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Nonfuel Operation and Maintenance Costs for Large Steam-Electric Power Plants—1982

M. L. Myers
L. C. Fuller
H. I. Bowers

Prepared for the
U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
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NONFUEL OPERATION AND MAINTENANCE COSTS FOR LARGE STEAM-ELECTRIC POWER PLANTS – 1982

M. L. Myers L. C. Fuller
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ABSTRACT

Revised guidelines for 1982 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 January 1979 in ORNL/TM-6467, *A Procedure for Estimating Nonfuel Operation and Maintenance Costs for Large Steam-Electric Power Plants*. Estimates for coal-fired plants include the option of scrubbing for flue-gas desulfurization. A computer program, OMCOST, that covers all plant options is also revised.

Keywords: operation and maintenance costs, power plant economics, economic evaluations, LWR, coal plants, steam-electric plants, flue gas desulfurization.

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1. INTRODUCTION

This report delineates a procedure for estimating annual nonfuel operation and maintenance (O&M) costs for large steam-electric power plants. Since 1978, when the previous cost-estimating procedure was developed and reported in ORNL/TM-6467 (Ref. 1), a number of developments have affected parts of the procedure significantly. The existing large generation sources for new baseload steam-electric power plants are the light-water reactor (LWR) plants and the coal-fired plants. The LWR plants incorporate the concepts of both the boiling-water reactor (BWR) and the pressurized-water reactor (PWR). The LWRs are treated in the 800- to 1200-MW(e) class and in arrangements of one to four units per plant site; coal plants are similarly treated in unit sizes of 400 to 800 MW(e). Significant cost developments in LWR plants have increased the costs of operating the plant, managing physical security, and conforming with state and federal regulations. In addition, plant operators have concentrated their efforts on maintaining high plant output. The result is that the use of labor and materials has increased at rates in excess of the inflation rate.

Tables 1.1 and 1.2 show comparisons of the 1982 cost-estimating guidelines developed in this study with the 1978 cost-estimating guidelines developed in a previous study. Both sets of costs are presented in 1982 dollars to facilitate the comparisons. Nuclear plant O&M cost estimates have more than doubled principally because of increases in onsite staffing requirements, offsite support services, insurance costs, and

Table 1.1. Comparison of 1982 and 1978 annual O&M cost-estimating guidelines for a 1 x 1150-MW(e) PWR plant at 65% capacity factor

(millions of 1982 dollars)

	1978[a]	1982
Onsite staff	6.6	14.8
Maintenance materials	2.3	4.3
Supplies and expenses	6.0	5.5
Regulatory fees, inspections, and reviews	0.1	0.5
Offsite support services	0	3.7
Insurance	0.4	6.0
Administrative and general	2.2	8.6
Total	17.6	43.4

[a]ORNL/TM-6467 (Ref. 1) escalated to 1982 dollars.

Table 1.2. Comparison of 1982 and 1978 annual O&M cost-estimating guidelines for a 2 x 575-MW(e) coal-fired plant at 65% capacity factor

(millions of 1982 dollars)

	1978[a]	1982
Onsite staff	9.9	9.5
Maintenance materials	4.2	4.0
Supplies and expenses	16.7	13.5
Regulatory fees, inspections, and reviews	0	0
Offsite support services	0	1.1
Insurance	0	0.2
Administrative and general	1.7	8.4
Total	32.5	36.7

[a]ORNL/TM-6467 (Ref. 1) escalated to 1982 dollars.

administrative and general expenses. The ~10% increase for coal plants is due to the increase in administrative and general expenses partially offset by decreases in onsite staffing requirements and supplies and expenses related to flue-gas desulfurization systems. Insurance costs and other administrative and general expenses, which are included here, are not traditionally included in O&M expenses reported by electric utilities to the federal government. Insurance costs include premiums for property-damage insurance, nuclear liability insurance, and replacement power insurance. Other administrative and general expenses are utility company overhead costs that are not chargeable to the direct O&M cost accounts. They include an allocation for compensation for executives and related expenses, legal expenses, certain regulatory expenses, and outside services.

The cost-estimating procedure involves the application of empirical functions that represent historical experience plus new factors arising from regulatory, operating, and economic considerations. 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 or segregated. Factors considered in formulating guidelines were plant design, training, organization, personnel motivation, outage planning, regulatory requirements, load, hours of service, and number of outages and start-ups.

The procedures for determining O&M costs are incorporated in the OMCOST computer program that is designed to assist in examining average trends in costs, determining sensitivity to technical and economic factors, and providing cost projections. 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 series of digital computers and requires about 52 K bytes of core. Execution time for 20 cases is about 1 s on the IBM 3330. The program can be obtained from the National Energy Software Center, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439.

2. FACTORS AND TRENDS AFFECTING O&M COSTS

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. In recent years political, regulatory, technical, and social influences, along with changing philosophies of management and operations, have had strong influence. These are not adequately reflected in the historical data now available publicly. Therefore, data from public records are not always applicable until adjusted for recent effects in those areas that are changing. Although gross dollars expended for overall operations may be available, segregation of these dollars into the major cost categories of labor, materials, or systems either is not sufficiently detailed to identify expenditures or is considered company confidential and not available. Because this breakdown for making 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.

2.1.1 Plant size and number of units

In practice, selecting unit size, fuel, and number of units is complex. This decision is especially difficult in the present economic conditions. Three important components considered in the evaluation of busbar energy costs are the fixed charges on the plant capital investment, O&M expense, and fuel expense. Historically, O&M costs are the least. This component has become more important because of recent operating requirements and now compares with the fuel cost for some older operating nuclear plants. This is not true for coal plants since fuel costs are very high.

New nuclear units are predominantly 1200 MW(e), whereas coal units are 400 to 800 MW(e). Thus the evaluation of new plants may involve units of different sizes — for example, three 800-MW(e) coal units might be compared with two 1200-MW(e) nuclear units or two 600-MW(e) or three 400-MW(e) coal units with one 1200-MW(e) nuclear unit.

2.1.2 Retrofitting

Examples of outstanding retrofitting requirements for nuclear plants include reactor safety systems, radioactive waste systems, and heat rejection systems including controls and instrumentation. Also, after commercial operation begins, the cooling systems, gas cleaning systems, and waste management systems of coal plants may undergo major design modifications to incorporate improved operation economics or meet new regulatory requirements. Expenses for these alterations are primarily of a capital

investment cost nature; although in practice for small projects, the charges may appear totally or in part in the annual O&M cost. In this report, such costs are assumed to be major changes and capitalized.

2.1.3 Unit 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. In fact, coal plant maintenance may be reduced to meet system load. On the other hand, nuclear plants are also subject to mandatory inspection outages as a result of conditions found in similar reactors at other plants. Some shutdowns are often brief (3 to 6 d), but, by their frequency, add up to unexpected maintenance expenses as well as replacement power costs usually of a higher magnitude.

Estimated plant availability factors for different types of outages are given in Table 2.1. 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. Since 1978, nuclear units have been subject to increased outages for safety or corrective action needs. The impact on average annual availability is not clearly defined at this time, although an allowance is given in Table 2.1.

Table 2.1. Estimated availability of 1200-MW(e) LWR units and 800-MW(e) coal units in the United States

Plant type	Estimated outage data [weeks per year (percentage rate)]			Availability (percentage rate)
	Forced[a]	Scheduled	Unscheduled	
Coal	6 (11.5)	6 (11.5)	1 (1.9)	75
Coal with FGD	7 (13.5)	6 (11.5)	3 (5.8)	69
LWR	6 (11.5)	8 (15)	4 (7.7)	66

[a]Equivalent forced outage data are not considered.

2.1.4 Plant protection

Because of public safety considerations, plant protection for nuclear power plants has become a regulated activity. Personnel safety onsite and property protection are the principal concerns for coal plants and also apply to nuclear plants. Assurance of a reliable power supply is important for both cases.

2.1.4.1 Plant physical protection. Operators of nuclear plants are required to prepare and implement security plans or procedures that meet the approval of the Nuclear Regulatory Commission (NRC). Currently, security at coal plants is minimal, and some plants have no formal security staff. However, considering the many occurrences of damage to both public and private property, this expense for plant security is included for all coal plants. Personnel staffing for nuclear plants assumed for this report meets the current resource guard requirement of 10 CFR Part 73.55 and NRC's Physical Upgrade Rule.[2] For cost assessment purposes, security personnel are outlined in Table 2.2. The data for specific plants will vary from the values shown. Since 1978, security personnel have increased, and the skill requirements are greater. Personnel selection and training have also been upgraded. Contract service is used by many utilities and therefore may not be included in staff numbers. Because of the security nature of this work, the number of personnel is not reported or is confidential. Testing and maintenance of intrusion alarms, emergency alarms, access control equipment, communication equipment, physical barriers, and other security-related devices add an important amount of work to the annual maintenance costs. Plant maintenance outages also increase security requirements.

Table 2.2. Physical security force for nuclear and coal plants

Number of plant units	Captains	Lieutenants	Officers	Clerks	Total
		Nuclear[a,b]			
1-4	1	7	84	3	94
		Coal			
1-4		1	6		7

[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 and NRC's Physical Upgrade Rule.

[b]Extended plant outages require additional forces.

2.1.4.2 Plant fire protection. The purpose of fire protection systems for nuclear power plants is twofold.[3] The first is to maintain the ability to perform essential safety functions to limit radioactive release to the environment to acceptable levels in the event of a fire. The second relates to insurance aspects to protect the interests of utility company stockholders.[4]

Since the Browns Ferry fire in 1975, a concern and lack of phenomenological understanding about fires has resulted in what has been called a "defense-in-depth"[5] regulatory policy for power plant fire protection. In October 1980, the NRC fire protection rule was passed. The rule affects all plants licensed before 1980 and requires retrofitting systems and equipment to assure that fire would not destroy redundant safety systems. Another rule[6] being considered for 1983 promulgation would affect plants with post-1980 operating licenses. These policies require the use of numerous measures to prevent and control fires, including requirements for fire retardancy, automatic detection, fire barriers, automatic suppression, and fire brigades. The impact on plant O&M activities is not well defined because of interpretations and specific plant configuration needs. Except for certain testing and maintenance of hardware, the personnel involved are principally supervisory or technical.

2.1.5 Buildings and grounds

Housekeeping and grounds upkeep involves a number of people, especially for nuclear plants. This portion of the onsite staff is not consistent among plants because of work rules and operation philosophy. While coal plant requirements are optional, nuclear plants are under strong pressure to maintain this work, which is closely supervised. This cleanup is principally related to outage periods. Although aesthetics and pride in operation are the more obvious results, nuclear plants benefit in particular due to inherent problems related to radioactive contamination control. Personnel for these functions are classified under administrative functions in this report.

2.1.6 Training and licensing

Assuring public safety, including onsite personnel, and the production of efficient, reliable electricity supply have brought on-going training and routine testing of personnel to a high level of importance. Initial staff training that is conducted over a period of months to years is incorporated in the plant construction-phase costs. All subsequent expenses during commercial operation are charged to the direct O&M accounts.

2.1.6.1 Coal plants. Coal plant operator teams work one of three 8-h shifts per day. Typically, a plant has about five such teams allowing the equivalent of two teams to be available to cover maintenance outages, sickness, vacations, other miscellaneous personnel absences, and training. Usually, the shifts rotate 8 h every week through a complete rotation of shifts every 4 weeks. Unlike nuclear plants, coal plants are not subject to federal regulatory operator licensing. Due to increasing cost of coal and replacement energy since 1978, the principal changes have been to ensure an operator's complete familiarity with the specific plant being operated. Utilities have always acknowledged the need for effective training for personnel safety and efficiency of operation. Now more efforts are needed because of the introduction of more sophisticated controls and analytical instrumentation and the requirements for more

rigorous operating conditions.[7] Thus, the requirement for highly skilled and trained personnel has become very important. Unlike the experience of nuclear plants, operators in fossil plants are more likely to be exposed to violent injury and must be trained to cope with and to minimize this personal injury as well as loss of plant operation. Two recent events illustrate this little publicized fact of coal plant life. On Sunday, August 7, 1977, at ~6:30 AM, the 12-in. main steam line at the Williamsburg Station Unit 5 of the Pennsylvania Electric Company ruptured, killing six men.[8] These were plant personnel engaged in performing a routine maintenance operation of turbine water washing to clean blading. The second event[9] occurred at the Commonwealth Edison plant at Pekin, Illinois. At 4:10 AM on October 14, 1980, a spontaneous explosion in the coal breaker room resulted in injury that required hospital care for 7 of the plant's 15-person work force. The same event happening on the day shift would have exposed many more people to injury.

2.1.6.2 Nuclear plants. Nuclear plants are regulated both in regard to key personnel and scope of staff. Since May 1979, industry standards have been subject to technical and even emotional analysis.[10] In 1978, the NRC initiated overhaul and upgrading of the entire operator training system. The impact on onsite staff has not been significant in adding large numbers of shift operators but has been more significant in requirements for technical support and training. Many more technical people both onsite and offsite are involved in design and procedural activities than were previously involved. As with coal plants, operator teams work similar shift rotation, but key personnel are limited in duration of shift work. More work shifts or teams (six or more) are provided to perform relief, training, and operator functions. Considering eight people per shift at an average cost of $40,000 per year including fringes, the annual expense is $320,000 per shift. The 3-year preoperation on site is also an added cost to construction for new plants.

While in 1977 only a select group of utilities[11] had in-house simulator facilities for personnel training, now all nuclear plants are under obligation to provide this feature along with updated training provisions. The design and use of these training devices are under constant review and analysis at this time. A study issued in January 1981 (Ref. 12) concludes that the use of simulators in the nuclear industry has grown without the benefit of either a systematic methodology or a comprehensive regulatory structure; as a result, simulator requirements and training programs are specified largely by subjective judgment of the training staff, utility management, and possibly the simulator vendor. The effect that standardization of training programs will have on annual costs is probably small compared with the capital investment costs for training facilities.

As well as technical and operational upgrades, training and retraining efforts also involve all other work functions including security, maintenance, records, and participation in public and plant emergency functions.[13]

2.1.7 Spare parts and consumables

Requirements for spare parts in nuclear plants are subject to many factors, which not only affect the cost of items but also the number of parts required. Storage, handling, quality, and maintenance requirements and procedures add an important impact on costs compared with coal plants. Both plant type inventories are subject to long or uncertain lead times due to lengthy delivery schedules. Many items can be field-repaired on coal plants that cannot be field-repaired on nuclear plants because of the reluctance of maintenance service companies to bid on work qualified by nuclear standards. Thus, new parts are usually required. Such items may come from the exchange of parts between utility companies or from similar equipment awaiting installation at another plant under construction.

Since 1978, consumables have not been strongly affected for either plant type except in quantity for some items. Cost increases for consumables have approximately followed inflation rates.

2.1.8 Environmental considerations

Compliance with developing and revised guidelines from the various federal regulatory agencies is considered for major cost categories in the sections dealing with controlling solid, gas, and liquid wastes. These services may require contract and consulting groups. The changes affecting operating costs have been limited to specific operation processes and practices identified in Sect. 2.1.11 as "by-products management."

Federal requirements regarding materials movement across state boundaries either as an airborne substance or as overland movement may influence operating costs by reducing power levels and by requiring new onsite processes.

2.1.9 Personnel

Fringe costs for personnel are continuing to have a strong impact on the annual average cost of employees in both nuclear and coal plants. While total plant employees per megawatt are about the same for coal plants as in 1978, the number has almost doubled for nuclear plants. Problems with staffing continue to abound because of the shortage of qualified labor supply, turnover, overtime and shift work, plant site location, and proximity to educational institutions.

2.1.10 OSHA regulations

The regulations set forth by the Occupational Safety and Health Administration (OSHA) are primarily directed toward personnel safety as related to normal operations. These rules apply equally to coal and nuclear plants. As in 1978, it is expected that such measures will increase with time and with changes in the political system. Pending OSHA rules for cancer-causing substances are an example of possible cost

impact on annual operating costs. In this study, the effect of OSHA rules has not been shown separately. OSHA requirements do not necessarily create operational penalties. Initially, implementation of OSHA requirements was probably considered penalizing; however, some innovative developments may have improved job performance along with worker safety.

2.1.11 By-products management

In 1977, Congress passed a law to manage "hazardous wastes." This term is still undefined, and the scope has not been fully determined. There are regulatory requirements regarding both nuclear materials and chemicals, which apply to unavoidable by-products of power plant operations. The questions on ultimate disposal still exist.

In this report, the cost impacts are estimated for coal plant by-products, which include flue-gas desulfurization, flyash, and related materials. For nuclear plants, the fuel by-products managed are low-level radioactive liquids, solids, and gases. High level wastes (HLW) are associated with offsite spent-fuel management.[14] Low level wastes (LLW) are treated as dry and wet wastes. The dry materials generally contain trash comprised of items such as paper, rags, plastics, rubber, wood, glass, and metals that can be classified as combustible or noncombustible and compactible or noncompactible. Most of the wet wastes are derived from cleanup of aqueous processes prior to recycle or discharge to the environment. The volume of LLW is related to refueling and maintenance activities or to regeneration of ion exchange resins. In general, PWRs generate less LLW (volume/MWh output) than BWRs.[15,16] Since 1978, handling costs have been impacted by waste disposal laws enacted by some states. These laws require permits to show evidence of liability insurance specified by the state and to hold the state harmless with respect to "radiological injury or damage" during transportation of waste into or within the state.[17]

There have been six commercial LLW repositories in the United States, but only three remain in operation with use very restricted. Projections by the U.S. Department of Energy (DOE) of commercial LLW volumes requiring disposal through the year 2000 show that additional disposal capacity will be needed. Within 10 years, the disposal of low-level commercial wastes may require five to seven regional sites, including the three currently in operation.[16]

2.1.12 Federal and state emergency operating requirements

Following the Three Mile Island No. 2 (TMI-2) accident in 1979, federal, state, and local authorities have instituted emergency procedures for responding to major radiological events at every nuclear power plant. Each plant must have plans for onsite and offsite (out to 50 miles) application. Certain exercises are required yearly, and the total procedure has to be performed every 10 years. One such demonstration estimated to cost about $2 million (Ref. 18), performed on July 29, 1981, at the Zion Nuclear Power Plant of Commonwealth Edison Company, was an enormous and complex exercise. Some 2000 to 3000 principal players in 14 cities, 2 counties, 2 states, 2 state capitals, and the NRC's emergency

center in Bethesda, Maryland, were involved in this partial demonstration of the emergency procedures. At present, there are about four such exercises per month. This number will more than double when present plants being built are commissioned.[19] Emergency procedure exercises have been declared by NRC to be protective measures to bolster the protection provided by siting and engineering design features.[20]

2.2 Plant Features and Practices

Each plant type has unique requirements that control the nonfuel O&M expense to varying degrees. O&M are likely to be complicated by designs incorporated in the early 1970s. Optimizing the limitations of machinery, people, and suppliers of equipment and materials represents an organizational challenge without parallel.[21] Outages involve a need to correlate unit commitment, other power production systems, and fuel management. Regulatory requirements, inspections, procedures, records, and approvals require close cooperation among several groups.

Maintenance scheduling for operations purposes is a full-time activity since outage scheduling covers a year or more. Outages are usually several weeks in duration. Choosing a schedule to minimize annual production costs involves complex simulations and many approximations. Minimizing outage duration for coal plants within "reasonable variations" may not have significant effect on production costs.[21] Outage intervals must have flexibility to maximize average weighted availability. Each plant type has unique characteristics of loading, capacity, fuel, and design.

The approach that an individual plant takes to conduct maintenance varies even within a utility. While this practice may appear arbitrary, there are several controlling factors besides philosophy: (1) labor practices, (2) available replacement power, (3) size of fixed labor forces, and (4) other personnel available. Practices are now moving toward more "standard" maintenance with the trend in standard plant designs.

2.2.1 BWR plants

The direct steam cycle is the distinguishing feature of the BWR plant design. In the BWR, steam is produced in the reactor vessel, then routed directly to the turbine, condensed, and returned to the reactor vessel. In the process, the need for major components like a pressurizer and multiple steam generators is eliminated. Maintenance histories have marked steam generators in PWR plants as significant contributors to loss of availability. On the other hand, certain components such as condensate demineralizers and other service systems in the BWR plants are offsetting. Current product design and service programs have assisted licensees to reduce refueling and maintenance outages and minimize forced outages. From 1975–1978, the NRC Gray Book showed a favorable trend for BWR units in availability and capacity factors reaching 79 and 67%, respectively. In 1979 and subsequently, performance has been less favorable. The vendor offers maintenance training, engineering and test facilities, and other services for achievement of performance.

Historically, BWR plants have shipped larger amounts of radioactive wastes than have PWR plants. With current limitations on LLW repositories, various processes and procedures have greatly reduced these shipments for both BWR and PWR plants. Therefore, it is expected that in the future such wide difference will reflect management techniques rather than plant type.

2.2.2 PWR plants

As with the BWR plants, the design of PWR plants for safe, reliable, and efficient operation involves a full knowledge and understanding of the activities that must be carried out to operate and maintain the plant. The big difference from coal plants is that personnel access to components is complicated by personnel exposure to radiation, heat, and inert gases, and by exacting procedures. Because there are three major vendors for PWR plant reactor systems, the variety of possible maintenance jobs is greater, and proprietary-information problems probably arise more frequently. This may appear at the plant level as well as at regulatory proceedings. Currently, owners' groups have been asked to consider modifications to eliminate or mitigate the effects of "severe overcooling transients." The reports must include schedules for remedial action and analyses to support continued operation.[22] This impact has not been estimated.

2.2.3 Coal plants

The criteria for the design of coal plants are many and varied. Unit size and coal characteristics are, however, the most significant factors influencing the design and power production. The available sources of coal with the associated federal emission regulations on sulfur oxides, nitrogen oxides, and particulate matter force the use of a variety of coals and control systems comparable to chemical industry practices. The influence that these factors have on plant design and operation may be significant and is not easily determined until plant operation. For example, the operation of nonregenerative flue-gas desulfurization equipment is expected to reduce the gross output of a high-sulfur coal plant by ~5%. However, the further effects of coal variability may be even greater. Without proper evaluation, burning the lowest-cost coal may be more costly in the long run than burning more expensive higher-grade coal.[23]

The same human factors apply to coal plants as to nuclear plants.[24] In the past, plant facilities were designed for work forces of a few hundred people. Now these plants are confronted with managing forces of several hundred during outages. Equipment access is also a chronic problem originating in designs of the early 1970s.

Special repair procedures such as flame spraying and new surfacing alloys are available to coal plants and may contribute to expediting repairs. Vendors are reluctant or will not quote on similar applications for repair of nuclear plant equipment due to the more stringent specification requirements involved.[25] Other repair procedures are available to

coal plants and reduce the need to shut down at inopportune times without sacrificing personnel or equipment safety.

2.3 TMI-2 Accident

2.3.1 Overview

On March 28, 1979, Unit 2 of the TMI Nuclear Station at Middletown (near Harrisburg), Pennsylvania, began experiencing severe operating difficulties resulting in shutdown. Low-level radiation was released to the environment but was not significant to public health or safety. The reactor core was damaged substantially. Extensive accident reviews were conducted by official commissions, regulatory bodies, and several other groups. The NRC has approved reports that consolidate corrective actions derived from its own and other studies of the accident. Certain requirements under these reviews remain to be defined either by additional study or by NRC rulemaking.

Other activities by state and federal agencies in reviews related to nuclear power plants are in progress or expected. In testimony before the House Subcommittee on Energy Research and Production on May 22, 1979, Milton Levenson stated:

> A significant number of the lessons, perhaps the majority of lessons, will have nothing to do with the accident, but will be learned because the system is being subjected to a scrutiny considerably more intense than has been the case in the past.

One such consideration by a state is a nonresident inspector to monitor both the utility operations and the NRC resident inspector.[26] Another consideration under review involves NRC inspection fees, which have not been updated since 1977. The actual "custom" review of a reactor unit exceeded by a factor of 3 the present fee schedule.[27] The impact of TMI-2 on this case is not indicated by NRC. Technical specification reviews, which include TMI-2 actions, inspections for safety and safeguards, and other related expenses (excluding fines) are estimated to amount to about $400,000 annually (1981 dollars).[28] Expenses can be expected to increase even without a fee schedule revision as more technical specifications are filed to meet reviews and regulations.

The aftermath of TMI-2 shutdown has resulted, and is expected to continue in the foreseeable future, in direct impacts on nuclear plant operations for existing and new operating licenses. The emphasis will be on striving for the continuing goal of "improved safety."[29] Carrying out this goal consists of implementing mandates in NUREG-0737 (Ref. 30) and other regulatory instruments, not all of which are TMI-2 related. The nuclear power industry (utilities, manufacturers, and architect-engineers) is also instituting many measures to minimize future abnormal occurrences of the importance of the TMI-2 shutdown.

2.3.2 Effect on O&M costs

The annual operating costs in 1982 dollars for implementing TMI-2 corrective actions at a reference plant are estimated by considering the principal effects in the area of operations, training, professional and technical personnel, maintenance, and related supplies and expenses. The full impact of TMI-2 changes cannot be completely indicated because some areas are still in the process of study, interpretation, and implementation. Except in this section, the annual costs of TMI-2 corrective actions will not appear as a separate division of annual O&M costs. The actions now apparent since 1979 are

1. a large increase in commitment of resources to on-going training involving simulators, instructors, and additional staff;
2. task analysis and human factors engineering efforts for a more analytical approach to operations;
3. Shift Technical Advisor training programs and degree requirements for certain operators; and
4. the establishment of guidelines and criteria for operations analysis by utilities through the Institute of Nuclear Power Operations (INPO).

An evaluation of the TMI-2 corrective actions suggests that O&M expenses for a single-unit nuclear plant are increased 4 to 8 million dollars per year (Table 2.3). A review of NUREG-0737* and industry actions shows the following items applicable to plant operations:

1. Shift Technical Advisors (STA) or equivalent in other operators,
2. emergency assistance and communications contacts,
3. upgraded training for licensed and unlicensed personnel,
4. shift manning and overtime limitations,
5. operating procedure overhaul and updating,
6. design and technical reviews,
7. responses to NRC concerns,
8. emergency preparedness,
9. equipment testing and operations reports,
10. operations support and technical data centers, and
11. extended radiation monitoring and gas sampling.

The licensee's additional personnel chargeable to TMI-2 actions are displayed in Table 2.3. Estimated costs have been presented for a single-

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*NUREG-0737, *Clarification of TMI Action Plan Requirements*, was published in November 1980. The document includes a tabular form with technical clarification of all the post-TMI-2 approved requirements but does not constitute the total of the TMI-2 Action Plan. Subsequently, NRC determined that new requirements should be codified into regulations. In August 1981, NRC commissioners voted against making NUREG-0737 Action Plan items a rule.[22]

Table 2.3. Evaluation of annual costs for a single-unit nuclear plant to implement TMI-2 corrective actions

Plant departments	Number of personnel additions
Site operations	1–12
Site training	6–12
Professional/technical	
Onsite	12–24
Offsite	12–24
Maintenance	6–12
Personnel totals	37–84
For estimating purposes	40–80
Costs	
Total annual personnel cost, $1000	3000–6000
Related supplies and expenses, $1000	1000–2000
Total annual cost, $1000	4000–8000

unit plant. For a 2-, 3-, and 4-unit plant at the same site, the multiplying factors to adjust costs are ~1.5, 1.9, and 2.3, respectively. It is generally expected that more efficient utilization of technical, professional, and maintenance personnel results at multiple-unit plants.

3. O&M EXPENSE ACCOUNTS

Appendix A contains excerpts from the Code of Federal Regulations governing the Federal Energy Regulatory Commission (FERC), 18 CFR 101, defining O&M expense accounts. This study is concerned only with the nonfuel accounts and the share of administrative and general expenses allocated to the power plant.

Internal operating records of utility companies may consist of hundreds of entries. From these entries, which are unique to each utility's accounting needs, an annual summary is prepared for the annual report to be submitted to FERC on Form 1. The detailed data used to prepare these annual summaries are not available for public inspection; however, the data submitted on Form 1 by a given utility company are available for public inspection at the public document room of FERC in Washington, D.C. The data for all reporting utilities are assembled by the Energy Information Administration (EIA) and published annually.[31] Table 3.1 displays the reported nonfuel O&M expenses for a two-unit nuclear plant over a period of several years. Although individual plant accounts vary considerably, the total direct cost per kilowatt-hour at the busbar for this plant is almost level from 1974–1978. Beginning in 1979, the trend rises sharply.

An example of a utility company summary breakdown of nonfuel O&M expenses is given in Table 3.2. This data and the breakdown in Table 3.1 illustrate some of the differences in reporting, such as combined labor and material costs, total generation system compared with best unit, and annual and monthly reporting, that makes 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 expenses for individual accounts in the reactor or boiler plant and in the turbine plant. The breakdown (Table 3.3) is designed to facilitate the derivation of certain costs related to expenditures for personnel, consumables, and indirect expense. The direct accounts encompass those nonfuel expenses defined in Steam Power Generation accounts 500–514 and Nuclear Power Generation accounts 517–532; the indirect account encompasses Administrative and General Expenses accounts 920–932 as allocated to the power plant. 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 or nearly so with plant output. Section 4 gives guides and bases for estimating costs for each of the nonfuel O&M expense accounts in Table 3.3.

Table 3.1. Actual nonfuel O&M expenses for a two-unit nuclear plant [500 MW(e) each]

	Account	Year							
		1974	1975	1976	1977	1978	1979	1980	1981
				Operation					
Supervision and engineering	517	$ 465,770	$ 176,901	$ 417,602	$ 445,620	$ 498,000	$ 561,965	$ 764,461	
Coolants and water	519	166,946	396,658	275,376	279,288	351,000	284,060	413,232	
Steam expenses	520	997,533	1,230,266	1,582,330	2,211,512	1,702,000	2,215,351	3,037,226	
Electric expenses	523	99,462	101,441	110,388	130,354	123,000	165,930	167,051	
Miscellaneous expenses	524	986,253	1,726,230	1,609,282	1,697,330	1,813,000	2,821,114	3,723,844	
				Maintenance					
Supervision and engineering	538	67,394	73,493	71,160	142,320	130,000	89,676	85,474	
Structures	529	161,296	199,743	85,344	126,086	235,000	203,397	814,103	
Reactor plant equipment	530	966,232	1,429,738	1,280,780	1,277,302	1,498,000	4,535,031	6,816,906	
Electric plant	531	1,243,081	722,661	1,054,088	1,600,910	858,000	1,283,414	1,710,183	
Miscellaneous	532	63,426	118,366	100,566	201,132	189,000	301,738	373,399	
Total nonfuel O&M		$5,217,393	$6,175,497	$6,586,916	$6,372,528	$7,395,000	$12,461,676	$17,905,878	
Mills/kWh		0.8	0.9	0.9	1.1	1.0	1.8	3.0	3.9[a]

[a]Personal communication (preliminary estimate) to M. L. Myers, February 1, 1982.

Table 3.2. Direct unit power costs for internal reporting of nonfuel O&M expenses for coal plants (monthly report) 1981

	Cost (mills/kWh)	
	System	Best unit
Operating supervision and engineering	0.085	0.062
Operating labor	0.666	0.362
Operating other expenses	0.260	0.147
Maintenance supervision and engineering	0.091	0.057
Maintenance labor	1.175	0.371
Maintenance other expense	0.942	−0.239[a]
Training	0.061	0.023
Other production expense	0.175	0.088
Total cost	3.455	0.871

[a]Credit.

Table 3.3. Nonfuel O&M expense accounts used in this report

Direct
Staff
Maintenance materials
Fixed
Variable
Supplies and expenses
Fixed
Variable
Regulatory fees, inspections, and reviews[a]
Offsite services[a]
Indirect[b]
Administrative and general
Insurance

[a]Expenses that can be charged directly to the power plant.

[b]Expenses allocated to the power plant.

4. COST-ESTIMATING GUIDELINES

4.1 Personnel

4.1.1 Staff requirements

Evaluating personnel needs is an important first step in estimating total annual O&M costs. Historically, a function of investment has been useful and is still useful in certain cases for many maintenance applications but is not as valuable to assess total O&M costs under present conditions of high capital investment costs.

To quantify plant staff for both coal and nuclear plants, the various functions and tasks have been studied. The results, which are displayed for nuclear and coal plants, respectively, in Tables 4.1 and 4.2, have been compared with information received from public and private utility sources. The data do not represent a survey composite but an analysis judged to be appropriate for the representative plant following mandatory job positions (nuclear cases) and performance consistent with staff and equipment generally expected today. This staffing has been developed primarily for estimating O&M costs and is not intended to be a recommendation for standardized staffing.

The functional organizational chart for each plant type has not been presented because organizations vary in position responsibility. The tasks displayed in Tables 4.1–4.4 are sufficient to develop several portions of the O&M costs. Table 4.5 shows the positions in LWR plants requiring NRC operator licenses. Licensed job positions are not required in coal plants by regulatory agencies.

Since 1979, the personnel needs for nuclear plants have expanded significantly in most areas, for both onsite and offsite activities. The distinction between onsite and offsite staff is their physical location. In both cases, expenses are charged to a direct plant account and should not be identified with administrative and general (A&G) expenses, which are distributed system wide. Offsite personnel charged to direct operating accounts do not appear in Tables 4.1–4.4, but are indicated as an expense termed "Offsite Support Services."

Generally, these increases occur because of increased physical plant security requirements, extra shifts for training and operating positions, increased efforts to improve performance and maintain equipment, and increased technical and engineering requirements for reports, technical performance evaluation, testing, and public safety.

New coal plants are considered to be equipped with flue-gas desulfurization (FGD) scrubbers and fly ash collection equipment (above 99% efficiency) regardless of coal quality. Revised Prevention of Significant Deterioration of Air Quality (PSD) regulations mandate, in effect, the application of the best available control technology. Potentially stringent control equipment for nitrogen oxides, heavy metals, and trace elements has not been included. Labor and materials expended in waste handling and disposal activities outside the immediate plant area are included in the unit costs for ash and sludge handling because these are variable costs and also may be contracted activities.

Table 4.1. Onsite staff requirement for LWR power plants

[800–1200 MW(e) unit size]

Function	Units per site			
	1	2	3	4
Plant manager's office				
Manager	1	1	1	1
Assistant	1	2	3	4
Quality assurance	6	6	7	8
Environmental control	1	1	1	1
Public relations	1	1	1	1
Training	12	12	12	12
Safety and fire protection	1	2	3	4
Administrative services	49	55	65	78
Health services	2	2	2	2
Security	94	94	94	94
Subtotal	168	176	189	205
Operations				
Supervision (excluding shift)	9	9	18	18
Shifts	52	104	156	208
Subtotal	61	113	174	226
Maintenance				
Supervision	12	14	26	28
Crafts	55	71	87	103
Peak maintenance annualized	55	110	165	220
Subtotal	122	195	278	351
Technical and engineering				
Reactor	5	5	7	7
Radiochemical	8	8	12	12
Engineering	16	16	16	16
Performance, reports, and technicians	21	30	39	48
Subtotal	50	59	74	83
Total	401	543	715	865
Less security	307	449	621	771
Less security and peak maintenance	252	339	456	551

Table 4.2. Onsite staff requirement for coal-fired power plants without FGD systems

[400–800 MW(e) unit size]

Function	Units per site			
	1	2	3	4
Plant manager's office				
Manager	1	1	1	1
Assistant	1	2	3	4
Environmental control	1	1	1	1
Public relations	1	1	1	1
Training	1	1	1	1
Safety	1	1	1	1
Administrative services	12	13	14	15
Health services	1	1	1	2
Security	7	7	7	7
Subtotal	26	28	30	33
Operations				
Supervision (excluding shift)	2	2	4	4
Shifts	45	50	60	65
Fuel handling	12	12	12	18
Subtotal	59	64	76	87
Maintenance				
Supervision	6	6	8	10
Crafts	75	90	105	120
Peak maintenance annualized	15	30	45	60
Subtotal	96	126	158	190
Technical and engineering				
Chemical	2	2	3	4
Instrumentation and controls	2	2	3	4
Performance, reports, and technicians	12	15	18	21
Subtotal	16	19	24	29
Total	197	237	288	339

Table 4.3. Onsite staff requirement for coal-fired power plants with wet FGD systems

[400–800 MW(e) unit size]

Function	Units per site			
	1	2	3	4
Plant manager's office				
Manager	1	1	1	1
Assistant	1	2	3	4
Environmental control	1	1	1	1
Public relations	1	1	1	1
Training	1	1	1	1
Safety	1	1	1	1
Administrative services	13	14	15	16
Health services	1	1	1	2
Security	7	7	7	7
Subtotal	27	29	31	34
Operations				
Supervision (excluding shift)	3	3	5	5
Shifts	45	50	60	65
Fuel and limestone handling	12	12	12	18
Waste systems	10	20	30	40
Subtotal	70	85	107	128
Maintenance				
Supervision	8	8	10	12
Crafts	90	110	130	150
Peak maintenance annualized	20	40	60	80
Subtotal	118	158	200	242
Technical and engineering				
Waste	1	2	3	4
Chemical	2	2	3	4
Instrumentation and controls	2	2	3	4
Performance, reports, and technicians	14	17	21	24
Subtotal	19	23	30	36
Total	234	295	368	440

Table 4.4. Onsite staff requirement for coal-fired power plants with dry FGD systems

[400–800 MW(e) unit size]

Function	Units per site			
	1	2	3	4
Plant manager's office				
Manager	1	1	1	1
Assistant	1	2	3	4
Environmental control	1	1	1	1
Public relations	1	1	1	1
Training	1	1	1	1
Safety	1	1	1	1
Administrative services	13	14	15	16
Health services	1	1	1	2
Security	7	7	7	7
Subtotal	27	29	31	34
Operations				
Supervision (excluding shift)	3	3	5	5
Shifts	45	50	60	65
Fuel and limestone handling	12	12	12	18
Waste systems	5	10	15	20
Subtotal	65	75	92	108
Maintenance				
Supervision	8	8	10	12
Crafts	77	94	111	128
Peak maintenance annualized	20	40	60	80
Subtotal	105	142	181	220
Technical and engineering				
Waste	1	2	3	4
Chemical	2	2	3	4
Instrumentation and controls	2	2	3	4
Performance, reports, and technicians	14	17	21	24
Subtotal	19	23	30	36
Total	216	269	334	398

Table 4.5. LWR plant positions requiring NRC reactor operator licenses[a]

Positions	Senior reactor operator	Reactor operator
Plant manager	1	
Assistant plant manager	1	
Training manager	1	
Shift supervisor	6	
Control operations supervisor	6	
Nuclear control operators		18

[a]Single-unit plant and six-shift staffing.

In the long term, the labor requirement for scheduled outages for maintenance will vary from year to year. To compensate for this effect, a four-year cycle of peak forces was developed and is presented in Table 4.6. This labor has been included, on an annualized basis, in the plant maintenance totals of Tables 4.1–4.4. The cycle includes all types of labor routinely charged to direct plant accounts expended beyond the normal onsite and offsite staffs, including security, technical, engineering, and contract services.

Table 4.6. Extra (or peak) personnel for scheduled overhaul[a]

Year of time cycle	Extra personnel/outage weeks	
	LWR	Coal with FGD
1	200/6	145/6
2	200/6	145/6
3	200/6	145/6
4	800/8	145/8

[a]46 weeks of work equals one person.

4.1.2 Salary expense

Average annual salary expense for power plant personnel has been developed as shown in Table 4.7. Although licensed reactor operators may receive higher basic hourly rates, both nuclear and coal-fired plant personnel have been assigned the same basic rate here; the differences have

Table 4.7. Development of average annual salary expense for power plant personnel

	Coal-fired plant	LWR plant
Basic hourly rate,[a] $/h	10.45	10.45
Multipliers		
Supervisory and technical support	1.10	1.20
Fringe benefits[b]	1.35	1.35
Premiums and penalties[c]	1.00	1.05
Total multiplier	1.49	1.70
Average hourly rate, $/h	15.50	17.80
Average annual salary expense, $	32,000	37,000

[a]Based on $9.65/h for the average hourly earnings of nonsupervisory workers in the electric, gas, and sanitary services[32] in March 1981 and increased by 8.2%.

[b]Insurance, social security, sick leave, and personal leave.

[c]Licensing, training, overtime, safety, radiation, and productivity.

been accounted for by assigning higher multipliers for fringe benefits, premiums, and penalties. Licensed LWR operators make up only about 5% of the onsite staff for nuclear plants. Nonlicensed positions in fossil and nuclear plants are not significantly different in function. However, considerably more preparation and training may be required to learn nuclear plant procedures for repairs and inspections and for control of personnel exposure to radioactivity.

The estimated average annual salary expense in 1982 (Table 4.7) is ~$32,000/year for coal-fired plants and $37,000/year for nuclear plants. This compares with estimates of $22,000/year and $23,000/year, respectively in 1978, corresponding to average annual increases of 10.7%/year for coal-fired plants and 12.6%/year for nuclear plants.

Because nuclear plants require total onsite staffing approximately double that of comparable coal-fired plants, the total annual payroll expense is significantly higher for nuclear plants.

4.1.3 Offsite support services

Engineering, research, and development expenses incurred offsite by company personnel, consultants, and others are charged to direct plant accounts. These charges constitute an important amount for nuclear plants

and less so for coal plants. The total number cannot be identified in a consistent manner using published data. However, it appears that a function related to onsite personnel can be used for cost-estimating purposes. Both nuclear plants and coal plants are estimated to require offsite staff equal to the onsite technical and engineering staff. Successive units at the same site are estimated to follow onsite plant staffing trends. For this study, the average annual salary expense for offsite personnel is estimated to be approximately double the onsite staff salary expense for nuclear plants and one and one-half times for coal plants.

4.2 Maintenance Materials

The amount of the various major replacement items, expendable materials, and related items used to maintain the power plant is variable throughout the plant life. Historical experience on older plant designs is publicly available in some technical reports.[33,34] However, the common method of reporting labor and material combined hinders the use of such data. Also, utilities do not report these expenses explicitly so that costs can readily be distinguished. For this study, the relationship of materials to maintenance labor was estimated by major tasks and consolidated for 80% plant capacity factor as shown in Table 4.8.

Table 4.8. Maintenance materials cost factors as a percentage of maintenance labor cost

Plant type	Percentage		
	Fixed	Variable[a]	Total
LWR	75	25	100
Coal	50	17	67
Coal with wet FGD	62	20	82
Coal with dry FGD	55	18	73

[a]Based on 80% plant capacity factor; varies in proportion to specified capacity factor.

4.2.1 LWR plants

Major retrofitting of plant systems or modifications involving capital investment are not considered in these cost procedures. Such costs may appear to some extent in the O&M expenses reported annually on Form 1 to FERC and need to be considered when examining reported data. Examples

of major retrofitting work are radioactive-waste-system alterations, safety-system additions, cooling-water-system modifications, and emergency onsite and offsite activities. Specific plants will report costs that may vary widely from year to year for individual expense accounts because of deferral of major work or because of unanticipated problems. The variable, or energy-related, component for nuclear plants is extremely difficult to define and may even be inversely related to energy generation because of the economic incentive to keep nuclear plants operating at the highest possible level. For this study, 25% of the total of maintenance materials at 80% capacity factor has been allocated to the variable component.

4.2.2 Coal plants

Day-to-day maintenance of coal-fired plants requires about the same onsite labor as that of LWR plants; however, when special and scheduled work is considered, coal-fired plant requirements are considerably less. Quality assurance documentation and related administrative controls are not required for regulatory purposes as in nuclear plants. Less effort is necessary for establishing reliable performance of a coal plant because public safety considerations are limited.

Maintenance costs are estimated for operation at baseload conditions near 100% capability. The number of starts and stops, for whatever reason, has an important effect on equipment life and maintenance. 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 waste, and valve deterioration. Both fossil-fueled and nuclear plant turbines may experience accelerated erosion and overheating at low loading.

Typical hot and cold starts for baseload units will average between 1 and 2 per week over the unit life.[35] Comparison with specific field data may show a wide difference because units may operate as either baseload or cyclic.

Variable maintenance costs are not reported separately on FERC Form 1 and are difficult to establish. For this study, 25% of the total of maintenance material at 80% capacity factor has been allocated to the variable component. This judgment is based on factors that influence incremental costs for coal pulverizers, fuel handling, heat transfer surfaces, and other maintenance supplies sensitive to load. An alternative approach, which can be used only if adequate operating data are available, is to plot annual maintenance costs as a function of annual generation. If a linear relationship is assumed, this procedure will establish the fixed cost level at the zero-load intercept.

To maintain performance, scrubbing and sludge-handling systems require careful attention to O&M. Although modular components may be serviced during reduced steam generator loads, major system maintenance will require boiler outages. The cost of materials for this work is judged to be about twice that of the associated labor. This relationship is included in Table 4.8 as part of the total plant maintenance.

4.3 Supplies and Expenses

Supplies and expenses include certain consumable materials and items 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 waste management. Costs of lime, limestone, ash handling, and sludge disposal associated with the dry and wet scrubbing process for FGD are also included but treated as a separate category. Although consumption 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 the aquifer from which it was withdrawn. Water rights in some parts of the United States, however, are highly appropriated, and siting of power plants in these areas 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.

Fuel oil for standby and emergency diesel-engine generators and for auxiliary steam for building heating is not a nonfuel O&M expense but is defined by the FERC as belonging in the fuel expense account for both nuclear and fossil-fueled plants (see Appendix A). In most evaluations, however, this expense (including handling) is overlooked in the fuel charges. An estimated allowance for a 1200-MW(e) LWR unit, which is not included here, is $1 million/year ($1 \times 10^6$ gal of No. 2 fuel oil at about $1.00/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.

Guidelines for estimating costs of supplies and expenses are summarized in Table 4.9. The variation with plant load is small over the range of operation covered in this report and is difficult to estimate because the fixed and variable components are not identified in published data.

The expense associated with the handling of radioactive wastes requiring long-term storage includes resins, 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 variations can be expected because of differences in designs for site location, fuel performance, and operating procedures.

The expenses for nonradioactive wastes are principally those related to treatment of various wastewater streams. Typical liquid waste flows for a coal-fired plant are given in Table 4.10. The higher cooling tower blowdown for nuclear plants tends to balance waste streams from air pollution control systems and ash ponds for coal-fired plants. Both LWR and coal-fired plants require the treatment of an estimated 1500 gpd/MW(e) of installed capacity. New plant designs provide for the extensive reuse of water. If the Resource Conservation and Recovery Act (RCRA) passed in 1976, which sets up a cradle-to-the-grave approach for handling hazardous

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

Category	LWR	Coal	Coal with FGD
Fixed costs, $1000/unit-year			
Potable water, lubricants, communication, security, transportation, laboratory chemicals, clothing, lamping, gases, and miscellaneous	900	600	600
Makeup water and chemicals	800	600	600
Training simulator and data-processing services	1600	500	500
Radioactive waste management	1200		
Nonradioactive waste management[a]	200	300	500
Total fixed costs	4800	2000	2200
Variable costs, mills/kWh	0.10	0.08	0.12

[a]May increase pending determinations by EPA regarding hazardous wastes.

Table 4.10. Typical liquid waste flows for a coal plant

Waste	Volume [gpd/MW(e)]
Air pollution control waste	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, p. 138 (April 1977).

wastes, should be applied to power plant effluents, then waste management costs may increase drastically.

An example for reagent (limestone or lime) and ash and sludge disposal costs for FGD systems is shown in Table 4.11. The principal supply is limestone or lime for wet and dry FGD systems, respectively, which varies directly with the sulfur content of the fuel and with the ratio of reagent to sulfur required in the scrubbing operation. The estimated unit cost of ash and sludge disposal, $5/dry ton, is based on onsite disposal using plant staff and equipment. The unit cost for offsite disposal using contract services is estimated to be $10/dry ton for a 10-mile haul distance.

Table 4.11. Example of FGD reagent and ash and sludge disposal costs

Item	Wet FGD	Dry FGD
Fuel, tons/year	3,000,000	4,000,000
Ash in fuel, wt %	11.6	7.3
Ash in fuel, tons/year	348,000	292,000
Sulfur in fuel, wt %	3.5	0.5
Sulfur removed, wt %	90	70
Sulfur removed, tons/year	94,500	14,000
Tons of reagent required per ton of sulfur removed[a]	4	1
Reagent, tons/year	378,000	14,000
Dry sludge, tons/year	378,000[b]	28,000[c]
Dry ash and sludge, tons/year	726,000	320,000
Cost of reagent, $/year	4,725,000[d]	980,000[e]
Cost of ash and sludge disposal,[f] $/year	3,630,000	1,600,000

[a]Approximation for cost estimating.

[b]Chemical reaction yields about 4 tons of dry sludge for 1 ton of sulfur and 4 tons of limestone.

[c]Chemical reaction yields about 2 tons of dry sludge for 1 ton of sulfur and 1 ton of lime.

[d]Limestone at $12.50/ton.

[e]Lime at $70/ton.

[f]At $5/ton, dry basis.

4.4 Regulatory Fees, Inspections, and Review Expenses

Safety, environmental, and health physics inspections for nuclear plants are routinely performed at specified frequencies 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 (1) direct observations of operations, (2) personnel interviews, (3) independent measurements and evaluations, and (4) selective record and procedure examinations. 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 fees and facility inspections are summarized in Table 4.12. The resident NRC inspector expense involves providing office space and related facilities, which are not itemized separately. In addition, at least one state is considering a nonresident inspector to review procedures and records, and several states are considering legislation requiring cost support from utilities for implementation of emergency preparedness plans. Facility inspection and review fees generally are not required for coal-fired plants.

Table 4.12. Estimated annual costs for nuclear facility inspections

	First unit	Each additional unit[a]
NRC fee[b]	$ 76,000	$ 60,000
NRC reviews[c]	300,000	200,000
Total	$376,000	$260,000

[a]At same time and site as first unit.

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

[c]Allowance for NRC costs; NRC professional manpower is about $40/h (1977); revision is expected in 1982.

4.5 Offsite Support Services

Costs for a number of activities by personnel not assigned full time to the plant site are also collected in power plant direct expense accounts. Although the scope of this work is greater for nuclear plants, coal-fired plants have similar charges. These expenses are not a part of overhead costs, which are described in Sect. 4.6. After the 1979 accident at TMI-2, nuclear plant offsite support increased as did onsite support.

While each utility organization varies widely in practice, an estimate of this scope has been made based on the number of onsite personnel in the technical and engineering category. The average annual salary expense of personnel in this group is expected to be approximately double that of the onsite average as determined in Sect. 4.1.2 or ~$74,000/year for a nuclear plant and $64,000/year for a coal-fired plant. The total annual cost of offsite support is estimated to be ~$4,000,000 for a single-unit nuclear plant and $1,300,000 for a single-unit coal-fired plant. Examples of these direct offsite functions are:

1. research and development on specific plant applications,
2. safety reviews,
3. offsite training center,
4. environmental radiation monitoring,
5. meteorological surveys,
6. engineered safety design,
7. power planning,
8. environmental studies,
9. computer activities,
10. purchasing plant items, and
11. fuel studies.

4.6 A&G Expenses

A&G expenses are overhead costs that are included in 18 CFR 101 under expense accounts 920–935 (see Appendix A). In general, this expense category includes A&G salaries and related expenses, legal and certain regulatory expenses, payment for outside services not applicable to direct accounts, welfare, pensions, and insurance (including nuclear liability). A value of 30% of the direct O&M expenses has been estimated for other A&G expenses, not including insurance.[36] Insurance expenses have been estimated separately in the following sections of this report.

4.6.1 Nuclear liability insurance

From the time nuclear fuel is delivered to a nuclear project site, the licensee is required to protect itself from public liability claims arising from a nuclear incident. This protection is provided through a three-layer combination of commercial insurance, self-insurance, and government indemnity as summarized with estimated annual premiums in Table 4.13.

The first layer is commercial nuclear liability insurance, the current maximum amount available being $160 million. The estimated premiums are typical for commercial insurance. Specific sites must be specified before firm rates can be quoted.

The second layer is a mandatory industry-wide program of self-insurance, under which nuclear plant licensees can be assessed for each operational reactor owned, an amount not to exceed $5 million for each nuclear incident and not to exceed $10 million/year in the event of more than one incident. With the 74 reactors licensed for commercial operation in

Table 4.13. Estimated annual premiums for nuclear liability insurance

Type of insurance	Premium cost for number of units			
	1	2	3	4
Commercial ($160 million)[a]	$400,000	$562,000	$723,000	$885,000
Self ($370 million)[b]	10,000	20,000	30,000	40,000
Government ($30 million)[c]	18,000	36,000	54,000	72,000
Total ($560 million)	$428,000	$618,000	$807,000	$997,000

[a]Typical premiums for commercial insurance; specific sites must be specified before firm rates can be quoted.

[b]Estimated allowance; see text.

[c]$6/MW(t) for a maximum of 3000 MW(t) for each reactor.

January 1982, this self-insurance produces $370 million in coverage. There are no requirements for annual payments or premiums to establish a fund to cover this potential liability. However, the annual financial risk per reactor for this self-insurance can be estimated from the probability distribution of offsite mitigation measures' cost resulting from severe radioactivity releases, which have been presented in recent environmental impact statements.[37,38] For both PWRs and BWRs, the probability per reactor per year of the total cost of offsite mitigation measures exceeding $160 million is estimated to be on the order of 10^{-5}. Thus, the estimated financial risk, assuming 100 operating reactors, is $10,000/year [($10^{-5}$/reactor year) x (100 reactor years) x (2 incidents/year) x ($5 x 10^6/incident) = $10,000/year]. There is obviously a great deal of uncertainty in this estimated value. It could easily vary higher or lower.

The third layer is a federal government indemnity that makes up the difference between the total of the commercially available liability insurance and the self-insurance and $560 million, which is currently the maximum liability per occurrence under the Price-Anderson Act.[39] Currently, the premium is $6/MW(t) for a maximum of 3000 MW(t)/reactor. As the number of reactors increases, the government indemnity will gradually be phased out. However, in the Price-Anderson Act, Congress expressed the intent that the $560 million limitation will be raised if available assessments exceed that limit.

For commercial coverage, experience has shown that after ten years, a portion of the premium is refunded. The refund program operates by placing 70% of each year's premium in a reserve fund used only to pay claims and related expenses. After ten years, the unused portion of the reserve is refunded. From 1971 to 1980, which included the 1979 accident at TMI-2 (Ref. 40), refunds totaling $1.7 million were issued.

4.6.2 Property-damage insurance

The NRC issued a new rule in March 1982 that requires electric utility licensees "to obtain onsite property-damage insurance available at reasonable costs and on reasonable terms."[41] This rule requires, as a minimum, primary nuclear property insurance that is offered by Nuclear Mutual Limited (NML) or American Nuclear Insurers (ANI) and Mutual Atomic Energy Reinsurance Pool (MAERP), plus excess property insurance offered by either Nuclear Electric Insurance Limited (NEIL) or ANI/MAERP.[42] Primary nuclear property-damage insurance in the amount of ~$450 million is now available, and this is expected to increase to $500 million by the end of 1982. The nuclear insurance pools and the Edison Electric Institute (EEI) have announced plans to develop additional nuclear property-damage insurance in the amount of $500 million, which will eventually provide a total of $1 billion in coverage. At present, about $300 million of the excess property-damage insurance is available. References 41-46 provide a more complete discussion of nuclear property-damage insurance availability and estimated costs.

Property-damage insurance for coal-fired plants is usually part of an overall policy that includes all fossil plants owned by the utility and that may include other utility plant property such as transmission, distribution, and general plant. The estimated premium to be allocated to a large coal-fired plant is ~$100,000/year.

Recommended cost-estimating guidelines for property insurance premiums are summarized in Table 4.14.

Table 4.14. Estimated annual premiums for commercial property-damage insurance

Type of insurance	Premium cost for number of units			
	1	2	3	4
	Nuclear plants			
Primary ($500 million)	$2,000,000	$3,600,000	$5,300,000	$7,000,000
Secondary ($500 million)	1,600,000	1,800,000	2,000,000	2,200,000
Total ($1000 million)	$3,600,000	$5,400.000	$7,300,000	$9,200,000
	Coal-fired plants			
Commercial	$ 100,000	$ 200,000	$ 300,000	$ 400,000

4.6.3 Replacement power insurance

NEIL presently covers the cost of buying replacement power for damaged nuclear plants. The premium for a single unit for maximum coverage

of $156 million is in the range of $1.5 to $2 million a year.[47] Rates for multiple units at a single site are determined by the extent to which units are interdependent. The plant operator can also be assessed up to five times the annual premium to cover early claims if necessary. A 6-month deductible period precedes the first pay out ($2 million/week for 52 weeks, then $1 million/week for 52 weeks). At present, replacement power insurance is not generally believed to be required for coal-fired plants.

5. THE OMCOST COMPUTER PROGRAM

5.1 General Description

The OMCOST computer program offers four basic O&M cost-estimating models for steam-electric power plants, one coal-fired with wet limestone FGD system, one coal-fired with dry FGD system, one coal-fired without FGD system, and the fourth an LWR.

The cost models are based on early 1982 costs. Escalation rates are included for wages, materials, supplies, government and commercial liability insurance, inspection fees, ash disposal, sludge disposal, lime and limestone costs, property insurance, and replacement power insurance.

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. A coal-fired case can be run with no more input than plant type and net electrical output. The user may elect to change any of the default conditions as detailed in Sect. 5.5. The options available include the following: (1) a general escalation rate to replace the separate escalation rates, (2) the number of units per plant (up to four), (3) wage rates, (4) operator fringe benefits, (5) plant supervision expenses, (6) heating value of coal, (7) sulfur content, (8) tons of lime or limestone per ton of sulfur, and (9) unit costs of purchased lime or limestone and ash and sludge disposal.

The user may specify one, two, three, or four units per plant with O&M costs for all units escalated to a single specified year. It is not possible to produce incremental O&M cost estimates for individual units in multiple-unit plants either in constant-year dollars or in current-year dollars except by multiple computer runs and hand-calculated differences and escalations. This produces incremental O&M cost estimates for each additional unit but does not accurately represent the average cost per unit, which is better approximated by dividing total annual O&M costs for the multiple-unit plant by the number of units. Total O&M cost estimates, as units are added to multiple-unit plants, can be produced by specifying, for example, a single-unit plant in the initial year of operation of the first unit or a two-unit plant in the initial year of operation of the second unit. The OMCOST computer program consists of a main program and nine subroutines written in IBM FORTRAN IV. The program is run locally on the IBM 3033 digital computer. Execution time for 20 cases is ~1 s.

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 FORTRAN listing of the OMCOST code. A variable dictionary for MAIN and all subroutines is included in the FORTRAN listing of MAIN.

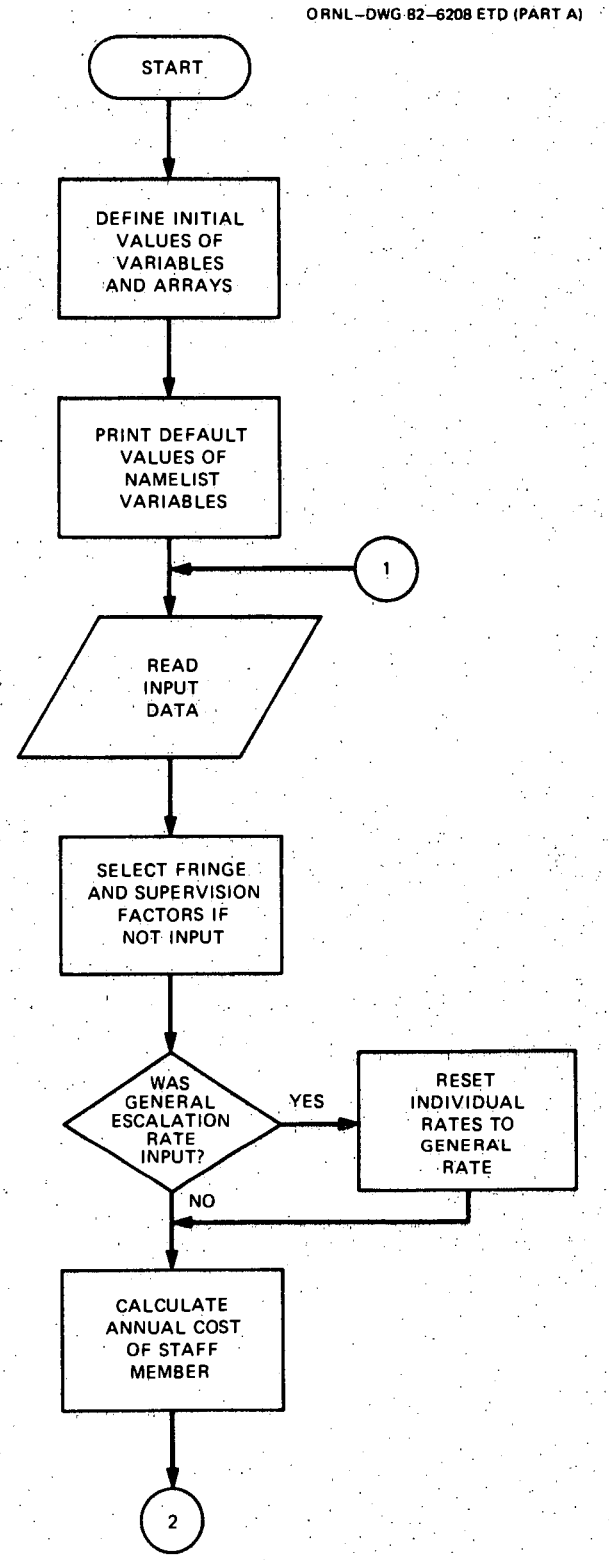

Fig. 5.1. OMCOST MAIN program.

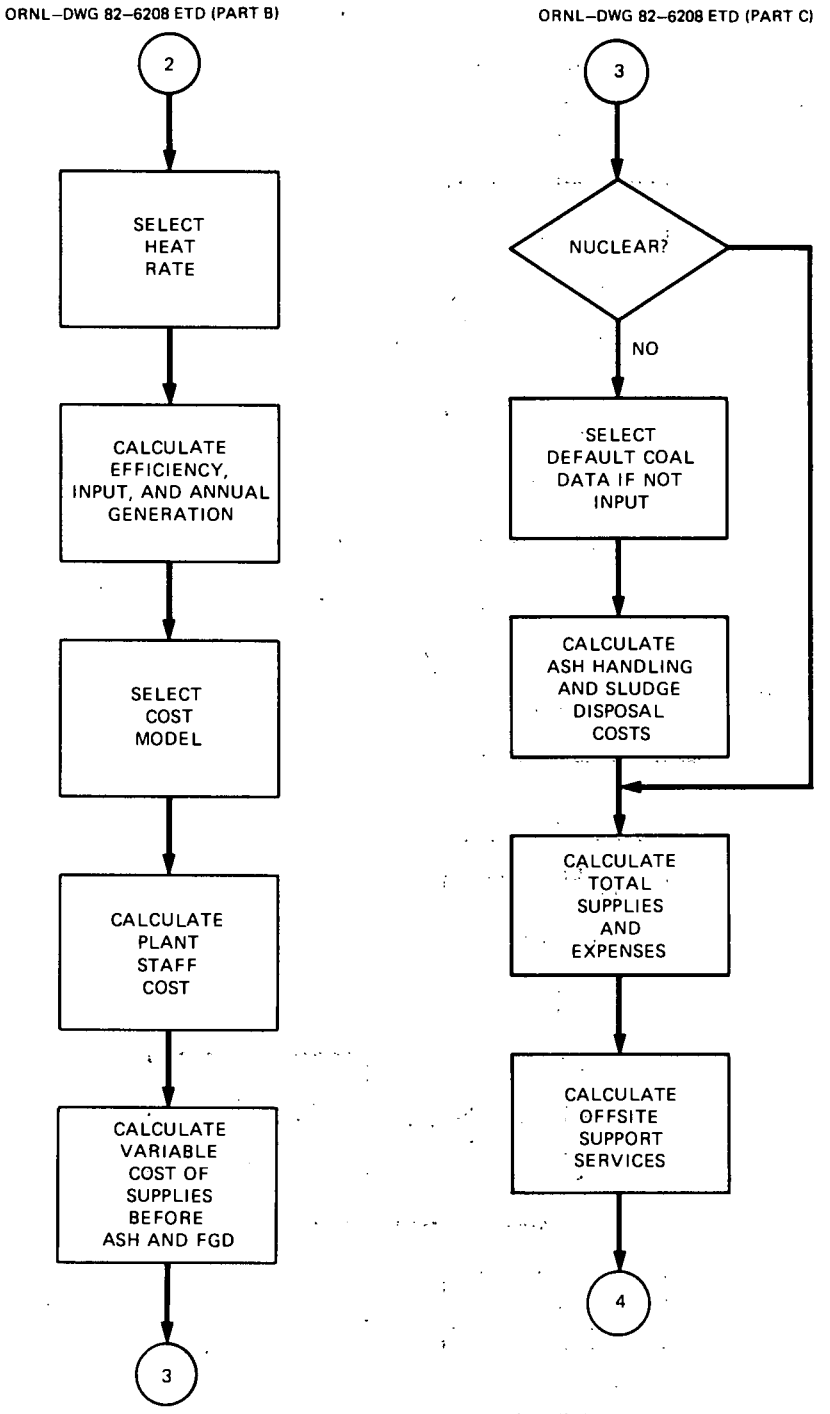

Fig. 5.1 (continued)

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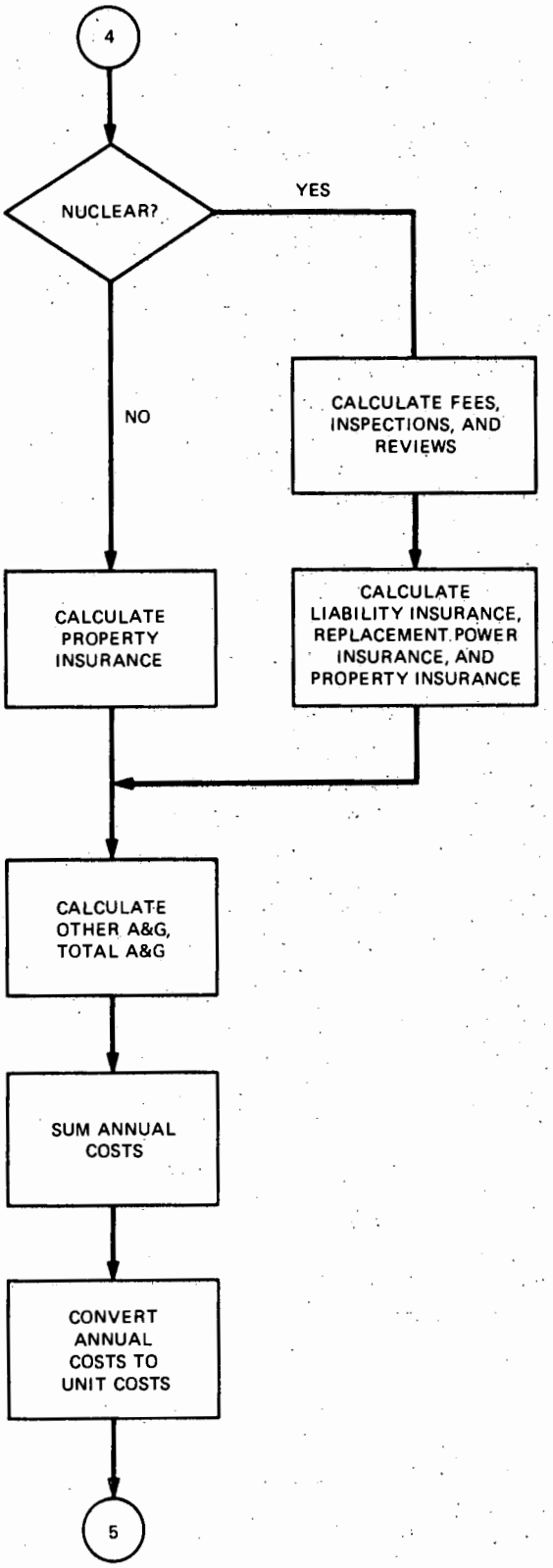

ORNL–DWG 82–6208 ETD (PART E)

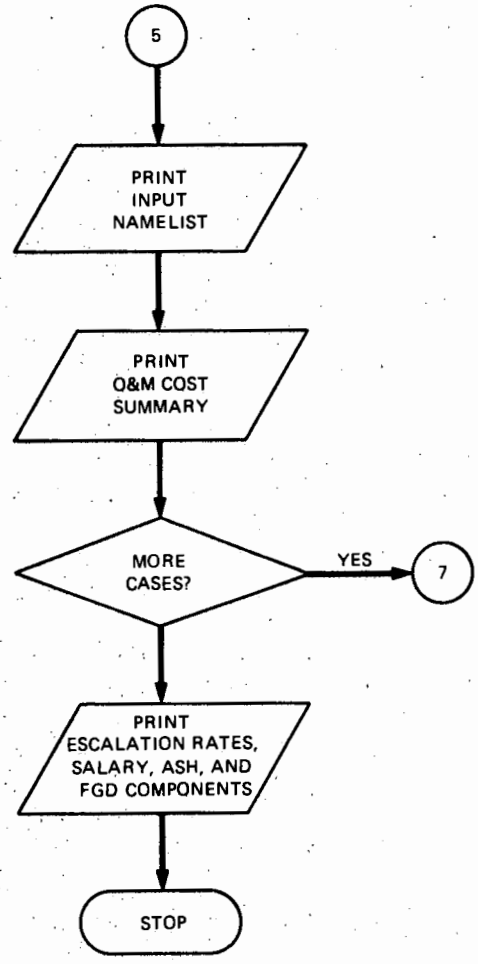

Fig. 5.1 (continued)

A series of variables is initialized through DATA statements. All variables contained in NAMELIST NAME1 that have not been initialized through DATA statements are initialized with 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. The default values of NAMELIST NAME1 variables are printed out before any other output, even if the user fails to include any data input cards.

The complete list of variables that may be input through NAMELIST NAME1 is included in Sect. 5.5. The plant type, TYPE, is compared with a list of valid types, and an integer, ITYPE, is returned as 1 for nuclear or 2 for coal-fired. Nonvalid types produce an error message, and the code reads new input data. This is done by subroutine TYPER.

There are numerous variables that require two default values, either one value for nuclear plants and one value for coal-fired plants, or one value for wet limestone FGD systems and another value for dry FGD systems. A short subroutine CHKDEF checks the value of a variable for a particular run to determine whether it has been newly input or whether it matches one of the default values. If it has been newly input, it will not match either default value, and the default value will then be reset to the input value and will remain the default value for the remainder of the run. As an example, there are two values of operator fringe benefit as a percentage of wage rate stored in MAIN. One value is used for LWR cases and another value for coal-fired cases. These values are stored in an array FRING. If the appropriate default value is to be overridden for any case, an input variable FRINGE will be set in NAMELIST NAME1 and will not match either FRING(1) or FRING(2). The new value of FRINGE will be stored as FRING(1) or FRING(2) for additional cases as appropriate.

The general escalation rate, ESCGEN, is compared with -99.0 to determine whether a value for the general escalation rate has been input. Eleven individual escalation rates (listed in Sect. 5.5) are set equal to the general escalation rate if a value other than -99.0 is input.

A test is made to ensure that the number of units per plant, UNITS, is in the range of 1–4. If it is out of range, a message is printed and the next set of data cards is read.

The average annual cost of a plant staff member, MANCOS, is then calculated using a basic hourly rate with adjustments for fringe benefits, plant supervision and engineering, and a penalties factor for nuclear on-site labor. Staff costs are escalated from a base year, BASEYR, to the year of operation, YEAR, using escalation rate ESWAGE.

Subroutine HEATRT selects a heat rate appropriate for the plant type, and, if coal-fired, the type of FGD system. If the heat rate has been input, the new heat rate becomes default for remaining cases for that plant type. Plant net efficiency, thermal input per unit, and annual net electrical generation are then calculated. The appropriate cost-model subroutine is then called.

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 lime or limestone and sludge disposal and ash disposal costs. For coal-fired plants, the NAMELIST input data are compared with default

values to determine if input values or default values should be used. If new values have been input, these are stored for additional cases in the run. These checks are made for heating value of coal, ash content, sulfur content, and percentage of sulfur to be removed by the FGD system. 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.

For coal-fired plants with FGD, the costs of purchased lime or limestone and of sludge disposal are 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. The sulfur to be removed is calculated as the tons of original sulfur times the fraction of sulfur to be removed, PCTSRM/100.

Annual cost of sludge disposal is the product of the sulfur to be removed, SULREM, the dry sludge to sulfur ratio, SLUSUL, and the escalated unit cost of sludge disposal, SLURRY, plus an ash disposal cost term. Ash disposal cost is the product of coal consumption, fraction of ash, and the escalated cost of ash disposal, $$ASH.

The calculation of limestone requirements for wet limestone FGD and lime requirements for dry FGD are exactly analogous except for variable names. Limestone requirements, TONLMS, are calculated using the tons of sulfur to be removed, SULREM, and the limestone to sulfur ratio, XLIMSS. Annual limestone cost is the limestone requirement multiplied by the escalated cost per ton of limestone, COLIMS. Total variable cost of supplies and expenses is determined by adding the basic variable cost of supplies and expenses to sludge disposal, ash disposal, and lime or limestone costs, as 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 supplies escalation rate, ESCSUP, and added to the variable supplies and expenses, VARSE, to obtain total annual cost of supplies and expenses, SUPEXP.

The cost of fees, inspections, and reviews for nuclear plants are calculated as a straight-line function of the number of units, and the escalation rate is specified by the parameter ESFEES.

Offsite support services are calculated as a multiple of technical and engineering staff costs for both LWR and coal-fired plants.

Cost of commercial and government nuclear liability insurance, retrospective premium for self-insurance, and replacement power insurance are calculated for nuclear plants only. Commercial liability insurance, self-insurance, and replacement power insurance are straight-line functions of the number of units. Government liability insurance is directly proportional to 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 ESCINS for commercial liability insurance and self-insurance, ESGINS for government liability insurance, and ESCPOW for replacement power insurance.

The cost of property-damage insurance is calculated as a direct function of the number units in the plant. The costs of primary and secondary property-damage insurance for nuclear plants are each calculated as a product of the coverage, an insurance premium rate, and a straight-line function of the number of units in the plant. The escalation rate is specified by ESCPIN for both coal and nuclear plants.

In addition to the insurance premium expenses discussed in the preceding paragraphs, a category called "other" administrative and general costs is calculated as a percentage of total direct costs (onsite staff, maintenance materials, supplies and expenses, offsite support services, and fees, inspections, and reviews).

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/kWh.

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 LWR plants (subroutine LWR),

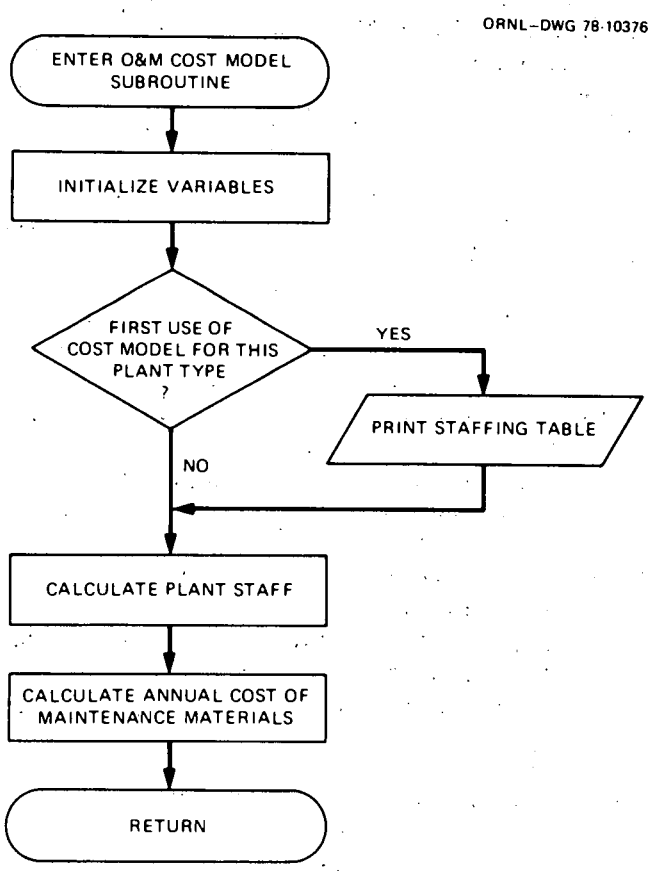

Fig. 5.2. Subroutines LWR, COAL, COAWLS, and COALDS.

coal-fired plants without FGD (subroutine COAL), coal-fired plants with wet limestone FGD (subroutine COALWS), and coal-fired plants with dry FGD (subroutine COALDS) differ only in data values and array sizes. The logic for all subroutines is identical.

Each cost-model subroutine passes its arguments to and from MAIN through two COMMON statements, one for integer variables and one for real variables. DATA initialization statements contain information on staff complement in accordance with Tables 4.1–4.4, and factors defining maintenance materials costs in accordance with Table 4.8. ARITHMETIC statements define supplies and expenses costs in accordance with Tables 4.9 and 4.11.

The first time a cost-model subroutine is called, a table of staff requirements for 1–4 units per plant is printed out. Fixed costs of supplies and expenses for a single unit are set through an ARITHMETIC statement. Similarly, variable supplies and expenses are set. The appropriate staff total is selected from the table. Annual costs of maintenance materials at a reference capacity factor are determined as a function of maintenance staff costs. Maintenance materials costs are broken into fixed and variable components, and the variable component is adjusted for capacity factor. Technical and engineering staff subtotal is returned to the MAIN program for use in calculating cost of offsite support services.

5.4 Other Subroutines

There are five short subroutines, which are included primarily to reduce the length of the MAIN program. Subroutine TYPER examines the plant type, TYPE, and returns an integer value of 0, 1, or 2. If plant type is input as PWR, LWR, or BWR with or without a trailing blank, ITYPE is set equal to 1. If TYPE is input as COAL, ITYPE is set equal to 2. Any other input results in ITYPE of 0.

Subroutine SELECT calls the appropriate plant type subroutine based on the values of ITYPE, ISOX, and WETDRY. SELECT contains multiple RETURNs, one of which directs the program to read a new data card since the specified plant type could not be found.

Subroutine HEATRT is used to select a heat rate based on plant type and the absence or presence and type of FGD system for coal-fired plants. A heat rate is simply selected rather than calculated.

Subroutine CHKDEF compares an input variable with two default values. If a new value has been input, it will be saved as a future default value. If no new value has been input, one of the existing default values will be selected as appropriate.

Subroutine UNITCK checks the specified number of units per plant, UNITS, to be sure that the value is not greater than four or less than one. If the number of units is out of range, a new NAMELIST NAME1 data card will be read, and the data for the previous case will be discarded. The user is informed of the action by a suitable diagnostic message.

5.5 Data Input Description

All input data are read through a NAMELIST statement, NAME1, which must be read for each case. 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.

The makeup of data cards for batch operation 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 2-80 of additional cards can be used. In this case, data items are separated by commas, and the total data sets are 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. 5.6, along with an example of interactive input.

5.6 Sample Problems

To illustrate the use of OMCOST, three sample problems with computer output listings are included in this section. The preparation of input data for the batch mode is illustrated in Fig. 5.3 and for the interactive mode in Fig. 5.4; the output listings follow. All problems use the default input data defined in Table 5.1, 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 changed in a succeeding NAMELIST.

In problem 1, an 1150-MW(e) PWR was specified. Problem 2 calls for two 575-MW(e) coal-fired units with wet limestone FGD. Problem 3 calls for a rerun of problem 2 with dry FGD. Note that the number of units and rating specified in example problem 2 were carried over to problem 3.

Table 5.1. NAME1 input data variables and default values

Variable name	Definition	Default value
YEAR	Year of operation	1982.0
TYPE	Plant type (LWR, COAL, COALWS, COALDS)	PWR
PLTFAC	Baseload plant capacity factor	0.65
MWN	Net plant electrical output (single unit), MW	1,150
HTRATE	Plant net heat rate, Btu/kWh(e)	10,700
ISOX	= 0 (FGD not specified) = 1 (FGD specified)	0
WETDRY	= 1 (wet limestone FGD specified) = 2 (dry FGD specified)	1
UNITS	Number of units per station	1
WAGERT	Wage rate before adders (base year), $/year	10.45
FRINGE	Operator fringe benefits as percentage of wage rate	35
SUPER	Plant supervision as percentage of wages plus fringe benefits	20
BTUCOL	Heating value of coal, Btu/lb	11,026
XLIMSS	Tons of limestone per ton of sulfur	4.00
XLIMS	Tons of lime per ton of sulfur	1.00
$ASH	Ash handling cost (base year), $/ton	6 .00
ASHPCT	Ash in coal, %	11.60
PCTSRM	Sulfur removed, %	90.00
PCTSUL	Sulfur in coal, %	3.50
SLURY	Cost of sludge disposal (base year), $/ton	5.00
COSLMS	Cost of limestone (base year), $/ton	12.50
COSLM	Cost of lime (base year), $/ton	70.00
ESWAGE	Escalation rate of wages, %/year	8.0
ESSLUR	Escalation rate of cost of sludge disposal, %/year	10.0
ESLIMS	Escalation rate of cost of limestone, %/year	10.0
ESLIM	Escalation rate of cost of lime, %/year	10.0
ESCINS	Escalation rate of cost of commercial liability insurance, %/year	6.0
ESGINS	Escalation rate of cost of government liability insurance, %/year	0.0
ESFEES	Escalation rate of cost of fees, inspections, reviews, %/year	8.0
ESMATL	Escalation rate of cost of materials, %/year	10.0
ESCSUP	Escalation rate of cost of supplies and expenses, %/year	10.0
ESCPIN	Escalation rate of cost of property insurance, %/year	6.0
ESCPOW	Escalation rate of cost of replacement power insurance, %/year	9.0
ESCGEN	General escalation rate	-99.0

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CODED BY _____

DATE _____ REQUEST NO. _____

FORTRAN

PROBLEM _____

PROGRAM _____

PAGE _____ OF _____

STATEMENT TYPE	STATEMENT NUMBER	CONT	FORTRAN STATEMENT	IDENTIFICATION
1	2 3 4 5	6	7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72	73 74 75 76 77 78 79 80

```
$NAME/ TYPE='PWR ', $END
$NAME/ TYPE='CØAL', UNITS=2, ISØX=1, WETDRY=1, MWN=575., $END
$NAME/ WETDRY=2, $END
```

Fig. 5.3. Batch-mode input data for sample problems.

ORNL–DWG 82-6210ETD

```
READY
EX LIBRARY(OMIN)
VERSION 3-17-82
OMCOST INPUT DATA PREPARATION ROUTINE

INPUT PLANT TYPE: PWR, BWR, LWR, OR COAL
PWR
INPUT NET PLANT ELECTRICAL OUTPUT, MW
IF 0 IS INPUT, DEFAULT VALUE IS USED
0
DO YOU WANT TO SKIP TO NAMELIST INPUT? (Y OR N)
Y
INPUT NAMELIST CARDS (SPACE TO COL. 2)
TYPE "END" TO TERMINATE NAMELIST INPUT
END
ARE THERE ADDITIONAL CASES? (Y OR N)
Y
DO YOU WANT TO SKIP TO NAMELIST INPUT? (Y OR N)
N
INPUT PLANT TYPE: PWR, BWR, LWR, OR COAL
COAL
DO YOU WANT SCRUBBERS? (Y OR N)
Y
WET OR DRY?
WET
INPUT NET PLANT ELECTRICAL OUTPUT, MW
IF 0 IS INPUT, VALUE IS NOT CHANGED FROM PREVIOUS RUN
575
DO YOU WANT TO SKIP TO NAMELIST INPUT? (Y OR N)
N
INPUT YEAR OF OPERATION
0
INPUT BASE LOAD CAPACITY FACTOR (DECIMAL)
0
INPUT NUMBER OF UNITS PER STATION
2
DO YOU WANT TO SKIP TO NAMELIST INPUT? (Y OR N)
Y
INPUT NAMELIST CARDS (SPACE TO COL. 2)
TYPE "END" TO TERMINATE NAMELIST INPUT
END
ARE THERE ADDITIONAL CASES? (Y OR N)
Y
DO YOU WANT TO SKIP TO NAMELIST INPUT? (Y OR N)
N
INPUT PLANT TYPE: PWR, BWR, LWR, OR COAL
COAL
DO YOU WANT SCRUBBERS? (Y OR N)
Y
WET OR DRY?
DRY
INPUT NET PLANT ELECTRICAL OUTPUT, MW
IF 0 IS INPUT, VALUE IS NOT CHANGED FROM PREVIOUS RUN
0
DO YOU WANT TO SKIP TO NAMELIST INPUT? (Y OR N)
Y
INPUT NAMELIST CARDS (SPACE TO COL. 2)
TYPE "END" TO TERMINATE NAMELIST INPUT
END
ARE THERE ADDITIONAL CASES? (Y OR N)
N
OMCOST INPUT FILE APPEARS AS FOLLOWS:
$NAME1
TYPE='PWR ',
$END
$NAME1
TYPE='COAL',
ISOX=1,
WETDRY=1,
MWN= 575.,
UNITS=2,
$END
$NAME1
TYPE='COAL',
ISOX=1,
WETDRY=2,
$END
READY
```

Fig. 5.4. Interactive-mode input data for sample problems.

DEFAULT VALUES OF NAMELIST NAME1 VARIABLES

YEAR	1982.0
TYPE	PWR
PLTFAC	0.65
MWN	1150.
HTRATE	10700.
ISOX	1
WETDRY	1
UNITS	1
WAGERT	10.45
FRINGE	35.
SUPER	20.
BTUCOL	11000.
XLIMSS	4.00
XLIMS	1.00
$ASH	5.00
ASHPCT	11.60
PCTSRM	90.00
PCTSUL	3.50
SLURY	5.00
COSLMS	12.50
COSLM	70.00
ESWAGE	8.0
ESSLUR	10.0
ESLIMS	10.0
ESLIM	10.0
ESCINS	6.0
ESGINS	0.0
ESFEES	8.0
ESMATL	10.0
ESCSUP	10.0
ESCPIN	6.0
ESCPOW	9.0
ESCGEN	-99.0

SITE STAFF REQUIREMENT FOR LWR POWER PLANTS

	NO. UNITS PER SITE			
	1	2	3	4
PLANT MANAGER'S OFFICE				
MANAGER	1	1	1	1
ASSISTANT	1	2	3	4
QUALITY ASSURANCE	6	6	7	8
ENVIRONMENTAL CONTROL	1	1	1	1
PUBLIC RELATIONS	1	1	1	1
TRAINING	12	12	12	12
SAFETY & FIRE	1	2	3	4
ADMIN. & SERVICES	49	55	65	78
HEALTH SERVICES	2	2	2	2
SECURITY	94	94	94	94
SUBTOTAL	168	176	189	205
OPERATIONS				
SUPERVISION (EXC. SHIFT)	9	9	18	18
SHIFTS	52	104	156	208
SUBTOTAL	61	113	174	226
MAINTENANCE				
SUPERVISION	12	14	26	28
CRAFTS	55	71	87	103
PEAK MAINT. ANNUALIZED	55	110	165	220
SUBTOTAL	122	195	278	351
TECHNICAL AND ENGINEERING				
REACTOR	5	5	7	7
RADIO-CHEMICAL	8	8	12	12
ENGINEERING	16	16	16	16
PERFORM., REPORTS, TECH.	21	30	39	48
SUBTOTAL	50	59	74	83
TOTAL	401	543	715	865
LESS SECURITY	307	449	621	771
LESS SEC., PEAK MAINT	252	339	456	551

NAMELIST FOR FOLLOWING CASE

YEAR	1982.C
TYPE	PWR
PLTFAC	0.65
MWN	1150.
HTRATE	10700.
ISOX	1
WETDRY	1
UNITS	1
WAGERT	10.45
FRINGE	35.
SUPER	20.
BTUCOL	11000.
XLIMSS	4.00
XLIMS	1.00
$ASH	5.00
ASHPCT	11.60
PCTSRM	90.00
PCTSUL	3.50
SLURY	5.00
COSLMS	12.50
COSLM	70.00
ESWAGE	8.0
ESSLUR	10.0
ESLIMS	10.0
ESLIM	10.0
ESCINS	6.0
ESGINS	0.0
ESFEES	8.0
ESMATL	10.0
ESCSUP	10.0
ESCPIN	6.0
ESCPOW	9.0
ESCGEN	-99.0

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1982.0
USING OMCOST VERSION 6-4-82

PLANT TYPE IS PWR
NUMBER OF UNITS PER PLANT 1
THERMAL INPUT PER UNIT IS 3606. MWT
PLANT NET HEAT RATE 10700.
PLANT NET EFFICIENCY, PERCENT 31.89
EACH UNIT IS 1150. MWE NET RATING
ANNUAL NET GENERATION, MILLION KWH 6553.
WITH BASE LOAD CAPACITY FACTOR OF 0.65

DIRECT COSTS $1000/YEAR		
STAFF ONSITE	14826.	
(401 PERSONS AT $ 36973.)		
MAINTENANCE MATERIAL	4299.	
FIXED		3383.
VARIABLE		916.
SUPPLIES AND EXPENSES	5455.	
FIXED		4800.
VARIABLE		655.
FEES, INSPECTIONS, REVIEWS	488.	
OFFSITE SUPPORT SERVICES	3697.	
INDIRECT COSTS		
ADMINISTRATIVE AND GENERAL	14659.	
COMMERCIAL LIABILITY INS.		401.
RETROSPECTIVE PREMIUM		10.
GOVERNMENT LIABILITY INS.		18.
PROPERTY INS. (PRIMARY)		2000.
PROPERTY INS. (EXCESS)		1600.
REPLACEMENT POWER INS.		2000.
OTHER A&G		8630.

COSTS $1000/YEAR	
TOTAL FIXED DIRECTS AND INDIRECTS	41853.
TOTAL VARIABLE DIRECTS AND INDIRECTS	1571.
TOTAL ANNUAL NONFUEL O&M	43425.

UNIT COSTS MILLS/KWH(E)	
FIXED DIRECTS AND INDIRECTS	6.39
VARIABLE DIRECTS AND INDIRECTS	0.24
TOTAL NONFUEL O&M	6.63
TOTAL NONFUEL O&M LESS 'OTHER A&G'	5.31
TOTAL NONFUEL O&M LESS A&G	4.39

SITE STAFF REQUIREMENT FOR COAL-FIRED POWER PLANTS WITH WET LIMESTONE FGD SYSTEMS

	NO. UNITS PER SITE			
	1	2	3	4
PLANT MANAGER'S OFFICE				
MANAGER	1	1	1	1
ASSISTANT	1	2	3	4
ENVIRONMENTAL CONTROL	1	1	1	1
PUBLIC RELATIONS	1	1	1	1
TRAINING	1	1	1	1
SAFETY	1	1	1	1
ADMIN. & SERVICES	13	14	15	16
HEALTH SERVICES	1	1	1	2
SECURITY	7	7	7	7
SUBTOTAL	27	29	31	34
OPERATIONS				
SUPERVISION (EXC. SHIFT)	3	3	5	5
SHIFTS	45	50	60	65
FUEL AND LIMESTONE REC.	12	12	12	18
WASTE SYSTEMS	10	20	30	40
SUBTOTAL	70	85	107	128
MAINTENANCE				
SUPERVISION	8	8	10	12
CRAFTS	90	110	130	150
PEAK MAINT. ANNUALIZED	20	40	60	80
SUBTOTAL	118	158	200	242
TECHNICAL AND ENGINEERING				
WASTE	1	2	3	4
CHEMICAL	2	2	3	4
I & C	2	2	3	4
PERFORM., REPORTS, TECH.	14	17	21	24
SUBTOTAL	19	23	30	36
TOTAL	234	295	368	440

NAMELIST FOR FOLLOWING CASE

YEAR	1982.0
TYPE	COAL
PLTFAC	0.65
MWN	575.
HTRATE	9980.
ISOX	1
WETDRY	1
UNITS	2
WAGERT	10.45
FRINGE	35.
SUPER	10.
BTUCOL	11000.
XLIMSS	4.00
XLIMS	1.00
$ASH	5.00
ASHPCT	11.60
PCTSRM	90.00
PCTSUL	3.50
SLURY	5.00
COSLMS	12.50
COSLM	70.00
ESWAGE	8.0
ESSLUR	10.0
ESLIMS	10.0
ESLIM	10.0
ESCINS	6.0
ESGINS	0.0
ESFEES	8.0
ESMATL	10.0
ESCSUP	10.0
ESCPIN	6.0
ESCPOW	9.0
ESCGEN	-99.0

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1982.0
USING OMCOST VERSION 6-4-82

PLANT TYPE IS COAL
NUMBER OF UNITS PER PLANT 2
WITH WET LIMESTONE FGD SYSTEMS
THERMAL INPUT PER UNIT IS 1682. MWT
PLANT NET HEAT RATE 9980.
PLANT NET EFFICIENCY, PERCENT 34.19
EACH UNIT IS 575. MWE NET RATING
ANNUAL NET GENERATION, MILLION KWH 6553.
WITH BASE LOAD CAPACITY FACTOR OF 0.65

DIRECT COSTS $1000/YEAR			
STAFF ONSITE		9522.	
(295 PERSONS AT $ 32278.)			
MAINTENANCE MATERIAL		3991.	
	FIXED		3162.
	VARIABLE		829.
SUPPLIES AND EXPENSES		13465.	
	FIXED		4400.
	VAR. - PLANT		786.
	- LIMESTONE		4682.
	- ASH & FGD SLUDGE		3597.
OFFSITE SUPPORT SERVICES		1114.	
INDIRECT COSTS			
ADMINISTRATIVE AND GENERAL		8627.	
	PROPERTY INSURANCE		200.
	OTHER A&G		8427.

COSTS $1000/YEAR	
TOTAL FIXED DIRECTS AND INDIRECTS	26825.
TOTAL VARIABLE DIRECTS AND INDIRECTS	9893.
TOTAL ANNUAL NONFUEL O&M	36718.

UNIT COSTS MILLS/KWH(E)	
FIXED DIRECTS AND INDIRECTS	4.09
VARIABLE DIRECTS AND INDIRECTS	1.51
TOTAL NONFUEL O&M	5.60
TOTAL NONFUEL O&M LESS 'OTHER A&G'	4.32
TOTAL NONFUEL O&M LESS A&G	4.29

HEATING VALUE OF COAL, BTU/LB	11000.
COAL BURNED, TONS/YEAR	2972462.
PERCENT ASH	11.60
COST OF ASH DISPOSAL, $/TON	5.00
PERCENT SULFUR	3.50
SULFUR (100 PCT.), TONS/YR	104036.
PERCENT SULFUR REMOVED	90.00
SULFUR REMOVED, TONS/YEAR	93633.
TONS LIMESTONE PER TON SULFUR	4.00
TONS/YEAR LIMESTONE	374532.
COST OF LIMESTONE, $/TON	12.50
COST OF SLUDGE DISPOSAL, $/DRY TON	5.00

SITE STAFF REQUIREMENT FOR COAL-FIRED POWER PLANTS WITH DRY FGD SYSTEMS

	NO. UNITS PER SITE			
	1	2	3	4
PLANT MANAGER'S OFFICE				
MANAGER	1	1	1	1
ASSISTANT	1	2	3	4
ENVIRONMENTAL CONTROL	1	1	1	1
PUBLIC RELATIONS	1	1	1	1
TRAINING	1	1	1	1
SAFETY	1	1	1	1
ADMIN. & SERVICES	13	14	15	16
HEALTH SERVICES	1	1	1	2
SECURITY	7	7	7	7
SUBTOTAL	27	29	31	34
OPERATIONS				
SUPERVISION (EXC. SHIFT)	3	3	5	5
SHIFTS	45	50	60	65
FUEL AND LIMESTONE REC.	12	12	12	18
WASTE SYSTEMS	5	10	15	20
SUBTOTAL	65	75	92	108
MAINTENANCE				
SUPERVISION	8	8	10	12
CRAFTS	77	94	111	128
PEAK MAINT. ANNUALIZED	20	40	60	80
SUBTOTAL	105	142	181	220
TECHNICAL AND ENGINEERING				
WASTE	1	2	3	4
CHEMICAL	2	2	3	4
I & C	2	2	3	4
PERFORM., REPORTS, TECH.	14	17	21	24
SUBTOTAL	19	23	30	36
TOTAL	216	269	334	398

NAMELIST FOR FOLLOWING CASE

YEAR	1982.0
TYPE	COAL
PLTFAC	0.65
MWN	575.
HTRATE	9780.
ISOX	1
WETDRY	2
UNITS	2
WAGERT	10.45
FRINGE	35.
SUPER	10.
BTUCOL	8200.
XLIMSS	4.00
XLIMS	1.00
$ASH	5.00
ASHPCT	7.30
PCTSRM	70.00
PCTSUL	0.50
SLURY	5.00
COSLMS	12.50
COSLM	70.00
ESWAGE	8.0
ESSLUR	10.0
ESLIMS	10.0
ESLIM	10.0
ESCINS	6.0
ESGINS	0.0
ESFEES	8.0
ESMATL	10.0
ESCSUP	10.0
ESCPIN	6.0
ESCPUW	9.0
ESCGEN	-99.0

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1982.0
USING OMCOST VERSION 6-4-82

PLANT TYPE IS COAL
NUMBER OF UNITS PER PLANT 2
WITH WET LIMESTONE FGD SYSTEMS
THERMAL INPUT PER UNIT IS 1682. MWT
PLANT NET HEAT RATE 9980.
PLANT NET EFFICIENCY, PERCENT 34.19
EACH UNIT IS 575. MWE NET RATING
ANNUAL NET GENERATION, MILLION KWH 6553.
WITH BASE LOAD CAPACITY FACTOR OF 0.65

DIRECT COSTS $1000/YEAR		
STAFF ONSITE	9522.	
(295 PERSONS AT $ 32278.)		
MAINTENANCE MATERIAL	3991.	
FIXED		3162.
VARIABLE		829.
SUPPLIES AND EXPENSES	13465.	
FIXED		4400.
VAR. - PLANT		786.
- LIMESTONE		4682.
- ASH & FGD SLUDGE		3597.
OFFSITE SUPPORT SERVICES	1114.	
INDIRECT COSTS		
ADMINISTRATIVE AND GENERAL	8627.	
PROPERTY INSURANCE		200.
OTHER A&G		8427.

COSTS $1000/YEAR	
TOTAL FIXED DIRECTS AND INDIRECTS	26825.
TOTAL VARIABLE DIRECTS AND INDIRECTS	9893.
TOTAL ANNUAL NONFUEL O&M	36718.

UNIT COSTS MILLS/KWH(E)	
FIXED DIRECTS AND INDIRECTS	4.09
VARIABLE DIRECTS AND INDIRECTS	1.51
TOTAL NONFUEL O&M	5.60
TOTAL NONFUEL O&M LESS 'OTHER A&G'	4.32
TOTAL NONFUEL O&M LESS A&G	4.29

HEATING VALUE OF COAL, BTU/LB	11000.
COAL BURNED, TONS/YEAR	2972462.
PERCENT ASH	11.60
COST OF ASH DISPOSAL, $/TON	5.00
PERCENT SULFUR	3.50
SULFUR (100 PCT.), TONS/YR	104036.
PERCENT SULFUR REMOVED	90.00
SULFUR REMOVED, TONS/YEAR	93633.
TONS LIMESTONE PER TON SULFUR	4.00
TONS/YEAR LIMESTONE	374532.
COST OF LIMESTONE, $/TON	12.50
COST OF SLUDGE DISPOSAL, $/DRY TON	5.00

ESCALATION RATES, PERCENT/YEAR

WAGES	8.0
SLUDGE DISPOSAL COST	10.0
LIMESTONE COST	10.0
LIME COST	10.0
COML. LIAB. INS. COST	6.0
GOVT. LIAB. INS. COST	0.0
INSPECTION FEES & EXP.	8.0
MATERIAL	10.0
SUPPLIES AND EXPENSES	10.0
PROPERTY INSURANCE	6.0
REPLACEMENT POWER INS.	9.0
GENERAL ESCALATION	-99.0

ANNUAL AVERAGE SALARY COMPONENTS

WAGE RATE BEFORE ADDERS (BASE YEAR), $/HR	10.45
OPERATOR FRINGE BENEFITS, PCT.	35.
PLANT SUPERVISION & TECHNICAL, PCT.	10.
SPECIAL NUCLEAR PENALTY, PERCENT	5.

FGD COST COMPONENTS AT BASE YEAR 1982.0

COST OF LIMESTONE, $/TON	12.50
COST OF LIME, $/TON	70.00
COST OF SLUDGE DISPOSAL, $/DRY TON	5.00

ASH DISPOSAL COST COMPONENTS AT BASE YEAR

COST OF ASH DISPOSAL, $/TON	5.00
PCT. ASH IN COAL - WET LIMESTONE FGD	11.60
PCT. ASH IN COAL - DRY FGD	7.30

6. COMPARISON WITH REPORTED O&M COSTS

Cost estimates produced by the OMCOST code using the procedures developed in this report at 60% capacity factor are compared with O&M costs for 1980 as reported by utilities on FERC Form 1. Figures 6.1 and 6.2 show these comparisons for nuclear and coal-fired plants, respectively. The scatter plots show the reported data, which are tabulated in Tables 6.1 and 6.2; the numbers on the plots indicate the number of units in each plant. Because the cost-estimating procedures developed for the OMCOST code are for baseload plants operating at capacity factors of 40–80%, four of the single-unit plants in Table 6.1, Beaver Valley 1, Davis-Besse 1, Oyster Creek, and San Onofre 1 (which operated at very low capacity factors in 1980), are not included in Fig. 6.1. There is a wide range of reported O&M costs for any specific year because of variations in annual major maintenance requirements, utility practices, capacity factors, plant sizes and number of units, and regional costs. The continuous curves produced by the OMCOST computer code do not include A&G expenses, including insurance premiums, because these expenses are not allocated to the O&M expense accounts in 18 CFR 101 and on FERC Form 1. The addition of A&G

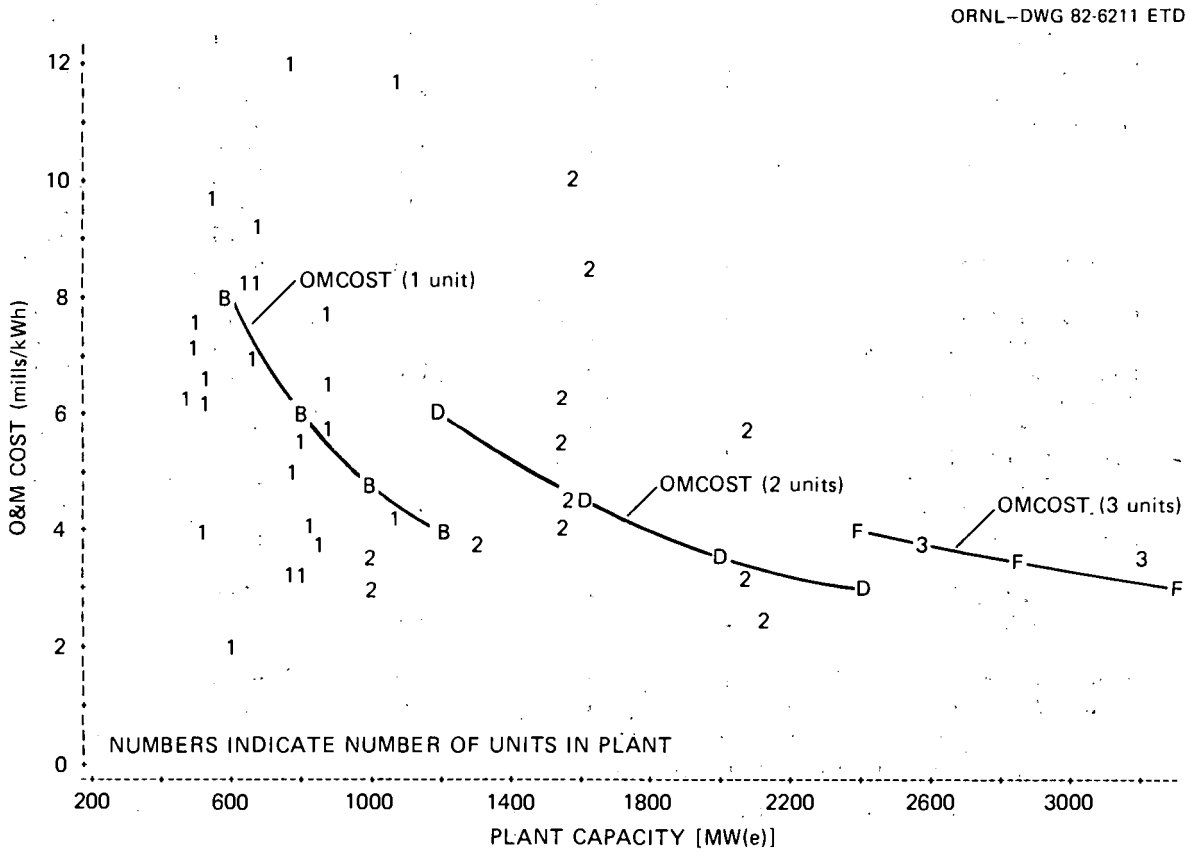

Fig. 6.1. Comparison of OMCOST at 60% capacity factor with 1980 reported costs for nuclear plants.

Table 6.1. Nuclear power plant O&M costs reported on FERC Form 1 for 1980

Plant name	Region[a]	Number of units	Net capability [MW(e)]	Capacity factor (%)	O&M cost (mills/kWh)
Arkansas Nuclear One 1	3	1	836	51.6	4.07
Arnold	5	1	515	61.7	6.61
Beaver Valley 1[b]	2	1	810	4.0	128.50
Connecticut Yankee	1	1	555	73.3	9.87
Cooper	5	1	764	56.6	5.02
Crystal River 3	3	1	782	49.0	11.88
Davis-Besse 1[b]	4	1	890	26.8	20.07
Farley 1	3	1	804	65.4	5.59
Fort Calhoun	5	1	490	46.5	7.19
Ginna	1	1	470	74.7	6.14
Indian Point 2	1	1	864	56.1	7.76
Kewaunee	4	1	518	80.0	4.09
Maine Yankee	1	1	810	61.9	3.19
Millstone 1	1	1	654	59.4	8.13
Millstone 2	1	1	864	64.8	5.83
Monticello	5	1	536	73.4	6.20
Nine Mile Point 1	1	1	610	84.7	2.07
North Anna 1	3	1	850	75.4	3.76
Oyster Creek[b]	2	1	620	35.8	19.32
Palisades	4	1	635	41.9	8.25
Pilgrim 1	1	1	670	51.9	9.13
Rancho Seco	6	1	873	57.5	6.44
Robinson 2	3	1	665	54.6	6.92
Salem 1	2	1	1079	59.9	11.74
San Onofre 1[b]	6	1	436	21.8	39.00
St. Lucie 1	3	1	777	76.4	3.15
Trojan	6	1	1080	64.0	4.31
Vermont Yankee	1	1	504	67.5	7.58
Brunswick 1 & 2	3	2	1580	41.6	9.98
Calvert Cliffs 1 & 2	2	2	1635	76.4	8.60
Cook 1 & 2	4	2	2126	70.6	2.46
Dresden 2 & 3	4	2	1545	65.6	4.28
Hatch 1 & 2	3	2	1576	62.8	4.56
Peach Bottom 2 & 3	2	2	2086	63.1	5.74
Point Beach 1 & 2	4	2	990	69.9	2.95
Prairie Island 1 & 2	5	2	1003	74.6	3.52
Quad Cities 1 & 2	4	2	1538	52.2	5.49
Surry 1 & 2	3	2	1550	34.7	6.25
Turkey Point 3 & 4	3	2	1292	72.8	3.74
Zion 1 & 2	4	2	2080	64.7	3.19
Browns Ferry 1, 2, & 3	3	3	3195	66.3	3.60
Oconee 1, 2, & 3	3	3	2580	62.9	3.66

[a]Regions are defined in Table 6.4.

[b]Not included in Fig. 6.1.

Table 6.2. Large baseload coal-fired power plant O&M costs reported on FERC Form 1 for 1980

Plant name	Region[a]	Number of units	Net capability [MW(e)]	Capacity factor (%)	O&M cost (mills/kWh)
Bull Run	3	1	943	84.3	1.03
Cheswick	2	1	547	67.8	2.78
Conesville 4	4	1	808	24.9	8.21
Council Bluffs 3	5	1	650	57.2	2.97
Gentleman 1	5	1	600	43.9	3.41
King	5	1	560	48.7	1.85
Miller 1	3	1	660	33.0	3.12
Neal 3	5	1	525	71.5	1.15
Neal 4	5	1	576	64.8	1.35
Nebraska City 1	5	1	575	39.0	3.42
Newton 1	4	1	577	59.8	4.06
Belews Creek 1 & 2	3	2	2240	66.7	1.07
Big Brown 1 & 2	3	2	1150	72.4	2.37
Cayuga 1 & 2	4	2	1036	61.4	1.42
Centralia 1 & 2	6	2	1300	62.5	3.09
Coffeen 1 & 2	4	2	740	54.7	5.83
Columbia 1 & 2	4	2	1054	62.4	1.62
Cumberland 1 & 2	3	2	2543	50.0	3.77
Fort Martin 1 & 2	4	2	1104	65.9	1.49
Four Corners 4 & 5	6	2	1034	66.1	3.18
Gavin 1 & 2	4	2	2600	64.2	1.05
Ghent 1 & 2	4	2	1050	54.6	1.13
Keystone 1 & 2	2	2	1640	73.8	2.25
Miami Fort 1 & 2	4	2	1000	59.5	1.98
Mitchell 1 & 2	4	2	1460	65.8	1.46
Montour 1 & 2	2	2	1495	77.0	1.52
Mount Storm 1 & 2	4	2	1574	40.9	4.62
Rush Island 1 & 2	5	2	1150	61.6	1.55
Schahfer 1 & 2	4	2	903	41.8	5.20
Sherbourne County 1 & 2	5	2	1402	67.7	2.38
Sioux	5	2	904	50.0	3.88
Welsh 1 & 2	3	2	1056	63.2	2.53
Baldwin 1, 2, & 3	4	3	1800	64.6	1.52
Cardinal 1, 2, & 3	4	3	1800	55.3	2.69
Harrison 1, 2, & 3	4	3	1922	65.0	1.43
Hatsfield Ferry 1, 2, & 3	2	3	1500	62.8	2.37
Homer City 1, 2, & 3	2	3	1886	62.5	2.70
Martin Lake 1, 2, & 3	3	3	2250	67.6	3.77
Monticello 1, 2, & 3	3	3	1900	66.2	3.56
Paradise 1, 2, & 3	3	3	2348	51.4	3.65
Bridger 1, 2, 3, & 4	6	4	2000	53.3	4.93
Gibson 1, 2, 3, & 4	4	4	2600	54.3	1.76
Labadie 1, 2, 3, & 4	5	4	2220	62.6	2.24
Monroe 1, 2, 3, & 4	4	4	3000	61.9	2.70
Stuart 1, 2, 3, & 4	4	4	2325	60.6	2.62

[a]Regions are defined in Table 6.4.

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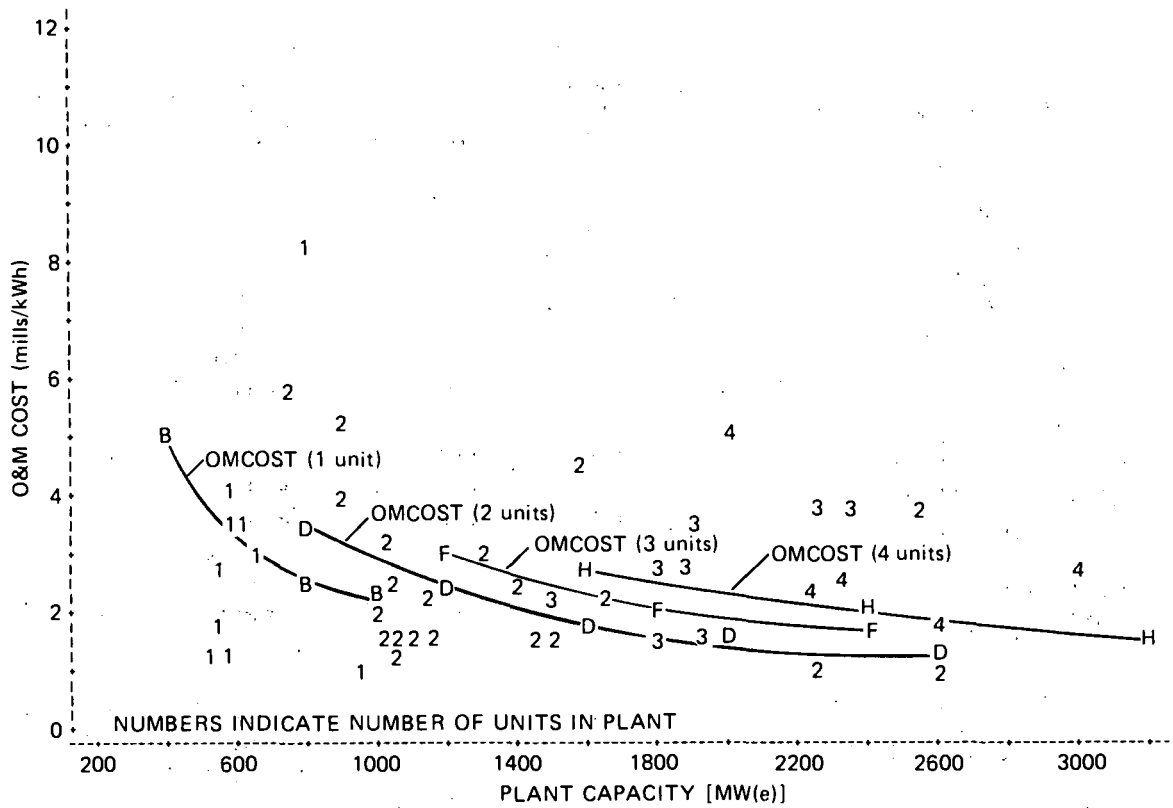

Fig. 6.2. Comparison of OMCOST at 60% capacity factor with 1980 reported costs for coal-fired plants.

expenses, including insurance premiums, will increase estimated O&M costs about 30% for coal-fired plants and about 50% for nuclear plants. Also, the OMCOST curves shown in Fig. 6.2 do not include FGD systems, because only about 10% of the reported coal-fired units in Table 6.2 include FGD systems.

Table 6.3 shows a regional comparison of reported O&M cost data for 1980. It indicates that O&M costs are highest for nuclear plants in the Northeast, the Middle Atlantic, and the Far West and highest for coal-fired plants in the Far West. The states in each of the six regions are defined in Table 6.4.

It is difficult to draw conclusions from these comparisons because of the large scatter in reported costs. Linear-regression analysis and normalization of reported costs to constant capacity factor showed no statistical significance. A multiple-regression analysis of reported O&M costs as a function of plant size and number of units, location, fuel type and quality, reactor type, capacity factor, year of operation, age, and other parameters might help to explain the variability. The only conclusion that can be made with confidence is that the procedures developed in this study provide reasonable cost estimates that fall within the range of reported costs for 1980.

Table 6.3. Regional O&M costs for 1980[a]

Region[b]	Fuel	Number of units	Average unit size [MW(e)]	Capacity factor (%)	O&M costs (mills/kWh)
Northeast	Nuclear	9	667	64.8	6.36
	Coal	0			
Middle Atlantic	Nuclear	7	890	55.5	8.12
	Coal	11	641	68.8	2.26
South	Nuclear	20	823	59.3	4.82
	Coal	16	797	62.1	2.58
East North Central	Nuclear	13	794	60.7	4.39
	Coal	48	648	56.6	2.43
West North Central	Nuclear	6	637	55.4	5.18
	Coal	15	606	59.2	2.29
Far West	Nuclear	3	797	53.9	7.70
	Coal	8	542	59.1	3.88
United States	Nuclear	58	771	59.9	5.35
	Coal	98	657	59.5	2.52
OMCOST[c]	Nuclear	1	800	60	6.0
	Coal	1	650	60	3.0

[a]Source: *UPDATE*, Nuclear Power Program Information and Data, U.S. Department of Energy, May/June 1981.

[b]Regions are defined in Table 6.4.

[c]From Figs. 6.1 and 6.2.

Table 6.4. Definition of regions

1. Northeast: New England states and New York
2. Middle Atlantic: Pennsylvania, New Jersey, Maryland, and Delaware
3. South: Virginia, North and South Carolina, Georgia, Florida, Tennessee, Alabama, Mississippi, Texas, Louisiana, Arkansas, and Oklahoma
4. East North Central: Ohio, Indiana, Michigan, Illinois, Wisconsin, Kentucky, and West Virginia
5. West North Central: Minnesota, Iowa, Nebraska, Kansas, Missouri, and North and South Dakota
6. Far West: Mountain and Pacific states

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Appendix A

EXCERPT FROM THE FEDERAL ENERGY REGULATORY COMMISSION UNIFORM SYSTEM OF ACCOUNTS (18 CFR 101)

18

Conservation of Power and Water Resources

PARTS 1 TO 149

Revised as of April 1, 1980

CONTAINING
A CODIFICATION OF DOCUMENTS
OF GENERAL APPLICABILITY
AND FUTURE EFFECT

AS OF APRIL 1, 1980

With Ancillaries

Published by
the Office of the Federal Register
National Archives and Records Service
General Services Administration

as a Special Edition of
the Federal Register

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 station. 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, development, and demonstration 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:

1. Inlet flange of throttle valve on prime mover.
2. Flange of all steam extraction lines on prime mover.
3. Hotwell pump outlet on condensate lines.
4. Inlet flange of all turbine-room auxiliaries.
5. 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, development, and demonstration 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.)

NOTE.—Office expenses which are clearly applicable to any group of operating expenses other than the administrative and general group shall be included in the appropriate account in such group. Further, general expenses which apply to the utility as a whole rather than to a particular administrative function shall be included in account 930.2, Miscellaneous General Expenses.

ITEMS

1. Automobile service, including charges through clearing account.
2. Bank messenger and service charges.
3. Books, periodicals, bulletins and subscriptions to newspapers, newsletters, tax services, etc.
4. Building service expenses for customer accounts, sales, and administrative and general purposes.
5. Communication service expenses.
6. Cost of individual items of office equipment used by general departments which are of small value or short life.
7. Membership fees and dues in trade, technical, and professional associations paid by a utility for employees. (Company memberships are includible in account 930.2.)
8. Office supplies and expenses.
9. Payment of court costs, witness fees and other expenses of legal department.
10. Postage, printing and stationery.
11. Meals, traveling and incidental expenses.

7. ADMINISTRATIVE AND GENERAL EXPENSES

Operation

920 Administrative and general salaries.

A. This account shall include the compensation (salaries, bonuses, and other consideration for services, but not including directors' fees) of officers, executives, and other employees of the utility properly chargeable to utility operations and not chargeable directly to a particular operating function.

B. This account may be subdivided in accordance with a classification appropriate to the departmental or other functional organization of the utility.

921 Office supplies and expenses.

A. This account shall include office supplies and expenses incurred in connection with the general administration of the utility's operations which are assignable to specific administrative or general departments and are not specifically provided for in other accounts. This includes the expenses of the various administrative and general departments, the salaries and wages of which are includible in account 920.

B. This account may be subdivided in accordance with a classification appropriate to the departmental or other functional organization of the utility.

922 Administrative expenses transferred—Credit.

This account shall be credited with administrative expenses recorded in accounts 920 and 921 which are transferred to construction costs or to nonutility accounts. (See electric plant instruction 4.)

923 Outside services employed.

A. This account shall include the fees and expenses of professional consultants and others for general services which are not applicable to a particular operating function or to other accounts. It shall include also the pay and expenses of persons engaged for a special or temporary administrative or general purpose in circumstances where the person so engaged is not considered as an employee of the utility.

B. This account shall be so maintained as to permit ready summarization according to the nature of service and the person furnishing the same.

ITEMS

1. Fees, pay and expenses of accountants and auditors, actuaries, appraisers, attorneys, engineering consultants, management consultants, negotiators, public relations counsel, tax consultants, etc.
2. Supervision fees and expenses paid under contracts for general management services.

NOTE: Do not include inspection and brokerage fees and commissions chargeable to other accounts or fees and expenses in connection with security issues which are includible in the expenses of issuing securities.

924 Property insurance.

A. This account shall include the cost of insurance or reserve accruals to protect the utility against losses and damages to owned or leased property used in its utility operations. It shall include also the cost of labor and related supplies and expenses incurred in property insurance activities.

B. Recoveries from insurance companies or others for property damages shall be credited to the account charged with the cost of the damage. If the damaged property has been retired, the credit shall be to the appropriate account for accumulated provision for depreciation.

C. Records shall be kept so as to show the amount of coverage for each class of insurance carried, the property covered, and the applicable premiums. Any dividends distributed by mutual insurance companies shall be credited to the accounts to which the insurance premiums were charged.

ITEMS

1. Premiums payable to insurance companies for fire, storm, burglary, boiler explosion, lightning, fidelity, riot, and similar insurance.
2. Amounts credited to account 261, Property Insurance Reserve, for similar protection.
3. Special costs incurred in procuring insurance.
4. Insurance inspection service.
5. Insurance counsel, brokerage fees, and expenses.

NOTE A: The cost of insurance or reserve accruals capitalized shall be charged to construction either directly or by transfer to construction work orders from this account.

NOTE B: The cost of insurance or reserve accruals for the following classes of property shall be charged as indicated.

(1) Materials and supplies and stores equipment, to account 163, Stores Expense Undistributed, or appropriate materials account.
(2) Transportation and other general equipment to appropriate clearing accounts that may be maintained.
(3) Electric plant leased to others, to account 413, Expenses of Electric Plant Leased to Others.
(4) Nonutility property, to the appropriate nonutility income account.
(5) Merchandise and jobbing property, to Account 416, Costs and Expenses of Merchandising, Jobbing and Contract Work.

NOTE C: The cost of labor and related supplies and expenses of administrative and general employees who are only incidentally engaged in property insurance work may be included in accounts 920 and 921, as appropriate.

925 Injuries and damages.

A. This account shall include the cost of insurance or reserve accruals to protect the utility against injuries and damages claims of employees or others, losses of such character not covered by insurance, and expenses incurred in settlement of injuries and damages claims. It shall also include the cost of labor and related supplies and expenses incurred in injuries and damages activities.

B. Reimbursements from insurance companies or others for expenses charged hereto on account of injuries and damages and insurance dividends or refunds shall be credited to this account.

ITEMS

1. Premiums payable to insurance companies for protection against claims from injuries and damages by employees or others, such as public liability, property damages, casualty, employee liability, etc., and amounts credited to account 262, Injuries and Damages Reserve, for similar protection.
2. Losses not covered by insurance or reserve accruals on account of injuries or deaths to employees or others and damages to the property of others.
3. Fees and expenses of claim investigators.
4. Payment of awards to claimants for court costs and attorneys' services.
5. Medical and hospital service and expenses for employees as the result of occupational injuries, or resulting from claims of others.
6. Compensation payments under workmen's compensation laws.

7. Compensation paid while incapacitated as the result of occupational injuries. (See Note A.)

8. Cost of safety, accident prevention and similar educational activities.

NOTE A: Payments to or in behalf of employees for accident or death benefits, hospital expenses, medical supplies or for salaries while incapacitated for service or on leave of absence beyond periods normally allowed, when not the result of occupational injuries, shall be charged to account 926, Employee Pensions and Benefits. (See also Note B of account 926.)

NOTE B: The cost of injuries and damages or reserve accruals capitalized shall be charged to construction directly or by transfer to construction work orders from this account.

NOTE C: Exclude herefrom the time and expenses of employees (except those engaged in injuries and damages activities) spent in attendance at safety and accident prevention educational meetings, if occurring during the regular work period.

NOTE D: The cost of labor and related supplies and expenses of administrative and general employees who are only incidentally engaged in injuries and damages activities may be included in accounts 920 and 921, as appropriate.

926 Employee pensions and benefits.

A. This account shall include pensions paid to or on behalf of retired employees, or accruals to provide for pensions, or payments for the purchase of annuities for this purpose, when the utility has definitely, by contract, committed itself to a pension plan under which the pension funds are irrevocably devoted to pension purposes, and payments for employee accident, sickness, hospital, and death benefits, or insurance therefor. Include, also, expenses incurred in medical, educational or recreational activities for the benefit of employees, and administrative expenses in connection with employee pensions and benefits.

B. The utility shall maintain a complete record of accruals or payments for pensions and be prepared to furnish full information to the Commission of the plan under which it has created or proposes to create a pension fund and a copy of the declaration of trust or resolution under which the pension plan is established.

C. There shall be credited to this account the portion of pensions and benefits expenses which is applicable to nonutility operations or which is charged to construction unless such amounts are distributed directly to the accounts involved and are not included herein in the first instance.

D. Records in support of this account shall be so kept that the total pensions expense, the total benefits expense, the administrative expenses included herein, and the amounts of pensions and benefits expenses transferred to construction or other accounts will be readily available.

ITEMS

1. Payment of pensions under a nonaccrual or nonfunded basis.

2. Accruals for or payments to pension funds or to insurance companies for pension purposes.

3. Group and life insurance premiums (credit dividends received).

4. Payments for medical and hospital services and expenses of employees when not the result of occupational injuries.

5. Payments for accident, sickness, hospital, and death benefits or insurance.

6. Payments to employees incapacitated for service or on leave of absence beyond periods normally allowed, when not the result of occupational injuries, or in excess of statutory awards.

7. Expenses in connection with educational and recreational activities for the benefit of employees.

NOTE A: The cost of labor and related supplies and expenses of administrative and general employees who are only incidentally engaged in employee pension and benefit activities may be included in accounts 920 and 921, as appropriate.

NOTE B: Salaries paid to employees during periods of nonoccupational sickness may be charged to the appropriate labor account rather than to employee benefits.

927 Franchise requirements.

A. This account shall include payments to municipal or other governmental authorities, and the cost of materials, supplies and services furnished such authorities without reimbursement in compliance with franchise, ordinance, or similar requirements; provided, however, that the utility may charge to this account at regular tariff rates, instead of cost, utility service furnished without charge under provisions of franchises.

B. When no direct outlay is involved, concurrent credit for such charges

shall be made to account 929, Duplicate Charges—Credit.

C. The account shall be maintained so as to readily reflect the amounts of cash outlays, utility service supplied without charge, and other items furnished without charge.

NOTE A: Franchise taxes shall not be charged to this account but to account 408.1, Taxes Other Than Income Taxes, Utility Operating Income.

NOTE B: Any amount paid as initial consideration for a franchise running for more than one year shall be charged to account 302, Franchises and Consents.

928 Regulatory commission expenses.

A. This account shall include all expenses (except pay of regular employees only incidentally engaged in such work) properly includible in utility operating expenses, incurred by the utility in connection with formal cases before regulatory commissions, or other regulatory bodies, or cases in which such a body is a party, including payments made to a regulatory commission for fees assessed against the utility for pay and expenses of such commission, its officers, agents, and employees, and also including payments made to the United States for the administration of the Federal Power Act.

B. Amounts of regulatory commission expenses which by approval or direction of the Commission are to be spread over future periods shall be charged to account 186, Miscellaneous Deferred Debits, and amortized by charges to this account.

C. The utility shall be prepared to show the cost of each formal case.

ITEMS

1. Salaries, fees, retainers, and expenses of counsel, solicitors, attorneys, accountants, engineers, clerks, attendants, witnesses, and others engaged in the prosecution of, or defense against petitions or complaints presented to regulatory bodies, or in the valuation of property owned or used by the utility in connection with such cases.

2. Office supplies and expenses, payments to public service or other regulatory commissions, stationery and printing, traveling expenses, and other expenses incurred directly in connection with formal cases before regulatory commissions.

NOTE A: Exclude from this account and include in other appropriate operating expense accounts, expenses incurred in the improvement of service, additional inspection, or rendering reports, which are made necessary by the rules and regulations, or orders, of regulatory bodies.

NOTE B: Do not include in this account amounts includible in account 302, Franchises and Consents, account 181, Unamortized Debt Expense, or account 214, Capital Stock Expense.

929 Duplicate charges—Credit.

This account shall include concurrent credits for charges which may be made to operating expenses or to other accounts for the use of utility service from its own supply. Include, also, offsetting credits for any other charges made to operating expenses for which there is no direct money outlay.

930.1 General advertising expenses.

This account shall include the cost of labor, materials used, and expenses incurred in advertising and related activities, the cost of which by their content and purpose are not provided for elsewhere.

ITEMS

Labor:

1. Supervision.
2. Preparing advertising material for newspapers, periodicals, billboards, etc., and preparing or conducting motion pictures, radio and television programs.
3. Preparing booklets, bulletins, etc., used in direct mail advertising.
4. Preparing window and other displays.
5. Clerical and stenographic work.
6. Investigating and employing advertising agencies, selecting media and conducting negotiations in connection with the placement and subject matter of advertising.

Materials and Expenses:

7. Advertising in newspapers, periodicals, billboards, radio, etc.
8. Advertising matter such as posters, bulletins, booklets, and related items.
9. Fees and expenses of advertising agencies and commercial artists.
10. Postage and direct mail advertising.
11. Printing of booklets, dodgers, bulletins, etc.
12. Supplies and expenses in preparing advertising materials.
13. Office supplies and expenses.

NOTE A.—Properly includible in this account is the cost of advertising activities on a local or national basis of a good will or institutional nature, which is primarily designed to improve the image of the utility or

the industry, including advertisements which inform the public concerning matters affecting the company's operations, such as, the cost of providing service, the company's efforts to improve the quality of service, the company's efforts to improve and protect the environment, etc. Entries relating to advertising included in this account shall contain or refer to supporting documents which identify the specific advertising message. If references are used, copies of the advertising message shall be readily available.

NOTE B.—Exclude from this account and include in account 426.4, Expenditures for Certain Civic, Political and Related Activities, expenses for advertising activities, which are designed to solicit public support or the support of public officials in matters of a political nature.

930.2 Miscellaneous general expenses.

This account shall include the cost of labor and expenses incurred in connection with the general management of the utility not provided for elsewhere.

ITEMS

Labor:

1. Miscellaneous labor not elsewhere provided for.

Expenses:

2. Industry association dues for company memberships.
3. Contributions for conventions and meetings of the industry.
4. Research, development, and demonstration expenses not charged to other operation and maintenance expense accounts on a functional basis.
5. Communication service not chargeable to other accounts.
6. Trustee, registrar, and transfer agent fees and expenses.
7. Stockholders meeting expenses.
8. Dividend and other financial notices.
9. Printing and mailing dividend checks.
10. Directors' fees and expenses.
11. Publishing and distributing annual reports to stockholders.
12. Public notices of financial, operating and other data required by regulatory statutes, not including, however, notices required in connection with security issues or acquisitions of property.

931 Rents.

This account shall include rents properly includible in utility operating expenses for the property of others used, occupied, or operated in connection with the customer accounts, customer service and informational, sales, and general and administrative functions of the utility. (See operating expense instruction 3.)

Maintenance

932 Maintenance of general plant.

A. This account shall include the cost assignable to customer accounts, sales and administrative and general functions of labor, materials used and expenses incurred in the maintenance of property, the book cost of which is includible in account 390, Structures and Improvements, account 391, Office Furniture and Equipment, account 397, Communication Equipment, and account 398 Miscellaneous Equipment. (See operating expense instruction 2.)

B. Maintenance expenses on office furniture and equipment used elsewhere than in general, commercial and sales offices shall be charged to the following accounts:

Steam Power Generation, Account 514.
Nuclear Power Generation, Account 532.
Hydraulic Power Generation, Account 545.
Other Power Generation, Account 554.
Transmission, Account 573.
Distribution, Account 598.
Merchandise and Jobbing, Account 416.
Garages, Shops, etc., Appropriate clearing account, if used.

NOTE: Maintenance of plant included in other general equipment accounts shall be included herein unless charged to clearing accounts or to the particular functional maintenance expense account indicated by the use of the equipment.

Appendix B

OMCOST COMPUTER PROGRAM FORTRAN LISTING

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C                                                                       MAIN
C_______________________________________________________________________MAIN  10
C|                                                                      |MAIN  20
C|                              O M C O S T                             |MAIN  30
C|                                                                      |MAIN  40
C|     M. L. MYERS    --  PROCEDURE                                     |MAIN  50
C|     PHONE: (615) 574-0332 (COMMERCIAL)                               |MAIN  60
C|                  624-0332 (FTS)                                      |MAIN  70
C|                                                                      |MAIN  80
C|     L. C. FULLER   --  PROGRAM                                       |MAIN  90
C|     PHONE: (615) 574-0333 (COMMERCIAL)                               |MAIN 100
C|                  624-0333 (FTS)                                      |MAIN 110
C|                                                                      |MAIN 120
C|     ENGINEERING TECHNOLOGY DIVISION                                  |MAIN 130
C|     OAK RIDGE NATIONAL LABORATORY                                    |MAIN 140
C|     BUILDING 9104-1                                                  |MAIN 150
C|     P. O. BOX Y                                                      |MAIN 160
C|     OAK RIDGE, TENNESSEE 37830                                       |MAIN 170
C|                                                                      |MAIN 180
C|______________________________________________________________________|MAIN 190
C                                                                       MAIN 200
C=====VARIABLE DICTIONARY                                               MAIN 210
C    H        DEFAULT VALUES OF PLANT NET HEAT RATE                     MAIN 220
C    X        ALTERNATE FORMS FOR PLANT TYPE                            MAIN 230
C    IW       NUMBER OF WRITE UNIT (NORMALLY 6)                         MAIN 240
C    ADM      A&G COSTS OTHER THAN COMINS, GOVINS, RETRO, PROPIN, RPOWER MAIN 250
C    ASH      ASH IN COAL, PERCENT; ASH(1)FOR PLANTS WITH WET SCRUBBERS, MAIN 260
C             ASH(2) FOR PLANTS WITH DRY SCRUBBERS                      MAIN 270
C    BTU      HEATING VALUE OF COAL, BTU/LB                             MAIN 280
C             BTU(1)  FOR PLANTS WITH WET LIMESTONE FGD                 MAIN 290
C             BTU(2)  FOR PLANTS WITH DRY FGD                           MAIN 300
C    MWN      NET PLANT ELECTRICAL OUTPUT (SINGLE UNIT), MW             MAIN 310
C    MWT      THERMAL INPUT TO PLANT (SINGLE UNIT), MW                  MAIN 320
C    SUL      SULFUR IN COAL, PERCENT; SUL(1) FOR WET FGD, SUL(2) FOR DRY MAIN 330
C    $ASH     $/TON ASH HANDLING COST(BASE YEAR)                        MAIN 340
C    BASM     ANNUAL COST OF MAINTENANCE MATERIAL AT REFERENCE CAPACITY MAIN 350
C             FACTOR, $THOUSAND/YEAR                                    MAIN 360
C    ISOX     =1 FLUE GAS DESULFURIZATION SPECIFIED                     MAIN 370
C             =0 FLUE GAS DESULFURIZATION NOT SPECIFIED                 MAIN 380
C    SUPR     PLANT SUPER. & ENGRG. AS PCT. OF WAGES & FRINGES          MAIN 390
C             SUPR(1) FOR LWR PLANTS, SUPR(2) FOR COAL-FIRED PLANTS     MAIN 400
C    TYPE     PLANT TYPE (LWR OR COAL)                                  MAIN 410
C    VERS     VERSION (DATE) OF OMCOST                                  MAIN 420
C    YEAR     YEAR OF OPERATION                                         MAIN 430
C    $$ASH    $/TON ASH HANDLING COST(YEAR OF OPERATION)                MAIN 440
C    CLIME    S&E ADDER FOR LIME COST, $THOUSAND/YEAR                   MAIN 450
C    COLIM    COST OF LIME, $/TON                                       MAIN 460
C    COSLM    COST OF LIME (BASE YEAR), $/TON                           MAIN 470
C    COVER    PROPERTY INSURANCE COVERAGE, $THOUSAND                    MAIN 480
C    ESLIM    ESCALATION RATE ON COST OF LIME, PERCENT/YEAR             MAIN 490
C    FIXSE    FIXED ANNUAL COST OF SUPPLIES & EXPENSES, $THOUSAND/YEAR  MAIN 500
C    FRING    OPERATOR FRINGE BENEFITS AS PERCENT OF WAGE RATE, PERCENT MAIN 510
C             FRING(1) FOR LWR PLANTS, FRING(2) FOR COAL-FIRED PLANTS   MAIN 520
C    ITYPE    INDEX OF PLANT TYPE =1 PWR, BWR, LWR, =2 COAL             MAIN 530
C    NAME1    INPUT NAMELIST NAME                                       MAIN 540
C    OFFON    OFFSITE/ONSITE AVE. EMPLOYEE COST RATIO, OFFON(ITYPE)     MAIN 550
C             OFFON(1) LWR, OFFON(2) COAL-FIRED                         MAIN 560
C    RETRO    RETROSPECTIVE PREMIUM INSURANCE, $THOUSAND/YEAR           MAIN 570
C    SLURY    BASE YEAR COST OF SLUDGE DISPOSAL, $/DRY TON              MAIN 580
C    STAFF    STAFF TOTAL, PERSONS                                      MAIN 590
C    SUPER    PLANT SUPER. & ENGRG. AS PCT. OF WAGES & FRINGES          MAIN 600
C    TONLM    LIME, TONS/YEAR                                           MAIN 610
C    TOTAL    TOTAL ANNUAL O & M COSTS, $THOUSAND/YEAR                  MAIN 620
C    UNITS    NUMBER OF UNITS PER STATION                               MAIN 630
C    VARSE    VARIABLE ANNUAL COST OF SUPPLIES & EXPENSES, $THOUSAND/YEAR MAIN 640
C    XLIMS    TONS LIME/TON SULFUR                                      MAIN 650
C    ADMGEN   ADMINISTRATIVE AND GENERAL, $THOUSAND/YEAR                MAIN 660
C    AGFACT   'OTHER' ADMINISTRATIVE AND GENERAL EXPENSES AS A PERCENTAGE MAIN 670
C             OF TOTAL DIRECT COST                                      MAIN 680
C    ANNGEN   ANNUAL NET GENERATION, MILLION KWH                        MAIN 690
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C     ASHPCT  ASH IN COAL, PERCENT                                        MAIN 700
C     BASECF  REFERENCE CAPACITY FACTOR IN COST MODELS FOR VARMNT         MAIN 710
C     BASEYR  BASE YEAR FOR COST MODEL                                    MAIN 720
C     BASTAF  STAFF TOTAL, PERSONS                                        MAIN 730
C     BTUCOL  HEATING VALUE OF COAL, BTU/LB                               MAIN 740
C     CLIMES  S&E ADDER FOR LIMESTONE COST, $THOUSAND/YEAR                MAIN 750
C     COLIMS  COST OF LIMESTONE, $/TON                                    MAIN 760
C     COMINS  COMMERCIAL LIABILITY INSURANCE, $THOUSAND/YEAR              MAIN 770
C     COSLMS  COST OF LIMESTONE (BASE YEAR), $/TON                        MAIN 780
C     COSTAF  ANNUAL COST OF STAFF (TOTAL), $THOUSAND/YEAR                MAIN 790
C     DIRECT  TOTAL DIRECT COST, $THOUSAND/YEAR                           MAIN 800
C     DISPOS  S&E ADDER FOR FIXATION, HANDLING, DISPOSAL, $THOUSAND/YEAR  MAIN 810
C     ESCGEN  GENERAL ESCALATION RATE, PERCENT/YEAR                       MAIN 820
C     ESCINS  ESCALATION RATE ON COST OF COMMERCIAL LIABILITY INS., PCT/YRMAIN 830
C     ESCPIN  ESCALATION RATE ON PROPERTY INSURANCE                       MAIN 840
C     ESCPOW  ESCALATION RATE ON COST OF REPLACEMENT POWER INSURANCE      MAIN 850
C     ESCSUP  ESCALATION RATE ON SUPPLIES AND EXPENSES, PERCENT/YEAR      MAIN 860
C     ESFEES  ESCALATION RATE ON COST OF INSPECTION FEES, PERCENT/YEAR    MAIN 870
C     ESGINS  ESCALATION RATE ON COST OF GOVERNMENT LIABILITY INS., PCT/YRMAIN 880
C     ESLIMS  ESCALATION RATE ON COST OF LIMESTONE, PERCENT/YEAR          MAIN 890
C     ESMATL  ESCALATION RATE ON MATERIAL, PERCENT/YEAR                   MAIN 900
C     ESSLUR  ESCALATION RATE ON COST OF SLUDGE DISPOSAL, PERCENT/YEAR    MAIN 910
C     ESWAGE  ESCALATION RATE ON WAGES, PERCENT/YEAR                      MAIN 920
C     ETANET  PLANT NET EFFICIENCY, PERCENT                               MAIN 930
C     EXCESS  PROPERTY INSURANCE, EXCESS AMOUNT, $THOUSAND/YEAR           MAIN 940
C     EXCMUL  MULTIPLIER FOR PROPERTY INSURANCE, EXCESS                   MAIN 950
C     FEEINS  FEES, INSPECTIONS, REVIEWS, $THOUSAND/YEAR                  MAIN 960
C     FIXFAC  FIXED PORTION OF PLANT MAINTENANCE MATL. COSTS, DECIMAL     MAIN 970
C     FIXMIL  FIXED UNIT O & M COSTS, MILLS/KWH(E)                        MAIN 980
C     FIXMNT  ANNUAL COST FIXED MAINTENANCE MATL., $THOUSAND/YEAR         MAIN 990
C     FORTYR  HOURS PER YEAR AT 40 HOURS PER WEEK                         MAIN1000
C     FRINGE  OPERATOR FRINGE BENEFITS AS PERCENT OF WAGE RATE, PERCENT   MAIN1010
C     FULLYR  TOTAL HOURS IN A YEAR                                       MAIN1020
C     GOVINS  GOVERNMENT LIABILITY INSURANCE, $THOUSAND/YEAR              MAIN1030
C     HTRATE  PLANT NET HEAT RATE, BTU/KWH(E)                             MAIN1040
C     MANCOS  ANNUAL COST OF STAFF MEMBER, $/MAN-YEAR                     MAIN1050
C     PCTSRM  PERCENT SULFUR REMOVED                                      MAIN1060
C     PCTSUL  SULFUR IN COAL, PERCENT                                     MAIN1070
C     PENPCT  SPECIAL PENALTIES PERCENT FOR ONSITE LABOR, PENPCT(ITYPE)   MAIN1080
C     PLTFAC  BASE LOAD CAPACITY FACTOR                                   MAIN1090
C     PRIMAR  PROPERTY INSURANCE, PRIMARY AMOUNT, $THOUSAND/YEAR          MAIN1100
C     PRIMUL  MULTIPLIER FOR PPROPERTY INSURANCE, PRIMARY                 MAIN1110
C     PROPIN  PROPERTY INSURANCE, $THOUSAND/YEAR                          MAIN1120
C     PROPRT  PROPERTY INSURANCE RATE, CENTS/$HUNDRED                     MAIN1130
C     REMOVL  PERCENT SULFUR REMOVED; REMOVL(1) FOR WET FGD, (2) DRY      MAIN1140
C     RPOWER  REPLACEMENT POWER INSURANCE, $THOUSAND/YEAR                 MAIN1150
C     SLURRY  COST OF SLUDGE DISPOSAL (YEAR OF OPERATION), $/DRY TON      MAIN1160
C     SLUSUL  DRY SLUDGE TO SULFUR RATIO FOR FLUE GAS DESULFURIZATION     MAIN1170
C     STAFF4  TECHNICAL AND ENGINEERING STAFF SUBTOTAL                    MAIN1180
C     SULREM  SULFUR REMOVED, TONS/YEAR                                   MAIN1190
C     SUPAD2  ASH DISPOSAL COST, $1000/YR                                 MAIN1200
C     SUPEXF  COST OF CHEMICALS, GASES, LUBRICANTS, OFFICE, SECURITY      MAIN1210
C             AND PERSONNEL, SUPPLIES, TRAINING, LWR RADWASTE             MAIN1220
C     SUPEXP  SUPPLIES & EXPENSES (TOTAL), $THOUSAND/YEAR                 MAIN1230
C     SUPORT  OFFSITE SUPPORT SERVICES, $THOUSAND/YEAR                    MAIN1240
C     TONCOL  COAL BURNED, TONS/YEAR                                      MAIN1250
C     TONLMS  LIMESTONE, TONS/YEAR                                        MAIN1260
C     TONSUL  SULFUR IN COAL (100 PCT.), TONS/YEAR                        MAIN1270
C     TOTFIX  TOTAL FIXED COSTS, $THOUSAND/YEAR                           MAIN1280
C     TOTMIL  TOTAL UNIT O & M COSTS, MILLS/KWH(E)                        MAIN1290
C     TOTML2  TOTAL UNIT O&M COST LESS 'OTHER A&G', MILLS/KWH(E)          MAIN1300
C     TOTML3  TOTAL UNIT O&M COST LESS A&G, MILLS/KWH(E)                  MAIN1310
C     TOTMNT  ANNUAL COST OF MAINTENANCE MATERIAL, $THOUSAND/YEAR         MAIN1320
C     TOTVAR  TOTAL VARIABLE COSTS, $THOUSAND/YEAR                        MAIN1330
C     VARFAC  VARIABLE PORTION OF PLANT MAINTENANCE COSTS, DECIMAL        MAIN1340
C     VARMIL  VARIABLE UNIT O & M COSTS, MILLS/KWH(E)                     MAIN1350
C     VARMNT  ANNUAL COST VARIABLE MAINTENANCE MATL., $THOUSAND/YEAR      MAIN1360
C     VSEBAS  VARIABLE COST OF SUPPLIES AND EXPENSES (BEFORE SLUDGE       MAIN1370
C             DISPOSAL, FLYASH, LIME/LIMESTONE COST), $THOUSAND/YEAR      MAIN1380
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C    VSEMIL  BASE YEAR VARIABLE COST OF SUPPLIES AND EXPENSES(BEFORE      MAIN1390
C            SLUDGE DISPOSAL, FLYASH), MILLS/KWH(E)                       MAIN1400
C    WAGERT  WAGE RATE (BEFORE ADDERS), $/HOUR                            MAIN1410
C    WETDRY  =1 WET SCRUBBERS SPECIFIED, =2 DRY SCRUBBERS SPECIFIED       MAIN1420
C    XLIMSS  TONS LIMESTONE/TON SULFUR                                    MAIN1430
      REAL*8 VERS                                                         MAIN1440
      REAL*4 MWT, MWN, MANCOS                                             MAIN1450
      INTEGER*4 STAFF, UNITS, WETDRY, STAFF4                              MAIN1460
      DIMENSION ASH(2)                                                    MAIN1470
      DIMENSION BTU(2)                                                    MAIN1480
      DIMENSION SUL(2)                                                    MAIN1490
      DIMENSION SUPR(2)                                                   MAIN1500
      DIMENSION FRING(2)                                                  MAIN1510
      DIMENSION OFFON(2)                                                  MAIN1520
      DIMENSION AGFACT(2)                                                 MAIN1530
      DIMENSION PENPCT(2)                                                 MAIN1540
      DIMENSION REMOVL(2)                                                 MAIN1550
      COMMON /COM1/ ISOX, STAFF, UNITS, STAFF4                            MAIN1560
      COMMON /COM2/ MWN, YEAR, BASECF, BASEYR, ESMATL, ESWAGE, FIXMNT,    MAIN1570
     * MANCOS, PLTFAC, SUPEXF, TOTMNT, VARMNT, VSEMIL                     MAIN1580
      NAMELIST /NAME1/ MWN, $ASH, ISOX, TYPE, YEAR, COSLM, SLURY,         MAIN1590
     * COSLMS, ESLIM, ESLIMS, XLIMSS, ESCSUP,                             MAIN1600
     * SUPER, UNITS, XLIMS, ASHPCT, BTUCOL, ESCGEN, ESCINS, ESCPIN,       MAIN1610
     * ESCPOW, ESFEES, ESGINS,          ESMATL, ESSLUR, ESWAGE, FRINGE,   MAIN1620
     * HTRATE, PCTSRM, PCTSUL, PLTFAC, WAGERT, WETDRY                     MAIN1630
      DATA IW/6/                                                          MAIN1640
      DATA ASH/11.6001,7.3001/                                            MAIN1650
      DATA BTU/11000.1,8200.01/                                           MAIN1660
      DATA SUL/3.50001,.500001/                                           MAIN1670
      DATA $ASH/5.0/                                                      MAIN1680
      DATA SUPR/20.0001,10.0001/                                          MAIN1690
      DATA TYPE/'PWR '/                                                   MAIN1700
      DATA VERS/'6-4-82  '/                                               MAIN1710
      DATA COSLM/70.0/                                                    MAIN1720
      DATA COVER/500000./                                                 MAIN1730
      DATA FRING/35.0001,35.0001/                                         MAIN1740
      DATA OFFON/2.0,1.5/                                                 MAIN1750
      DATA SLURY/5.0/                                                     MAIN1760
      DATA SUPER/20.0001/                                                 MAIN1770
      DATA XLIMS/1.0/                                                     MAIN1780
      DATA AGFACT/30.,30./                                                MAIN1790
      DATA ASHPCT/11.6001/                                                MAIN1800
      DATA BTUCOL/11000.1/                                                MAIN1810
      DATA COSLMS/12.5/                                                   MAIN1820
      DATA FRINGE/35.0001/                                                MAIN1830
      DATA PCTSRM/90.0001/                                                MAIN1840
      DATA PCTSUL/3.50001/                                                MAIN1850
      DATA PENPCT/5.0,0.0/                                                MAIN1860
      DATA PROPRT/.40/                                                    MAIN1870
      DATA REMOVL/90.0001,70.0001/                                        MAIN1880
      DATA SLUSUL/4.0/                                                    MAIN1890
      DATA WAGERT/10.45/                                                  MAIN1900
      DATA XLIMSS/4.0/                                                    MAIN1910
C=====THIS SECTION FOR ALL PLANT TYPES                                    MAIN1920
      MWN=1150.                                                           MAIN1930
      UNITS=1                                                             MAIN1940
      YEAR = 1982.0                                                       MAIN1950
      BASEYR = 1982.0                                                     MAIN1960
      ESCGEN = -99.                                                       MAIN1970
      ESCSUP = 10.0                                                       MAIN1980
      ESWAGE = 8.0                                                        MAIN1990
      ESSLUR = 10.0                                                       MAIN2000
      ESLIM  = 10.0                                                       MAIN2010
      ESLIMS = 10.0                                                       MAIN2020
      ESCINS = 6.0                                                        MAIN2030
      ESGINS = 0.0                                                        MAIN2040
      ESFEES = 8.0                                                        MAIN2050
      ESCPIN = 6.0                                                        MAIN2060
      ESCPOW = 9.0                                                        MAIN2070
      ESMATL = 10.0                                                       MAIN2080
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      BASECF = .80                                                      MAIN2090
      PLTFAC = .65                                                      MAIN2100
      WETDRY=1                                                          MAIN2110
      FULLYR = 365.25 * 24.                                             MAIN2120
      FORTYR = 52. * 40.                                                MAIN2130
      HTRATE=10700.                                                     MAIN2140
      ISOX = 1                                                          MAIN2150
C-----PRINT DEFAULT VALUES OF NAMELIST NAME1 VARIABLES                  MAIN2160
      WRITE(IW,821) YEAR, TYPE, PLTFAC, MWN, HTRATE, ISOX, WETDRY, UNITSMAIN2170
  821 FORMAT('1',T12,'DEFAULT VALUES OF NAMELIST NAME1 VARIABLES'//     MAIN2180
     *       ' ',T20,'YEAR  ',T40,F6.1 /                                MAIN2190
     *       ' ',T20,'TYPE  ',T40,A4   /                                MAIN2200
     *       ' ',T20,'PLTFAC',T40,F4.2 /                                MAIN2210
     *       ' ',T20,'MWN   ',T40,F5.0 /                                MAIN2220
     *       ' ',T20,'HTRATE',T38,F8.0 /                                MAIN2230
     *       ' ',T20,'ISOX  ',T40,I1   /                                MAIN2240
     *       ' ',T20,'WETDRY',T40,I1   /                                MAIN2250
     *       ' ',T20,'UNITS ',T40,I1   )                                MAIN2260
      WRITE(IW,858) WAGERT, FRINGE, SUPER, BTUCOL, XLIMSS, XLIMS        MAIN2270
  858 FORMAT(' ',T20,'WAGERT',T39,F5.2 /                                MAIN2280
     *       ' ',T20,'FRINGE',T38,F5.0 /                                MAIN2290
     *       ' ',T20,'SUPER ',T38,F5.0 /                                MAIN2300
     *       ' ',T20,'BTUCOL',T38,F8.0 /                                MAIN2310
     *       ' ',T20,'XLIMSS',T36,F8.2 /                                MAIN2320
     *       ' ',T20,'XLIMS ',T36,F8.2 )                                MAIN2330
      WRITE(IW,819)$ASH,ASHPCT                                          MAIN2340
  819 FORMAT(' ',T20,'$ASH',T36,F8.2/                                   MAIN2350
     *       ' ',T20,'ASHPCT',T36,F8.2)                                 MAIN2360
      WRITE(IW,859)PCTSRM, PCTSUL, SLURY, COSLMS, COSLM, ESWAGE         MAIN2370
  859 FORMAT(' ',T20,'PCTSRM',T36,F8.2/                                 MAIN2380
     *       ' ',T20,'PCTSUL',T36,F8.2 /                                MAIN2390
     *       ' ',T20,'SLURY ',T36,F8.2 /                                MAIN2400
     *       ' ',T20,'COSLMS',T36,F8.2 /                                MAIN2410
     *       ' ',T20,'COSLM ',T36,F8.2 /                                MAIN2420
     *       ' ',T20,'ESWAGE',T37,F6.1 )                                MAIN2430
      WRITE(IW,870)ESSLUR, ESLIMS, ESLIM, ESCINS, ESGINS, ESFEES,       MAIN2440
     * ESMATL, ESCSUP, ESCPIN, ESCPOW, ESCGEN                           MAIN2450
  870 FORMAT(' ',T20,'ESSLUR',T37,F6.1 /                                MAIN2460
     *       ' ',T20,'ESLIMS',T37,F6.1 /                                MAIN2470
     *       ' ',T20,'ESLIM ',T37,F6.1 /                                MAIN2480
     *       ' ',T20,'ESCINS',T37,F6.1 /                                MAIN2490
     *       ' ',T20,'ESGINS',T37,F6.1 /                                MAIN2500
     *       ' ',T20,'ESFEES',T37,F6.1 /                                MAIN2510
     *       ' ',T20,'ESMATL',T37,F6.1 /                                MAIN2520
     *       ' ',T20,'ESCSUP',T37,F6.1 /                                MAIN2530
     *       ' ',T20,'ESCPIN',T37,F6.1 /                                MAIN2540
     *       ' ',T20,'ESCPOW',T37,F6.1 /                                MAIN2550
     *       ' ',T20,'ESCGEN',T37,F6.1 )                                MAIN2560
  610 CONTINUE                                                          MAIN2570
C=====THIS SECTION FOR ALL PLANT TYPES                                  MAIN2580
C=====NEW CASE                                                          MAIN2590
C-----READ INPUT DATA                                                   MAIN2600
      READ(5 ,NAME1,END=708)                                            MAIN2610
C-----CHECK FOR NUMBER OF UNITS OUT OF RANGE                            MAIN2620
      CALL UNITCK(UNITS,&610)                                           MAIN2630
C-----DETERMINE INDEX 'ITYPE' CORRESPONDING TO SELECTED PLANT TYPE      MAIN2640
      CALL TYPER(TYPE,ITYPE)                                            MAIN2650
C-----SELECT APPROPRIATE FACTORS FOR OPERATOR FRINGE BENEFITS AND PLANT MAIN2660
C     SUPERVISION AND ENGINEERING                                       MAIN2670
      CALL CHKDEF(FRINGE,FRING,ITYPE)                                   MAIN2680
      CALL CHKDEF(SUPER,SUPR,ITYPE)                                     MAIN2690
      IF(ESCGEN.EQ.-99.) GO TO 601                                      MAIN2700
C-----SET INDIVIDUAL ESCALATION RATES EQUAL TO GENERAL ESCALATION RATE  MAIN2710
C     IF GENERAL ESCALATION RATE WAS INPUT                              MAIN2720
      ESWAGE = ESCGEN                                                   MAIN2730
      ESSLUR = ESCGEN                                                   MAIN2740
      ESLIM  = ESCGEN                                                   MAIN2750
      ESLIMS = ESCGEN                                                   MAIN2760
      ESCINS = ESCGEN                                                   MAIN2770
      ESGINS = ESCGEN                                                   MAIN2780
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      ESFEES = ESCGEN                                                   MAIN2790
      ESCPIN = ESCGEN                                                   MAIN2800
      ESCPOW = ESCGEN                                                   MAIN2810
      ESMATL = ESCGEN                                                   MAIN2820
      ESCSUP = ESCGEN                                                   MAIN2830
  601 CONTINUE                                                          MAIN2840
C-----CALCULATE ANNUAL COST OF A STAFF MEMBER                           MAIN2850
      MANCOS=FORTYR*WAGERT*(1.+FRINGE/100.)*(1.+SUPER/100.)             MAIN2860
     * *(1.+PENPCT(ITYPE)/100.)                                         MAIN2870
     * *(1.0+ESWAGE/100.)**(YEAR-BASEYR)                                MAIN2880
C-----ASSIGN A HEAT RATE                                                MAIN2890
      CALL HEATRT(HTRATE,ITYPE,ISOX,WETDRY)                             MAIN2900
C-----CALCULATE PLANT NET EFFICIENCY                                    MAIN2910
      ETANET=3412.140 * 100. / HTRATE                                   MAIN2920
C-----CALCULATE THERMAL INPUT PER UNIT                                  MAIN2930
      MWT = MWN * 100. /ETANET                                          MAIN2940
C-----CALCULATE ANNUAL NET GENERATION                                   MAIN2950
      ANNGEN = (MWN * FULLYR * PLTFAC / 1000.) * UNITS                  MAIN2960
C-----SELECT APPROPRIATE COST MODEL                                     MAIN2970
      CALL SELECT(ITYPE,ISOX,WETDRY,&610,&600)                          MAIN2980
  600 CONTINUE                                                          MAIN2990
C-----CALCULATE TOTAL COST OF PLANT STAFF                               MAIN3000
      COSTAF = STAFF * MANCOS / 1000.                                   MAIN3010
C-----CALCULATE VARIABLE S&E BEFORE ASH, FGD SLUDGE DISPOSAL, LIME/     MAIN3020
C     LIMESTONE                                                         MAIN3030
      VSEBAS = VSEMIL*ANNGEN                                            MAIN3040
     * *(1.0+ESCSUP/100.)**(YEAR-BASEYR)                                MAIN3050
      SUPAD2=0.0                                                        MAIN3060
      DISPOS=0.0                                                        MAIN3070
      IF(ITYPE.EQ. 1)GO TO 617                                          MAIN3080
C=====THIS SECTION FOR COAL-FIRED PLANTS ONLY                           MAIN3090
C-----SELECT APPROPRIATE DEFAULT COAL DATA IF DATA WERE NOT INPUT       MAIN3100
      CALL CHKDEF(BTUCOL,BTU,WETDRY)                                    MAIN3110
C     DITTO     ASH IN COAL                                             MAIN3120
      CALL CHKDEF(ASHPCT,ASH,WETDRY)                                    MAIN3130
C     DITTO     SULFUR IN COAL                                          MAIN3140
      CALL CHKDEF(PCTSUL,SUL,WETDRY)                                    MAIN3150
C     DITTO     PERCENT SULFUR REMOVED                                  MAIN3160
      CALL CHKDEF(PCTSRM,REMOVL,WETDRY)                                 MAIN3170
C-----CALCULATE TONS OF COAL BURNED PER YEAR                            MAIN3180
      TONCOL = ANNGEN * HTRATE * 1.E6/(BTU(       WETDRY) * 2000.)      MAIN3190
C-----CALCULATE $/TON ASH HANDLING COST                                 MAIN3200
      $$ASH=$ASH*(1.0 +ESSLUR/100.)**(YEAR - BASEYR)                    MAIN3210
      IF(ISOX.EQ.0) GO TO 619                                           MAIN3220
C=====THIS SECTION FOR COAL-FIRED PLANTS WITH FGD                       MAIN3230
C-----CALCULATE TONS OF SULFUR IN COAL(100 PERCENT)                     MAIN3240
      TONSUL = TONCOL * PCTSUL/100.                                     MAIN3250
C-----CALCULATE SULFUR REMOVED IN TONS PER YEAR                         MAIN3260
      SULREM = TONSUL * PCTSRM / 100.                                   MAIN3270
C-----CALCULATE COST OF SLUDGE DISPOSAL, $/DRY TON                      MAIN3280
      SLURRY = SLURY * (1.0 +ESSLUR/100.)**(YEAR-BASEYR)                MAIN3290
C     DISPOS=FGD SLUDGE DISPOSAL COST + ASH DISPOSAL COST -- FOR WET    MAIN3300
C     FOR DRY THE EXPRESSIONS ARE COMBINED                              MAIN3310
      DISPOS=SULREM*SLUSUL*SLURRY/1000.                                 MAIN3320
     *      +TONCOL*(ASH(WETDRY)/100.)*$$ASH/1000.                      MAIN3330
      IF(WETDRY.EQ.2)GO TO 632                                          MAIN3340
C=====COAL WITH WET LIMESTONE FGD ONLY                                  MAIN3350
C-----CALCULATE LIMESTONE, TONS/YEAR                                    MAIN3360
      TONLMS=SULREM*XLIMSS                                              MAIN3370
C-----CALCULATE COST OF LIMESTONE, $/TON                                MAIN3380
      COLIMS=COSLMS*(1.0+ESLIMS/100.)**(YEAR-BASEYR)                    MAIN3390
C-----CALCULATE S&E ADDER FOR LIMESTONE COST, $THOUSAND/YEAR            MAIN3400
      CLIMES=TONLMS*COLIMS/1000.                                        MAIN3410
      GO TO 617                                                         MAIN3420
632   CONTINUE                                                          MAIN3430
C=====COAL WITH DRY FGD ONLY                                            MAIN3440
C-----CALCULATE LIME, TONS/YEAR                                         MAIN3450
      TONLM =SULREM*XLIMS                                               MAIN3460
C-----CALCULATE COST OF LIME, $/TON                                     MAIN3470
      COLIM =COSLM *(1.0+ESLIM /100.)**(YEAR-BASEYR)                    MAIN3480
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C-----CALCULATE S&E ADDER FOR LIME COST, $THOUSAND/YEAR                  MAIN3490
      CLIME =TONLM *COLIM/1000.                                          MAIN3500
      GO TO 617                                                          MAIN3510
  619 CONTINUE                                                           MAIN3520
C=====THIS SECTION FOR COAL-FIRED PLANTS WITHOUT FGD                     MAIN3530
C-----CALCULATE ASH DISPOSAL COST                                        MAIN3540
      SUPAD2=TONCOL*(ASH(WETDRY)/100.)*$$ASH/1000.                       MAIN3550
  617 CONTINUE                                                           MAIN3560
C=====THIS SECTION FOR ALL PLANT TYPES                                   MAIN3570
C-----CALCULATE VARIABLE SUPPLIES AND EXPENSES                           MAIN3580
      VARSE = VSEBAS + SUPAD2 +          DISPOS                          MAIN3590
      IF(ISOX.EQ.0)GO TO 634                                             MAIN3600
      IF(WETDRY.EQ.1)VARSE=VARSE+CLIMES                                  MAIN3610
      IF(WETDRY.EQ.2)VARSE=VARSE+CLIME                                   MAIN3620
634   CONTINUE                                                           MAIN3630
C-----CALCULATE FIXED SUPPLIES AND EXPENSES                              MAIN3640
      FIXSE = SUPEXF*UNITS                                               MAIN3650
     * *(1.0+ESCSUP/100.)**(YEAR-BASEYR)                                 MAIN3660
C-----CALCULATE TOTAL SUPPLIES AND EXPENSES                              MAIN3670
      SUPEXP = FIXSE + VARSE                                             MAIN3680
C-----CALCULATE OFFSITE SUPPORT SERVICES                                 MAIN3690
      SUPORT=STAFF4 * MANCOS * OFFCN(ITYPE) / 1000.                      MAIN3700
      IF(ITYPE.EQ.1)GO TO 12                                             MAIN3710
C=====THIS SECTION FOR COAL-FIRED PLANTS ONLY                            MAIN3720
      FEEINS=0.0                                                         MAIN3730
      COMINS=0.0                                                         MAIN3740
      GOVINS=0.0                                                         MAIN3750
      RETRO=0.0                                                          MAIN3760
      RPOWER=0.                                                          MAIN3770
C-----CALCULATE PROPERTY INSURANCE                                       MAIN3780
      PROPIN = UNITS * 100.                                              MAIN3790
     * *(1.0+ESCPIN/100.)**(YEAR-BASEYR)                                 MAIN3800
      GO TO 15                                                           MAIN3810
   12 CONTINUE                                                           MAIN3820
C=====THIS SECTION FOR LWR PLANTS ONLY                                   MAIN3830
C-----CALCULATE FEES, INSPECTIONS, REVIEWS, $THOUSAND/YEAR               MAIN3840
      FEEINS = (219. + 269. * UNITS)                                     MAIN3850
     * * (1.0 + ESFEES/100.)**(YEAR-BASEYR)                              MAIN3860
C-----CALCULATE COMMERCIAL LIABILITY INSURANCE, $THOUSAND/YEAR           MAIN3870
      COMINS = (239.68+ 161.21* UNITS)*(1.0+ESCINS/100.)**(YEAR-BASEYR) MAIN3880
C-----CALCULATE GOVERNMENT LIABILITY INSURANCE, $THOUSAND/YEAR           MAIN3890
      GOVINS=(6.*AMIN1(MWT,3000.) *UNITS/1000.)                          MAIN3900
     * *(1.0+ESGINS/100.)**(YEAR-BASEYR)                                 MAIN3910
C-----CALCULATE RETROSPECTIVE PREMIUM INSURANCE, $THOUSAND/YEAR          MAIN3920
      RETRO  = (  10.* UNITS)*(1.0+ESCINS/100.)**(YEAR-BASEYR)           MAIN3930
C-----CALCULATE REPLACEMENT POWER INSURANCE, $THOUSAND/YEAR              MAIN3940
      RPOWER=UNITS * 2000. * (1.0+ESCPOW/100.)**(YEAR-BASEYR)            MAIN3950
C-----CALCULATE PRIMARY AND EXCESS PROPERTY INSURANCE                    MAIN3960
      PRIMUL=.18+.82*UNITS                                               MAIN3970
      EXCMUL=.86+.14*UNITS                                               MAIN3980
      PRIMAR=PRIMUL*PROPRT*COVER/100.                                    MAIN3990
     * *(1.0+ESCPIN/100.)**(YEAR-BASEYR)                                 MAIN4000
      EXCESS=EXCMUL * .8 * PROPRT * COVER/100.                           MAIN4010
     * *(1.0+ESCPIN/100.)**(YEAR-BASEYR)                                 MAIN4020
      PROPIN=PRIMAR+EXCESS                                               MAIN4030
   15 CONTINUE                                                           MAIN4040
C=====THIS SECTION FOR ALL PLANT TYPES                                   MAIN4050
C-----CALCULATE TOTAL DIRECT COST                                        MAIN4060
      DIRECT = COSTAF + TOTMNT + SUPEXP + FEEINS + SUPORT                MAIN4070
C-----CALCULATE 'OTHER' ADMINISTRATIVE AND GENERAL COSTS                 MAIN4080
      ADM = AGFACT(ITYPE) * DIRECT / 100.                                MAIN4090
C-----CALCULATE ADMINISTRATIVE AND GENERAL COSTS                         MAIN4100
      ADMGEN=ADM+COMINS+GOVINS+RETRO+PROPIN+RPOWER                       MAIN4110
C-----SUM ANNUAL FIXED COSTS, ANNUAL VARIABLE COSTS, TOTAL ANNUAL COSTS MAIN4120
      TOTFIX=COSTAF+FIXMNT+FEEINS+ADMGEN+FIXSE+SUPORT                    MAIN4130
      TOTVAR = VARMNT + VARSE                                            MAIN4140
      TOTAL = TOTVAR + TOTFIX                                            MAIN4150
C-----CONVERT ANNUAL COSTS TO UNIT COSTS                                 MAIN4160
      FIXMIL = TOTFIX / ANNGEN                                           MAIN4170
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      VARMIL = TOTVAR / ANNGEN                                          MAIN4180
      TOTMIL = TOTAL / ANNGEN                                           MAIN4190
C-----CALCULATE TOTAL UNIT O&M COST LESS 'OTHER A&G', MILLS/KWH(E)       MAIN4200
      TOTML2=(TOTAL-ADM    )/ANNGEN                                     MAIN4210
C-----CALCULATE TOTAL UNIT O&M COST LESS A&G, MILLS/KWH(E)               MAIN4220
      TOTML3=(TOTAL-ADMGEN)/ANNGEN                                      MAIN4230
C-----PRINT NAMELIST                                                    MAIN4240
      WRITE(IW,804)YEAR,TYPE,PLTFAC,MWN,HTRATE,ISOX,WETDRY,UNITS        MAIN4250
  804 FORMAT('1',T20,'NAMELIST FOR FOLLOWING CASE'//                    MAIN4260
     *       ' ',T20,'YEAR  ',T40,F6.1 /                                MAIN4270
     *       ' ',T20,'TYPE  ',T40,A4   /                                MAIN4280
     *       ' ',T20,'PLTFAC',T40,F4.2 /                                MAIN4290
     *       ' ',T20,'MWN   ',T40,F5.0 /                                MAIN4300
     *       ' ',T20,'HTRATE',T38,F8.0 /                                MAIN4310
     *       ' ',T20,'ISOX  ',T40,I1   /                                MAIN4320
     *       ' ',T20,'WETDRY',T40,I1   /                                MAIN4330
     *       ' ',T20,'UNITS ',T40,I1   )                                MAIN4340
      WRITE(IW,858) WAGERT, FRINGE, SUPER, BTUCOL, XLIMSS, XLIMS        MAIN4350
      WRITE(IW,819)$ASH,ASHPCT                                          MAIN4360
      WRITE(IW,859)PCTSRM, PCTSUL, SLURY, COSLMS, COSLM, ESWAGE         MAIN4370
      WRITE(IW,870)ESSLUR, ESLIMS, ESLIM, ESCINS, ESGINS, ESFEES,       MAIN4380
     * ESMATL, ESCSUP, ESCPIN, ESCPOW, ESCGEN                            MAIN4390
C-----PRINT OPERATION AND MAINTENANCE COST SUMMARY                      MAIN4400
      WRITE(IW,802) YEAR, VERS                                          MAIN4410
  802 FORMAT('1',T15,                                                   MAIN4420
     * 'SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS'/     MAIN4430
     * T18,'FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN ',F6.1/        MAIN4440
     * T29,'USING OMCOST VERSION ',A8/)                                 MAIN4450
      WRITE(IW,808) TYPE                                                MAIN4460
  808 FORMAT(' ',T20,'PLANT TYPE IS ',A4)                               MAIN4470
      WRITE (IW,811) UNITS                                              MAIN4480
  811 FORMAT (' ',T20,'NUMBER OF UNITS PER PLANT ',I1)                  MAIN4490
      IF(ITYPE.NE.2)GO TO 604                                           MAIN4500
      IF(ISOX.EQ.1 .AND. WETDRY.EQ.1) WRITE(IW,809)                     MAIN4510
  809 FORMAT(' ',T20,'WITH WET LIMESTONE FGD SYSTEMS')                  MAIN4520
      IF(ISOX.EQ.1 .AND. WETDRY.EQ.2) WRITE(IW,801)                     MAIN4530
  801 FORMAT(' ',T20,'WITH DRY FGD SYSTEMS')                            MAIN4540
      IF (ISOX.EQ.0) WRITE (IW,810)                                     MAIN4550
  810 FORMAT(' ',T20,'WITHOUT FGD SYSTEMS')                             MAIN4560
  604 CONTINUE                                                          MAIN4570
      WRITE(IW,807) MWT                                                 MAIN4580
  807 FORMAT(' ',T20,'THERMAL INPUT PER UNIT IS ',F5.0,' MWT')          MAIN4590
      WRITE(IW,827) HTRATE                                              MAIN4600
  827 FORMAT(' ',T20,'PLANT NET HEAT RATE ',F7.0)                       MAIN4610
      WRITE(IW,826) ETANET                                              MAIN4620
  826 FORMAT(' ',T20,'PLANT NET EFFICIENCY, PERCENT ',F7.2)             MAIN4630
      WRITE(IW,805) MWN                                                 MAIN4640
  805 FORMAT(' ',T20,'EACH UNIT IS ',F5.0,' MWE NET RATING')            MAIN4650
      WRITE(IW,816) ANNGEN                                              MAIN4660
  816 FORMAT(' ',T20,'ANNUAL NET GENERATION, MILLION KWH',F7.0)         MAIN4670
      WRITE(IW,806) PLTFAC                                              MAIN4680
  806 FORMAT(' ',T20,'WITH BASE LOAD CAPACITY FACTOR OF ',F4.2/)        MAIN4690
      IF((PLTFAC.GT..80).OR.(PLTFAC.LT..50)) WRITE(IW,862)              MAIN4700
  862 FORMAT(' ',T20,'CAPACITY FACTOR OUT OF RANGE (.50 TO .80) <<<<<'/)MAIN4710
      WRITE(IW,812)                                                     MAIN4720
  812 FORMAT(' ',T31,'DIRECT COSTS  $1000/YEAR')                        MAIN4730
      WRITE(IW,814) COSTAF, STAFF, MANCOS                               MAIN4740
  814 FORMAT(' ',T20,'STAFF ONSITE'          ,T54,F7.0/                 MAIN4750
     *           T25,'(',I3,' PERSONS AT $',F7.0,')')                   MAIN4760
      WRITE(IW,817) TOTMNT                                              MAIN4770
  817 FORMAT('0',T20,'MAINTENANCE MATERIAL'          ,T55,F6.0)         MAIN4780
      WRITE(IW,866) FIXMNT                                              MAIN4790
  866 FORMAT(' ',T30,'FIXED'          ,T60,F6.0)                        MAIN4800
      WRITE(IW,854) VARMNT                                              MAIN4810
      WRITE(IW,822) SUPEXP                                              MAIN4820
  822 FORMAT('0',T20,'SUPPLIES AND EXPENSES'          ,T55,F6.0)        MAIN4830
      WRITE(IW,853) FIXSE                                               MAIN4840
  853 FORMAT(' ',T30,'FIXED          ',T60,F6.0)                        MAIN4850
      IF(ITYPE.EQ. 1)GO TO 603                                          MAIN4860
      WRITE(IW,815) VSEBAS                                              MAIN4870
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815 FORMAT(' ',T30,'VAR.  - PLANT ',T60,F6.0)                          MAIN4880
    GO TO 609                                                          MAIN4890
603 CONTINUE                                                           MAIN4900
    WRITE(IW,854) VSEBAS                                               MAIN4910
854 FORMAT(' ',T30,'VARIABLE      ',T60,F6.0)                          MAIN4920
609 CONTINUE                                                           MAIN4930
    IF(ISOX.EQ.0 .OR. ITYPE.EQ. 1)GO TO 608                            MAIN4940
    IF(WETDRY.EQ. 1)WRITE(IW,855)CLIMES                                MAIN4950
855 FORMAT(' ',T30,'      - LIMESTONE          ',T60,F6.0)            MAIN4960
    IF(WETDRY.EQ. 2)WRITE(IW,872)CLIME                                 MAIN4970
872 FORMAT(' ',T30,'      - LIME               ',T60,F6.0)            MAIN4980
    IF(DISPOS.NE. 0.0)WRITE(IW,838)DISPOS                              MAIN4990
838 FORMAT(' ',T30,'      - ASH & FGD SLUDGE   ',T60,F6.0)            MAIN5000
608 CONTINUE                                                           MAIN5010
    IF(SUPAD2.NE.0.0)WRITE(IW,865) SUPAD2                              MAIN5020
865 FORMAT(' ',T36,'- ASH DISPOSAL',T60,F6.0)                          MAIN5030
    IF(ITYPE.EQ.2)GO TO 702                                            MAIN5040
    WRITE(IW,833) FEEINS                                               MAIN5050
833 FORMAT('0',T20,'FEES, INSPECTIONS, REVIEWS      ',T55,F6.0)        MAIN5060
702 CONTINUE                                                           MAIN5070
    WRITE(IW,850)SUPORT                                                MAIN5080
850 FORMAT('0',T20,'OFFSITE SUPPORT SERVICES'            ,T55,F6.0)    MAIN5090
    WRITE(IW,836)                                                      MAIN5100
836 FORMAT('0',T31,'INDIRECT COSTS')                                   MAIN5110
    WRITE(IW,825) ADMGEN                                               MAIN5120
825 FORMAT(' ',T20,'ADMINISTRATIVE AND GENERAL  ',T55,F6.0)            MAIN5130
    IF(COMINS.NE.0.)WRITE(IW,820)COMINS                                MAIN5140
820 FORMAT(' ',T30,'COMMERCIAL LIABILITY INS.     ',T60,F6.0)          MAIN5150
    IF(RETRO.NE.0.)WRITE(IW,835)RETRO                                  MAIN5160
835 FORMAT(' ',T30,'RETROSPECTIVE PREMIUM',T60,F6.0)                   MAIN5170
    IF(GOVINS.NE.0.)WRITE(IW,824)GOVINS                                MAIN5180
824 FORMAT(' ',T30,'GOVERNMENT LIABILITY INS.     ',T60,F6.0)          MAIN5190
    IF(ITYPE.EQ.2)GO TO 615                                            MAIN5200
    WRITE(IW,803)PRIMAR                                                MAIN5210
803 FORMAT(' ',T30,'PROPERTY INS. (PRIMARY)       ',T60,F6.0)          MAIN5220
    WRITE(IW,869)EXCESS                                                MAIN5230
869 FORMAT(' ',T30,'PROPERTY INS. (EXCESS)        ',T60,F6.0)          MAIN5240
    GO TO 616                                                          MAIN5250
615 CONTINUE                                                           MAIN5260
    WRITE(IW,842)PROPIN                                                MAIN5270
842 FORMAT(' ',T30,'PROPERTY INSURANCE            ',T60,F6.0)          MAIN5280
616 CONTINUE                                                           MAIN5290
    IF(RPOWER.NE. 0.0)WRITE(IW,845)RPOWER                              MAIN5300
845 FORMAT(' ',T30,'REPLACEMENT POWER INS.        ',T60,F6.0)          MAIN5310
    WRITE(IW,837)ADM                                                   MAIN5320
837 FORMAT(' ',T30,'OTHER A&G',T60,F6.0)                               MAIN5330
    WRITE(IW,851)                                                      MAIN5340
851 FORMAT('0',T31,'COSTS $1000/YEAR')                                 MAIN5350
    WRITE(IW,830) TOTFIX                                               MAIN5360
830 FORMAT(' ',T20,'TOTAL FIXED DIRECTS AND INDIRECTS',T64,F7.0)       MAIN5370
    WRITE(IW,831) TOTVAR                                               MAIN5380
831 FORMAT(' ',T20,'TOTAL VARIABLE DIRECTS AND INDIRECTS',T64,F7.0)    MAIN5390
    WRITE(IW,832) TOTAL                                                MAIN5400
832 FORMAT(' ',T20,'TOTAL ANNUAL NONFUEL O&M',T64,F7.0)                MAIN5410
    WRITE(IW,852)                                                      MAIN5420
852 FORMAT('0',T31,'UNIT COSTS  MILLS/KWH(E)')                         MAIN5430
    WRITE(IW,828) FIXMIL                                               MAIN5440
828 FORMAT(' ',T20,'FIXED DIRECTS AND INDIRECTS',T65,F6.2)             MAIN5450
    WRITE(IW,829) VARMIL                                               MAIN5460
829 FORMAT(' ',T20,'VARIABLE DIRECTS AND INDIRECTS',T65,F6.2)          MAIN5470
    WRITE(IW,834) TOTMIL                                               MAIN5480
834 FORMAT(' ',T20,'TOTAL NONFUEL O&M',T65,F6.2)                       MAIN5490
    WRITE(IW,856)TOTML2                                                MAIN5500
856 FORMAT('0',T20,'TOTAL NONFUEL O&M LESS ''OTHER A&G''',T65,F6.2)    MAIN5510
    WRITE(IW,857)TOTML3                                                MAIN5520
857 FORMAT(' ',T20,'TOTAL NONFUEL O&M LESS A&G',T65,F6.2)              MAIN5530
    IF(ITYPE.EQ.1)GO TO 602                                            MAIN5540
    WRITE(IW,848) BTU(          WETDRY)                                MAIN5550
848 FORMAT(//         T20,'HEATING VALUE OF COAL, BTU/LB',T55,F8.0)    MAIN5560
    WRITE(IW,849) TONCOL                                               MAIN5570
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  849 FORMAT(' ',T20,'COAL BURNED, TONS/YEAR          ',T54,F9.0)        MAIN5580
      WRITE(IW,871) ASH(WETDRY)                                          MAIN5590
  871 FORMAT(' ',T20,'PERCENT ASH',T55,F8.2)                             MAIN5600
      WRITE(IW,864)$$ASH                                                 MAIN5610
  864 FORMAT(' ',T20,'COST OF ASH DISPOSAL, $/TON ',T55,F8.2)            MAIN5620
      IF(ISOX.NE.1)GO TO 602                                             MAIN5630
      WRITE(IW,839) PCTSUL                                               MAIN5640
  839 FORMAT(' ',T20,'PERCENT SULFUR',T55,F8.2)                          MAIN5650
      IF(WETDRY.EQ.2 .AND. PCTSUL.GT. 1.5)WRITE(IW,823)                  MAIN5660
  823 FORMAT(' ','>>>>>>>>>> NOTE:',T20,                                 MAIN5670
     *'DRY FGD SYSTEM WITH > 1.5 PCT. SULFUR, NOT VALID ASSUMPTION')     MAIN5680
      WRITE(IW,840) TONSUL                                               MAIN5690
  840 FORMAT(' ',T20,'SULFUR (100 PCT.), TONS/YR',T55,F8.0)              MAIN5700
      WRITE(IW,860)PCTSRM                                                MAIN5710
  860 FORMAT(' ',T20,'PERCENT SULFUR REMOVED',T55,F8.2)                  MAIN5720
      WRITE(IW,868)SULREM                                                MAIN5730
  868 FORMAT(' ',T20,'SULFUR REMOVED, TONS/YEAR',T55,F8.0)               MAIN5740
      IF(WETDRY.EQ. 2)GO TO 620                                          MAIN5750
      WRITE(IW,841) XLIMSS                                               MAIN5760
  841 FORMAT(' ',T20,'TONS LIMESTONE PER TON SULFUR',T55,F8.2)           MAIN5770
      WRITE(IW,844) TONLMS                                               MAIN5780
  844 FORMAT(' ', T20,'TONS/YEAR LIMESTONE',T55,F8.0)                    MAIN5790
      WRITE(IW,847) COLIMS                                               MAIN5800
  847 FORMAT(' ',T20,'COST OF LIMESTONE, $/TON',T55,F8.2)                MAIN5810
      GO TO 621                                                          MAIN5820
620   CONTINUE                                                           MAIN5830
      WRITE(IW,873)XLIMS                                                 MAIN5840
  873 FORMAT(' ',T20,'TONS LIME PER TON SULFUR      ',T55,F8.2)          MAIN5850
      WRITE(IW,874)TONLM                                                 MAIN5860
  874 FORMAT(' ',T20,'TONS/YEAR LIME      ',T55,F8.0)                    MAIN5870
      WRITE(IW,875)COLIM                                                 MAIN5880
  875 FORMAT(' ',T20,'COST OF LIME, $/TON      ',T55,F8.2)               MAIN5890
621   CONTINUE                                                           MAIN5900
      WRITE(IW,843) SLURRY                                               MAIN5910
  843 FORMAT(' ',T20,'COST OF SLUDGE DISPOSAL, $/DRY TON',T55,F8.2)      MAIN5920
  602 CONTINUE                                                           MAIN5930
      GO TO 610                                                          MAIN5940
  708 CONTINUE                                                           MAIN5950
C=====NO MORE CASES TO RUN                                               MAIN5960
C-----PRINT ESCALATION RATES, ANNUAL AVERAGE SALARY COMPONENTS, FGD COSTMAIN5970
C     COMPONENTS, ASH DISPOSAL COST COMPONENTS                           MAIN5980
      WRITE(IW,861)ESWAGE,ESSLUR,ESLIMS,ESLIM,ESCINS,ESGINS,ESFEES,      MAIN5990
     * ESMATL, ESCSUP, ESCPIN, ESCPOW, ESCGEN                             MAIN6000
  861 FORMAT('1',T15,'ESCALATION RATES, PERCENT/YEAR'//                  MAIN6010
     * ' ',T20,'WAGES                    ',T62,F6.1/                     MAIN6020
     * ' ',T20,'SLUDGE DISPOSAL COST     ',T62,F6.1/                     MAIN6030
     * ' ',T20,'LIMESTONE COST           ',T62,F6.1/                     MAIN6040
     * ' ',T20,'LIME COST                ',T62,F6.1/                     MAIN6050
     * ' ',T20,'COML. LIAB. INS. COST ',T62,F6.1/                        MAIN6060
     * ' ',T20,'GOVT. LIAB. INS. COST ',T62,F6.1/                        MAIN6070
     * ' ',T20,'INSPECTION FEES & EXP.',T62,F6.1/                        MAIN6080
     * ' ',T20,'MATERIAL                 ',T62,F6.1/                     MAIN6090
     * ' ',T20,'SUPPLIES AND EXPENSES ',T62,F6.1/                        MAIN6100
     * ' ',T20,'PROPERTY INSURANCE       ',T62,F6.1/                     MAIN6110
     * ' ',T20,'REPLACEMENT POWER INS.',T62,F6.1/                        MAIN6120
     * ' ',T20,'GENERAL ESCALATION       ',T62,F6.1)                     MAIN6130
      WRITE(IW,846) WAGERT, FRINGE, SUPER, PENPCT(1)                     MAIN6140
  846 FORMAT('0',T15,'ANNUAL AVERAGE SALARY COMPONENTS'//T20,            MAIN6150
     * 'WAGE RATE BEFORE ADDERS (BASE YEAR), $/HR',T64,F5.2/T20,         MAIN6160
     * 'OPERATOR FRINGE BENEFITS, PCT.',T62,F5.0/T20,                    MAIN6170
     * 'PLANT SUPERVISION & TECHNICAL, PCT.',T62,F5.0/T20,               MAIN6180
     * 'SPECIAL NUCLEAR PENALTY, PERCENT',T62,F5.0)                      MAIN6190
      WRITE(IW,818) BASEYR, COSLMS,COSLM,SLURY                           MAIN6200
  818 FORMAT('0',T15,        'FGD COST COMPONENTS AT BASE YEAR ',F6.1// MAIN6210
     * T20,'COST OF LIMESTONE, $/TON '       ,T61,F8.2/                  MAIN6220
     * T20,'COST OF LIME, $/TON      '       ,T61,F8.2/                  MAIN6230
     * T20,'COST OF SLUDGE DISPOSAL, $/DRY TON ',T61,F8.2)               MAIN6240
      WRITE(IW,863)$ASH,ASH                                              MAIN6250
  863 FORMAT('0',T15,'ASH DISPOSAL COST COMPONENTS AT BASE YEAR'//       MAIN6260
     *  T20,'COST OF ASH DISPOSAL, $/TON',T61,F8.2/                      MAIN6270
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* T20,'PCT. ASH IN COAL - WET LIMESTONE FGD  ',T61,F8.2/          MAIN6280
* T20,'PCT. ASH IN COAL - DRY FGD            ',T61,F8.2)          MAIN6290
 STOP                                                             MAIN6300
 END                                                              MAIN6310
```

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C                                                                       LWR
      SUBROUTINE LWR                                                    LWR   10
      REAL*4 MWN, MANCOS                                                LWR   20
      INTEGER*4 UNITS, BASTAF(4,26),STAFF, STAFF4                       LWR   30
      INTEGER*4 UNITS2                                                  LWR   40
      REAL*8 TITLE                                                      LWR   50
      DIMENSION NO(4)                                                   LWR   60
      DIMENSION TITLE(3,19)                                             LWR   70
      COMMON /COM1/ ISOX, STAFF, UNITS, STAFF4                          LWR   80
      COMMON /COM2/ MWN, YEAR, BASECF, BASEYR, ESMATL, ESWAGE, FIXMNT,  LWR   90
     * MANCOS, PLTFAC, SUPEXF, TOTMNT, VARMNT, VSEMIL                   LWR  100
      DATA NO/10,2,3,4/                                                 LWR  110
      DATA TITLE/'MANAGER ','        ','        ',                      LWR  120
     *           'ASSISTAN','T       ','        ',                      LWR  130
     *           'QUALITY ','ASSURANC','E       ',                      LWR  140
     *           'ENVIRONM','ENTAL CO','NTROL   ',                      LWR  150
     *           'PUBLIC R','ELATICNS','        ',                      LWR  160
     *           'TRAINING','        ','        ',                      LWR  170
     *           'SAFETY &','FIRE    ','        ',                      LWR  180
     *           'ADMIN. &',' SERVICE','S       ',                      LWR  190
     *           'HEALTH S','ERVICES ','        ',                      LWR  200
     *           'SECURITY','        ','        ',                      LWR  210
     *           'SUPERVIS','ION (EXC','. SHIFT)',                      LWR  220
     *           'SHIFTS  ','        ','        ',                      LWR  230
     *           'SUPERVIS','ION     ','        ',                      LWR  240
     *           'CRAFTS  ','        ','        ',                      LWR  250
     *           'PEAK MAI','NT. ANNU','ALIZED  ',                      LWR  260
     *           'REACTOR ','        ','        ',                      LWR  270
     *           'RADIO-CH','EMICAL  ','        ',                      LWR  280
     *           'ENGINEER','ING     ','        ',                      LWR  290
     *           'PERFORM.','', REPCRT','S, TECH.'/                     LWR  300
      DATA BASTAF/4*1, 1,2,3,4, 6,6,7,8, 4*1, 4*1, 4*12, 1,2,3,4,       LWR  310
     * 49,55,65,78, 4*2, 4*94, 9,9,18,18, 52,104,156,208,               LWR  320
     * 12,14,26,28, 55,71,87,103, 55,110,165,220, 5,5,7,7, 8,8,12,12,   LWR  330
     * 4*16, 21,30,39,48, 28*0/                                         LWR  340
      DATA FIXFAC/.75/                                                  LWR  350
      DATA VARFAC/.25/                                                  LWR  360
      DATA KSKIP/1/                                                     LWR  370
      DATA IW/6/                                                        LWR  380
      UNITS2 = UNITS                                                    LWR  390
      I1=1                                                              LWR  400
      I2=NO(1)                                                          LWR  410
      I3=I2+1                                                           LWR  420
      I4=I2+NO(2)                                                       LWR  430
      I5=I4+1                                                           LWR  440
      I6=I4+NO(3)                                                       LWR  450
      I7=I6+1                                                           LWR  460
      I8=I6+NO(4)                                                       LWR  470
      J1=I8+1                                                           LWR  480
      J2=I8+2                                                           LWR  490
      J3=I8+3                                                           LWR  500
      J4=I8+4                                                           LWR  510
      K1=J4+1                                                           LWR  520
      K2=K1+1                                                           LWR  530
      K3=K2+1                                                           LWR  540
      DO 601 UNITS = 1,4                                                LWR  550
      BASTAF(UNITS,J1)=0                                                LWR  560
      DO 602 I=I1,I2                                                    LWR  570
      BASTAF(UNITS,J1)=BASTAF(UNITS,J1)+BASTAF(UNITS,I)                 LWR  580
  602 CONTINUE                                                          LWR  590
      BASTAF(UNITS,J2)=0                                                LWR  600
      DO 603 I=I3,I4                                                    LWR  610
      BASTAF(UNITS,J2)=BASTAF(UNITS,J2)+BASTAF(UNITS,I)                 LWR  620
  603 CONTINUE                                                          LWR  630
      BASTAF(UNITS,J3)=0                                                LWR  640
      DO 604 I=I5,I6                                                    LWR  650
      BASTAF(UNITS,J3)=BASTAF(UNITS,J3)+BASTAF(UNITS,I)                 LWR  660
  604 CONTINUE                                                          LWR  670
      BASTAF(UNITS,J4)=0                                                LWR  680
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      DO 605 I=I7,I8                                                    LWR  690
      BASTAF(UNITS,J4)=BASTAF(UNITS,J4)+BASTAF(UNITS,I)                 LWR  700
  605 CONTINUE                                                          LWR  710
      BASTAF(UNITS,K1)=BASTAF(UNITS,J1)+BASTAF(UNITS,J2)                LWR  720
     * +BASTAF(UNITS,J3)+BASTAF(UNITS,J4)                               LWR  730
      BASTAF(UNITS,K2)=BASTAF(UNITS,K1)-BASTAF(UNITS,I2)                LWR  740
      BASTAF(UNITS,K3)=BASTAF(UNITS,K2)-BASTAF(UNITS,I6)                LWR  750
  601 CONTINUE                                                          LWR  760
      IF(KSKIP.GT.1) GO TO 606                                          LWR  770
      WRITE(IW,803)                                                     LWR  780
  803 FORMAT('1',T8,'SITE STAFF REQUIREMENT FOR LWR POWER PLANTS'/      LWR  790
     *       ' ',T8,43('-')//                                           LWR  800
     *       ' ',T36,'NO. UNITS PER SITE'/                              LWR  810
     *       ' ',T38,'1    2    3    4'/                               LWR  820
     *       ' ',T36,18('-'))                                           LWR  830
      WRITE(IW,805)                                                     LWR  840
  805 FORMAT('0',T7,'PLANT MANAGER''S OFFICE'/)                         LWR  850
      DO 600 I=I1,I8                                                    LWR  860
      WRITE(IW,800) (TITLE(J,I),J=1,3)                                  LWR  870
     * ,(BASTAF(UNITS,I),UNITS=1,4)                                     LWR  880
  800 FORMAT(' ',T10,3A8,4(2X,I3))                                      LWR  890
      IF(I.EQ.I2)WRITE(IW,811)                                          LWR  900
     *  (BASTAF(UNITS,J1),UNITS=1,4)                                    LWR  910
      IF(I.EQ.I2)WRITE(IW,806)                                          LWR  920
  806 FORMAT(' ',T7,'OPERATIONS'/)                                      LWR  930
      IF(I.EQ.I4)WRITE(IW,811)                                          LWR  940
     *  (BASTAF(UNITS,J2),UNITS=1,4)                                    LWR  950
      IF(I.EQ.I4)WRITE(IW,807)                                          LWR  960
  807 FORMAT(' ',T7,'MAINTENANCE'/)                                     LWR  970
      IF(I.EQ.I6)WRITE(IW,811)                                          LWR  980
     *  (BASTAF(UNITS,J3),UNITS=1,4)                                    LWR  990
      IF(I.EQ.I6)WRITE(IW,808)                                          LWR 1000
  808 FORMAT(' ',T7,'TECHNICAL AND ENGINEERING'/)                       LWR 1010
  600 CONTINUE                                                          LWR 1020
                WRITE(IW,811)                                           LWR 1030
     *  (BASTAF(UNITS,J4),UNITS=1,4)                                    LWR 1040
  811 FORMAT(/  T13,'SUBTOTAL',T34,4(2X,I3)/)                           LWR 1050
      WRITE(IW,820)                                                     LWR 1060
     *  (BASTAF(UNITS,K1),UNITS=1,4)                                    LWR 1070
  820 FORMAT( T13,'TOTAL',T34,4(2X,I3)/                                 LWR 1080
     *       ' ',T34,4('  ===='))                                       LWR 1090
      WRITE(IW,801)                                                     LWR 1100
     *  (BASTAF(UNITS,K2),UNITS=1,4)                                    LWR 1110
  801 FORMAT(/T13,'LESS SECURITY',T34,4(2X,I3))                         LWR 1120
      WRITE(IW,802)                                                     LWR 1130
     *  (BASTAF(UNITS,K3),UNITS=1,4)                                    LWR 1140
  802 FORMAT(/T13,'LESS SEC., PEAK MAINT.',T34,4(2X,I3))                LWR 1150
  606 CONTINUE                                                          LWR 1160
      UNITS = UNITS2                                                    LWR 1170
      SUPEXF=4800.                                                      LWR 1180
      VSEMIL = 0.1                                                      LWR 1190
C  NOTE... RATIO OF ESCALATION FACTORS ELIMINATES WAGE ESCALATION FROM  LWR 1200
C          MANCOS AND REPLACES IT WITH MATERIAL ESCALATION RATE         LWR 1210
      BASM=BASTAF(UNITS,J3)*(MANCOS/1000.)                              LWR 1220
     * *((100.+ESMATL)/(100.+ESWAGE))**(YEAR-BASEYR)                   LWR 1230
      STAFF = BASTAF(UNITS,K1)                                          LWR 1240
      STAFF4=BASTAF(UNITS,J4)                                           LWR 1250
      FIXMNT = FIXFAC * BASM                                            LWR 1260
      VARMNT = VARFAC * BASM * (PLTFAC / BASECF)                        LWR 1270
      TOTMNT = FIXMNT + VARMNT                                          LWR 1280
      KSKIP = KSKIP + 1                                                 LWR 1290
      RETURN                                                            LWR 1300
      END                                                               LWR 1310
```

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C                                                                       WETS
      SUBROUTINE COALWS                                                 WETS  10
      REAL*4 MWN, MANCOS                                                WETS  20
      INTEGER*4 UNITS, BASTAF(4,25),STAFF, STAFF4                       WETS  30
      INTEGER*4 UNITS2                                                  WETS  40
      REAL*8 TITLE                                                      WETS  50
      DIMENSION NO(4)                                                   WETS  60
      DIMENSION TITLE(3,20)                                             WETS  70
      COMMON /COM1/ ISOX, STAFF, UNITS, STAFF4                          WETS  80
      COMMON /COM2/ MWN, YEAR, BASECF, BASEYR, ESMATL, ESWAGE, FIXMNT,  WETS  90
     * MANCOS, PLTFAC, SUPEXF, TOTMNT, VARMNT, VSEMIL                   WETS 100
      DATA NO/9,4,3,4/                                                  WETS 110
      DATA TITLE/'MANAGER ','        ','        ',                      WETS 120
     *           'ASSISTAN','T       ','        ',                      WETS 130
     *           'ENVIRONM','ENTAL CO','NTROL  ',                      WETS 140
     *           'PUBLIC R','ELATICNS','        ',                      WETS 150
     *           'TRAINING','        ','        ',                      WETS 160
     *           'SAFETY  ','        ','        ',                      WETS 170
     *           'ADMIN. &',' SERVICE','S       ',                      WETS 180
     *           'HEALTH S','ERVICES ','        ',                      WETS 190
     *           'SECURITY','        ','        ',                      WETS 200
     *           'SUPERVIS','ION (EXC','. SHIFT)',                      WETS 210
     *           'SHIFTS  ','        ','        ',                      WETS 220
     *           'FUEL AND',' LIMESTO','NE REC. ',                      WETS 230
     *           'WASTE SY','STEMS   ','        ',                      WETS 240
     *           'SUPERVIS','ION     ','        ',                      WETS 250
     *           'CRAFTS  ','        ','        ',                      WETS 260
     *           'PEAK MAI','NT. ANNU','ALIZED  ',                      WETS 270
     *           'WASTE   ','        ','        ',                      WETS 280
     *           'CHEMICAL','        ','        ',                      WETS 290
     *           'I & C   ','        ','        ',                      WETS 300
     *           'PERFORM.','. REPORT','S, TECH.'/                      WETS 310
      DATA BASTAF/4*1, 1,2,3,4, 4*1, 4*1, 4*1, 4*1, 13,14,15,16,        WETS 320
     * 3*1,2, 4*7, 3,3,5,5, 45,50,60,65, 3*12,18,                       WETS 330
     * 10,20,30,40,                                                     WETS 340
     * 8,8,10,12,                                                       WETS 350
     * 90,110,130,150, 20,40,60,80, 1,2,3,4, 2,2,3,4, 2,2,3,4,          WETS 360
     * 14,17,21,24, 20*0/                                               WETS 370
      DATA FIXFAC/.62/                                                  WETS 380
      DATA VARFAC/.20/                                                  WETS 390
      DATA KSKIP/1/                                                     WETS 400
      DATA IW/6/                                                        WETS 410
      UNITS2 = UNITS                                                    WETS 420
      I1=1                                                              WETS 430
      I2=NO(1)                                                          WETS 440
      I3=I2+1                                                           WETS 450
      I4=I2+NO(2)                                                       WETS 460
      I5=I4+1                                                           WETS 470
      I6=I4+NO(3)                                                       WETS 480
      I7=I6+1                                                           WETS 490
      I8=I6+NO(4)                                                       WETS 500
      J1=I8+1                                                           WETS 510
      J2=I8+2                                                           WETS 520
      J3=I8+3                                                           WETS 530
      J4=I8+4                                                           WETS 540
      K1=J4+1                                                           WETS 550
      DO 601 UNITS = 1,4                                                WETS 560
      BASTAF(UNITS,J1)=0                                                WETS 570
      DO 602 I=I1,I2                                                    WETS 580
      BASTAF(UNITS,J1)=BASTAF(UNITS,J1)+BASTAF(UNITS,I)                 WETS 590
  602 CONTINUE                                                          WETS 600
      BASTAF(UNITS,J2)=0                                                WETS 610
      DO 603 I=I3,I4                                                    WETS 620
      BASTAF(UNITS,J2)=BASTAF(UNITS,J2)+BASTAF(UNITS,I)                 WETS 630
  603 CONTINUE                                                          WETS 640
      BASTAF(UNITS,J3)=0                                                WETS 650
      DO 604 I=I5,I6                                                    WETS 660
      BASTAF(UNITS,J3)=BASTAF(UNITS,J3)+BASTAF(UNITS,I)                 WETS 670
  604 CONTINUE                                                          WETS 680
      BASTAF(UNITS,J4)=0                                                WETS 690
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      DO 605 I=I7,I8                                                    WETS 700
      BASTAF(UNITS,J4)=BASTAF(UNITS,J4)+BASTAF(UNITS,I)                 WETS 710
  605 CONTINUE                                                          WETS 720
      BASTAF(UNITS,K1)=BASTAF(UNITS,J1)+BASTAF(UNITS,J2)                WETS 730
     * +BASTAF(UNITS,J3)+BASTAF(UNITS,J4)                               WETS 740
  601 CONTINUE                                                          WETS 750
      IF(KSKIP.GT.1) GO TO 606                                          WETS 760
      WRITE(IW,803)                                                     WETS 770
  803 FORMAT('1',T4,                                                    WETS 780
     * 'SITE STAFF REQUIREMENT FOR COAL-FIRED POWER PLANTS'/            WETS 790
     *        ' ',T14,'WITH WET LIMESTONE FGD SYSTEMS'/                 WETS 800
     *        ' ',T14,30('-')//                                         WETS 810
     *        ' ',T36,'NO. UNITS PER SITE'/                             WETS 820
     *        ' ',T38,'1    2    3    4'/                              WETS 830
     *        ' ',T36,18('-'))                                          WETS 840
      WRITE(IW,805)                                                     WETS 850
  805 FORMAT('0',T7,'PLANT MANAGER''S OFFICE'/)                         WETS 860
      DO 600 I=I1,I8                                                    WETS 870
      WRITE(IW,800) (TITLE(J,I),J=1,3)                                  WETS 880
     * ,(BASTAF(UNITS,I),UNITS=1,4)                                     WETS 890
  800 FORMAT(' ',T10,3A8,4(2X,I3))                                      WETS 900
      IF(I.EQ.I2)WRITE(IW,811)                                          WETS 910
     *  (BASTAF(UNITS,J1),UNITS=1,4)                                    WETS 920
      IF(I.EQ.I2)WRITE(IW,806)                                          WETS 930
  806 FORMAT(' ',T7,'OPERATIONS'/)                                      WETS 940
      IF(I.EQ.I4)WRITE(IW,811)                                          WETS 950
     *  (BASTAF(UNITS,J2),UNITS=1,4)                                    WETS 960
      IF(I.EQ.I4)WRITE(IW,807)                                          WETS 970
  807 FORMAT(' ',T7,'MAINTENANCE'/)                                     WETS 980
      IF(I.EQ.I6)WRITE(IW,811)                                          WETS 990
     *  (BASTAF(UNITS,J3),UNITS=1,4)                                    WETS1000
      IF(I.EQ.I6)WRITE(IW,808)                                          WETS1010
  808 FORMAT(' ',T7,'TECHNICAL AND ENGINEERING'/)                       WETS1020
  600 CONTINUE                                                          WETS1030
                WRITE(IW,811)                                           WETS1040
     *  (BASTAF(UNITS,J4),UNITS=1,4)                                    WETS1050
  811 FORMAT(/  T13,'SUBTOTAL',T34,4(2X,I3)/)                           WETS1060
      WRITE(IW,820)                                                     WETS1070
     *  (BASTAF(UNITS,K1),UNITS=1,4)                                    WETS1080
  820 FORMAT( T13,'TOTAL',T34,4(2X,I3)/                                 WETS1090
     *        ' ',T34,4('  ===''))                                      WETS1100
  606 CONTINUE                                                          WETS1110
      UNITS = UNITS2                                                    WETS1120
      SUPEXF=2200.                                                      WETS1130
      VSEMIL = .12                                                      WETS1140
C  NOTE... RATIO OF ESCALATION FACTORS ELIMINATES WAGE ESCALATION FROM  WETS1150
C          MANCOS AND REPLACES IT WITH MATERIAL ESCALATION RATE         WETS1160
      BASM=BASTAF(UNITS,J3)*(MANCOS/1000.)                              WETS1170
     * *((100.+ESMATL)/(100.+ESWAGE))**(YEAR-BASEYR)                   WETS1180
      STAFF = BASTAF(UNITS,K1)                                          WETS1190
      STAFF4=BASTAF(UNITS,J4)                                           WETS1200
      FIXMNT = FIXFAC * BASM                                            WETS1210
      VARMNT = VARFAC * BASM * (PLTFAC / BASECF)                        WETS1220
      TOTMNT = FIXMNT + VARMNT                                          WETS1230
      KSKIP = KSKIP + 1                                                 WETS1240
      RETURN                                                            WETS1250
      END                                                               WETS1260
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C                                                                       DRYS
      SUBROUTINE COALDS                                                 DRYS  10
      REAL*4 MWN, MANCOS                                                DRYS  20
      INTEGER*4 UNITS, BASTAF(4,25),STAFF, STAFF4                       DRYS  30
      INTEGER*4 UNITS2                                                  DRYS  40
      REAL*8 TITLE                                                      DRYS  50
      DIMENSION NO(4)                                                   DRYS  60
      DIMENSION TITLE(3,20)                                             DRYS  70
      COMMON /COM1/ ISOX, STAFF, UNITS, STAFF4                          DRYS  80
      COMMON /COM2/ MWN, YEAR, BASECF, BASEYR, ESMATL, ESWAGE, FIXMNT,  DRYS  90
     * MANCOS, PLTFAC, SUPEXF, TOTMNT, VARMNT, VSEMIL                   DRYS 100
      DATA NO/9,4,3,4/                                                  DRYS 110
      DATA TITLE/'MANAGER ','        ','        ',                      DRYS 120
     *           'ASSISTAN','T       ','        ',                      DRYS 130
     *           'ENVIRONM','ENTAL CO','NTROL   ',                      DRYS 140
     *           'PUBLIC R','ELATICNS','        ',                      DRYS 150
     *           'TRAINING','        ','        ',                      DRYS 160
     *           'SAFETY  ','        ','        ',                      DRYS 170
     *           'ADMIN. &','  SERVICE','S       ',                      DRYS 180
     *           'HEALTH S','ERVICES ','        ',                      DRYS 190
     *           'SECURITY','        ','        ',                      DRYS 200
     *           'SUPERVIS','ION (EXC','. SHIFT)',                      DRYS 210
     *           'SHIFTS  ','        ','        ',                      DRYS 220
     *           'FUEL AND','  LIMESTO','NE REC. ',                      DRYS 230
     *           'WASTE SY','STEMS   ','        ',                      DRYS 240
     *           'SUPERVIS','ION     ','        ',                      DRYS 250
     *           'CRAFTS  ','        ','        ',                      DRYS 260
     *           'PEAK MAI','NT. ANNU','ALIZED  ',                      DRYS 270
     *           'WASTE   ','        ','        ',                      DRYS 280
     *           'CHEMICAL','        ','        ',                      DRYS 290
     *           'I & C   ','        ','        ',                      DRYS 300
     *           'PERFORM.','  REPORT','S. TECH.'/                      DRYS 310
      DATA BASTAF/4*1, 1,2,3,4, 4*1, 4*1, 4*1, 4*1, 13,14,15,16,        DRYS 320
     * 3*1,2, 4*7, 3,3,5,5, 45,50,60,65, 3*12,18,                       DRYS 330
     * 5,10,15,20,                                                      DRYS 340
     * 8,8,10,12,                                                       DRYS 350
     * 77,94,111,128,                                                   DRYS 360
     *                20,40,60,80, 1,2,3,4, 2,2,3,4, 2,2,3,4,           DRYS 370
     * 14,17,21,24, 20*0/                                               DRYS 380
      DATA FIXFAC/.55/                                                  DRYS 390
      DATA VARFAC/.18/                                                  DRYS 400
      DATA KSKIP/1/                                                     DRYS 410
      DATA IW/6/                                                        DRYS 420
      UNITS2 = UNITS                                                    DRYS 430
      I1=1                                                              DRYS 440
      I2=NO(1)                                                          DRYS 450
      I3=I2+1                                                           DRYS 460
      I4=I2+NO(2)                                                       DRYS 470
      I5=I4+1                                                           DRYS 480
      I6=I4+NO(3)                                                       DRYS 490
      I7=I6+1                                                           DRYS 500
      I8=I6+NO(4)                                                       DRYS 510
      J1=I8+1                                                           DRYS 520
      J2=I8+2                                                           DRYS 530
      J3=I8+3                                                           DRYS 540
      J4=I8+4                                                           DRYS 550
      K1=J4+1                                                           DRYS 560
      DO 601 UNITS = 1,4                                                DRYS 570
      BASTAF(UNITS,J1)=0                                                DRYS 580
      DO 602 I=I1,I2                                                    DRYS 590
      BASTAF(UNITS,J1)=BASTAF(UNITS,J1)+BASTAF(UNITS,I)                 DRYS 600
  602 CONTINUE                                                          DRYS 610
      BASTAF(UNITS,J2)=0                                                DRYS 620
      DO 603 I=I3,I4                                                    DRYS 630
      BASTAF(UNITS,J2)=BASTAF(UNITS,J2)+BASTAF(UNITS,I)                 DRYS 640
  603 CONTINUE                                                          DRYS 650
      BASTAF(UNITS,J3)=0                                                DRYS 660
      DO 604 I=I5,I6                                                    DRYS 670
      BASTAF(UNITS,J3)=BASTAF(UNITS,J3)+BASTAF(UNITS,I)                 DRYS 680
```

```
  604 CONTINUE                                                          DRYS 690
      BASTAF(UNITS,J4)=0                                                DRYS 700
      DO 605 I=I7,I8                                                    DRYS 710
      BASTAF(UNITS,J4)=BASTAF(UNITS,J4)+BASTAF(UNITS,I)                 DRYS 720
  605 CONTINUE                                                          DRYS 730
      BASTAF(UNITS,K1)=BASTAF(UNITS,J1)+BASTAF(UNITS,J2)                DRYS 740
     * +BASTAF(UNITS,J3)+BASTAF(UNITS,J4)                               DRYS 750
  601 CONTINUE                                                          DRYS 760
      IF(KSKIP.GT.1) GO TO 606                                          DRYS 770
      WRITE(IW,803)                                                     DRYS 780
  803 FORMAT('1',T4,                                                    DRYS 790
     * 'SITE STAFF REQUIREMENT FOR COAL-FIRED POWER PLANTS'/            DRYS 800
     *       ' ',T19,'WITH DRY FGD SYSTEMS'/                            DRYS 810
     *       ' ',T19,20('-')//                                          DRYS 820
     *       ' ',T36,'NO. UNITS PER SITE'/                              DRYS 830
     *       ' ',T38,'1    2    3    4'/                               DRYS 840
     *       ' ',T36,18('-'))                                           DRYS 850
      WRITE(IW,805)                                                     DRYS 860
  805 FORMAT('0',T7,'PLANT MANAGER''S OFFICE'/)                         DRYS 870
      DO 600 I=I1,I8                                                    DRYS 880
      WRITE(IW,800) (TITLE(J,I),J=1,3)                                  DRYS 890
     * ,(BASTAF(UNITS,I),UNITS=1,4)                                     DRYS 900
  800 FORMAT(' ',T10,3A8,4(2X,I3))                                      DRYS 910
      IF(I.EQ.I2)WRITE(IW,811)                                          DRYS 920
     *  (BASTAF(UNITS,J1),UNITS=1,4)                                    DRYS 930
      IF(I.EQ.I2)WRITE(IW,806)                                          DRYS 940
  806 FORMAT(' ',T7,'OPERATIUNS'/)                                      DRYS 950
      IF(I.EQ.I4)WRITE(IW,811)                                          DRYS 960
     *  (BASTAF(UNITS,J2),UNITS=1,4)                                    DRYS 970
      IF(I.EQ.I4)WRITE(IW,807)                                          DRYS 980
  807 FORMAT(' ',T7,'MAINTENANCE'/)                                     DRYS 990
      IF(I.EQ.I6)WRITE(IW,811)                                          DRYS1000
     *  (BASTAF(UNITS,J3),UNITS=1,4)                                    DRYS1010
      IF(I.EQ.I6)WRITE(IW,808)                                          DRYS1020
  808 FORMAT(' ',T7,'TECHNICAL AND ENGINEERING'/)                       DRYS1030
  600 CONTINUE                                                          DRYS1040
                WRITE(IW,811)                                           DRYS1050
     *  (BASTAF(UNITS,J4),UNITS=1,4)                                    DRYS1060
  811 FORMAT(/  T13,'SUBTOTAL',T34,4(2X,I3)/)                           DRYS1070
      WRITE(IW,820)                                                     DRYS1080
     *  (BASTAF(UNITS,K1),UNITS=1,4)                                    DRYS1090
  820 FORMAT( T13,'TOTAL',T34,4(2X,I3)/                                 DRYS1100
     *       ' ',T34,4('  ===='))                                       DRYS1110
  606 CONTINUE                                                          DRYS1120
      UNITS = UNITS2                                                    DRYS1130
      SUPEXF=2200.                                                      DRYS1140
      VSEMIL = .12                                                      DRYS1150
C  NOTE... RATIO OF ESCALATION FACTORS ELIMINATES WAGE ESCALATION FROM   DRYS1160
C          MANCOS AND REPLACES IT WITH MATERIAL ESCALATION RATE         DRYS1170
      BASM=BASTAF(UNITS,J3)*(MANCOS/1000.)                              DRYS1180
     * *((100.+ESMATL)/(100.+ESWAGE))**(YEAR-BASEYR)                    DRYS1190
      STAFF = BASTAF(UNITS,K1)                                          DRYS1200
      STAFF4=BASTAF(UNITS,J4)                                           DRYS1210
      FIXMNT = FIXFAC * BASM                                            DRYS1220
      VARMNT = VARFAC * BASM * (PLTFAC / BASECF)                        DRYS1230
      TOTMNT = FIXMNT + VARMNT                                          DRYS1240
      KSKIP = KSKIP + 1                                                 DRYS1250
      RETURN                                                            DRYS1260
      END                                                               DRYS1270
```

```
C                                                                       COAL
      SUBROUTINE COAL                                                   COAL  10
      REAL*4 MWN, MANCOS                                                COAL  20
      INTEGER*4 UNITS, BASTAF(4,23),STAFF, STAFF4                       COAL  30
      INTEGER*4 UNITS2                                                  COAL  40
      REAL*8 TITLE                                                      COAL  50
      DIMENSION NO(4)                                                   COAL  60
      DIMENSION TITLE(3,18)                                             COAL  70
      COMMON /COM1/ ISOX, STAFF, UNITS, STAFF4                          COAL  80
      COMMON /COM2/ MWN, YEAR, BASECF, BASEYR, ESMATL, ESWAGE, FIXMNT,  COAL  90
     * MANCOS, PLTFAC, SUPEXF, TOTMNT, VARMNT, VSEMIL                   COAL 100
      DATA NO/9,3,3,3/                                                  COAL 110
      DATA TITLE/'MANAGER ','        ','        ',                      COAL 120
     *           'ASSISTAN','T       ','        ',                      COAL 130
     *           'ENVIRONM','ENTAL CO','NTROL   ',                      COAL 140
     *           'PUBLIC R','ELATIONS','        ',                      COAL 150
     *           'TRAINING','        ','        ',                      COAL 160
     *           'SAFETY  ','        ','        ',                      COAL 170
     *           'ADMIN. &',' SERVICE','S       ',                      COAL 180
     *           'HEALTH S','ERVICES ','        ',                      COAL 190
     *           'SECURITY','        ','        ',                      COAL 200
     *           'SUPERVIS','ION (EXC','. SHIFT)',                      COAL 210
     *           'SHIFTS  ','        ','        ',                      COAL 220
     *           'FUEL HAN','DLING   ','        ',                      COAL 230
     *           'SUPERVIS','ION     ','        ',                      COAL 240
     *           'CRAFTS  ','        ','        ',                      COAL 250
     *           'PEAK MAI','NT. ANNU','ALIZED  ',                      COAL 260
     *           'CHEMICAL','        ','        ',                      COAL 270
     *           'I & C   ','        ','        ',                      COAL 280
     *           'PERFORM.','', REPORT','S, TECH.'/                     COAL 290
      DATA BASTAF/4*1, 1,2,3,4, 4*1, 4*1, 4*1, 4*1, 12,13,14,15,        COAL 300
     * 3*1,2, 4*7,                                                      COAL 310
     * 2,2,4,4,                                                         COAL 320
     *                     45,50,60,65, 3*12,18,                        COAL 330
     * 6,6,8,10, 75,90,105,120, 15,30,45,60, 2,2,3,4, 2,2,3,4,          COAL 340
     * 12,15,18,21, 20*0/                                               COAL 350
      DATA FIXFAC/.50/                                                  COAL 360
      DATA VARFAC/.17/                                                  COAL 370
      DATA KSKIP/1/                                                     COAL 380
      DATA IW/6/                                                        COAL 390
      UNITS2 = UNITS                                                    COAL 400
      I1=1                                                              COAL 410
      I2=NO(1)                                                          COAL 420
      I3=I2+1                                                           COAL 430
      I4=I2+NO(2)                                                       COAL 440
      I5=I4+1                                                           COAL 450
      I6=I4+NO(3)                                                       COAL 460
      I7=I6+1                                                           COAL 470
      I8=I6+NO(4)                                                       COAL 480
      J1=I8+1                                                           COAL 490
      J2=I8+2                                                           COAL 500
      J3=I8+3                                                           COAL 510
      J4=I8+4                                                           COAL 520
      K1=J4+1                                                           COAL 530
      DO 601 UNITS = 1,4                                                COAL 540
      BASTAF(UNITS,J1)=0                                                COAL 550
      DO 602 I=I1,I2                                                    COAL 560
      BASTAF(UNITS,J1)=BASTAF(UNITS,J1)+BASTAF(UNITS,I)                 COAL 570
  602 CONTINUE                                                          COAL 580
      BASTAF(UNITS,J2)=0                                                COAL 590
      DO 603 I=I3,I4                                                    COAL 600
      BASTAF(UNITS,J2)=BASTAF(UNITS,J2)+BASTAF(UNITS,I)                 COAL 610
  603 CONTINUE                                                          COAL 620
      BASTAF(UNITS,J3)=0                                                COAL 630
      DO 604 I=I5,I6                                                    COAL 640
      BASTAF(UNITS,J3)=BASTAF(UNITS,J3)+BASTAF(UNITS,I)                 COAL 650
  604 CONTINUE                                                          COAL 660
      BASTAF(UNITS,J4)=0                                                COAL 670
      DO 605 I=I7,I8                                                    COAL 680
      BASTAF(UNITS,J4)=BASTAF(UNITS,J4)+BASTAF(UNITS,I)                 COAL 690
```

```
  605 CONTINUE                                                          COAL 700
      BASTAF(UNITS,K1)=BASTAF(UNITS,J1)+BASTAF(UNITS,J2)                COAL 710
     * +BASTAF(UNITS,J3)+BASTAF(UNITS,J4)                               COAL 720
  601 CONTINUE                                                          COAL 730
      IF(KSKIP.GT.1) GO TO 606                                          COAL 740
      WRITE(IW,803)                                                     COAL 750
  803 FORMAT('1',T4,                                                    COAL 760
     * 'SITE STAFF REQUIREMENT FOR COAL-FIRED POWER PLANTS'/            COAL 770
     *        ' ',T19,'WITHOUT FGD SYSTEMS'/                            COAL 780
     *        ' ',T19,19('-')//                                         COAL 790
     *        ' ',T36,'NO. UNITS PER SITE'/                             COAL 800
     *        ' ',T38,'1    2    3    4'/                              COAL 810
     *        ' ',T36,18('-'))                                          COAL 820
      WRITE(IW,805)                                                     COAL 830
  805 FORMAT('0',T7,'PLANT MANAGER''S OFFICE'/)                         COAL 840
      DO 600 I=I1,I8                                                    COAL 850
      WRITE(IW,800) (TITLE(J,I),J=1,3)                                  COAL 860
     * ,(BASTAF(UNITS,I),UNITS=1,4)                                     COAL 870
  800 FORMAT(' ',T10,3A8,4(2X,I3))                                      COAL 880
      IF(I.EQ.I2)WRITE(IW,811)                                          COAL 890
     *  (BASTAF(UNITS,J1),UNITS=1,4)                                    COAL 900
      IF(I.EQ.I2)WRITE(IW,806)                                          COAL 910
  806 FORMAT(' ',T7,'OPERATIONS'/)                                      COAL 920
      IF(I.EQ.I4)WRITE(IW,811)                                          COAL 930
     *  (BASTAF(UNITS,J2),UNITS=1,4)                                    COAL 940
      IF(I.EQ.I4)WRITE(IW,807)                                          COAL 950
  807 FORMAT(' ',T7,'MAINTENANCE'/)                                     COAL 960
      IF(I.EQ.I6)WRITE(IW,811)                                          COAL 970
     *  (BASTAF(UNITS,J3),UNITS=1,4)                                    COAL 980
      IF(I.EQ.I6)WRITE(IW,808)                                          COAL 990
  808 FORMAT(' ',T7,'TECHNICAL AND ENGINEERING'/)                       COAL1000
  600 CONTINUE                                                          COAL1010
                WRITE(IW,811)                                           COAL1020
     *  (BASTAF(UNITS,J4),UNITS=1,4)                                    COAL1030
  811 FORMAT(/  T13,'SUBTOTAL',T34,4(2X,I3)/)                           COAL1040
      WRITE(IW,820)                                                     COAL1050
     *  (BASTAF(UNITS,K1),UNITS=1,4)                                    COAL1060
  820 FORMAT( T13,'TOTAL',T34,4(2X,I3)/                                 COAL1070
     *        ' ',T34,4('  ===''))                                      COAL1080
  606 CONTINUE                                                          COAL1090
      UNITS = UNITS2                                                    COAL1100
      SUPEXF=2000.                                                      COAL1110
      VSEMIL = .08                                                      COAL1120
C  NOTE... RATIO OF ESCALATION FACTORS ELIMINATES WAGE ESCALATION FROM   COAL1130
C          MANCOS AND REPLACES IT WITH MATERIAL ESCALATION RATE         COAL1140
      BASM=BASTAF(UNITS,J3)*(MANCOS/1000.)                              COAL1150
     * *((100.+ESMATL)/(100.+ESWAGE))**(YEAR-BASEYR)                   COAL1160
      STAFF = BASTAF(UNITS,K1)                                          COAL1170
      STAFF4=BASTAF(UNITS,J4)                                           COAL1180
      FIXMNT = FIXFAC * BASM                                            COAL1190
      VARMNT = VARFAC * BASM * (PLTFAC / BASECF)                        COAL1200
      TOTMNT = FIXMNT + VARMNT                                          COAL1210
      KSKIP = KSKIP + 1                                                 COAL1220
      RETURN                                                            COAL1230
      END                                                               COAL1240
```

```
C                                                                       TYPE
      SUBROUTINE TYPER(TYPE,ITYPE)                                      TYPE   10
      DIMENSION X(7)                                                    TYPE   20
      DATA X/'PWR ','PWR','BWR ','BWR','LWR ','LWR','COAL'/             TYPE   30
      ITYPE=0                                                           TYPE   40
      IF(TYPE.EQ.X(1).OR.TYPE.EQ.X(2)) ITYPE=1                          TYPE   50
      IF(TYPE.EQ.X(3).OR.TYPE.EQ.X(4)) ITYPE=1                          TYPE   60
      IF(TYPE.EQ.X(5).OR.TYPE.EQ.X(6)) ITYPE=1                          TYPE   70
      IF(TYPE.EQ.X(7)) ITYPE=2                                          TYPE   80
      RETURN                                                            TYPE   90
      END                                                               TYPE  100
```

```
C                                                                       SELE
      SUBROUTINE SELECT(ITYPE,ISOX,WETDRY,*,*)                          SELE  10
      INTEGER*4 WETDRY                                                  SELE  20
      DATA IW/6/                                                        SELE  30
      IF(ITYPE.NE.1)GO TO 450                                           SELE  40
      CALL LWR                                                          SELE  50
      RETURN 2                                                          SELE  60
  450 IF(ITYPE.NE.2)GO TO 700                                           SELE  70
      IF(ISOX.EQ. 0) CALL COAL                                          SELE  80
      IF(ISOX.EQ.1 .AND. WETDRY.EQ.1) CALL COALWS                       SELE  90
      IF(ISOX.EQ.1 .AND. WETDRY.EQ.2) CALL COALDS                       SELE 100
      RETURN 2                                                          SELE 110
  700 WRITE(IW,800)                                                     SELE 120
  800 FORMAT('1',T20,'NO COMPARISON OF PLANT TYPE <<<<<'/               SELE 130
     * T20,'NEXT DATA CARD WILL BE READ'/'1')                            SELE 140
      RETURN 1                                                          SELE 150
      END                                                               SELE 160
```

```
C                                                                       HTRT
      SUBROUTINE HEATRT(HTRATE,ITYPE,ISOX,WETDRY)                       HTRT  10
      INTEGER WETDRY                                                    HTRT  20
      DIMENSION H(4)                                                    HTRT  30
      DATA H/10700.,9380.,9980.,9780./                                  HTRT  40
      DO 500 I=1,4                                                      HTRT  50
      IF(HTRATE.EQ.H(I))GO TO 501                                       HTRT  60
  500 CONTINUE                                                          HTRT  70
      GO TO 502                                                         HTRT  80
  501 CONTINUE                                                          HTRT  90
      IF(ITYPE.EQ. 1)GO TO 600                                          HTRT 100
      IF(ITYPE.EQ. 2)GO TO 602                                          HTRT 110
  600 CONTINUE                                                          HTRT 120
C=====LWR                                                               HTRT 130
      HTRATE=10700.                                                     HTRT 140
      GO TO 601                                                         HTRT 150
  602 CONTINUE                                                          HTRT 160
      IF(ISOX.EQ. 0)GO TO 603                                           HTRT 170
      IF(ISOX.EQ. 1)GO TO 604                                           HTRT 180
  603 CONTINUE                                                          HTRT 190
C=====COAL-FIRED WITHOUT FGD                                            HTRT 200
      HTRATE=9380.                                                      HTRT 210
      GO TO 601                                                         HTRT 220
  604 CONTINUE                                                          HTRT 230
C=====COAL-FIRED WITH FGD                                               HTRT 240
      IF(WETDRY.EQ.1)GO TO 605                                          HTRT 250
      IF(WETDRY.EQ.2)GO TO 606                                          HTRT 260
  605 CONTINUE                                                          HTRT 270
C=====COAL-FIRED WITH WET LIMESTONE FGD                                 HTRT 280
      HTRATE=9980.                                                      HTRT 290
      GO TO 601                                                         HTRT 300
  606 CONTINUE                                                          HTRT 310
C=====COAL-FIRED WITH DRY FGD                                           HTRT 320
      HTRATE=9780.                                                      HTRT 330
      GO TO 601                                                         HTRT 340
  601 CONTINUE                                                          HTRT 350
  502 CONTINUE                                                          HTRT 360
      RETURN                                                            HTRT 370
      END                                                               HTRT 380
```

```
C                                                                       CHKD
      SUBROUTINE CHKDEF(ONE,TWO,I)                                      CHKD  10
      DIMENSION TWO(2)                                                  CHKD  20
      IF(ONE.EQ.TWO(1) .OR. ONE.EQ.TWO(2))ONE=TWO(I)                    CHKD  30
      TWO(I)=ONE                                                        CHKD  40
      RETURN                                                            CHKD  50
      END                                                               CHKD  60
```

```
C                                                                       UNIT
      SUBROUTINE UNITCK(UNITS,*)                                        UNIT  10
      INTEGER*4 UNITS                                                   UNIT  20
      DATA IW/6/                                                        UNIT  30
      IF(UNITS.GT.4 .OR. UNITS.LT. 1)GO TO 700                          UNIT  40
      RETURN                                                            UNIT  50
  700 WRITE(IW,800)                                                     UNIT  60
  800 FORMAT('1',T20,'UNITS GREATER THAN 4 OR LESS THAN 1 <<<<<'/       UNIT  70
     * T20,'NEXT DATA CARD WILL BE READ'/'1')                            UNIT  80
      RETURN 1                                                          UNIT  90
      END                                                               UNIT 100
```

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