stations. Direct supervision of specific activities, such as fuel handling, reactor operations, generator operations, etc., shall be charged to the appropriate account. (See operating expense instruction 1.)

518 Nuclear fuel expense.

A. This account shall be debited and account 120.5, Accumulated Provision for Amortization of Nuclear Fuel Assemblies, credited for the amortization of the net cost of nuclear fuel assemblies used in the production of energy. The net cost of nuclear fuel assemblies subject to amortization shall be the cost of nuclear fuel assemblies plus or less the expected net salvage of uranium, plutonium, and other byproducts and unburned fuel. The utility shall adopt the necessary procedures to assure that charges to this account are distributed according to the thermal energy produced in such periods.

B. This account shall also include the costs involved when fuel is leased.

C. This account shall also include the cost of other fuels, used for ancillary steam facilities, including superheat.

D. This account shall be debited or credited as appropriate for significant changes in the amounts estimated as the net salvage value of uranium, plutonium, and other byproducts contained in account 157, Nuclear Materials Held for Sale and the amount realized upon the final disposition of the materials. Significant declines in the estimated realizable value of items carried in account 157 may be recognized at the time of market price declines by charging this account and crediting account 157. When the declining change occurs while the fuel is recorded in account 120.3, Nuclear Fuel Assemblies in Reactor, the effect shall be amortized over the remaining life of the fuel.

519 Coolants and water.

This account shall include the cost of labor, materials used and expenses incurred for heat transfer materials and water used for steam and cooling purposes.

ITEMS

Labor:
1. Operation of water supply facilities.
2. Handling of coolants and heat transfer materials.

Materials and Expenses:
3. Chemicals.
4. Additions to or refining of, fluids used in reactor systems.
5. Lubricants.
6. Pumping supplies and expenses.
7. Miscellaneous supplies and expenses.
8. Purchased water.

NOTE: Do not include in this account water for general station use or the initial charge for coolants, heat transfer or moderator fluids, chemicals or other supplies capitalized.

520 Steam expenses.

This account shall include the cost of labor, materials used and expenses incurred in production of steam through nuclear processes, and similar expenses for operation of any auxiliary superheat facilities.

ITEMS

Labor:
1. Supervising steam production.
2. Fuel handling including removal, insertion, disassembly and preparation for cooling operations and shipment.
3. Testing instruments and gauges.
4. Health, safety, monitoring and decontamination activities.
5. Waste disposal.
6. Operating steam boilers and auxiliary steam, superheat facilities.

Materials and Expenses:
7. Chemical supplies.
8. Charts, logs, etc.
9. Health, safety, monitoring and decontamination supplies.
10. Boiler inspection fees.
11. Lubricants.

521 Steam from other sources.

This account shall include the cost of steam purchased or transferred from another department of the utility or from others under a joint facility operating arrangement for use in prime movers devoted to the production of electricity.

NOTE: The records shall be so kept as to show separately for each company from which steam is purchased, the point of delivery, the quantity, the price, and the total charge. When steam is transferred from another operating department, the utility shall be prepared to show full details of the cost of producing such steam, the basis of the charges to electric generation, and the extent and manner of use by each department involved.

522 Steam transferred—Credit.

A. This account shall include credits for expenses of producing steam which are charged to others or to other utility departments under a joint operating arrangement. Include also credits for steam expenses chargeable to other electric accounts outside of the steam generation group. Full details of the basis of determination of the cost of steam transferred shall be maintained.

B. If the charges to others or to other departments of the utility include an amount for depreciation, taxes and return on the joint steam facilities, such portion of the charge shall be credited, in the case of others, to account 454, Rent from Electric Property, and in the case of other departments of the utility, to account 455, Interdepartmental Rents.

523 Electric expenses.

This account shall include the cost of labor, materials used and expenses incurred in operating turbogenerators, steam turbines and their auxiliary apparatus, switch gear and other electric equipment to the points where electricity leaves for conversion for transmission or distribution.

ITEMS

Labor:
1. Supervising electric production.
2. Operating turbines, engines, generators and exciters.
3. Operating condensers, circulating water systems and other auxiliary apparatus.
4. Operating generator cooling system.
5. Operating lubrication and oil control system, including oil purification.
6. Operating switchboards, switch gear and electric control and protective equipment.
7. Keeping plant log and records and preparing reports on electric plant operations.
8. Testing, checking and adjusting meters, gauges, and other instruments, relays, controls and other equipment in the electric plant.
9. Cleaning electric plant equipment when not incidental to maintenance.
10. Repacking glands and replacing gauge glasses.

Materials and Expenses:
11. Lubricants and control system oils.
12. Generator cooling gases.
13. Log sheets and charts.
14. Motor and generator brushes.

524 Miscellaneous nuclear power expenses.

This account shall include the cost of labor, materials used and expenses incurred which are not specifically provided for or are not readily assignable to other nuclear generation operation accounts.

ITEMS

Labor:

1. General clerical and stenographic work.
2. Plant security.
3. Building service.
4. Care of grounds, including snow removal, cutting grass, etc.
5. Miscellaneous labor.

Materials and Expenses:

6. General operating supplies, such as tools, gaskets, hose, indicating lamps, record and report forms, etc.
7. First-aid supplies and safety equipment.
8. Employees' service facilities expenses.
9. Building service supplies.
10. Communication service.
11. Miscellaneous office supplies and expenses, printing and stationery.
12. Transportation expenses.
13. Meals, traveling and incidental expenses.
14. Research and development expenses.

525 Rents.

This account shall include all rents of property of others used, occupied or operated in connection with nuclear generation. (See operating expense instruction 3.)

Maintenance

528 Maintenance supervision and engineering.

This account shall include the cost of labor and expenses incurred in the general supervision and direction of maintenance of nuclear generation facilities. Direct field supervision of specific jobs shall be charged to the appropriate maintenance account. (See operating expense instruction 1.)

529 Maintenance of structures.

This account shall include the cost of labor, materials used and expenses incurred in the maintenance of structures, the book cost of which is includible in account 321, Structures and Improvements. (See operating expense instruction 2.)

530 Maintenance of reactor plant equipment.

This account shall include the cost of labor, materials used and expenses incurred in the maintenance of reactor plant, the book cost of which is includible in account 322, Reactor Plant Equipment. (See operating expense instruction 2.)

531 Maintenance of electric plant.

This account shall include the cost of labor, materials used and expenses incurred in the maintenance of electric plant, the book cost of which is includible in account 323, Turbogenerator Units, and account 324, Accessory Electric Equipment. (See operating expense instruction 2.)

532 Maintenance of miscellaneous nuclear plant.

This account shall include the cost of labor, materials used and expenses incurred in maintenance of miscellaneous nuclear generating plant, the book cost of which is includible in account 325, Miscellaneous Power Plant Equipment. (See operating expense instruction 2.)

Appendix B

OMCOST COMPUTER PROGRAM FLOW CHARTS AND FORTRAN LISTING

```
                                    (ENTRANCE)
                                        I
                                        I
*****************************************************************************
*C     PROGRAM OMCOST                                                       *
*C     E1       PLANT NET EFFICIENCY W/O FLUE GAS DESULFURIZATION, PERCENT  *
*C     E2       EFFICIENCY MULTIPLIER FOR FLUE GAS DESULFURIZATION, DECIMAL *
*C     ASH      ASH IN COAL, PERCENT                                        *
*C     BTU      HEATING VALUE OF COAL, BTU/LB                               *
*C     MWN      NET PLANT ELECTRICAL OUTPUT (SINGLE UNIT), MW               *
*C     MWT      THERMAL INPUT TO PLANT (SINGLE UNIT), MW                    *
*C     $ASH     $/TON ASH HANDLING COST(BASE YEAR)                          *
*C     BASM     ANNUAL COST OF MAINTENANCE MATERIAL AT REFERENCE CAPACITY   *
*C              FACTOR, $THOUSAND/YEAR                                      *
*C     ISOX     =1 FLUE GAS DESULFURIZATION SPECIFIED                       *
*C              =0 FLUE GAS DESULFURIZATION NOT SPECIFIED                   *
*C     TYPE     PLANT TYPE (LWR OR COAL)                                    *
*C     XMWT     MAXIMUM THERMAL INPUT FOR GOVT. LIABILITY INSURANCE CALC.   *
*C     YEAR     YEAR OF OPERATION                                           *
*C     $$ASH    $/TON ASH HANDLING COST(YEAR OF OPERATION)                  *
*C     COSLM    COST OF LIMESTONE (BASE YEAR), $/TON                        *
*C     FIXSE    FIXED ANNUAL COST OF SUPPLIES & EXPENSES, $THOUSAND/YEAR    *
*C     ISIZE    INDEX OF UNIT SIZE =1 400-700 MWE, =2 701-1300 MWE          *
*C     ITYPE    INDEX OF PLANT TYPE =1 PWR, BWR, LWR, =2 COAL               *
*C     RETRO    RETROSPECTIVE PREMIUM INSURANCE, $THOUSAND/YEAR             *
*C     SLURY    BASE YEAR COST OF SLUDGE DISPOSAL, $/DRY TON                *
*C     STAFF    STAFF TOTAL, PERSONS                                        *
*C     SUPER    PLANT SUPER. & ENGRG. AS PCT. OF WAGES & FRINGES            *
*C     TOTAL    TOTAL ANNUAL O & M COSTS, $THOUSAND/YEAR                    *
*C     UNITS    NUMBER OF UNITS PER STATION                                 *
*C     VARSE    VARIABLE ANNUAL COST OF SUPPLIES & EXPENSES, $THOUSAND/YEAR *
*C     XLIMS    TONS LIMESTONE/TON SULFUR                                   *
*C     ADMGEN   ADMINISTRATIVE AND GENERAL, $THOUSAND/YEAR                  *
*C     AGFACT   A & G, PERCENT OF STAFF, FIXED MAINTENANCE,                 *
*C              FIXED SUPPLIES AND EXPENSES                                 *
*C     ANNGEN   ANNUAL NET GENERATION, MILLION KWH                          *
*C     ASHPCT   ASH IN COAL, PERCENT                                        *
*C     BASEYR   BASE YEAR FOR COST MODEL                                    *
*C     BASTAF   STAFF TOTAL, PERSONS                                        *
*C     BTUCOL   HEATING VALUE OF COAL, BTU/LB                               *
*C     COMINS   COMMERCIAL LIABILITY INSURANCE, $THOUSAND/YEAR              *
*C     COSLIM   COST OF LIMESTONE, $/TON                                    *
*C     COSTAF   ANNUAL COST OF STAFF (TOTAL), $THOUSAND/YEAR                *
*C     ESCGEN   GENERAL ESCALATION RATE, PERCENT/YEAR                       *
*C     ESCINS   ESCALATION RATE ON COST OF COMMERCIAL LIABILITY INS., PCT/YR*
*C     ESFEES   ESCALATION RATE ON COST OF INSPECTION FEES, PERCENT/YEAR    *
*C     ESGINS   ESCALATION RATE ON COST OF GOVERNMENT LIABILITY INS., PCT/YR*
*C     ESLIME   ESCALATION RATE ON COST OF LIMESTONE, PERCENT/YEAR          *
*C     ESMATL   ESCALATION RATE ON MATERIAL, PERCENT/YEAR                   *
*C     ESSLUR   ESCALATION RATE ON COST OF SLUDGE DISPOSAL, PERCENT/YEAR    *
*C     ESWAGE   ESCALATION RATE ON WAGES, PERCENT/YEAR                      *
*C     ETANET   PLANT NET EFFICIENCY, PERCENT                               *
*C     FACMAT   MATERIAL COMPONENT OF DIRECT MAINTENANCE, DECIMAL           *
*C     FEEINS   INSURANCE AND FEES, $THOUSAND/YEAR                          *
*C     FIXFAC   FIXED PORTION OF PLANT MAINTENANCE MATL. COSTS, DECIMAL     *
*C     FIXMIL   FIXED UNIT O & M COSTS, MILLS/KWH(E)                        *
*C     FIXMNT   ANNUAL COST FIXED MAINTENANCE MATL., $THOUSAND/YEAR         *
*C     FORTYR   HOURS PER YEAR AT 40 HOURS PER WEEK                         *
*C     FRINGE   OPERATOR FRINGE BENEFITS AS PERCENT OF WAGE RATE, PERCENT   *
*C     FULLYR   TOTAL HOURS IN A YEAR                                       *
*C     GOVINS   GOVERNMENT LIABILITY INSURANCE, $THOUSAND/YEAR              *
*C     HTRATE   PLANT NET HEAT RATE, BTU/KWH(E)                             *
*C     MANCOS   ANNUAL COST OF STAFF MEMBER, $/MAN-YEAR                     *
*C     OPFEES   INSPECTION FEES, $THOUSAND/YEAR                             *
*C     PCTSUL   SULFUR IN COAL, PERCENT                                     *
*C     PLTFAC   PLANT FACTOR, DECIMAL                                       *
*C     SLURRY   COST OF SLUDGE DISPOSAL (YEAR OF OPERATION), $/DRY TON      *
*C     SLUSUL   DRY SLUDGE TO SULFUR RATIO FOR FLUE GAS DESULFURIZATION     *
*C     SUPADD   S&E ADDER FOR LIMESTONE; SLUDGE DISPOSAL, $THOUSAND/YEAR    *
*C     SUPAD2   ASH DISPOSAL COST, $1000/YR                                 *
*C     SUPEXF   COST OF CHEMICALS, GASES, LUBRICANTS, OFFICE AND PERSONNEL  *
*C              SUPPLIES, OFF SITE CONTRACT SERVICES                        *
*C     SUPEXP   SUPPLIES & EXPENSES (TOTAL), $THOUSAND/YEAR                 *
*C     TONCOL   COAL BURNED, TONS/YEAR                                      *
*C     TONLIM   LIMESTONE, TONS/YEAR                                        *
*C     TONSUL   SULFUR IN COAL (ORIGINAL), TONS/YEAR                        *
*C     TOTFIX   TOTAL FIXED COSTS, $THOUSAND/YEAR                           *
*C     TOTMIL   TOTAL UNIT O & M COSTS, MILLS/KWH(E)                        *
*C     TOTMNT   ANNUAL COST OF MAINTENANCE MATERIAL, $THOUSAND/YEAR         *
*C     TOTVAR   TOTAL VARIABLE COSTS, $THOUSAND/YEAR                        *
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*C    VARFAC   VARIABLE PORTION OF PLANT MAINTENANCE COSTS, DECIMAL            *
*C    VARMIL   VARIABLE UNIT O & M COSTS, MILLS/KWH(E)                          *
*C    VARMNT   ANNUAL COST VARIABLE MAINTENANCE MATL., $THOUSAND/YEAR           *
*C    VSEBAS   BASE YEAR VARIABLE COST OF SUPPLIES AND EXPENSES(BEFORE          *
*C             SLUDGE DISPOSAL, FLYASH), $THOUSAND/YEAR                         *
*C    VSEMIL   BASE YEAR VARIABLE COST OF SUPPLIES AND EXPENSES(BEFORE          *
*C             SLUDGE DISPOSAL, FLYASH), MILLS/KWH(E)                           *
*C    WAGERT   WAGE RATE (BEFORE ADDERS), $/HOUR                                *
*        REAL*4 MWT, MWN, MANCOS                                                *
*        INTEGER*4 STAFF, UNITS                                                 *
*        DIMENSION X(7)                                                         *
*        DIMENSION BTU(2),ASH(2)                                                *
*        COMMON /COM1/ MWN, ISOX, YEAR, ISIZE, STAFF, UNITS, BASEYR,            *
*       * ESMATL, FIXMNT, ESWAGE, MANCOS, PLTFAC, SUPEXF, VARMNT, TOTMNT,       *
*       * VSEMIL                                                                *
*        NAMELIST /NAME1/ MWN, MWT, ISOX,              TYPE, YEAR,              *
*       * COSLM,        SLURY, SUPER, UNITS, XLIMS,          BTUCOL, ESCINS,*
*       * ESCGEN,                                                               *
*       * $ASH, ASHPCT,                                                         *
*       * ESFEES, ESGINS, ESLIME, ESMATL, ESSLUR, ESWAGE, FRINGE,               *
*       * PCTSUL, PLTFAC,          WAGERT                                       *
*        DATA IW/6/                                                             *
*        DATA TYPE/'PWR '/                                                      *
*        DATA X/'PWR ','PWR','BWR ','BWR','LWR ','LWR','COAL'/                  *
*        DATA WAGERT/7.25/, FRINGE/35./, SUPER/15./                             *
*        DATA BTU/8164.0,11026.0/                                               *
*        DATA BTUCOL/6164.0C/,XLIMS/4.0/,PCTSUL/3.5/                            *
*        DATA ASH/7.3,11.6/                                                     *
*        DATA COSLM/15./, SLURY/12./                                            *
*        DATA SLGSUL/4.0/                                                       *
*        DATA $ASH/4./,ASHPCT/7.3/                                              *
*        MWN=1000.                                                              *
*        UNITS=1                                                                *
*        YEAR = 1978.0                                                          *
*        BASEYR = 1978.0                                                        *
*        ESCGEN = -99.                                                          *
*        ESWAGE = 7.0                                                           *
*        ESSLUR = 6.0                                                           *
*        ESLIME = 6.0                                                           *
*        ESCINS = 5.0                                                           *
*        ESGINS = 5.0                                                           *
*        ESFEES = 3.0                                                           *
*        ESMATL=6.0                                                             *
*        PLTFAC = .60                                                           *
*        FULLYR = 365.25 * 24.                                                  *
*        FORTYR = 52. * 40.                                                     *
*        INAME1 = 1                                                             *
*****************************************************************************
                                         I
                                         O(........................................O
                                         I                                         I
*****************************************************************************      I
*  605 CONTINUE                                                             *      I
*        MWT=3092.                                                          *      I
*        ISOX = 0                                                           *      I
*****************************************************************************      I
                                         I                                         I
                                         I                                         I
                                         I                                         I
*****************************************************************************      I
*        IF(INAME1.NE.1) GO TO 610                                          *......I.......O
*****************************************************************************      I       I
                                         I                                         I       I
                                         I                                         I       I
                                         I                                         I       I
*****************************************************************************      I       I
*        WRITE(IW,821) YEAR, TYPE,       PLTFAC, MWT, MWN, ISOX, UNITS      *      I       I
*  821 FORMAT('1',T20,'DEFAULT VALUES OF NAMELIST NAME1 VARIABLES'//        *      I       I
*     *           ' ',T20,'YEAR   ',T40,F6.1 /                             *      I       I
*     *           ' ',T20,'TYPE   ',T40,A4   /                             *      I       I
*     *           ' ',T20,'PLTFAC',T40,F4.2 /                              *      I       I
*     *           ' ',T20,'MWT    ',T40,F5.0 /                             *      I       I
*     *           ' ',T20,'MWN    ',T40,F5.0 /                             *      I       I
*     *           ' ',T20,'ISOX   ',T40,I1   /                             *      I       I
*     *           ' ',T20,'UNITS  ',T40,I1   )                             *      I       I
*        WRITE(IW,858) WAGERT, FRINGE, SUPER, BTUCOL, XLIMS                 *      I       I
*  858 FORMAT(' ',T20,'WAGERT',T39,F5.2 /                                   *      I       I
*     *           ' ',T20,'FRINGE',T38,F5.0 /                              *      I       I
*     *           ' ',T20,'SUPER ',T38,F5.0 /                              *      I       I
*     *           ' ',T20,'BTUCOL',T38,F8.0 /                              *      I       I
```

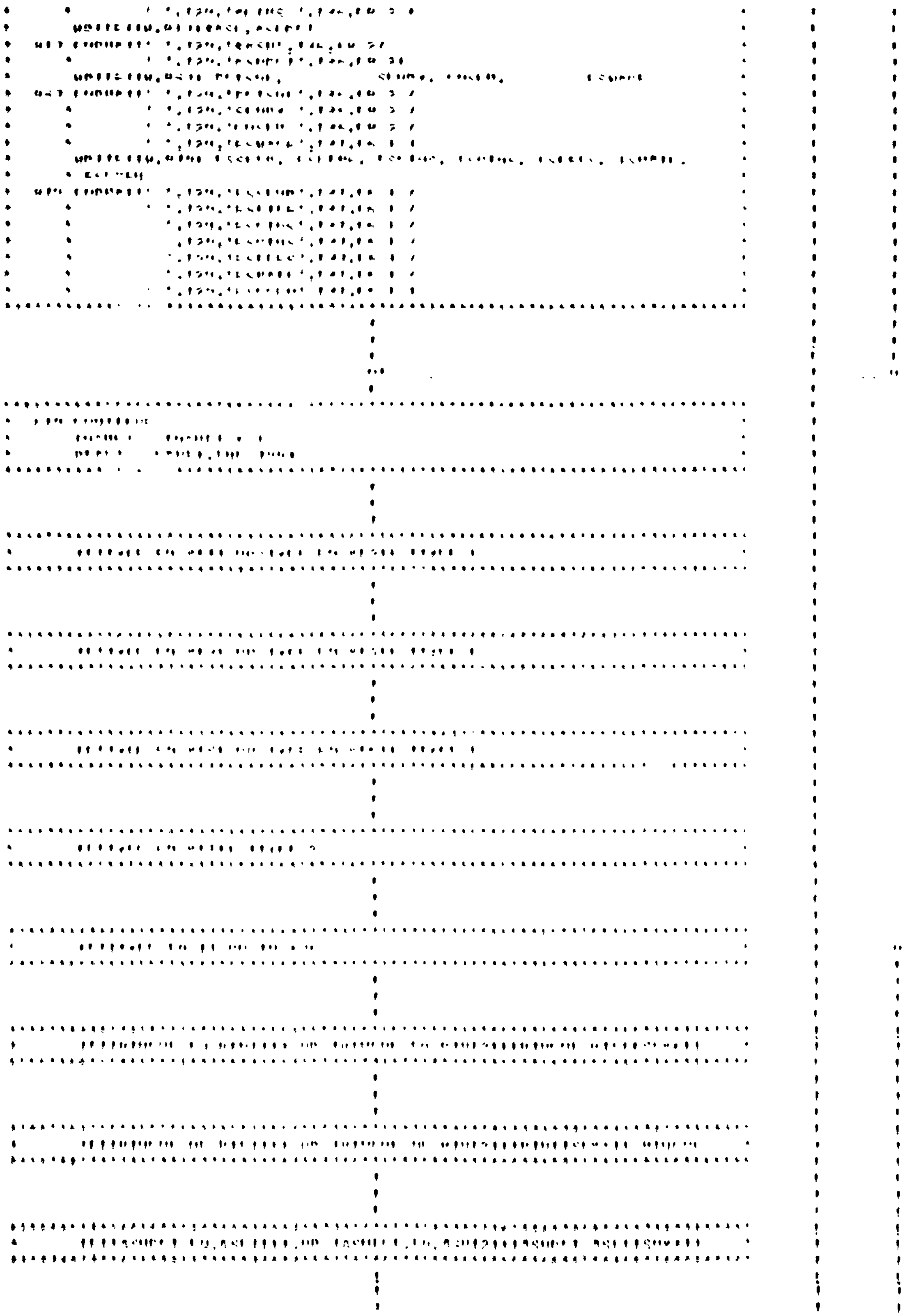

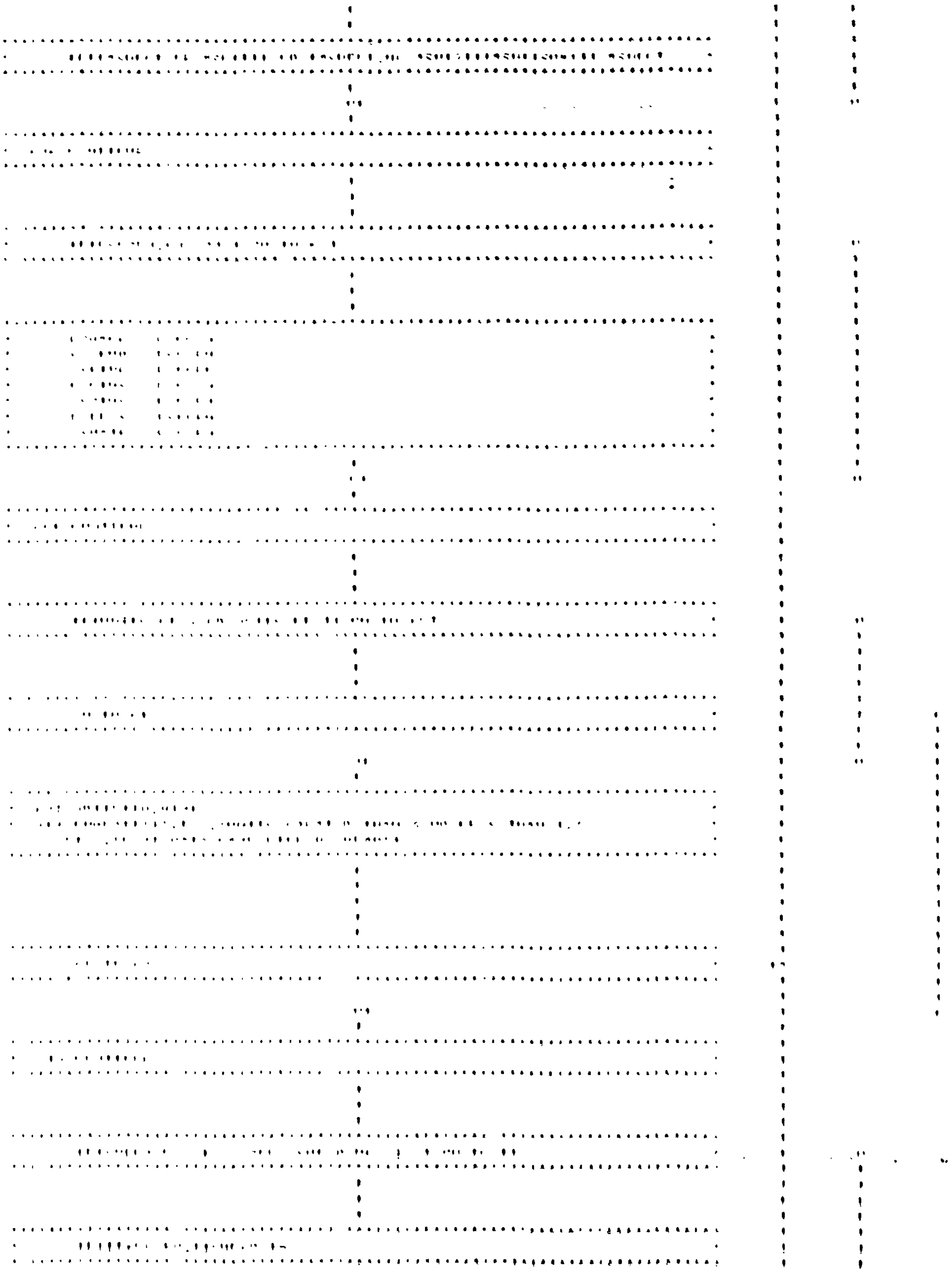

```
      IF(ITYPE.EQ.2)SUPER=10.

   11 MANCOS=FORTYR*WAGERT*(1.+FRINGE/100.)*(1.+SUPER/100.)
     * *(1.0+ESWAGE/100.)**(YEAR-BASEYR)
      COSLIM = COSLM * (1.0 +ESLIME/100.)**(YEAR-BASEYR)
      SLURRY = SLURY * (1.0 +ESSLUR/100.)**(YEAR-BASEYR)
      $SASH=$ASH*(1.0 +ESSLUR/100.)**(YEAR - BASEYR)

      IF(MWT.EQ.3092.) GO TO 20

      ETANET = 100. * MWN / MWT

      GO TO 603

   20 E1 = 32.34
      E2 = 1.0

      IF(ITYPE.EQ.2)E1=34.77

      IF((ITYPE.EQ.2).AND.(ISOX.EQ.1))E2=1.0345

      ETANET = E1 * E2
      MWT = MWN * 100./ETANET

  603 HTRATE = 3412.142 * 100. / ETANET

      IF((MWN.LT.400.0).OR.(MWN.GT.1300.)) GO TO 701

      IF(MWN.LE.700.0) GO TO 10
```

```
      ISIZE=2

      GO TO 410

   10 ISIZE=1

      GO TO 410

  701 WRITE(IW,601)
  601 FORMAT(' ',T10,'NET UNIT ELECTRICAL OUTPUT OUT OF RANGE'/
     * T10,'400 TO 1300 MWE PER UNIT'/'1')

      GO TO 605

  410 ANNGEN = (MWN * FULLYR * PLTFAC / 1000.) * UNITS

      IF(ITYPE.NE.1)GO TO 450

      CALL $LWR

      GO TO 600

  450 IF(ITYPE.NE.2)GO TO 700

      IF(ISCR.EQ. 0) CALL $COAL
```

```
      IF(ISOX.EQ. 1) CALL SCLALS

      GO TO 600

  700 WRITE(IW,800)
  800 FORMAT('0',T20,'NO COMPARISON OF PLANT TYPE'/'1')

      GO TO 635

  600 CONTINUE
      COSTAF = STAFF * MANCOS / 1000.
      VSEBAS = VSEMIL*ANNGEN
     * *(1.0+ESWAGE/100.)**(YEAR-BASEYR)
      SUPADD = 0.0
      SUPAD2=0.0
      TONCOL = ANNGEN * HTRATE * 1.E6/(BTU(ISOX+1) * 2000.)

      IF(ISOX.EQ.0) GO TO 619

      TONSUL = TONCOL * PCTSUL/100.
      TONLIM = TONSUL * XLIMS
      SUPADD=((TONLIM*COSLIM)+(TONSUL*SLUSUL*SLURRY))/1000.+TONCOL
     * *(ASH(ISOX+1)/100.)*$$ASH/1000.

  619 CONTINUE

      IF(ISOX.EQ.0 .AND. ITYPE.EQ.2)SUPAD2=TONCOL*(ASH(ISOX+1)/100.)
     * *$$ASH/1000.

      VARSE = VSEBAS + SUPADD + SUPAD2
      FIXSE = SUPEXF*UNITS
     * *(1.0+ESWAGE/100.)**(YEAR-BASEYR)
      SUPEXP = FIXSE + VARSE

      IF(ITYPE.EQ.1)GO TO 12
```

```
      COMINS=0.0
      GOVINS=0.0
      RETRO=0.0
      UPFEES=0.0

      GO TO 15

   12 COMINS = (169.8 + 114.2 * UNITS)*(1.0+ESCINS/100.)**(YEAR-BASEYR)

      IF(MWT.LE.3000.)GO TO 13

      XMWT=3000.

      GO TO 14

   13 XMWT=MWT

   14 GOVINS=( 6.*XMWT*UNITS/1000.)*(1.0+ESGINS/100.)**(YEAR-BASEYR)
      RETRO  = (  6.* UNITS)*(1.0+ESCINS/100.)**(YEAR-BASEYR)
      UPFEES = (100.* UNITS)*(1.0+ESFEES/100.)**(YEAR-BASEYR)

   15 FEEINS = COMINS + GOVINS + UPFEES + RETRO
      AGFACT = 15.

      IF(ITYPE.EQ.2)AGFACT=10.

      ADMGEN=AGFACT*(COSTAF+FIXMNT+       FIXSE       )/100.
      TOTFIX=COSTAF+FIXMNT+ADMGEN+FEEINS+FIXSE
      TOTVAR = VARMNT + VARSE
      TOTAL = TOTVAR + TOTFIX
      FIXMIL = TOTFIX / ANNGEN
      VARMIL = TOTVAR / ANNGEN
      TOTMIL = TOTAL / ANNGEN
      WRITE(IW,802) YEAR
  802 FORMAT('1',T15,
```

```
*     * 'SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS'/      *      I
*     * T18,'FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN ',F6.1/)         *      I
*       WRITE(IW,808) TYPE                                                  *      I
*  808 FORMAT(' ',T20,'PLANT TYPE IS ',A4)                                  *      I
*       WRITE(IW,804)                                                       *      I
*  804 FORMAT(' ',T20,'WITH EVAPORATIVE COOLING TOWERS')                    *      I
*       WRITE (IW,811) UNITS                                                *      I
*  811 FORMAT (' ',T20,'NUMBER OF UNITS PER STATION ',I1)                   *      I
*************************************************************************      I
                                    I                                          I
                                    I                                          I
                                    I                                          I
*************************************************************************      I
*      IF(ITYPE.NE.2)GO TO 604                                          *......I.......O
*************************************************************************      I       I
                                    I                                          I       I
                                    I                                          I       I
                                    I                                          I       I
*************************************************************************      I       I
*      IF (ISOX.EQ.1) WRITE (IW,809)                                    *      I       I
*************************************************************************      I       I
                                    I                                          I       I
                                    I                                          I       I
                                    I                                          I       I
*************************************************************************      I       I
*  809 FORMAT(' ',T20,'WITH FGD SYSTEMS')                                *      I       I
*************************************************************************      I       I
                                    I                                          I       I
                                    I                                          I       I
                                    I                                          I       I
*************************************************************************      I       I
*      IF (ISOX.EQ.0) WRITE (IW,810)                                    *      I       I
*************************************************************************      I       I
                                    I                                          I       I
                                    I                                          I       I
                                    I                                          I       I
*************************************************************************      I       I
*  810 FORMAT(' ',T20,'WITHOUT FGD SYSTEMS')                             *      I       I
*************************************************************************      I       I
                                    I                                          I       I
                                    OI.........................................I.......O
                                    I                                          I
*************************************************************************      I
*  604 CONTINUE                                                         *      I
*       WRITE(IW,807) MWT                                               *      I
*  807 FORMAT(' ',T20,'THERMAL INPUT PER UNIT IS ',F5.0,' MWT')          *      I
*       WRITE(IW,827) HIRATE                                            *      I
*  827 FORMAT(' ',T20,'PLANT NET HEAT RATE ',F7.0)                      *      I
*       WRITE(IW,826) ETANET                                            *      I
*  826 FORMAT(' ',T20,'PLANT NET EFFICIENCY, PERCENT ',F7.2)            *      I
*       WRITE(IW,805) MWN                                               *      I
*  805 FORMAT(' ',T20,'EACH UNIT IS ',F5.0,' MWE NET RATING')           *      I
*       WRITE(IW,816) ANNGEN                                            *      I
*  816 FORMAT(' ',T20,'ANNUAL NET GENERATION, MILLION KWH',F7.0)        *      I
*       WRITE(IW,806) PLTFAC                                            *      I
*  806 FORMAT(' ',T20,'WITH A PLANT FACTOR OF ',F4.2/)                  *      I
*************************************************************************      I
                                    I                                          I
                                    I                                          I
                                    I                                          I
                                    I                                          I
                                    I                                          I
*************************************************************************      I
*      IF((PLTFAC.GT..80).OR.(PLTFAC.LT..50)) WRITE(IW,862)             *      I
*************************************************************************      I
                                    I                                          I
                                    I                                          I
                                    I                                          I
*************************************************************************      I
*  862 FORMAT(' ',T10,'PLANT FACTOR OUT OF RANGE (.50 TO .80)')         *      I
*       WRITE(IW,814) COSTAF, STAFF, MANCOS                             *      I
*  814 FORMAT(' ',T20,'STAFF, $1000/YR      ',T55,F6.0,' (',I3,         *      I
*      *' PERSONS AT $',F6.0,')')                                       *      I
*       WRITE(IW,817) TOTMNT                                            *      I
*  817 FORMAT('0',T20,'MAINTENANCE MATERIAL, $1000/YR',T55,F6.0)        *      I
*       WRITE(IW,866) FIXMNT                                            *      I
*  866 FORMAT(' ',T30,'FIXED'         ,T60,F6.0)                        *      I
*       WRITE(IW,867) VARMNT                                            *      I
*  867 FORMAT(' ',T30,'VARIABLE'      ,T60,F6.0)                        *      I
*       WRITE(IW,822) SUPEXP                                            *      I
```

```
*   822 FORMAT('0',T20,'SUPPLIES AND EXPENSES, $1000/YR',T55,F6.0)          *      I
*       WRITE(IW,803) FIXSE                                                  *      I
*   803 FORMAT(' ',T30,'FIXED  - PLANT ',T6 ,F6.0)                          *      I
*       WRITE(IW,815) VSEBAS                                                 *      I
*   815 FORMAT(' ',T30,'VAR.   - PLANT ',T6 ,F6.0)                          *      I
**************************************************************************      I
                                    I                                          I
                                    I                                          I
                                    I                                          I
**************************************************************************      I
*       IF(ISCA.EQ.0) GO TO 666                                              *......I.......O
**************************************************************************      I       I
                                    I                                          I       I
                                    I                                          I       I
                                    I                                          I       I
**************************************************************************      I       I
*       WRITE(IW,834) SUPADD                                                 *      I       I
*   834 FORMAT(' ',T30,'       - ASH & FGD SLUDGE  ',T60,F6.0)              *      I       I
**************************************************************************      I       I
                                    I                                          I       I
                                    C(.........................................I.......O
                                    I                                          I
**************************************************************************      I
*   666 CONTINUE                                                             *      I
**************************************************************************      I
                                    I                                          I
                                    I                                          I
                                    I                                          I
**************************************************************************      I
*       IF(SUPA02.NE.0.0)WRITE(IW,865) SUPA02                                *      I
**************************************************************************      I
                                    I                                          I
                                    I                                          I
                                    I                                          I
                                    I                                          I
                                    I                                          I
**************************************************************************      I
*   865 FORMAT(' ',T30,'- ASH DISPOSAL',T60,F6.0)                           *      I
**************************************************************************      I
                                    I                                          I
                                    I                                          I
                                    I                                          I
**************************************************************************      I
*       IF(ITYPE.EQ.2)GO TO 702                                              *......I.......O
**************************************************************************      I       I
                                    I                                          I       I
                                    I                                          I       I
                                    I                                          I       I
**************************************************************************      I       I
*       WRITE(IW,833) FEEINS                                                 *      I       I
*   833 FORMAT('0',T20,'INSURANCE AND FEES, $1000/YR',T55,F6.0)             *      I       I
*       WRITE(IW,820) COMINS                                                 *      I       I
*   820 FORMAT(' ',T30,'COMM. LIAB. INS. ',T60,F6.0)                        *      I       I
*       WRITE(IW,824) GOVINS                                                 *      I       I
*   824 FORMAT(' ',T30,'GOV. LIAB. INS. ',T60,F6.0)                         *      I       I
*       WRITE(IW,835) RETRL                                                  *      I       I
*   835 FORMAT(' ',T30,'RETROSPECTIVE PREMIUM',T60,F6.0)                    *      I       I
*       WRITE(IW,823) OPFEES                                                 *      I       I
*   823 FORMAT(' ',T30,'INSPECTION FEES & EXPENSES',T60,F6.0)               *      I       I
**************************************************************************      I       I
                                    I                                          I       I
                                    C(.........................................I.......O
                                    I                                          I
**************************************************************************      I
*   702 WRITE(IW,825) ADMGEN                                                 *      I
*   825 FORMAT('0',T20,'ADMIN. AND GENERAL, $1000/YR',T55,F6.0)             *      I
*       WRITE(IW,830) TOTFIX                                                 *      I
*   830 FORMAT('0',T20,'TOTAL FIXED COSTS, $1000/YR',T65,F6.0)              *      I
*       WRITE(IW,831) TOTVAR                                                 *      I
*   831 FORMAT(' ',T20,'TOTAL VARIABLE COSTS, $1000/YR',T65,F6.0)           *      I
*       WRITE(IW,832) TOTAL                                                  *      I
*   832 FORMAT(' ',T20,'TOTAL ANNUAL O & M COSTS, $1000/YR',T65,F6.0)       *      I
*       WRITE(IW,828) FIXMIL                                                 *      I
*   828 FORMAT('0',T20,'FIXED UNIT O & M COSTS, MILLS/KWH(E) ',T65,F6.2)    *      I
*       WRITE(IW,829) VARMIL                                                 *      I
*   829 FORMAT(' ',T20,'VARIABLE UNIT O & M COSTS, MILLS/KWH(E) ',T65,      *      I
*      * F6.2)                                                               *      I
*       WRITE(IW,834) TOTMIL                                                 *      I
*   834 FORMAT(' ',T20,'TOTAL UNIT O & M COSTS, MILLS/KWH(E) ',T65,F6.2)    *      I
**************************************************************************      I
```

```
      IF(ITYPE.EQ.1)GO TO 602

      WRITE(IW,848) BTU(ISOX + 1)
  848 FORMAT(///////////T20,'HEATING VALUE OF COAL, BTU/LB',T55,F8.0)
      WRITE(IW,849) TONCOL
  849 FORMAT(' ',T20,'COAL BURNED, TONS/YEAR            ',T54,F9.0)
      WRITE(IW,871) ASH(ISOX+1)
  871 FORMAT(' ',T20,'PERCENT ASH',T55,F8.2)
      WRITE(IW,864)$SASH
  864 FORMAT(' ',T20,'COST OF ASH DISPOSAL, $/TON ',T55,F8.2)

      IF(ISOX.NE.1)GO TO 602

      WRITE(IW,839) PCTSUL
  839 FORMAT(' ',T20,'PERCENT SULFUR',T55,F8.2)
      WRITE(IW,840) TONSUL
  840 FORMAT(' ',T20,'SULFUR (ORIGINAL),TONS/YR',T55,F8.0)
      WRITE(IW,841) XLIMS
  841 FORMAT(' ',T20,'TONS LIMESTONE PER TON SULFUR',T55,F8.2)
      WRITE(IW,844) TONLIM
  844 FORMAT(' ',T20,'TONS/YEAR LIMESTONE',T55,F8.0)
      WRITE(IW,847) COSLIM
  847 FORMAT(' ',T20,'COST OF LIMESTONE, $/TON',T55,F8.2)
      WRITE(IW,843) SLURRY
  843 FORMAT(' ',T20,'COST OF SLUDGE DISPOSAL, $/DRY TON',T55,F8.2)

  602 CONTINUE

      GO TO 605

  708 CONTINUE

      IF(INAME1.EQ.2) GO TO 611

      WRITE(IW,861)     ESWAGE,      ESSLUR,ESLIME,ESCINS,ESGINS,ESFEES,
     * ESMATL, ESCGEN
  861 FORMAT('1',T15,'ESCALATION RATES, PERCENT/YEAR'//
     * ' ',T20,'WAGES                  ',T62,F6.1/
     * ' ',T20,'SLUDGE DISPOSAL COST  ',T62,F6.1/
     * ' ',T20,'LIMESTONE COST        ',T62,F6.1/
```

```
*     * ' ',T20,'COMPL. LIAB. INS. COST ',T62,F6.1/                        *      I
*     * ' ',T20,'GOVT. LIAB. INS. COST ',T62,F6.1/                         *      I
*     * ' ',T20,'INSPECTION FEES & EXP.',T62,F6.1/                         *      I
*     * ' ',T20,'MATERIAL                ',T62,F6.1/                       *      I
*     * ' ',T20,'GENERAL ESCALATION      ',T62,F6.1)                       *      I
*      WRITE(IW,846) WAGERT, FRINGE, SUPER                                 *      I
*  846 FORMAT('0',T15,'ANNUAL AVERAGE SALARY COMPONENTS'//T20,             *      I
*     * 'WAGE RATE BEFORE ADDERS (BASE YEAR), $/HR',T64,F5.2/T20,          *      I
*     * 'OPERATOR FRINGE BENEFITS, PCT.',T62,F5.0/T20,                     *      I
*     * 'PLANT SUPERVISION & TECHNICAL, PCT.',T62,F5.0)                    *      I
*      WRITE(IW,818) BASEYR, COSLM, SLURY                                  *      I
*  818 FORMAT('0',T15,        'FGD COST COMPONENTS AT BASE YEAR ',F6.1// *      I
*     * T20,'COST OF LIMESTONE, $/TON '       ,T61,F8.2/                   *      I
*     * T20,'COST OF SLUDGE DISPOSAL, $/DRY TON ',T61,F8.2)                *      I
***************************************************************************      I
                                       I                                         I
                                       U(.........................................O
                                       I
***************************************************************************
*  611 CONTINUE                                                            *
*      WRITE(IW,863)BASH,ASH                                               *
*  863 FORMAT('0',T15,'ASH DISPOSAL COST COMPONENTS AT BASE YEAR'//        *
*     *  T20,'COST OF ASH DISPOSAL, $/TON',T61,F8.2/                       *
*     *  T20,'PERCENT ASH IN LOW SULFUR COAL ',T61,F8.2/                   *
*     *  T20,'PERCENT ASH IN HIGH SULFUR COAL ',T61,F8.2)                  *
*      CALL BYE                                                            *
***************************************************************************
                                       I
                                       I
                                       I
***************************************************************************
*       STOP                                                               *
***************************************************************************


***************************************************************************
*       END                                                                *
***************************************************************************
```

```
                                        (ENTRANCE)
                                            I
                                            I
          *********************************************************************
          *      SUBROUTINE SLWR                                              *
          *      REAL*4 MWN, MANCCS                                           *
          *      INTEGER*4 UNITS, BASTAF(4,2,26), STAFF                       *
          *      REAL*8 TITLE                                                 *
          *      DIMENSION NO(4)                                              *
          *      DIMENSION TITLE(3,24)                                        *
          *      COMMON /COM1/ MWN, ISOX, YEAR, ISIZE, STAFF, UNITS, BASEYR,  *
          *     * ESMATL, FIXMNT, ESWAGE, MANCOS, PLTFAC, SUPEXF, VARMNT, TOTMNT, *
          *     * VSEMIL                                                      *
          *      DATA NO/10,2,3,4/                                            *
          *      DATA TITLE/'MANAGER ','        ','        ',                 *
          *     *           'ASSISTAN','T       ','        ',                 *
          *     *           'QUALITY ','ASSURANC','E       ',                 *
          *     *           'ENVIRONM','ENTAL CO','NTROL   ',                 *
          *     *           'PUBLIC R','ELATIONS','        ',                 *
          *     *           'TRAINING','        ','        ',                 *
          *     *           'SAFETY  ','        ','        ',                 *
          *     *           'ADMIN. &',' SERVICE','S       ',                 *
          *     *           'HEALTH S','ERVICES ','        ',                 *
          *     *           'SECURITY','        ','        ',                 *
          *     *           'SUPERVIS','ION (EXC','. SHIFT)',                 *
          *     *           'SHIFTS  ','        ','        ',                 *
          *     *           'SUPERVIS','ION     ','        ',                 *
          *     *           'CRAFTS  ','        ','        ',                 *
          *     *           'PEAK MAI','NT. ANNU','ALIZED  ',                 *
          *     *           'REACTOR ','        ','        ',                 *
          *     *           'RADIO-CH','EMICAL  ','        ',                 *
          *     *           'I & C   ','        ','        ',                 *
          *     *           'PERFORM.',', REPORT','S, TECH.',                 *
          *     *           '        ','        ','        '/                 *
          *      DATA BASTAF/1,1,1,1,1,1,1,1,1,2,3,4,1,2,3,4,3,4,5,6,3,4,5,6, *
          *     * 1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1, 1,1,2,2,1,1,2,2,1,1,1,1,1,1,1,1,*
          *     * 13,15,17,19,13,15,17,19, 1,1,1,2,1,1,1,2,                   *
          *     * 56,56,56,105,56,56,56,112,                                  *
          *     * 2,2,4,4,2,2,4,4, 28,48,68,88,33,58,83,108,                  *
          *     * 8,8,10,12,8,8,10,12, 14,22,30,38,16,26,36,46,               *
          *     * 55,110,165,220,55,110,165,220,                              *
          *     * 1,2,3,4,1,2,3,4, 2,2,3,4,2,2,3,4, 2,2,3,4,2,2,3,4,          *
          *     * 17,21,25,29,17,21,25,29/                                    *
          *      DATA FIXFAC/1.0/                                             *
          *      DATA FACMAT/.50/                                             *
          *      DATA KSKIP/1/                                                *
          *      DATA IW/6/                                                   *
          *      ISIZE2 = ISIZE                                               *
          *      UNITS2 = UNITS                                               *
          *      I1=1                                                         *
          *      I2=NO(1)                                                     *
          *      I3=I2+1                                                      *
          *      I4=I2+NO(2)                                                  *
          *      I5=I4+1                                                      *
          *      I6=I4+NO(3)                                                  *
          *      I7=I6+1                                                      *
          *      I8=I6+NO(4)                                                  *
          *      J1=I8+1                                                      *
          *      J2=I8+2                                                      *
          *      J3=I8+3                                                      *
          *      J4=I8+4                                                      *
          *      K1=J4+1                                                      *
          *      K2=K1+1                                                      *
          *      K3=K2+1                                                      *
          *********************************************************************
                                            I
                                            I
                                            I
          *********************************************************************
I.........*      DO 601 ISIZE =1,2                                            *
I         *********************************************************************
I                                           I
I                                           I
I                                           I
I         *********************************************************************
I I.......*      DO 601 UNITS = 1,4                                           *
I I       *********************************************************************
I I                                         I
I I                                         I
I I                                         I
```

```
I I                  ***************************************************************
I I                  *        BASTAF(UNITS,ISIZE,J1)=0                             *
I I                  ***************************************************************
I I                                                  I
I I                                                  I
I I                                                  I
I I                  ***************************************************************
I I  I...............*        DO 602 I=I1,I2                                       *
I I  I               ***************************************************************
I I  I                                               I
I I  I                                               I
I I  I                                               I
I I  I               ***************************************************************
I I  I               *        BASTAF(UNITS,ISIZE,J1)=                              *
I I  I               *      * BASTAF(UNITS,ISIZE,J1)+BASTAF(UNITS,ISIZE,I)         *
I I  I               ***************************************************************
I I  I                                               I
I I  I                                               I
I I  I                                               I
I I  I               ***************************************************************
I I   ...............*   602 CONTINUE                                              *
I I                  ***************************************************************
I I                                                  I
I I                                                  I
I I                                                  I
I I                  ***************************************************************
I I                  *        BASTAF(UNITS,ISIZE,J2)=0                             *
I I                  ***************************************************************
I I                                                  I
I I                                                  I
I I                                                  I
I I                  ***************************************************************
I I  I...............*        DO 603 I=I3,I4                                       *
I I  I               ***************************************************************
I I  I                                               I
I I  I                                               I
I I  I                                               I
I I  I               ***************************************************************
I I  I               *        BASTAF(UNITS,ISIZE,J2)=                              *
I I  I               *      * BASTAF(UNITS,ISIZE,J2)+BASTAF(UNITS,ISIZE,I)         *
I I  I               ***************************************************************
I I  I                                               I
I I  I                                               I
I I  I                                               I
I I  I                                               I
I I  I                                               I
I I  I               ***************************************************************
I I   ...............*   603 CONTINUE                                              *
I I                  ***************************************************************
I I                                                  I
I I                                                  I
I I                                                  I
I I                  ***************************************************************
I I                  *        BASTAF(UNITS,ISIZE,J3)=0                             *
I I                  ***************************************************************
I I                                                  I
I I                                                  I
I I                                                  I
I I                  ***************************************************************
I I  I...............*        DO 604 I=I5,I6                                       *
I I  I               ***************************************************************
I I  I                                               I
I I  I                                               I
I I  I                                               I
I I  I               ***************************************************************
I I  I               *        BASTAF(UNITS,ISIZE,J3)=                              *
I I  I               *      * BASTAF(UNITS,ISIZE,J3)+BASTAF(UNITS,ISIZE,I)         *
I I  I               ***************************************************************
I I  I                                               I
I I  I                                               I
I I  I                                               I
I I  I               ***************************************************************
I I   ...............*   604 CONTINUE                                              *
I I                  ***************************************************************
I I                                                  I
I I                                                  I
I I                                                  I
I I                  ***************************************************************
I I                  *        BASTAF(UNITS,ISIZE,J4)=0                             *
I I                  ***************************************************************
```

```
I I                                      I
I I                                      I
I I                                      I
I I      *****************************************************************
I I I.............*    DO 605 I=I7,I8                                     *
I I I    *****************************************************************
I I I                                    I
I I I                                    I
I I I                                    I
I I I    *****************************************************************
I I I    *    BASTAF(UNITS,ISIZE,J4)=                                     *
I I I    *    * BASTAF(UNITS,ISIZE,J4)+BASTAF(UNITS,ISIZE,I)              *
I I I    *****************************************************************
I I I                                    I
I I I                                    I
I I I                                    I
I I I    *****************************************************************
I I ..............*  605 CONTINUE                                         *
I I      *****************************************************************
I I                                      I
I I                                      I
I I                                      I
I I                                      I
I I                                      I
I I      *****************************************************************
I I      *     BASTAF(UNITS,ISIZE,K1)=BASTAF(UNITS,ISIZE,J1)+             *
I I      *    *BASTAF(UNITS,ISIZE,J2)+BASTAF(UNITS,ISIZE,J3)+             *
I I      *    *BASTAF(UNITS,ISIZE,J4)                                     *
I I      *     BASTAF(UNITS,ISIZE,K2)=BASTAF(UNITS,ISIZE,K1) -            *
I I      *    *BASTAF(UNITS,ISIZE,I2)                                     *
I I      *     BASTAF(UNITS,ISIZE,K3)=BASTAF(UNITS,ISIZE,K2) -            *
I I      *    *BASTAF(UNITS,ISIZE,I6)                                     *
I I      *****************************************************************
I I                                      I
I I                                      I
I I                                      I
I I      *****************************************************************
.................*  601 CONTINUE                                          *
         *****************************************************************
                                         I
                                         I
                                         I
         *****************************************************************
         *      IF(KSKIP.GT.1) GO TO 606                                  *......O
         *****************************************************************      I
                                         I                                      I
                                         I                                      I
                                         I                                      I
         *****************************************************************      I
         *      WRITE(IW,803)                                             *      I
         *  803 FORMAT('1',T35,'STAFF REQUIREMENT FOR LWR POWER PLANTS'/  *      I
         *     *        ' ',T35,38('-')/                                  *      I
         *     *        ' ',T45,'UNIT SIZE RANGE MW(E)'/                  *      I
         *     *        ' ',T42,'400-700',T62,'701-1300'/                 *      I
         *     *        ' ',T36,17('-'),T56,19('-')/                      *      I
         *     *        ' ',T36,'NO. UNITS PER SITE   NO. UNITS PER SITE'/*      I
         *     *        ' ',T38,'1    2    3    4    1    2    3    4'/   *      I
         *     *        ' ',T36,17('-'),T56,19('-'))                      *      I
         *      WRITE(IW,805)                                             *      I
         *  805 FORMAT('0',T7,'PLANT MANAGER''S OFFICE'/)                 *      I
         *****************************************************************      I
                                         I                                      I
                                         I                                      I
                                         I                                      I
         *****************************************************************      I
I................*      DO 600 I=I1,I8                                    *      I
I        *****************************************************************      I
I                                        I                                      I
I                                        I                                      I
I                                        I                                      I
I        *****************************************************************      I
I        *      WRITE(IW,800) (TITLE(J,I),J=1,3)                          *      I
I        *     *,((BASTAF(UNITS,ISIZE,I),UNITS=1,4),ISIZE=1,2)            *      I
I        *  800 FORMAT(' ',T10,3A8,8(2X,I3))                              *      I
I        *****************************************************************      I
I                                        I                                      I
I                                        I                                      I
I                                        I                                      I
I                                        I                                      I
I                                        I                                      I
```

```
      IF(I.EQ.I2)WRITE(IW,811)
     * ((BASTAF(UNITS,ISIZE,J1),UNITS=1,4),ISIZE=1,2)

      IF(I.EQ.I2)WRITE(IW,806)

  806 FORMAT(' ',T7,'OPERATIONS'/)

      IF(I.EQ.I4)WRITE(IW,811)
     * ((BASTAF(UNITS,ISIZE,J2),UNITS=1,4),ISIZE=1,2)

      IF(I.EQ.I4)WRITE(IW,807)

  807 FORMAT(' ',T7,'MAINTENANCE'/)

      IF(I.EQ.I6)WRITE(IW,811)
     * ((BASTAF(UNITS,ISIZE,J3),UNITS=1,4),ISIZE=1,2)

      IF(I.EQ.I6)WRITE(IW,808)

  808 FORMAT(' ',T7,'TECHNICAL AND ENGINEERING'/)

  800 CONTINUE

      WRITE(IW,811)
     * ((BASTAF(UNITS,ISIZE,J4),UNITS=1,4),ISIZE=1,2)
  811 FORMAT(/  T13,'SUBTOTAL',T34,8(2X,I3)/)
      WRITE(IW,820)
     * ((BASTAF(UNITS,ISIZE,K1),UNITS=1,4),ISIZE=1,2)
  820 FORMAT( T13,'TOTAL',T34,8(2X,I3)/
     *          ' ',T34,8('  ==='))
      WRITE(IW,801)
     * ((BASTAF(UNITS,ISIZE,K2),UNITS=1,4),ISIZE=1,2)
  801 FORMAT(/T13,'LESS SECURITY',T34,8(2X,I3))
      WRITE(IW,802)
     * ((BASTAF(UNITS,ISIZE,K3),UNITS=1,4),ISIZE=1,2)
  802 FORMAT(/T13,'LESS SEC., PEAK MAINT.',T34,8(2X,I3))
```

```
                                         I                                         I
                                         U(........................................O
                                         :
***************************************************************************************
*  606 CONTINUE                                                                        *
*      ISIZE = ISIZE2                                                                  *
*      UNITS = UNITS2                                                                  *
*      SUPEXF=4200.                                                                    *
*      VSEMIL = .06                                                                    *
*      VARFAC = 1.0 - FIXFAC                                                           *
*C  NOTE... RATIO OF ESCALATION FACTORS ELIMINATES WAGE ESCALATION FROM               *
*C            MANCOS AND REPLACES IT WITH MATERIAL ESCALATION RATE                     *
*      BASM=(FACMAT/(1.-FACMAT))*BASTAF(UNITS,ISIZE,J3)                               *
*     * *(MANCOS/1000.)                                                                *
*     * *((100.+ESMATL)/(100.+ESWAGE))**(YEAR-BASEYR)                                  *
*      STAFF = BASTAF(UNITS,ISIZE,K1)                                                  *
*      FIXMNT = FIXFAC * BASM                                                          *
*      VARMNT = VARFAC * BASM          * (PLTFAC/.80)                                  *
*      TOTMNT = FIXMNT + VARMNT                                                        *
*      KSKIP = KSKIP + 1                                                               *
***************************************************************************************
                                         I
                                         I
                                         I
***************************************************************************************
*      RETURN                                                                          *
***************************************************************************************

***************************************************************************************
*      END                                                                             *
***************************************************************************************
```

```
                                    (ENTRANCE)
                                         I
                                         I
                   ****************************************************************
                   *      SUBROUTINE SCOAL                                        *
                   *      REAL*4 MWN, MANCOS                                      *
                   *      INTEGER*4 UNITS, BASTAF(4,2,23), STAFF                  *
                   *      REAL*8 TITLE                                            *
                   *      DIMENSION NO(4)                                         *
                   *      DIMENSION TITLE(3,24)                                   *
                   *      COMMON /COM1/ MWN, ISOX, YEAR, ISIZE, STAFF, UNITS, BASEYR,  *
                   *     * ESMATL, FIXMNT, ESWAGE, MANCOS, PLTFAC, SUPEXF, VARMNT, TOTMNT, *
                   *     * VSEMIL                                                 *
                   *      DATA NO/9,3,3,3/                                        *
                   *      DATA TITLE/'MANAGER ','        ','        ',             *
                   *     *           'ASSISTAN','T       ','        ',             *
                   *     *           'ENVIRONM','ENTAL CO','NTROL   ',             *
                   *     *           'PUBLIC R','ELATIONS','        ',             *
                   *     *           'TRAINING','        ','        ',             *
                   *     *           'SAFETY  ','        ','        ',             *
                   *     *           'ADMIN. &',' SERVICE','S       ',             *
                   *     *           'HEALTH S','ERVICES ','        ',             *
                   *     *           'SECURITY','        ','        ',             *
                   *     *           'SUPERVIS','ION (EXC','. SHIFT)',             *
                   *     *           'SHIFTS  ','        ','        ',             *
                   *     *           'FUEL HAN','DLING   ','        ',             *
                   *     *           'SUPERVIS','ION     ','        ',             *
                   *     *           'CRAFTS  ','        ','        ',             *
                   *     *           'PEAK MAI','NT. ANNU','ALIZED  ',             *
                   *     *           'RADIO-CH','EMICAL  ','        ',             *
                   *     *           'I & C   ','        ','        ',             *
                   *     *           'PERFORM.',', REPORT','S, TECH.'/             *
                   *      DATA BASTAF/8*1, 1,2,3,4,1,2,3,4, 8*1, 8*1, 8*1, 8*1,  *
                   *     * 12,13,14,15,12,13,14,15, 3*1,2,3*1,2, 7,7,9,14,7,7,9,14,  *
                   *     * 2,2,4,4,2,2,4,4, 45,50,60,65,45,50,60,65, 3*12,18,3*12,18,  *
                   *     * 6,6,8,10,6,6,8,10, 75,90,100,110,80,95,105,115,       *
                   *     * 32,64,96,128,32,64,96,128,            2,2,3,4,2,2,3,4, *
                   *     * 2,2,3,4,2,2,3,4, 12,15,18,21,15,18,21,24/             *
                   *      DATA FIXFAC/.75/                                        *
                   *      DATA FACMAT/.43/                                        *
                   *      DATA KSKIP/1/                                           *
                   *      DATA IW/6/                                              *
                   *      ISIZE2 = ISIZE                                          *
                   *      UNITS2 = UNITS                                          *
                   *      I1=1                                                    *
                   *      I2=NO(1)                                                *
                   *      I3=I2+1                                                 *
                   *      I4=I2+NO(2)                                             *
                   *      I5=I4+1                                                 *
                   *      I6=I4+NO(3)                                             *
                   *      I7=I6+1                                                 *
                   *      I8=I6+NO(4)                                             *
                   *      J1=I8+1                                                 *
                   *      J2=I8+2                                                 *
                   *      J3=I8+3                                                 *
                   *      J4=I8+4                                                 *
                   *      K1=J4+1                                                 *
                   ****************************************************************
                                         I
                                         I
                                         I
                                         I
                                         I
                   ****************************************************************
I..................*      DO 601 ISIZE =1,2                                       *
I                  ****************************************************************
I                                        I
I                                        I
I                                        I
I                  ****************************************************************
I I................*      DO 601 UNITS = 1,4                                      *
I I                ****************************************************************
I I                                      I
I I                                      I
I I                                      I
I I                ****************************************************************
I I                *      BASTAF(UNITS,ISIZE,J1)=0                                *
I I                ****************************************************************
I I                                      I
I I                                      I
```

```
      DO 602 I=I1,I2

      BASTAF(UNITS,ISIZE,J1)=
     * BASTAF(UNITS,ISIZE,J1)+BASTAF(UNITS,ISIZE,I)

  602 CONTINUE

      BASTAF(UNITS,ISIZE,J2)=0

      DO 603 I=I3,I4

      BASTAF(UNITS,ISIZE,J2)=
     * BASTAF(UNITS,ISIZE,J2)+BASTAF(UNITS,ISIZE,I)

  603 CONTINUE

      BASTAF(UNITS,ISIZE,J3)=0

      DO 604 I=I5,I6

      BASTAF(UNITS,ISIZE,J3)=
     * BASTAF(UNITS,ISIZE,J3)+BASTAF(UNITS,ISIZE,I)

  604 CONTINUE

      BASTAF(UNITS,ISIZE,J4)=0

      DO 605 I=I7,I8
```

```
      BASTAF(UNITS,ISIZE,J4)=
     * BASTAF(UNITS,ISIZE,J4)+BASTAF(UNITS,ISIZE,I)

  605 CONTINUE

      BASTAF(UNITS,ISIZE,K1)=BASTAF(UNITS,ISIZE,J1)+
     *BASTAF(UNITS,ISIZE,J2)+BASTAF(UNITS,ISIZE,J3)+
     *BASTAF(UNITS,ISIZE,J4)

  601 CONTINUE

      IF(KSKIP.GT.1) GO TO 606

      WRITE(IW,803)
  803 FORMAT('1',T35,'STAFF REQUIREMENT FOR COAL-FIRED POWER PLANTS'/
     *        ' ',T45,'WITHOUT FGD SYSTEMS'/
     *        ' ',T45,19('-')/
     *        ' ',T45,'UNIT SIZE RANGE MW(E)'/
     *        ' ',T42,'400-700',T62,'701-1300'/
     *        ' ',T36,17('-'),T56,19('-')/
     *        ' ',T36,'NO. UNITS PER SITE   NO. UNITS PER SITE'/
     *        ' ',T38,'1    2    3    4    1    2    3    4'/
     *        ' ',T36,17('-'),T56,19('-'))
      WRITE(IW,805)
  805 FORMAT('0',T7,'PLANT MANAGER''S OFFICE'/)

      DO 600 I=I1,I8

      WRITE(IW,800) (TITLE(J,I),J=1,3)
     *,((BASTAF(UNITS,ISIZE,I),UNITS=1,4),ISIZE=1,2)
  800 FORMAT(' ',T10,3A8,8(2X,I3))

      IF(I.EQ.I2)WRITE(IW,611)
     * ((BASTAF(UNITS,ISIZE,J1),UNITS=1,4),ISIZE=1,2)
```

```
      IF(I.EQ.I2)WRITE(IW,806)

  806 FORMAT(' ',T7,'OPERATIONS'/)

      IF(I.EQ.I4)WRITE(IW,811)
     * ((BASTAF(UNITS,ISIZE,J2),UNITS=1,4),ISIZE=1,2)

      IF(I.EQ.I4)WRITE(IW,807)

  807 FORMAT(' ',T7,'MAINTENANCE'/)

      IF(I.EQ.I6)WRITE(IW,811)
     * ((BASTAF(UNITS,ISIZE,J3),UNITS=1,4),ISIZE=1,2)

      IF(I.EQ.I6)WRITE(IW,808)

  808 FORMAT(' ',T7,'TECHNICAL AND ENGINEERING'/)

  600 CONTINUE

      WRITE(IW,811)
     * ((BASTAF(UNITS,ISIZE,J4),UNITS=1,4),ISIZE=1,2)
  811 FORMAT(/  T13,'SUBTOTAL',T34,8(2X,I3)/)
      WRITE(IW,820)
     * ((BASTAF(UNITS,ISIZE,K1),UNITS=1,4),ISIZE=1,2)
  820 FORMAT( T13,'TOTAL',T34,8(2X,I3)/
     *        ' ',T34,8('  ==='))

  606 CONTINUE
      ISIZE = ISIZE2
      UNITS = UNITS2
      SUPEXF=1300.
      VSEMIL = .04
      VARFAC = 1.0 - FIXFAC
C  NOTE... RATIO OF ESCALATION FACTORS ELIMINATES WAGE ESCALATION FROM
C          MANCOS AND REPLACES IT WITH MATERIAL ESCALATION RATE
      BASM=(FACMAT/(1.-FACMAT))*BASTAF(UNITS,ISIZE,J3)
```

```
*     * *(MANCOS/1C00.)                                                  *
*     * *((100.+ESMATL)/(100.+ESWAGE))**(YEAR-BASEYR)                    *
*      STAFF = BASTAF(UNITS,ISIZE,K1)                                    *
*      FIXMNT = FIXFAC * BASM                                            *
*      VARMNT = VARFAC * BASM         * (PLTFAC/.80)                     *
*      TOTMNT = FIXMNT + VARMNT                                          *
*      KSKIP = KSKIP + 1                                                 *
**************************************************************************
                                  I
                                  I
                                  I
**************************************************************************
*      RETURN                                                            *
**************************************************************************


**************************************************************************
*      END                                                               *
**************************************************************************
```

```
                              (ENTRANCE)
                                  I
                                  I
*****************************************************************
*      SUBROUTINE SCOALS                                        *
*      REAL*4 MWN, MANCOS                                       *
*      INTEGER*4 UNITS, BASTAF(4,2,25), STAFF                   *
*      REAL*8 TITLE                                             *
*      DIMENSION NO(4)                                          *
*      DIMENSION TITLE(3,24)                                    *
*      COMMON /COM1/ MWN, ISOX, YEAR, ISIZE, STAFF, UNITS, BASEYR,  *
*     * ESMAIL, FIXMNT, ESWAGE, MANCOS, PLTFAC, SUPEXF, VARMNT, TOTMNT,  *
*     * VSEMIL                                                  *
*      DATA NO/9,4,3,4/                                         *
*      DATA TITLE/'MANAGER ','        ','        ',             *
*     *           'ASSISTAN','T       ','        ',             *
*     *           'ENVIRONM','ENTAL CO','NTROL   ',             *
*     *           'PUBLIC R','ELATIONS','        ',             *
*     *           'TRAINING','        ','        ',             *
*     *           'SAFETY  ','        ','        ',             *
*     *           'ADMIN. &',' SERVICE','S       ',             *
*     *           'HEALTH S','ERVICES ','        ',             *
*     *           'SECURITY','        ','        ',             *
*     *           'SUPERVIS','ION (EXC','. SHIFT)',             *
*     *           'SHIFTS  ','        ','        ',             *
*     *           'FUEL AND',' LIMESTO','NE REC. ',             *
*     *           'WASTE SY','STEMS   ','        ',             *
*     *           'SUPERVIS','ION     ','        ',             *
*     *           'CRAFTS  ','        ','        ',             *
*     *           'PEAK MAI','NT. ANNU','ALIZED  ',             *
*     *           'WASTE   ','        ','        ',             *
*     *           'RADIO-CH','EMICAL  ','        ',             *
*     *           'I & C   ','        ','        ',             *
*     *           'PERFORM.',', REPORT','S, TECH.'/             *
*      DATA BASTAF/8*1, 1,2,3,4,1,2,3,4, 8*1, 8*1, 8*1, 8*1,    *
*     * 13,14,15,16,13,14,15,16, 3*1,2,3*1,2, 7,7,9,14,7,7,9,14,  *
*     * 3,3,5,5,3,3,5,5, 45,50,60,65,45,50,60,65, 3*12,18,3*12,18,  *
*     * 15,30,45,60,15,30,45,60,                                *
*     * 8,8,10,12,8,8,10,12, 90,115,135,155,95,120,140,160,     *
*     * 33,66,99,132,35,70,105,140, 1,2,3,4,1,2,3,4, 2,2,3,4,2,2,3,4,  *
*     * 2,2,3,4,2,2,3,4, 14,17,21,24,14,17,21,24/               *
*      DATA FIXFAC/.75/                                         *
*      DATA FACMAT/.45/                                         *
*      DATA KSKIP/1/                                            *
*      DATA IW/6/                                               *
*      ISIZE2 = ISIZE                                           *
*      UNITS2 = UNITS                                           *
*      I1=1                                                     *
*      I2=NO(1)                                                 *
*      I3=I2+1                                                  *
*      I4=I2+NO(2)                                              *
*      I5=I4+1                                                  *
*      I6=I4+NO(3)                                              *
*      I7=I6+1                                                  *
*      I8=I6+NO(4)                                              *
*      J1=I8+1                                                  *
*      J2=I8+2                                                  *
*      J3=I8+3                                                  *
*      J4=I8+4                                                  *
*      K1=J4+1                                                  *
*****************************************************************
                                  I
                                  I
                                  I
                                  I
                                  I
*****************************************************************
I..................*      DO 601 ISIZE =1,2                     *
I                  *****************************************************************
I                                 I
I                                 I
I                                 I
I                  *****************************************************************
I I................*      DO 601 UNITS = 1,4                    *
I I                *****************************************************************
I I                               I
I I                               I
I I                               I
I I                *****************************************************************
I I                *      BASTAF(UNITS,ISIZE,J1)=0              *
I I                *****************************************************************
```

```
I I                                       I
I I                                       I
I I                                       I
I I      ******************************************************************
I I I.............*      DO 602 I=I1,I2                                   *
I I I    ******************************************************************
I I I                                     I
I I I                                     I
I I I                                     I
I I I    ******************************************************************
I I I    *      BASTAF(UNITS,ISIZE,J1)=                                    *
I I I    *     * BASTAF(UNITS,ISIZE,J1)+BASTAF(UNITS,ISIZE,I)             *
I I I    ******************************************************************
I I I                                     I
I I I                                     I
I I I                                     I
I I I    ******************************************************************
I I ..............*  602 CONTINUE                                          *
I I      ******************************************************************
I I                                       I
I I                                       I
I I                                       I
I I      ******************************************************************
I I      *      BASTAF(UNITS,ISIZE,J2)=0                                   *
I I      ******************************************************************
I I                                       I
I I                                       I
I I                                       I
I I      ******************************************************************
I I I.............*      DO 603 I=I3,I4                                   *
I I I    ******************************************************************
I I I                                     I
I I I                                     I
I I I                                     I
I I I    ******************************************************************
I I I    *      BASTAF(UNITS,ISIZE,J2)=                                    *
I I I    *     * BASTAF(UNITS,ISIZE,J2)+BASTAF(UNITS,ISIZE,I)             *
I I I    ******************************************************************
I I I                                     I
I I I                                     I
I I I                                     I
I I I                                     I
I I I                                     I
I I I    ******************************************************************
I I ..............*  603 CONTINUE                                          *
I I      ******************************************************************
I I                                       I
I I                                       I
I I                                       I
I I      ******************************************************************
I I      *      BASTAF(UNITS,ISIZE,J3)=0                                   *
I I      ******************************************************************
I I                                       I
I I                                       I
I I                                       I
I I      ******************************************************************
I I I.............*      DO 604 I=I5,I6                                   *
I I I    ******************************************************************
I I I                                     I
I I I                                     I
I I I                                     I
I I I    ******************************************************************
I I I    *      BASTAF(UNITS,ISIZE,J3)=                                    *
I I I    *     * BASTAF(UNITS,ISIZE,J3)+BASTAF(UNITS,ISIZE,I)             *
I I I    ******************************************************************
I I I                                     I
I I I                                     I
I I I                                     I
I I I    ******************************************************************
I I ..............*  604 CONTINUE                                          *
I I      ******************************************************************
I I                                       I
I I                                       I
I I                                       I
I I      ******************************************************************
I I      *      BASTAF(UNITS,ISIZE,J4)=0                                   *
I I      ******************************************************************
I I                                       I
I I                                       I
I I                                       I
```

```
      DO 605 I=I7,I8

      BASTAF(UNITS,ISIZE,J4)=
     * BASTAF(UNITS,ISIZE,J4)+BASTAF(UNITS,ISIZE,I)

  605 CONTINUE

      BASTAF(UNITS,ISIZE,K1)=BASTAF(UNITS,ISIZE,J1)+
     *BASTAF(UNITS,ISIZE,J2)+BASTAF(UNITS,ISIZE,J3)+
     *BASTAF(UNITS,ISIZE,J4)

  601 CONTINUE

      IF(KSKIP.GT.1) GO TO 606

      WRITE(IW,803)
  803 FORMAT('1',T35,'STAFF REQUIREMENT FOR COAL-FIRED POWER PLANTS'/
     *        ' ',T45,'WITH FGD SYSTEMS'/
     *        ' ',T45,16('-')/
     *        ' ',T45,'UNIT SIZE RANGE MW(E)'/
     *        ' ',T42,'400-700',T62,'701-1300'/
     *        ' ',T36,17('-'),T56,19('-')/
     *        ' ',T36,'NO. UNITS PER SITE   NO. UNITS PER SITE'/
     *        ' ',T38,'1    2    3    4    1    2    3    4'/
     *        ' ',T36,17('-'),T56,19('-'))
      WRITE(IW,805)
  805 FORMAT('C',T7,'PLANT MANAGER''S OFFICE'/)

      DO 600 I=I1,I8

      WRITE(IW,800) (TITLE(J,I),J=1,3)
     *,((BASTAF(UNITS,ISIZE,I),UNITS=1,4),ISIZE=1,2)
  600 FORMAT(' ',T10,3A8,8(2X,I3))

      IF(I.EQ.I2)WRITE(IW,811)
     * ((BASTAF(UNITS,ISIZE,J1),UNITS=1,4),ISIZE=1,2)
```

```
      IF(I.EQ.12)WRITE(IW,806)

  806 FORMAT(' ',T7,'OPERATIONS'/)

      IF(I.EQ.14)WRITE(IW,811)
     * ((BASTAF(UNITS,ISIZE,J2),UNITS=1,4),ISIZE=1,2)

      IF(I.EQ.14)WRITE(IW,807)

  807 FORMAT(' ',T7,'MAINTENANCE'/)

      IF(I.EQ.16)WRITE(IW,811)
     * ((BASTAF(UNITS,ISIZE,J3),UNITS=1,4),ISIZE=1,2)

      IF(I.EQ.16)WRITE(IW,808)

  808 FORMAT(' ',T7,'TECHNICAL AND ENGINEERING'/)

  600 CONTINUE

      WRITE(IW,811)
     * ((BASTAF(UNITS,ISIZE,J4),UNITS=1,4),ISIZE=1,2)
  811 FORMAT(/  T13,'SUBTOTAL',T34,8(2X,I3)/)
      WRITE(IW,820)
     * ((BASTAF(UNITS,ISIZE,K1),UNITS=1,4),ISIZE=1,2)
  820 FORMAT( T13,'TOTAL',T34,8(2X,I3)/
     *         ' ',T34,8('  ==='))

  606 CONTINUE
      ISIZE = ISIZE2
      UNITS = UNITS2
      SUPEXF=1400.
      VSEMIL = .05
      VARFAC = 1.0 - FIXFAC
```

```
*C  NOTE... RATIO OF ESCALATION FACTORS ELIMINATES WAGE ESCALATION FROM   *
*C          MANCOS AND REPLACES IT WITH MATERIAL ESCALATION RATE          *
*      BASM=(FACMAT/(1.-FACMAT))*BASTAF(UNITS,ISIZE,J3)                   *
*     * *(MANCOS/1000.)                                                   *
*     * *((100.+ESMATL)/(100.+ESWAGE))**(YEAR-BASEYR)                     *
*      STAFF = BASTAF(UNITS,ISIZE,K1)                                     *
*      FIXMNT = FIXFAC * BASM                                             *
*      VARMNT = VARFAC * BASM          * (PLTFAC/.80)                     *
*      TOTMNT = FIXMNT + VARMNT                                           *
*      KSKIP = KSKIP + 1                                                  *
***************************************************************************
                                    I
                                    I
                                    I
***************************************************************************
*      RETURN                                                             *
***************************************************************************


***************************************************************************
*      END                                                                *
***************************************************************************
```

```
                                    (ENTRANCE)
                                        I
                                        I
*************************************************************************
*      SUBROUTINE BYE                                                   *
*      REAL*8 TODAY, VERS, CLOCK                                        *
*      DATA VERS/' 5-16-78'/                                            *
*      CALL IDAY(TODAY)                                                 *
*      CALL TIME(CLOCK)                                                 *
*      DATA IW/6/                                                       *
*      WRITE(IW,864) TODAY                                              *
*  864 FORMAT('1',T10,'DATE OF COMPUTER RUN ',A8)                       *
*      WRITE(IW,869) CLOCK                                              *
*  869 FORMAT(' ',T10,'TIME OF COMPUTER RUN ',A8)                       *
*      WRITE(IW,863) VERS                                               *
*  863 FORMAT('0',T10,'OMCOST, VERSION ',A8)                            *
*************************************************************************
                                        I
                                        I
                                        I
*************************************************************************
*      RETURN                                                           *
*************************************************************************


*************************************************************************
*      END                                                              *
*************************************************************************
```

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