Dr - 2/21

3-29-76

SOCIAL COST STUDIES PROGRAM

ELECTRICAL UTILITY GENERATING SYSTEM RELIABILITY ANALYSIS CODE, SYSREL

U of C AUA USERDA

MASTER

ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS

Prepared for the U. S. ENERGY RESEARCH
AND DEVELOPMENT ADMINISTRATION

Division of Biomedical and Environmental Research
under Contract W-31-109-ENG-38

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

The facilities of Argonne National Laboratory are owned by the United States Government. Under the terms of a contract (W-31-109-Eng-38) between the U. S. Energy Research and Development Administration, Argonne Universities Association and The University of Chicago, the University employs the staff and operates the Laboratory in accordance with policies and programs formulated, approved and reviewed by the Association.

MEMBERS OF ARGONNE UNIVERSITIES ASSOCIATION

The University of Arizona
Carnegie-Mellon University
Case Western Reserve University
The University of Chicago
University of Cincinnati
Illinois Institute of Technology
University of Illinois
Indiana University
Iowa State University
The University of Iowa

Kansas State University
The University of Kansas
Loyola University
Marquette University
Michigan State University
The University of Michigan
University of Minnesota
University of Missouri
Northwestern University
University of Notre Dame

The Ohio State University
Ohio University
The Pennsylvania State University
Purdue University
Saint Louis University
Southern Illinois University
The University of Texas at Austin
Washington University
Wayne State University
The University of Wisconsin

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately-owned rights. Mention of commercial products, their manufacturers, or their suppliers in this publication does not imply or connote approval or disapproval of the product by Argonne National Laboratory or the U. S. Energy Research and Development Administration.

Printed in the United States of America
Available from
National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
Price: Printed Copy \$7.75; Microfiche \$2.25

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
Argonne, Illinois 60439

SOCIAL COST STUDIES PROGRAM

ELECTRICAL UTILITY GENERATING SYSTEM
RELIABILITY ANALYSIS CODE,
SYSREL

by

K. Hub, L. Conley, W. Buehring,*
B. Rowland,* and M. Stephenson**

Energy and Environmental Systems Division

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

September 1975

*Now at the University of Wisconsin
**Engineering Division, Argonne

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	1
I. INTRODUCTION	1
II. TECHNICAL DESCRIPTION	5
II.1 DESCRIPTION OF OVERALL CALCULATION	5
II.2 MAINTENANCE SCHEDULING	7
II.3 SYSTEM RELIABILITY	8
II.4 RESERVE REQUIREMENT	17
II.5 ENERGY ALLOCATION	19
II.6 ENERGY COST	25
ACKNOWLEDGMENTS	27
REFERENCES	28
III. APPENDIXES	29
A - CODE DESCRIPTION	A.1
B - INPUT	B.1
C - PROGRAM LISTING	C.1
D - SAMPLE EXECUTION	D.1
E - PARAMETER STUDIES	E.1

LIST OF FIGURES

<u>No.</u>	<u>Title</u>	<u>Page</u>
I.1	The SYSREL Method	3
II.1	Calculation Sequence	6
II.2	Pseudo-load Curve	9
II.3	Load-range Curve Showing Peak Demand on Day of Highest Load and Peak Demand on Day of Lowest Load During Period	16
B-1	Program-parameters Input	B.8
B-2	Subsystem-characteristics Input	B.9
B-3	Energy-intertie Input	B.10
B-4	Update Card	B.11
B-5	Cost Input	B.12
B-6	Data-deck Structure	B.13
E-1	Required Reserve Capacity as a Function of Forced-outage Rates	E.2
E-2	Effect on MTBF of Incrementing Forced-outage Rates of Several Large Plants	E.3
E-3	Percent of States Saved During Tenth Period as a Function of CRITER, the Calculation-limiting Variable	E.5
E-4	Variation in Calculated Values as a Function of the Calculation-limiting Variable, CRITER, for the 5000-Mw Mock System	E.7
E-5	Variation in Calculated Values as a Function of the Calculation-limiting Variable, CRITER, for the 7030-Mw System	E.8
E-6	Calculated Values of Energy Generated During 14th Period as a Function of STE	E.9
E-7	Difference Between Calculated Values of Energy Demanded and Energy Generated for Several Table Sizes	E.10
E-8	CPU Execution Time as a Function of Table Size	E.11

LIST OF FIGURES (Contd.)

<u>No.</u>	<u>Title</u>	<u>Page</u>
E-9	MTBF vs Annual Peak Demand for 5 Similar Power-generating Systems	E.13
E-10	True-capacity Increment vs Estimated-capacity Increment Using Selected Values for BB (Annual Peak Demand = 5000 Mw)	E.14

LIST OF TABLES

<u>No.</u>	<u>Title</u>	<u>Page</u>
II.1	Biweekly Contributions to the Annual Failure Frequency for a Large Utility System	18
A-1	Reduction of Calculations Using NLIM and CRITER	A.3
B-1	Input Description	B.2
E-1	Effect of Size of Units on MTBF	E.4

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

ELECTRICAL UTILITY GENERATING SYSTEM RELIABILITY ANALYSIS CODE, SYSREL

by

K. Hub, L. Conley, W. Buehring,
R. Rowland, and M. Stephenson

ABSTRACT

The system reliability code, SYSREL, is a system planning tool that can be used to assess the reliability and economic performance of alternative expansion patterns of electric utility generation systems. Given input information such as capacity, forced-outage rate, number of weeks of annual scheduled maintenance, and economic data for individual units along with the expected load characteristics, the code produces estimates of the mean time between system failures, required reserve capacity to meet a specified system-failure-frequency criterion, expected energy generation from each unit, and system energy cost.

The categories of calculations performed by the code are five: maintenance scheduling, reliability, capacity requirement, energy production allocation, and energy cost. The code is designed to examine alternative generating units and system expansion patterns based on the constraints and general economic conditions imposed by the investigator. The computer running time to execute a study is short and many system alternatives can be examined at a relatively low cost.

The report contains a technical description of the code, list of input data requirements, program listing, sample execution, and parameter studies.

I. INTRODUCTION

The purpose of this report is to provide the description of a code that can be used to calculate the reliability of electrical generating systems. In particular, the code is oriented toward use by the planner or system analyzer. Dollar costs to generate electrical energy using various energy sources or system-expansion schemes may be calculated.

The code, SYSREL, deals with maintenance unit scheduling, electrical energy allocation to units, needed generating-reserve margin for a specified reliability criterion, and generating costs. Figure I.1 provides a schematic of the SYSREL method for performing the required calculations: The reliability calculations use the loss-of-capacity method. The energy allocation portion of the code determines the energy generated by each unit; capacity factors and energy costs are computed from the energy-allocation calculations.

Two types of information are used to describe the utility system. General system description and data comprise the first type. The data consist of biweekly peak loads (fractions of annual peak load) and associated standard deviations. Also necessary is a curve describing the probability of load demands. The load information, contained in the data statements of the program, can easily be changed and should be checked for applicability to the study situation. Energy-intertie purchases and sales, as well as emergency intertie capacity, can also be input each year.

Plant (generating unit) description, along with that of projected utility-system changes, comprises the second type of information. The first step in providing a description of those plants to be considered in applying the loss-of-capacity method is to divide the plants into groups of units with identical (or adequately similar) characteristics. Associated with each group is average forced-outage rate, repair time, and unit-generating capacity. The required annual maintenance time and costs are input for each unit. Loading order and heat rate are input with each block of capacity for the unit (three blocks per unit are allowed).

To model expansion of the power system, the cost and performance changes are input over each year that is being analyzed. Comparisons between alternative strategies are based on systems that have a fixed reliability criterion.

The code evolved from the study of LMFBR characteristics and their possible influence on electrical utility planning and operation of generating facilities. To study the impact of LMFBR plants, a systems approach was needed. Emphasis in this approach was placed on the reliability consideration for new technology because of its importance to electrical utilities. The code development passed through a number of stages, and is now a flexible tool for planning and impact studies. The inherent advantage of the code is that it

Fig. I.1. The SYSREL Method

represents a rather complete assembly of generating-system factors, which are tied together by reliability criteria. Reliable power has been a characteristic of electrical utilities, fundamentally derived from their business charters that mandate them to supply power when needed.

Although the basis of a study approach, using reliability as the key linking parameter, is firm, the results are only indicators of system reliability. The failure to meet the criterion does not mean failure of the system. Indeed, if it were so, one would expect to see annually more systems failures in the U.S., yet they rarely occur. More often transmission- and distribution-system components failures are the initiating agents for partial loss of power by customers than is the failure of a generating-system component. The investigator can use the results of reliability and cost studies to develop information on the relative ranking of alternatives. Results from using this code also can be helpful in system planning, although the essential ingredient of a successful plan is judgment, based on a detailed familiarity with the electrical system under study.

The material in the report is divided into two main sections: Section II, the technical description of the code, and Section III, the appendixes, which deal with the code description, input information, program listing, sample execution, and parameter studies.

II. TECHNICAL DESCRIPTION

II.1 DESCRIPTION OF OVERALL CALCULATION

The objective of the SYStem RELiability code, SYSREL, is to assess a utility system's reliability and economic performances over a study period that may range from one to several years. Given certain input such as capacity, forced-outage rate, number of weeks of annual scheduled maintenance, and economic data for the individual units, along with the expected load characteristics, the code produces the mean time between system failures, required reserve capacity to meet the specified system-failure-frequency criterion, expected generation from each unit, and system-energy cost. Figure II.1 shows the overall calculation sequence in SYSREL.

For the study period, calculations are made for 26 biweekly periods in each year. First, an annual maintenance schedule is established from the input characteristics of the units in the system. Next, the reliability calculations proceed for the individual biweekly periods, followed by calculations of the expected generation for each unit not on scheduled maintenance -- a modified Baleriaux-Jamouille method, with an input loading order is used. After these calculations have been completed for all 26 biweekly periods, an additional capacity reserve requirement for that year is determined as a function of the calculated mean time between system failures and a specified system reliability criterion; the capacity requirement estimate is obtained without using an iterative procedure. Finally, the annual and cumulative system generation costs are determined.

Input to the calculations is permitted at the start of each biweekly period to account for the addition of new plants, increased peak loads, changes in plant characteristics or costs, etc.

The costs for the system, including capacity requirements to satisfy the reliability criterion, can be estimated if desired. Since system expansion alternatives and parameter studies should be compared on a consistent reliability basis, the costs associated with adding peaking capacity or purchasing power from other utilities need to be included for a comprehensive comparison of alternatives.

Fig. II.1. Calculation Sequence

The calculations can be broken down into five distinct categories that serve as the topics for the remainder of this section. They are maintenance scheduling, system reliability, capacity requirement, energy allocation, and energy cost.

II.2 MAINTENANCE SCHEDULING

As part of the input to the SYSREL code, the utility's generating units are combined into groups of units that have similar capacities, forced-outage rates, and average repair times. Each unit has associated with it only one annual scheduled maintenance period of 0, 2, 4, 6, or 8 weeks; the scheduled maintenance downtime is continuous until the annual allotment is completed. Biweekly period 1 is assumed to follow biweekly period 26; hence, an assigned 8-week scheduled downtime that starts in biweekly period 26 would run through biweekly period 3.

The objective in deriving a maintenance scheduler is to schedule downtime approximately when, from a reserve standpoint, the system least needs the generating unit. This downtime scheduling is carried out by means of a technique that generates a pseudo-load curve, which is the sum of the expected biweekly peak-load curve and the scheduled maintenance. A unit that needs to be scheduled for downtime is then scheduled for the period when the addition of its capacity to the scheduled maintenance results in the lowest maximum in the pseudo-load curve for the weeks during which maintenance is scheduled. This procedure results in a relatively flat pseudo-load curve for the biweekly periods that have any scheduled maintenance and keeps scheduled downtime from occurring at all during times of the year when the biweekly peak load is expected to be substantially greater than most other biweekly periods.

The calculation proceeds in the following order:

1. Group 1 units with 8 weeks scheduled downtime.
2. 1 6
3. 1 4
4. 1 2
5. 2 8
6. 2 6 etc.

The user can help flatten the pseudo-load curve by placing large units and units with large amounts of scheduled downtime in the early groups. For example, in a system having only one 1100-Mw unit with 6 weeks scheduled downtime and many 50-Mw units with 2 weeks scheduled downtime, the large unit should be placed into the schedule for maintenance first and the small peaking units, which will help flatten out the pseudo-load curve, last. Placing the large unit in the last group would cause the curve to have a 1100-Mw bulge for three consecutive biweekly periods.

Based on an ANL study, Fig. II.2 shows the pseudo-load curve developed for a large utility that has a summer peak load of about 16,500 Mw and a spring minimum load of about 9300 Mw. No maintenance is scheduled from biweekly period 10 (early May) through biweekly period 18 (mid-September). The pseudo-load curve is quite flat for the periods when maintenance is scheduled (maximum, 13,489 Mw; minimum, 12,470 Mw). The system has 89 peaking units of 70 Mw or less that need four weeks scheduled outage per year; the largest unit on the system is 1093 Mw.

Once the maintenance schedule has been established, the calculations proceed on a biweekly basis. Each unit is scheduled to be either up or down for a particular biweekly period, so the system must meet the expected load-duration curve with the units that are scheduled up.

In a multiyear analysis, SYSREL does not recalculate the scheduled outage from year to year, unless the rescheduling code option is used; however, if the option is used, there is little control on the time interval between scheduled maintenance periods. This lack of control could lead to some inconsistencies, particularly in the case of nuclear units that have relatively inflexible refueling periods. However, the assumptions on which the maintenance schedule is built are considered reasonable for the purpose of carrying out system reliability calculations.

II.3 SYSTEM RELIABILITY

Input

The input required for the reliability calculations includes the following:

Fig. II.2. Pseudo-load Curve

1. Annual peak load and sales to and purchases from other utilities.
2. Average intertie capacity for emergency power.
3. Biweekly peak load as a fraction of the annual peak. (This curve is built into the code, but should be reviewed whenever data for a specific utility are available.)
4. Number of groups of units.
5. For each group:
 - a. Number of units
 - b. Megawatts per unit
 - c. Forced-outage rate (time forced down divided by scheduled generating time)
 - d. Average time to repair (hours)
 - e. Maximum number of units in this group to be considered forced out at a single time
6. A constant used in the rejection of nonimportant "state conditions" (up and down are states) for possible combinations of units.

The data in 5.e and 6 are required to limit the size of the calculation for large systems; the methods used in limiting the calculation are described in App. A.

State probability, duration of outage, and capacity forced out

For each weekly period, the code determines the frequency of combined forced outages based on their probability and duration. M. E. Stephenson of Argonne National Laboratory developed the first version of SYSREL, described in his internal ANL study of June 1970.¹ Only the fundamentals for the probabilistic approach used in SYSREL are given here.

Each group of units is sequentially examined for a biweekly period. Each possible outage combination for the group is estimated, and three pieces of information are associated with an outage:

1. The probability of occurrence,
2. The expected duration if it were to occur, and
3. The quantity of capacity forced out.

After all of the outage combinations are determined for the first group, the same procedure is used for the second group. The two data sets are then combined (meshed) to give a single data set describing the combined probabilities. The third group is examined, and the resulting data set is meshed with the data set for groups 1 and 2 to yield the single data set again. The calculation proceeds in this manner until all groups have been examined.

In the calculations for a single group consisting of n identical units, the probability (P_r) of r units being forced out at a single time is given by:

$$P_r = \frac{n!}{r! (n-r)!} f^r (1-f)^{n-r},$$

where f is the forced-outage rate or the probability of finding the component in a failed state at any time that it is not scheduled to be down. The factorial coefficient represents the number of combinations of n things taken r at a time, or the number of ways of choosing r components out of n components. Thus, if a group had 4 units with a forced-outage rate of 0.06, the possible states for the group would have the following probabilities of occurrence:

State	Probability of Occurrence
4 up	0.78074896
3 up, 1 down	0.19934016
2 up, 2 down	0.01908576
1 up, 3 down	0.00081216
0 up, 4 down	0.00001296
Total:	1.00000000

The average duration of an r -fold outage, T_r , is given by Adler^{2,3} and was used by Stephenson.¹ The equation is

$$T_r = \frac{T(1-f)}{r+f(n-2r)},$$

where T is the average time to repair a single unit. For example, if the four units discussed above have average repair times of 100 hours, the average durations of the outages are:

<u>State</u>	<u>Average Duration</u>
1 down	83.9 hours
2 down	47.0 hours
3 down	32.6 hours
4 down	25.0 hours

The duration represents the average time before transition to another state; for example, 2 down can switch to 1 down or 3 down.

The third piece of information associated with each state is the megawatt outage; that is, just r times the megawatts per unit in the group.

Examining every possible state for a group may not be necessary in certain cases; some highly unlikely states can be discarded without significantly reducing the accuracy of the results. When a group consists of a small number of units, every possible state should be examined. However, when a group consists of a large number of units that have a low forced-outage rate, some states are so unlikely that they need not be examined, especially if the capacity of a unit is a small fraction of the system capacity. For example, one study carried out with SYSREL had a group with 18 units that had a forced-outage rate of only 0.012. As shown below, states with more than four or five units out at one time are remote possibilities.

<u>State</u>		<u>Probability Of Occurrence</u>
<u>Units up</u>	<u>Units down</u>	
18	0	0.8047
17	1	0.1759
16	2	0.0182
15	3	1.18-3*
14	4	5.36-5
13	5	1.82-6
12	6	4.79-8
11	7	9.99-10
10	8	1.67-11
.	.	.
.	.	.
.	.	.
1	17	3.94-32
0	18	2.66-35

*NOTE: A.A-B means A.A times 10^{-B}

The study was carried out by discarding states with more than seven units forced out at any one time with no apparent loss in accuracy. Note that there were other units in the system that had forced-outage rates as high as 0.09. In the discarding process, care must be used to assure that the maximum term in the binomial expansion is always included in the states saved. (The maximum term of an expansion containing $n+1$ terms for units with a forced outage, f , is approximately the nf term.)

Meshing the Groups

After calculating all possible states for two groups, the meshing procedure is carried out to reduce the information to a single data set. The number of megawatts on forced outage associated with the meshed point (M_{AB}) is the sum of the megawatts forced out associated with the data point from Group A (M_A) plus the megawatts forced out associated with the data point from Group B (M_B):

$$M_{AB} = M_A + M_B .$$

The probability of occurrence of the meshed point is the probability of occurrence for the situation from Group A times the probability of occurrence for the data point from Group B:

$$P_{AB} = P_A P_B .$$

The average outage duration for data point AB is:

$$T_{AB} = \frac{T_A T_B}{T_A + T_B} .$$

When very large power systems are being considered, the calculations could require a vast number of data points and much calculation time. Various calculation limiters have been incorporated into the code and are discussed in the Appendixes A and E.

Frequency of Outage

The frequency (F) of occurrence for an outage combination is the ratio of the probability of occurrence and the duration

$$F = P/T .$$

This frequency is for an outage of magnitude equal to the number of megawatts forced out, associated with P and T.

In order to calculate the frequency of outages that are greater than the capacity of the system, minus the scheduled maintenance, minus the expected load, a load variation calculation has been incorporated in the code. Since weekend and holiday loads are generally much lower than weekday loads, a month was assumed to be composed of 21 weekdays. For these 21 days, the daily peak load was assumed to follow a normal (Gaussian) distribution. Calculations for the 21 daily peak-load values were based on the location of the centers of 21 equal areas under the Gaussian probability curve. The load curve needs to be adjusted for power received from other utility systems. Firm power purchases should be subtracted from the peak, but firm power sales should be added to the peak.

The load for any particular day (LOAD) is related to the mean load (XMEAN) by adding the product of the standard deviation (SIG) and the appropriate number (VAL) as follows:

$$LOAD = XMEAN + VAL * SIG.$$

VAL takes on 21 values from -1.98 to +1.98. Therefore, the peak load (XMPK) is related to the mean load as follows:

$$XMPK = XMEAN + 1.98 * SIG.$$

The peak load occurs one day of the 21 days (VAL = +1.98), the mean load occurs one day (VAL = 0.0), and the minimum load occurs one day (VAL = -1.98).

Some studies by others have indicated that values for the ratio of standard deviation to mean load (SOM = SIG/XMEAN) vary from 0.02 to 0.04; however, we have observed that SOM appears to vary more than this among utilities.

Investigations of data for two specific utilities indicated higher values of SOM during certain periods of the year. Values for SOM are in the code data list and account for seasonal changes; SOM ranges from 0.04 to 0.08, the higher values usually occurring in the peak summer season. Figure II.3 shows the maximum and minimum daily peak loads (excluding Saturday and Sunday) for each biweekly period for one year in a study carried out with SYSREL. If data relative to a specific study are available, these values for SOM should be reviewed. Similarly, values for the biweekly peak load as a fraction of the annual peak are built into the code (XMF). These fractional values should also be compared with actual data when possible.

After determining the 21-day load variation of the biweekly peak load and the Gaussian distribution, each calculated outage stage for the biweekly period is compared to the 21 values of the critical forced-outage magnitude corresponding to the 21 daily peak loads:

$$\text{CRITICAL OUTAGE} = \text{SYSTEM CAPACITY} - \text{SCHEDULED MAINTENANCE} - \text{DAILY LOAD}.$$

More terms are included in the above equation if firm purchases and sales and use of emergency intertie capacity with other utilities are included in the system description. Each time the calculated outage stage has a magnitude greater than the critical forced-outage magnitude, the system has failed to meet the load. The failure frequencies for the failure states of the 21-day period are added and averaged to give an average failure frequency (SDFR):

$$\text{SDFR} = \frac{1}{21} * \sum_i \quad \begin{array}{l} \text{This is summed for all states} \\ \text{with megawatts forced out} > \\ \text{CRITICAL OUTAGE} \end{array}$$

To put the failure frequency on a true average basis, SDFR must be corrected for weekends by multiplying by 5/7 (weekday to full week). A correction must also be made for the fraction of time, on a day basis, that the system is exposed to the equivalent load. A failure frequency for each of the 26 biweekly periods is calculated and averaged to give the failure frequency (ANNFR) on an annual basis:

$$\text{ANNFR} = \frac{\text{ADJFE}}{26} * \sum_{j=1}^{26} \text{SDFR}_j \times \frac{5}{7},$$

Fig. II.3. Load-range Curve Showing Peak Demand on Day of Highest Load and Peak Demand on Day of Lowest Load During Period

where ADJFE is an adjustment factor for equivalent daily exposure and has a value of about 1/3. The mean time between system failures to meet the load in years (TIME) is just the inverse of ANNFR:

$$TIME = 1/ANNFR.$$

Table II.1 shows, for the year of the study carried out with SYSREL, the biweekly contributions to the annual failure frequency that served as a basis for Figs. II.2 and II.3. The adjusted failure frequency (ANNFR) is 8.8 per year, and the mean time between system failures to meet the load is 0.11 years, in this case. Note that the main contributions to the failure frequency are from biweekly periods 11 through 18, which is when, as Figs. II.2 and II.3 indicate, the large summer loads occur. Results that include interties during this peak season would significantly reduce the annual failure frequency and could establish a mean time between failures of about five years.

II.4 GENERATING CAPACITY REQUIREMENT

Often desirable to know is the amount of capacity that would have to be added for the system to meet a specified reliability criterion, such as a mean time of five years between system failures to meet the load. Thus, if the mean time between failures were once in three years, adding an appropriate amount of reserve capacity would reduce the failure frequency to once in five years. On the other hand, if the failure frequency were once in seven years, the system would have more capacity than it needed to meet the specified reliability criterion.

Past studies have indicated that the amount of capacity required to meet a reliability criterion can be estimated by an empirical equation, which has acceptable accuracy over reasonable ranges of parameter variations. The following equation presents the relationship used in the calculations:

$$DELMEG = 0.7 (CAPAC - ADEQL) (e^{\frac{1}{BB} \ln TIME/T1} - 1).$$

DELMEG is the additional capacity required for TIME to equal T1, the reliability criterion. DELMEG can be either negative or positive. CAPAC is the

TABLE II.1. Biweekly Contributions to the Annual Failure Frequency for a Large Utility System

Biweekly Period	Unadjusted Frequency (1/yr)
1	3.11 - 1
2	2.11 - 1
3	2.21 - 1
4	2.13 - 1
5	1.60 - 1
6	0.79 - 1
7	1.71 - 1
8	0.84 - 1
9	4.74 - 1
10	1.20
11	1.11 + 1
12	3.30 + 1
13	1.06 + 2
14	2.14 + 2
15	1.59 + 2
16	1.06 + 2
17	3.99 + 1
18	1.12 + 1
19	1.26
20	1.19
21	7.80 - 1
22	7.80 - 1
23	7.80 - 1
24	7.20 - 1
25	7.35 - 1
26	5.39 - 2

∴ Failure Frequency (ANNFR) = (26.5)(1/3)

Mean Time Between System Failures to Meet the Load (TIME) = 0.113 yr

NOTE: A.A-B means A.A times 10^{-B}

installed capacity and ADEQL is the average of biweekly peak loads adjusted for firm power purchases and sales, scheduled maintenance, and emergency intertie power. The BB (a program constant used to estimate capacity requirements) can be input to the calculations and has a value in the range of 5 to 8. By making several runs for the system, with varying capacity, the investigator can find an appropriate value of BB.

The accuracy of the DELMEG estimate can then be checked by making another run with the appropriate capacity actually added to the system. The estimate of additional reserve capacity in the program (RESREQ) is DELMEG divided by 0.95, which approximates the effect of an estimated 5% forced-outage rate for the additional reserve capacity, consisting of very small units in a large system.

When a system has a mean time between failures that is greater than the specified reliability criterion, T1, DELMEG will be less than zero, in which case the additional reserve requirement (RESREQ) is set to zero.

These estimates of additional capacity requirements are important in studies concerned with economics. System expansion alternatives need to be compared on a consistent reliability basis and to achieve a valid comparison, the costs associated with adding peaking capacity or purchasing power from other utilities need to be included.

Costs associated with the additional reserve capacity requirements (e.g., fuel cost in \$/MBtu) are required as input each year. These input costs can be set to zero if the cost of such reserves is not to be included in the calculations.

A significant advantage of this program is that it can be used to determine the magnitude of additional capacity requirement without using an iterative procedure. Although the code must be "tuned" somewhat to properly represent the utility system of interest, one who follows this preparation procedure can carry out a variety of studies.

II.5 ENERGY ALLOCATION

After the reliability calculations have been carried out for a bi-weekly period, Subroutine ENCALC is called to ascertain the energy generated by each unit scheduled to be in operation for the biweekly period. The energy

generation for each unit is accumulated until after the 26th biweekly period, when the annual generation costs are determined (Subroutine ECOST).

The required input to the energy allocation subroutine includes:

1. Units scheduled up for the biweekly period
2. Number of blocks of capacity for each unit
3. Loading order for all blocks of capacity in the system
4. Megawatts of capacity in each block
5. Forced-outage rate for each unit
6. Biweekly peak load
7. Load-duration curve
8. Number of steps to be used in energy allocation table
9. Capacity factor adjustment parameters

Note that in the reliability calculations, the size of every unit in a group is the same; however, in the energy calculations (and the costs), the number of megawatts for each unit can be input to the program, so that the energies calculated can be for an actual unit, rather than for an average-sized one.

The energy allocation is based on an extension of the loss-of-load probability analysis first proposed by Baleriaux et al., whose work is discussed in References 4 and 5. The only purpose that the Baleriaux-type analysis serves in this code is to predict expected generation from each unit so that generation costs can be computed.

The loss-of-load method involves preparing two probability curves versus capacity. One is the incremental-load probability, i.e., the probability that the load will be equal to the number of megawatts on the abscissa. The second curve is the probability that the number of megawatts will be forced out at any time. An equivalent-load curve is then formed and compared to the total capacity of the loading order at each position.

As an example, suppose a system is made up of four 1000-Mw units, each having a forced-outage rate of 10%. Then the outage-probability curve would be:

<u>Outage Distribution</u>	
<u>Mw Out</u>	<u>Probability</u>
0	0.6561
1000	.2916
2000	.0486
3000	.0036
4000	<u>.0001</u>
	1.0000

Also suppose the incremental-load probability is given as follows:

<u>Load Distribution</u>	
<u>Mw Load</u>	<u>Probability</u>
0	0.0
1000	0.1
2000	0.6
3000	0.3
4000	<u>0.0</u>
	1.0

Equivalent load is defined to be the sum of the load and the capacity of outage. The equivalent-load, incremental-probability curve for this case is determined by convolution of the two curves. For example, the probability of an equivalent load of 1000 Mw is given by the sum of the probabilities of two possible states: (1) zero load and 1000-Mw forced out and (2) 1000-Mw load and zero forced out.

<u>Equivalent-load Distribution</u>	
<u>Mw-equivalent Load</u>	<u>Probability</u>
0	0.00000
1000	0.06561
2000	0.42282
3000	0.37665
4000	0.11700
5000	0.01675
6000	0.00114
7000	<u>0.00003</u>
	1.00000

In this particular case, zero load has a zero probability, so only one possible state yields the equivalent load for 1000 Mw.

Next the cumulative-probability distribution curve may be obtained by summing probabilities from bottom to top to give the probability that the load will be greater than the given equivalent load.

Equivalent-load Distribution	
Mw-equivalent load	Probability that the equivalent load is equal to or greater than the given equivalent load
0	1.00000
1000	1.00000
2000	0.93439
3000	0.51157
4000	0.13492
5000	0.01792
6000	0.00117
7000	0.00003

Since the system capacity is 4000 Mw, the loss-of-load probability is 0.01792, i.e., the probability that the equivalent load is 5000 Mw or greater.

One of the reasons why this type of probability analysis is not used in the SYSREL reliability calculations is that only the probability of failure is calculated, whereas the duration of the outage is not. An advantage, therefore, of the method used in the reliability calculations in this code is that the results are expressed in terms of frequency.

Using only those units loaded before a particular unit, the energy that is expected to be generated by the latter is determined by preparing a cumulative-probability curve. The average value of the probability that corresponds to the appropriate range of capacity in the equivalent load is the fraction of time that the unit will be called upon to generate. That is, the probability associated with the last 1000-Mw unit in the above example would be the equivalent-load, cumulative probability at 4000 Mw calculated for a system made up of only three of the 1000-Mw units. The calculations are shown below.

<u>Mw</u>	<u>Incremental- load Probability</u>	<u>Outage Probability</u>	<u>Equivalent- load, Incremental Probability</u>	<u>Equivalent- load, Cumulative Probability</u>
0	0.0	0.729	0.0	1.0
1000	0.1	0.243	0.0729	1.0
2000	0.6	0.027	0.4617	0.9271
3000	0.3	0.001	0.3672	0.4654
4000	0.0		0.0892	0.0982
5000			0.0087	0.0090
6000			0.0003	0.0003

Thus, the fraction of time that the fourth 1000-Mw unit would be called upon to generate is 0.0982. However, the unit has a forced-outage probability of 10%, so on the average the unit will be able to deliver only 90% of the requested energy shown below:

$$\text{Expected Generation} = (1000 \text{ Mw})(0.9)(0.0982)(\text{HOURS}),$$

where HOURS is the number of hours in the period being studied. For a bi-weekly period, this would be 336 hours, and the expected generation would be 29,700 megawatt-hours.

The expected energy for the 1000-Mw unit that is third in the loading order can be calculated by building the cumulative-probability curve, using a system consisting of only the first two units. In this way, the energy can be determined for each unit in the system from the last unit in the loading order down through the second unit in the loading order. When the first unit is reached, the same calculation cannot be carried out since the outage probability for no units in the system is meaningless. Usually, however, the expected load is greater than the capacity of the first unit in the system for all of the time. Therefore, the first unit is called upon to generate all the time.

The calculations for an actual system have many complicating factors. One of these is that the unit is not always 100% on or off at any given time. This particular dilemma can be partially accounted for in the loss-of-load analysis for splitting the units into blocks of capacity that have different positions in the loading order. The block that is further down in the loading order might represent the load-following portion of the unit's capacity,

which does not eliminate the difficulty, but does produce more realistic capacity factors in some cases.

The capacity factor prediction for peaking units is another area of difficulty. Using this methodology, if the utility system is very reliable (has a long mean time between failures), the generation prediction for the last peaking unit in the loading order will be extremely small. This determination is to be expected since the loss-of-load probability is the value of the cumulative probability at the next higher value of megawatts on the equivalent load.

The calculated annual-capacity factors for some plants from an actual study are shown below.

<u>Position in Loading Order</u>	<u>Unit Capacity (Mw)</u>	<u>Forced- outage Rate (%)</u>	<u>Annual Scheduled Maintenance (weeks)</u>	<u>Calculated Annual- capacity Factor</u>
1	593	5	4	0.876922
6	500	9	6	0.661175
23	50	1.2	2	0.003789
35	50	1.2	2	0.000577
43	42	6	2	0.000223

The annual-capacity factor for the first unit in the loading order is just $(52-4) \cdot (1.0-0.05)/52 = 0.877$, thereby indicating that it runs at full power every minute that it is not on forced outage or scheduled maintenance. In this study, the second and third units in the loading order (identical to the first unit in the loading order) also operated full time; the annual peak load in this case was 5956 Mw. By the time the sixth unit, which fell between 2872 and 3372 Mw, in the loading order was reached, the unit did not have to operate full time as is shown above. The 23rd unit in the loading order was a 50-Mw peaking unit that stood between 6004 and 6054 Mw in the loading order. This unit was called upon to operate only 33 hr/yr; the 35th unit for only 5 hr/yr; and the last unit in the loading order (the 43rd) for less than 2 hr/yr. Yet the system in this case had a mean time between failures of only 2 years, which is less than acceptable performance for most systems.

In order to more realistically estimate actual loading procedures, an optional capacity-factor adjustment routine has been built into the code.

The adjustment is made by removing a portion of the energy generated by the units at the top of the loading order and assigning it to units that are positioned later in the loading order. The predicted capacity factors without adjustment can be used in the energy cost calculations by setting all the input energy adjustment factors to zero.

II.6 ENERGY COST:

The energy cost subroutine, ECOST, utilizes the energy generation calculations and input cost data to determine annual and cumulative generation costs. The cost data required for each unit are:

1. Capital cost in \$/kw
2. Fuel cost in ¢/MBtu
3. Operation and maintenance cost in mills/kwh
4. Operation and maintenance cost (in addition to that above) in \$/kw-yr
5. For each block of capacity in the unit, the expected heat rate for the mode of operation in thousands of Btu/kwh
6. Intertie demand cost in \$/kw-day
7. Intertie-energy-use cost in mills/kwh

The calculated capacity requirement to meet the reliability criterion can be included in the annual and cumulative generation cost by providing values for each of the first five cost factors listed above and the expected capacity factor for the additional capacity requirement. If it is desired not to include the calculated additional capacity in the costs, the capital cost, the operation and maintenance cost, and the capacity factor must all be input at 0.0. If the capacity requirement is met by purchases from other utilities, the input numbers should be set to properly reflect these costs.

An annual capital-charge rate must also be input to allow calculation of annual generation costs. This capital-charge rate includes factors such as a weighted-average cost of money, depreciation, federal income tax, state and local taxes, interim replacements, and property insurance. Typically, it is on the order of 15% per year.

The costs of generating power for each block of capacity, as well as for the units, are calculated and displayed. For the blocks, the fuel costs in mills/kwh are calculated based on an average heat rate for the block. The incremental portion of the O&M costs is added to the fuel cost for each block to produce a block running cost; however, only the fuel cost varies from block to block. In addition to the running costs for each block and the total cost for the unit, the code also calculates the total yearly cost for the system.

A present value estimate is also made through the use of an input discount factor. The discounting of costs is performed by referencing the costs to the first day of the first year; an assumption is made that the costs occur midyear. This present-value approach is especially useful when studying multiyear expansion plans. The present value of the power costs for the plan is given at the end of the last year.

For SYSREL runs of more than one year, a routine to calculate average generation costs has been incorporated in the program. The calculation proceeds as follows: where M represents the annual expenses of generation in mills, E is the annual generation in kwh, i is the year (i=1 is the first year), N is the total number of years in the calculation, and G is the average generation cost in mills/kwh.

$$G \equiv \frac{\sum_{i=1}^N M_i / (1.07)^i}{\sum_{i=1}^N E_i / (1.07)^i} .$$

Thus, this average generation cost is helpful to show the average mills/kwh variation over the expansion period.

Subroutine ECOST is called each time the calculations for the 26th biweekly period have been completed.

ACKNOWLEDGMENTS

The authors are grateful to the many contributors who, because of the long code-development time and variation in their input, are most appropriately thanked anonymously; notwithstanding, we wish to single out the fine pioneer work of H. A. Adler in this field and also wish to thank him for his direct aid and encouragement in the code development.

REFERENCES

1. Stephenson, E., ANL internal study of June 1970 on reliability and LMFBRs.
2. Adler, H. A., "Principles and Methods of Calculation of Probability of Loss of Generating Capacity," IEEE Trans. on Power Apparatus and Systems PAS-86(12):1467-1479 (Dec 1967).
3. Halperin, H., and H. A. Adler, "Determination of Reserve-generating Capability," Trans. AIEE, 77, Part III:530-544 (Aug 1958).
4. Booth, R. R., "Power System Simulation Model Based on Probability Analysis," Proc. of IEEE PICA Conf., pp 62 69 (May 24 26, 1971).
5. Booth, R. R., "Optimal Generating Planning Considering Uncertainty," Proc. of IEEE PICA Conf., pp 70-77 (May 24-26, 1971).

III. APPENDIXES

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

APPENDIX A - CODE DESCRIPTION

The program SYSREL consists of a driver and 5 subroutines that are linked by 10 labeled common blocks of S2-S11. The common blocks show the size limitations placed on the calculations; the user can increase the dimensions of the appropriate variable in common if studies of larger systems are desired. The system can include 10 subsystems (groups) and is limited to 120 plants. The first subsystem may have 100 plants; the rest are limited to 70. The year consists of 26 calculation periods -- thus each is 2 weeks long; at most, 4 periods may be used for scheduled maintenance for an individual plant. The calculations may proceed for 15 years.

MAIN. The driver of SYSREL contains data in the form of base-ten logarithms for the first 101 factorials (FACT), ratios of standard deviation to mean for the periods' demands (SOM), and the normal Gaussian distribution of the 21 daily loads in a month (VAL). From the meshed subsystem data, 15,000 forced-outage states can be saved.

The results of the meshing of the last group in the system with all previous groups are not saved in memory, because they do not need to be called for subsequent calculations. The driver first reads input for various calculation parameters and then the description of the power system itself. A call to the DISPLY routine will output the system characteristics and maintenance schedule.

The rest of the program is in the form of a loop for each year and each period within the year that calculates the forced outage probabilities and the failure frequency contributed by that period. Each year energy-inertie power commitments are read, and at the beginning of each period as many updates to the system characteristics as desired can be input to modify the system.

An optional call may be made to the energy and costs routines each period and year, respectively. The probability, capacity, and duration of an n-fold outage are calculated each period for each subsystem for n from zero to either the number of generating units operational or the limit to be considered down as specified in the input. These probabilities are then meshed as previously mentioned.

Since 10 subsystems of 9 generating units in each subsystem could require 10^{10} or 10 billion states to be saved, some method of reducing the number of states saved was necessary. Several methods have been incorporated into the code.

First is the input variable CRITER. When more than 100 states have been examined, all states with a probability of less than CRITER times the average probability will be ignored; the average probability is just one divided by the total number of possible states. A value of 0.001 (10^{-3}) or smaller for CRITER has been found to result in negligible error. It has been noted that the percentage of states saved grows linearly with the negative logarithm of CRITER (see Appendix E).

Another method is input along with the plant characteristics. NLIM specifies how many generating units should be considered as the maximum number forced out at any one time. The smaller NLIM is, the fewer the states that are examined. Care should be taken when reducing NLIM below NPL, as large errors can be introduced into the calculations by ignoring states with a high probability of occurrence. The equation

$$P = \binom{NPL}{NLIM} PDIM^{NLIM} (1-PDIM)^{(NPL-NLIM)}$$

gives the probability P that NLIM of NPL units with a forced-outage rate of PDIM will be down at one time. If P is significant for a given NLIM, it should be included in the calculations. For a group containing a small number of units, all the states should be examined, especially if the size (Mw) of the unit is large. For large NPL (≥ 10), a guide is $PDIM \times NPL$, which is the expected value of the number of units forced out.

An example of the reduction of number of states saved is summarized in Table A-1, where only 1/10 of 1% of the total possible states needed to be saved in memory.

The program utilized two other space-saving methods. The states will be aggregated in 10-Mw increments and placed in a table after 3000 states have been accumulated. If more than 15,000 states have occurred during a single meshing, CRITER will temporarily be tripled and the meshing will be restarted.

A.3

When this occurs a warning message will be given. If the routine fails yet to find room to store the probability states, a termination message is written dumping several program parameters.

Table A-1. Reduction of Calculations Using NLIM and CRITER

Group No.	F.O. Rate	No. of Units	(NLIM) Max. No. Out at One Time	
1	0.1	3	3	
2	0.1	3	3	
3	0.1	1	1	
4	0.1	1	1	
5	0.1	4	4	
6	0.15	1	1	
7	0.15	10	5	
8	0.2	31	15	
9	0.05	58	11	

After Meshing Group	Total Possible States	Total States Using Maximum Number Out at One Time	Total States Calculated	Total States Saved
2	16	16	16	16
3	32	32	32	32
4	64	64	64	64
5	320	320	320	129
6	640	640	258	227
7	7,040	3,840	1,362	1,184
8	225,280	61,440	18,944	14,574
9	13,291,520	737,280	227,328	-

At the end of each year the sum of the periodic failure frequencies is the annual failure frequency, and its inverse is the mean time between failures. The estimate of the required reserve can be made from the empirical relationship within the code. The constant BB in the equation can be determined by runs that either change the demand or increase the system capacity each year.

BLOCK DATA. The fraction of annual peak load that occurs as peak load each period is contained in the block data and should be changed for each system under investigation. The data in the program was derived from information for a medium-sized utility. These data are modified for any energy-intertie commitments that are input each year.

MAIN

MAIN (Contd.)

MAIN (Contd.)

MAIN (Contd.)

MAIN (Contd.)

MAIN (Contd.)

MAIN (Contd.)

SUBROUTINE DISPLY

Purpose:

Any time that maintenance is required to be scheduled either at the start of the run or when major changes have occurred to the makeup of the power system, the subroutine DISPLY is called. It will first output a description of the system according to the input variable KP, the print indicator, and then link the entire system to the maintenance scheduler.

Input:

KP	-	Print indicator
NSYS	-	Number of subsystems in initial data set
PDIM	-	Forced outage rate
TAUDIM	-	Average repair time
XMDIM	-	Average capacity
NPL	-	Number of plants in subsystem
NLIM	-	Maximum number of plants to be considered out at one time
PLTID	-	Plant identification name
CAPCOS	-	Capital cost of each plant
OPE	-	O&M cost of each plant
FUEL	-	Fuel cost of each plant
NPARTS	-	Number of blocks per plant
LOA	-	Loading order of each block
HEAT	-	Heat rate of each block
YMWRA	-	Generating capacity of each block

Output:

K	-	Biweekly period number
NUP	-	Total number of plants that are scheduled to be up
NDOWN	-	Total number of plants that are scheduled to be down
SCHED	-	Total capacity associated with scheduled downtime
XLEV	-	Sum of the expected peak load and the capacity associated with scheduled downtime

Subprograms
Called:

MAINT

SUBROUTINE DISPLY

SUBROUTINE DISPLY (Contd.)

SUBROUTINE ECOST

Purpose:

Subroutine ECOST will utilize the energy generation calculations and input cost data to determine annual and cumulative generation costs.

Input:

OPE	-	O&M cost in mills/kw-hr
DPKWY	-	O&M cost in \$/kw-yr
FUEL	-	Fuel cost in ¢/MBtu
CAPCUS	-	Capital cost in \$/kw
PLTID	-	Plant identification name
YMWRA	-	Capacity of each block
HEAT	-	Plant heat rate
ENERGY	-	Energy generated by each block
RESREQ	-	Real reserve estimate
IYR	-	Year index
HRS	-	Number of hours per day that intertie power is available
F		Reserve fuel cost
HR	-	Reserve heat rate
O	-	Reserve O&M cost
OH	-	Reserve capital cost in mills/kw-hr
C	-	Reserve capital cost in \$/kw
RESCF	-	Reserve capacity factor
CHGRT	-	Levelized charge rate on all capital
FIRMCC	-	Levelized capital cost of power purchases
FIRMEC	-	Levelized energy cost of power purchases
DISC	-	Discount factor to present value energy costs

Output:

Cost Data	-	Reserve cost input information and individual unit costs
Summary	-	Total costs:
		Fuel
		Operation and Maintenance
		Capital
		Reserve energy estimate
		Power purchases
		Weighted average cost

Energy - Total energy generated by the system
Present - Present value of total energy cost
Value

Procedure:

This subroutine is called at the end of the calculations for each year. The characteristics for the reserve requirement are read first. If the user desires the reserve requirement to be excluded from the system costs, all he needs to do is input RESCF=0., O=0., OH=0., and C=0.0.

The calculation is simple since it uses just the input costs and calculated energy from each unit (or block). Only the fuel cost can vary for the units with more than one block; the operation and maintenance and capital costs are calculated for the whole unit at the same time. The system and energy costs are present valued, with an annual discount factor of 7% to the first year of calculation.

Subprograms
Called:

None.

SUBROUTINE ECOST

SUBROUTINE ECOST (Contd.)

SUBROUTINE ECOST (contd.)

SUBROUTINE ENCALC

Purpose:

This subroutine computes the amount of energy generated by each plant that is scheduled to be in operation during the biweekly period IX.

Input:

KP - Print indicator
 APK - Megawatts of initial annual peak load
 XMF - Fraction of the annual peak used as a biweekly peak load
 FPM - Fraction of the annual peak that is the minimal demand during the year
 STE - Number of steps to be used in energy calculation
 IX - Biweekly period number
 TIETO - Expected intertie capacity
 RMA - Fraction of the biweekly load below which the intertie power should be distributed
 HRS - Number of hours per day for which intertie power is available
 FIRM - Megawatts of power that will be bought or sold through interties
 TIE - Additional capacity that is needed through interties in order to meet the RMA specification
 CFC - Energy adjustment factor
 CFD - Energy adjustment factor
 CFE - Energy adjustment factor
 CFF - Energy adjustment factor
 ISTAT - Schedule of up units
 NPARTS - Number of blocks of capacity
 LOA - Loading order of blocks
 YMWRA - Megawatts of capacity of each block
 FOR - Forced-outage rate

Output:

IX - Biweekly period number
 SUMF - Amount of energy demanded
 SUME - Amount of energy generated
 FIRM - As stated above

TIE	- As stated above
TIETO	- As stated above
RMA	- As stated above
HRS	- As stated above
LOAD	- Loading order of each block
NPLA	- Plant identification number
PLTID	- Plant identification name
YMW	- Capacity of each block
S	- Cumulative sum of block capacities
EN	- Block capacity resulting from demand adjustment
CC	- Fraction of the block capacity associated with demand adjustment
ENERGY	- Total energy generated by the block
C	- Fraction of the block capacity that was used to generate ENERGY
ENETOT	- Cumulative sum of biweekly energy demanded
SUMG	- Cumulative sum of biweekly energy generated
SUMTOT	- Sum of energy generated plus energy purchased

Procedure:

This subroutine (ENCALC) calculates the energy allocation to each block of capacity for each biweekly period. The Baleriaux-Jamouille method is used for energy allocation, although some adjustment factor can be used to simulate more realistic operation. The probability of load curve is stored in PM. $PM(i)$ is the probability that the load will be between $(i-1)/50$ and $i/50$ of the peak period. This load curve is fitted to each period so that the peak is the periodic peak and the minimum possible load is FPM times the annual peak. If FPM is not specified the default value is 0.30. The data in this array should be adjusted to that of the power generating system to be studied.

The outage curve for the system is computed next according to the step-size used. It is done by building the outage table by the loading order of the blocks. The equivalent curve is just the convolution of the load and outage curves. Both energy demanded and generated are calculated. The latter is found for each block, plant, and the entire system by periods and years. The energy allocation is adjusted according to the factors CFC, CFD, CFE, CFF, and capacity factors are computed. For further information, see Section II.5 of this report.

Subprograms Called:

None.

SUBROUTINE ENCALC

SUBROUTINE ENCALC (Contd.)

SUBROUTINE MAINT

Purpose:

To allot the annual scheduled maintenance of 2, 4, 6, or 8 weeks so that unit downtime will occur during the biweekly period when the system least needs the generating plant in order to meet the expected load.

Input:

JSUB - Subsystem identification number

IW - Maintenance schedule class number:

- 1 = 8 weeks
- 2 = 6 weeks
- 3 = 4 weeks
- 4 = 2 weeks

I1 - Total number of plants in class IW

NUMPL - Plant number of the plant to be scheduled down

NPER - Number of biweekly periods included in this study (26 periods = 1 year)

XLEV - Expected biweekly peak load of the system

XMDIM - Average capacity of generating plant

ISS - Plant subsystem assignment number

Output:

NUMPL - Plant number of plant being scheduled down

ISTAT - Flag that indicates that a plant is scheduled to be up (1) or down (-1) for a particular biweekly period

XLEV - The expected biweekly peak load of the system plus average capacity of the scheduled outage

NDOWN - Total number of plants in subsystem JSUB that have been scheduled down during a particular biweekly period

NUP - Total number of plants in subsystem JSUB that are operative during a particular biweekly period

SCHED - Total amount of energy that has been scheduled down during a particular biweekly period

Procedure:

The algorithm examines the current load plus scheduled outage curve and finds the string of periods with the minimal peak load that can be used to schedule downtime. For further details, see Section II.2.

Subprograms

Called:

None.

SUBROUTINE MAINT

SUBROUTINE MAINT (Contd.)

SUBROUTINE MAINT (Contd.)

SUBROUTINE UPDATE

Purpose:

Whenever some modification to the power system is indicated by a non-blank update card, subroutine UPDATE will perform the appropriate change assignments.

Input:

- LY - Year number in which change is to occur
- LP - Period number in which change is to occur
- LSS - Subsystem identification number to which change should apply
- LPLT - Plant number to which change should apply
- IV - Type of update (Numbered from 1 through 10 as described below in Output)
- CH - Change parameters are defined according
- III - to each of 10 update types. See
- IC - Table B-1, UPDATE CARDS, for their
- JC - associated definition.

Output:

- IV = 1 - New annual peak demand
- 2 - Total system capacity
- 3 - Subsystem number and new forced outage rate
- 4 - Plant/subsystem number and new fuel cost
- 5 - Plant number of retired plant and new system capacity
- 6 - Total number of subsystems, plants, and loading position of new block of capacity
- 7 - Subsystem number and its new repair time
- 8 - New plant costs
- 9 - Exchanged loading order of two blocks
- 10 - New load order for one block

Procedure:

Modifications to the power system can be introduced in any period of any year and the subroutine UPDATE makes the appropriate changes as specified on an update card. Modifications to the power system can be introduced by the input UPDATE CARDS.

The peak demand is altered by supplying the ratio of current to original demand. Update type IV is input as 1 in that case. IV=2 will add a single plant to one of the existing subsystems. This new plant can be inserted at any position in the loading order. IV=9 will allow any two existing plants to have their loading orders exchanged, while IV=10 will allow any one plant to be repositioned such that all plants thereafter are displaced by 1 in the loading order. The forced outage rate of a subsystem is changed when IV=3. Plant fuel costs are altered for either a subsystem (IV=4), or a single plant (IV=8). Plants will be retired one at a time and new subsystems will be added to the system when IV is set to 5 and 6, respectively. A new system contains only one plant at its input, but this may be increased by plant additions. Since subsystem additions are often large plants, any new subsystem becomes group 1 and the other group members are incremented by one. Repair time of a group is changed whenever IV=7.

Subprograms
Called:

DISPLY

SUBROUTINE UPDATE

SUBROUTINE UPDATE (Contd.)

SUBROUTINE UPDATE (Contd.)

SUBROUTINE UPDATE (Contd.)

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

APPENDIX B - INPUT

DATA-DECK STRUCTURE

The first two cards in the data deck (see Table B-1) are the program parameter input cards. They are followed by the subsystem characteristics input, which is grouped by subsystem. For each subsystem there is a card #1 followed by a card #2. The data for the plants within the subsystem are next. For each plant there is a card #3 followed by a card #4. If a blank card is inserted in place of cards #3 and #4, all the remaining plants in the subsystem will assume characteristics identical to the past plant previously described for that subsystem, with position in the loading order immediately following the blocks of that plant. This last option was included to avoid having to punch redundant data for similar plants. Data for subsequent subsystems follow the plant descriptions of the first group.

The rest of the data is grouped by year. The energy-intertie input cards are first and are followed by the update cards for the year in chronological order if there are any. Each year's update data is completed by a blank card and, if energy and cost calculations are performed, a reserve cost data card.

Figures B-1 through B-5 indicate the position on the cards for the input.

A summary of the deck structure is found in Fig. B-6.

Table B-1. Input Description

	(I)	refers to Integer format
	(F)	refers to floating decimal format
		Position on card is indicated in Figs. B-1 to B-5
<hr/>		
<u>PROGRAM PARAMETERS INPUT (see Fig. B-1)</u>		
<u>First Card</u>		
KP	(I)	Print indicator =0, all output listed =1, omit periodic subtotals =2, same as 1 and omit plant descriptions
CRITER	(F)	All states with a probability of less than CRITER/ total number of states will be dropped from memory.
STE	(F)	Number of steps to be used in energy calculations. If =0, energy and cost calculations are omitted; also omit reserve cost input card.
T1	(F)	Reliability criterion for mean time between failures in years; default =5.0.
BB	(F)	Reserve margin constant; default =7.0.
CFC	(F)	These last four variables are energy adjustment fac- tors used to simulate realistic loading. CFC is the fraction of the system capacity starting from the top, which has CFD subtracted from its load factor. This energy is then divided among the units at the bottom of the loading order, which is equivalent to 2 times CFC. CFE is the fraction of system capacity starting from the top, which has CFF subtracted from its load factor. This energy is divided among the same fractions of the system capacity that follow CFE.
CFD	(F)	
CFE	(F)	
CFF	(F)	
<u>Second Card</u>		
NYR	(I)	Number of years to be run
NSYS	(I)	Number of subsystems in initial data set
ANNPK	(F)	Megawatts of initial annual peak load
FPM	(F)	Fraction of annual peak that is the minimal demand during the year. Default is 0.30. Increasing the value will increase the amount of energy generated.
ADJFE	(F)	Adjustment factor for the equivalent fraction of day that is exposed to the peak.

Table B-1. (Contd.)

SUBSYSTEM CHARACTERISTICS INPUT (see Fig. B-2)

Card #1 (One per subsystem)

PDIM	(F)	Forced-outage rate
TAUDIM	(F)	Time to repair (hr)
XMDIM	(F)	Plant capacity (Mw)
FXDIM	(F)	(1.-FXDIM) is fraction of capacity average outage magnitude; this accounts for partial outage if desired
NPL	(I)	Number of plants in subsystem
NLIM	(I)	Maximum number of plants to be considered out at one time in this subsystem

Card #2 (One per subsystem)

NKR ₁	(I)	Number of plants on 2-week maintenance
NKR ₂	(I)	Number of plants on 4-week maintenance
NKR ₃	(I)	Number of plants on 6-week maintenance
NKR ₄	(I)	Number of plants on 8-week maintenance

Card #3 (One for each plant in subsystem, unless identical plant option is signaled by a blank card)

NPARTS	(I)	Number of blocks in plant
CAPCOS	(F)	Capital cost in \$/kw
OPE	(F)	O&M cost in mills/kw-hr
FUEL	(F)	Fuel cost in ¢/MBtu
DPKWY	(F)	O&M cost in \$/kw-hr
PLTID	(A)	Identification of the generating unit

Card #4 (One for each plant in subsystem, unless identical plant option is signaled by a blank card)

YMWRA	(F)	Capacity of block in Mw
-------	-----	-------------------------

Table B-1. (Contd.)

LOA	(I)	Loading order of block
-----	-----	------------------------

HH	(F)	Heat rate in KBtu/kw-hr
----	-----	-------------------------

(Note: The three variables above are repeated across the card for each block in the plant.)

ENERGY INTERTIE INPUT (see Fig. B-3)

First Card (Once per year)

FIRMi (i=1, ..., 13)	(F)	Mw of power that will be bought (positive value) or sold (negative value) during period i through interties to other power systems
-------------------------	-----	--

Second Card (Once per year)

FIRMi (i=14, ..., 26)	(F)	As above
--------------------------	-----	----------

Third Card (Once per year)

HRS	(F)	Hours per day that power will be available through interties
-----	-----	--

TIEIO	(F)	Expected average tie capacity for emergencies
-------	-----	---

RMA	(F)	Test reserve margin factor for distributing tie capacity to periods (RMA =0.5)
-----	-----	--

UPDATE CARDS (see Fig. B-4)

(Note that a blank card signals the end of the update information for each year.)

One card per system change

LY	(I)	Year in which change is to occur
----	-----	----------------------------------

LP	(I)	Period in which change is to occur
----	-----	------------------------------------

- to change demand -

IV	(I)	=1
----	-----	----

CH	(F)	Factor by which base year peak demand is multiplied
----	-----	---

Table B-1. (Contd.)

- to add a plant -

LSS	(I)	Subsystem number getting new plant
LPLT	(I)	Plant number with similar characteristics
IV	(I)	=2
CH	(F)	If > 0, system maintenance will be rescheduled
IC	(I)	Position in loading order
JC	(I)	Number of periods of maintenance
HH	(F)	Heat rate of plant (KBtu/kw-hr)

- to change forced outage rate of a subsystem -

LSS	(I)	Subsystem number
IV	(I)	=3
CH	(F)	New forced outage rate

- to change plant fuel cost -

LPLT	(I)	Plant number
IV	(I)	=4
CH	(F)	New fuel cost (¢/MBtu)

- to retire a plant -

LPLT	(I)	Plant number
IV	(I)	=5
CH	(F)	If > 0, system maintenance to be recalculated
JC	(I)	Number of periods of maintenance it had been scheduled

- to add a subsystem -

IV	(I)	=6*
CH	(F)	If > 0, system maintenance to be recalculated

Table B-1. (Contd.)

- to change repair time for a subsystem -

LSS	(I)	Subsystem number
IV	(I)	=7
CH	(F)	New repair time (hr)

- to change all plant costs for a single plant -

LPLT	(I)	Plant number
IV	(I)	=8

(Then input Card #3 of subsystem characteristics input)

- to exchange loading order positions -

LPLT	(I)	Plant number
LSS	(I)	Block number
IV	(I)	=9
IC	(I)	Other plant number
JC	(I)	Other block number

- to change loading order -

LPLT	(I)	Plant number
LSS	(I)	Block number
IV	(I)	=10
IC	(I)	New loading order for plant LPLT in block LSS

COST INPUT (see Fig. B-5)

One card per year (omitted when STE=0)

F	(F)	Reserve fuel cost in ¢/MBtu
HR	(F)	Reserve heat rate in KBtu/kw-hr
O	(F)	Reserve O&M cost in \$/kw-yr

Table B-1. (Contd.)

OH	(F)	Reserve capital cost in mills/kw-hr
C	(F)	Reserve capital cost in \$/kw
RESCF	(F)	Reserve capacity factor
CHGRT	(F)	Levelized charge rate on all capital
FIRMCC	(F)	Levelized capital cost of firm power purchases in \$/kw-day
FIRMEC	(F)	Levelized energy cost of firm power purchases in mills/kw-hr
DISC	(F)	Discount factor to present value energy costs to the beginning of the first year for investigations of generating unit expansion patterns

B.8

Fig. B-1. Program-parameters Input

YMWRA										LOA										HH										YMWRA										LOA										HH																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
-------	--	--	--	--	--	--	--	--	--	-----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--	--	-------	--	--	--	--	--	--	--	--	--	-----	--	--	--	--	--	--	--	--	--	----	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

F	HR	O	OH	C	RESCE	CHGRT	FIRMC	FIRMEQ	DISC
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
11111111	11111111	11111111	11111111	11111111	11111111	11111111	11111111	11111111	11111111
22222222	22222222	22222222	22222222	22222222	22222222	22222222	22222222	22222222	22222222
33333333	33333333	33333333	33333333	33333333	33333333	33333333	33333333	33333333	33333333
44444444	44444444	44444444	44444444	44444444	44444444	44444444	44444444	44444444	44444444
55555555	55555555	55555555	55555555	55555555	55555555	55555555	55555555	55555555	55555555
66666666	66666666	66666666	66666666	66666666	66666666	66666666	66666666	66666666	66666666
77777777	77777777	77777777	77777777	77777777	77777777	77777777	77777777	77777777	77777777
88888888	88888888	88888888	88888888	88888888	88888888	88888888	88888888	88888888	88888888
99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999	99999999

IBM [5081]

B.12

Fig. B-5. Cost Input

NOTE : A BLANK CARD COMPLETES THE UPDATE DATA FOR EACH YEAR.
THE RESERVE COST DATA CARD FOLLOWS THIS BLANK CARD
IF STE IS NOT SET TO 0.0.

Fig. B-6. Data-deck Structure

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

APPENDIX C - PROGRAM LISTING

```

COMMON/S2/FCR(120),YMW(120),APK,NPER,ISTAT(26,120),XMF(26),    NUM00000001
IPLA,IX,STE,CFC,CFD,CFE,CFF,KP    00000003
COMMON/S3/ENERG(120),ELOAD(360),FIRM(26),HRS,FPM    00000005
COMMON/S4/CAPCOS(120),OPE(120),DPKWY(120),FUEL(120),HEAT(360)    00000007
COMMON/S5/RESREQ(15),IYR    00000009
COMMON/S6/NPARTS(120),YMWRA(120,3),LOA(120,3),PLTID(120)    00000011
COMMON/S7/XLEV(26),NDOWN(26,10),NUP(26,10),SCHED(26),XMDIM(10),    00000013
.XA(4)    00000015
COMMON/S8/ANNPK,NPL(10),NLIM(10),PDIM(10),ISS(120),CAPAC    00000017
COMMON/S9/TAUDIM(10),FXDIM(10),NKR(10,4)    00000019
COMMON/S10/NSYS    00000021
COMMON/S11/TIE(26),TIET1,RMA    00000023
DIMENSION HH(3),VAL(21),FACT(101),SOM(26),FRQ(26),PRB(70),XMRB(70)    00000025
DIMENSION PRA(3000),XMRA(3000),TAURA(3000)    00000027
DIMENSION XMD(15000),PD(15000),TAUD(15000)    00000029
DIMENSION TAURB(70)    00000031
DATA FACT/0.,0.,.301,.778,1.380,2.079,2.857,3.702,4.606,5.56,6.56,00000033
17.601,8.68,9.794,10.94,12.117,13.321,14.551,15.806,17.085,18.386,100000035
29.708,21.051,22.412,23.793,25.191,26.606,28.037,29.484,30.947,32.40000037
324,33.915,35.420,36.939,38.470,40.014,41.571,43.139,44.719,46.31,400000039
47.912,49.524,51.148,52.781,54.425,56.078,57.741,59.513,61.094,62.70000041
584,64.483,66.191,67.907,69.631,71.363,73.104,74.852,76.608,78.371,00000043
680.142,81.920,83.706,85.498,87.297,89.103,90.916,92.736,94.562,96.00000045
7394,98.233,100.078,101.93,103.787,105.65,107.52,109.395,111.275,1100000047
83.162,115.054,116.952,118.855,120.763,122.677,124.596,126.52,128.40000049
95,130.384,132.324,134.268,136.218,138.172,140.131,142.055,144.063,00000051
1146.036,148.014,149.996,151.983,153.974,155.97,157.97/    00000053
DATA SOM/6*.04,5*.05,6*.08,4*.05,5*.04/    00000055
DATA VAL/1.98,1.465,1.179,.967,.792,.637,.497,.366,.241,.119,0.,-.00000057
1119,-.241,-.366,-.497,-.637,-.792,-.967,-1.179,-1.465,-1.980/    00000059
C    00000061
C    00000063
C    SYSTEM RELIABILITY CALCULATIONS    00000065
C    00000067
C    CALLS DISPLY    00000069
C    ECOST    00000071
C    ENCALC    00000073
C    UPDATE    00000075
C    00000077
C..... INPUT PROGRAM PARAMETERS .....    00000079
C    00000081
C    PRINT 1234    00000083
C    READ 1,KP,CRITER,STE,T1,BB,CFC,CFD,CFE,CFF    00000085
C    READ 2,NYR,NSYS,ANNPK,FPM,ADJFE    00000087
C    NPER = 26    00000089
C    XNPER=NPER    00000091
C    NUMPLA=0    00000093
C    APK=ANNPK    00000095
C    IF (BB.EQ.0.0) BB = 7.0    00000097
C    IF (T1.EQ.0.0) T1=5.    00000099
C    IF (STE.NE.0.0) STE=1.0/STE    00000101
C    WRITE(6,37) CRITER    00000103
C    WRITE(6,5) NYR,STE,CFC,CFD,CFE,CFF    00000105

```

WRITE(6,56)ADJFE,88	00000107
IF (FPM.EQ.0.0) GO TO 117	00000109
PRINT 116, FPM	00000111
117. CONTINUE	00000113
C..... INPUT PLANT CHARACTERISTICS	00000115
C	00000117
DO 301 JSUB = 1, NSYS	00000119
READ 13, PDIM(JSUB), TAUDIM(JSUB), XMDIM(JSUB), FXDIM(JSUB),	00000121
1 NPL(JSUB), NLIM(JSUB)	00000123
READ 14, (NKR(JSUB,J), J=1,4)	00000125
N=NPL(JSUB)	00000127
C GIVE CAP COST-\$/KWE-O&M-\$/KWE-YR AND M/KWH-FUEL-C/MBTU-HEAT RATE-THOU	00000129
C NOT IN THAT ORDER---DPKWY IS \$/KWE-YR FOR O&M COST.	00000131
DO 21 J=1,N	00000133
NUMPLA=NUMPLA+1	00000135
M=NUMPLA	00000137
READ(5,130) NPARTS(M), CAPCOS(M), OPE(M), FUEL(M), DPKWY(M), PLTID(M)	00000139
I=J	00000141
ISS(M)=JSUB	00000143
IF(CAPCOS(NUMPLA).LE.0.) GO TO 22	00000145
NN=NPARTS(NUMPLA)	00000147
READ(5,131) (YMWRA(NUMPLA,K), LOA(NUMPLA,K), HH(K), K=1, NN)	00000149
DO 132 I=1, NN	00000151
L=LOA(NUMPLA, I)	00000153
132 HEAT(L)=HH(I)	00000155
FOR(NUMPLA)=PDIM(JSUB)*(1.-FXDIM(JSUB))	00000157
21 YMWRA(NUMPLA)=XMDIM(JSUB)	00000159
GO TO 301	00000161
C..... COPY PLANT CHARACTERISTICS FROM PREVIOUS PLANT	00000163
22 CONTINUE	00000165
NPARTS(NUMPLA)=NPARTS(NUMPLA-1)	00000167
NUMPLA=NUMPLA-1	00000169
DO 23 J=1, N	00000171
NUMPLA=NUMPLA+1	00000173
NPARTS(NUMPLA)=NPARTS(NUMPLA-1)	00000175
CAPCOS(NUMPLA)=CAPCOS(NUMPLA-1)	00000177
OPE(NUMPLA)=OPE(NUMPLA-1)	00000179
FUEL(NUMPLA)=FUEL(NUMPLA-1)	00000181
DPKWY(NUMPLA)=DPKWY(NUMPLA-1)	00000183
FOR(NUMPLA)=PDIM(JSUB)*(1.-FXDIM(JSUB))	00000185
YMWRA(NUMPLA)=XMDIM(JSUB)	00000187
NN=NPARTS(NUMPLA)	00000189
ISS(NUMPLA)=JSUB	00000191
DO 134 JJ=1, NN	00000193
YMWRA(NUMPLA, JJ)=YMWRA(NUMPLA-1, JJ)	00000195
L=LOA(NUMPLA-1, JJ)+NN	00000197
LOA(NUMPLA, JJ)=L	00000199
134 HEAT(L)=HEAT(L-NN)	00000201
23 CONTINUE	00000203
301 CONTINUE	00000205
CAPAC=0.	00000207
DO 24 I=1, NSYS	00000209
24 CAPAC=CAPAC+XMDIM(I)*NPL(I)	00000211
PRINT 33, APK, CAPAC	00000213
WRITE(6,7) NSYS	00000215

```

DO 25 I=1,26                                00000217
25 TIE(I)=0.0                                00000219
3134 DO 850 IYR=1,NYR                        00000221
C.....READ FIRM ENERGY TIES.....00000223
      READ 6, FIRM                           00000225
      PRINT 3,IYR                            00000227
C.....READ NUMBER OF HOURS PER DAY FOR WHICH INTERTIE POWER IS AVAILABLE00000229
C.....AVERAGE ENERGY(PURCHASES OR SALES) EXPECTED THROUGH TIE, TIETO....00000231
C.....<<<TEST RESERVE MARGIN FOR THE SYSTEM, RMA;.....00000233
      READ 8,HRS,TIETO,RMA                   00000235
      TIETO=TIETO*26.                         00000237
      IF(TIETO) 26,26,28                     00000239
26 DO 27 I=1,26                              00000241
27 TIE(I)=0.0                                00000243
28 TIET1=TIETO                               00000245
C.....READ UPDATE INFORMATION .....00000247
      READ 403,LY,LPL,LSS,LPLT,IV,CH,IC,JC,HR 00000249
      AL=-1.0                                00000251
      IF(IV.EQ.1.AND.LP.EQ.1)AL=CH           00000253
      IF(AL.LT.0.) GO TO 439                 00000255
      APK=ANNPK*AL                           00000257
      WRITE(6,1235) LY,APK                   00000259
1235 FORMAT(' YEAR NO. ',I3,' ANNUAL PEAK LOAD ADJUSTED TO ',F10.2,' MW00000261
1')
      READ 403,LY,LPL,LSS,LPLT,IV,CH,IC,JC,HR 00000263
439 CONTINUE                                00000267
      CALL DISPLY                             00000269
      IF(TIETO.EQ.0.) GO TO 445              00000271
      SGTIE=0.                               00000273
      DO 440 I=1,26                          00000275
      LOAD=APK*XMF(I)                        00000277
      RM=(CAPAC-LOAD-SCHED(I)+FIRM(I))/LOAD  00000279
      TIE(I)=(RMA-RM)*LOAD                   00000281
      IF(RM.GT.RMA)TIE(I)=0.                 00000283
      SGTIE=SGTIE+TIE(I)                    00000285
440 CONTINUE                                00000287
      IF(SGTIE.EQ.0.) GO TO 445              00000289
      DO 441 I=1,26                          00000291
      TIE(I)=TIE(I)*TIETO/SGTIE              00000293
441 CONTINUE                                00000295
445 CONTINUE                                00000297
      ANNFR = 0.0                            00000299
      DO 800 IX=1,NPER                       00000301
      IFLAG=0                                00000303
402 IF(LY.NE.IYR.OR.LP.NE.IX)GO TO 401      00000305
      PRINT 404,IYR,IX                       00000307
404 FORMAT('OAT YEAR ',I2,' PERIOD ',I2)    00000309
      CALL UPDATE(LSS,LPLT,IV,CH,HR,IC,JC)  00000311
      READ 403,LY,LPL,LSS,LPLT,IV,CH,IC,JC,HR 00000313
      IFLAG=1                                00000315
      GO TO 402                              00000317
401 IF(KP.EQ.0)PRINT 39,IX                  00000319
C.....CALCULATE PERIODICAL FORCED OUTAGE PROBABILITIES ..00000321
C                                           00000323
      IF(TIETO.EQ.0.) GO TO 442              00000325

```

SGTIE=0.	00000327
DO 443 I=IX,26	00000329
LOAD=APK*XMF(I)	00000331
RM=(CAPAC-LOAD-SCHED(I)+FIRM(I))/LOAD	00000333
TIE(I)=(RMA-RM)*LOAD	00000335
IF(RM.GT.RMA) TIE(I)=0.	00000337
SGTIE=SGTIE+TIE(I)	00000339
443 CONTINUE	00000341
IF(SGTIE.EQ.0.) GO TO 442	00000343
DO 444 I=IX,26	00000345
444 TIE(I)=TIE(I)*TIEI0/SGTIE	00000347
TIEI0=TIEI0-TIE(I)	00000349
442 CONTINUE	00000351
SDFR = 0.0	00000353
IF(IX.EQ.1.OR.IFLAG.EQ.1)GO TO 1022	00000355
DO 400 I=1,NSYS	00000357
IF(NUP(IX,I)-NUP(IX-1,I))1022,400,1022	00000359
400 CONTINUE	00000361
GO TO 102	00000363
1022 JSUB = 0	00000365
NS=NSYS	00000367
1023 IF(NUP(IX,NS).GT.0)GO TO 121	00000369
NS=NS-1	00000371
GO TO 1023	00000373
121 JSUB = JSUB + 1	00000375
P = PDIM(JSUB)	00000377
TAU = TAUDIM(JSUB)	00000379
XM = XMDIM(JSUB)	00000381
FX = FXDIM(JSUB)	00000383
NI = NUP(IX,JSUB)	00000385
IF(NI.LE.0)GO TO 121	00000387
TAU = TAU/8760.	00000389
NIPO = NI + 1	00000391
NLIMPO=NLIM(JSUB)+1	00000393
NIPOUS=AMINO(NLIMPO,NIPO)	00000395
C	00000397
C	00000399
C	00000401
IF(NIPOUS.GT.100)GO TO 992	00000403
DO 10 I=1,NIPOUS	00000405
XI = I	00000407
R = XI - 1.0	00000409
XN = NI	00000411
C=10.**((FACT(NI+1)-FACT(I)-FACT(NI-I+2))	00000413
PRA(I) = C*(P**R)*((1.0 - P)**(XN-R))	00000415
TAURA(I)= TAU*(1.0 - P)/(R + P*(XN - 2.0*R))	00000417
XMRA(I) = R*XM*(1.0 - FX)	00000419
10 CONTINUE	00000421
KMAX=NIPOUS	00000423
KMAXT=NIPOUS	00000425
30 IF(JSUB - NSYS)31,998,998	00000427
31 JSUB = JSUB + 1	00000429
P = PDIM(JSUB)	00000431
TAU = TAUDIM(JSUB)	00000433
XM = XMDIM(JSUB)	00000435

	FX = FXDIM(JSUB)	00000437
	NJ = NUP(IX,JSUB)	00000439
	IF(NJ.LT.1) GO TO 30	00000441
	TAU = TAU/8760.	00000443
	NJPO = NJ + 1	00000445
	NLIMPO=NLIM(JSUB)+1	00000447
	NJPOUS=AMINO(NLIMPO,NJPO)	00000449
C		00000451
C	DEFINE B(J) VECTORS	00000453
	IF(NJPOUS.GT.70)GO TO 996	00000455
	DO 40 J=1,NJPOUS	00000457
	XJ = J	00000459
	R = XJ - 1.0	00000461
	XN = N.J	00000463
	C=10.**(FACT(NJ+1)-FACT(J)-FACT(NJ-J+2))	00000465
	PRD(J) = C*(P**R)*((1.0 - P)**(XN=R))	00000467
	TAURB(J) = TAU*(1.0 - P)/(R + P*(XN - 2.0*R))	00000469
	XMRB(J) = R*XM*(1.0 - FX)	00000471
40	CONTINUE	00000473
	KMAXT=KMAXT*NJPOUS	00000475
	CRIT=CRITER/KMAXT	00000477
	IF(KMAXT.LT.100)CRIT=0.	00000479
C		00000481
C	MESHING EQUATIONS MESH A(I) VECTORS AND B(J) VECTORS INTO	00000483
C	(K) VECTORS	00000485
C		00000487
	IF(JSUB.EQ.NS)GO TO 102	00000489
47	K=0	00000491
	DO 60 I = 1,KMAX	00000493
	DO 50 J=1,NJPOUS	00000495
	K = K+1	00000497
	IF(K.GT.15000)GO TO 45	00000499
	XMD(K) = XMRA(I) + XMRB(J)	00000501
	PD(K) = PRA(I)*PRB(J)	00000503
	TAUD(K) = (TAURA(I)*TAURB(J))/(TAURA(I) + TAURB(J))	00000505
	IF(PD(K).LT.CRIT)K=K-1	00000507
50	CONTINUE	00000509
60	CONTINUE	00000511
	J=NJPOUS*KMAX	00000513
	IF(KP.EQ.0)PRINT 19,KMAXT,J,K	00000515
	KMAX = K	00000517
C	TRANSFORM (K) VECTORS INTO A(I) VECTORS	00000519
	IF(JSUB.EQ.NS-1)GO TO 30	00000521
	IF(KMAX.GT.3000)GO TO 65	00000523
	DO 80 I = 1,KMAX	00000525
	PRA(I) = PD(I)	00000527
	XMRA(I) = XMD(I)	00000529
	TAURA(I) = TAUD(I)	00000531
80	CONTINUE	00000533
90	GO TO 30	00000535
45	CRIT=CRIT*3.0	00000537
	IF(CRIT.EQ.0.)GO TO 998	00000539
	IF(CRIT*KMAXT.GT.0.1)GO TO 998	00000541
	PRINT 46	00000543
	GO TO 47	00000545

65	DO 66 K=1,3000	00000547
	TAURA(K)=0.	00000549
66	PRA(K)=0.	00000551
	MCAP=0	00000553
	DO 67 K=1,KMAX	00000555
	ICAP=XMD(K)/10.	00000557
	IF(XMD(K)-ICAP*10.0.GE.5.)ICAP=ICAP+1	00000559
	ICAP=ICAP+1	00000561
	PRA(ICAP)=PRA(ICAP)+PD(K)	00000563
	TAURA(ICAP)=TAURA(ICAP)+PD(K)*TAUD(K)	00000565
	IF(ICAP.GT.MCAP)MCAP=ICAP	00000567
67	CONTINUE	00000569
	K=0	00000571
	DO 68 KK=1,MCAP	00000573
	IF(PRA(KK).LE.0.)GO TO 68	00000575
	K=K+1	00000577
	PRA(K)=PRA(KK)	00000579
	XMRA(K)=(KK-1)*10.	00000581
	TAURA(K)=TAURA(KK)/PRA(KK)	00000583
68	CONTINUE	00000585
	KMAX=K	00000587
	GO TO 30	00000589
102	CONTINUE	00000591
	XMPK=APK*XMF(IX)-FIRM(IX)	00000593
	XMEAN = XMPK/(1.0 + 1.98*SOM(IX))	00000595
	SIG = XMEAN * SOM(IX)	00000597
	OUTAG=CAPAC-XMEAN-SCHED(IX)+TIE(IX)	00000599
	DO 100 I=1,KMAX	00000601
	DO 100 J=1,NJPOUS	00000603
	XPD=PD(I)*PRB(J)	00000605
	XXMD=XMD(I) +XMRB(J)	00000607
	DO 101 KX=1,21	00000609
	OUTAGE=OUTAG -VAL(KX)*SIG	00000611
	IF(XXMD-OUTAGE) 100,103,103	00000613
103	XTAUD=TAUD(I)*TAURB(J)/(TAUD(I)+TAURB(J))	00000615
	SDFR=SDFR+XPD/XTAUD	00000617
101	CONTINUE	00000619
100	CONTINUE	00000621
	FRQ(IX)=ADJFE*SDFR/21.	00000623
	ANNFR=ANNFR+ADJFE*SDFR*(5./((147.*XNPER)))	00000625
	IF(ANNFR.EQ.0.0)GO TO 104	00000627
	TIME = 1.0/ANNFR	00000629
	GO TO 105	00000631
104	TIME=0.	00000633
105	IF(KP.EQ.0)PRINT 41,KMAXT	00000635
	IF(KP.EQ.0)PRINT 4,FRQ(IX),ANNFR,TIME	00000637
	IF(STE.GT.0.0)CALL ENCALC	00000639
800	CONTINUE	00000641
	T2 = TIME	00000643
	SXLEV=0	00000645
	SFIRM=0	00000647
	STT=0.	00000649
	DO 115 LL=1,26	00000651
	STT=STT+TIE(LL)	00000653
	SFIRM=SFIRM+FIRM(LL)	00000655

```

115 SXLEV= SXLEV+XLEV(LL)                                00000657
    ADEQL=(SXLEV-SFIRM-STT)/26.                          00000659
    COMPO=CAPAC-ADEQL                                    00000661
    ZYX = EXP(ALOG(T1/T2)/BB) -1.0.                      00000663
    DELMEG=COMPO*ZYX*0.7                                  00000665
    IF(DELM EG) 802, 804, 804                             00000667
802 RESREQ(IYR) = 0.0                                     00000669
    GO TO 806                                              00000671
804 RESREQ(IYR) = DELMEG/.95                              00000673
806 CONTINUE                                              00000675
    IF(IYR - 1) 812, 812, 808                             00000677
808 IYRMO = IYR - 1                                       00000679
    IF(RESREQ(IYR) - RESREQ(IYRMO)) 810, 812, 812        00000681
810 RESREQ(IYR) = RESREQ(IYRMO)                          00000683
812 CONTINUE                                              00000685
    PRINT 106,ANNFR,TIME                                  00000687
    PRINT 1006,IYR,T1,RESREQ(IYR),DELM EG               00000689
    IF(STE.GT.0.0)CALL ECCST                             00000691
850 CONTINUE                                              00000693
1021 CONTINUE                                             00000695
    STOP                                                  00000697
C..... ERROR MESSAGES .....00000699
992 PRINT 993                                             00000701
    STOP                                                  00000703
996 PRINT 997                                             00000705
    STOP                                                  00000707
998 PRINT 999,IX,JSUB,NIPOUS,NJPOUS,KMAX,K.             00000709
    STOP                                                  00000711
C..... FORMATS .....00000713
1. FORMAT(I1,F9.0,7F10.0)                                00000715
2. FORMAT(2I5,3F10.0)                                    00000717
3. FORMAT('1***** YEAR NUMBER ',I2,' *****')         00000719
4. FORMAT(' FRQ(IX)',5X,E13.5,/' ANNFR',7X,E13.5,/' TIME',8X,E13.5) 00000721
5. FORMAT(' NUMBER OF YEARS IN THIS PROBLEM',I3,/' STEP SIZE FOR ENCR00000723
   1GY ALLOCATION AS FRACTION OF PFAK',F8.5,/' ADJUSTED ENERGY FACTORS00000725
   2',4F8.4)                                              00000727
6. FORMAT(13F6.0/13F6.0)                                  00000729
7. FORMAT(' THE NUMBER OF GROUPS OF UNITS IS',I4)         00000731
8. FORMAT(3F10.0)                                          00000733
13. FORMAT(4F12.0,2I12)                                    00000735
14. FORMAT (4I12)                                          00000737
19. FORMAT(' OUT OF',I8,' POSSIBILITIES',I8,' WERE EXAMINED AND',I8,' 00000739
   1WERE RETAINED')                                       00000741
33. FORMAT(/' ANNUAL PEAK',F14.1,' MWE',/' SYSTEM CAPACITY',F10.1,' MW00000743
   1E ')                                                  00000745
37. FORMAT(' ANY SITUATION WITH A PROBABILITY LESS THAN',F9.6,1X,'TIME00000747
   1S THE AVERAGE PROBABILITY FOR ALL SITUATIONS WILL BE DROPPED FROM 00000749
   2MEMORY')                                              00000751
39. FORMAT(/' BIWEEKLY PERIOD NUMBER ',I2)                00000753
41. FORMAT(' THERE WERE',I9,' OUTAGE COMBINATIONS IN THIS BIWEEKLY PER00000755
   2IOD')                                                 00000757
46. FORMAT(' WARNING: CRIT HAS BEEN TRIPLED TO SAVE SPACE') 00000759
106. FORMAT(1H0,'ANNUAL FAILURE FREQUENCY =' ,E13.5/      00000761
   . ' MEAN TIME BETWEEN FAILUES (IN YRS.) =' ,E13.5/)    00000763
116. FORMAT (' MINIMUM DEMAND IS ' , F7.3, ' OF PEAK DEMAND ') 00000765

```



```

130 FORMAT(11,F11.0,2F12.0,12X,F12.0,9X,A4) 00000767
131 FORMAT(4(F6.0,I6,F6.0)) 00000769
403 FORMAT(5I5,F5.0,2I5,F5.0) 00000771
993 FORMAT(' MORE THAN 100 PLANTS IN FIRST GROUP') 00000773
997 FORMAT(' MORE THAN 70 PLANTS IN ONE GROUP') 00000775
999 FORMAT(' OPROGRAM TERMINATION DUE TO ATTEMPT TO SAVE TOO MANY STATE 00000777
.S.'/' O E I T H E R   E N L A R G E   D I M E N S I O N S   O R   R A I S E   C R I T E R   O N   S U B S E Q U E N T   R U N S 00000779
.. ' / ' O I X = ' , I 5 , '   J S U B = ' , I 5 , '   N I P O U S = ' , I 5 , '   N J P O U S = ' , I 5 , '   K M A X = ' , I 5 , ' 00000781
.K = ' , I 5 ) 00000783
1006 FORMAT(' IN YEAR NO. ' , I 2 , '   T O   M E E T   O N C E   I N ' , F 5 . 1 , '   Y E A R S   C R I T E R I O N 00000785
.F O R   F A I L U R E ' / '   R E S E R V E   R E Q U I R E M E N T   I S   ' , F 6 . 0 , '   M W E ' , '   ( D E L M E G = ' , 00000787
.F 7 . 1 , ' ) ' / ) 00000789
1234 FORMAT(////////////////, 00000791
. ' ..... P O W E R   S Y S T E M   R E L I A B I L I T Y 00000793
.A N A L Y S I S ..... ' / / 10X , ' C A L C U L A T I N G . . . A N N U A L   F A I L U R E   F R E Q U E N 00000795
.C Y ' / T 2 5 , ' M E A N   T I M E   B E T W E E N   F A I L U R E S ' / T 2 5 , ' R E S E R V E   E N E R G Y   R E Q U I R E M E 00000797
.N T S ' / T 2 5 , ' G E N E R A T E D   E N E R G Y ' / T 2 5 , ' C A P A C I T Y   F A C T O R S ' / T 2 5 , ' C O S T S ' / / ) 00000799
56 FORMAT(' DAYPEAK ADJUSTMENT FACTOR' , F 6 . 3 , '   R E S E R V E   M W   C O N S T A N T 00000801
188 , F 6 . 3 ) 00000803
END 00000805

```

	SUBROUTINE DISPLY	00000807
	COMMON/S2/FOR(120),YMW(120),APK,NPER,ISTAT(26,120),XMF(26),	NUM00000809
	1PLA,IQ,STE,CFC,CFD,CFE,CFF,KP	00000811
	COMMON/S4/CAPCOS(120),OPE(120),DPKWY(120),FUEL(120),HEAT(360)	00000813
	COMMON/S6/NPARTS(120),YMWRA(120,3),LOA(120,3),PLTID(120)	00000815
	COMMON/S7/XLEV(26),NDCWN(26,10),NUP(26,10),SCHED(26),XMDIM(10),	00000817
	.XA(4)	00000819
	COMMON/S8/ANNPK,NPL(10),NLIM(10),PDIM(10),ISS(120),CAPAC	00000821
	COMMON/S9/TAUDIM(10),FXDIM(10),NKR(10,4)	00000823
	COMMON/S10/NSYS	00000825
C		00000827
C		00000829
C	P L A N T C H A R A C T E R I S T I C S D I S P L A Y	00000831
C		00000833
C		00000835
C	CALL BY MAIN	00000837
C	UPDATE	00000839
C		00000841
	WRITE(6,8)	00000843
	DO 6 J=1,NSYS	00000845
	WRITE(6,9) J,PDIM(J),TAUDIM(J),XMDIM(J),NPL(J),NLIM(J)	00000847
6	CONTINUE	00000849
	IF(KP.EQ.2)GO TO 352	00000851
	WRITE(6,16)	00000853
	DO 38 J=1,NUMPLA	00000855
	WRITE(6,17) J,PLTID(J),CAPCOS(J),OPE(J),DPKWY(J),FUEL(J),NPARTS(J)	00000857
	N=NPARTS(J)	00000859
	DO 38 I=1,N	00000861
	L=LOA(J,I)	00000863
	IF(I.EQ.1)PRINT 132,L,HEAT(L),YMWRA(J,I)	00000865
	IF(I.GT.1)PRINT 133,L,HEAT(L),YMWRA(J,I)	00000867
38	CONTINUE	00000869
	PRINT 35	00000871
	DO 351 I=1,NSYS	00000873
351	PRINT 34,I,(NKR(I,J),J=1,4)	00000875
352	DO 20 J=1,NUMPLA	00000877
	DO 20 I=1,NPER	00000879
	IF(ISS(J).GT.0)ISTAT(I,J)=1	00000881
20	CONTINUE	00000883
	DO 303 IX = 1,NPER	00000885
	XMPK = APK * XMF(IX)	00000887
	XLEV(IX) = XMPK	00000889
	SCHED(IX) = 0.0	00000891
	DO 302 JSUB = 1,NSYS	00000893
	NUP(IX,JSUB) = NPL(JSUB)	00000895
	NDOWN(IX,JSUB) = 0	00000897
302	CONTINUE	00000899
303	CONTINUE	00000901
	DO 399 JSUB=1,NSYS	00000903
	DO 396 I=1,NUMPLA	00000905
	IF(ISS(I).EQ.JSUB)GO TO 397	00000907
396	CONTINUE	00000909
397	NUMPL=I	00000911

```

DO 398 IW=1,4                                00000913
I1=NKR(JSUB,5-IW)                            00000915
IF(I1.EQ.0)GO TO 398                        00000917
CALL MAINT(JSUB,IW,I1,NUMPL)                 00000919
398 CONTINUE                                00000921
399 CONTINUE                                00000923
IF(KP.EQ.2)GO TO 3134                       00000925
PRINT 15,((I),I=1,9)                       00000927
PRINT 312                                    00000929
DO 3131 K=1,NPER                             00000931
PRINT 3132,K,(NUP(K,KK),NDOWN(K,KK),KK=1,NSYS) 00000933
3131 PRINT 3133,SCHED(K),XLEV(K)            00000935
3134 RETURN                                  00000937
8 FORMAT(// ' GROUP NO.',7X,'FO RATE',5X,'TIME TO REPAIR (HRS)',5X,'
1MWE PER UNIT',5X,'NO. OF UNITS'5X,'MAX NO OUT AT ONE TIME') 00000941
9 FORMAT(I10,F15.3,15X,F10.1,F17.1,10X,I7,20X,I7) 00000943
16 FORMAT(' PLANT NAME CAP COST',7X,'O&M',9X,'O&M',8X,'FUEL',3X,'
1BLOCKS',5X,'LOAD',3X,'HEAT RATE',6X,'MWE IN',16X,'$/KWE',7X,'M/KW
2H',4X,'$/KWE-YR',6X,'C/MBTU',19X,'THO BTU/KWH',6X,'BLOCK') 00000949
17 FORMAT(I5,2X,A5,F9.0,3F12.2,I9)          00000951
34 FORMAT(I9,4I12)                          00000953
35 FORMAT(// ' NUMBER OF WEEKS OF SCHEDULED OUTAGE BY GROUP AND BY TWO
1 WEEK CATEGORIES',/, ' GROUP NO',5X,'2 WEEKS',5X,'4 WEEKS',5X,'6 WEE
2KS',5X,'8 WEEKS')                          00000959
132 FORMAT(1H+,65X,I9,2F12.2)               00000961
133 FORMAT(66X,I9,2F12.2)                   00000963
312 FORMAT(' PERIOD ',9(' UP,DOWN'),4X,'SCHEDULED OUTAGE',4X,'SCHEDU
1LED OUTAGE'//)                             00000967
3132 FORMAT(5X,I2,2X,10(I4,I3,2X))          00000969
3133 FORMAT('+',89X,2F20.1)                 00000971
15 FORMAT(/// ' BIWEEKLY',9(' ---',I1,'---'),15X,'TOTAL',11X,'LOAD PL
1US')                                         00000975
END                                           00000977

```

	SUBROUTINE MAINT(JSUB,IW,I1,NUMPL)	00000979
	COMMON/S2/X(241),NPER,ISTAT(26,120),Y(26),NUMPLA,K,Z(5),KP	00000981
	COMMON/S7/XLEV(26),NDOWN(26,10),NUP(26,10),SCHED(26),XMDIM(10),	00000983
	XA(4)	00000985
	COMMON/S8/ANNPK,NPL(10),NLIM(10),PDIM(10),ISS(120),CAPAC	00000987
C		00000989
C		00000991
C	MAINTENANCE SCHEDULING ALGORITHM	00000993
C		00000995
C		00000997
C	CALL BY DISPLY	00000999
C	IW = NO. OF PERIODS OF MAINTENANCE	00001001
C	I1 = NO. OF PLANTS TO SCHEDULE	00001003
C	JSUB = GROUP NO.	00001005
C	NUMPL = PLANT NO. BEING SCHEDULED	00001007
C		00001009
	DO 435 J1=1,I1	00001011
432	DO 433 IX=1,NPER	00001013
	IXL=IX+4-IW	00001015
	JR=0	00001017
	XA(2)=0.	00001019
	XA(3)=0.	00001021
	XA(4)=0.	00001023
	DO 4521 J2=IX,IXL	00001025
	JR=JR+1	00001027
	J2R=J2	00001029
	IF(J2R.GT.NPER)J2R=J2R-NPER	00001031
4521	XA(JR)=XLEV(J2R)	00001033
	XIND=AMAX1(XA(1),XA(2),XA(3),XA(4))	00001035
C	FIND LOW POINT IN SCHEDULED OUTAGE PLUS LOAD CURVE	00001037
	IF(XIND.GE.XX.AND.IX.NE.1)GO TO 433	00001039
	II=IX	00001041
	XX=XIND	00001043
433	CONTINUE	00001045
	IIL=II+4-IW	00001047
	DO 4331 J3=II,IIL	00001049
	JR=J3	00001051
	IF(JR.GT.NPER)JR=JR-NPER	00001053
	ISTAT(JR,NUMPL)=-1	00001055
	XLEV(JR)=XLEV(JR)+XMDIM(JSUB)	00001057
	NDOWN(JR,JSUB)=NDOWN(JR,JSUB)+1	00001059
	NUP(JR,JSUB)=NUP(JR,JSUB)-1	00001061
4331	SCHED(JR)=SCHED(JR)+XMDIM(JSUB)	00001063
	NUMPL=NUMPL+1	00001065
	DO 434 I=NUMPL,NUMPLA	00001067
	IF(ISS(I).EQ.JSUB)GO TO 435	00001069
434	CONTINUE	00001071
435	NUMPL=I	00001073
	RETURN	00001075
	END	00001077

```

SUBROUTINE UPDATE(LSS,LPLT,IV,CH,HH,IC,JC)
COMMON/S2/FOR(120),YMWR(120),APK,NPER,ISTAT(26,120),XMF(26),
1PLA,IX,STE,CFC,CFD,CFE,CFF,KP
COMMON/S3/ENERG(120),ELOAD(360),FIRM(26),HRS,FPM
COMMON/S4/CAPCOS(120),OPE(120),DPKWY(120),FUEL(120),HEAT(360)
COMMON/S6/NPARTS(120),YMWRA(120,3),LOA(120,3),PLTID(120)
COMMON/S7/XLEV(26),NDOWN(26,10),NUP(26,10),SCHED(26),XMDIM(10),
.XA(4)
COMMON/S8/ANNPK,NPL(10),NLIM(10),PDIM(10),ISS(120),CAPAC
COMMON/S9/TAUDIM(10),FXDIM(10),NKR(10,4)
COMMON/S10/NSYS

```

00001079
NUM00001081

00001083

00001085

00001087

00001089

00001091

00001093

00001095

00001097

00001099

00001101

00001103

00001105

00001107

00001109

00001111

00001113

00001115

00001117

00001119

00001121

00001123

00001125

00001127

00001129

00001131

00001133

00001135

00001137

00001139

00001141

00001143

00001145

00001147

00001149

00001151

00001153

00001155

00001157

00001159

00001161

00001163

00001165

00001167

00001169

00001171

00001173

00001175

00001177

00001179

00001181

00001183

SYSTEM CHANGE ROUTINE

CALLED BY MAIN

LSS = GROUP NO.

LPLT = PLANT NO.

IV = TYPE OF CHANGE

CH,HH,IC,& JC ARE CHANGE PARAMETERS

GO TO (1,2,3,4,5,6,7,8,9,10),IV

..... CHANGE DEMAND

IV=1 INPUT(CH)

1 APK=ANNPK*CH

PRINT 100,APK

RETURN

..... ADD A PLANT

IV=2 INPUT(LSS,LPLT,CH,IC,JC,HH)

2 N=NUMPLA+1

NPARTS(N)=1

CAPCOS(N)=CAPCOS(LPLT)

OPE(N)=OPE(LPLT)

FUEL(N)=FUEL(LPLT)

DPKWY(N)=DPKWY(LPLT)

FOR(N)=FOR(LPLT)

YMWR(N)=YMWR(LPLT)

YMWRA(N,1)=YMWR(N)

ISS(N)=LSS

NKR(LSS,JC)=NKR(LSS,JC)+1

PRINT 200,LSS,IC

NPL(LSS)=NPL(LSS)+1

NLIM(LSS)=NLIM(LSS)+1

CAPAC=CAPAC+XMDIM(LSS)

DO 21 I=1,NPER

ISTAT(I,N)=1

DO 22 I=1,NUMPLA

NN=NPARTS(I)

DO 22 J=1,NN

IF(LOA(I,J).GE.IC)LOA(I,J)=LOA(I,J)+1

CONTINUE

IND=360+IC

	DO 23 I=IC,359	00001185
	ELOAD(IND-I)=ELOAD(IND-I-1)	00001187
23	HEAT(IND-I)=HEAT(IND-I-1)	00001189
	LOA(N,1)=IC	00001191
	ELOAD(IC)=0.0	00001193
	HEAT(IC)=HH	00001195
	NUMPLA=NUMPLA+1	00001197
	PRINT 201,CAPAC	00001199
	IF(CH.GT.0.)CALL DISPLY	00001201
	RETURN	00001203
C.....	CHANGE FORCED OUTAGE RATE	00001205
C	IV=3 INPUT(LSS,CH)	00001207
3	POIM(LSS)=CH	00001209
	DO 31 I=1,NUMPLA	00001211
	IF(ISS(I).EQ.LSS)FOR(I)=CH*(1.-FXDIM(LSS))	00001213
31	CONTINUE	00001215
	PRINT 300,LSS,CH	00001217
	RETURN	00001219
C.....	CHANGE FUEL COST	00001221
C	IV=4 INPUT(LSS OR LPLT,CH)	00001223
4	IF(LPLT.EQ.0)GO TO 41	00001225
	PRINT 400,LPLT,CH	00001227
	FUEL(LPLT)=CH	00001229
	RETURN	00001231
41	DO 42 I=1,NUMPLA	00001233
	IF(ISS(I).EQ.LSS)FUEL(I)=CH	00001235
42	CONTINUE	00001237
	PRINT 401,LSS,CH	00001239
	RETURN	00001241
C.....	RETIRE A PLANT	00001243
C	IV=5 INPUT(LPLT,CH,JC)	00001245
5	PRINT 500,LPLT	00001247
	CAPAC=CAPAC-YMWR(LPLT)	00001249
	LSS=ISS(LPLT)	00001251
	ISS(LPLT)=0	00001253
	NPL(LSS)=NPL(LSS)-1	00001255
	NLIM(LSS)=NLIM(LSS)-1	00001257
	YMWR(LPLT)=0.	00001259
	DO 51 I=1,26	00001261
51	ISTAT(I,LPLT)=-1	00001263
	NN=NPARTS(LPLT)	00001265
	DO 52 I=1,NN	00001267
52	YMWRA(LPLT,I)=0.0	00001269
	PRINT 201,CAPAC	00001271
	NKR(LSS,JC)=NKR(LSS,JC)-1	00001273
	IF(CH.GT.0.)CALL DISPLY	00001275
	RETURN	00001277
C.....	ADD A SUBSYSTEM	00001279
C	IV=6 INPUT(CH AND PLANT CHARACTERISTICS)	00001281
6	DO 60 I=1,NUMPLA	00001283
60	ISS(I)=ISS(I)+1	00001285
	J=NSYS+1	00001287
	DO 61 I=1,NSYS	00001289
	PDIM(J)=PDIM(J-1)	00001291
	TAUDIM(J)=TAUDIM(J-1)	00001293

	XMDIM(J)=XMDIM(J-1)	00001295
	FXDIM(J)=FXDIM(J-1)	00001297
	NPL(J)=NPL(J-1)	00001299
	NLIM(J)=NLIM(J-1)	00001301
	DO 62 K=1,4	00001303
62	NKR(J,K)=NKJ(J-1,K)	00001305
61	J=J-1	00001307
	NSYS=NSYS+1	00001309
	M=NUMPLA+1	00001311
	READ 600,PDIM(1),TAUDIM(1),XMDIM(1),FXDIM(1)	00001313
	NPL(1)=1	00001315
	NLIM(1)=1	00001317
	READ 601,(NKJ(1,J),J=1,4)	00001319
	ISS(M)=1	00001321
	READ 604,CAPCOS(M),OPE(M),FUEL(M),DPKWY(M)	00001323
	READ(5,602)YMWRA(M,1),IC,HH	00001325
	PRINT 603,NSYS,M,IC	00001327
	NPARTS(M)=1	00001329
	YMWRA(M)=XMDIM(1)	00001331
	CAPAC=CAPAC+XMDIM(1)	00001333
	FOR(M)=PDIM(1)*(1.-FXDIM(1))	00001335
	N=M	00001337
	GO TO 20	00001339
C.....	CHANGE GROUP REPAIR TIME	00001341
C	IV=7 INPUT(LSS,CH)	00001343
7	TAUDIM(LSS)=CH	00001345
	PRINT 700,LSS,CH	00001347
	RETURN	00001349
C.....	CHANGE PLANT COSTS	00001351
C	IV=8 INPUT(LPLT AND TYPE # 3 CARD)	00001353
8	READ 604,CAPCOS(LPLT),OPE(LPLT),FUEL(LPLT),DPKWY(LPLT)	00001355
	PRINT 701,LPLT,CAPCOS(LPLT),OPE(LPLT),FUEL(LPLT),DPKWY(LPLT)	00001357
	RETURN	00001359
C.....	EXCHANGE POSITIONS IN LOADING ORDER	00001361
C	IV=9 INPUT(LPLT,LSS,IC,JC)	00001363
9	K=LOA(LPLT,LSS)	00001365
	ENE=ELOAD(K)	00001367
	KK=LOA(IC,JC)	00001369
	HEA=HEAT(K)	00001371
	HEAT(K)=HEAT(KK)	00001373
	HEAT(KK)=HEA	00001375
	LOA(LPLT,LSS)=LOA(IC,JC)	00001377
	ELOAD(K)=ELOAD(KK)	00001379
	ELOAD(KK)=ENE	00001381
	LOA(IC,JC)=K	00001383
	PRINT 702,LPLT,LSS,LOA(LPLT,LSS),IC,JC,LOA(IC,JC)	00001385
	RETURN	00001387
C.....	CHANGE LOADING ORDER	00001389
C	IV=10 INPUT(LPLT,LSS,IC)	00001391
10	L=LOA(LPLT,LSS)	00001393
	HEA=HEAT(L)	00001395
	ELO=ELOAD(L)	00001397
	WRITE(6,1000)LPLT,LSS,L,IC	00001399
	IF(L.GT.IC)GO TO 70	00001401
	IF(L.EQ.IC) RETURN	00001403

L START=L+1	00001405
DO 71 I=LSTART, IC	00001407
DO 72 J=1, NUMPLA	00001409
NN=NPARTS(J)	00001411
DO 72 JJ=1, NN	00001413
IF(LOA(J, JJ).EQ.I) GO TO 74	00001415
72 CONTINUE	00001417
GO TO 71	00001419
74 LOA(J, JJ)=I-1	00001421
HEAT(I-1)=HEAT(I)	00001423
ELOAD(I-1)=ELOAD(I)	00001425
71 CONTINUE	00001427
LOA(LPLT, LSS)=IC	00001429
HEAT(IC)=HFA	00001431
ELOAD(IC)=ELO	00001433
RETURN	00001435
70 LFIN=L-1	00001437
DO 75 I=IC, LFIN	00001439
II=LFIN+IC-I	00001441
DO 76 J=1, NUMPLA	00001443
NN=NPARTS(J)	00001445
DO 76 JJ=1, NN	00001447
IF(LOA(J, JJ).EQ.II) GO TO 77	00001449
76 CONTINUE	00001451
GO TO 75	00001453
77 LOA(J, JJ)=II+1	00001455
HEAT(II+1)=HEAT(II)	00001457
ELOAD(II+1)=ELOAD(II)	00001459
75 CONTINUE	00001461
LOA(LPLT, LSS)=IC	00001463
HEAT(IC)=HFA	00001465
ELOAD(IC)=ELO	00001467
RETURN	00001469
1000 FORMAT(1X, 'CHANGE LOADING ORDER FOR PLANT NUMBER ',	00001471
1I3, ', BLOCK NUMBER ', I2, ', FROM ', I3, ' TO ', I3)	00001473
100 FORMAT('OANNUAL PEAK', F14.1, ' MWE')	00001475
200 FORMAT('OA NEW PLANT IS ADDED TO GROUP ', I2, ' AT LOADING ORDER ', I3,	00001477
3)	00001479
201 FORMAT(' SYSTEM CAPACITY', F10.1, ' MWE')	00001481
300 FORMAT('O THE FORCED OUTAGE RATE OF GROUP ', I2, ' IS NOW ', F6.4)	00001483
400 FORMAT('OFUEL COST OF PLANT ', I3, ' IS NOW ', F6.1, ' CENTS/MBTU')	00001485
401 FORMAT('OFUEL COST OF GROUP ', I3, ' IS NOW ', F6.1, ' CENTS/MBTU')	00001487
500 FORMAT('OPLANT ', I3, ' HAS BEEN RETIRED')	00001489
600 FORMAT(4F12.0)	00001491
601 FORMAT(4I12)	00001493
602 FORMAT(F6.0, I6, F6.0)	00001495
603 FORMAT('OGROUP ', I2, ' (PLANT ', I3, ') HAS BEEN ADDED TO SYSTEM AT LOADING ORDER ', I3, ' IT BECOMES GROUP 1')	00001499
604 FORMAT(3F12.0, I2X, F12.0)	00001501
700 FORMAT('OREPAIR TIME OF GROUP ', I2, ' IS NOW ', F6.0, ' HOURS')	00001503
701 FORMAT(1X, 'COST FOR PLANT', I3, 'CHANGED: CAP COST \$/KWE O&M M/KWE	00001505
1 FUEL C/MBTU O&M \$/KWE', /, 32X, 4F12.0)	00001507
702 FORMAT('OLOADING ORDER EXCHANGED. PLANT', I3, ', BLOCK', I2, ' IS NOW	00001509
1LOADED NO.', I3, /, I27, 'PLANT', I3, ', BLOCK', I2, ' IS NOW LOADED NO.',	00001511
2I3)	00001513
END	00001515


```

SUBROUTINE ECOST                                00001517
COMMON/S2/FOR(120),YMW(120),APK,NPER,I STAT(26,120),XMF(26), NUM00001519
1PLA,IX,STE,CFC,CFD,CFE,CFF                    00001521
COMMON /S3/ENERG(120),ELOAD(360),FIRM(26),HRS    00001523
COMMON/S4/CAPCOS(120),OPE(120),DPKWY(120),FUEL(120),HEAT(360) 00001525
COMMON/S5/RESREQ(15),IYR                        00001527
COMMON/S6/NPARTS(120),YMWRA(120,3),LOA(120,3),PLTID(120) 00001529
DIMENSION TOTCOS(15),TOTEN(15)                 00001531
PVALUE(A,JYR)=A/(1.07**(JYR))                 00001533
100 FORMAT(// ' TOTAL ENERGY (KWH)',T41,E12.6,    00001535
1/ ' WEIGHTED AVERAGE COST      (MILLS/KWH)',T39,  00001537
2F8.4,/)                                          00001539
101 FORMAT(12F6.3)                               00001541
102 FORMAT(// ' INPUT RESERVE INFO--FUEL(C/MBTU)--HEAT RATE(THOU BTU/KWH) 00001543
1)--O&M($/KWE-YR)--O&M(M/KWH)--CAPITAL($/KWE)--CAPACITY FACTOR--CHA00001545
2RGE RATE',/21X,F12.2,F25.3,F15.3,F12.2,F16.2,F17.4,F13.4) 00001547
103 FORMAT( ' INTERTIE CAPITAL COST = ',F7.2, ' $/KW-DAY   INTERTIE ENE00001549
.RGY COST = ',F7.2, ' MILLS/KWH')              00001551
104 FORMAT(//5X, ' INDIVIDUAL UNIT COSTS IN MILLS',    00001553
1' PER KWH',/1X, ' PLANT ORDER MWE BLKMW BLKFU ',    00001555
2' INCOP',4X, ' RUN',4X, ' FUEL',4X, ' O&M',4X, ' CAPITAL',2X, ' TOTAL', 00001557
3 ' NAME')                                           00001559
105 FORMAT(I5,F12.0,F34.2,3F8.2,3X,A4)             00001561
106 FORMAT(//5X, ' COST SUMMARY'/46X, ' DOLLARS',5X,  00001563
1' MILLS/KWH',/1' FUEL',T32,F21.2,F14.2/,          00001565
2' OPERATION AND MAINTENANCE',T32,F21.2,F14.2/,    00001567
3' CAPITAL',T32,F21.2,F14.2/,T32,21(1H-),5X,9(1H-)/, 00001569
415X, ' SUBTOTAL',T32,F21.2,F14.2)                 00001571
107 FORMAT(// ' RESERVE',T32,F21.2,F14.2/,T32,21(1H-),5X, 00001573
19(1H-)/,15X, ' SUBTOTAL',T32,F21.2,F14.2)         00001575
108 FORMAT(// ' FIRM PURCHASES ',T32,F21.2,F14.2/,  00001577
1T32,21(1H-),5X,9(1H-)/,15X, ' TOTAL',T32,F21.2,F14.2) 00001579
109 FORMAT(I10,F12.0,F8.2,2F7.2)                  00001581
C                                                    00001583
C                                                    00001585
C COST ANALYSIS ROUTINE                          00001587
C                                                    00001589
C CALLED BY MAIN                                00001591
C                                                    00001593
C READ 101,F,HR,O,OH,C,RESCF,CHGRT,FIRMCC,FIRMEC,DISC 00001595
C WRITE(6,102)F,HR,O,OH,C,RESCF,CHGRT             00001597
C PRINT 103,FIRMCC,FIRMEC                         00001599
C FUE=0.                                           00001601
C OP=0.                                             00001603
C CAP=0.                                           00001605
C ENE=0.                                           00001607
C DCOST=0.                                         00001609
C ECO=0.                                           00001611
C FIRME=0.                                         00001613
C FIRMC=0.                                         00001615
C WRITE(6,104)                                     00001617
C DO 203 JX=1,NPER                                00001619
C IF FIRM IS LESS THAN ZERO(SALES),THE ENERGY    00001621

```

C	IS SET TO ZERO FOR THAT PERIOD. THE COSTS WILL TURN	00001623
C	OUT NEGATIVE (CREDIT) AND SHOULD REFLECT THE	00001625
C	SELLING PRICE.	00001627
	IF(FIRM(JX).LE.0.0)GO TO 203	00001629
	FIRME=FIRME+FIRM(JX)*1.E4*HRS	00001631
203	FIRMC=FIRMC+10.*FIRM(JX)*(FIRMCC*1.E3+HRS*FIRMEC*1.E-3)	00001633
	DO 200 J=1,NUMPLA	00001635
	N=NPARTS(J)	00001637
	YMWET = 0.0	00001639
	FU=0.0	00001641
	DO 202 JJ=1,N	00001643
	YMWET = YMWET + YMWRA(J,JJ)	00001645
	L=LOA(J,JJ)	00001647
	BLKFU=HEAT(L)*FUEL(J)/100	00001649
	ROAM=OPE(J)	00001651
	RUN=BLKFU+OPE(J)	00001653
	WRITE(6,109)L,YMWRA(J,JJ),BLKFU,ROAM,RUN	00001655
	FU=FU+HEAT(L)*FUEL(J)*ELOAD(L)/100.	00001657
202	FUE=FUE+HEAT(L)*FUEL(J)*ELOAD(L)*1.0E-5	00001659
	FU=FU/ENERG(J)	00001661
	OPER=(OPE(J)*ENERG(J)+DPKWY(J)*YMWET*1.0E+6)/ENERG(J)	00001663
	CA=CHGRT*CAPCOS(J)*YMWET*1.0E+6/ENERG(J)	00001665
	TOTAL=FU+OPER+CA	00001667
	WRITE(6,105)J,YMWET,FU,OPER,CA,TOTAL,PLT ID(J)	00001669
	OP=OP+OPER*ENERG(J)/1000.	00001671
	CAP=CAP+CA*ENERG(J)/1000.	00001673
200	ENE=ENE+ENERG(J)	00001675
	FU=1000.*FUE/ENE	00001677
	OPER=1000.*OP/ENE	00001679
	CA=1000.*CAP/ENE	00001681
	TOTAL=FU+OPER+CA	00001683
	TOTCOS(IYR)=FUE+OP+CAP	00001685
	WRITE(6,106)FUE,FU,OP,OPER,CAP,CA,	00001687
	1TOTCOS(IYR),TOTAL	00001689
	RESE=RESREQ(IYR)*RESCF*8760.*1000.	00001691
	FU=F*HR/100.	00001693
	IF(RESE.LE.0.0)GO TO 210	00001695
	OPER=(OH*RESE+O*RESREQ(IYR)*1.0E+6)/RESE	00001697
	CA=CHGRT*C*RESREQ(IYR)*1.0E+6/RESE	00001699
	FUE=FUE+RESF*FU/1000.	00001701
	OP=OP+RESE*OPER/1000.	00001703
	CAP=CAP+RESE*CA/1000.	00001705
	TOTAL=FU+OPER+CA	00001707
	TOTCOS(IYR)=FUE+OP+CAP	00001709
	ENE=ENE+RESE	00001711
	STOT=RESE*(FU+OPER+CA)/1000.	00001713
	GO TO 211	00001715
210	STOT=0.0	00001717
	TOTAL=0.0	00001719
211	TTOT=TOTCOS(IYR)*1000./ENE	00001721
	WRITE(6,107)STOT,TOTAL,TOTCOS(IYR),TTOT	00001723
	IF(FIRME.LE.0.0)GO TO 212	00001725
	ENE=ENE+FIRME	00001727
	TOTAL=FIRMC*1000./FIRME	00001729
	GO TO 213	00001731

```

212 TOTAL=0.0                                00001733
    FIRMCO=0.                                00001735
213 TOTCOS(IYR)=TOTCOS(IYR)+FIRMCO.          00001737
    TTOT=TOTCOS(IYR)*1000./ENE               00001739
    TOTEN(IYR)=ENE                           00001741
    WRITE(6,108)FIRMCO,TOTAL,TOTCOS(IYR),TTOT 00001743
    IF(IYR.NE.1) GO TO 209                   00001745
    PVDOL=0.0                                00001747
    COMPUTE PRESENT VALUE OF TOTAL COST ***** 00001749
209 PVDOL=PVDOL+TOTCOS(IYR)*(1.+DISC/2.)/(1.+DISC)**IYR 00001751
    DO 201 J=1, IYR                          00001753
    DCOST=DCOST+PVALUE(TOTCOS(J),J)          00001755
201 ECO=ECO+PVALUE(TOTEN(J),J)              00001757
    PCOST=1000.*DCOST/ECO                    00001759
    WRITE(6,100)ENE,PCOST                    00001761
    WRITE(6,110) IYR,DISC,PVDOL             00001763
110 FORMAT(' YEAR ',I2,' DISCOUNT FACTOR= ',F4.2,/, ' PRESENT VALUE AT 00001765
    1BASE YEAR          ',F15.2)            00001767
    RETURN                                   00001769
    END                                     00001771

```

```

SUBROUTINE ENCALC                                00001773
C THIS SUBROUTINE CALCULATES ENERGY ALLOCATION FOR EACH BIWEEKLY PERIOD 00001775
C EACH UNIT                                     00001777
C NOTE THAT 1/STE MUST BE INTEGER TO AVOID PEAK SHIFTING 00001779
COMMON/S2/FOR(120),YMWR(120),APK,NPER,ISTAT(26,120),XMF(26), NUM00001781
1PLA,IX,STE,CFC,CFD,CFE,CFF,KP 00001783
COMMON/S3/ENERG(120),ELOAD(360),FIRM(26),HRS,FPM 00001785
COMMON/S6/NPARTS(120),YMWRA(120,3),LCA(120,3),PLTID(120) 00001787
COMMON/S11/TIE(26),TIETO,RMA 00001789
DIMENSION PLO(1000),PL(75),POU(1000),P(2000),SP(2000),PO(1000),FD(00001791
1360),YMW(360),PM(75),NPLA(120),EN(360),LOAD(360),ENERGY(360) 00001793
DATA PM/15*0.,.002,.007,.009,.011,.021,.050,.055,.055,.045,.045,.000001795
140,.037,.037,.031,.027,.028,.029,.029,.030,.032,.037,.048,.061,.0700001797
23,.061,.030,.020,.018,.008,.007,.007,.004,.003,.002,.001,25*0./ 00001799
90 FORMAT(I6,F10.1,2X,F10.1) 00001801
91 FORMAT(' FIRM ENERGY PURCHASES (OR SALES)',F10.1,' HOURS PER DAY F00001803
1OR 10 DAYS PER PERIOD'/' PERIOD MWE TIE') 00001805
92 FORMAT(' ..NONE...') 00001807
93 FORMAT('OENERGY ALLOCATION') 00001809
99 FORMAT(' SUMMED BIWEEK TIE CAPACITY',F7.0,' MWE, TEST MARGIN',F6.200001811
1) 00001813
108 FORMAT(' DURING THE',I3,1X,'BIWEEKLY PERIOD',E15.8,1X,'KWH WERE GE00001815
1NERATED AND',E15.8,1X,'KWH WERE DEMANDED') 00001817
110 FORMAT('OENERGY TOTALS'/' DEMANDED:',E12.6,' KWH GENERATED:', 00001819
1E12.6,' KWH GENERATED PLUS FIRM:',E12.6,' KWH') 00001821
111 FORMAT(2I6,2X,A4,2F9.0,E18.6,F14.8,E19.6,F14.8,) 00001823
112 FORMAT(' LOAD PLANT NAME',T23,'MWE',T30,'SUM MWE',T39, 00001825
1 'ADJUSTED ENERGY',T58,'ADJUSTED CF',T72, 00001827
2 'UNADJUSTED ENERGY UNADJUSTED CF') 00001829
114 FORMAT('// PLANTS WITH MORE THAN ONE BLOCK OF CAPACITY', 00001831
1//1X,'PLANT NAME',3X,'BLOCKS',4X,'MWE',5X, 00001833
2 'ADJUSTED ENERGY',4X,'ADJUSTED CF',3X, 00001835
3 'UNADJUSTED ENERGY UNADJUSTED CF') 00001837
115 FORMAT(I5,2X,A4,I5,F10.1,E20.6,F15.8,E20.6,F15.8) 00001839
C 00001841
C 00001843
C ENERGY CALCULATIONS 00001845
C 00001847
C CALLED BY MAIN 00001849
C 00001851
C 00001853
C THE UNADJUSTED&ADJUSTED CAPACITY FACTORS AND ENERGIES HAVE BEEN 00001855
C DECREASED (INCREASED) PROPORTIONATELY ACCORDING TO 00001857
C THE EXPECTED ENERGY GENERATION FOR EACH UNIT TO ACCOUNT FOR 00001859
C FIRM PURCHASES (SALES). IF FIRM PURCHASES OR SALES ARE 00001861
C RELATIVELY LARGE, A MORE DETAILED METHOD FOR DETERMINING WHICH 00001863
C UNITS PRODUCE LESS (OR MORE, FOR SALES) MAY BE APPROPRIATE. 00001865
C FOR EXAMPLE, FIRM PURCHASES WOULD NOT AFFECT THOSE UNITS 00001867
C IN THE LOADING ORDER BELOW THE MINIMUM LOAD FOR THE 00001869
C PERIOD. ALSO, FIRM SALES WOULD NOT AFFECT 00001871
C THOSE UNITS THAT ALREADY PRODUCE AS MUCH 00001873
C ENERGY AS POSSIBLE IN THE BIWEEKLY PERIOD. 00001875
C 00001877

```

	MC=1	00001879
	MD=1	00001881
C		00001883
C	I. INITIALIZATION OF ENERGY CALCULATIONS	00001885
	YMWTTOT=0.	00001887
	NCARDS=0	00001889
C	A. CREATE LOADING ORDER FOR UP PLANTS	00001891
	DO 13 J=1,NUMPLA	00001893
	NPA = NPARTS(J)	00001895
	DO 501 I = 1, NPA	00001897
501	YMWTTOT = YMWTTOT + YMWRA(J,I)	00001899
	IF(ISTAT(IX,J))13,13,14	00001901
14	NN=NPARTS(J)	00001903
	NCARDS=NCARDS+NN	00001905
	DO 200 I=1,NN	00001907
200	LOAD(NCARDS+1-I)=LOA(J,I)	00001909
13	CONTINUE	00001911
	NCO=NCARDS-1	00001913
C	B. SORT LOAD INTO INCREASING ORDER	00001915
	DO 201 I=1,NCO	00001917
	IP=I+1	00001919
	DO 201 J=IP,NCARDS	00001921
	IF(LOAD(I)-LOAD(J)) 201,201,202	00001923
202	L=LOAD(I)	00001925
	LOAD(I)=LOAD(J)	00001927
	LOAD(J)=L	00001929
201	CONTINUE	00001931
C	C. GET BLOCK CHAR.S INTO LOADING ORDER	00001933
	DO 205 M=1,NCARDS	00001935
	DO 205 I=1,NUMPLA	00001937
	N=NPARTS(I)	00001939
	DO 205 J=1,N	00001941
	IF(LOAD(M)-LOA(I,J))205,206,205	00001943
206	NPLA(M)=I	00001945
	FO(M)=FOR(I)	00001947
	YMW(M)=YMWRA(I,J)	00001949
	IF(M.EQ.1) NLA=I	00001951
205	CONTINUE	00001953
C	II. CALCULATE LOAD CURVE	00001955
C		00001957
	HOURS=8736./NPER	00001959
	ANNPK=APK*XMF(IX)	00001961
	IF(FPM.EQ.0.)FPM=0.30	00001963
	POWMIN=FPM*APK	00001965
	S=ANNPK/49.	00001967
	A=-S	00001969
C	A. FIT THE YEARLY LOAD PROBABILITY CURVE	00001971
C	TO THAT OF THIS PERIOD	00001973
	DO 49 J=1,75	00001975
	A=A+S	00001977
	IF(A-POWMIN)40,40,41	00001979
40	N=J	00001981
	PL(J)=0.	00001983
	GO TO 49	00001985
41	IF(A-ANNPK)43,43,42	00001987

42	PL(J)=0.	00001989
	GO TO 49	00001991
43	XNX=(50.-14.)*(J-N)/(50.-N)+14.	00001993
	NX=XNX	00001995
	PL(J)=PM(NX)	00001997
49	CONTINUE	00001999
	STEP=STE*ANNPK	00002001
	IF(IX.GT.1) GO TO 16	00002003
C		00002005
	FIRTOT=0.	00002007
	DO 15 J=1,360	00002009
	ENERG(J)=0.	00002011
15	ELoad(J)=0.	00002013
	ENETOT=0.	00002015
	SUMG=0.	00002017
16	CONTINUE	00002019
	NPL=0	00002021
	ZMW=0.	00002023
	JMAX=2	00002025
	BMW=0.	00002027
	XMW=0.	00002029
	SUME=0.	00002031
	ASTEP=50.*STE	00002033
	XINO=1./STF+1	00002035
	INO=XINO	00002037
	DIFF=XINO-INO	00002039
	X=0.	00002041
	IF(DIFF.GT.0.01) INC=INO+1	00002043
	XINO=INO	00002045
	DO 2 J=1,INC	00002047
2	PLO(J)=0.	00002049
	IF(STE-0.02) 4,4,3	00002051
4	CONTINUE	00002053
	NX=0	00002055
C		00002057
C		00002059
	DO 20 J=1,INO	00002061
	OX=X	00002063
	NOX=NX	00002065
	X=J*50./XINO	00002067
	NX=X	00002069
	IF(NX-1) 11,12,12	00002071
11	PLO(J)=PL(1)	00002073
	GO TO 20	00002075
12	IF(NOX-NX) 17,18,17	00002077
18	PLO(J)=((X-OX)*PL(NX+1)*(NX+.5))/(J-1)	00002079
	GO TO 20	00002081
17	PLO(J)=((X-NX)*PL(NX+1)*(NX+.5)+(NX-OX)*PL(NX)*(NX-.5))/(J-1)	00002083
20	CONTINUE	00002085
	GO TO 8	00002087
C		00002089
C		00002091
	3 PLO(1)=0.	00002093
	B=ASTEP/2.	00002095
	DO 6 J=2,INO	00002097
		00002099
		00002101
		00002103
		00002105
		00002107
		00002109
		00002111
		00002113
		00002115
		00002117
		00002119
		00002121
		00002123
		00002125
		00002127
		00002129
		00002131
		00002133
		00002135
		00002137
		00002139
		00002141
		00002143
		00002145
		00002147
		00002149
		00002151
		00002153
		00002155
		00002157
		00002159
		00002161
		00002163
		00002165
		00002167
		00002169
		00002171
		00002173
		00002175
		00002177
		00002179
		00002181
		00002183
		00002185
		00002187
		00002189
		00002191
		00002193
		00002195
		00002197
		00002199
		00002201
		00002203
		00002205
		00002207
		00002209
		00002211
		00002213
		00002215
		00002217
		00002219
		00002221
		00002223

	AB=8	00002099
	B=B+ASTEP	00002101
	IB=8	00002103
	JB=AB+1	00002105
	JSTEP=ASTEP-JB+AB-B+IB	00002107
	PLO(J)=(JB-AB)*PL(JB)*(JB-0.5)+(B-IB)*PL(IB+1)*(IB+0.5)	00002109
	IF(JSTEP.LT.1) GO TO 6	00002111
	DO 7 I=1,JSTEP	00002113
	7 PLO(J)=PLO(J)+PL(IB+1-I)*(IB+0.5-I)	00002115
	6 CONTINUE	00002117
	DO 9 J=2,INO	00002119
	9 PLO(J)=PLO(J)/(J-1)	00002121
C	E. NORMALIZE PROBABILITIES	00002123
	8 SUM=0.	00002125
	DO 25 J=1,INO	00002127
	25 SUM=SUM+PLO(J)	00002129
	DO 26 J=1,INO	00002131
	26 PLO(J)=PLO(J)/SUM	00002133
C	III. CALCULATE OUTAGE AND EQUIVALENT LOAD CURVE	00002135
	SUMF=0.	00002137
	DO 68 J=1,INO	00002139
	X=(J-1)*STEP	00002141
68	SUMF=SUMF+X*PLO(J)*1.E3*HOURS	00002143
	FIRME=FIRM(IX)*1.E4*HRS	00002145
	FRCT=FIRME/SUMF	00002147
	FIRTOT=FIRTOT+FIRME	00002149
C		00002151
	DO 27 J=1,NCARDS	00002153
	27 XMW=XMW+YMW(J)	00002155
	KMAX=XMW/STEP+5	00002157
C	A. INITIALIZATIONS	00002159
	DO 30 J=1,KMAX	00002161
	POU(J)=0.	00002163
	30 PC(J)=0.	00002165
	S=1.	00002167
	POU(1)=1.	00002169
	TOTMW=0.	00002171
	ICO=0	00002173
	GO TO 65	00002175
	29 NPL=NPL+1	00002177
	ZMW=ZMW+YMW(NPL)	00002179
	NP=NPL+1	00002181
C	B. FIND PARTICULAR PLANT	00002183
	DO 215 I=1,NMPLA	00002185
	N=NPARTS(I)	00002187
	DO 215 J=1,N	00002189
	IF(LOAD(NP)=LCA(I,J)) 215,216,215	00002191
216	MA=MC	00002193
	MB=MD	00002195
	MC=I	00002197
	MD=J	00002199
	IF(I.EQ.NLA.AND.ICO.EQ.0) GO TO 65	00002201
	IF(J.GT.1) GO TO 300	00002203
	GO TO 218	00002205
215	CONTINUE	00002207

218	CONTINUE	00002209
C		
	IF(MB-1) 213,213,214	C. OUTAGE PROB.S FOR FIRST BLOCK OF 00002211
213	YY=YMW(NPL)	00002213
	GO TO 212	00002215
214	YY=0.	00002217
	DO 220 K=1,MB	00002219
220	YY=YY+YMWRA(MA,K)	00002221
212	CONTINUE	00002223
	TOTMW=TOTMW+YY	00002225
	DO 31 J=1,JMAX	00002227
31	PO(J)=POU(J)*(1.-FO(NPL))	00002229
	JMAX=TOTMW/STEP+2	00002231
	JM=YY/STEP+1	00002233
	DO 32 J=JM,JMAX	00002235
	POUT=POU(J-1)*FO(NPL)	00002237
	AMW=J-JM+1+YY/STEP	00002239
	N=AMW	00002241
	PO(N)=PO(N)+(1.-N-AMW)*POUT	00002243
32	PO(N+1)=PO(N+1)+(AMW-N)*PCUT	00002245
	JJMAX=JMAX+1	00002247
	DO 50 J=1,JJMAX	00002249
35	POU(J)=PO(J)	00002251
50	CONTINUE	00002253
	ICO=1	00002255
	GO TO 53	00002257
C		
		D. OUTAGE PROB.S FOR OTHER BLOCKS OF 00002259
300	TOTMW=0.	00002261
	JMAX=2	00002263
	DO 301 I=1,KMAX	00002265
	POU(I)=0.	00002267
301	PU(I)=0.	00002269
	POU(I)=1.	00002271
	DO 350 I=1,NPL	00002273
	YY=YMW(I)	00002275
	N=NPLA(I)	00002277
	IF(N.EQ.MC) GO TO 350	00002279
	KK=I-1	00002281
	IF(KK.LT.1) GO TO 306	00002283
	DO 305 K=1,KK	00002285
	IF(NPLA(K).EQ.N) GO TO 350	00002287
305	CONTINUE	00002289
306	TOTMW=TOTMW+YY	00002291
	IF(I.EQ.NPL) GO TO 310	00002293
	II=I+1	00002295
	DO 309 K=II,NPL	00002297
	IF(NPLA(K).NE.N) GO TO 309	00002299
	TOTMW=TOTMW+YMW(K)	00002301
	YY=YY+YMW(K)	00002303
309	CONTINUE	00002305
310	CONTINUE	00002307
	DO 331 J=1,JMAX	00002309
331	PO(J)=POU(J)*(1.-FO(I))	00002311
	JMAX=TOTMW/STEP+2	00002313
	JM=YY/STEP+1	00002315
		00002317

DO 332 J=JM,JMAX	00002319
POUT=POU(J-JM+1)*FO(I)	00002321
AMW=J-JM+1+YY/STEP	00002323
N=AMW	00002325
PO(N)=PO(N)+(1.+N-AMW)*POUT	00002327
332 PO(N+1)=PO(N+1)+(AMW-N)*POUT	00002329
JJMAX=JJMAX+1	00002331
DO 333 J=1,JJMAX	00002333
333 POU(J)=PO(J)	00002335
350 CONTINUE	00002337
C E. FORM EQUIVALENT LOAD CURVE	
53 JJ=JJMAX+INO	00002341
DO 51 J=1,JJ	00002343
51 P(J)=0.	00002345
DO 52 J=1,JJMAX	00002347
DO 52 I=1,INO	00002349
NPE=J+I-1	00002351
52 P(NPE)=P(NPE)+PLO(I)*POU(J)	00002353
S=0.	00002355
DO 54 J=1,JJ	00002357
S=S+P(JJ-J+1)	00002359
SP(JJ-J+1)=S	00002361
54 CONTINUE	00002363
57 BMW=ZMW+YMW(NPL+1)	00002365
N=ZMW/STEP+2	00002367
S=(N-ZMW/STEP-1)*SP(N)	00002369
X=(BMW-(N-1)*STEP)/STEP	00002371
JX=X	00002373
IF(JX-1) 61,60,60	00002375
60 CONTINUE	00002377
DO 63 J=1,JX	00002379
63 S=S+SP(N+J)	00002381
S=(S+SP(N+JX+1))*(X-JX)*STEP/YMW(NPL+1)	00002383
GO TO 65	00002385
61 IF(X) 64,66,66	00002387
64 S=SP(N)	00002389
GO TO 65	00002391
66 S=(S+X*SP(N+1))*STEP/YMW(NPL+1)	00002393
65 CONTINUE	00002395
N=NPL+1	00002397
C F. GENERATED ENERGY BY BLOCK BY PERIOD	
ENERGY(N)=S*YMW(N)*(1.-FO(N))*HOURS*1.E3*(1.-FRCT)	00002401
SUME=SUME+ENERGY(N)	00002403
IF(BMW.GE.XMW) GO TO 67	00002405
GO TO 29	00002407
67 IF(KP.EQ.0)PRINT 108,IX,SUME,SUMF	00002409
DO 71 J=1,NCARDS	00002411
II=LOAD(J)	00002413
71 ELOAD(II)=ELOAD(II)+ENERGY(J)	00002415
ENETOT=ENETOT+SUME	00002417
SUMG=SUMG+SUME	00002419
IF(IX-NPER) 75,74,74	00002421
74 IF(KP.NE.2) PRINT 99,TIETO,RMA	00002423
IF(KP.NE.2) PRINT 91,HRS	00002425
J=0	00002427

	DO 89 I=1,NPER	00002429
C	J=1	00002431
	IF(KP.NE.2)PRINT 90,I,FIRM(I),TIE(I)	00002433
89	CONTINUE	00002435
	IF(KP.NE.2.AND.J.EQ.0)PRINT 92	00002437
	PRINT 93	00002439
	PRINT 112	00002441
		00002443
C	IV. ADJUST ENERGY LEVELS, FIND CAPACITY FACTORS	00002445
C		00002447
	ICOUNT=0	00002449
	II=0	00002451
	III=0	00002453
	S=0.	00002455
	SUME=0.	00002457
	SUMF=0.	00002459
	SUMH=0.	00002461
	SUMI=0.	00002463
	NCARDS=0.	00002465
	DO 400 M=1,NUMPLA	00002467
	NN=NPARTS(M)	00002469
	NCARDS=NCARDS+NN	00002471
	DO 401 I=1,NN	00002473
401	LOAD(NCARDS+1-I)=LOA(M,I)	00002475
400	CONTINUE	00002477
	NCO=NCARDS-1	00002479
	DO 403 I=1,NCO	00002481
	IP=I+1	00002483
	DO 403 J=IP,NCARDS	00002485
	IF(LOAD(I)-LOAD(J))403,403,402	00002487
402	L=LOAD(I)	00002489
	LOAD(I)=LOAD(J)	00002491
	LOAD(J)=L	00002493
403	CONTINUE	00002495
	DO 405 M=1,NCARDS	00002497
	DO 405 I=1,NUMPLA	00002499
	N=NPARTS(I)	00002501
	DO 405 J=1,N	00002503
	IF(LOAD(M)-LOA(I,J))405,406,405	00002505
406	L=LOA(I,J)	00002507
	YMW(M)=YMWRA(I,J)	00002509
	NPLA(M)=I	00002511
	ENERGY(M)=ELOAD(L)	00002513
405	CONTINUE	00002515
	DO 407 I=1,NCARDS	00002517
	YMEGAW=YMW(I)	00002519
	IF(YMEGAW.GT.0.0)GO TO 408	00002521
407	CONTINUE	00002523
408	ZCHECK=YMEGAW-2.*CFE*YMWTOT	00002525
	Y=0.	00002527
	DO 76 J=1,NCARDS	00002529
	IF(YMW(J).LE.0.0)GO TO 76	00002531
	Z=YMW(J)*NPER*HOURS	00002533
	C=ENERGY(J)/(Z*1000.)	00002535
	ENE=ENERGY(J)	00002537

CC=C	00002539
R=S/YMWTOT	00002541
S=S+YMW(J)	00002543
IF(R-CFC)77,77,78	00002545
77 Y=S	00002547
CC=C-CFD	00002549
SUME=SUME+Z*1000.*CFD	00002551
ENE=CC*Z*1000.	00002553
78 CONTINUE	00002555
R=S-YMW(J)/2.-YMWTOT+2.*Y	00002557
IF(R)79,79,80	00002559
80 IF(II.EQ.0)SS=S-YMW(J)	00002561
II=1	00002563
ENE=ENERGY(J)+SUME*YMW(J)/(YMWTOT-SS)	00002565
CC=ENE/(Z*1000.)	00002567
79 CONTINUE	00002569
EN(J)=ENE	00002571
IF(CFE.LE.0.0.OR.CFF.LE.0.0)GO TO 76	00002573
IF(ZCHECK.GT.0.0) GO TO 76	00002575
RR=(S-YMW(J))/YMWTOT	00002577
IF(RR-CFE)81,81,82	00002579
81 CC=CC-CFF	00002581
SUMF=SUMF+Z*1000.*CFF	00002583
ENE=CC*Z*1000.	00002585
SUMI=SUMI+ENE	00002587
EN(J)=ENE	00002589
CPBAR=SUMI/(S*NPER*HOURS*1000.)	00002591
GO TO 76	00002593
82 IF(III.GT.0) GO TO 87	00002595
III=J	00002597
87 FRAC=2.*CFE	00002599
SUMH=SUMH+(CPBAR-CC)*YMW(J)	00002601
IF(RR.GE.FRAC)GO TO 86	00002603
GO TO 76	00002605
86 IF(ICOUNT.GT.0) GO TO 76	00002607
ICOUNT=1	00002609
DO 96 K=III,J	00002611
IF(YMW(K).LE.0.0) GO TO 96	00002613
Z=YMW(K)*NPER*HOURS*1000.	00002615
CC=EN(K)/Z	00002617
EN(K)=EN(K)+((CPBAR-CC)*SUMF*YMW(K)/SUMH	00002619
96 CONTINUE	00002621
76 CONTINUE	00002623
S=0.	00002625
DO 413 J=1,NCARDS	00002627
IF(YMW(J).LE.0.)GO TO 411	00002629
Z=YMW(J)*NPER*HOURS*1000.	00002631
C=ENERGY(J)/Z	00002633
CC=EN(J)/Z	00002635
412 S=S+YMW(J)	00002637
I=NPLA(J)	00002639
WRITE(6,111)LOAD(J),NPLA(J),PLTID(I),YMW(J),S,EN(J),CC,ENERGY(J),C	00002641
GO TO 410	00002643
411 C=0.	00002645
CC=0.	00002647

GO TO 412	00002649
410 I=NPLA(J)	00002651
L=LOAD(J)	00002653
ENERG(I)=ENERG(I)+EN(J)	00002655
ELOAD(L)=EN(J)	00002657
413 CONTINUE	00002659
K=0	00002661
DO 420 J=1,NCARDS	00002663
I=NPLA(J)	00002665
L=LOAD(J)	00002667
N=NPARTS(I)	00002669
IF(N.LT.2) GO TO 420	00002671
IF(L.NE.LOA(I,1))GO TO 420	00002673
IF(K.EQ.0) WRITE(6,114)	00002675
K=1	00002677
YMWET=0.0	00002679
DO 421 IP=1,N	00002681
421 YMWET=YMWET+YMWRA(I,IP)	00002683
Z=YMWET*NPRT*HOURS*1000.	00002685
ENE=0.	00002687
DO 422 IP=J,NCARDS	00002689
IF(NPLA(IP).NE.I) GO TO 422	00002691
ENE=ENE+ENERGY(IP)	00002693
422 CONTINUE	00002695
IF(Z.LE.0.0) GO TO 423	00002697
C=ENERG(I)/Z	00002699
CC=ENE/Z	00002701
GO TO 424	00002703
423 C=0.	00002705
CC=0.	00002707
424 CONTINUE	00002709
WRITE(6,115)I,PLTID(I),N,YMWET,ENERG(I),C,ENE,CC	00002711
420 CONTINUE	00002713
SUMTOT=SUMG+FIRTOT	00002715
PRINT 110,ENETOT,SUMG,SUMTOT	00002717
75 RETURN	00002719
END	00002721

BLOCK DATA	00002723
COMMON/S2/FOR(120),YMW(120),APK,NPER,ISTAT(26,120),XMF(26).	NUM00002725
1PLA,IX,STE,CFC,CFD,CFE,CFF,KP	00002727
DATA XMF/.82,.83,.81,.80,.80,.79,.78,.80,.83,.85,.90,.95,.96,.98,100002729	
1.00,.98,.96,.90,.85,.85,.80,.82,.85,.85,.88,.86/	00002731
END	00002733

APPENDIX D - SAMPLE EXECUTION

In order to show some features of the code, a sample execution of SYSREL is included in this appendix. The input data cards and computer printout are given.

Briefly, calculations are made for a three-year study period. The initial input describes a system consisting of four groups. There are 19 generating units providing 4450 Mw of capacity for a system that has a peak load of 3700 Mw. Firm biweekly power purchases from adjoining systems are assumed to be 200 Mw for the full year; in addition 175 Mw may be counted upon for emergency power from interties during the year. The reliability criterion for the system is a mean time between failures of once in 10 years.

Prior to start of the calculation for the first period of the first year, a change feature of the code is demonstrated; the forced outage rate for group three has been changed from 0.05 to 0.06. This change, or any allowed change, could be input for any biweekly period in the year.

The printout for the system and the calculations for the three-year study period are shown in the following pages. For the first year, a code feature that allows for output of reliability calculations for each biweekly period is demonstrated. This biweekly display is omitted from output shown for years 2 and 3.

At the beginning of the second year of calculation, the annual peak load is changed from 3700 Mw to 3885 Mw and a new plant to occupy position 1 in the loading order is added to group one. Also, plant repair time for group one is changed from 80 hours to 60 hours.

Other change features of the code are demonstrated during the calculations for the third year. In addition to changing the annual peak load from 3885 Mw to 4144 Mw, plant #16 is retired in the fifth period and one other plant is added to group one in the eighth period.

1 2 3 4 5 6 7 8
123456789012345678901234567890123456789012345678901234567890

INPUT FOR SAMPLE RUN

	1	2	3	4	5	6	7	8
	.0002	50.0	10.0	6.0	0.2	.03	.45	.03
	3	4	3700.	.35	500.	0.33		
	.08	80.		500.	0.0	4	4	
				1	3			
2	300.	0.24		23.		4.0	PG11	
	340.	1	12.0	160.	12			PG11
2	300.	0.24		23.		4.0	PG21	
	340.	2	12.0	160.	11			PG21
2	300.	0.24		23.		4.0	PG31	
	300.	3	9.0	200.	7			PG31
2	300.	0.17		55.		2.5	PG41	
	200.	6	9.5	300.	4			PG41
	.04	40.		275.	0.0	6	4	
		3		2	1			
2	200.	.35		84.		3.0	PG12	
	130.	14	10.1	110.	16			PG12
2	200.	.35		84.		3.0	PG22	
	140.	13	9.8	110.	17			PG22
2	200.	.29		84.		3.0	PG32	
	160.	10	9.3	110.	18			PG32
2	200.	.29		84.		3.0	PG42	
	170.	9	8.9	110.	19			PG42
2	200.	.12		88.		3.0	PG52	
	190.	8	9.8	130.	15			PG52
1	200.	.42		249.		3.0	PG62	
	290.	5	14.0					PG62
	.05	40.		120.	0.0	5	3	
	0	5		0	0			
1	200.	.12		75.		3.0	PG13	
	110.	20	10.5					PG13
1	200.	.12		75.		3.0	PG23	
	110.	21	10.5					PG23
1	200.	.12		75.		3.0	PG33	
	110.	22	10.5					PG33
1	200.	.40		104.		3.0	PG43	
	70.	23	11.0					PG43
1	200.	.48		104.		3.0	PG53	
	70.	28	11.0					PG53
	.06	40.		50.	0.0	4	3	
	4	0		0	0			
1	100.	.41		215.		1.0	PG14	
	30.	24	13.1					PG14
1	100.	.41		215.		1.0	PG24	
	30.	25	13.1					PG24
1	100.	.60		247.		1.0	PG34	
	20.	26	17.0					PG34
1	100.	.60		247.		1.0	PG44	
	20.	27	17.0					PG44
	200.	200.	200.	200.	200.	200.	200.	200.
	200.	200.	200.	200.	200.	200.	200.	200.
	4.	175.0	0.4					
	1	1	3	3	.06			

BLANK CARD 1

D.3

200.	14.0	1.0	0.8	150.	0.005	0.16	0.3	15.	.07					
200.	200.	200.	200.	200.	200.	200.	200.	200.	200.	200.	200.	200.	200.	200.
200.	200.	200.	200.	200.	200.	200.	200.	200.	200.	200.	200.	200.	200.	200.
	4.	175.0			0.4									
2	1			1	1.05									
2	1	1	1	2	1	1	3	12.0						
2	1	1		7	60.									

BLANK CARD 2

200.	14.0	1.0	0.8	150.	0.005	0.16	0.3	15.	.07					
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4.	175.0			0.4									
3	1			1	1.12									
3	5		16	5	1.	1								
3	8	1	1	2	1	1	3	12.0						

BLANK CARD 3

200.	14.0	1.0	0.8	150.	0.005	0.16	0.3	15.	.07					
------	------	-----	-----	------	-------	------	-----	-----	-----	--	--	--	--	--

..... POWER SYSTEM RELIABILITY ANALYSIS

CALCULATING...ANNUAL FAILURE FREQUENCY
MEAN TIME BETWEEN FAILURES
RESERVE ENERGY REQUIREMENTS
GENERATED ENERGY
CAPACITY FACTORS
COSTS

ANY SITUATION WITH A PROBABILITY LESS THAN 0.000200 TIMES THE AVERAGE PROBABILITY FOR ALL SITUATIONS WILL BE DROPPED FROM MEMORY
NUMBER OF YEARS IN THIS PROBLEM 3
STEP SIZE FOR ENERGY ALLOCATION AS FRACTION OF PEAK 0.02000
ADJUSTED ENERGY FACTORS 0.2000 0.0300 0.4500 0.0300
DAYPEAK ADJUSTMENT FACTOR 0.330 RESERVE MW CONSTANT 6.000
MINIMUM DEMAND IS 0.350 OF PEAK DEMAND

ANNUAL PEAK 3700.0 MWE
SYSTEM CAPACITY 4450.0 MWE
THE NUMBER OF GROUPS OF UNITS IS 4

***** YEAR NUMBER 1 *****

GROUP NO.	FG RATE	TIME TO REPAIR (HRS)	MWE PER UNIT	NO. OF UNITS	MAX NO OUT AT ONE TIME
1	0.080	80.0	500.0	4	4
2	0.040	40.0	275.0	6	4
3	0.050	40.0	120.0	5	3
4	0.060	40.0	50.0	4	3

PLANT NAME	CAP COST \$/KWE	O&M M/KWH	C&M \$/KWE-YR	FUEL C/MRTU	BLOCKS	LOAD	HEAT RATE THC BTU/KWH	MWE IN BLOCK
1 PG11	300.	0.24	4.00	23.00	2	1	12.00	340.00
						12	9.90	160.00
2 PG21	300.	0.24	4.00	23.00	2	2	12.00	340.00
						11	9.90	160.00
3 PG31	300.	0.24	4.00	23.00	2	3	9.00	300.00
						7	9.50	200.00
4 PG41	300.	0.17	2.50	55.00	2	6	9.50	200.00
						4	9.50	300.00
5 PG12	200.	0.35	3.00	84.00	2	14	10.10	130.00
						16	8.40	110.00
6 PG22	200.	0.35	3.00	84.00	2	13	9.80	140.00
						17	8.30	110.00
7 PG32	200.	0.29	3.00	84.00	2	10	9.30	160.00
						18	8.90	110.00
8 PG42	200.	0.29	3.00	84.00	2	9	8.90	170.00
						19	8.60	110.00
9 PG52	200.	0.12	3.00	88.00	2	8	9.80	190.00
						15	8.50	130.00
10 PG62	200.	0.42	3.00	249.00	1	5	14.00	290.00
11 PG13	200.	0.12	3.00	75.00	1	20	10.50	110.00
12 PG23	200.	0.12	3.00	75.00	1	21	10.50	110.00
13 PG33	200.	0.12	3.00	75.00	1	22	10.50	110.00
14 PG43	200.	0.48	3.00	104.00	1	23	11.00	70.00
15 PG53	200.	0.48	3.00	104.00	1	28	11.00	70.00
16 PG14	100.	0.41	1.00	215.00	1	24	13.10	30.00
17 PG24	100.	0.41	1.00	215.00	1	25	13.10	30.00
18 PG34	100.	0.60	1.00	247.00	1	26	17.00	20.00
19 PG44	100.	0.60	1.00	247.00	1	27	17.00	20.00

NUMBER OF WEEKS OF SCHEDULED OUTAGE BY GROUP AND BY TWO WEEK CATEGORIES

GROUP NO	2 WEEKS	4 WEEKS	6 WEEKS	8 WEEKS
1	0	0	1	3
2	0	3	2	1
3	0	5	0	0
4	4	0	0	0

BIWEEKLY PERIOD	---1---	---2---	---3---	---4---	---5---	---6---	---7---	---8---	---9---	TOTAL SCHEDULED OUTAGE	LOAD PLUS SCHEDULED OUTAGE
UP,DOWN	UP,DOWN	UP,DOWN	UP,DOWN	UP,DOWN	UP,DOWN	UP,DOWN	UP,DOWN	UP,DOWN	UP,DOWN		
1	3 1	6 0	4 1	4 0						620.0	3654.0
2	3 1	6 0	4 1	4 0						620.0	3691.0
3	3 1	6 0	5 0	1 3						650.0	3647.0
4	3 1	5 1	5 0	4 0						775.0	3735.0
5	3 1	5 1	5 0	4 0						775.0	3735.0
6	3 1	5 1	5 0	4 0						775.0	3698.0
7	3 1	5 1	5 0	4 0						775.0	3661.0
8	3 1	6 0	4 1	3 1						670.0	3630.0
9	3 1	6 0	4 1	4 0						620.0	3691.0

10	3	1	6	0	4	1	4	0
11	4	0	5	1	4	1	4	0
12	4	0	5	1	5	0	4	0
13	4	0	6	0	4	1	4	0
14	4	0	6	0	4	1	4	0
15	4	0	6	0	5	0	4	0
16	4	0	6	0	5	0	4	0
17	4	0	5	1	5	0	4	0
18	4	0	5	1	4	1	4	0
19	3	1	6	0	4	1	4	0
20	3	1	6	0	5	0	4	0
21	3	1	5	1	5	0	4	0
22	3	1	5	1	5	0	4	0
23	4	0	4	2	5	0	4	0
24	4	0	4	2	5	0	4	0
25	4	0	4	2	5	0	4	0
26	3	1	6	0	5	0	4	0

620.0	3765.0
395.0	3725.0
275.0	3750.0
120.0	3672.0
120.0	3746.0
0.0	3700.0
0.0	3626.0
275.0	3827.0
395.0	3725.0
620.0	3765.0
500.0	3645.0
775.0	3735.0
775.0	3809.0
550.0	3695.0
550.0	3695.0
550.0	3806.0
500.0	3682.0

AT YEAR 1, PERIOD 1

THE FORCED OUTAGE RATE CF GRUP 3 IS NOW 0.0600

BIWEEKLY PERIOD NUMBER 1

OUT CF 20 POSSIBILITIES 20 WERE EXAMINED AND 20 WERE RETAINED

OUT OF 80 POSSIBILITIES 80 WERE EXAMINED AND 80 WERE RETAINED

THERE WERE 320 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD

FRQ(IX) 0.80042E 00

ANNFR 0.21989E-01

TIME 0.45476E 02

DURING THE 1 BIWEEKLY PERIOD 0.70349645E 09 KWH WERE GENERATED AND 0.71041818E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 2

THERE WERE 320 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD

FRQ(IX) 0.85320E 00

ANNFR 0.45429E-01

TIME 0.22012E 02

DURING THE 2 BIWEEKLY PERIOD 0.71201715E 09 KWH WERE GENERATED AND 0.71908147E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 3

OUT CF 20 POSSIBILITIES 20 WERE EXAMINED AND 20 WERE RETAINED

OUT OF 80 POSSIBILITIES 80 WERE EXAMINED AND 80 WERE RETAINED

THERE WERE 160 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD

FRQ(IX) 0.78651E 00

ANNFR 0.67036E-01

TIME 0.14917E 02

DURING THE 3 BIWEEKLY PERIOD 0.70824013E 09 KWH WERE GENERATED AND 0.71519488E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 4

OUT CF 20 POSSIBILITIES 20 WERE EXAMINED AND 20 WERE RETAINED

OUT OF 80 POSSIBILITIES 80 WERE EXAMINED AND 80 WERE RETAINED

THERE WERE 320 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD

FRQ(IX) 0.10062E 01

ANNFR 0.94681E-01

TIME 0.10562E 02

DURING THE 4 BIWEEKLY PERIOD 0.69795814E 09 KWH WERE GENERATED AND 0.70636467E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 5

THERE WERE 320 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD

FRQ(IX) 0.10062E 01

ANNFR 0.12232E 00

TIME 0.81750E 01

DURING THE 5 BIWEEKLY PERIOD 0.69795814E 09 KWH WERE GENERATED AND 0.70636467E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 6
THERE WERE 320 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.99335E 00
ANNFR 0.14961E 00
TIME 0.66638E 01
DURING THE 6 BIWEEKLY PERIOD 0.68919219E 09 KWH WERE GENERATED AND 0.69753600E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 7
THERE WERE 320 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.76471E 00
ANNFR 0.17062E 00
TIME 0.58609E 01
DURING THE 7 BIWEEKLY PERIOD 0.68042189E 09 KWH WERE GENERATED AND 0.68870605E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 8
OUT OF 20 POSSIBILITIES 20 WERE EXAMINED AND 20 WERE RETAINED
OUT OF 80 POSSIBILITIES 80 WERE EXAMINED AND 80 WERE RETAINED
THERE WERE 320 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.66910E 00
ANNFR 0.18900E 00
TIME 0.52909E 01
DURING THE 8 BIWEEKLY PERIOD 0.69815552E 09 KWH WERE GENERATED AND 0.70636467E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 9
OUT OF 20 POSSIBILITIES 20 WERE EXAMINED AND 20 WERE RETAINED
OUT OF 80 POSSIBILITIES 80 WERE EXAMINED AND 80 WERE RETAINED
THERE WERE 320 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.71724E 00
ANNFR 0.20871E 00
TIME 0.47914E 01
DURING THE 9 BIWEEKLY PERIOD 0.71072461E 09 KWH WERE GENERATED AND 0.71908147E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 10
THERE WERE 320 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.76548E 00
ANNFR 0.22974E 00
TIME 0.43528E 01
DURING THE 10 BIWEEKLY PERIOD 0.72801075E 09 KWH WERE GENERATED AND 0.73640986E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 11
OUT OF 25 POSSIBILITIES 25 WERE EXAMINED AND 25 WERE RETAINED
OUT OF 100 POSSIBILITIES 100 WERE EXAMINED AND 56 WERE RETAINED
THERE WERE 400 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.89950E 00
ANNFR 0.25445E 00
TIME 0.39300E 01
DURING THE 11 BIWEEKLY PERIOD 0.76097766E 09 KWH WERE GENERATED AND 0.76919501E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 12
OUT OF 25 POSSIBILITIES 25 WERE EXAMINED AND 25 WERE RETAINED
OUT OF 100 POSSIBILITIES 100 WERE EXAMINED AND 58 WERE RETAINED
THERE WERE 400 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.58113E 00
ANNFR 0.27042E 00
TIME 0.36980E 01
DURING THE 12 BIWEEKLY PERIOD 0.80204390E 09 KWH WERE GENERATED AND 0.81064294E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 13
OUT OF 25 POSSIBILITIES 25 WERE EXAMINED AND 25 WERE RETAINED
OUT OF 100 POSSIBILITIES 100 WERE EXAMINED AND 57 WERE RETAINED
THERE WERE 400 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD

FRQ(IX) 0.44845E 00
ANNFR 0.28274E 00
TIME 0.35369E 01
DURING THE 13 BIWEEKLY PERIOD 0.79C45146E 09 KWH WERE GENERATED AND 0.79860634E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 14
THERE WERE 400 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.46418E 00
ANNFR 0.29549E 00
TIME 0.33942E 01
DURING THE 14 BIWEEKLY PERIOD 0.80690227E 09 KWH WERE GENERATED AND 0.8152437E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 15
OUT OF 25 POSSIBILITIES 25 WERE EXAMINED AND 25 WERE RETAINED
OUT OF 100 POSSIBILITIES 100 WERE EXAMINED AND 59 WERE RETAINED
THERE WERE 400 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.41044E 00
ANNFR 0.30676E 00
TIME 0.32598E 01
DURING THE 15 BIWEEKLY PERIOD 0.82358784E 09 KWH WERE GENERATED AND 0.83188122E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 16
THERE WERE 400 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.38595E 00
ANNFR 0.31737E 00
TIME 0.31509E 01
DURING THE 16 BIWEEKLY PERIOD 0.80710753E 09 KWH WERE GENERATED AND 0.81524378E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 17
OUT OF 25 POSSIBILITIES 25 WERE EXAMINED AND 25 WERE RETAINED
OUT OF 100 POSSIBILITIES 100 WERE EXAMINED AND 58 WERE RETAINED
THERE WERE 400 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.58713E 00
ANNFR 0.33350E 00
TIME 0.29985E 01
DURING THE 17 BIWEEKLY PERIOD 0.78979840E 09 KWH WERE GENERATED AND 0.79860634E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 18
OUT OF 25 POSSIBILITIES 25 WERE EXAMINED AND 25 WERE RETAINED
OUT OF 100 POSSIBILITIES 100 WERE EXAMINED AND 56 WERE RETAINED
THERE WERE 400 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.89950E 00
ANNFR 0.35821E 00
TIME 0.27917E 01
DURING THE 18 BIWEEKLY PERIOD 0.76073216E 09 KWH WERE GENERATED AND 0.76919501E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 19
OUT OF 20 POSSIBILITIES 20 WERE EXAMINED AND 20 WERE RETAINED
OUT OF 80 POSSIBILITIES 80 WERE EXAMINED AND 80 WERE RETAINED
THERE WERE 320 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.76548E 00
ANNFR 0.37924E 00
TIME 0.26369E 01
DURING THE 19 BIWEEKLY PERIOD 0.72800333E 09 KWH WERE GENERATED AND 0.73640986E 09 KWH WERE DEMANDED.

BIWEEKLY PERIOD NUMBER 20
OUT OF 20 POSSIBILITIES 20 WERE EXAMINED AND 20 WERE RETAINED
OUT OF 80 POSSIBILITIES 80 WERE EXAMINED AND 80 WERE RETAINED
THERE WERE 320 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.59262E 00
ANNFR 0.39552E 00
TIME 0.25283E 01

DURING THE 20 BIWEEKLY PERIOD 0.72813005E 09 KWH WERE GENERATED AND 0.73640986E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 21

OUT OF 20 POSSIBILITIES 20 WERE EXAMINED AND 20 WERE RETAINED
OUT OF 80 POSSIBILITIES 80 WERE EXAMINED AND 80 WERE RETAINED
THERE WERE 320 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.84567E 00
ANNFR 0.41875E 00
TIME 0.238E1E 01

DURING THE 21 BIWEEKLY PERIOD 0.69774490E 09 KWH WERE GENERATED AND 0.70636467E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 22

THERE WERE 320 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.11419E 01
ANNFR 0.45012E 00
TIME 0.22216E 01

DURING THE 22 BIWEEKLY PERIOD 0.70157235E 09 KWH WERE GENERATED AND 0.71041818E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 23

OUT OF 25 POSSIBILITIES 25 WERE EXAMINED AND 25 WERE RETAINED
OUT OF 100 POSSIBILITIES 100 WERE EXAMINED AND 53 WERE RETAINED
THERE WERE 400 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.12792E 01
ANNFR 0.48526E 00
TIME 0.20607E 01

DURING THE 23 BIWEEKLY PERIOD 0.72826163E 09 KWH WERE GENERATED AND 0.73640986E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 24

THERE WERE 400 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.12792E 01
ANNFR 0.52040E 00
TIME 0.19216E 01

DURING THE 24 BIWEEKLY PERIOD 0.72826163E 09 KWH WERE GENERATED AND 0.73640986E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 25

THERE WERE 400 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.14198E 01
ANNFR 0.55941E 00
TIME 0.17876E 01

DURING THE 25 BIWEEKLY PERIOD 0.74368589E 09 KWH WERE GENERATED AND 0.75210240E 09 KWH WERE DEMANDED

BIWEEKLY PERIOD NUMBER 26

OUT OF 20 POSSIBILITIES 20 WERE EXAMINED AND 20 WERE RETAINED
OUT OF 80 POSSIBILITIES 80 WERE EXAMINED AND 80 WERE RETAINED
THERE WERE 320 OUTAGE COMBINATIONS IN THIS BIWEEKLY PERIOD
FRQ(IX) 0.75757E 00
ANNFR 0.58022E 00
TIME 0.17235E 01

DURING THE 26 BIWEEKLY PERIOD 0.72793062E 09 KWH WERE GENERATED AND 0.73500826E 09 KWH WERE DEMANDED

SUMMED BIWEEKLY CAPACITY 4550. MWE, TEST MARGIN 0.40

FIRM ENERGY PURCHASES (OR SALES) 4.0 HOURS PER DAY FOR 10 DAYS PER PERIOD

PERIOD	MWE	TIE
1	200.0	110.3
2	200.0	136.8
3	200.0	99.2
4	200.0	136.6
5	200.0	136.6
6	200.0	110.1
7	200.0	83.7
8	200.0	83.0
9	200.0	136.8
10	200.0	189.7

11	200.0	207.0
12	200.0	278.0
13	200.0	225.3
14	200.0	278.2
15	200.0	270.5
16	200.0	216.9
17	200.0	304.4
18	200.0	207.0
19	200.0	189.7
20	200.0	128.4
21	200.0	136.5
22	200.0	189.5
23	200.0	153.9
24	200.0	153.5
25	200.0	233.2
26	200.0	154.8

ENERGY ALLOCATION

LOAD	PLANT	NAME	MWE	SUM MWE	ADJUSTED ENERGY	ADJUSTED CF	UNADJUSTED ENERGY	UNADJUSTED CF
1	1	PG11	340.	340.	0.210936E 10	0.71016508	0.228758E 10	0.77016556
2	2	PG21	340.	680.	0.210921E 10	0.71011460	0.228743E 10	0.77011496
3	3	PG31	300.	980.	0.186108E 10	0.71011895	0.201833E 10	0.77011931
4	4	PG41	300.	1280.	0.203142E 10	0.77511519	0.211005E 10	0.80511558
5	10	PG62	290.	1570.	0.214178E 10	0.84540492	0.221779E 10	0.87540531
6	4	PG41	200.	1770.	0.133017E 10	0.76131457	0.138259E 10	0.79131514
7	3	PG31	200.	1970.	0.118934E 10	0.68071014	0.124175E 10	0.71071059
8	9	PG52	190.	2160.	0.123721E 10	0.74537987	0.123762E 10	0.74562843
9	8	PG42	170.	2330.	0.995339E 09	0.67020762	0.987117E 09	0.66467154
10	7	PG32	160.	2490.	0.834540E 09	0.59705526	0.797191E 09	0.57033461
11	2	PG21	160.	2650.	0.639082E 09	0.45721883	0.586693E 09	0.41573770
12	1	PG11	160.	2810.	0.583893E 09	0.41773474	0.527256E 09	0.37721515
13	6	PG22	140.	2950.	0.490904E 09	0.40138018	0.439808E 09	0.35960227
14	5	PG12	130.	3080.	0.350111E 09	0.33828333	0.254529E 09	0.25534154
15	9	PG52	130.	3210.	0.278222E 09	0.24498278	0.217108E 09	0.19116963
16	5	PG12	110.	3320.	0.191273E 09	0.19904357	0.136164E 09	0.14169538
17	6	PG22	110.	3430.	0.171655E 09	0.17862898	0.115036E 09	0.11970965
18	7	PG32	110.	3540.	0.141893E 09	0.14765787	0.829842E 08	0.08635551
19	8	PG42	110.	3650.	0.124037E 09	0.12907612	0.627538E 08	0.06634384
20	11	PG13	110.	3760.	0.106445E 09	0.11076927	0.448080E 08	0.04662832
21	12	PG23	110.	3870.	0.934845E 08	0.09728241	0.308503E 08	0.03210361
22	13	PG33	110.	3980.	0.841757E 08	0.08759534	0.208251E 08	0.02167114
23	14	PG43	70.	4050.	0.188992E 08	0.03090526	0.938666E 07	0.01534971
24	16	PG14	30.	4080.	0.759924E 07	0.02899588	0.352244E 07	0.01344033
25	17	PG24	30.	4110.	0.715755E 07	0.02731054	0.308075E 07	0.01175499
26	18	PG34	20.	4130.	0.455352E 07	0.02606182	0.183566E 07	0.01050628
27	19	PG44	20.	4150.	0.442263E 07	0.02531264	0.170476E 07	0.00957570
28	15	PG53	70.	4220.	0.141354E 08	0.02312167	0.462634E 07	0.00756612

PLANTS WITH MORE THAN ONE BLOCK OF CAPACITY

PLANT	NAME	BLOCKS	MWE	ADJUSTED ENERGY	ADJUSTED CF	UNADJUSTED ENERGY	UNADJUSTED CF
1	PG11	2	500.0	0.269325E 10	0.61658752	0.281483E 10	0.64442158
2	PG21	2	500.0	0.274829E 10	0.62918812	0.287412E 10	0.65799439
3	PG31	2	500.0	0.305042E 10	0.69335562	0.326008E 10	0.74635631
4	PG41	2	500.0	0.336159E 10	0.76939509	0.138259E 10	0.31652611
9	PG52	2	320.0	0.151543E 10	0.54209358	0.145473E 10	0.52037954
8	PG42	2	280.0	0.111928E 10	0.45762014	0.105087E 10	0.42961419
7	PG32	2	270.0	0.576433E 09	0.41396737	0.880175E 09	0.37315792
6	PG22	2	250.0	0.662559E 09	0.30336958	0.554844E 09	0.25404960
5	PG12	2	240.0	0.541334E 09	0.25821501	0.430693E 09	0.20542037

ENERGY TOTALS

DEMANDED:0.193636E 11 KWH GENERATED:0.191513E 11 KWH GENERATED PLUS FIRM:0.193593E 11 KWH

ANNUAL FAILURE FREQUENCY = 0.58022E 00

MEAN TIME BETWEEN FAILURES (IN YRS.) = 0.17235E 01

IN YEAR NO. 1 TO MEET ONCE IN 10.0 YEARS CRITERION FOR FAILURE

RESERVE REQUIREMENT IS 279. MWE (DELMG = 264.9)

INPUT RESERVE INFO--FUEL(C/MBTU)--HEAT RATE(THOU BTU/KWH)--O&M(\$/KWE-YR)--O&M(M/KWH)--CAPITAL(\$/KWE)--CAPACITY FACTOR--CHARGE RATE
 200.00 14.000 1.000 0.80 150.00 0.0050 0.1600
 INTERTIE CAPITAL COST = 0.30 \$/KW-DAY INTERTIE ENERGY CCST = 15.00 MILLS/KWH

INDIVIDUAL UNIT COSTS IN MILLS PER KWH											
PLANT	ORDER	MWE	BLKMW	BLKFW	INCOP	RUN	FUEL	O&M	CAPITAL	TOTAL	NAME
	1		340.	2.76	0.24	3.00					
	12		160.	2.28	0.24	2.52					
1	2	500.	340.	2.76	0.24	3.00	2.66	0.98	8.91	12.55	PG11
	11		160.	2.28	0.24	2.52					
2	3	500.	300.	2.07	0.24	2.31	2.65	0.97	8.73	12.35	PG21
	7		200.	2.18	0.24	2.42					
3	6	500.	200.	5.22	0.17	5.39	2.11	0.90	7.87	10.88	PG31
	4		300.	5.22	0.17	5.39					
4	14	500.	130.	8.48	0.35	8.83	5.22	0.54	7.14	12.91	PG41
	16		110.	7.06	0.35	7.41					
5	13	240.	140.	8.23	0.35	8.58	7.98	1.68	14.19	23.85	PG12
	17		110.	6.97	0.35	7.32					
6	10	250.	160.	7.81	0.29	8.10	7.91	1.46	12.07	21.46	PG22
	18		110.	7.48	0.29	7.77					
7	9	270.	170.	7.48	0.29	7.77	7.76	1.12	8.85	17.73	PG32
	19		110.	7.22	0.29	7.51					
8	8	280.	190.	8.62	0.12	8.74	7.45	1.04	8.00	16.49	PG42
	15		130.	7.48	0.12	7.60					
9	5	320.	290.	34.86	0.42	35.28	8.41	0.75	6.76	15.92	PG52
10	20	290.	110.	7.88	0.12	7.99	34.86	0.83	4.33	40.02	PG62
11	21	110.	110.	7.88	0.12	7.99	7.87	3.22	33.07	44.16	PG13
12	22	110.	110.	7.88	0.12	7.99	7.87	3.65	37.65	49.18	PG23
13	23	110.	70.	11.44	0.48	11.92	7.87	4.04	41.82	53.73	PG33
14	24	70.	70.	11.44	0.48	11.92	11.44	11.55	118.52	141.56	PG43
15	25	70.	30.	28.16	0.41	28.57	11.44	15.33	158.42	185.19	PG53
16	26	30.	30.	28.16	0.41	28.57	28.16	4.36	63.16	95.69	PG14
17	27	30.	20.	41.99	0.60	42.59	28.16	4.60	67.06	99.83	PG24
18	28	20.					41.99	4.99	70.28	117.26	PG34

19 27 20. 41.99 0.60 42.59 41.99 5.12 72.36 119.47 PG44

COST SUMMARY

	DOLLARS	MILLS/KWH
FUEL	154739648.00	8.08
OPERATION AND MAINTENANCE	18491392.00	0.97
CAPITAL	165429696.00	8.64
SUBTOTAL	338670592.00	17.68
RESERVE	7323832.00	599.58
SUBTOTAL	345994496.00	18.05
FIRM PURCHASES	15603094.00	75.01
TOTAL	361597440.00	18.67

TOTAL ENERGY (KWH) 0.193716E 11
 WEIGHTED AVERAGE COST (MILLS/KWH) 18.6664

YEAR 1 DISCOUNT FACTOR= 0.07
 PRESENT VALUE AT BASE YEAR 345769216.00

***** YEAR NUMBER 2 *****

YEAR NO. 2 ANNUAL PEAK LOAD ADJUSTED TO 3885.00 MW

GROUP NO.	FO RATE	TIME TC REPAIR (HRS)	MWE PER UNIT	NO. OF UNITS	MAX NO OUT AT ONE TIME
1	0.080	80.0	500.0	4	4
2	0.040	40.0	275.0	6	4
3	0.060	40.0	120.0	5	3
4	0.060	40.0	50.0	4	3

PLANT NAME	CAP COST \$/KWE	GEM M/KWH	C&M \$/KWE-YR	FUEL C/MBTU	BLGCKS	LOAD	HEAT RATE THO BTU/KWH	MWE IN BLCK
1 PG11	300.	0.24	4.00	23.00	2	1	12.00	340.00
						12	9.90	160.00
2 PG21	300.	0.24	4.00	23.00	2	2	12.00	340.00
						11	9.90	160.00
3 PG31	300.	0.24	4.00	23.00	2	3	9.00	300.00
						7	9.50	200.00
4 PG41	300.	0.17	2.50	55.00	2	6	9.50	200.00
						4	9.50	300.00
5 PG12	200.	0.35	3.00	84.00	2	14	10.10	130.00
						16	8.40	110.00
6 PG22	200.	0.35	3.00	84.00	2	13	9.80	140.00
						17	8.30	110.00
7 PG32	200.	0.29	3.00	84.00	2	10	9.30	160.00
						18	8.90	110.00
8 PG42	200.	0.29	3.00	84.00	2	9	8.90	170.00
						19	8.60	110.00
9 PG52	200.	0.12	3.00	88.00	2	8	9.80	190.00
						15	8.50	130.00
10 PG62	200.	0.42	3.00	249.00	1	5	14.00	290.00
11 PG13	200.	0.12	3.00	75.00	1	20	10.50	110.00
12 PG23	200.	0.12	3.00	75.00	1	21	10.50	110.00
13 PG33	200.	0.12	3.00	75.00	1	22	10.50	110.00
14 PG43	200.	0.48	3.00	104.00	1	23	11.00	70.00
15 PG53	200.	0.48	3.00	104.00	1	28	11.00	70.00
16 PG14	100.	0.41	1.00	215.00	1	24	13.10	30.00
17 PG24	100.	0.41	1.00	215.00	1	25	13.10	30.00
18 PG34	100.	0.60	1.00	247.00	1	26	17.00	20.00
19 PG44	100.	0.60	1.00	247.00	1	27	17.00	20.00

NUMBER OF WEEKS OF SCHEDULED OUTAGE BY GROUP AND BY TWO WEEK CATEGORIES

GROUP NO	2 WEEKS	4 WEEKS	6 WEEKS	8 WEEKS
1	0	0	1	3
2	0	3	2	1
3	0	5	0	0
4	4	0	0	0

BIWEEKLY PERIOD	---1---	---2---	---3---	---4---	---5---	---6---	---7---	---8---	---9---	TOTAL SCHEDULED OUTAGE	LOAD PLUS SCHEDULED OUTAGE
	UP,DOWN	UP,DOWN	UP,DOWN	UP,DOWN	UP,DOWN	UP,DOWN	UP,DOWN	UP,DOWN	UP,DOWN		
1	3 1	5 1	5 0	4 0						775.0	3960.7
2	3 1	5 1	5 0	4 0						775.0	3999.5
3	3 1	6 0	5 0	2 2						600.0	3746.8
4	3 1	5 1	5 0	4 0						775.0	3883.0
5	3 1	5 1	5 0	4 0						775.0	3883.0
6	3 1	5 1	5 0	4 0						775.0	3844.1
7	3 1	5 1	4 1	4 0						855.0	3925.3
8	3 1	6 0	3 2	4 0						740.0	3848.0

9	3	1	6	0	4	1	4	0
10	3	1	6	0	4	1	4	0
11	4	0	5	1	4	1	4	0
12	4	0	5	1	5	0	4	0
13	4	0	6	0	5	0	3	1
14	4	0	6	0	5	0	4	0
15	4	0	6	0	5	0	4	0
16	4	0	6	0	5	0	4	0
17	4	0	6	0	4	1	4	0
18	4	0	6	0	3	2	3	1
19	3	1	6	0	4	1	4	0
20	3	1	6	0	5	0	4	0
21	3	1	5	1	5	0	4	0
22	3	1	5	1	5	0	4	0
23	4	0	4	2	5	0	4	0
24	4	0	4	2	5	0	4	0
25	4	0	4	2	5	0	4	0
26	3	1	6	0	5	0	4	0

620.0	3844.5
620.0	3922.2
395.0	3891.5
275.0	3965.7
50.0	3779.6
0.0	3807.3
0.0	3885.0
0.0	3807.3
120.0	3849.6
290.0	3786.5
620.0	3922.2
500.0	3802.2
775.0	3883.0
775.0	3960.7
550.0	3852.2
550.0	3852.2
550.0	3968.8
500.0	3841.1

AT YEAR 2, PERIOD 1.

A NEW PLANT IS ADDED TO GROUP 1 AT LOADING ORDER 1
SYSTEM CAPACITY 4950.0 MWE

GROUP NO.	FC RATE	TIME TO REPAIR (HRS)	MWE PER UNIT	NO. OF UNITS	MAX NO OUT AT ONE TIME
1	0.080	80.0	500.0	5	5
2	0.040	40.0	275.0	6	4
3	0.060	40.0	120.0	5	3
4	0.060	40.0	50.0	4	3

PLANT NAME	CAP COST \$/KWE	O&M \$/KWH	O&M \$/KWE-YR	FUEL C/MBTU	BLOCKS	LOAD	HEAT RATE THO BTU/KWH	MWE IN BLOCK
1 PG11	300.	0.24	4.00	23.00	2	2	12.00	340.00
2 PG21	300.	0.24	4.00	23.00	2	13	9.50	160.00
3 PG31	300.	0.24	4.00	23.00	2	3	12.00	340.00
4 PG41	300.	0.17	2.50	55.00	2	12	9.90	160.00
5 PG12	200.	0.35	3.00	84.00	2	4	9.00	300.00
6 PG22	200.	0.35	3.00	84.00	2	8	9.50	200.00
7 PG32	200.	0.29	3.00	84.00	2	7	9.50	200.00
8 PG42	200.	0.29	3.00	84.00	2	5	9.50	300.00
9 PG52	200.	0.12	3.00	88.00	2	15	10.10	130.00
10 PG62	200.	0.42	3.00	249.00	1	17	8.40	110.00
11 PG13	200.	0.12	3.00	75.00	1	14	9.80	140.00
12 PG23	200.	0.12	3.00	75.00	1	18	8.30	110.00
13 PG33	200.	0.12	3.00	75.00	1	11	9.30	160.00
14 PG43	200.	0.48	3.00	104.00	1	19	8.90	110.00
15 PG53	200.	0.48	3.00	104.00	1	10	8.90	170.00
16 PG14	100.	0.41	1.00	215.00	1	20	8.60	110.00
17 PG24	100.	0.41	1.00	215.00	1	9	9.80	150.00
18 PG34	100.	0.60	1.00	247.00	1	16	8.50	130.00
19 PG44	100.	0.60	1.00	247.00	1	6	14.00	290.00
20	300.	0.24	4.00	23.00	1	21	10.50	110.00
						22	10.50	110.00
						23	10.50	110.00
						24	11.00	70.00
						25	11.00	70.00
						26	13.10	30.00
						27	17.00	20.00
						28	17.00	20.00
						1	12.00	500.00

NUMBER OF WEEKS OF SCHEDULED OUTAGE BY GROUP AND BY TWO WEEK CATEGORIES

GROUP NO	2 WEEKS	4 WEEKS	6 WEEKS	8 WEEKS
1	0	0	2	3
2	0	3	2	1
3	0	5	0	0
4	4	0	0	0

BIWEEKLY PERIOD	---1--- UP,DOWN	---2--- UP,DOWN	---3--- UP,DOWN	---4--- UP,DOWN	---5--- UP,DOWN	---6--- UP,DOWN	---7--- UP,DOWN	---8--- UP,DOWN	---9--- UP,DOWN	TOTAL SCHEDULED OUTAGE	LCAC PLUS SCHEDULED OUTAGE
1	4 1	5 1	5 0	4 0						775.0	3960.7
2	4 1	5 1	5 0	4 0						775.0	3999.5
3	4 1	5 1	5 0	4 0						775.0	3921.8
4	4 1	5 1	4 1	4 0						895.0	4003.0
5	4 1	5 1	4 1	4 0						895.0	4003.0
6	4 1	5 1	4 1	4 0						895.0	3964.1
7	4 1	5 1	4 1	4 0						895.0	3925.3
8	4 1	5 1	5 0	4 0						775.0	3883.0
9	4 1	5 1	5 0	4 0						775.0	3999.5
10	4 1	6 0	4 1	4 0						620.0	3922.2
11	5 0	5 1	4 1	4 0						395.0	3891.5
12	5 0	5 1	5 0	4 0						275.0	3965.7
13	5 0	5 1	5 0	4 0						275.0	4004.6
14	5 0	6 0	5 0	3 1						50.0	3857.3
15	5 0	6 0	5 0	4 0						0.0	3885.0
16	5 0	6 0	5 0	3 1						50.0	3857.3
17	5 0	5 1	5 0	4 0						275.0	4004.6
18	5 0	5 1	4 1	4 0						395.0	3851.5
19	4 1	6 0	4 1	4 0						620.0	3922.2
20	4 1	6 0	5 0	3 1						550.0	3852.2
21	4 1	5 1	5 0	4 0						775.0	3883.0
22	4 1	5 1	5 0	4 0						775.0	3960.7
23	4 1	6 0	4 1	4 0						620.0	3922.2
24	4 1	6 0	4 1	4 0						620.0	3922.2
25	4 1	6 0	5 0	4 0						500.0	3918.8
26	4 1	6 0	5 0	3 1						550.0	3891.1

AT YEAR 2, PERIOD 1

REPAIR TIME OF GROUP 1 IS NOW 60. HOURS
SUMMED BIWEEK TIE CAPACITY 4550. MWE, TEST MARGIN 0.40
FIRM ENERGY PURCHASES (OR SALES) 4.0 HCUPS PER DAY FOR 10 DAYS PER PERIOD

PERIOD	MWE	TIE
1	200.0	115.1
2	200.0	183.9
3	200.0	40.3
4	200.0	129.9
5	200.0	129.9
6	200.0	57.0
7	200.0	0.0
8	200.0	0.0
9	200.0	189.9
10	200.0	127.2
11	200.0	191.0
12	200.0	398.7
13	200.0	473.6
14	200.0	314.9
15	200.0	394.1

16	200.0	314.9
17	200.0	473.6
18	200.0	191.0
19	200.0	127.2
20	200.0	31.2
21	200.0	0.0
22	200.0	115.1
23	200.0	127.2
24	200.0	127.2
25	200.0	185.3
26	200.0	106.1

ENERGY ALLOCATION

LOAD	PLANT	NAME	MWE	SUM MWE	ADJUSTED ENERGY	ADJUSTED CF	UNADJUSTED ENERGY	UNADJUSTED CF
1	20		500.	500.	0.325632E 10	0.74549574	0.351840E 10	0.00549560
2	1	PG11	340.	840.	0.211053E 10	0.71055967	0.228875E 10	0.770560C3
3	2	PG21	340.	1180.	0.211035E 10	0.71051151	0.228861E 10	0.77051187
4	3	PG31	300.	1480.	0.194063E 10	0.74047154	0.201925E 10	0.77047199
5	4	PG41	300.	1780.	0.202221E 10	0.77159870	0.210083E 10	0.30159909
6	10	PG62	290.	2070.	0.205368E 10	0.81063098	0.212969E 10	0.34063125
7	4	PG41	200.	2270.	0.114520E 10	0.65544981	0.119762E 10	0.58544996
8	3	PG31	200.	2470.	0.103410E 10	0.59186357	0.990074E 09	0.56666315
9	9	PG52	190.	2660.	0.987182E 09	0.59474546	0.945705E 09	0.56975681
10	8	PG42	170.	2830.	0.780213E 09	0.52535349	0.735530E 09	0.49526632
11	7	PG32	160.	2990.	0.610475E 09	0.43675256	0.559322E 09	0.40015566
12	2	PG21	160.	3150.	0.445371E 09	0.31853183	0.382087E 09	0.27335638
13	1	PG11	160.	3310.	0.375112E 09	0.26836663	0.306666E 09	0.21539796
14	6	PG22	140.	3450.	0.275907E 09	0.22559118	0.212172E 09	0.17347950
15	5	PG12	130.	3580.	0.210863E 09	0.18567079	0.148349E 09	0.13062602
16	9	PG52	130.	3710.	0.173585E 09	0.15285003	0.108337E 09	0.09539384
17	5	PG12	110.	3820.	0.120420E 09	0.12531197	0.632624E 08	0.66583250
18	6	PG22	110.	3930.	0.104225E 09	0.10845876	0.458772E 08	0.04774106
19	7	PG32	110.	4040.	0.929773E 08	0.09675461	0.338036E 08	0.03517694
20	8	PG42	110.	4150.	0.844736E 08	0.08790541	0.246751E 08	0.02567755
21	11	PG13	110.	4260.	0.780897E 08	0.08126211	0.178221E 08	0.01854615
22	12	PG23	110.	4370.	0.725332E 08	0.07547998	0.118574E 08	0.01233917
23	13	PG33	110.	4480.	0.215467E 08	0.02242208	0.766186E 07	0.00797312
24	14	PG43	70.	4550.	0.122680E 08	0.02006147	0.343216E 07	0.00561251
25	16	PG14	30.	4580.	0.504284E 07	0.01924159	0.125605E 07	0.00479262
26	17	PG24	30.	4610.	0.488187E 07	0.01862742	0.109509E 07	0.00417845
27	18	PG34	20.	4630.	0.318945E 07	0.01825465	0.664930E 06	0.00380569
28	19	PG44	20.	4650.	0.312433E 07	0.01788194	0.599811E 06	0.00343299
29	15	PG53	70.	4720.	0.104959E 08	0.01716359	0.166005E 07	0.00271462

PLANTS WITH MORE THAN ONE BLOCK OF CAPACITY

PLANT	NAME	BLOCKS	MWE	ADJUSTED ENERGY	ADJUSTED CF	UNADJUSTED ENERGY	UNADJUSTED CF
1	PG11	2	500.0	0.248555E 10	0.56905806	0.259541E 10	0.59418827
2	PG21	2	500.0	0.255576E 10	0.58511013	0.267069E 10	0.61142224
3	PG31	2	500.0	0.297473E 10	0.68102854	0.300933E 10	0.68894857
4	PG41	2	500.0	0.316741E 10	0.72513932	0.119762E 10	0.27418000
9	PG52	2	320.0	0.116077E 10	0.41522545	0.105404E 10	0.37704638
8	PG42	2	280.0	0.864687E 09	0.35345888	0.760205E 09	0.31078500
7	PG32	2	270.0	0.703452E 09	0.29823476	0.593125E 09	0.25146055
6	PG22	2	250.0	0.380132E 09	0.17405289	0.258050E 09	0.11815459
5	PG12	2	240.0	0.331282E 09	0.15800631	0.211612E 09	0.10092902

ENERGY TOTALS

DEMANDED:0.203318E 11 KWH GENERATED:0.201450E 11 KWH GENERATED PLUS FIRM:0.203530E 11 KWH

ANNUAL FAILURE FREQUENCY = 0.20313E 00

MEAN TIME BETWEEN FAILURES (IN YRS.) = 0.32589E 01

IN YEAR NO. 2 TO MEET ONCE IN 10.0 YEARS CRITERION FOR FAILURE
RESERVE REQUIREMENT IS 279. MWE (DELMG = 198.1)

INPUT RESERVE INFO--FUEL(C/MBTU)--HEAT RATE(THOU BTU/KWH)--O&M(\$/KWE-YR)--O&M(M/KWH)--CAPITAL(\$/KWE)--CAPACITY FACTOR--CHARGE RATE
200.00 14.000 1.000 0.80 150.00 0.0050 0.1600
INTERTIE CAPITAL COST = 0.30 \$/KW-DAY INTERTIE ENERGY COST = 15.00 MILLS/KWH

INDIVIDUAL UNIT COSTS IN MILLS PER KWH						FUEL	O&M	CAPITAL	TOTAL	NAME
PLANT	ORDER	MWE	BLKMW	BLKFU	INCCP					
	2		340.	2.76	0.24	3.00				
	13		160.	2.28	0.24	2.52				
1		500.								
	3		340.	2.76	0.24	3.00	2.69	1.04	9.66	PG11
	12		160.	2.28	0.24	2.52				
2		500.								
	4		300.	2.07	0.24	2.31	2.68	1.02	9.39	PG21
	8		200.	2.18	0.24	2.42				
3		500.								
	7		200.	5.22	0.17	5.39	2.11	0.91	8.07	PG31
	5		300.	5.22	0.17	5.39				
4		500.								
	15		130.	8.48	0.35	8.83	5.22	0.56	7.58	PG41
	17		110.	7.06	0.35	7.41				
5		240.								
	14		140.	8.23	0.35	8.58	7.96	2.52	23.18	PG12
	18		110.	6.97	0.35	7.32				
6		250.								
	11		160.	7.81	0.29	8.10	7.89	2.32	21.05	PG22
	19		110.	7.48	0.29	7.77				
7		270.								
	10		170.	7.48	0.29	7.77	7.77	1.44	12.28	PG32
	20		110.	7.22	0.29	7.51				
8		280.								
	9		190.	8.62	0.12	8.74	7.45	1.26	10.36	PG42
	16		130.	7.48	0.12	7.60				
9		320.								
	6		290.	34.86	0.42	35.28	8.45	0.95	8.82	PG52
10		290.								
	21		110.	7.88	0.12	7.99	34.86	0.84	4.52	PG62
11		110.								
	22		110.	7.88	0.12	7.99	7.87	4.35	45.08	PG13
12		110.								
	23		110.	7.88	0.12	7.99	7.87	4.67	48.53	PG23
13		110.								
	24		70.	11.44	0.48	11.92	7.87	15.44	163.37	PG33
14		70.								
	29		70.	11.44	0.48	11.92	11.44	17.60	182.59	PG43
15		70.								
	25		30.	28.16	0.41	28.57	11.44	20.49	213.42	PG53
16		30.								
	26		30.	28.16	0.41	28.57	28.16	6.36	95.18	PG14
17		30.								
	27		20.	41.99	0.60	42.59	28.16	6.56	98.32	PG24
18		20.								
	28		20.	41.99	0.60	42.59	41.99	6.87	100.33	PG34
19		20.								
	1		500.	2.76	0.24	3.00	41.99	7.00	102.42	PG44
20		500.								
							2.76	0.85	7.37	10.98

COST SUMMARY

	DOLLARS	MILLS/KWH
FUEL	146439584.00	7.27
OPERATION AND MAINTENANCE	20658816.00	1.03
CAPITAL	189439680.00	9.40
SUBTOTAL	356578048.00	17.70
RESERVE	7323832.00	599.58
SUBTOTAL	363901696.00	18.05
FIRM PURCHASES	15603054.00	75.01
TOTAL	379504640.00	18.63

TOTAL ENERGY (KWH) 0.203652E 11
 WEIGHTED AVERAGE COST (MILLS/KWH) 18.6508

YEAR 2 DISCOUNT FACTOR= 0.07
 PRESENT VALUE AT BASE YEAR 692845056.00

***** YEAR NUMBER 3 *****
 YEAR NO. 3 ANNUAL PEAK LOAD ADJUSTED TO 4144.00 MW

GROUP NO.	FG RATE	TIME TC REPAIR (HRS)	MWE PER UNIT	NO. OF UNITS	MAX NO OUT AT ONE TIME
1	0.080	60.0	500.0	5	5
2	0.040	40.0	275.0	6	4
3	0.060	40.0	120.0	5	3
4	0.060	40.0	50.0	4	3

PLANT NAME	CAP COST \$/KWE	O&M M/KWH	O&M \$/KWE-YR	FUEL C/MBTU	BLOCKS	LOAD	HEAT RATE THE BTU/KWH	MWE IN BLOCK
1 PG11	300.	0.24	4.00	23.00	2	2	12.00	340.00
						13	9.90	160.00
2 PG21	300.	0.24	4.00	23.00	2	3	12.00	340.00
						12	9.90	160.00
3 PG31	300.	0.24	4.00	23.00	2	4	9.00	300.00
						8	9.50	200.00
4 PG41	300.	0.17	2.50	55.00	2	7	9.50	200.00
						5	9.50	300.00
5 PG12	200.	0.35	3.00	84.00	2	15	10.10	130.00
						17	8.40	110.00
6 PG22	200.	0.35	3.00	84.00	2	14	9.80	140.00
						18	8.30	110.00
7 PG32	200.	0.29	3.00	84.00	2	11	9.30	160.00
						19	8.90	110.00
8 PG42	200.	0.29	3.00	84.00	2	10	8.90	170.00
						20	8.60	110.00
9 PG52	200.	0.12	3.00	88.00	2	9	9.80	190.00
						16	8.50	130.00
10 PG62	200.	0.42	3.00	249.00	1	6	14.00	290.00
11 PG13	200.	0.12	3.00	75.00	1	21	10.50	110.00
12 PG23	200.	0.12	3.00	75.00	1	22	10.50	110.00
13 PG33	200.	0.12	3.00	75.00	1	23	10.50	110.00
14 PG43	200.	0.48	3.00	104.00	1	24	11.00	70.00
15 PG53	200.	0.48	3.00	104.00	1	29	11.00	70.00
16 PG14	100.	0.41	1.00	215.00	1	25	13.10	30.00
17 PG24	100.	0.41	1.00	215.00	1	26	13.10	30.00
18 PG34	100.	0.60	1.00	247.00	1	27	17.00	20.00
19 PG44	100.	0.60	1.00	247.00	1	28	17.00	20.00
20	300.	0.24	4.00	23.00	1	1	12.00	500.00

NUMBER OF WEEKS OF SCHEDULED OUTAGE BY GROUP AND BY TWO WEEK CATEGORIES

GROUP NO	2 WEEKS	4 WEEKS	6 WEEKS	8 WEEKS
1	0	0	2	3
2	0	3	2	1
3	0	5	0	0
4	4	0	0	0

BIWEEKLY PERIOD	---1--- UP,DOWN	---2--- UP,DOWN	---3--- UP,DOWN	---4--- UP,DOWN	---5--- UP,DOWN	---6--- UP,DOWN	---7--- UP,DOWN	---8--- UP,DOWN	---9--- UP,DOWN	TOTAL SCHEDULED OUTAGE	LOAD PLUS SCHEDULED OUTAGE
1	4 1	5 1	5 0	4 0						775.0	4173.1
2	4 1	5 1	5 0	4 0						775.0	4214.5
3	4 1	5 1	5 0	4 0						775.0	4131.6
4	4 1	5 1	4 1	4 0						895.0	4210.2
5	4 1	5 1	4 1	4 0						895.0	4210.2
6	4 1	5 1	4 1	4 0						895.0	4168.8
7	4 1	5 1	4 1	4 0						895.0	4127.3

8	4	1	5	1	5	0	4	0	775.0	4090.2
9	4	1	5	1	5	0	4	0	775.0	4214.5
10	4	1	6	0	4	1	4	0	620.0	4142.4
11	5	0	5	1	4	1	4	0	395.0	4124.6
12	5	0	5	1	5	0	4	0	275.0	4211.8
13	5	0	5	1	5	0	4	0	275.0	4253.2
14	5	0	6	0	5	0	3	1	50.0	4111.1
15	5	0	6	0	5	0	4	0	0.0	4144.0
16	5	0	6	0	5	0	3	1	50.0	4111.1
17	5	0	5	1	5	0	4	0	275.0	4253.2
18	5	0	5	1	4	1	4	0	395.0	4124.6
19	4	1	6	0	4	1	4	0	620.0	4142.4
20	4	1	6	0	5	0	3	1	550.0	4072.4
21	4	1	5	1	5	0	4	0	775.0	4090.2
22	4	1	5	1	5	0	4	0	775.0	4173.1
23	4	1	6	0	4	1	4	0	620.0	4142.4
24	4	1	6	0	4	1	4	0	620.0	4142.4
25	4	1	6	0	5	0	4	0	500.0	4146.7
26	4	1	6	0	5	0	3	1	550.0	4113.8

AT YEAR 3, PERIOD 5

PLANT 16 HAS BEEN RETIRED
SYSTEM CAPACITY 4900.0 MWE

GROUP NO.	FO RATE	TIME TO REPAIR (HRS)	MWE PER UNIT	NO. OF UNITS	MAX NO OUT AT ONE TIME
1	0.080	60.0	500.0	5	5
2	0.040	40.0	275.0	6	4
3	0.060	40.0	120.0	5	3
4	0.060	40.0	50.0	3	2

PLANT NAME	CAP COST	DEM	DEM	FUEL	BLOCKS	LOAD	HEAT RATE	MWE IN
	\$/KWH	%/KWH	\$/KWH-YR	C/MBTU			THO BTU/KWH	ELOC
1 PG11	300.	0.24	4.00	23.00	2	2	12.00	340.00
2 PG21	300.	0.24	4.00	23.00	2	13	9.90	160.00
3 PG31	300.	0.24	4.00	23.00	2	3	12.00	340.00
4 PG41	300.	0.17	2.50	55.00	2	12	9.90	160.00
5 PG12	200.	0.35	3.00	84.00	2	4	9.00	300.00
6 PG22	200.	0.35	3.00	84.00	2	8	9.50	200.00
7 PG32	200.	0.29	3.00	84.00	2	7	9.50	200.00
8 PG42	200.	0.29	3.00	84.00	2	5	9.50	200.00
9 PG52	200.	0.12	3.00	88.00	2	15	10.10	130.00
10 PG62	200.	0.42	3.00	249.00	1	17	8.40	110.00
11 PG13	200.	0.12	3.00	75.00	1	14	9.50	140.00
12 PG23	200.	0.12	3.00	75.00	1	18	8.20	110.00
13 PG33	200.	0.12	3.00	75.00	1	11	9.30	150.00
14 PG43	200.	0.43	3.00	104.00	1	19	8.90	110.00
15 PG53	200.	0.48	3.00	104.00	1	10	8.90	170.00
16 PG14	100.	0.41	1.00	215.00	1	20	8.60	110.00
17 PG24	100.	0.41	1.00	215.00	1	9	9.80	190.00
18 PG34	100.	0.60	1.00	247.00	1	16	8.50	130.00
19 PG44	100.	0.60	1.00	247.00	1	6	14.00	290.00

20 300. 0.24 4.00 23.00 1 1 12.00 500.00

NUMBER OF WEEKS OF SCHEDULED OUTAGE BY GROUP AND BY TWO WEEK CATEGORIES

GROUP NO	2 WEEKS	4 WEEKS	6 WEEKS	8 WEEKS
1	0	0	2	3
2	0	3	2	1
3	0	5	0	0
4	3	0	0	0

BIWEEKLY PERIOD	---1--- UP,DOWN	---2--- UP,DOWN	---3--- UP,DOWN	---4--- UP,DOWN	---5--- UP,DOWN	---6--- UP,DOWN	---7--- UP,DOWN	---8--- UP,DOWN	---9--- UP,DOWN	TOTAL SCHEDULED OUTAGE	LOAD PLUS SCHEDULED OUTAGE
1	4 1	5 1	5 0	3 0						775.0	4173.1
2	4 1	5 1	5 0	3 0						775.0	4214.5
3	4 1	5 1	5 0	3 0						775.0	4131.6
4	4 1	5 1	4 1	3 0						895.0	4210.2
5	4 1	5 1	4 1	3 0						895.0	4210.2
6	4 1	5 1	4 1	3 0						895.0	4168.8
7	4 1	5 1	4 1	3 0						895.0	4127.3
8	4 1	5 1	5 0	3 0						775.0	4090.2
9	4 1	5 1	5 0	3 0						775.0	4214.5
10	4 1	6 0	4 1	3 0						620.0	4142.4
11	5 0	5 1	4 1	3 0						395.0	4124.6
12	5 0	5 1	5 0	3 0						275.0	4211.8
13	5 0	5 1	5 0	3 0						275.0	4253.2
14	5 0	6 0	5 0	2 1						50.0	4111.1
15	5 0	6 0	5 0	3 0						0.0	4144.0
16	5 0	6 0	5 0	2 1						50.0	4111.1
17	5 0	5 1	5 0	3 0						275.0	4253.2
18	5 0	5 1	4 1	3 0						395.0	4124.6
19	4 1	6 0	4 1	3 0						620.0	4142.4
20	4 1	6 0	5 0	2 1						550.0	4072.4
21	4 1	5 1	5 0	3 0						775.0	4090.2
22	4 1	5 1	5 0	3 0						775.0	4173.1
23	4 1	6 0	4 1	3 0						620.0	4142.4
24	4 1	6 0	4 1	3 0						620.0	4142.4
25	4 1	6 0	5 0	3 0						500.0	4146.7
26	4 1	6 0	5 0	3 0						500.0	4063.8

AT YEAR 3, PERIOD 8

A NEW PLANT IS ADDED TO GROUP 1 AT LOADING ORDER 1
SYSTEM CAPACITY 5400.0 MWE

GROUP NO.	FO RATE	TIME TO REPAIR (HRS)	MWE PER UNIT	NO. OF UNITS	MAX NO OUT AT ONE TIME
1	0.060	60.0	500.0	6	6
2	0.040	40.0	275.0	6	4
3	0.060	40.0	120.0	5	3
4	0.060	40.0	50.0	3	2

PLANT NAME	CAP COST \$/KWE	O&M \$/KWH	O&M \$/KWE-YR	FUEL C/MBTU	BLOCKS	LOAD	HEAT RATE THO BTU/KWH	MWE IN BLOCK
1 PG11	300.	0.24	4.00	23.00	2	3	12.00	340.00
						14	9.90	160.00
2 PG21	300.	0.24	4.00	23.00	2	4	12.00	340.00
						13	9.90	160.00
3 PG31	300.	0.24	4.00	23.00	2	5	9.00	300.00
						9	9.50	200.00

4	PG41	300.	C.17	2.50	55.00	2	8	9.50	200.00
							6	9.50	300.00
5	PG12	200.	C.35	3.00	84.00	2	16	10.10	130.00
							18	8.40	110.00
6	PG22	200.	C.35	3.00	84.00	2	15	9.80	140.00
							19	8.30	110.00
7	PG32	200.	C.29	3.00	84.00	2	12	9.30	160.00
							20	8.90	110.00
8	PG42	200.	C.29	3.00	84.00	2	11	8.90	170.00
							21	8.60	110.00
9	PG52	200.	C.12	3.00	86.00	2	10	9.80	190.00
							17	8.50	130.00
10	PG62	200.	C.42	3.00	249.00	1	7	14.00	290.00
11	PG13	200.	0.12	3.00	75.00	1	22	10.50	110.00
12	PG23	200.	C.12	3.00	75.00	1	23	10.50	110.00
13	PG33	200.	0.12	3.00	75.00	1	24	10.50	110.00
14	PG43	200.	0.48	3.00	104.00	1	25	11.00	70.00
15	PG53	200.	0.48	3.00	104.00	1	30	11.00	70.00
16	PG14	100.	0.41	1.00	215.00	1	26	13.10	0.0
17	PG24	100.	0.41	1.00	215.00	1	27	13.10	30.00
18	PG34	100.	0.60	1.00	247.00	1	28	17.00	20.00
19	PG44	100.	0.60	1.00	247.00	1	29	17.00	20.00
20		300.	0.24	4.00	23.00	1	2	12.00	500.00
21		300.	0.24	4.00	23.00	1	1	12.00	500.00

NUMBER OF WEEKS OF SCHEDULED OUTAGE BY GROUP AND BY TWO WEEK CATEGORIES

GROUP NO	2 WEEKS	4 WEEKS	6 WEEKS	8 WEEKS
1	0	0	3	3
2	0	3	2	1
3	0	5	0	0
4	3	0	0	0

BIWEEKLY PERIOD	---1---	---2---	---3---	---4---	---5---	---6---	---7---	---8---	---9---	SCHEDULED OUTAGE	TOTAL SCHEDULED OUTAGE	LOAD PLUS SCHEDULED OUTAGE
1	5 1	5 1	5 0	3 0						775.0	775.0	4173.1
2	5 1	5 1	5 0	3 0						775.0	775.0	4214.5
3	5 1	5 1	5 0	3 0						775.0	775.0	4131.6
4	4 2	6 0	5 0	3 0						1000.0	1000.0	4315.2
5	4 2	6 0	5 0	3 0						1000.0	1000.0	4315.2
6	4 2	6 0	5 0	3 0						1000.0	1000.0	4273.8
7	5 1	5 1	4 1	3 0						895.0	895.0	4127.3
8	5 1	5 1	4 1	3 0						895.0	895.0	4210.2
9	5 1	5 1	5 0	3 0						775.0	775.0	4214.5
10	5 1	5 1	5 0	3 0						775.0	775.0	4257.4
11	6 0	5 1	5 0	1 2						375.0	375.0	4104.6
12	6 0	5 1	5 0	3 0						275.0	275.0	4211.8
13	6 0	5 1	5 0	3 0						275.0	275.0	4253.2
14	6 0	6 0	4 1	3 0						120.0	120.0	4181.1
15	6 0	6 0	4 1	3 0						120.0	120.0	4264.0
16	6 0	6 0	5 0	2 1						50.0	50.0	4111.1
17	6 0	5 1	5 0	3 0						275.0	275.0	4253.2
18	6 0	4 2	5 0	3 0						550.0	550.0	4275.6
19	5 1	5 1	5 0	3 0						775.0	775.0	4297.4
20	5 1	6 0	4 1	3 0						620.0	620.0	4142.4
21	5 1	5 1	4 1	3 0						895.0	895.0	4210.2
22	5 1	5 1	5 0	3 0						775.0	775.0	4173.1
23	5 1	6 0	3 2	3 0						740.0	740.0	4262.4
24	5 1	6 0	3 2	3 0						740.0	740.0	4262.4

25 5 1 6 0 5 0 3 0
 26 5 1 6 0 5 0 3 0
 SUMMED BIWEEK TIE CAPACITY 4550. MWE, TEST MARGIN 0.40
 FIRM ENERGY PURCHASES (OR SALES) 4.0 HGURS PER DAY FOR 10 DAYS PER PERIOD

500.0
 500.0

4146.7
 4063.8

PERIOD	MWE	TIE
1	0.0	159.4
2	0.0	175.1
3	0.0	143.3
4	0.0	160.4
5	0.0	162.2
6	0.0	147.2
7	0.0	132.6
8	0.0	89.2
9	0.0	124.3
10	0.0	200.5
11	0.0	128.3
12	0.0	252.7
13	0.0	291.3
14	0.0	265.8
15	0.0	341.1
16	0.0	219.9
17	0.0	291.3
18	0.0	243.0
19	0.0	200.5
20	0.0	98.9
21	0.0	89.2
22	0.0	86.7
23	0.0	177.6
24	0.0	177.6
25	0.0	134.0
26	0.0	57.8

ENERGY ALLOCATION

LOAD	PLANT	NAME	MWE	SUM MWE	ADJUSTED ENERGY	ADJUSTED CF	UNADJUSTED ENERGY	UNADJUSTED CF
1	21		500.	500.	0.267456E 10	0.61230779	0.293664E 10	0.67230785
2	20		500.	1000.	0.325280E 10	0.75384557	0.355488E 10	0.81384557
3	1	PG11	340.	1340.	0.213400E 10	0.71845937	0.221221E 10	0.77845961
4	2	PG21	340.	1680.	0.222118E 10	0.74781322	0.231029E 10	0.77781361
5	3	PG31	300.	1980.	0.192179E 10	0.73328447	0.200042E 10	0.76328456
6	4	PG41	300.	2280.	0.192121E 10	0.73306119	0.199982E 10	0.76306164
7	10	PG62	290.	2570.	0.181514E 10	0.71647114	0.189114E 10	0.74647170
8	4	PG41	200.	2770.	0.110119E 10	0.63025796	0.106325E 10	0.60854530
9	3	PG31	200.	2970.	0.876292E 09	0.50154090	0.820786E 09	0.46977228
10	9	PG52	190.	3160.	0.864828E 09	0.52103102	0.814625E 09	0.49078506
11	8	PG42	170.	3330.	0.662719E 09	0.44623929	0.609123E 09	0.41015035
12	7	PG32	160.	3490.	0.501040E 09	0.35845894	0.441010E 09	0.31551224
13	2	PG21	160.	3650.	0.349162E 09	0.24980086	0.277267E 09	0.19836515
14	1	PG11	160.	3810.	0.272957E 09	0.19528204	0.195109E 09	0.13958704
15	6	PG22	140.	3950.	0.209844E 09	0.17157567	0.139461E 09	0.11402851
16	5	PG12	130.	4080.	0.156776E 09	0.13804573	0.884457E 08	0.07787907
17	9	PG52	130.	4210.	0.155396E 09	0.13683110	0.869586E 08	0.07656956
18	5	PG12	110.	4320.	0.989461E 08	0.10296593	0.384947E 08	0.04005859
19	6	PG22	110.	4430.	0.969842E 08	0.10092425	0.363796E 08	0.03785751
20	7	PG32	110.	4540.	0.956856E 08	0.09957701	0.349838E 08	0.03640503
21	8	PG42	110.	4650.	0.856005E 08	0.08907807	0.241065E 08	0.02508584
22	11	PG13	110.	4760.	0.789232E 08	0.08212954	0.169076E 08	0.01759449
23	12	PG23	110.	4870.	0.739975E 08	0.07700366	0.115970E 08	0.01206814
24	13	PG33	110.	4980.	0.223653E 08	0.02327389	0.762080E 07	0.00793040
25	14	PG43	70.	5050.	0.123564E 08	0.02020597	0.297350E 07	0.00486247
26	16	PG14	0.	5050.	0.488187E 07	0.0	0.508123E 06	0.0
27	17	PG24	30.	5080.	0.522301E 07	0.01992907	0.120179E 07	0.00458557
28	18	PG34	20.	5100.	0.340356E 07	0.01548006	0.722741E 06	0.00413656

29	19	PG44	20.	5120.	0.334609E 07	0.01515115	0.665274E 06	0.00380766
30	15	PG53	70.	5190.	0.109565E 08	0.01791682	0.157364E 07	0.00257332

PLANTS WITH MORE THAN ONE BLOCK OF CAPACITY

PLANT NAME	BLOCKS	MWE	ADJUSTED ENERGY	ADJUSTED CF	UNADJUSTED ENERGY	UNADJUSTED CF
1 PG11	2	500.0	0.240595E 10	0.55104274	0.250732E 10	0.57402050
2 PG21	2	500.0	0.257035E 10	0.55844942	0.258756E 10	0.59235024
3 PG31	2	500.0	0.279303E 10	0.64058721	0.282120E 10	0.645879E1
4 PG41	2	500.0	0.302239E 10	0.69194007	0.106325E 10	0.24341816
9 PG52	2	320.0	0.102022E 10	0.36494976	0.901583E 09	0.32250954
8 PG42	2	280.0	0.748313E 09	0.30592585	0.633229E 09	0.258875G1
7 PG32	2	270.0	0.596729E 09	0.25298852	0.475994E 09	0.20180184
6 PG22	2	250.0	0.306823E 09	0.14048895	0.175841E 09	0.08051324
5 PG12	2	240.0	0.255722E 09	0.12196743	0.126940E 09	0.06054469

ENERGY TOTALS

DEMANDED:0.216372E 11 KWH GENERATED:0.217191E 11 KWH GENERATED PLUS FIRM:0.217191E 11 KWH

ANNUAL FAILURE FREQUENCY = 0.10524E 01

MEAN TIME BETWEEN FAILURES (IN YRS.) = 0.95020E 00

IN YEAR NO. 3 TO MEET ONCE IN 10.0 YEARS CRITERION FOR FAILURE
RESERVE REQUIREMENT IS 433. MWE (DELMEG = 458.61)

INPUT RESERVE INFO--FUEL(C/MBtu)--HEAT RATE(THOU BTU/KWH)--O&M(\$/KWE-YR)--O&M(M/KWH)--CAPITAL(\$/KWE)--CAPACITY FACTOR--CHARGE RATE

	200.00	14.000	1.000	0.80	150.00	0.0050	0.1600
--	--------	--------	-------	------	--------	--------	--------

INTERIE CAPITAL COST = 0.30 \$/KW-DAY INTERIE ENERGY COST = 15.00 MILLS/KWH

INDIVIDUAL UNIT COSTS IN MILLS PER KWH

PLANT	ORDER	MWE	BLKMW	BLKfu	INCCP	FUN	FUEL	O&M	CAPITAL	TOTAL	NAME
	3		340.	2.76	0.24	3.00					
	14		160.	2.28	0.24	2.52					
1	4	500.	340.	2.76	0.24	3.00	2.71	1.07	9.97	13.75	PG11
	13		160.	2.28	0.24	2.52					
2	5	500.	300.	2.07	0.24	2.31	2.69	1.02	9.34	13.05	PG21
	9		200.	2.18	0.24	2.42					
3	8	500.	200.	5.22	0.17	5.39	2.11	0.95	8.58	11.64	PG31
	6		300.	5.22	0.17	5.39					
4	16	500.	130.	8.48	0.35	8.83	5.22	0.58	7.94	13.75	PG41
	18		110.	7.06	0.35	7.41					
5	15	240.	140.	8.23	0.35	8.58	7.93	3.17	30.03	41.13	PG12
	19		110.	6.97	0.35	7.32					
6	12	250.	160.	7.81	0.29	8.10	7.83	2.79	26.07	36.70	PG22
	20		110.	7.48	0.29	7.77					
7	11	270.	170.	7.48	0.29	7.77	7.76	1.65	14.48	23.88	PG32
	21		110.	7.22	0.29	7.51					
8	10	280.	150.	8.62	0.12	8.74	7.45	1.41	11.97	20.83	PG42
	17		130.	7.48	0.12	7.60					
9	7	320.	290.	34.86	0.42	35.28	8.45	1.06	10.04	19.55	PG52

10		290.					34.86	0.90	5.11	40.87	PG62
11	22	110.	110.	7.88	0.12	7.99	7.87	4.30	44.60	56.78	PG12
12	23	110.	110.	7.88	0.12	7.99	7.87	4.58	47.57	60.02	PG23
13	24	110.	110.	7.88	0.12	7.99	7.87	14.87	157.39	180.14	PG33
14	25	70.	70.	11.44	0.48	11.92	11.44	17.48	181.28	210.20	PG43
15	30	70.	70.	11.44	0.48	11.92	11.44	19.65	204.44	235.53	PG53
16	26	0.	0.	28.16	0.41	28.57	28.16	0.41	0.0	28.57	PG14
17	27	30.	30.	28.16	0.41	28.57	28.16	6.15	91.90	126.22	PG24
18	28	20.	20.	41.99	0.60	42.59	41.99	6.48	94.02	142.49	PG34
19	29	20.	20.	41.99	0.60	42.59	41.99	6.58	95.63	144.20	PG44
20	2	500.	500.	2.76	0.24	3.00	2.76	0.85	7.29	10.90	
21	1	500.	500.	2.76	0.24	3.00	2.76	0.99	8.97	12.72	

COST SUMMARY

	DOLLARS	MILLS/KWH
FUEL	140326976.00	6.46
OPERATION AND MAINTENANCE	23004128.00	1.06
CAPITAL	212959680.00	9.80
SUBTOTAL	376300544.00	17.32
RESERVE	12677062.00	599.58
SUBTOTAL	388977664.00	17.89
FIRM PURCHASES	0.0	0.0
TOTAL	388977664.00	17.89

TOTAL ENERGY (KWH) 0.217446E 11
 WEIGHTED AVERAGE COST (MILLS/KWH) 18.3985

YEAR 3 DISCOUNT FACTOR= 0.07
 PRESENT VALUE AT BASE YEAR 1021480448.00

APPENDIX E - PARAMETER STUDIES

In order to assess the sensitivity of the computations in SYSREL to variations in its input, several parameter studies were made using the code. In most instances, one parameter was varied while holding all others constant so that the effect of the single parameter could be measured. The studies here concerned forced-outage rates, the calculation limiter (CRITER), the number of steps used in the energy calculations (STE), the program constant used to estimate capacity requirements (BB), and the average repair time.

1. Effect of Changing Forced-outage Rate

A 5990-Mw power generating system under a 5000-Mw annual peak demand was used to demonstrate the effect upon required reserve of perturbing the forced outage rates of plants. The characteristics of this system are summarized below.

<u>Group of Plants</u>	<u>Forced- outage Rate</u>	<u>Mw Per Unit</u>	<u>No. of Units in Group</u>
1	.08	500	4
2	.04	275	6
3	.05	120	12
4	.06	50	18

The application of SYSREL to this system yielded the results shown in Fig. E-1. The curve shows in percent the required reserve as all forced-outage rates in the base case are changed. The required reserve is the amount of capacity needed to meet a reliability criterion of system failure once in ten years. The lowering of the forced-outage rates sharply reduces the required reserve capacity needed to meet the reliability criterion.

In another study, SYSREL was used to assess the effect upon the mean time between system failures (MTBF) when forced-outage rate increases were not applied to all units but to various groups. The results of this study are shown in Fig. E-2. The plots show the mean time between system failures as the forced outage to each group is changed. Any increase to forced-outage rates will lower a plant's availability to the power-generating system and, in effect, reduce the reliability of the system as a whole. In a case such

Fig. E-1. Required Reserve Capacity as a Function of Forced-outage Rates

Fig. E-2. Effect on MTBF of Incrementing Forced-outage Rates of Several Large Plants

as this, a larger reserve requirement will be needed if the same reliability standard is to be met.

Another study was the assessment of the effect of size of units on the mean time between failures. For the purposes of this comparative study, the same Group 3 outage rates were assumed for (9) 160-Mw replacement units as for (12) 120-Mw existing units. Table E-1 summarizes the results of this study. For a fixed amount of megawatts (1440), the MTBF becomes larger as units of a smaller size are added to the system.

Table E-1. Effect of Size of Units on MTBF

Increment to Forced- outage Rate	MTBF (Years)	
	9 Units @ 160 Mw	12 Units @ 120 Mw
.01	6.74	8.36
.02	5.78	7.12
.04	4.31	5.28
.05	3.73	4.57

2. The Calculation Limiting Variable, CRITER

Since the calculation limiting variable, CRITER, is used to limit the memory requirements of the program, there will obviously be a tradeoff between accuracy and number of states saved. Two systems were used here to investigate the effects of varying CRITER, an actual system (7030 Mw) and a mock 5000-Mw system of 23 units.

The graph in Fig. E-3 shows the relationship between CRITER and the percent of states saved in the two systems. While the slope of the curves varies due to a heavy dependence of system size, load, and forced-outage rates, it is interesting to note that in the range of CRITER investigated (10^{-1} to 10^{-6}) the percent of states saved grows nearly linearly with the negative logarithm of CRITER. Percent of states saved is defined here (see Table A-1, Appendix A) as the number retained after the next to last meshing divided by the number of possible states using the maximum number down at one time limitation (NLIM).

Fig. E-3. Percent of States Saved During Tenth Period as a Function of CRITER, the Calculation-limiting Variable

The inaccuracy that occurs with varying CRITER is shown in Figs. E-4 and E-5. These two graphs represent runs on the 5000-Mw mock system and 7030-Mw actual system, respectively. For various values of CRITER both the mean time between failures (MTBF) and the additional reserve capacity needed (DELMEG) are plotted showing that large errors will occur with values of CRITER greater than 10^{-3} . A substantial increase in CPU time did not occur as CRITER became smaller. These studies show that a value larger than 10^{-3} leads to large inaccuracy and a value less than 10^{-5} only slightly improves the calculation and greatly increases the calculation time.

3. The Number of Steps Used in the Energy Calculation, STE

STE is a program variable that denotes the number of steps to use in the loss-of-load probability table used in the energy calculations. STE has no effect on the reliability calculation. It is difficult to assess the accuracy of the energy calculation, except perhaps by the difference between the amount of energy demanded and the amount generated. Because of the method used to calculate expected energy, the energy demanded would equal the energy generated only for a system that had perfectly reliable capacity that totaled more than the annual peak; thus some difference between energy demanded and energy generated is expected for all realistic systems. In one study with SYSREL, the demand-generation difference was observed to level off after 40 or more steps. The energy generated and difference between load and generated energy for one period in the study mentioned are shown plotted in Figs. E-6 and E-7, respectively. Of course, as the number of steps grows, the execution time does also. Execution time is graphed as a function of table size in Fig. E-8 for the studies used in Figs. E-6 and E-7. The sharp increase in execution time after 50 and 100 steps and the rather small differences between calculated energy levels for from 10 to 200 steps suggests that a number on the order of 20 to 50 is adequate for this type of computation.

4. Estimation of Required Capacity to Satisfy the Reliability Criterion

A routine is included in the code that calculates the megawatts of capacity required to meet the reliability criterion. This increment to required reserve capacity (DELMEG), is positive if the mean time between failures is less than time established as the criterion. The calculational routine

Fig. E-4. Variation in Calculated Values as a Function of the Calculation-limiting Variable, CRITER, for the 5000-Mw Mock System

Fig. E-5. Variation in Calculated Values as a Function of the Calculation-limiting Variable, CRITER, for the 7030-Mw System.

Fig. E-6. Calculated Values of Energy Generated During 14th Period as a Function of STE

Fig. E-7. Difference Between Calculated Values of Energy Demanded and Energy Generated for Several Table Sizes

^a(System of 23 plants run with SYSREL on an IBM 370/195, Batch)

Fig. E-8. CPU Execution Time as a Function of Table Size

is empirical; capacity requirements depend on system and generating unit characteristics. In order to provide flexibility, the user may input a constant BB, or use the default constant of 7.0. In either case, the appropriateness of the constant should be checked. Calculations have been made to show the impact on calculated capacity requirements with various values of BB. First, the code was used to calculate the mean time between failures versus the annual peak demand for systems of different capacities. The results of the calculations are shown as a series of curves in Fig. E-9. The next step was to calculate the additional amount of capacity required to meet the 10-year MTBF criteria at various points on these curves for various values of the constant BB. Using the results of these calculations, curves could be plotted showing the "additional estimated capacity" as calculated using BB versus the "true capacity increment" as determined using the curves in Fig. E-9. A plot of "additional estimated capacity" versus "true capacity increment" is shown in Fig. E-10 for various values of BB. The heavy solid 45° line is a plot of the desired curve. For this system, a value of BB equal to about 6.0 would give best results.

5. Effect of Varying Group Repair Time

In a study very similar to the one assessing forced-outage rates, the same system was used to observe the relationship between repair time and MTBF. Only group repair times were changed; forced-outage rates remained constant. All repair times in the system were altered by the same factor. As is shown in Fig. E-11, increasing repair times causes the mean time between failures to increase, and the relationship is linear. The explanation is that with a constant forced-outage rate and with an average repair time increase, the number of outages per unit time (frequency) decreases and the interval between outages must increase. For example, a plant with a forced-outage rate of 10% and average repair time of 8.76 hours would be expected to fail 100 times during the year (neglecting maintenance). Another plant with a 10% forced-outage rate and an average repair time of 876 hours would be expected to fail only once per year. The frequency of outages for the first plant is 100 times greater than the second plant; yet they are forced out the same amount of time (10%). Therefore, this study shows that with longer repair times and everything else unchanged, system failures occur less often but the average duration of the failures is longer.

Fig. E-9. MTBF vs Annual Peak Demand for 5 Similar Power-generating Systems

Fig. E-10. True-capacity Increment vs Estimated-capacity Increment Using Selected Values for BB (Annual Peak Demand = 5000 Mw)

Fig. E-11. MTBF vs Repair Time for Constant Forced-outage Rates