SYSGEN
Production Costing and Reliability Model
User Documentation

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PROGRAM SUMMARY

TITLE: ELECTRIC UTILITY SYSTEM GENERATION (SYSGEN)

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PURPOSE: The objective is to find the least cost operating schedule subject to operating constraints and to find the frequency, duration, and probability of loss of load for a given mix of generation units and given customer demand.

METHOD: The program uses a modified Booth-Baleriaux technique. This methodology treats plant outages as randomly occuring loads on other plants in a utility system.

SCOPE: The program can handle up to 34 time periods with up to 52 subperiods each and 300 generating units with five valve points. There can be up to 50 conventional hydro units and up to 50 storage units.

INPUT: The program requires the following general information: discount rate, customer load shapes, O&M and fuel escalation rates, immature forced outage correction factors, and for each generating unit: capacity plant lifetime, fuel cost, variable and fixed O&M costs, heat rate, mature forced outage rate, and a maintenance schedule. Optional inputs are load frequency curves, spinning reserve requirements, loading order, and for generating units: mean time to repair, spinning reserve cost, and penalty factor.

OUTPUT: Three levels of output are:

a. Initial and final load curves, system loss-of-load probability, unserved energy, and the total energy generated.

b. All of the above, plus yearly report of the energy generated and the associated costs for each unit.

c. All of the above plus an echo report of the input data and additional information on conventional and pumped hydro units.

I. Introduction

SYSGEN is a production costing and reliability model for thermal, hydro, and storage units on an electric power system. The methodology used in SYSGEN is described in the companion technical report, "Electric Power System Production Costing and Reliability Analysis including Hydroelectric, Storage, and Time Dependent Power Plants."[1] Two auxiliary programs, ELECTRA and SCYLLA are necessary for analyzing time dependent power plants as described in reference 3. Documentation for these programs is also available.[2,3]

SYSGEN was developed from a program, SYSINT, by Paul F. Deaton at MIT in 1973 to be used within a larger model for nuclear power management. In 1974, SYSGEN was incorporated into another MIT model, the Generation Expansion Model (GEM). GEM is a long-range planning model for electric utilities that includes environmental constraints. A discussion of the optimization can be found in reference 1, and a discussion of the data structure can be found in reference 6.

Since the work on GEM, SYSGEN has been modified substantially to include time subperiods, units with multiple valve points, maintenance scheduling, spinning reserve, startup costs. New algorithms have been developed for computing the effective load carrying capability of units, the frequency and duration of outages, and the energy available for storage.

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[1]Finger, S., "Electric Power System Producting Costing and Reliability Analysis Including Hydro-electric, Storage, and Time Dependent Power Plants, MIT Energy Lab Technical Report, January 1979.

[2]Finger, S., "ELECTRA, Time Dependent Electric Power Generation Operation Model, User Documentation," MIT Energy Lab Technical Report, May 1979.

[3]Finger, S., "SCYLLA, Time Dependent Electric Power Generation Evaluation Model User Documentation," MIT Energy Lab Technical Report, May 1979.

The following sections describe the available options, the interpretation and general form of input data, the functional algorithms, the logical flow of the program, the input format and the output reports. Detailed documentation of the subroutines and labelled commons are included as well as a sample problem and output report.

II. Operating Instructions

II.A. Level of Detail Options

SYSGEN has a set of logical variables that can be used to control the level of detail in the model. The options supersede any input parameters. For example, if the spinning reserve option, MSPIN, is set to false and the spinning reserve requirement is set to 200 MW, no spinning reserve algorithms will be implemented.

MULT controls the multiple increment algorithms. If MULT is set to false, units are modeled as on-off variables (i.e. as a single increment). The single increment characteristics can be input, or, if left blank, will be computed from the data for multiple increments.

MFREQ controls the frequency and duration algorithms. If MFREQ is set to false, no frequency curves are read in and no frequency calculations, such as the expected number of startups, are made. If it is necessary to compute the average duration of a load level for spinning reserve, the frequency of every load is assumed to be one.

MLORD controls the loading order computation. If MLORD is set to false, the loading order is input rather than being computed in the program. Only one loading order is read in and it is assumed to be the same for all time periods. If a plant is unavailable because it is on maintenance, retired or not yet installed, it is skipped over in the loading stack. The capacity of hydro plants and storage plants is adjusted so that they discharge as much energy as possible at their designated loading point. If MLORD is false and MSPIN is true, SYSGEN will compute the cost of keeping the necessary units on spinning reserve, but it will not change the loading order. Section III.A.10 explains how the loading order is found if MLORD is true.

MSPIN controls the spinning reserve requirements. If MSPIN is false, the loading order is not altered to meet reserve requirements and no computation of the cost of spinning reserve is made. Section III.A explains how the spinning reserve is computed if MSPIN is true. If MULT is false, MSPIN is automatically set to false.

MDLAY controls the hydro and storage dispatch strategy. If MDLAY is set to false, then reservoir hydro units are always loaded first, at reduced capacity to generate all their energy. Storage units are loaded as soon as their marginal costs put them in the loading order. If MDLAY is set to true, then hydro and storage units are delayed until they can generate all their energy at full capacity.

MOVE also controls the hydro and dispatch strategy. If MOVE is set to false, limited energy plants are loaded only at valve points of other units. That is, tests are made on the viability of bringing up a storage or hydro plant only after the previous increment has been completely loaded. If MOVE is true, then tests are made for every possible loading point. Setting MOVE to true will result in more efficient use of hydro and storage energy, but the running time will be longer. If MDLAY is set to false, MOVE is automatically set to false.

MSTOR controls the storage programs. If MSTOR is set to false, then the marginal cost of storage is set to the average cost of base load energy. The expected energy available is taken from the input reservoir size. An approximation of base load energy supplied is made on the basis of excess base load energy available disregarding capacity constraints. If MSTOR is true, then the storage algorithms are implemented. The dispatch of the storage is controlled in either case by MDLAY and MOVE.

MAINT controls the maintenance option. If MAINT is set to false, then the maintenance schedule must be input. If MAINT is set to true, then the submodel MAINTS is called and the maintenance schedule is calculated using the technique of filling in the valleys in the loss of load probability.

Note: This option is not yet implemented and MAINT is always false.

MSUB controls the time structure. If MSUB is set to false, then the subperiod data are aggregated and the program is run on time periods (normally years) without subperiods. This option is designed to facilitate using SYSGEN inside a long-range planning program without having to alter the data base. If MSUB is true, then the subperiods are run as they are input.

Note: This option is not yet implemented and MSUB is always true.

II.B. Time Structure

SYSGEN is currently designed to run for thirty-four time periods with up to fifty-two subperiods each. Normally the time periods are years. This is reflected in the data required. For example, in the input data the start and end times are in years, the discount rate and escalation factors are for one year. The immature forced outage multipliers are applied on a yearly basis, and the maintenance schedule is given in yearly cycles.

The subperiods may be months, weeks, or, in some cases, days. There can be at most fifty-two subperiods, but they may be of varying length. Each time period in the study has the same subperiod structure, i.e., it is not possible to have one year with twelve subperiods and another with only one subperiod within the same run.

Normally, the subperiods are months or weeks. Their length is determined by NWEEKS(i), the number of weeks in subperiod i, and HRWEEK, the number of hours in a week.

When changing from weeks to months or vice-versa, several portions of the input file must be changed. In the load data (card set C), one card is read for each subperiod, so the number of cards must equal the number of subperiods. If there are too many cards, the program will use the first cards it encounters and write a warning. If there are not enough cards, execution halts. If there are reservoir hydro units, the program reads the expected energy in each subperiod. Again, the program will write a warning if there are too many entries, and halt execution if there are too few.

Several variables are input in weekly values: NWEEKS(i), the number of weeks in subperiod i, WKSTOR(j), the weekly energy capacity of storage unit j, CHSIZE(i,j), the weekly energy size of hydro unit j in subperiod i, and NWPM(k,j), the number of weeks of preventative maintenance for unit j in maintenance period k, and INWK(j) and IRWK(j), the installment and retirement week of unit j. These variables are converted into hourly values by multiplying them by HRWEEK. Therefore, the time structure can be changed to days rather than weeks by setting HRWEEK=24.0 and modifying the inputs accordingly. This can be reflected in the output files by setting WKDAY = ' DAY'

II.C Present Worth and Escalation Factors

The discount rate, DR, is interpreted as a yearly value. The discount rate is applied to all dollar costs and it is assumed to be constant throughout the planning period. The value is entered as a fraction, i.e., a discount rate of 10.2 percent is entered as: '.102'. If present worth values are not desired, set the discount rate to 0.0. Costs are reported in the dollars of the year designated in the input in the input file as IRPDOL. The year of the costs in the input file are specified by INDOL. INDOL is used only for reporting. The conversion factor from input to report year dollars is given by CONVRT. It is assumed that the discount rate and escalation rates are nominal rates. A CPI can be specified to convert inflated dollars to real dollars.

The cross references for the escalation rates for fuel and for operating and maintenance costs are entered with the class data. This requires that all plants within a class, e.g. all intermediate oil-fired plants, have the same escalation factor series. (If this is not true, a new class can be created.) The escalation rates are entered in a table, ESCFAC (i,j) where i is the cross reference number and j is the year from the start of the study.

The formulas used to compute the present worth of escalated costs are given in section III.A.3. The value computed for each time period is assumed to be constant throughout subperiods of the time period.

II.D Customer Load

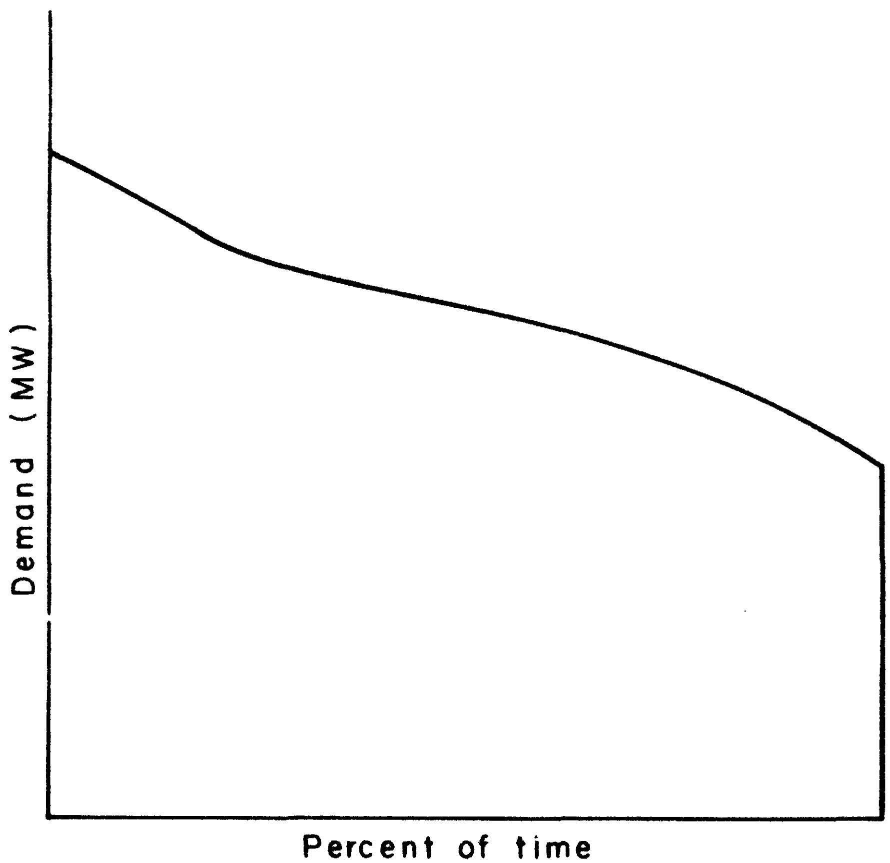
II.D.1 Load Duration Curve

The data on the customer load required by SYSGEN are the peak demand in each subperiod and the normalized load duration curve for each subperiod. If MFREQ is true, then a cumulative frequency curve is also required.

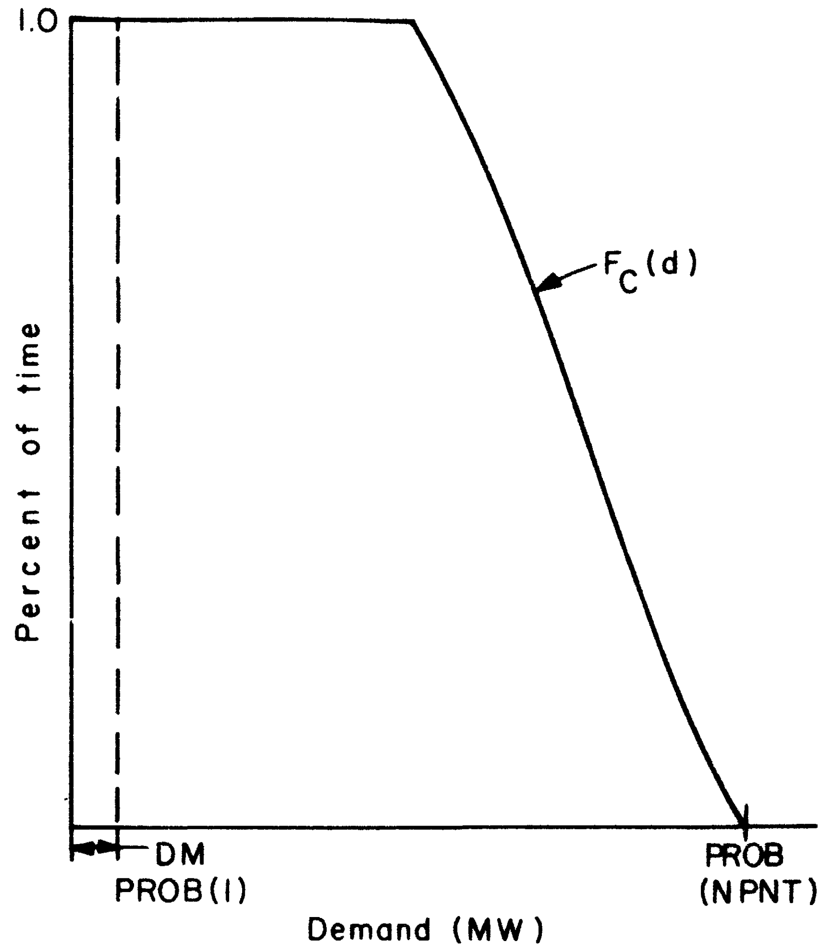
One card is entered for each subperiod, in sequential order, in the planning period. The information is the year number, the peak load in megawatts and the load shape number. The load shape number is a cross-reference to the curve entries that follow. There must be at least as many load shapes as the maximum load shape number entered here. After the subperiod cards, the load shapes are entered with no cards separating them. The number of values read is given by NPNT, the number of points in each curve. If the last entry in the curve is not zero, an error message is written and execution halts.

The load shape is entered in inverted form. That is, the value entered is the percent of time that a given load level is exceeded. This is equivalent to plotting the load duration curve with the vertical axis as time and the horizontal axis as megawatts. Values of time are then read off at equal megawatt spacings. For the input data, the horizontal axis should be divided into NPNT equal spacings. The first value entered is not the value on the vertical axis, but the value at the first spacing. The value on the vertical axis is assumed to be 1.0. The last value entered is the percent of time the peak demand is exceeded and should be zero. See figure 1.

The cumulative load duration curves can be computed from standard EEI hourly load data using ELECTRA (reference 4). The output of ELECTRA is in the proper format to be read into SYSGEN. If ELECTRA is run with time dependent units, the case number and unit characteristics can be printed in the echo report of the input data to SYSGEN.



Ia. Original load duration curve.



Ib. Inverted load duration curve.

Figure 1. Conversion of load duration curve to cumulative probability curve.

II.D.2. Frequency Curves

The frequency curves are stored in a separate file from the load curves and are ready only if MFREQ is set to true. The frequency curves are read in the same format as the load duration curve. The number of values read is given by NPNT. An error occurs if the last value is not zero. The first frequency curve is given the same cross-reference number as the first load shape and they are always used together.

The cumulative frequency curves can be created from the time of day customer demand curve by counting the number of times the load goes from a given demand level to a higher demand level as shown in figure 2. This value is normalized by the number of hours. The cumulative frequency curve is found by summing the number of times the load enters a state greater than the one it is currently in. See reference 3, section III.A.2 for more detail. These curves are also created in ELECTRA in the proper format to be read into SYSGEN.

II.E Class Data

Each plant in SYSGEN belongs to a class. The class identifies the type of plant, e.g., time dependent, conventional hydro, or storage; the loading class, e.g., base intermediate, or peak; the escalation factors; and the immature forced outage rates.

The plant type for the most part is used for reporting information only. The exceptions are hydro, storage, and time dependent plants. For a plant to be treated as conventional hydro, its plant type must be the same as ICHY as defined in the input file. For a plant to treated as storage, its plant type must be the same as ISTO as defined in the input file. Time dependent plants must have a plant type ITDP as defined in the input file.

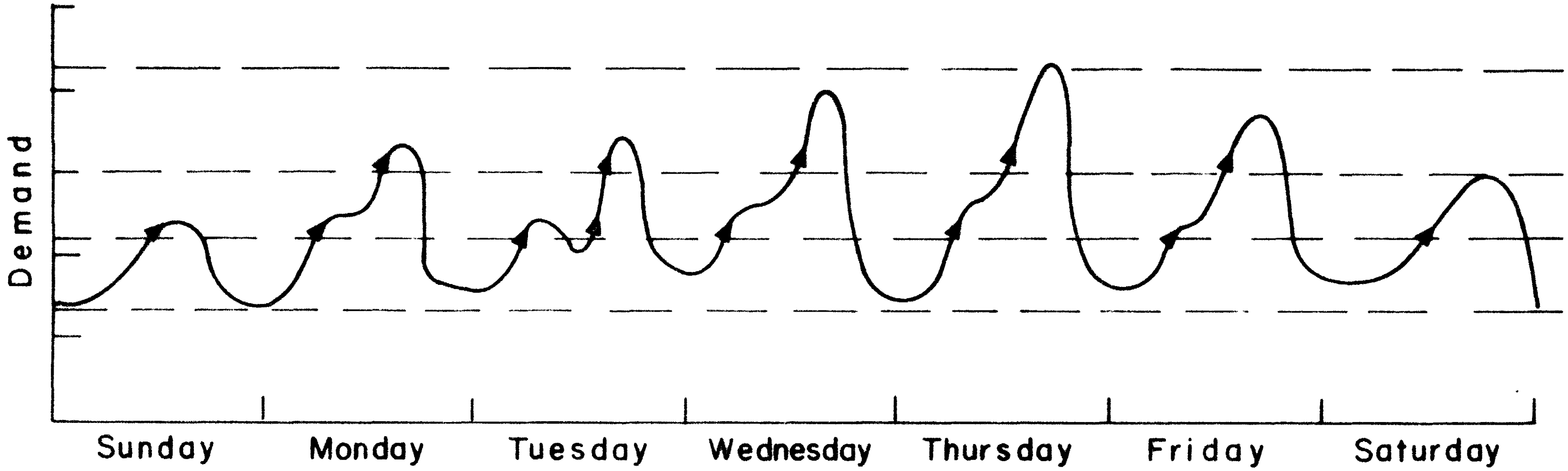


Figure 6a Weekly time dependent demand curve

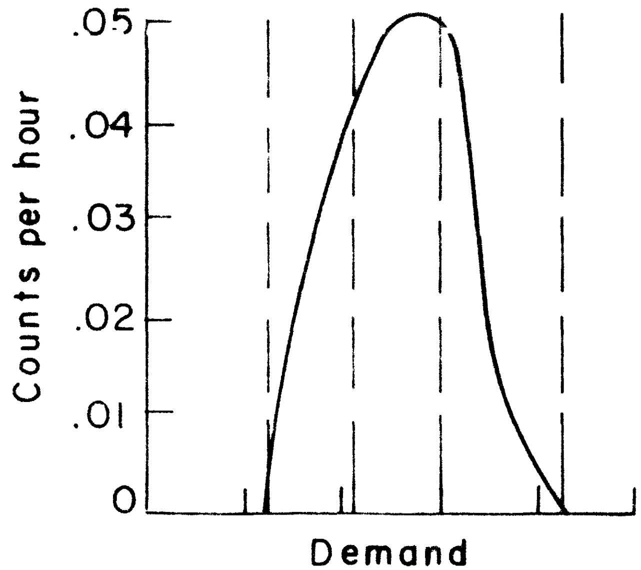


Figure 6b Frequency curve corresponding to curve 6a. The vertical axis plots the number of times the demand crosses a given level, normalized by the number of hours in a week

Figure 6 Demand frequency curve

The use of the loading type is discussed below in section II.G. The escalation factors are discussed in sections II.C and III.A.1. The immature forced outage rate is discussed below in section II.F.1.

II.F. Unit Data

Each unit can be modeled as an on-off variable with either all the capacity available or none of it available, or partial outages of units can be modeled. If partial outages are modeled, then the capacity, incremental heat rate, and forced outage rate for each valve point must be entered. If partial outages are not modeled, then the total capacity, total heat rate and equivalent forced outage rate are entered. Normally, both the individual valve point data and the total plant data are included in the input file. The program writes a warning if they are not consistent. If the logical variable MULT is set to true, partial outages are modeled.

Note: Within SYSGEN, the unit ID is used only for reporting.

Note: The class number is a cross-reference to the class information table. Specifying the class number specifies the plant type, the loading type, the escalation factors, and the immature forced outage multipliers.

Note: The installment year is the first year in which the unit operates. The installment week is the first week in the installment year that the unit operates. The retirement year is the last year in which the unit operates. The retirement week is the last week in the retirement year that the unit operates.

II.F.1 Forced Outage Rates

For multiple valve points, a forced outage rate must be entered for each valve point. The value entered should be the probability that the unit has a partial outage that includes that valve point but not the one beneath it. I.e., there is a probability, q_1, that the unit will have no capacity available, and a probability, q_2, that it will have just the first valve point available, and finally, a probability of p, that all the valve points will be available. This is discussed in greater detail in reference 3, section III.A.2 and is illustrated in figure 3.

If the program is run with all plants modeled as on-off variables, then an equivalent availabiity rate must be computed. The formula for this is given by:

$$p_E = 1 - \frac{\sum_{j=1}^{N} q_j \, CAP_j}{CAP} .$$

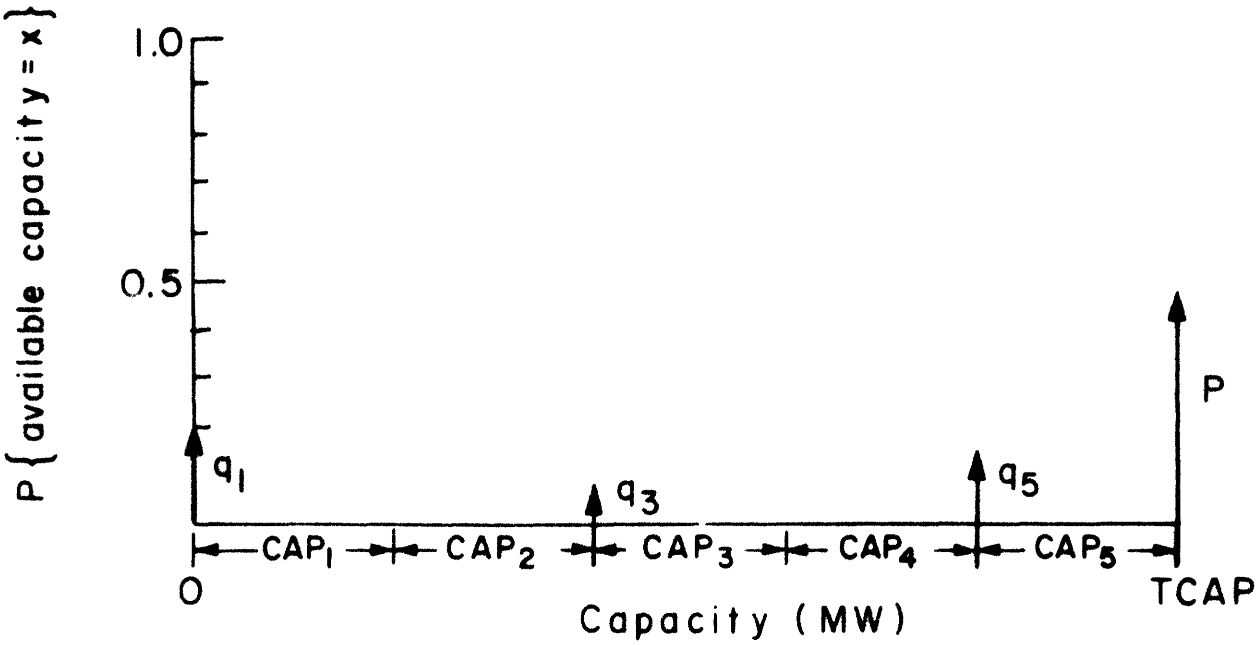
where

CAP = total capacity,

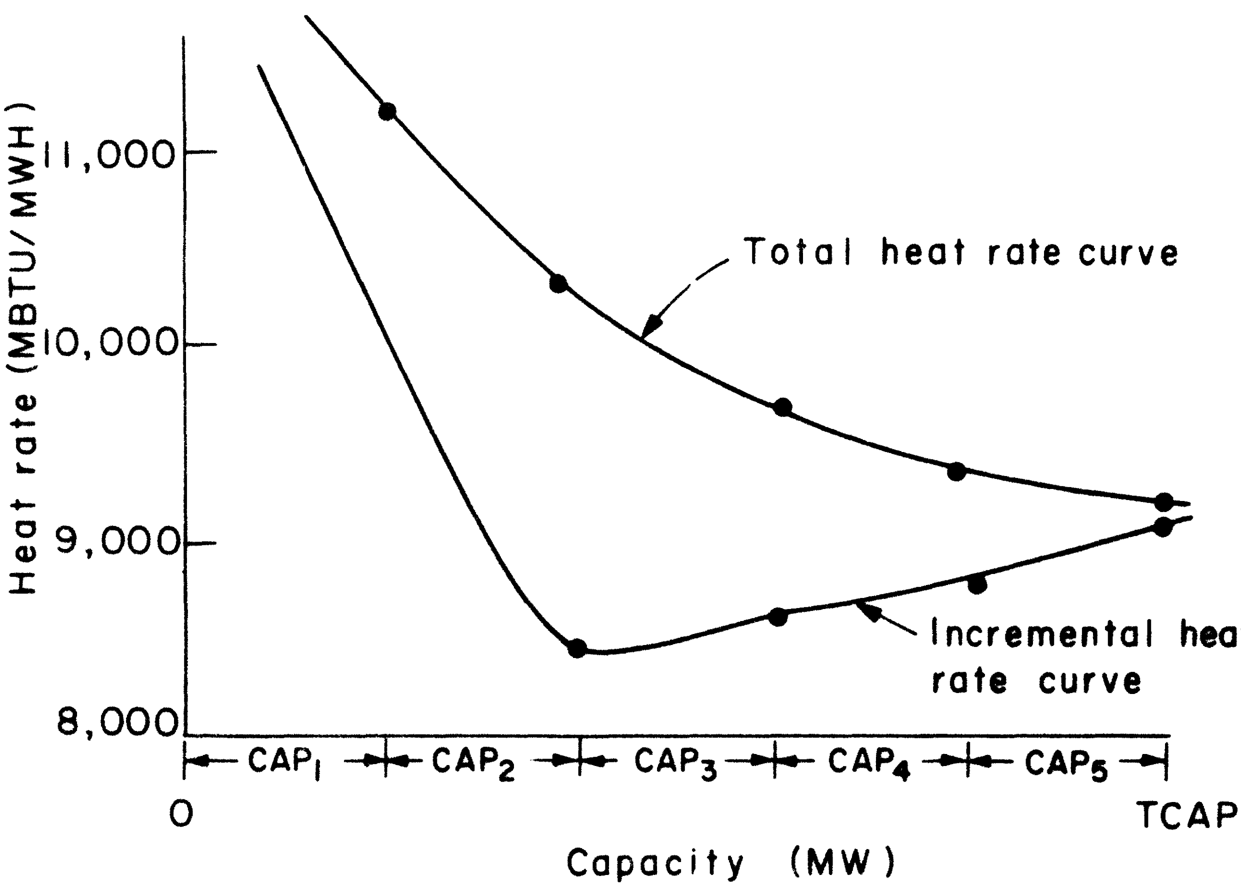
CAP_j = capacity forced out when valve point j fails.

The immature forced outage multipliers are used to allow for variations in reliability when a unit is first installed. The multipliers are entered in sets of up to ten years. For example, set 1 might be applicable to new combined cycle units. For the first year of operation, the forced outage rate of a combined cycle unit would be multiplied by the first entry in the first set of multipliers. During its second year of operation, its forced outage rate would be multiplied by the second entry in the first set and so on up to the tenth year of operation.

If no multipliers are desired for some class, a set of all "1.0" should be entered. If no multipliers are desired for all classes, then



3a. Probability distribution. $p + \Sigma q = 1$.



3b. Heat rate curves

Figure 3. Multiple valve pcint unit characteristics

one set of "1.0" should be entered. All cross-references to the immature forced outage table should be "01" pointing to that one set.

There can be up to ten sets of ten years each. The sets are referenced from the class data.

Note: Leaving an entry in the immature forced outage rate table blank, or equivalently setting it to zero, will result in a plant having a forced outage rate of zero. That is, the plant will be total reliable and will only be taken out of the system for preventative maintenance.

II.F.2 Frequency Characteristics

The unit input data include the mean time to repair a unit after it has failed. The mean time to repair is converted to the average forced outage occurrence rate using the following definitions and formulas:

R = mean time to repair (hours)

μ = 1/R

μ = average restoral rate (restorals per hour)

λ = average forced outage occurrence rate (outages per hour)

q = forced outage rate

= $\lambda/(\lambda+\mu)$

p = plant availability

= $\mu/(\lambda+\mu)$

λ = $q/(R * p)$.

In the conversion, the equivalent forced outage rate for the unit is used (see section II.F.1). In the frequency convolution all units are treated as on-off variables to avoid unproductive computations (see section II.A.8).

II.F.3 Limited Energy Units

The size for a conventional hydro unit is the expected energy available during one week discounting plant failures, i.e., it is the expected amount of water available expressed in MWHrs.

Purchase power can be modeled as a conventional hydro unit. The fuel cost ($/MBTU) should be set to the purchase price ($/MWH) and the heat rate set to 1.0. All other variables are equivalent to the hydro variables.

The size for a storage unit is the expected energy available during a week. The most realistic value for the size can be found from the maximum number of hours that the storage unit would generate on a typical day if there were no base loaded plant failures and no charging or generating failures for the storage unit. The generating to charging efficiency is the overall efficiency of the storage and generation process.

If a unit's class corresponds to ITDP, that is, it is a time dependent unit, then it must be modeled in ELECTRA using the load reduction algorithms. Time dependent units are included in SYSGEN only in the reports.

II.G Maintenance Schedule

If the maintenance schedule is input, the preventative maintenance is assumed to occur cyclically. The schedule is given by the number of years in the cycle, the subperiods in which maintenance starts and the number of weeks that the plant is down for each maintenance period. For example, a plant might have a maintenance cycle of 5 years, the plant being brought down in the 12th, 30th, 46th, and 55th subperiods of the

5-year period, and being down for 2 weeks the first time, 3 weeks the second time, 2 weeks the third time, and 5 weeks the last time. In the input file, this schedule would be given as

5 12 2 30 3 46 2 55 5.

The cycle would repeat and the plant would be brought down in the 12th month of the 6th year. If a plant is to be taken out for more than one subperiod in a row, then they must be entered explicitly.

II.H Loading Order

If MLORD is set to false, the loading order must be input as card set H. The loading order is entered by giving the valve point number then the unit index of the first increment to be loaded, then the valve point and unit index of the second and so on. The unit index is the number of the plant in the input deck. For example, the first unit in the input deck has the unit index 1. Specifying the loading order will save computer time.

The loading order can also be computed within SYSGEN. The loading order is found by ranking the units in order of increasing marginal cost. This ranking is subject to the constraints that valve points of a unit must be loaded in order and that hydro and storage units are interpolated where they can discharge all their energy to minimize costs (subject to MDLAY and MOVE). The ranking can also be modified by specifying a loading order option that sorts the units into base, intermediate and peaking groups as described below. The ranking may also be modified by specifying a spinning reserve requirement as described in section II.J.

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The loading order option LORDOP gives the user flexibility in loading the units. Each unit is labeled as a base, intermediate or peaking unit in the class input data . The labels can be used to form loading groups. For example, the intermediate and peaking units could be made into a loading group. In this case, the base-loaded units would be

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The loading order option itself is a three-digit number. The first digit refers to the group number of the base-loaded units, the second to the intermediate group number, and the third to the peaking group number. Within each group, plants are sorted in order of increasing marginal cost. Several examples follow:

LORDOP = 123 Base group is number one. Intermediate group number is two. Peak group number is three. All base-loaded units are loaded in order of increasing cost, then all intermediate units are loaded in order of increasing cost, then all peaking units are loaded in order of increasing cost.

LORDOP = 321 Base group number is three: Intermediate group number is two. Peak group number is one. All peaking units are loaded in order of increasing cost, then all intermediate units are loaded in order of increasing cost, and then all base units are loaded in order of increasing cost. This option is not likely to be chosen. It is shown only to illustrate how the group number is interpreted.

LORDOP = 112 Base and intermediate units are group one. Peak units are group two. Base and intermediate units are sorted together in order of increasing cost. After the most expensive base or intermediate unit has been loaded, then the least expensive peaking unit is loaded.

Note: When storage units are included in the study, units labeled BASE are used to charge storage. It is assumed that plants labeled BASE are designed to be run as much as possible. This may be an operating constraint, or it may reflect the marginal cost of the unit. In addition, all units labeled BASE must be loaded before the first storage unit can generate.

Note: Care should be taken in labeling conventional hydro units when storage units are included. Normally, the loading designation (BASE, INTR, or PEAK) is irrelevant for conventional hydro since it is interpolated into the loading order wherever it has sufficient energy to generate at full capacity. So that even though a conventional hydro unit is labeled BASE, it may be loaded with the intermediate or peaking units. This is only important if there are storage units in the study. The storage algorithm assumes that any unit labeled BASE has sufficient energy to generate 100 percent of the time. Therefore, only conventional hydro with enough energy to generate 100 percent of the time at full capacity should be labeled BASE.

Note: The loading designation for storage is not used unless MLORD is set to false. If MLORD is false, then after all the base units are loaded, the expected cost for each storage unit is computed from the cost of the energy used for storage. As soon as the marginal cost of the storage unit is less than the cost of the next plant to be loaded, the storage unit becomes available. Available storage units are loaded as soon as they have enough energy, generating at full capacity, to meet the demand. In practice, because of the inefficiencies in charging and the small size of storage units, they are usually used near the top of the loading order.

II.J Spinning Reserve

If MSPIN is set to true, then the program will modify the loading order to meet spinning reserve requirements and will compute the cost of keeping units in spinning reserve. The reserve requirement can be input as a percentage of the peak load, a percentage of the largest unit on-line, or as an absolute megawatt value. The variable PERCNT can be input to limit the maximum spinning reserve credit for any unit. As units are brought up unutilized capacity, up to maximum allowed, is put into the available reserve. If the available reserve does not equal the required reserve, then the loading order is modified to bring up another unit so that the reserve requirement is met. A variable, MXSRCH, can be specified to limit the number of units to be searched to find an acceptable plant. If a unit cannot be found, then another unit, not yet loaded, is put into the available reserve and is charged a spinning reserve cost.

III Program Structure

III.A Functional Description

SYSGEN is designed to implement the methodology presented in reference 3. The program is structured so that each subroutine performs one of the following functions: supervising the logical flow of the program, performing basic computations, or writing reports. This section will deal with the basic computational functions which are used throughout the program. The logic flow which governs the computations is shown in sections III.B and III.C. The reports are described in section V.

Throughout this section the following variables will be used:

L = Unit index. Most plant data are stored in the order in which the units are read. This is the unit index.

N = Valve point number for unit L

I = Class number of unit L

= ICLNUM(L) from /PLTDAT/

T = current time period (e.g. year)

= NPER from /TIMDAT/

t = current subperiod (e.g. month or week)

= NSPER from /TIMDAT/.

Whenever a new variables is used, a reference is made to the common block in which it is found e.g. /TIMDAT/. The common blocks are described in section VIII.

The major computational functions are the following:

III.A.1 Unit Availability (Function: AVAILB)

The function AVAILB returns the availability of the capacity up to and including increment N of unit L. The availability of a unit is a function of the time period because of the maintenance schedule and because the outage rate of a new unit changes as it matures. The availability is given by:

$$AVAILB_t(N,L) = [1.0 - FOR(N,L) \ * FORM_T(I)] * [1.0 - SUBMNT_t(L)] \tag{1}$$

where

FOR(N,L)	=	[1.0 - probability that the first N valve points of unit L are generating] from /PLTDAT/ (see section II.F.1).
$FORM_T(I)$	=	Immature forced outage rate multiplier for class I in time period T from /GCLASS/ (see section II.F.1).
$SUBMNT_{t}(L)$	=	Fraction of subperiod t that unit L is on preventative maintenance from /MNTDAT/ (see section II.G).

If N is set to zero, AVAILB returns the probability that unit outages equal zero. This is given by:

$$AVAILB_t(0,L) = 1.0 - \sum_{n=1}^{NVPT} (1.0 - AVAILB_t(n,L)) \tag{2}$$

where NVPT = total number of valve points for unit L from /PLTDAT/.

If N is set to NVPT+1, AVAILB returns the equivalent availability modified by maintenance and immature forced outage multipliers:

$$AVAILB_t(NVPT+1,L) = 1.0 - [(1.0 - EQAVAL\ (L)) \tag{3}$$

$$* FORM_T(I) * (1.0 - SUBMNT_t(L)]$$

where EQAVAVL (L) = equivalent unit availability (see section III.A.2).

If a storage ID is passed to AVAILB, it returns the availability for the charging cycle of a storage unit. The formula is the same as equation (1) except that FOR(N,L) is replaced by CHGFOR(L), the forced outage rate of the charging cycle from /HYDDAT/.

III.A.2 Equivalent Unit Availability (Function: EQVAVL)

The function EQVAVL returns the equivalent availability of unit L. The equivalent availability is defined to be:

$$EQVAVL(L) = 1.0 - \frac{\sum_{n=1}^{NVPT} FOR(n,L) * CAP(n, L)}{TCAP(L)} \qquad (4)$$

where CUMCAP(N,L) = capacity lost when valve point N of unit L fails,

TCAP(L) = total capacity of unit L.

III.A.3 Present Worth and Escalator Factors (Subroutine: FACTOR)

FACTOR computes the present worth factor and the escalator factors for fuel, O&M, and capital for units in class I in the current time period, T.

$$PWF_T = \left(\frac{1}{1. + DR}\right)^T$$

$$ESCOM_T(I) = \prod_{t=1}^{T} [1 + ER_{OM}(I,t)]$$

$$ESCFL_T(I) = \prod_{t=1}^{T} [1 + ER_{FL}(I,t)] \qquad (5)$$

$$CORR = CONVRT / (1 + CPI)^T$$

$$C_T = C_{IN} * CORR * ESC_T (I) * PWF_T$$

where

C_T	=	present value in report year dollars at a cost incurred in time period T of the study
C_{IN}	=	cost in the input file year dollars
DR	=	discount rate from /GGENRL/ (fraction)
$ER_{OM}(I,T)$	=	escalation rate for operation and maintenance (O&M) for class I in time T.
	=	ESCFAC (k,T) from /FINANC/ where k = ICLASS (I,5), the O&M escalation cross reference for class I.
$ER_{FL}(I,T)$	=	escalation rate for fuel for class I in time T.
	=	ESCFAC (k,T) from /FINANC/ where k = ICLASS (I,6), the fuel escalation cross reference for class I.
CONVRT	=	conversion factor from input year to report year dollars
PWF_T	=	present worth factor in time T
$ESCOM_T(I)$	=	escalator factor for O&M for class I in time T
$ESCFL_T(I)$	=	escalator factor for fuel for class I in time T

III.A.4 Marginal Cost of a Plant (Subroutine: CSTSET, CSTLVL)

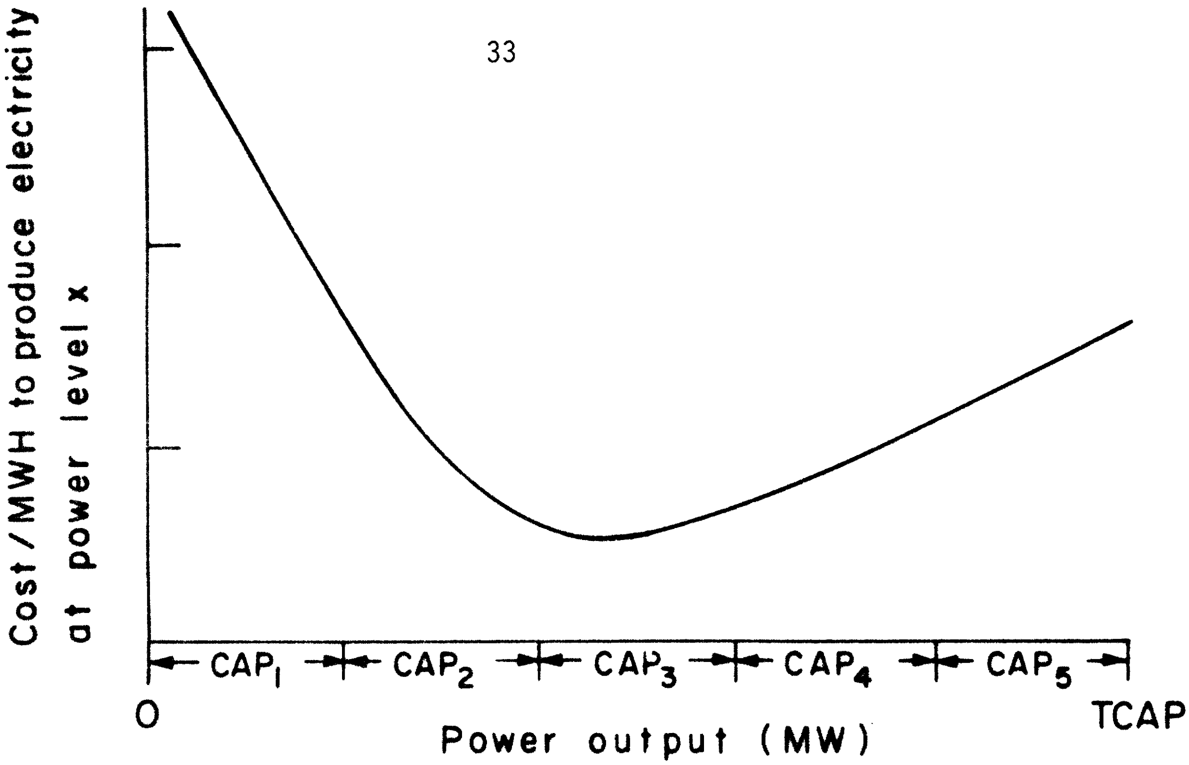
The subroutine CSTSET computes the marginal cost for each valve point using the formula:

$$CSTMRG_T(N,L) = [HTRATE(N,L) * FUCST(L) * ESCFL_T(I) + VAROMC(N,L) * ESCOM_T(I)] * PWF_T \quad (6)$$

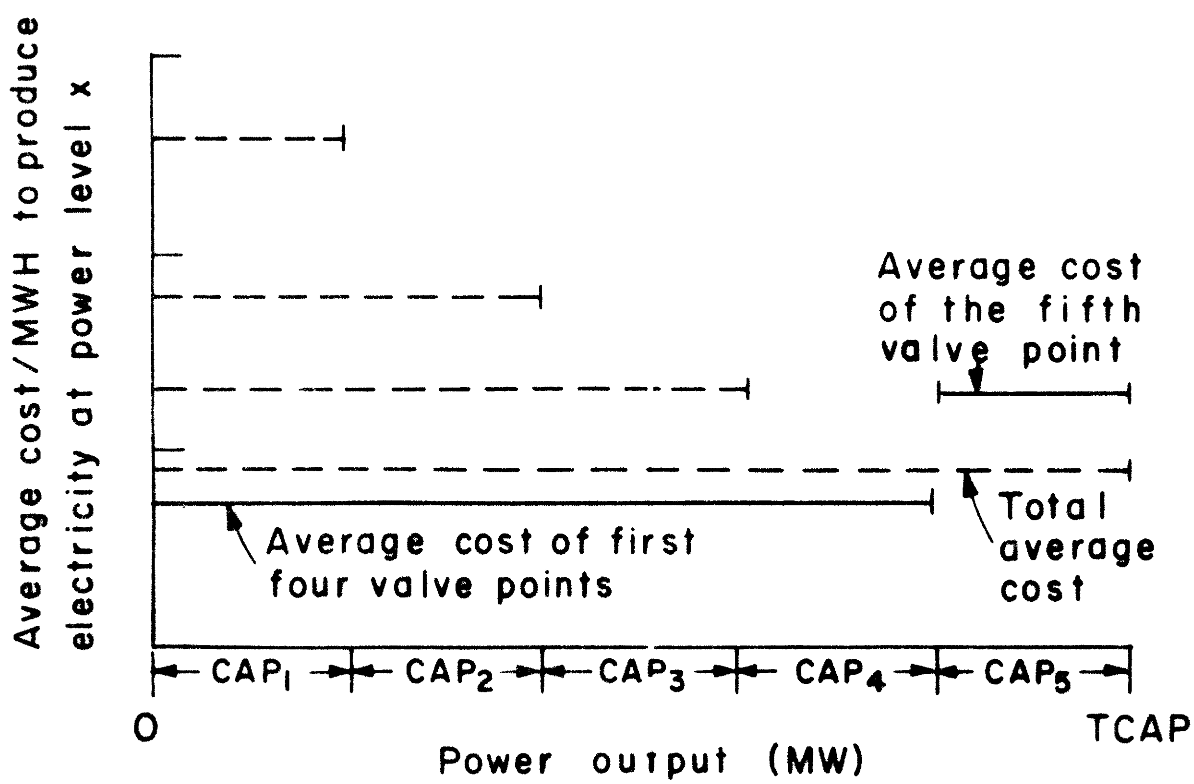
where:

HTRATE(N,L)	=	heat rate of increment N of unit L (MBTU/MWH) from /PLTDAT/
FUCST(L)	=	fuel cost of unit L ($/MBTU) from /PLTDAT/
VAROMC(L)	=	variable O&M cost of unit L ($/MWH) from /PLTDAT/

If all units have only one valve point, then the units are loaded in order of increasing marginal cost subject to the loading order constraint (see section II.H). However, for multiple valve point units, the valve points cannot always be brought up in strict economic order because of the physical constraint that the valve points within a unit must be used in sequence. For example, figure 4 shows a typical marginal cost curve in which the second valve point is cheaper to operate than the first. In this case, once the first valve point has been brought up, the second will always be brought up also because its marginal cost is lower. So the first two valve points can be treated as one since they are always used together. Their cost is their average marginal cost weighted by their capacities. In general, the valve points are grouped so that the average cost is minimized. This is illustrated in figure 4 where the average cost of the first valve point plus each successive valve point is plotted. For this particular unit the minimum average cost occurs when the first four valve points are loaded together. These valve points are treated as a single increment in the economic loading order using their weighted average cost. The last valve point is treated separately.



4a. Incremental operating cost curve



4b. Levelized operating cost curve
Dotted lines are average costs to produce electricity at successive valve points.
Solid lines are the levelized costs used for dispatching

Figure 4. Incremental and levelized operating cost curves

In CSTLVL, the levelized marginal costs are computed using the following formulas:

$$AVGCST_T(j,L) = \frac{\sum_{i=1}^{j} CSTMRG_T(i,L) * CAP(i,L)}{\sum_{i=1} CAP(i,L)} \qquad (7)$$

where

CAP(i,L)	=	capacity of valve point i of unit L from /PLTDAT/ (MW)
$AVGCST_T(j,L)$	=	average marginal cost of valve points j through N for unit L in time T ($/MWH)

Then,

$$CSTLVL_T(N,L) = \max[CSTLVL_T(N-1, L), \min[AVGCST_T(j,L), j = N, \ldots, NVPT)] \qquad (8)$$

where

$CSTLVL_T(N,L)$	=	levelized marginal cost of valve point N of unit L in time T ($/MWH)
max(i,j,k)	=	maximum value within the parentheses, e.g. max (5,7,4) = 7
min(i.j.k)	=	minimum value within the parentheses, e.g. min (5,7,4) = 4

The levelized cost is multipled by the units' penalty factor to account for energy lost in transmission. The units are put in the loading order based on this augmented levelized cost. However, when the cost of generating energy is computed, the original marginal cost is used.

III.A.5 Probability Convolution (Subroutine: CONVLV)

Convolution is used to find the probability distribution of the customer load plus unit outages which is defined to be the equivalent demand. A mathematical description of convolution is given in reference 3. Within SYSGEN, the convolution can be performed either by using the interpolation technique described below or fast Fourier transforms as described in reference 2. The interpolation technique is faster than Fourier transforms; however, the interpolation technique is unstable under certain conditions. Therefore, when using the interpolation technique, small units with large forced outage rates should not be included and, in the maintenance schedule, units should be taken out either for the entire subperiod or for less than half of it.

The formula from reference 3 for computing the new equivalent load curve, F, for a single increment unit is given by:

$$F(x) = pF'(x) + qF'(x - k) \quad (9)$$

where

F' = old equivalent load curve

x = demand level

k = capacity of the unit

q = forced outage rate of the unit.

The new probability curve is always a function of the previous curve. In addition, it is a function only of preceding points on the curve. Using this fact, only one curve needs to be stored. It is not necessary to keep a working array if the new values are computed from right (highest MW values) to left (lowest MW values).

```
PROB(J)= P * PROB(J) + Q * (PROB(J-INC)
                 + FC * (PROB(J-INC-1) - PROB(J-INC)))    (10)
```

where

J = current position in the probability array.
(J is a backward do-loop counter.)

DM = number of MWs between each array point from /DEMAND/.

PROB(J) = probability that the demand exceeds JxDM from /DEMAND/.

Q = forced outage rate of the unit = 1-AVAILB.

INC = integral number of spacings of the unit capacity = INT(K/DM)

FC = fraction of a spacing remaining for the unit capacity i.e., if the plant capacity is k, then k = (INC + FC) x DM.

For multiple valve point units, the last part of equation (9) must be repeated for each valve point:

$$F(x) = pF'(x) + \sum_{i=1}^{NVPT} q_i F'(x - K_i) \qquad (11)$$

where

K_i = capacity up to and including valve point i

q_i = forced outage rate for valve point i.

Implementing equation (11) on the computer requires that the second part of equation (9) be repeated for each valve point.

III.A.6 Probability Deconvolution (Subroutine: DECONV)

Deconvolution is used to remove unit outages from the equivalent load curve. A complete description can be found in reference 3. Basically, deconvolution is performed by rearranging equation (9):

$$F'(x) = 1/p[F(x) - qF'(x - k)] \qquad (12)$$

If the curve, F', is evaluated from right to left, then the value of

F'(x - k) will be available to compute the value of F'(x). Rewriting equation (12) for the computer using linear interpolation yields:

PROB(J) = 1/p * (PROB(J) - Q * [PROB(J-INC)

+ FC * (PROB(J-INC-1) - PROB(J-INC))]) (13)

where the variables are the same as defined in equation (10). Again, for multiple increment units, the second part of equation (13) must be repeated for each valve point.

III.A.7 Area (Subroutine: AREADM)

The area under a curve is computed by summing the areas of trapezoids using the formula:

$$A = 1/2(a + b)h \qquad (14)$$

where

a = length of one parallel side

b = length of the opposite side

h = distance between sides a and b.

For the demand curve, the lengths a and b are the height of the curve and h is the curve spacing (see figure 5). The area between points x and y on the demand curve is given by:

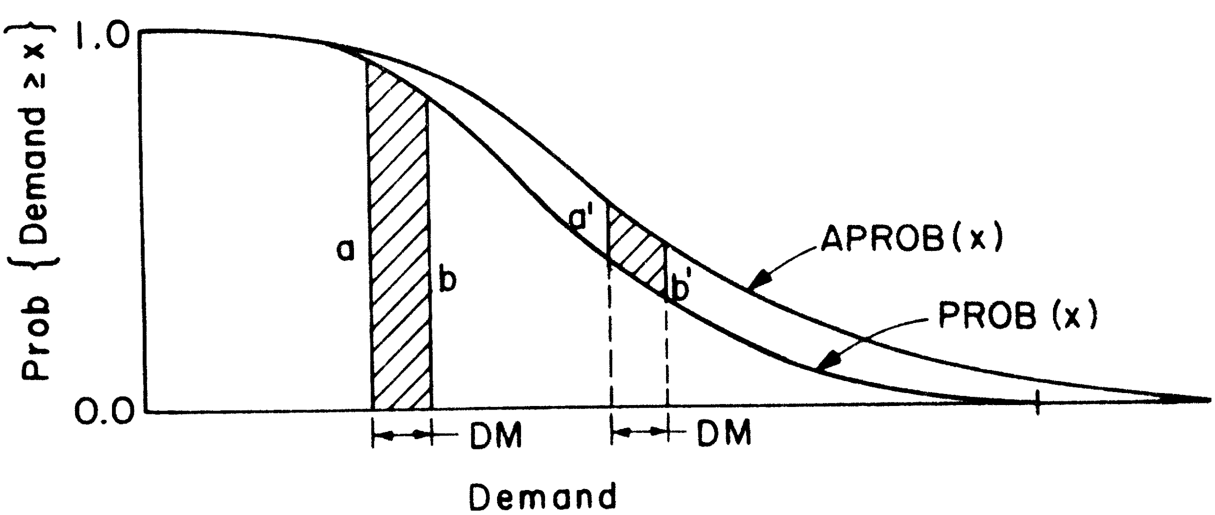


Figure 5 Area computation. Area = $\frac{1}{2}(a+b)\cdot DM$

$$AREA(x,y) = \sum_{i=x}^{y} \frac{1}{2} [PROB(i) + PROB(i+1)] * DM$$

$$= [\frac{1}{2} (PROB(y) + PROB(x)) + \sum_{i=x+1}^{y-1} PROB(i)] * DM$$

The area between the two probability curves, APROB and APROB', will be required below in section III.A.9. This computation uses the same formula except that the lengths a and b are now the differences between the curves:

$$AREA'(x,y) = [\frac{1}{2} (APROB(x) - APROB'(x) + APROB(y) - APROB'(y))$$

$$+ \sum_{i=x+1}^{y-1} (APROB(i) - APROB'(i))] * DM$$

Since APROB is created from APROB', the differences can be computed as the new curve is computed:

$$DELTA(i) = APROB(i) - APROB'(i)$$

$$= P * [APROB'(i) - APROB'(i-k)] \qquad (17)$$

(See equation (27), section III.A.9.)

The formula for the area becomes:

$$AREA'(x,y) = \sum_{i=x}^{y} \frac{1}{2} [DELTA(i) + DELTA'(i+1)] * DM \qquad (18)$$

$$= \frac{1}{2} [DELTA(x) + DELTA(y)] * DM + \sum_{i=x+1}^{y-1} DELTA(i) * DM$$

III.A.8 Frequency Convolution (Subroutine CONVFQ)

The frequency convolution is similar to the probability convolution except that it has both a frequency and a probability part. From reference 3, the frequency curve is:

$$FQ(x) = q\,[F'(x) + F'(x - k)] + pFQ'(x) + qFQ'(x - k) \quad (19)$$

where

FQ' = old frequency curve

= average forced outage occurrence rate.

The average forced outage occurrence rate of a unit is computed from the input variable, the mean time to repair:

AVFORR(L) = TFOR(L)/[ATTR * (1.0 - TFOR(L))] (20)

where

AVFORR(L) = average forced outage occurrence rate of unit L.

TFOR(L) = equivalent forced outage rate of unit L from /PLTDAT/.

ATTR = mean time to repair for unit L in hours from input file.

In CONVFQ, equation (10) is written

```
FREQ(J) = QM * [PROB(J) + PROB(J-INC) + FC * (PROB(J-INC-1)
                - PROB(J-INC))] + P * FREQ(J) + Q * [(FREQ(J-INC)
                + FC * (FREQ(J-INC-1) - FREQ(J-INC))]
                                                            (21)
```

where

QM = Q * AVFORR(L)

FREQ(x) = frequency that the load is greater than x from /DEMAND/.

For the frequency convolution, there is no multiple valve point algorithm nor is there a deconvolution algorithm. The unit is loaded once onto the frequency curve with its equivalent forced outage occurrence rate and total capacity.

III.A.9 Storage Convolution (Subroutine CONVST)

The storage algorithm implemented in SYSGEN is a simplification of the one presented in reference 3. Several assumptions are made to cut down on the storage space and computation time required. Basically, these assumptions involve neglecting second-order effects in computing the expected energy and cost for storage.

The augmented demand curve, APROB, for the first storage unit is computed using the equation from reference 3.

$$\mathrm{APROB}(x) = \mathrm{PROB}(x) + P_1 * [\mathrm{PROB}(x) - \mathrm{PROB}(x\text{-}\mathrm{CCAP}(1))] \quad (22)$$

where

P_1 = availability of the charging cycle of storage unit 1 (fraction)
= 1 - CHGFOR(1) from /HYDDAT/

CCAP(1) = charging capacity of storage unit 1 (MW) from /HYDDAT/

M = index of first base load plant with excess capacity.

The computation of the augmented demand curve stops when the area between the augmented and original curves equals the size of the storage reservoir divided by the length of the time period. The algorithm for computing the area is explained below. The ending point y is determined such that:

$$\mathrm{AREA}'(U_L,y) = \mathrm{STSIZE}(1) * \mathrm{NWEEKS}(t)/(\mathrm{CGEFF}(1) * \mathrm{HRSUB}) \quad (23)$$

where

STSIZE(1) = reservoir size of storage unit 1 (MWH) per week from /HYDDAT/

CGEFF(1) = overall efficiency of storage unit 1 (fraction) from /HYDDAT/

U_L = loading point of unit L

NWEEKS(t) = number of weeks in subperiod t from /TIMDAT/

HRSUB = hours in subperiod t from /TIMDAT/

The energy supplied by base load unit L to storage unit 1 is given by:

$$ENERGY(L,1) = AREA'(U_L, U_{L+1}) * AVAIL(N,L) * HRSUB. \qquad (24)$$

If the cutoff point, y, for the storage unit is greater than the loading point of the next unit, U_{L+1}, then the next unit also supplies energy to storage unit 1. This energy is approximately:

$$ENERGY(L+1,1) = AREA'(U_{L+1}, U_{L+2}) * AVAIL(N,L+1) * HRSUB$$

This equation is an approximation because it ignores the effects of outages of unit L. The total energy supplied to storage unit 1 is given by:

$$STGNRG(1) = \sum_{i=L}^{M} ENERGY(i,1) * CGEFF(1) * P_1 \qquad (25)$$

$$CSTMRG(1,IDST(1)) = [\sum_{i=L}^{M} CSTMRG(N,i) * ENERGY(i,1)]/STGNRG(1) \qquad (26)$$

where

STGNRG(1) = total expected energy available to storage unit 1 (MWH)

M = last base load unit expected to supply storage unit 1

IDST(1) = plant index of storage unit 1

MRGCST(1,IDST(1)) = weighted marginal cost of storage unit 1.

If there is still excess capacity available from the first base load unit with excess energy then the second storage unit is convolved into the augmented curve.

$$APROB(x) = APROB'(x) + P_2 * [APROB'(x) - APROB'(x-CCAP(2))] \quad (27)$$

Again, the computation stops when the reservoir demand has been met. The energy supplied to storage unit 2 is computed the same way that it was for unit 1.

Finally, if there is no more excess capacity available from base load unit L, then its outages are convolved into both the demand and the agumented demand curve.

$$APROB(x) = APROB'(x) + Q * [APROB'(x) - APROB'(x-CAP(N,L))] \quad (28)$$

where

$Q = 1 - AVAIL(N,L)$

= forced outage rate of increment N of unit L

The algorithm repeats for each base load plant adding storage units until there is no excess capacity left and then convolving the base plant outages into both curves.

III.A.10 Expected Startups (Subroutine: DERIVX)

The expected number of startups for a unit is given by the number of times the equivalent load crosses the unit's loading point. Since the frequency curve is stored in its cumulative form i.e., the number of times the load enters a state greater than or equal to x, it is necessary to take the derivative to find the number of times the load enters state x. The derivative is approximated by the slope of the cumulative frequency curve:

$$DERIVX(x) = FREQ(x) - FREQ(x+DM) \quad (29)$$

Then, the expected number of startups for unit L is:

$$EXSTRT(L) = DERIVX(U_L) * HRSUB \quad (30)$$

where

U_L = loading point of unit L.

DERIVX also can return the derivative of the probability curve, replacing FREQ with PROB in equation (29).

III.A.11 Average Duration (Function: AVGDUR)

The average duration of a load level is found using the equation:

$$AVGDUR(x) = \text{Length of time load} \geq x/\text{number of times load enters } x \quad (31)$$

The probability and frequency of load level x are found using the function DERIVX. Then,

$$AVGDUR(x) = DRVPRB(x) * HRSUB/DRVFRQ(x). \quad (32)$$

where

DRVFRQ(x) = derivative of the frequency curve at x.

III.A.12 Spinning Reserve (Subroutine: SPNRES)

The spinning reserve algorithm is implemented after the economic loading order has been set up. The loading order is modified to meet the reserve requirement, as specified in the input. SPNRES goes through the loading order keeping a total of the spinning reserve available. The available reserve contains the capacity of higher valve points, up to the maximum allowed of units that have been loaded. Whenever loading the next valve point of a unit would result in too low a value for reserve, SPNRES looks for another unit to start up so that the reserve remains adequate. A limit can be placed on the number of units to be searched so that no unit is moved too far out of its place in the loading order.

III.A.13 Effective Load Carrying Capability (Function: ELLCAP)

The effective load carrying capability of unit L is found by deconvolving the unit from the final demand curve, finding the demand level, x, on the new curve where the loss of load probability (LOLP) matches the LOLP of the final system, and computing the distance between x and the system capacity minus unit L. See figure 6 and reference 3, section III.I, for more detail.

The load level, x, is found by using the deconvolution algorithm (without saving the new curve), until the system LOLP is reached. Then,

$$ELLCAP = PE - TCAP(L) - x \qquad (33)$$

where

PE = final system loading point.

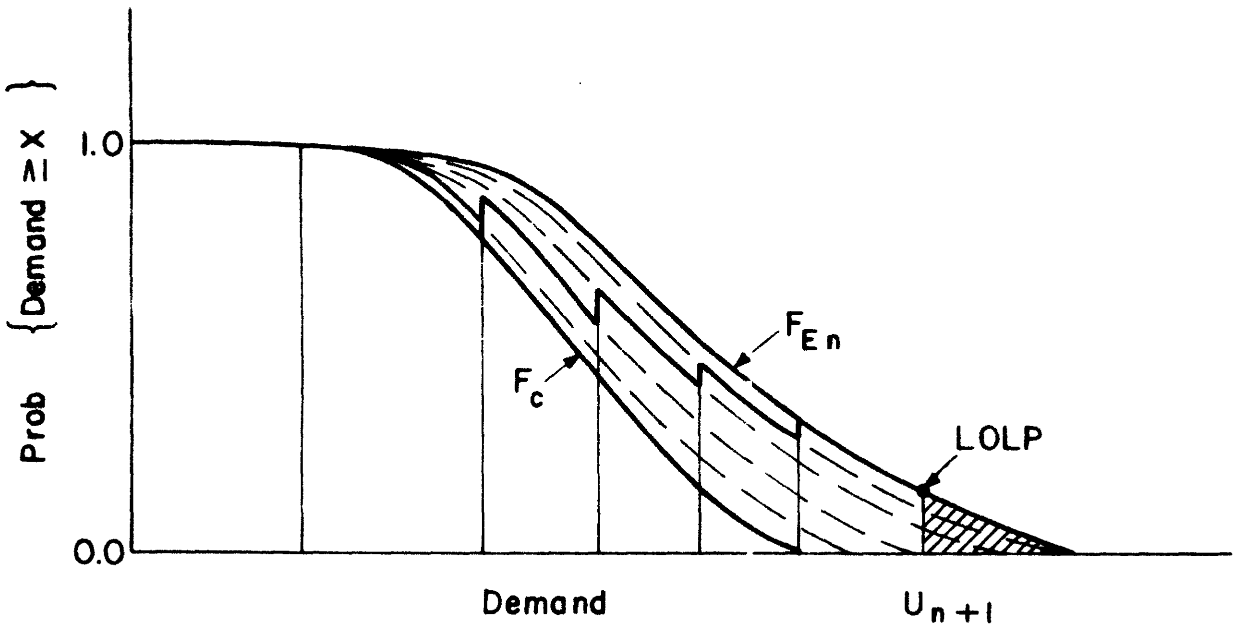


Figure 6 a. Final equivalent demand curve

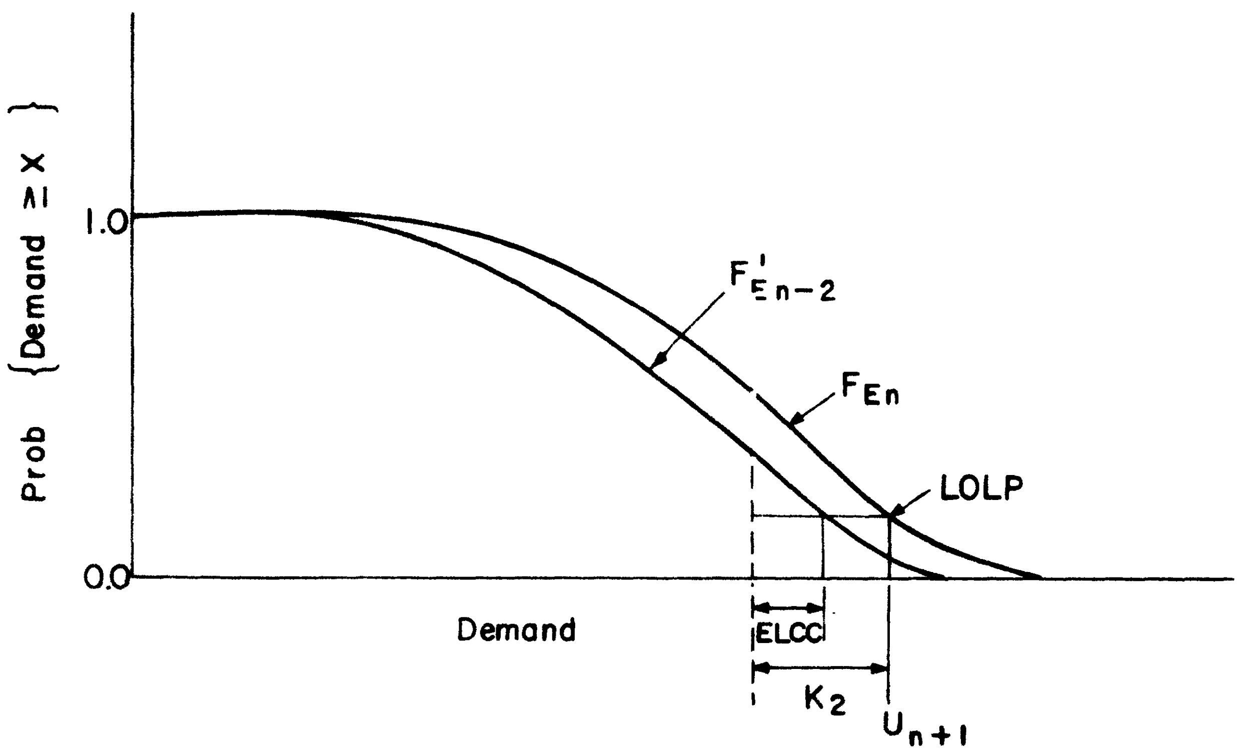
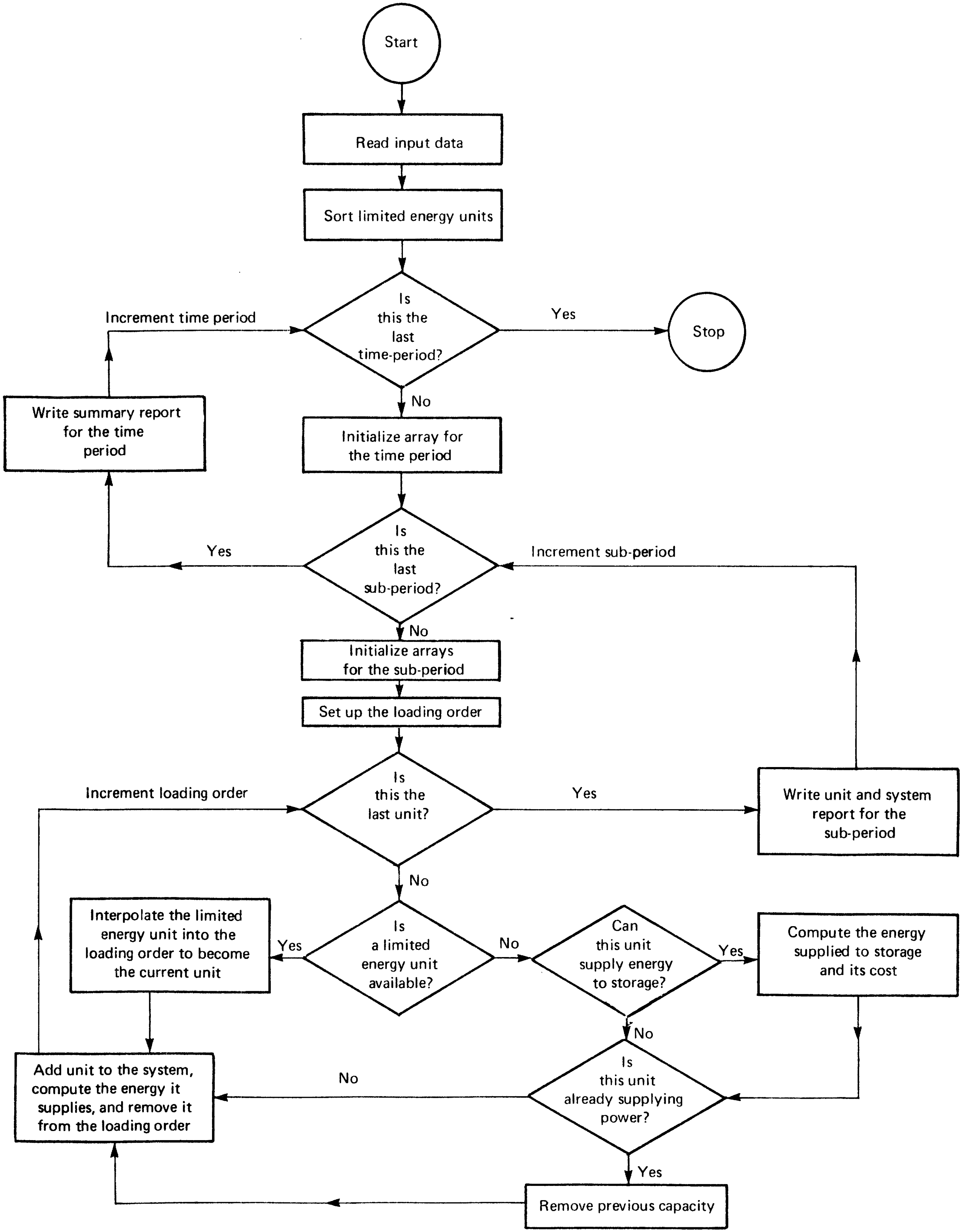
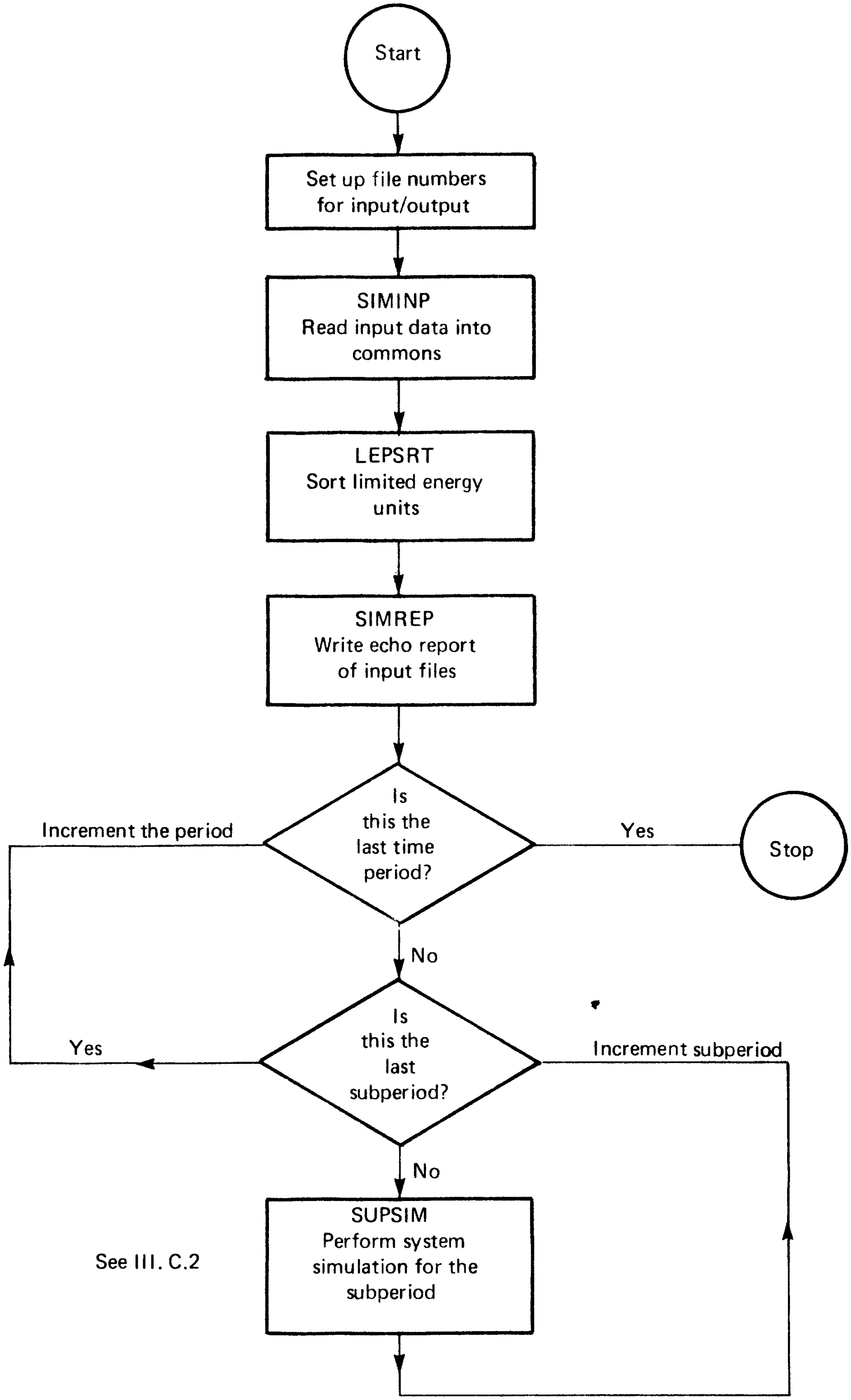


Figure 6 b. Equivalent load carrying capability for plant 2

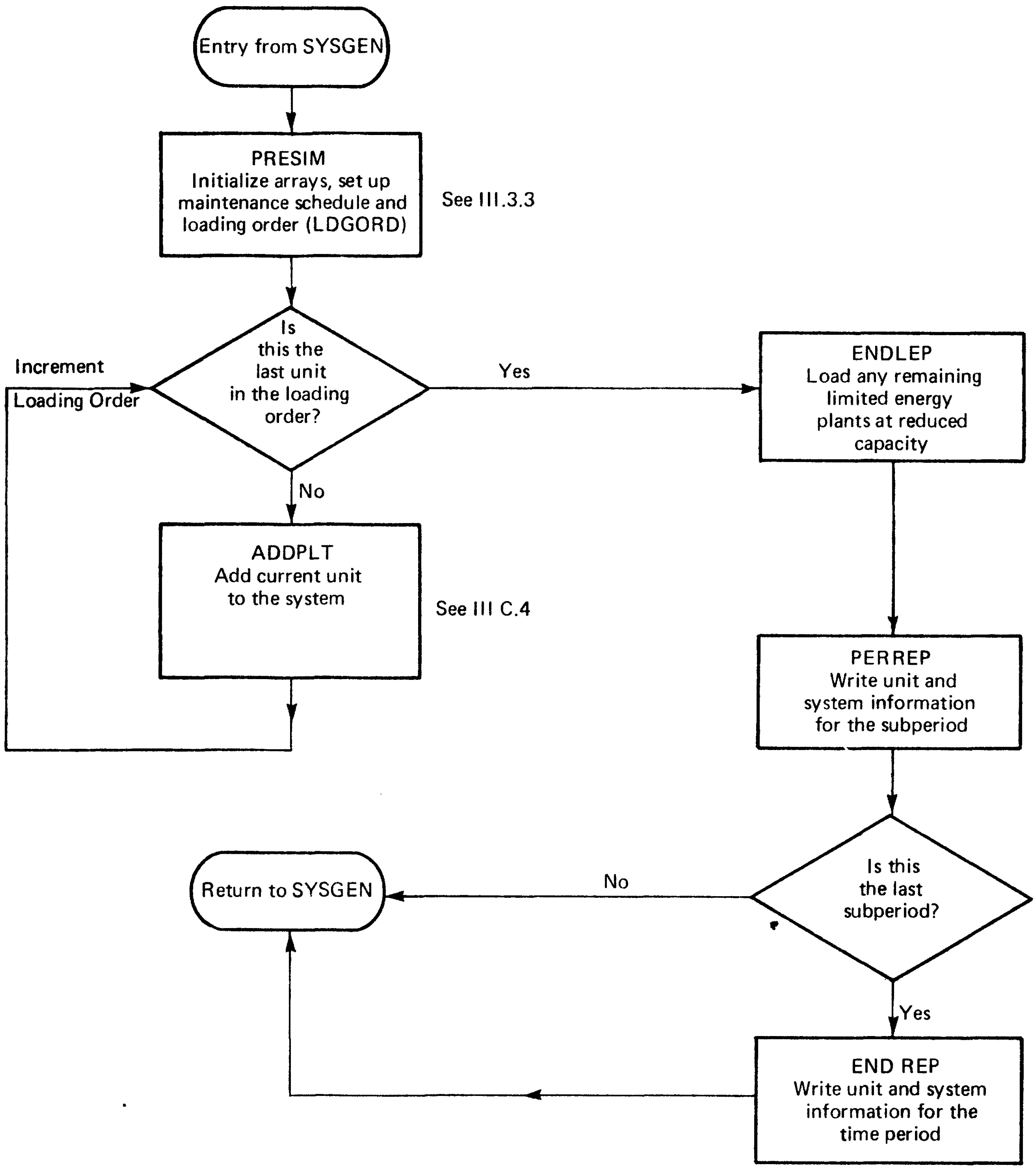
Figure 6 Final System Configuration



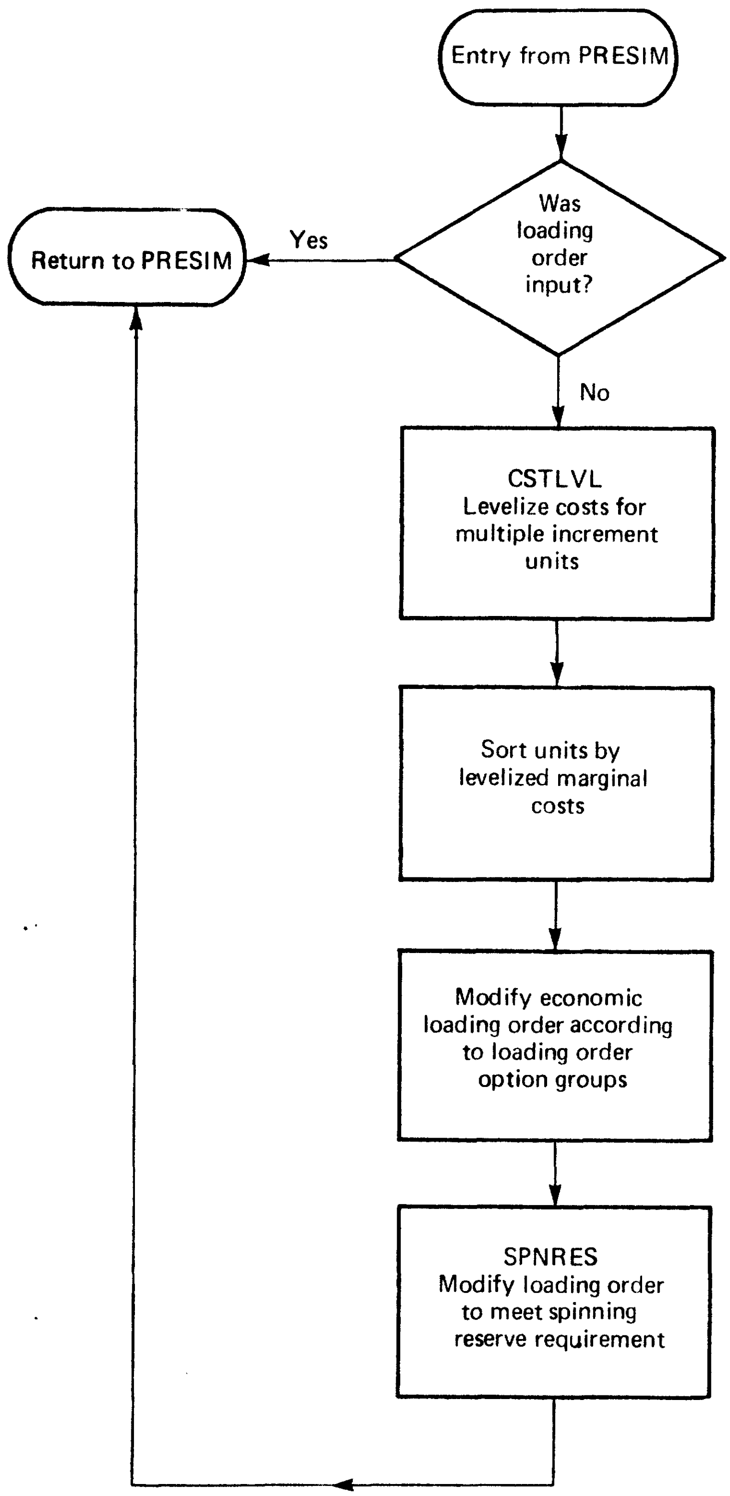
III.B GENERAL BLOCK DIAGRAM



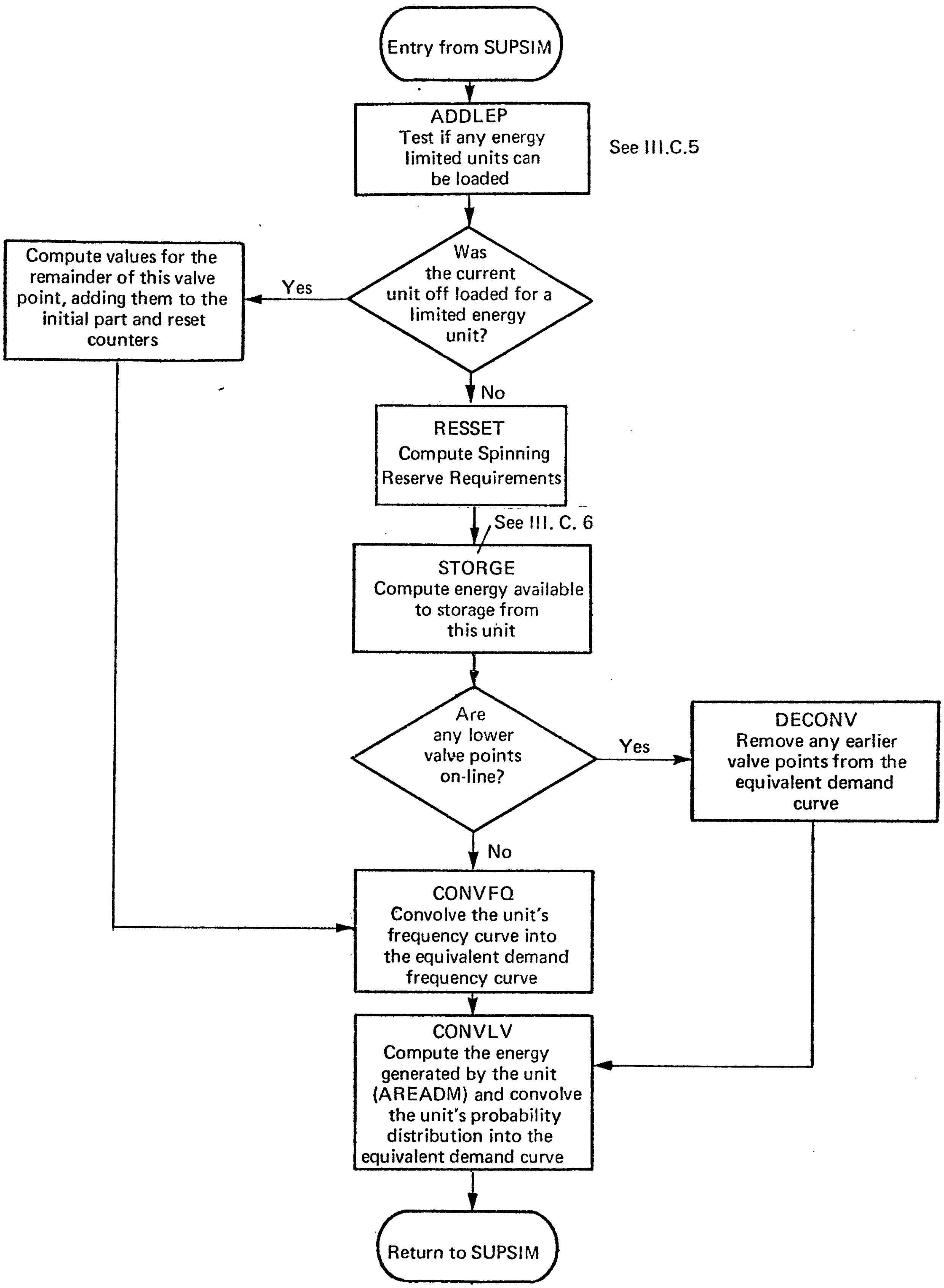
III C.1 MAIN SYSGEN SUBROUTINE FLOW CHART



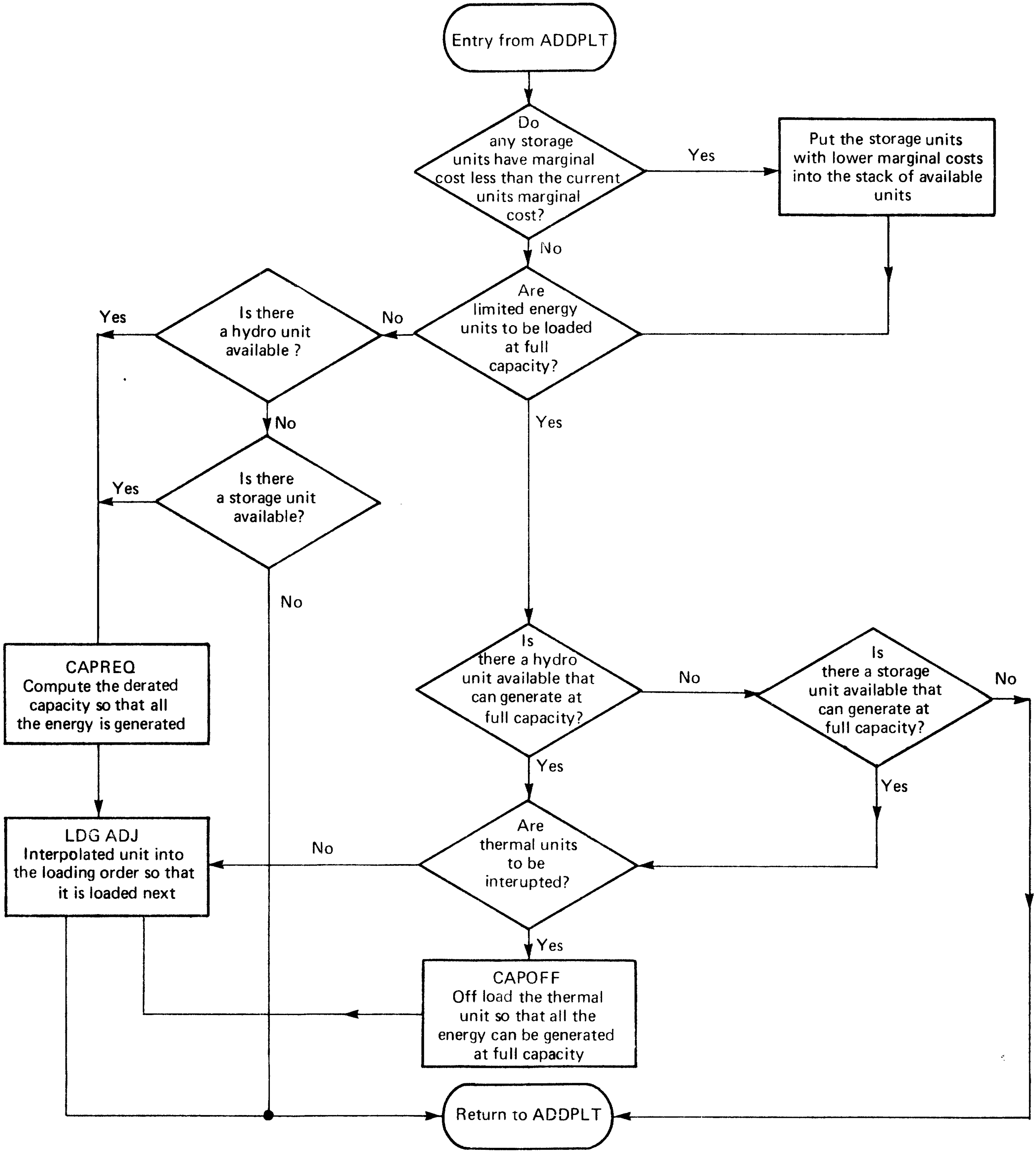
III C.2 SUPSIM SUBROUTINE FLOW CHART



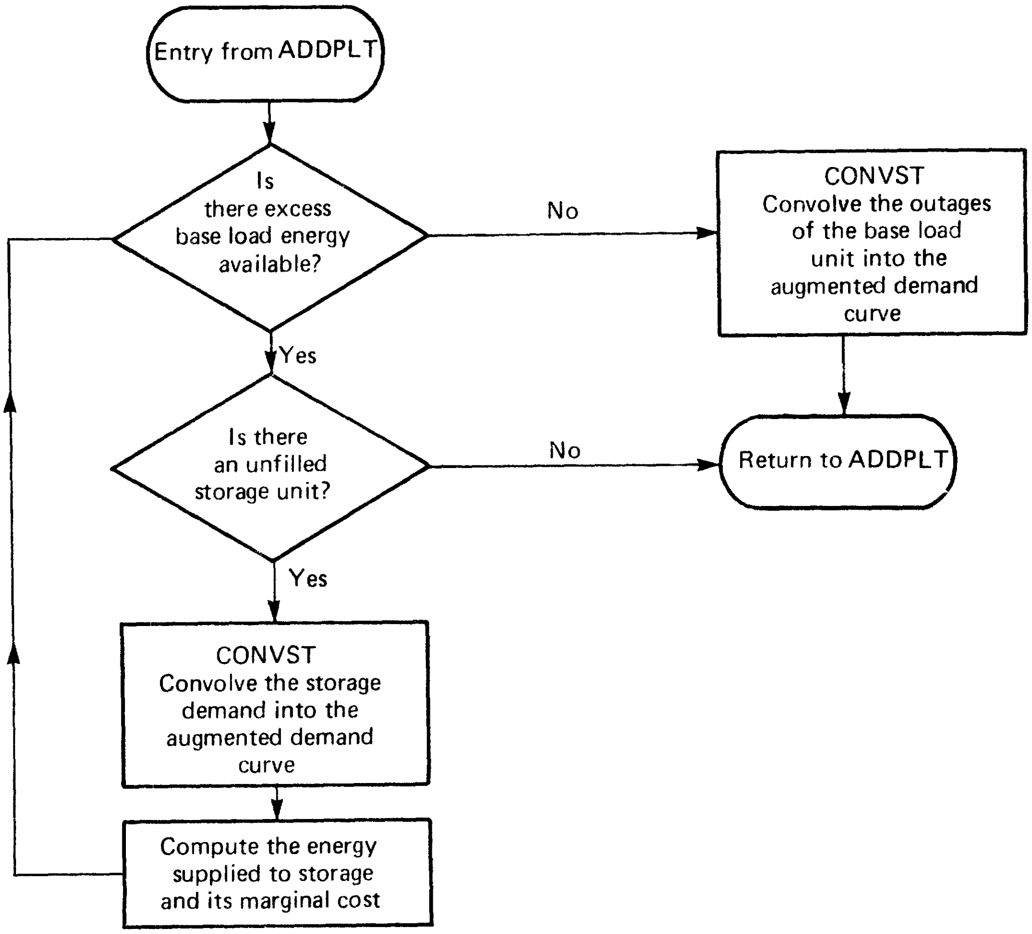
III C.3 LDGORD SUBROUTINE FLOW CHART



III C.4 ADDPLT SUBROUTINE FLOW CHART



III C.5 ADDLEP SUBROUTINE FLOW CHART



III C.6 STORGE SUBROUTINE FLOW CHART

IV Input Files

IV.A Card Set Description

File Unit Number	Card Number	Information to be Supplied
10		SYSGEN Options
	A/1/1	Debug options
	A/2/1	Print options
	A/2/2	Operating options
	A/2/3	Loading order option, spinning reserve
	A/2/4	Class identifiers
	A/2/5	Year dollars information
	A/2/6-9	Report headings
10		General Information
	B/1/1	Start, end of planning horizon
	B/2/1	Number of sub-periods, hours per week
	B/3/1-4	Number of weeks in a sub-period 13 sub-periods per card
	B/4-5	Time Dependent Unit Information
15		Load Data
	C/1	Peak load, pointer to load shape One card for each sub-period of each time period
	C/2/1	Number of load shapes
	C/3	Load shapes
20	D/1	Frequency Curves, if MFREQ is set to true
25		Generation Class Data
	E/1/1	Number of generation classes
	E/2	Class information and cross reference table. One card for each class
	E/3/1	Number of sets of immature FOR multipliers
	E/4	Immature forced outage rate table One card for each set
	E/5/1	Number of sets of escalation rate series
	E/6	Escalation rate series
30		Individual Unit Data
	F/n/1	Unit data for unit n
	F/n/2	Capacity, heat rate, and forced outage rate for 2 valve points of unit n
	F/n/3	Capacity, heat rate, and forced outage rate for last 3 valve points of unit n. Input card only if there are more than 2 valve points

	F/n/4	Storage unit information
	F/n/5	MWH size of reservoir for conventional hydro unit n. Input conventional hydro unit size for 6 sub-periods on each card.
	F/n/6	Time dependent unit data
35	G/1	Preventative Maintenance Data, if MAINT is set to false
40	H/1	Loading Order, if MLORD is set to false

IV.B Input Data Format

Card	Columns	Variables	Format	Description
				Debug Option For
A/1/1	2	IDEBUG(1)	L1	ADDHYD
	4	IDEBUG(2)	L1	ADDPLT
	6	IDEBUG(3)	L1	AREADM
	8	IDEBUG(4)	L1	AVAILB
	10	IDEBUG(5)	L1	CONVLV
	12	IDEBUG(6)	L1	CSTLVL
	14	IDEBUG(7)	L1	DECONV
	16	IDEBUG(8)	L1	ENDHYD
	18	IDEBUG(9)	L1	LDGADJ
	20	IDEBUG(10)	L1	LDGORD
	22	IDEBUG(11)	L1	PRESIM
	24	IDEBUG(12)	L1	PROBDM
	26	IDEBUG(13)	L1	SIMINP
	28	IDEBUG(14)	L1	STORGE
	30	IDEBUG(15)	L1	CONVFQ
	32	IDEBUG(16)	L1	EQAVAL
	34	IDEBUG(17)	L1	RESCHG
	36	IDEBUG(18)	L1	SPNRES
	38	IDEBUG(19)	L1	ELLCAP
	40	IDEBUG(20)	L1	CAPOFF
A/2/1	8	MGRID	L1	If TRUE, grid file is printed.
	16	MINI	L1	If TRUE, system summary report is printed.
	24	MIDI	L1	If TRUE, MINI plus plant summary reports.
	32	MAXI	L1	If TRUE, MINI, MIDI plus plant load report plus initial plant data.
	40	MMAXI	L1	If TRUE, MINI, MIDI, MAXI plus curve reports and hydro reports.
	48	MLCAP	L1	If TRUE, the effective load carrying capability of units is printed.
	56	MLRED	L1	If TRUE, information on the time dependent units is printed

Card	Columns	Variables	Format	Description
A/2/2	8	MULT	L1	If MULT = T, the multiple increment algorithms are used.
	16	MFREQ	L1	If MFREQ = T,the frequency algorithms are used. Note: If MFREQ = T, card set D must be input.
	24	MLORD	L1	If MLORD = T, the loading order is computed. Note: If MLORD = F, card set H must be input.
	32	MSPIN	L1	If MSPIN = T, the spinning reserve algorithms are implemented
	40	MDLAY	L1	If MDLAY = T, the hydro and storage dispatch algorithms are implemented.
	48	MOVE	L1	If MOVE = T, units can be loaded at partial valve points to use limited energy plants.
	56	MSTOR	L1	If MSTOR = T, the energy and cost algorithms for storage are implemented.
	64	MAINT	L1	If MAINT = T, the maintenance schedule is computed within SYSGEN. Note: If MAINT = F, card set G must be input. Note: MAINT is automatically set to False.
	72	MSUB	L1	If MSUB = T, the subperiods are modeled individually. If MSUB = F, only time periods are modeled. Note: MSUB is automatically set to True.

Card	Columns	Variable	Format	Description
A/2/3	3- 5	LORDOP	I3	Loading Order Option. Three digit number: 1st digit=base loaded group 2nd digit=intermediate group 3rd digit=peaking group LORDOP is read as I1, I2, I3. Plants are sorted by marginal cost within a group, e.g., LORDOP = 123: base, intermediate and peak units are sorted separately. All base units are loaded before the cheapest intermediate unit. LORDOP = 112: base and intermediate units are sorted together. Peak units are loaded after all others. [111 $\leq$ LORDOP $\leq$ 321]
	6-15	RES	F10.3	Required operating reserve margin as defined by ERVE
	16-18	ERVE	A3	'PER' required operating reserve, RES, is given as percent of peak load 'ABS', RES is given as an absolute megawatt value 'MAX', RES is given as the fraction of the largest unit needed for spinning reserve, e.g. RESERVE = 20.0 PER Reserve is 20% of the peak load, e.g. RESERVE = 1.5 MAX Reserve is 1-1/2 times the largest unit on line.
	19-23	PERCNT	F5.3	Maximum percent of any unit to be credited to spinning reserve.
	24-28	MXSRCH	I5	Maximum number of units to be displaced to meet spinning reserve. (See section III.A.12.)
A/2/4	2-5	ITDP	A4	Alpha identifier for time dependent units.

Card	Columns	Variable	Format	Description
	7-10	ICHY	A4	Alpha identifier for conventional hydro unit. (See card E/2/1). Normally set to ' CHY'.
	12-15	ISTO	A4	Alpha identifier for storage units. Normally set to ' STO'.
	17-20	IBASE	A4	Alpha identifier for base load class (see card E/2/1). Normally set to 'BASE'.
	22-25	INTR	A4	Alpha identifier for intermediate class. Normally set to 'INTR'.
	27-30	IPEAK	A4	Alpha identifier for peaking class. Normally set to 'PEAK'.
A/2/5	2-6	INDOL	I5	Year of costs in input file.
	7-11	IRPDOL	I5	Year that costs are reported in. (Costs are converted using the discount rate from B/1/1 and escalation rates from E/6)
	12-21	CONVRT	F10.3	Conversion factor from input year dollars
	22-31	CPI	F10.3	Consumer price index
A/2/6	2-41	TITLE(1-10)	10A4	Report Heading. A 40 character title (including blanks) to appear at the top of each page of each report
A/2/7	2-41	TITLE(11-20)	10A4	Title Page Heading. A 40 character head to appear on the title page
A/2/8	2-41	TITLE(21-30)	10A4	Title Page Heading. A second 40-character heading to appear on the title page
A/2/9	2-41	TITLE(31-40)	10A4	Title Page Heading. A third 40 character heading to appear on the title page

Card	Columns	Variable	Format	Description
B/1/1	1- 5	ISY	I5	Start year of planning horizon (e.g. 1985).
	6- 10	IEY	I5	End year of planning horizon (e.g. 1995). (ISY ≤ IEY)
	11- 13	NTP	I3	Number of time periods (years) in study (e.g. 10). [1 ≤ NTP ≤ 34] Note: NTP = IEY-ISY+1
	39- 44	HOURS	F6.1	Number of hours in a time period (e.g. 8736).
	46- 50	DR	F5.3	Discount rate used in present worth calculations. [DR ≥ 0.0]
B/2/1	2- 3	NSTP	I2	Number of time sub-periods. A sub-period may represent a week, a month, a 4-week period, or any other fraction of a year. [1 ≤ NSTP ≤ 52]
	5- 10	HRWEEK	F6.1	Hours in a week (e.g. 168.)
	12-15	WKDAY	A4	Alpha identifier used for reporting the length of HRWEEK (e.g. WKDAY = 'WEEK', if HRWEEK = 168.0)
B/3/1	2- 3	NWEEKS(1)	I2	Number of weeks in sub-period 1
	5- 6	NWEEKS(2)	I2	Number of weeks in sub-period 2
	8- 9	NWEEKS(3)	I2	Number of weeks in sub-period 3
	. . .	. . .		. . . . . .
	38- 39	NWEEKS(13)	I2	Number of weeks in sub-period 13
B/3/2				Same format as card B/3/1. Information pertains to sub-periods 14-26. Used only if there are more than 13 superiods.

Card	Columns	Variable	Format	Description
B/3/3				Same format as card B/3/1. Information pertains to subperiods 27-39. Used only if there more than 26 subperiods.
B/3/4				Same format as card B/3/1. Information pertains to subperiods 40-52. Used only if there are more than 39 subperiods.
B/4	2-3	NCASE	I2	Number of runs with time dependent units [0 ≤ NCASE ≤ 20]
B/5/1	2-3	NOTD	I2	Number of time dependent units in the first case
B/5/2	2-3	IDTD(1)	I2	Unit index of the first time dependent unit in case 1
	5-6	NPLNT(1)	I2	Number of units with index IDTD(1) in the first case
	. . .	. . .		. . . . . .
	23-24	NPLNT(4)	I2	Number of units with index IDTD(4) in the first case

Cards B/5/1 and 2 are repeated for each time dependent case until NCASEs have been entered. SYSGEN will report the information entered on the cards corresponding to case ICASE, where ICASE is read from the load data (Card Set C) created by ELECTRA.

Cards B/4 and B/5 are read only if MLRED is true.

Card	Columns	Variable	Format	Description
C/1/1	2-5	NPNT	I4	Number of points in each load shape
	6-10	ICASE	I5	Case number for the load shape from ELECTRA
C/1/1.1	2-3	NUMYR	I2	Time period number. Remainder of data on the card is for this period.
	5-11	PEAK(1,1)	F7.1	Peak load to be met in sub-period 1 of time period 1 (Mw). [0 ≤ PEAK(1,1)]
	32-33	NUMLDS(1,1)	I2	Pointer to load shape (subgroup number within group C/3) to be used in sub-period 1 of time period 1. [1 ≤ NUMLDS(1,1) ≤ NLDSHP]
C/1/1.2	5-11	PEAK(2,1)	F7.1	Peak load to be met in sub-period 2 of time period 1 (Mw).
	32-33	NUMLDS(2,1)	I2	Pointer to load shape to be used in sub-period 2 of time period 1.
⋮	⋮	⋮	⋮	⋮
C/1/1.NSTP				Same format as card C/1/1.2. Information pertains to sub-period NSTP of time period 1.
⋮	⋮	⋮	⋮	⋮

Card	Columns	Variable	Format	Description
C/1/NTP.1 C/1/NTP.NSTP				Same format as cards C/1/1.1 through C/1/1.NSTP. Information pertains to time period NTP (the last time period).
C/2/1	2- 3	NLDSHP	I2	Indicates the number of load shapes to be input (as subgroups in Group C). [1 ≤ NLDSHP ≤ 52]
C/3/1/1	1- 12	RLDSHP(1,1)	F12.8	Percent of time demand exceeds 1 * Peak Load/NPNT. [0.0 ≤ RLDSHP(1,1) ≤ 1.0]
	13- 24	RLDSHP(1,2)	F12.8	Percent of time demand exceeds 2 * Peak Load/NPNT. [0.0 ≤ RLDSHP(1,2) ≤ 1.0]
	25- 36	RLDSHP(1,3)	F12.8	Percent of time demand exceeds 3 * Peak Load/NPNT. [0.0 ≤ RLDSHP(1,3) ≤ 1.0]
	37- 48	RLDSHP(1,4)	F12.8	Percent of time demand exceeds 4 * Peak Load/NPNT. [0.0 ≤ RLDSHP(1,4) ≤ 1.0]
	49- 60	RLDSHP(1,5)	F12.8	Percent of time demand exceeds 5 * Peak Load/NPNT. [0.0 ≤ RLDSHP(1,5) ≤ 1.0]
C/3/1/2		. . .		Same format as card /3/1.1 Card 2 supplies RLDSHP (1,6 - 10) Card 3 supplies RLDSHP (1,11 - 15)
C/3/1.10				Card 10 supplies RLDSHP (1,46 - 50) [RLDSHP (1,50) = 0.0]
C/3/2.1 . . . C/3/2.10				Same format as cards C/3/1.1 through C/3/1.10. Data pertains to load shape number 2: RLDSHP (2,1 - 50)

Card	Columns	Variable	Format	Description
C/3/NLDSHP.1 . . . C/3/NLDSHP.10				Same format as cards C/3/1.1 through C/3/1.10. Data pertain to load shape NLDSHP (the last load shape): RLDSHP (NLDSHP, 1 - 50)

Card set D/1 is identical to C/3 except FRQSHP is entered instead of RLDSHP.

Card	Columns	Variable	Format	Description
D/1/1.1 . . . D/1/NLDSHP.10	1-12	FRQSHP(1,1)	F12.8	Number of times the demand enters a state greater than 1 * Peak Load/NPNT. Note: FRQSHP is normalized by the time period length in house, e.g.,7 entries/week =.0417/hour.

Group E/2 contains the class information and cross-reference table. Each unit in the system will have a class number (j) which refers to the information for the jth class, which is listed on the jth card in this group.

Card	Columns	Variable	Format	Description
E/1/1	2-3	NCLASS	12	Indicates the number of generation classes to be input. Each generation class will occupy one card in Group 2. [1≤NCLASS≤34]
E/2/1	2-5	ICLASS(1,1)	A4	Class name of Class 1. Can be any character string up to 4 characters long including blanks. NOTE: For storage class ISTO must be entered in columns 2-5 (as defined on card A/2/4)
	7-10	ICLASS(1,2)	A4	Class Type of Class 1 'BASE' = Base loaded unit 'INTR' = Intermediate unit 'PEAK' = Peaking unit NOTE: SYSGEN uses the class types in setting up the order under many of its loading order options.
	12-13	ICLASS(1,3)	I2	Not used in SYSGEN
	15-16	ICLASS(1,4)	I2	Not used in SYSGEN.
E/2/1	18-20	ICLASS(1,5)	I3	Operating and Maintenace (O&M) escalation cross reference. This number points to the card number in group E/6 that contains the O&M escalation rate series for this class [1 ≤ ICLASS(1,5) ≤ NESC]

Card	Columns	Variable	Format	Description
	22 - 24	ICLASS(1,6)	I3	Fuel cost escalation cross reference. This number points to the card number in group E/6 that contains the fuel escalation rate series for this class. [1 ≤ ICLASS (1,6) ≤ NESC]
	26 - 28	ICLASS(1,7)	I3	Not used in SYSGEN.
	30 - 31	ICLASS(1,8)	I2	Cross-reference to immature forced outage rate multipliers table. This number points to the card number in group E/4 that contains a set of multipliers by which a plant's mature forced outage rate is modified to account for higher initial usage failure rates. [1 ≤ ICLASS(1,8) ≤ NFORML] (see Groups E/3 and E/4)
E/2/2				Same format and information as in card one except the information refers to Class 2
E/2/3 E/2/NCLASS				Same format and information as in card one except the information refers to Class 3 - NCLASS
E/3/1	2 - 3	NFORML	I2	Indicates the number of sets of immature forced outage rate multipliers to be included in Group E/4 (there will be one set per card in Group E/4 [1 ≤ NFORML ≤ 10] (see Group E/4)
	5 - 6	NIMYRS	I2	Indicates the number of years to be included in each set (i.e. α of entries on each card of Group E/4 [1 ≤ NIMYRS ≤ 10] (see Group E/4)

Group E/4 contains the immature forced outage rate table. The forced outage rate (FOR) of a unit in the ith year of its operation (where i ≤ NIMYRS) is equal to the mature FOR of the unit times the ith immature forced outage rate multiplier (IFORM) listed on the card number within this group that is indicated by ICLASS (class number 8). (See section II.A.1.)

The mature FOR and Class number for each plant are found in Card set E

Card	Columns	Variable	Format	Description
E/4/1	2 - 6	FORML(1,1)	F5.2	FORML for the first set, first year
	7 - 11	FORML(1,2)	F5.2	FORML for the first set, second year

Card	Columns	Variable	Format	Description
	12-16	FORML(1,3)	F5.2	FORML for the first set, third year
	.	.	.	. .
	47-51	FORML(1,10)	F5.2	IFORM for the first set, 10th year [0 < FORML(1,10) < 10.0] NOTE: Only the first NIMYRS number will be read (e.g. if NIMYRS = 3 only FORM(1,1 3) will be read in.) The mature FOR is used by SYSGEN for plants after NIMYRS of operation.
E/4/2				Same format and information as in Card E/4/1 except the information refers to immature FOR multiplier set 2
E/4/3-NFORML				Same format and information as in card E/4/1 except the information refers to immature FOR multiplier Set 3 - NFORML
E/5	2-3	NESC	I2	Number of sets of escalation rates [1 < NESC < 10]
E/6/1.1	2-3	NYEAR	I2	Number of years in escalation set 1. [1 < NYEAR < 34]
	7-11	ESCFAC(1,1)	F5.2	Escalation rate for the first set in the first year of the study.
	12-16	ESCFAC(1,2)	F5.2	Escalation rate for the first set in the second year.
	.	.	.	.
	62-66	ESCFAC(1,12)	F5.2	Escalation rate for the first set in the twelfth year.

Card	Columns	Variable	Format	Description
E/6/1.2	7-11	ESCFAC(1,13)	F5.2	Escalation rate for the first set in the thirteenth year.
	.	.	.	.
	.	.	.	.
	.	.	.	.
	62-66	ESCFAC(1,24)	F5.2	Escalation rate for the first set in the twenty fourth year.
E/6/1.3	7-11	ESCFAC(1,25)	F5.2	Escalation rate for the first set in the twenty-fifth year.
	.	.	.	.
	.	.	.	.
	.	.	.	.
	52-56	ESCFAC(1,34)	F5.2	Escalation rate for the first set on the thirty-fourth year.

Card set E/6 is repeated for each escalation rate set, up to E/6/NESC.3. If for any set NYEAR is less than NTP, the number of time periods in the study, then the escalation rate is assumed to be constant for the remaining years and to be equal to the last value entered. (See section II.C)

Card	Columns	Variable	Format	Description
F/1/1	2-9	ADUM(1)	A8	Name of unit 1
	12-14	ICLNUM(1)	I3	Class number for unit 1. Cross-reference to data in Group E/2 [1 ≤ ICLNUM ≤ NCLASS]
	15-16	NVPTS(1)	I2	Number of valve points for unit 1
	17-21	INYR	I5	Installment year for unit 1 (e.g., 1980)
	22-24	INWK	I3	Installment week of unit 1 [1 ≤ INSTWK ≤ 52]
	25-29	IRYR	I5	Retirement year for unit 1 (e.g., 2000) [INSTYR ≤ IRETYR]
	30-32	IRWK	I3	Retirement week for unit 1 [1 ≤ IRETWK ≤ 52]
	33-39	FUCST(1)	F7.3	Fuel cost for plant 1 ($/MBTU)
	40-46	VAROMC(1)	F7.3	Variable O & M cost for plant 1 ($/MWH)
	47-53	STRCST(1)	F7.3	Cost per startup for unit 1 ($/startup)
	54-60	SPNCST(1)	F7.3	Cost per megawatt per hour to keep unit 1 as spinning reserve without generting power ($/MWH)

Card	Columns	Variable	Format	Description
	61-67	ATTR	F7.3	Mean time to repair after failure for unit 1 (hours) [0 ≤ ATTR ≤ HOURS]
	68-72	PENFAC(1)	F5.3	Penalty factor for unit 1 (real number ≥ 1.0)
F/1/2	2-8	TCAP(1)	F7.1	Total MW capacity of unit 1. Used only if MXVPT = 1
	9-18	THTRAT(1)	F10.3	Average heat rate for unit 1. Used only if MXVPT = 1.(MBTU/MWH) [THTRAT≥0.]
	19-24	TFOR(1)	F6.3	forced outage rate for unit 1. [0 ≤ TFOR ≤ 1.0]
	25-31	CAP(1,1)	F7.1	MW capacity of the first valve point of unit 1
	32-41	HTRAT(1,1)	F10.3	Incremental heat rate of the first valve point of unit 1 [HTRAT≥0.](MBTU/MWH)
	42-47	FOR(1,1)	F5.3	Forced outage rate for the first valve point of unit 1 (fraction [0 ≤ FOR ≤ 1.0]
	48-54	CAP(2,1)	F7.1	MW capacity of the second valve point of unit 1
	55-64	HTRAT(2,1)	F10.3	Incremental heat rate of the second valve point of unit 1 (MBTU/MWH)
	65-70	FOR(2,1)	F6.3	Forced outage rate for the second valve point of unit 1
F/1/3	2-8	CAP(3,1)	F7.1	MW capacity of the third valve point of unit 1
	9-18	HTRAT(3,1)	F10.3	Incremental heat rate of the third valve point of unit 1 (MBTU/MWH)
	19-23	FOR(3,1)	F6.3	Forced outage rate for the third valve point of unit 1
	24 30	CAP(4,1)	F7.1	MW capacity of the fourth valve point of unit 1
	31-40	HTRAT(4,1)	F10.3	Incremental heat rate of the fourth valve for unit 1 (MBTU/MWH)

Card	Columns	Variable	Format	Description
	42-47	FOR(4,1)	F6.3	Forced outage rate for the fourth valve point of unit 1
	48-54	CAP(5,1)	F7.1	MW capacity of the fifth valve point of unit 1
	55-64	HTRAT(5,1)	F10.3	Incremental heat rate of the fifth valve point of unit 1 (MBTU/MWH)
	65-70	FOR(5,1)	F6.3	Forced outage rate for the fifth valve point of unit 1

Card set F/1/4 is read only if the current plant type equals ISTO.

Card set F/1/5 is read only if the current plant type equals ICHY.

Card set F/1/6 is read only if the current plant type equals ITDP.

Card	Columns	Variable	Format	Description
F/1/4	2-8	CCAP(1)	F7.1	Charging capacity of storage unit 1 (MW)
	9-13	CHGFOR(1)	F5.3	Forced outage rate for charging cycle of storage unit 1 (fraction) [$0 \leq$ CHGFOR ≤ 1.0]
	14-23	WKSTOR (1)	F10.2	Weekly energy size of storage unit 1 (MWH)
	24-28	CGEFF(1)	F5.3	Generating/charging of efficiency of unit 1 (fraction) [$0 \leq$ CGEFF ≤ 1.0]

Repeat card set F/1/4 after every unit in class ISTO.

Card	Columns	Variable	Format	Description
F/1/5	2-10	CHSIZE(1,1)	F9.2	Weekly MWH size of reservoir for unit 1 for sub-period 1
	12-20	CHSIZE(2,1)	F9.2	Weekly MWH size of reservoir for unit 1 for sub-period 2
	22-30	CHSIZE(3,1)	F9.2	Weekly MWH size of reservoir for unit 1 for sub period 3
	32-40	CHSIZE(4,1)	F9.2	Weekly MWH size of reservoir for unit 1 for sub-period 4
	42-50	CHSIZE(5,1)	F9.2	Weekly MWH size of reservoir for unit 1 for sub-period 5
	52-60	CHSIZE(6,1)	F9.2	Weekly MWH size of reservoir for unit 1 for sub-period 6

Card	Columns	Variable	Format	Description
F/1/5.2		CHSIZE(7 - 12,1)		Same format as card F/1/5. Data pertains to sub-periods 7 - 12
				.
F/1/5.9		CHSIZE(49 - 52,1)		.

Repeat card set F/1/5 after every unit in class ICHY.

Card	Columns	Variable	Format	Description
F/1/6	1-3	NC	I3	Curve number for the time dependent unit (Not used in SYSGEN)
	5-10	RN	F6.1	Capacity multiplier for the time dependent unit (Not used in SYSGEN)

Repeat card F/1/6 after every unit in class ITDP.

Card	Columns	Variable	Format	Description
G/1/1	2-9	ADPM	A8	Name of unit 1. Must match name on unit data card.
	12-3	NYRCYC(1)	I2	Number of years in preventative maintenance cycle [1 $\leq$ NYRCYC(1) $\leq$ 10]
	14-16	NSPM(1.1)	I3	First sub-period within cycle for which preventative maintenance is scheduled
	17-18	NWPM(1,1)	I2	Number of weeks unit is removed for preventative maintenance in the first maintenance sub-period
	20-22	NSPM(2,1)	I3	Second sub-period within cycle for preventative maintenance
	23-24	NWPM(2,1)	I2	Number of weeks unit is removed for maintenance in the second maintenance sub-period
	.			.
	.			.
	.			.
	68-70	NSPM(10,1)	I3	Tenth sub-period within cycle for preventative maintenance
	71-72	NWPM(10,1)	I2	Number of weeks unit is removed for maintenance in the tenth maintenance sub-period

Card	Columns	Variable	Format	Description
G/1/2				Same format as card G/1/1. Data pertain to units 2 NOSTNS.
.				
.				
.				
G/1/NOSTNS				

Card set H is read only if MLORD = False.

Card	Columns	Variable	Format	Description
H/1/1	2-3	NORDER(1)	I2	Valve point of first increment to be loaded.
	4-6		I3	Unit index of first increment to be loaded
	7-8	NORDER(2)	I2	Valve point of second increment to be loaded.
	9-11		I3	Unit index of second increment to be loaded
	12-13	NORDER(3)	I2	Valve point of third increment to be loaded.
	14-16		I3	Unit index of third increment to be loaded
	17-18	NORDER(4)	I2	Valve point of fourth increment to be loaded.
	19-21		I3	Unit index of fourth increment to be loaded
	22-23	NORDER(5)	I2	Valve point of fifth increment to be loaded.
	24-26		I3	Unit index of fifth increment to be loaded
	27-28	NORDER(6)	I2	Valve point of sixth increment to be loaded.
	29-31		I3	Unit index of sixth increment to be loaded

Card	Columns	Variable	Format	Description
	32-22	NORDER(7)	I2	Valve point of seventh increment to be loaded.
	34-36		I3	Unit index of seventh increment to be loaded
	37-38	NORDER(8)	I2	Valve point of eighth increment to be loaded.
	39-41		I3	Unit index of eighth increment to be loaded
	42-43	NORDER(9)	I2	Valve point of ninth increment to be loaded.
	44-46		I3	Unit index of ninth increment to be loaded
	47-48	NORDER(10)	I2	Valve point of tenth increment to be loaded.
	49-51		I3	Unit index of tenth increment to be loaded

Repeat card H/1/1 until all valve points have been included.

V Output Files and Reports

V.A Report Modules

SYSGEN has four report options. The reports are written in modules. The print option determines which modules are used and to some extent which subroutines are executed. There are seven basic report modules.

V.A.1 Initial Plant and System Report (Subroutine: SIMREP)

The summary report is an echo print of the input data. (See pages 1 through 11 of the sample output file.) Card Sets A through G, as defined in section IV.A, are printed. In addition, the index number of the unit is printed. This is the number used internally to identify the unit, and gives the order in which the plant was read in (i.e., the first unit read in has the index = 1).

V.A.2 Sorted Limited Energy Plant Report (Subroutine: LEPREP)

The sorted limited energy plant report writes out conventional hydro and storage information showing the order in which they are considered for loading. (See pages 12 and 13 of the sample output file.)

CHY/STO ID	=	units' position in the loading stack, e.g., if STO ID = 2, then that unit will be loaded only after the storage unit with ID = 1 has been loaded, if unit 1 is available.
Unit Index	=	the units' unit index (see the last paragraph in Section III.A).

Hours per time period = the number of hours that the unit can generate at full capacity. (This is the reservoir size divided by the unit's capacity.) The hydro arrays are sorted on this number. The unit the greatest number of hours is the first plant in the stack.

MWHs per time period = Reservoir size of the unit.

V.A.3 Probability Curve Report (Subroutine: CRVREP)

This report writes out information for the equivalent load demand curve. All values (except the area) are in MWs for the curve. (See, for example, page 14 of the sample output file.)

Load curve spacing = number of MWs between each array point on the curve printed beneath.

Minimum demand = minimum customer demand.

Maximum demand = maximum equivalent demand. For the initial demand curve, this is the peak demand. For the final demand curve, this is the peak demand plus installed capacity.

Equivalent demand area = area under the probability curve. For the initial demand curve, this is the energy demand on the system. For all other curves, this value does not have physical significance.

Demand curve = equivalent demand probability curve. The values are printed at intervals of the spacing. The first value on the curve is the probability that the demand is greater than one load curve spacing. The last value is the probability that the demand is greater than the maximum.

V.A.4 Plant Report (Subroutine: PLTREP)

The plant report gives the information on each unit after it is loaded. (See pages 15 and 16 in the sample output.)

Unit index	=	input order of the unit (internal identification number).
Unit name	=	user identification for the unit.
Unit type	=	class name and loading type, e.g, OIL BASE.
Unit valve point	=	valve point of the unit currently being loaded.
MW added	=	capacity loaded in this step (MW).
Expected startups	=	expected number of times the unit is started up. Reported only for the first valve point.
Added expected energy	=	energy expected to be generated to meet customer demand by the current valve point (MWH).
Fuel cost	=	present worth of the expected fuel cost in the time period for the current valve point (thousand $).
O&M cost	=	present worth of the expected O&M cost in the time period for the current valve point (thousand $).
Expected startup cost	=	present worth of the expected cost of starting up the unit. Reported only for the first valve point (thousand $).
Spinning reserve cost	=	present worth of cost of using the unit for spinning reserve. Reported with the values for the last valve point (thousand $).
Total cost	=	Sum of fuel, O&M, startup and spinning reserve costs (thousand $).
Total capacity factor	=	unit capacity factor. Capacity factor = total energy generated divided by (the MWs loaded x the number of hours in the time period).
Energy used for storage	=	energy generated for storage by the current valve point (MWH).

Capacity factor after storage = total capacity factor for a base loaded plant that is used for storage.

V.A.5 Subperiod Report (Subroutine: SUMREP)

The system summary report prints out data on the system after all units have been loaded. (See pages 17, 18 and 19 of the sample output file.) The first page of the summary report gives the total energy generated and total costs for each unit in a format similar to the unit report (V.A.4). If MLCAP is true, the effective load-carrying capability of each unit is printed. A report on conventional hydro and storage generation and losses is written.

V.A.6 Plant Time Period Report (Subroutine: ENDREP)

ENDREP prints the same information as PERREP summed over all subperiods. (See page 30 of the output file.)

V.A.7 System Report (Subroutine SYSREP)

The system report prints the following variables for either a subperiod or for a time period (see pages 21 and 31 of the output):

Peak demand	=	peak customer demand (MW)
Customer energy demand	=	original customer energy demand (MWH).
Load factor	=	energy/(peak x hours).
Unserved energy demand	=	expected energy demand which cannot be met by the installed capacity (MWH).
Percent energy unserved	=	percent of original customer demand that cannot be net.
Loss-of-load probability	=	probability that the customer demand cannot be met, or percent of time customer demand cannot be met.

Magnitude of loss of load	=	expected magnitude of each loss of load (MW).
Frequency of loss of load	=	number of times in the subperiod that the load cannot be met
Duration of loss of load	=	Average duration of each loss of load.
Total expected energy generated	=	sum of the expected energies generated by each unit (MWH).
Fuel cost	=	total system expected fuel cost (million $).
O&M cost	=	total system expected O&M cost (million $).
Total cost	=	total system expected cost including fuel, O&M, startup, and spinning reserve costs (million $).
GBTU consumed	=	expected input energy consumed by each class, reported only at the end of the time period (10^9 BTU).

V.A.8 Grid File (Subroutine: GRDWRT)

GRDWRT writes a file to be read by SCYLLA. SCYLLA evaluates the worth of units to the system using a static economic analysis. For each subperiod, GRDWRT writes the following data:

Record	Variable	Format	Description
1	ICASE	I5	case number
	NTPER	I5	number of time periods
	NSPTP	I5	number of subperiods
2	NPER	I5	current time period
	NSPER	I5	current subperiod
3	PERCAP (1 - NCLASS)	6E12.5	Installed capacity for each class
4	PERNRG (1 - NCLASS)	6E12.5	Energy generated by each class
5	PERFLC (1 - NCLASS)	6E12.5	Fuel cost for each class
6	PEROMC (1 - NCLASS)	6E12.5	O&M cost for each class

Records 2 through 6 are repeated for each subperiod. At the end of each time period the following record is written:

7	ADM	E12.5	average load curve spacing
	PKLLP	E12.5	peak loss of load probability
	TOTFRQ	E12.5	average frequency of outages
	TOTDUR	E12.5	average duration of outages
8	IMXPK	I5	maximum load curve index
9	AVG(1-IMXPK)	4D20.15	average equivalent load curve

V.2 Report Options

MGRID

If MGRD is true the Grid File is written.

MINI

If MINI is true the System Summary Report is printed for each subperiod and for each time period.

MIDI

If MIDI is true, all of MINI is printed the Plant Subperiod and Time Period Reports are printed.

MAXI

If MAXI is true, all of MIDI is printed plus the Plant Loading Report.

MMAXI

If MMAXI is true, the Initial Plant Report, the Probability Curve Report for each unit at the beginning and end of the study and the Sorted Hydro Report.

VI Subroutine Documentation

NAME	SYSGEN
TYPE	MAIN
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	SYSGEN supervises the probabilistic simulation.
ARGUMENTS	None
COMMONS	/TIMDAT/, /IODEVS/, /DEBUGS/
SUBROUTINES	SIMINP, LEPSRT, SIMREP, SUPSIM
LOGIC	1) Define files. 2) Call SIMINP. 3) Call LEPSRT. 4) Call SIMREP. 5) Loop through time periods and subperiods; call SUPSIM. 6) End.
ERRORS	IFLG = -10 Error in call to subroutine
DEBUG	None

NAME	ADDLEP
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	1/28/80
DESCRIPTION	ADDLEP supervises the hydro and storage stacks. It adds hydro and storage units to the stack as they become cost effective in the loading order, and checks the conventional hydro and storage stacks for units with enough energy to be loaded.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag (returned)	I*4
IOFF	off-load status	I*4
N	valve point of off-loaded unit	I*4
L	unit index of off-loaded unit	I*4

COMMONS: /SYSDAT/, /PLTDAT/,/PERDAT/, /HYDDAT/, /LDGDAT/, /DEBUGS/, /OPTION/ /TIMDAT/

SUBROUTINES: INDEX, CAPOFF, CAPREQ, ICHECK, LDGADJ, INDLEP

LOGIC

1) If the loading order is input (MLORD = F), compute the reduced capacity for any limited energy units, then RETURN.

2) Loop through all hydro and storage units. If any have cost less than the current plant then change the loading status so that they will be considered for loading (i.e., set LDSTAT = 1).

3) If the limited energy plants are to be loaded at reduced capacity (MOVE=Fasle), compute the reduced capacity for any hydro or storage unit that can be loaded, then RETURN. Otherwise go to 4.

4) If the current unit is an LEP unit, then go to 10 to compute its energy.

5) Test successive sequences of units to find the longest sequence of units that will fit under the curve if the sequence is loaded as a single unit.

ADDLEP (continued)

6) If no hydro or storage unit can be loaded and a thermal unit has not been off-loaded then RETURN. Otherwise go to 7.

7) If no hydro or storage unit can be loaded, but a thermal unit has been off-loaded, then set IOFF = 2 so it will be reloaded in ADDPLT. Otherwise go to 8.

8) If a hydro or storage unit can be loaded and a thermal unit has already been off-loaded or MOVE is false, then interpolate the hydro or storage unit into the loading order at the current loading point and RETURN. Otherwise go to 9.

9) If a hydro or storage unit can be loaded and MOVE is true and a thermal unit has not been off-loaded, then call CAPOFF to find the loading capacity for the thermal unit. Put the reduced thermal unit, followed by the hydro or storage into the loading order. Then, RETURN.

10) Search through the LEP stack to find the LEP index of the current unit. Set its energy equal to its size minus any unused energy.

11) Return.

ERRORS

IFLG = -1	Call to CAPREQ results in unit size less than zero.
IFLG = -3	Current unit is an LEP unit, but no match is found for the unit index in the LEP stack.
IFLG = -10	Error in call to subroutine.

DEBUG

If IDEBUG(1) = True, print hydro ID, plant index, energy required, hydro size, unit to be moved, off-load status, and adjusted capacity.

NAME	ADDPLT
TYPE	SUBROUTINE
SYSTEM	GEM
UPDATE	1/28/80
DESCRIPTION	ADDPLT loads the unit which is next in the loading order (NORDER(NORD)) and adjusts all parameters which change when a unit is loaded onto the system.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag (returned)	I*4
IOFF	current status of interrupted units (sent and returned)	I*4

COMMONS

/SYSDAT/, /PLTDAT/,/PERDAT/, /LDGDAT/, /DEBUGS/, /TIMDAT/, /OPTION/, /HYDDAT/, /MAXMUM/

SUBROUTINES

ADDLEP, CONVLV, CONVFQ, DECONV, STORGE, INDEX, RESCHG, AREADM, INDLEP, RESSET

LOGIC

1) Call ADDLEP to check if a limited energy unit should be loaded next.

2) If MSPIN=True, call RESSET to compute the cost of spinning reserve.

3) If MSTOR=True, and the current unit is base load and there are storage units, call STORGE.

4) If MFREQ=True, call the frequency convolution routine and compute the expected number of startups for the unit.

5) If previous valve points of the unit were were loaded, call DECONV to remove them them from the equivalent demand curve.

6) Compute the expected energy for the current valve point.

7) Call CONVLV to put the unit up to the current valve point into the the equivalent demand curve.

8) Set the loading status to -1.

ADDPLT (continued)

9) If a unit has been partially removed for a limited energy unit, convolve the remainder of the unit into the curve.

10) Return.

ERRORS	IFLG = -1	Current unit in loading order does not have a loading status of 1
	IFLG = -2	Unit type is ICHY or ISTO, but unit index can't be found in LEP stack.
	IFLG = -3	Unable to find base load unit that was removed to load limited energy unit.
	IFLG = -10	Error in call to subroutine.

DEBUG

If IDEBUG(2) = True, print unit index, valve point, MW to be added, expected energy, loading point, expected outages.

NAME	AREADM
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	AREADM calculates the area between two given points for demand curve assuming linear interpolation.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag (returned)	I*4
XLOWER	lower point	R*4
XUPPER	upper point	R*4
AREA	area under probability curve (returned)	R*4

COMMONS: /MAXMUM/, /DEBUGS/, /DEMAND/

SUBROUTINES: None

LOGIC:

1) Test for values at start of curve
2) Calculate areas between calling values and closest integer spacing
3) Loop through array using formula given in section III.A.7.
4) Return

ERRORS: IFLG = -3 XLOWER greater than XUPPER

DEBUG: If IDEBUG(3) = True, print XLOWER, XUPPER, max index and max values for curve.

NAME	AVAILB
TYPE	FUNCTION
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	AVAILB returns the availability of the capacity up to valve point N of unit L in subperiod NSPER of time period NPER.

ARGUMENTS

NAME	DESCRIPTION	TYPE
N	valve point number	I*4
L	unit index	I*4
ID	storage index	I*4

COMMONS: /GCLASS/, /DEBUGS/, /HYDDAT/, /MNTDAT/,/PLTDAT/, /SYSDAT/, /TIMDAT/

SUBROUTINES: EQAVAL

LOGIC

1) Compute the age of the unit to get the immature forced outage multiplier.

2) If N is greater than the number of valve points, compute the equivalent availability from TFOR(L).

3) If N=0, compute the probability that outages equal zero.

4) If ID is greater than zero, return the availability of the charging cycle of storage unit L.

5) Multiply the availability by fraction of time that the unit is not on maintenance.

6) Return.

ERRORS

Warning if AVAILB is less than zero or greater than one.
Warning if ID = 0 and plant is not a storage unit.

DEBUG

If IDEBUG(4) = True, print unit index, age, availability, unweighted availability, and maintenance fraction.

NAME	AVGDUR
TYPE	FUNCTION
SYSTEM	SYSGEN
UPDATE	2/12/80
DESCRIPTION	AVGDUR returns the average duration, in hours that the load level equals X.

ARGUMENTS

NAME	DESCRIPTION	TYPE
X	load level	R*4

COMMONS	/DEMAND/, /OPTION/, /TIMDAT/
SUBROUTINES	DERIVX

LOGIC

1) Set AVGDUR = 0.0 for loads greater than the peak or less than the minimum

2) Compute AVGDUR = DERVI(PROB,X)/DERIVX(FREQ,X)

3) Return.

ERRORS	None
DEBUG	None

NAME	CAPOFF
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	1/28/80
DESCRIPTION	CAPOFF computes the adjusted capacity for a thermal unit that is interrupted to load a limited energy unit (see section III.A.13).

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error code (returned)	I*4
CAPT	capacity of the thermal unit (MW)	R*4
Q	outage rate of thermal unit	R*4
CAPH	capacity of intervening unit (MW)	R*4
ENERGY	energy available from the limited energy unit (MWH)	R*4
CAPADJ	capacity of the interrupted unit to be loaded before the limited energy unit (returned)	R*4

COMMONS /DEBUGS/, /LDGDAT/, /PERDAT/, /TIMDAT/, /DEMAND/

SUBROUTINES AREADM, PROBDM

LOGIC

1) Compute the energy that would be required if the limited energy unit were loaded next.

2) Compute the difference between the required and the available.

3) Compute the difference between the height of the curve where the unit would be taken off.

4) Assuming a constant slope, compute the distance the loading point should be moved so that the area under the curve equals the available energy (quadratic equation).

5) Test the approximation in 4 by calling AREADM at the new loading point. If the unit doesn't fit, add a difference term to the loading point and go to 1.

6) Return.

CAPOFF (continued)

ERRORS	IFLG = -1	Capacity doesn't converge after 20 iterations
	IFLG = -2	Adjusted capacity less than zero.
	IFLG = -10	Error in call to subroutine
	Warning if adjusted capacity exceeds the thermal capacity.	
DEBUGS	If IDEBUG(20) = True, print the capacities of the interrupted and interrupting units and the required energy. For each iteration, it prints the difference in energies and the new capacity.	

NAME	CAPREQ
TYPE	FUNCTION
SYSTEM	SYSGEN
UPDATE	10/29/79
DESCRIPTION	CAPREQ computes the capacity required to generate all of a block of energy (ENERGY) loaded at a specified point (XLOWER) on the equivalent demand curve.

ARGUMENTS

NAME	DESCRIPTION	TYPE
XLOWER	load point	R*4
ENERGY	area under curve to be filled in	R*4

COMMONS	/MAXMUM/, /DEMAND/ /TIMDAT/
SUBROUTINES	None
LOGIC	Starting from XLOWER add small increments of capacity, keeping a running total of the new area until it equals ENERGY (for area under the curve see AREADM).
ERRORS	None
DEBUG	None

NAME	CONVFQ
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	2/12/80
DESCRIPTION	CONVFQ convolves the frequency curve for unit L into the load frequency curve and computes the expected number of startups for unit L.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag (returned)	I*4
L	unit index	I*4
IOFF	Current status of loaded units (sent)	I*4
EXSTRT	expected startups for unit L (returned)	R*4

COMMONS /PLTDAT/, /PERDAT/, /DEMAND/, /MAXMUM/, /DEBUGS/, /TIMDAT/

SUBROUTINES DERIVX, AVAILB

LOGIC

1) Set the expected number of startups of unit L equal to the derivative of the frequency curve (DERIVX) at the current loading point.

2) Compute equivalent forced outage rate, equivalent outage frequency, and added capacity for unit L.

3) Set up variables to account for capacities that fall between the array spacings.

4) Set up do-loop counters for the start and and end of the convolution.

5) Compute the new frequency curve using the formula given in section III.A.8.

6) Return.

ERRORS

IFLG = -1	Expected startups less than zero
IFLG = -2	Unit size less than zero
IFLG = -3	Curve counters incorrect

DEBUG If IDEBUG(15) = True, print unit index, equivalent forced outage rate, equivalent frequency, and expected startups.

NAME	CONVLV
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	2/12/80
DESCRIPTION	CONVLV convolves the first N valve points of unit L into the equivalent demand curve.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag (returned)	I*4
N	valve point number	I*4
L	unit index	I*4
EXPNRG	expected energy (returned)	R*4

COMMONS: /DEBUGS/, /DEMAND/, /MAXMUM/, /PLTDAT/, /TIMDAT/, /PERDAT/, /LDGDAT/

SUBROUTINES: OUTAGE

LOGIC

1) Set up unit variables for the convolution.
2) Compute the new loading point.
3) Set up curve variables for the convolution.
4) Loop backwards through the equivalent demand curve using equation (1) from section III.A.5.
5) Return.

ERRORS

IFLG = -1	Curve counters incorrect MIN MAX
IFLG = -3	Unit size less than zero
IFLG = -4	Maximum points for probability curve exceeded.

DEBUG: If IDEBUG(5) = True, print size, availability, cost, forced outage rate, incremental space, and fraction of space.

NAME	CONVST
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	1/28/80
DESCRIPTION	CONVST convolves storage units into the augmented equivalent demand curve.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag (returned)	I*4
NB	base unit valve point	I*4
LB	base unit index	I*4
CAPBS	base unit capacity	R*4
ID	storage index ID=0 to convolve base unit	I*4
PS	availability of unit to be convolved	R*4
REQNRG	storage size (MWHs)	R*4
CAPIN	storage charging capacity (MW)	R*4
EXPNRG	excpected energy available to storage (returned) (MWHs)	R*4

COMMONS /TIMDAT/, /PERDAT/, /DEMAND/, /MAXMUM/, /DEBUGS/, /PLTDAT/

SUBROUTINES AVAILB

LOGIC

1) If CONVST has not been called before, set APROB=PROB.

2) If ID=0, set up variables to convolve the outages of the base unit.

3) If ID = storage index, set up variables to convolve demand of the storage unit.

4) Perform the convolution, ignoring multiple increment algorithm for base units

5) If the unit is storage, stop the convolution when EXPCAP=SIZE.

ERRORS IFLG = -1 Maximum number of points for proability curve exceeded.

DEBUG If IDEBUG(6) = True, print calling arguments, array counters and intermediate convolution values.

NAME	CRVREP
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	CRVREP writes out the load curve, and computes the area under the curve.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag (returned)	I*4
IPAGE	current page number	I*4
AREA	total area under curve (returned)	R*4

COMMONS	/DEMAND/, /IODEVS/, /TIMDAT/
SUBROUTINES	AREADM
LOGIC	1) Call AREADM. Write out curve information. 2) Return.
ERRORS	IFLG = -10 Error in call subroutine
DEBUG	None

NAME	CSTLVL
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	CSTLVL computes the levelized cost for units with more than one valve point.

ARGUMENTS

NAME	DESCRIPTION	TYPE
L	unit index	I*4

COMMONS	/LDGDAT/, /PLTDAT/, /PERDAT/, /HYDDAT/
SUBROUTINES	None

LOGIC

1) Compute the levelized cost for all valve points of unit L using the equations from section III.A.4.

2) Return.

ERRORS	None
DEBUG	None

NAME	CSTSET
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	1/23/80
DESCRIPTION	CSTSET computes the marginal cost for all units at the start of each time period.
ARGUMENTS	None
COMMONS	/PERDAT/, /PLTDAT/, /SYSDAT/, /TIMDAT/, /GCLASS/
SUBROUTINES	FACTOR
LOGIC	1) Loop through all units and valve points computing the cost according to the formula in section III.A.4.
ERRORS	None
DEBUG	None

NAME	CUMCAP		
TYPE	SUBROUTINE		
SYSTEM	SYSGEN		
UPDATE	4/23/79		
DESCRIPTION	CUMCAP returns the cumulative capacity from valve points N to the total capacity for unit L.		
ARGUMENTS	NAME	DESCRIPTION	TYPE
	N	valve point	I*4
	L	unit index	I*4
COMMONS	/PLTDAT/		
SUBROUTINES	None		
LOGIC	1) Loop through valve points N to NVPTS(L) and keep a running total of incremental capacities in CUMCAP.		
	2) Return.		
ERRORS	None		
DEBUG	None		

NAME	DECONV
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	DECONV removes the first N valve points of unit L from the equivalent load duration curve.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag (returned)	I*4
N	valve point	I*4
L	unit index	I*4

COMMONS	/DEMAND/, /DEBUGS/, /PERDAT/, /PLTDAT/, /TIMDAT/
SUBROUTINES	OUTAGE

LOGIC

1) Set up unit variables
2) Check bounds and set up temporary values
3) Deconvolve plant.
4) Return.

ERRORS: IFLG = -1 Capacity less than zero

DEBUG: If IDEBUG(7) = True, print capacity and availability.

Note: The linear interpolation deconvolution agorithm is numerically unstable. A warning is printed if the new curve violates the requirements for probability curves, and a fix up is made.

NAME	DERIVX
TYPE	FUNCTION
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	DERIVX returns the derivative of either the probability or frequency curve at load level X.

ARGUMENTS

NAME	DESCRIPTION	TYPE
ICRV	ICRV = 'PROB' or 'FREQ'	A*4
X	load level	R*4

COMMONS	/DEMAND/
SUBROUTINES	None

LOGIC

1) Compute derivative at X for the given curve using the formula from section III.A.10.
2) Return

ERRORS

Warning if ICRV is not equal to 'PROB' or 'FREQ'
Default value is 1.0

DEBUG

None

NAME	ELLCAP
TYPE	FUNCTION
SYSTEM	SYSGEN
UPDATE	7/26/79
DESCRIPTION	ELLCAP returns the effective load carrying capability of unit L in subperiod NSPER.

ARGUMENTS

NAME	DESCRIPTION	TYPE
L	unit index	I*4

COMMONS: /DEBUGS/, /DEMAND/, /PLTDAT/, /PERDAT/, /GRDDAT/, /TIMDAT/

SUBROUTINES: AVAILB

LOGIC

1) Perform a deconvolution using the logic of DECONV, but using a temporary array
2) Find the load level, x, such that the value of the temporary array equals PERLOP.
3) Subtract x and the unit capacity from the final loading point to give ELLCAP (see section III.A.13).
4) Return

ERRORS

Warning if ELLCAP greater than the unit capacity
Warning if ELLCAP cannot be computed. Default value is zero
Warning if new probability curve violates assumptions of a cumulative distribution function

DEBUG

If IDEBUG(19) = True, print the unit index, unit capacity, loading point, x, LOLP, and the two curves near the LOLP.

NAME	ENDLEP
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	1/28/80
DESCRIPTION	ENDLEP adds all limited energy units left in the stacks after all other plants have been loaded.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag (returned)	I*4

COMMONS: /PLTDAT/, /PERDAT/, /HYDDAT/, /LDGDAT/, /DEBUGS/, /TIMDAT/

SUBROUTINES: ADDPLT, CAPREQ

LOGIC:

1) Check the hydro stack then the storage stack. If there is a unit that has not been loaded, then:
   a) call CAPREQ to get the required capacity
   b) call ADDPLT using the adjusted MW.
2) Return.

ERRORS:

IFLG = -1	Loading order array index too large
IFLG = -10	Error in call to subroutine

DEBUG: If IDEBUG(8) = True, print unit index, adjusted capacity, energy required, size, loading order.

NAME	ENDREP
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	7/31/79
DESCRIPTION	ENDREP writes the report at the end of the time period summarizing the subperiods.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error code (returned)	I*4
IPAGE	current page number	I*4

COMMONS: /GGENRL/, /GCLASS/, /GRDDAT/, /IODEVS/, /OPTION/, /PLTDAT/, /PRINTC/, /SYSDAT/, /TIMDAT/, /TOTALS/

SUBROUTINES: NEWPAG

LOGIC:

1) Loop through units writing out time period totals.
2) Print system totals.
3) Return.

ERRORS: None

DEBUG: None

NAME	EQAVAL
TYPE	FUNCTION
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	EQAVAL returns the equivalent availability for unit L.

ARGUMENTS

NAME	DESCRIPTION	TYPE
L	unit index	I*4

COMMONS	/DEBUGS/, /PLTDAT/
SUBROUTINES	CUMCAP

LOGIC

1) Loop through all increments of unit L computing the sums as defined in section III.A.2.
2) Test to be sure the equivalent availability is between zero and one.
3) Return

ERRORS

Warning if the equivalent availability is greater than one or less than zero.

DEBUG

If IDEBUG(16) = True, print unit index, number of valve points, intermediate calculations, and the equivalent availability.

NAME	FREQDM
TYPE	FUNCTION
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	FREQDM returns the frequency that the load enters a state greater than or equal to X.

ARGUMENTS

NAME	DESCRIPTION	TYPE
X	load level	R*4

COMMONS	/DEMAND/, /OPTION/
SUBROUTINES	None

LOGIC

1) Set FREQDM = 1.0 if MFREQ = False.
2) Convert X to its equivalent spacing.
3) Using linear interpolation find FREQ.
4) Return.

ERRORS	None
DEBUG	None

NAME	GRDWRT
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	8/10/79
DESCRIPTION	GRDWRT writes a file to be read by SCYLLA.
ARGUMENTS	None
COMMONS	/GCLASS/, /SYSDAT/, /PLTDAT/, /PERDAT/, /IODEVS/, /MNTDAT/, /DEMAND/, /GRDDAT/, /TIMDAT/, /LREDAT/
SUBROUTINES	None
LOGIC	1) Initialize class arrays to zero. 2) Compute time period average equivalent load curve. 3) Loop through all units keeping totals for each class. 4) Write out class arrays and the equivalent load curve. 5) Return.
ERRORS	None
DEBUG	None

NAME	ICHECK
TYPE	FUNCTION
SYSTEM	SYSGEN
UPDATE	10/27/79
DESCRIPTION	ICHECK checks if the limited energy unit K has enough energy to generate at full capacity at loading point PETST.

ARGUMENTS

NAME	DESCRIPTION	TYPE
CAPTST	capacity (MW)	R*4
PETST	test loading point	R*4
ENERGY	energy available from unit K	R*4
FAIL	additional energy required if the next unit fails	R*4
AREA	Area under the curve	R*4

COMMONS	/TIMDAT/, /DEBUGS/
SUBROUTINES	AREADM

LOGIC

1) Set ICHECK = 0.
2) Call AREADM to find the area to be the test loading point plus the unit capacity.
3) If there is an error in AREADM, set ICHECK = -1.
4) Compute the required energy.
5) If the available energy is greater than the required energy set ICHECK = 1.
6) Return.

ERRORS	Warning if error in call to subroutine (ICHECK= -1)
DEBUG	If IDEBUG(1) = True, print unit index, test loading point, unit capacity, available energy, test energy, and ICHECK.

NAME	INDEX
TYPE	FUNCTION
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	INDEX returns the unit index and valve point number for the given increment in the loading order.

ARGUMENTS

NAME	DESCRIPTION	TYPE
I	loading order index	I*4
N	valve point number (returned)	I*4
INAME	unit class name (returned)	A*4
ILOAD	unit loading type (returned)	A*4

COMMONS	/LDGDAT/, /GCLASS/, /PLTDAT/, /MAXMUM/, /TIMDAT/
SUBROUTINES	None
LOGIC	1) N = NORDER(I)/1000. 2) INDEX = NORDER(I)-N*1000. 3) Set INAME and ILOAD from ICLASS.
ERRORS	Warning if loading order index is out of range
DEBUG	None

NAME	INDLEP
TYPE	FUNCTION
SYSTEM	SYSGEN
UPDATE	1/28/80
DESCRIPTION	INDLEP returns the unit index of limited energy units.

ARGUMENTS

NAME	DESCRIPTION	TYPE
J	LEP index (sent)	I*4
SIZE	energy available from LEP unit (MWH)(sent)	R*4
P	LEP unit availability	R*4

COMMONS /HYDDAT/, /TIMDAT/

SUBROUTINES None

LOGIC

1) If J is out of range, set INDLEP = -1 and RETURN.
2) Otherwise, if J is less than the number of conventional hydro units (NOCH), set INDLEP equal to the hydro unit index (IDCH).
3) If J is greater than NOCH, set INDLEP equal to the storage unit index (IDST).
4) If the unit is unavailable, set INDLEP = 0 and RETURN.
5) Otherwise set SIZE equal to the reservoir size (CHSIZE or STGNRG) and set P equal to the unit availability.
6) RETURN.

ERRORS Warning if J is greater than the total number of LEP units.

DEBUG None.

NAME	LDGADJ
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	LDGADJ interpolates valve point N of unit L into the loading order at LDORD. The increments above LDORD are each moved to the next array index, up to and including LSTOP.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error code (returned)	I*4
LDORD	index in NORDER where unit is to be put	I*4
LSTOP	index in NORDER where shifting is to stop	I*4
N	valve point of the to be interpolated	I*4
L	unit index	I*4

COMMONS: /LDGDAT/, /DEBUGS/, /TIMDAT/

SUBROUTINES: None

LOGIC:

1) Move all units in the NORDER array down one starting at LDORD ending at LSTOP.
2) Put the given unit into NORDER(LDORD).
3) Return.

ERRORS:

IFLG = -1	LDORD greater than the maximum number of loading increments
IFLG = -2	LDORD greater than LSTOP

DEBUG: If IDEBUG(9) = True, print unit index, valve point, loading order index and value.

NAME	LDGORD
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	10/28/79
DESCRIPTION	LDGORD sets up the loading order according to the loading order option, based on marginal costs.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag (returned)	I*4

COMMONS: /SYSDAT/, /MAXMUM/, /PLTDAT/, /PERDAT/, /HYDDAT/, /LDGDAT/, /DEBUGS/, /TIMDAT/, /OPTION/, /GCLASS/

SUBROUTINES: NEXTLD, SPNRES, CSTLVL, LDGADJ

LOGIC

1) Use equivalence statement to store the working array for the sort, WORK, in BSNRG.

2) Loop through all the units setting up the working arrays and counting the number of loading increments, NNORD.

3) Call CSTLVL to levelize costs.

4) Sort the units so that
   NORDER(1) = loading index of the cheapest unit
   NORDER(NNORD) = loading index of the most expensive unit.

5) For each loading group, loop through the increments to find the next cheapest unit in the current loading group using NEXTLD.

6) If there is a spinning reserve requirement, call SPNRES. SPNRES returns the loading index of the unit that should be used instead of the next cheapest one in order to meet the reserve requirement

7) Loop the reservoir hydro and storage units adding them to the total number of increments.

LDGORD (continued)

8) Return.

ERRORS

IFLG = -1	No units in loading order
IFLG = -2	Number of loading increments exceeds the maximum
IFLG = -3	At end of sort, number of increments and entries in NORDER do not agree
IFLG = -10	Error in call to subroutine

DEBUG

If IDEBUG(10) = True, print loading order array before and after the loading constraints are imposed.

NAME	LEPREP
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	1/12/80
DESCRIPTION	LEPREP writes an initial report on limited energy units.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error code (returned)	I*4
PSR	report name	A*4
IPAGE	report page number	I*4

COMMONS	/HYDDAT/, /IODEVS/, /PLTDAT/,/PRINTC/, /SYSDAT/, /TIMDAT/
SUBROUTINES	NEWPAG

LOGIC

1) Write expected subperiod energies for hydro units.
2) Write reservoir size for storage units.
3) Return.

ERRORS	None
DEBUG	None

NAME	LEPSRT
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	LEPSRT sorts through the limited energy arrays using the exchange method. Each array is sorted on size (MWH)/capacity (MW). The unit index of the largest storage unit is stored in IDST(1).
ARGUMENTS	None
COMMONS	/PLTDAT/, /HYDDAT/, /SYSDAT/, /TIMDAT/
SUBROUTINES	None
LOGIC	1) Sort CHY array on CHSIZE/CAP. Exchange IDCH and CHSIZE. 2) Sort STO array on STSIZE/CAP. Exchange IDST, STSIZE, CGEFF, and CHGFOR, CCAP.
ERRORS	None
DEBUG	None

NAME	NEXTLD
TYPE	FUNCTION
SYSTEM	SYSGEN
UPDATE	10/26/79
DESCRIPTION	NEXTLD returns the loading order index of the next increment in the current loading group.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IGRP	current loading group being searched	I*4
ISTART	loading order index from which the search starts	I*4
N	valve point number of the next unit (returned)	I*4
L	unit index of the next unit (returned)	I*4

COMMONS	/LDGDAT/, /PLTDAT/, /SYSDAT/, /MAXMUM/
SUBROUTINES	INDEX

LOGIC

1) If ISTART is greater than the number of loading points go to 4.
2) Loop through the loading order until a unit in the current group is found.
3) Set NEXTLD equal to the loading order index.
4) If no unit is found or ISTART is out of range set NEXTLD = NNORD + 1.
5) Return.

ERRORS	None
DEBUG	None

NAME	OUTAGE
TYPE	FUNCTION
SYSTEM	SYSGEN
UPDATE	10/26/79
DESCRIPTION	OUTAGE returns the forced outage rate for valve point N of unit L for the current subperiod.

ARGUMENTS

NAME	DESCRIPTION	TYPE
N	valve point	I*4
L	unit index	I*4

COMMONS	/GCLASS/, /DEBUGS/, /MNTDAT/, /PLTDAT/, /SYSDAT/, /TIMDAT/
SUBROUTINES	None
LOGIC	1) Compute age of unit. 2) Compute forced outage rate modified by the immature forced outage multiplier and the subperiod maintenance.
ERRORS	Warning of OUTAGE is less than zero or greater than one.
DEBUG	If IDEBUG(4) = True, print unit index, valve point, outage rate, outage rate modified by immature forced outage multiplier and the maintenance fraction.

NAME	PERREP
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	7/26/79
DESCRIPTION	PERREP writes the results of the simulation at the end of each time period.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag (returned)	I*4
IPAGE	current page number of the report (sent and returned)	I*4

COMMONS: /PERDAT/, /LDGDAT/, /IODEVS/, /PRINTC/, /HYDDAT/, /TIMDAT/, /OPTION/

SUBROUTINES: PLTREP, INDEX, SUMREP, NEWPAG

LOGIC

1) Loop through all loading increments calling PLTREP.
2) Write a warning if there are hydro or storage units that were not loaded.
3) If MINI is true, write out final system configuration.
4) If this is the last subperiod, call ENDREP
5) Return.

ERRORS: IFLG = -10 Error in call to subroutine

DEBUG: None

NAME	PLTREP
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	PLTREP reports on the loading of individual plants.

ARGUMENTS

NAME	DESCRIPTION	TYPE
ICOUNT	current line number of the report	I*4
L	unit index	I*4
N	unit valve point	I*4
LDGIND	unit loading order	I*4
INAME	unit type	A*4
ILOAD	unit load type	A*4

COMMONS: /GCLASS/, /SYSDAT/, /PLTDAT/, /PERDAT/, /OPTION/, /HYDDAT/,/IODEVS/, /PRINTC/, /TIMDAT/, /TOTALS/

SUBROUTINES: None

LOGIC

1) Find totals for previously loaded valve points of the same unit.
2) Compute capacity factor and energy to storage.
3) Write out unit information.
4) Return.

ERRORS: None

DEBUG: None

NAME	PLTSET
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	10/26/79
DESCRIPTION	PLTSET sets up the unit variables for the run.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error code (returned)	I*4
L	unit index	I*4
IN	installment year	I*4
INWK	installment week	I*4
IR	retirement year	I*4
IRWK	retirement week	I*4
ATTR	average time to repair	R*4

COMMONS: /GGENRL/, /GCLASS/, /HYDDAT/, /OPTION/, /PLTDAT/, /SYSDAT/, /TIMDAT/

SUBROUTINES: EQAVAL, IRANGE

LOGIC

1) If multiple increment option (MULT) is set to false, set the variables for the first valve point equal to the total capacity, total heat and equivalent forced outage rate.

2) If MULT is true, then compute the total capacity total heat rate, and equivalent forced outage rate based on data for the valve points. If these do not agree, print a warning. For internal consistency, the calculated values are used.

3) Call IRANGE to be sure the unit is installed before it is retired.

4) Set up INST and IRET where INST = install year * 100 + install week and IRET = retire year * 100 + retire week, i.e., for a study starting in 1977 a plant installed on January 1, 1978, INST = 2001.

ERRORS: Warning if input and calculated values do not agree.

DEBUG: None

NAME	PRESIM
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	PRESIM initializes all variables, sets up the hydro and storage stacks and the loading order.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag (returned)	I*4

COMMONS

/LOADAT/, /TIMDAT/, /TOTALS/, /MNTDAT/, /OPTION/, /SYSDAT/, /MAXMUM/, /PLTDAT/, /PERDAT/, /HYDDAT/, /LDGDAT/, /DEMAND/, /DEBUGS/

SUBROUTINES

CSTSET, SMAINT, AREADM, LDGORD

LOGIC

1) If NSPER = 1, initialize time period running totals. Call CSTSET to set up marginal costs.
2) Initialize subperiod counters.
3) Call SMAINT to set up the maintenance schedule.
4) Set up loading status array based on maintenance schedule
   LDSTAT = -1 if unit not available in subperiod
   LDSTAT = 0 for available storage units.
5) Set up PROB and its array counters.
6) Set up spinning reserve requirements.
7) Call LDGORD if loading order is not input.
8) Return.

ERRORS

IFLG = -10 Error in call to subroutine

DEBUG

IDEBUG = 11
Prints loading status array and counters associated with the demand and supply curves.

NAME	PROBDM
TYPE	DOUBLE PRECISION FUNCTION
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	PROBDM returns the probability of a given equivalent demand.

ARGUMENTS

NAME	DESCRIPTION	TYPE
X	Equivalent load (MW)	R*4

COMMONS	/DEMAND/, /DEBUGS/
SUBROUTINES	None
LOGIC	1) Convert X to its equivalent spacing. 2) Using linear interpolation find PROBDM. 3) Return.
ERRORS	None
DEBUG	If IDEBUG(12) = True, print X and PROBDM.

NAME	RESCHG
TYPE	FUNCTION
SYSTEM	SYSGEN
UPDATE	1/28/80
DESCRIPTION	RESCHG returns the change in available reserve when valve point N of unit L is loaded.

ARGUMENTS

NAME	DESCRIPTION	TYPE
N	valve point	I*4
L	unit index	I*4
RESNEW	new reserve credit (MW) (returned)	R*4

COMMONS	/DEBUGS/, /PLTDAT/, /SYSDAT/, /PERDAT/
SUBROUTINES	CUMCAP

LOGIC

1) Compute maximum spinning reserve credit for the unit.
2) Compute the new reserve credit.
3) Compute the old reserve credit.
4) Compute the difference.
5) Return.

ERRORS	None
DEBUG	If IDEBUG(17) = True, print unit index and valve point, unit maximum credit, old credit and new credit.

NAME	RESSET
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	1/28/80
DESCRIPTION	RESSET sets up the modified loading order based on spinning reserve requirements.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag	I*4
N	valve point (sent)	I*4
L	Unit index (sent)	I*4

COMMONS: /DEBUGS/, /LDGDAT/, /MAXMUM/, /PERDAT/, /PLTDAT/, /SYSDAT/, /TIMDAT/

SUBROUTINES: None

LOGIC

1) Put remainder of current plant into spinning reserve.

2) Loop through all units in reserve. Add the number of hours that the current unit is the marginal unit into each reserve unit's accumulated MWHs in spinning reserve.

3) If the spinning reserve is greater than the required reserve, then go to 5).

4) Otherwise, add new units into spinning reserve.

5) Return.

ERRORS: Warning if the time that the current unit is the marginal unit is less than zero.

DEBUG: If IDEBUG(2) = True, print the unit index, valve point, time in reserve, available spinning reserve, required spinning reserve. For each unit in spinning reserve, write the accumulated hours in reserve.

NAME	SIMINP
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	10/27/79
DESCRIPTION	SIMINP reads the input data and fills up the commons.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag (returned)	I*4

COMMONS	/GGENRL/, /GCLASS/, /SYSDAT/, /MAXMUM/, /PLTDAT/, /HYDDAT/, /FINANC/, /LDGDAT/, /IODEVS/, /PRINTC/, /DEBUGS/, /MNTDAT/, /LOADAT/, /OPTION/, /TIMDAT/, /LREDAT/, /CLSDAT/
SUBROUTINES	IRANGE, PLTSET, RRANGE
LOGIC	Fill up commons with card sets A through G and check for range errors.

ERRORS

IFLG = -1	End of file reached
IFLG = -2	Card set missing
IFLG = -3	Mismatch between unit input name and maintenance name
IFLG = -10	Error in all to subroutine

DEBUG None

NAME	SIMREP
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	1/28/80
DESCRIPTION	SIMREP reports on the initial system conditions.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	returned error flag	I*4
IPAGE	current page number	I*4

COMMONS: /GGENRL/, /GCLASS/, /SYSDAT/, /PLTDAT/, /HYDDAT/, /IODEVS/, /PRINTC/, /LDGDAT/, /MAXMUM/, /FINANC/, /LOADAT/, /MNTDAT/, /TIMDAT/, /OPTION/, /LREDAT/

SUBROUTINES: NEWPAG, TTLPAG, LEPREP

LOGIC:
1) Write header.
2) Write unit data.
3) Return.

ERRORS: IFLG = -10 Error in call to subroutine

DEBUG: None.

NAME	SMAINT
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	7/8/79
DESCRIPTION	SMAINT sets up the subperiod maintenance for each unit.
ARGUMENTS	None
COMMONS	/MNTDAT/, /PERDAT/, /PLTDAT/, /SYSDAT/, /TIMDAT/
SUBROUTINES	None
LOGIC	1) Check if unit has not yet been installed or is retired; set LDSTAT = -1 if true, otherwise go to 2. 2) Find the current year in the maintenance cycle. 3) Set the subperiod maintenance SUBMNT, to the fraction of the subperiod the unit is on maintenance. 4) If SUBMNT < 1, set LDSTAT = 1. 5) Return.
ERRORS	None
DEBUG	None

NAME	SPNRES
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	10/26/79
DESCRIPTION	SPNRES modifies the loading order to meet the spinning reserve requirement.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag (returned)	I*4
IGRP	the current loading group being searched	I*4
NEXT	loading order index of the next unit (returned)	I*4
N	valve point of next unit to be loaded (returned)	I*4
L	unit index of next unit to be loaded (returned)	I*4

COMMONS: /DEBUGS/, /LDGDAT/, /PERDAT/, /PLTDAT/, /SYSDAT/

SUBROUTINES: NEXTLD, RESCHG, CUMCAP

LOGIC:

1) Search through the next MXSRCH units in the loading order looking for a unit such that when it is loaded the spinning reserve will be sufficient.
2) If spinning reserve is set to the largest available unit on line, then reset it if necessary.
3) Return.

ERRORS: None

DEBUG: If IDEBUG(18) = True, print the unit index and the new reserves for each unit tested.

NAME	STORGE
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	1/28/80
DESCRIPTION	STORGE supervises the accounting for energy transferred from base to storage units.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	returned error flag	I*4
N	unit valve point	I*4
L	unit index	I*4

COMMONS: /SYSDAT/, /MAXMUM/, /PLTDAT/, /PERDAT/, /HYDDAT/, /LDGDAT/, /DEBUGS/, /TIMDAT/, /OPTION/, /TOTALS/

SUBROUTINES: CONVST, AREADM, AVAILB

LOGIC

1) Compute excess energy available from the base load unit.

2) If MSTOR is True, go to 6).

3) Otherwise, fill up the storage units with the excess energy, ignoring capacity constraints.

4) Compute the expected cost of the stored energy.

5) Return.

6) Compute the average cost of base load energy, adjust it by the storage efficiency, then set the cost of storage to the average base load cost.

7) Convolve available storage units onto the augmented demand curve until the current base load unit has no more energy.

8) Reduce the reservoir size of the storage units by the amount of energy supplied.

9) Compute the marginal cost of the storage energy from the base unit cost.

10) Convolve the outages of the base unit into the augmented demand curve.

11) After all the base units have been loaded compute the final marginal cost.

12) Return.

ERRORS

IFLG = -1	More base loaded units encountered than the maximum allowed (MXBAS)
IFLG = -10	Error in call to subroutine

DEBUG

If IDEBUG(14) =True, print base unit index, and expected energy to storage. For each storage unit print the index, energy supplied, and marginal cost.

NAME	SUMREP
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	7/26/79
DESCRIPTION	SUMREP prints unit totals for the end of the subperiod.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag (returned)	I*4
IPAGE	report page number	I*4

COMMONS	/GCLASS/, /SYSDAT/, /PLTDAT/, /PERDAT/, /HYDDAT/, /PRINTC/, /LDGDAT/, /MAXMUM/, /IODEVS/, /TOTALS/, /GRDDAT/, /TIMDAT/, /OPTION/, /GGENRL/
SUBROUTINES	NEWPAG, SYSREP
LOGIC	1) Keep running totals of unit and system variables. 2) Print variables. 3) Return.
ERRORS	IFLG = -10 Error in call to subroutine
DEBUG	None

NAME	SUPSIM
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	SUPSIM supervises the loading of units onto the system.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	returned error flag	I*4
IPAGE	current page number	I*4

COMMONS /LDGDAT/, /PRINTC/, /IODEVS/

SUBROUTINES PRESIM, ADDPLT, ENDLEP, PERREP, CRVREP, NEWPAG

LOGIC

1) Call PRESIM to initialize.
2) Call CRVREP to report on customer demand curve
3) Loop through loading order calling ADDPLT.
4) At end of loop call, ENDHYD to load any hydro or storage units that have not yet been loaded due to insufficient energy.
5) Call PERREP to report on final conditions and unit loading.
6) Return.

ERRORS IFLG = -10 Error in call to subroutine

DEBUG None

NAME	SYSREP
TYPE	SUBROUTINE
SYSTEM	SYSGEN
UPDATE	2/05/80
DESCRIPTION	SYSREP writes out the system variables at the end of each subperiod and time period.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IFLG	error flag (returned)	I*4
IPAGE	page number	I*4

COMMONS	/GGENRL/, /DEMAND/, /GRDDAT/, /PERDAT/, /PRINTC/, /IODEVS/, /MAXMUM/, /OPTION/, /SYSDAT/, /TIMDAT/, /TOTALS/, /GCLASS/
SUBROUTINES	PROBDM, FREQDM, AVGDUR, AREADM, GRDWRT, NEWPAG, CRVREP

LOGIC

1) Write out system variables according to OPTION and PRINTC.
2) Return.

ERRORS

IFLG = -10 Error in call to subroutine

DEBUG

None

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NAME	DEBUGS
TYPE	LABELED COMMON
SYSTEM	SYSGEN
UPDATE	1/28/80
DESCRIPTION	/DEBUGS/ contains the logical debug controls

ARGUMENTS

NAME	DESCRIPTION	TYPE
IBUG	Debug output file	I*4
IDEBUG(40)	Logical variable. If true then debug for that subroutine is printed. 1 = ADDLEP, ICHECK 2 = ADDPLT, RESSET 3 = AREADM 4 = AVAILB 5 = CONVLV 6 = CONVST 7 = DECONV 8 = ENDLEP 9 = LDGADJ 10 = LDGORD 11 = PRESIM 12 = PROBDM 13 = SIMINP 14 = STORGE 15 = CONVFQ 16 = EQAVAL 17 = RESCHG 18 = SPNRES 19 = ELLCAP 20 = CAPOFF	L*4

NAME	DEMAND
TYPE	LABELED COMMON
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	/DEMAND/ contains the equivalent demand curve.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IMIN	Min array value	I*4
IMAX	Max array value	I*4
PROB(300)	Demand curve	R*8
APROB(300)	Augmented demand curve	R*8
FREQ(300)	Frequency curve	R*4
DM	Curve spacing (MW)	R*8
PEMIN	Minimum load (MW)	R*4
PEMAX	Maximum load (MW)	R*4

NAME	FINANC
TYPE	LABELED COMMON
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	/FINANC/ contains information about costs.

ARGUMENTS

NAME	DESCRIPTION	TYPE
INDOL	Year of dollars in input file	I*4
IRPDOL	Year that costs are reported in	I*4
CONVRT	Conversion factor from input to report year dollars	R*4
CPI	Consumer price index	R*4
NESC	Number of escalation rate series	I*4
ESCFAC(10,34)	Escalation factors for up to thirty-four years	R*4

NAME	GCLASS
TYPE	LABELED COMMON
SYSTEM	GEM/SYSGEN
UPDATE	4/23/79
DESCRIPTION	/GCLASS/ contains class data that pertain to all units in a class

ARGUMENTS

NAME	DESCRIPTION	TYPE
NCLASS	Number of classes	I*4
NCLSVR	Number of variables associated with each class in the ICLASS table	I*4
ICLASS(J,1)	Class name	A*4
ICLASS(J,2)	Class type	A*4
ICLASS(J,3)	Not used in SYSGEN	I*4
ICLASS(J,4)	Not used in SYSGEN	I*4
ICLASS(J,5)	Cross reference to O&M escalation rate	I*4
ICLASS(J,6)	Cross reference to fuel cost escalation rate	I*4
ICLASS(J,7)	Not used in SYSGEN	I*4
ICLASS(J,8)	Cross reference to immature forced outage rate multipliers table	I*4
ICLASS(J,9)	Not used in SYSGEN	I*4
ICLASS(J,10)	Not used in SYSGEN	
ICLASS(J,11)	Not used in SYSGEN	I*4
NFORML	Number of sets of immature forced outage rate multipliers	I*4
NIMYRS	Number of years in each set of immature forced outage rate multipliers	I*4
FORML(10,10)	Immature forced outage rate multiplers table	I*4

NAME	GGENRL
TYPE	LABELED COMMON
SYSTEM	GEM/SYSGEN
UPDATE	4/23/79
DESCRIPTION	/GGENRL/ contains general information about the current GEM run.

ARGUMENTS

NAME	DESCRIPTION	TYPE
ISY	Starting year of planning horizon (integer)(e.g. 1985)	I*4
IEY	Final year of the planning horizon (integer)	I*4
NTP	Number of yearly time periods]=(IEY-ISY)+1[(integer)	I*4
NUMWK(12)	Not used in SYSGEN	
HOURS	Number of hours per year (real number) (hours)	R*4
DR	Discount rate (fraction)	R*4
TITLE(40)	Name of the current run (words 1 to 10 appear at top of each report)	R*4
ECOENV	Not used in SYSGEN	A*4

NAME	GRDDAT
TYPE	LABELED COMMON
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	/GRDDAT/ contains the data that are written to the grid for the current subperiod NSPER.

ARGUMENTS

NAME	DESCRIPTION	TYPE
PERLOP	Loss of load probability for subperiod NSPER	R*8
TOTCAP	Total available capacity for the sub-period (MW)	R*4
GWHTOT	Total energy generated in the subperiod (GWH)	R*4
DMDGWH	Customer energy demand in the subperiod (GWH)	R*4
PERPK	Peak demand in the subperiod (MW)	R*4
TOTUNS	Total unserved energy in for the time period, NPER (MWH)	R*4
TOTLLP	Cumulative loss of probability for the time period	R*4
PERFRQ	Frequency of loss of load in the subperiod	R*4
TOTFRQ	Frequency of loss of load in the time period	R*4
PERDUR	Duration of loss of load in the subperiod	R*4
TOTDUR	Duration of loss of load in the time period	R*4
CSTFUT	Subperiod total fuel cost (thousand $)	R*4

GRDDAT (continued)

CSTOMT	Subperiod total O&M cost (thousand $)	R*4
TCOST	Subperiod total cost including fuel, O&M, spinning reserve, and startup costs (thousand $)	R*4
UNSRVD	Subperiod unserved demand energy (MWHS)	R*4

NAME HYDDAT

TYPE LABELED COMMON

SYSTEM SYSGEN

UPDATE 4/23/79

DESCRIPTION /HYDDAT/ contains information needed for loading conventional and storage units. After the initial call to LEPSRT, all data is stored by the units ranking, denoted, below by i.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IDCH(52,50)	Unit index of the ith hydro unit in each subperiod	I*2
CHSIZE(52,50)	Hydro reservoir size (MWH/time period)	R*4
IDST(50)	Unit index for the ith storage unit	I*2
STSIZE(50)	Storage capacity in the current subperiod (MWH)	R*4
WKSTOR(50)	Weekly storage energy capacity (MWH)	R*4
CGEFF(50)	Pumping efficiency round trip storage efficiency the ith largest hydro unit	R*4
CHGFOR(50)	Forced outage rate of charging cycle	R*4
STGNRG(50)	Energy available from storage unit in the current subperiod (MWH)	R*4
CCAP(50)	Charging capacity of storage unit (MW)	R*4
BSNRG(1500)	Energy available to storage from the ith base increment (MWH)	R*4
NOCH	Number of conventional hydro units in the system	I*4
NOST	Number of storage units in the system	I*4
NOSTPR	Number of storage units in the current subperiod	I*4
NOCHPR	Number of hydro units in current subperiod	I*4

NAME IODEVS

TYPE LABELED COMMON

SYSTEM SYSGEN

UPDATE 4/23/79

DESCRIPTION /IODEVS/ contains the file number for all input and output files.

ARGUMENTS

NAME	DESCRIPTION	TYPE
IGENR	Input file with general information. Card sets A and B.	I*4
ILOAD	Input file with load data. Card set C.	I*4
IFREQ	Input file with load frequency curves. Card set D.	I*4
ICLAS	Input file with class data. Card set E.	I*4
IPLNT	Input file with plant data. Card set F.	
IPMNT	Input file with maintenance schedule. Card set G.	
ILODG	Input file if loading order is read in. Card set H.	I*4
IPR	Report file	I*4
IGRD	Output grid file	I*4

NAME	LDGDAT
TYPE	LABELED COMMON
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	/LDGDAT/ contains loading order information

ARGUMENTS

NAME	DESCRIPTION	TYPE
NORDER(1500)	Loading order of units. Units are stored as: index * 1000 + NVPT	I*2
NNORD	Total number of increments in the current subperiod	I*4
NORD	Current loading index	I*4
NOBASE	Number of base loaded units in the current subperiod	I*4
NBS	Number of base units encountered so far	I*4
I1,I2,I3	Loading order option Three digit number 1st digit = base group number; 2nd digit = intermediate group number 3rd digit = peak group number (See section II.H)	
MXSRCH	Maximum number of units to be searched in spinning reserve algorithm	I*4

NAME	LOADAT
TYPE	LABELED COMMON
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	/LOADAT/ contains the data on load and frequency shapes.

ARGUMENTS

NAME	DESCRIPTION	TYPE
NPNT	Number of points in the load and frequency curves	I*4
NLDSHP	Number of input load shapes	I*4
NUMLDS(52,34)	Load shape number of subperiod i of time period j	I*2
PEAK(52,34)	Peak demand in sub-period i of time period j	R*4
RLDSHP(52,100)	Load shape i (see section II.D)	R*4
FRQSHP(52,100)	Frequency shape i (see section II.D)	R*4

NAME LREDAT

TYPE LABELED COMMON

SYSTEM SYSGEN

UPDATE 1/28/80

DESCRIPTION /LREDAT/ contains data on the time dependent (load reducing) units.

ARGUMENTS

NAME	DESCRIPTION	TYPE
MLRED	Logical variable If True, load reduction information is printed	L*4
NCASE	Total number of cases in the study [0 $\leq$ NCASE $\leq$ 20]	I*4
ICASE	Load reduction case number from ELECTRA	I*4
NOTD	Number of time dependent units [0 $\leq$ NOTD $\leq$ 4]	I*4
IDTD(4)	Unit index of the time dependent unit	I*4
NPLNT(4)	Number of units with unit index	I*4
NCRV(20)	Curve number for each case	I*4
RNUM(20)	Multiplier for each curve	R*4

NAME	MAXMUM
TYPE	LABELED COMMON
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	/MAXMUM/ contains dimensions for each array type. /MAXMUM/ is set in SIMINP.

ARGUMENTS

NAME	DESCRIPTION	TYPE
MXPRB	Maximum PROB values	I*4
MXPLT	Maximum plants	I*4
MXPER	Maximum time periods	I*4
MXVPT	Maximum valve points per plant	I*4
MXINC	Maximum increments	I*4
MXBAS	Maximum base loaded increments	I*4
MXHYD	Maximum hydro units of each type	I*4
MXSUB	Maximum number of subperiods	I*4

NAME	MNTDAT
TYPE	LABELED COMMONS
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	/MNTDAT/ stores the input maintenance schedule See section II.G.

ARGUMENTS

NAME	DESCRIPTION	TYPE
NYRCYC(300)	Number of years in the preventative maintenance cycle for unit i.	I*4
NSPM(10,300)	Subperiods in which maintenance is scheduled	I*2
NWPM(10,300)	Number of weeks of maintenance in the ith period of the cycle	I*2
SUBMNT(300)	Percent of current subperiod that unit i is on maintenance (computed in SMAINT)	R*4

NAME OPTION

TYPE LABELED COMMON

SYSTEM SYSGEN

UPDATE 4/23/79

DESCRIPTION /OPTION/ contains logical variables to turn on or off options. See section III.B.

ARGUMENTS

NAME	DESCRIPTION	TYPE
MULT	If true, plants are modeled with multiple valve points	L*4
MFREQ	If true, the frequency characteristics of the equivalent load are computed	L*4
MLORD	If true, the loading order is computed, otherwise it is input	L*4
MSPIN	If true, spinning reserve is modeled	L*4
MDLAY	If true, hydro and storage plants are delayed until they can generate at full capacity, otherwise their capacity is reduced when their economic loading point is reached	L*4
MOVE	If true, hydro and storage plants are moved between other plant so all the energy is used	L*4
MSTOR	If true, the energy available and its marginal cost for storage units are computed, otherwise they are input	L*4

OPTION (continued)

MAINT	If true, SYSGEN computes the maintenance schedule (not yet implemented)	L*4
MSUB	If true, SYSGEN aggregates the subperiod data and runs by time periods (not yet implemented)	L*4

NAME PERDAT

TYPE LABELED COMMON

SYSTEM SYSGEN

UPDATE 2/12/80

DESCRIPTION /PERDAT/ contains data which varies during the run. Unit information is stored in the order that the units were read in. The first subscript references the valve point, and the second references the unit number.

ARGUMENTS

NAME	DESCRIPTION	TYPE
LDSTAT(5,300)	Loading status = -1 unit not available; = 0 available storage; = 1 unit in loading order	I*4
CSTMRG(5,300)	Marginal cost ($/MWH)	R*4
EXPMWH(5,300)	Expected MWS generated (MWH)	
CAPADJ(300)	Reduction in capacity of units that are loaded at less than full capacity(MW)	R*4
START(300)	Expected number of startups for the first valve point	R*4
SPNMWH(300)	Hours in the current subperiod that the unit is used as spinning reserve times the capacity that is in spinning reserve (MWH)	R*4
PVOM(34)	Factor that converts subperiod O&M costs for a class into the proper form (computed in FACTOR)	R*4
PVFL(34)	Factor that converts subperiod fuel costs for a class into the proper form (computed in FACTOR)	R*4
PE	Current loading point (MW)	R*4
RESREQ	Required spinning reserve (MW)	R*4

PERDAT (continued)

RESAVL	Available spinning reserve (MW)	R*4
DMDINT	Initial customer demand in subperiod NSPER (MWH)	R*4
EXOUT	Expected power outage (MW)	R*4
PKSUB	Subperiod peak demand (MW)	R*4
PKMAX	Period peak demand (MW)	R*4

NAME PLTDAT

TYPE LABELED COMMON

SYSTEM SYSGEN

UPDATE 4/23/79

DESCRIPTION /PLTDAT/ contains data pertaining to each plant in the system. It is created in SIMINP and remains constant throughout the run. Plant information is stored in the order that the plants are read in.

ARGUMENTS

NAME	DESCRIPTION	TYPE
ADUM(300)	Unit name	A*8
ICLNUM(300)	Unit class number, used as a pointer in ICLASS (see /GCLASS/)	I*2
NVPTS(300)	Number of valve points	I*2
INST(300)	Install year plus install week. Year from start of study. (see PLTSET)	I*2
IRET(300)	Retire year plus retire week	I*2
CAP(5,300)	Plant capacity for each valve point (MW)	R*4
HTRAT(5,300)	Heat rate for each incremental valve point (MBTU/MWH)	R*4
TCAP(300)	Total capacity (MW)	R*4
THTRAT(300)	Average heat rate (MBTU/MWH)	R*4
TFOR(300)	Equivalent forced outage rate (fraction)	R*4
FOR(5,300)	Mature forced outage rate for each valve point (fraction)	R*4
AVFORR(300)	Average forced outage occurrence rate per hour (fraction)	R*4
FUCST(300)	Fuel cost ($/MBTU)	R*4
VAROMC(300)	Variable O&M costs ($/MWH)	R*4
STRCST(300)	Cost per startup ($/start)	R*4
SPNCST(300)	Spinning reserve cost ($/MW/Hr)	R*4
PENFAC(300)	Transmission penalty factor (fraction $\geq$ 1.0)	R*4

NAME	PRINTC
TYPE	LABELED COMMON
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	/PRINTC/ contains the logical print controls for the report file.

ARGUMENTS

NAME	DESCRIPTION	TYPE
MGRID	Prints grid file	L*4
MINI	See section V.2	L*4
MIDI		L*4
MAXI		L*4
MMAXI		L*4
MLCAP	Prints effective load carrying capability for each unit	L*4

NAME	SYSDAT
TYPE	LABELED COMMON
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	/SYSDAT/ contains general system information.

ARGUMENTS

NAME	DESCRIPTION	TYPE
NOSTNS	Number of units in the system	I*4
HRWEEK	Number of hours in a week	R*4
PERCNT	Maximum percent of any plant that counts toward spinning reserve	R*4
RES	If ERVE = 'PER', then RES = percent of load that is kept in spinning reserve	R*4
ERVE	If ERVE = 'PER', then the spinning reserve is RES percent of the load If ERVE = 'ABS' then spinning reserve is kept at a constant level of RES megawatts. If ERVE = 'MAX', then spinning reserve is set equal to the largest plant on line (see section III.K)	A*4
WKDAY	WKDAY = 'WEEK' or 'DAY'. Used only in reporting as a reminder of how HRWEEK is set (see section II.B)	A*4
ITDP	Alphabetic test	A*4
ICHY	variables set in	A*4
ISTO	input card set	A*4
IBASE	A/2/2	A*4
INTR		A*4
IPEAK		A*4

NAME	TIMDAT
TYPE	LABELED COMMON
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	/TIMDAT/ contains information about the time and subperiods.

ARGUMENTS

NAME	DESCRIPTION	TYPE
NTPER	Number of time periods Same as NTP in /GGENRL/	I*4
NPER	Number of the current time period	I*4
NSTP	Number of time sub-periods	I*4
NSPER	Number of the current subperiod	I*4
NWEEKS(52)	Number of weeks in each subperiod	I*4
NTOTWK	Total number of weeks in a time period	I*4
HRSUB	Number of hours in the current subperiod	R*4

NAME	TOTALS
TYPE	LABELED COMMON
SYSTEM	SYSGEN
UPDATE	4/23/79
DESCRIPTION	/TOTALS/ contains totals for the current tme period for writing the summary report and the capacity file.

ARGUMENTS

NAME	VARIABLE	TYPE
PLNRG(300)	Total energy generated by unit in the time period (MWH)	R*4
PLFLC(300)	Total unit fuel cost in the time period (million $)	R*4
PLOMC(300)	Total unit O&M cost in the time period (million $)	R*4
PLTTC(300)	Total unit cost in the time period (million $)	R*4
PLCC(300)	Average load Carrying capability of the unit (MW)	R*4
PLSTO(300)	Total energy supplied to storage by the unit	R*4
CLMBTU(34)	Total energy consumed by the class (MBTU)	R*4
SSNRG	Total system energy (MWH)	R*4
SSFLC	Total system fuel cost (million $)	R*4
SSOMC	Total system O&M cost (million $)	R*4
SSTTC	Total system cost (million $)	R*4
SSSTO	Total energy supplied to storage (MWH)	R*4
TBSNRG	Total energy available for storage (MWH)	R*4
BSNRGT(300)	Total energy sent to storage from the unit	R*4
STORED	Total energy stored (MWH)	R*4

VIII. Sample Run

VIII.A. SYSGEN Input Files


```
F F F F F F F F F F F F F F F F F F F F F F F F F F F F F F F F F F F F F F F F
MGRID=F  MINI=T  MIDI=T  MAXI=T MMAXI=T MLCAP=T MLRED=F MCORR=F  MEEI=F
 MULT=T MFREQ=T MLORD=T MSPIN=F MDLAY=T  MOVE=T MSTOR=T MAINT=F  MSUB=T MCOST=F
 123    300.0 ABS 50.0    5
SUN  CHY  STO  BASE INTR PEAK
 1975 1975       1.0       0.0
           TESTW RUN (CASE 8)
               HYDRO TEST
             MSPIN=F MLORD=T
 MULT=T MFREQ=T MOVE=T MDLAY=T MSTOR=T
1975 1975 01                            1344.0 0.070
 2  168.0 WEEK    1   50
 4  4  4  4  4  4  4
 2
 0
 0  0
 1
 1  1
```

```
 15
 COAL PEAK        1   3   2   1            37485.0
 COAL INTR        1   3   2   1            37485.0
 COAL BASE        1   3   2   1            37485.0
 OIL  PEAK        1   3   2   1            28052.0
 OIL  INTR        1   3   2   1            28052.0
 OIL  BASE        1   3   2   1            28052.0
 CT   PEAK        1   3   2   1            15834.0
 NUC  BASE        1   3   2   1            68049.0
 STO  PEAK        1   3   2   1            98105.0
 CHY  INTR        1   3   2   1            58908.0
 CHY  BASE        1   3   2   1            58908.0
 GAS  PEAK        1   3   2   1            28052.0
 GAS  INTR        1   3   2   1            28052.0
 GAS  BASE        1   3   2   1            28052.0
 SUN  INTR        1   3   2   1            70000.0
  1  1
  1.0
  3
  9     .00  .00  .00  .00  .00  .00  .00  .00  .00
  9     .01  .01  .01  .01  .01  .01  .01  .01  .01
  9     .03  .03  .03  .03  .03  .03  .03  .03  .03
```

```
 50    1
 1  2000.0    893716.2         1
 1  2000.0    897743.9         2
 2
1.00000000  1.00000000  1.00000000  1.00000000  1.00000000
1.00000000  1.00000000  1.00000000  1.00000000  1.00000000
1.00000000  1.00000000  1.00000000  1.00000000  1.00000000
1.00000000  0.98240519  0.95272523  0.92304534  0.89336538
0.86368549  0.83400553  0.80432564  0.77464569  0.74496579
0.71528590  0.68560594  0.65592605  0.62624609  0.59656620
0.56688625  0.53720635  0.50752646  0.47784656  0.44816667
0.41848671  0.38880682  0.35912687  0.32944697  0.29976702
0.27008718  0.24040723  0.21072733  0.18104738  0.15136749
0.12168753  0.09200758  0.06232782  0.03264790  0.0
1.00000000  1.00000000  1.00000000  1.00000000  1.00000000
1.00000000  1.00000000  1.00000000  1.00000000  1.00000000
1.00000000  1.00000000  1.00000000  1.00000000  1.00000000
1.00000000  0.97858900  0.94815427  0.92474312  0.88962632
0.86621505  0.83109826  0.80768698  0.77257019  0.74915898
0.71404213  0.69063097  0.65551406  0.63210285  0.59698606
0.57357478  0.53845799  0.51504678  0.47992986  0.45651865
0.42140186  0.39799064  0.36287385  0.33946258  0.30434573
0.28093457  0.24581772  0.22240651  0.18728971  0.16387844
0.12876159  0.10535038  0.07023358  0.04682244  0.0
```

0.05059524	0.05059524	0.05059524	0.05059524	0.05059524
0.05059524	0.05059524	0.05059524	0.05059524	0.05059524
0.05059524	0.05059524	0.05059524	0.05059524	0.05059524
0.05059524	0.05059524	0.04761904	0.04613095	0.04464285
0.04315476	0.04166666	0.04017857	0.03869047	0.03720238
0.03571428	0.03422619	0.03273809	0.03125000	0.02976190
0.02827381	0.02678571	0.02529762	0.02380952	0.02232143
0.02083333	0.01934524	0.01785714	0.01636904	0.01488095
0.01339285	0.01190476	0.01041666	0.00892857	0.00744047
0.00595238	0.00446428	0.00297619	0.00148810	0.0
0.19791663	0.19791663	0.19791663	0.19791663	0.19791663
0.19791663	0.19791663	0.19791663	0.19791663	0.19791663
0.19791663	0.19791663	0.19791663	0.19791663	0.19791663
0.19791663	0.19791663	0.19047618	0.18452376	0.17857140
0.17261904	0.16666663	0.16071427	0.15476185	0.14880949
0.14285713	0.13690472	0.13095236	0.12500000	0.11904758
0.11309522	0.10714281	0.10119045	0.09523809	0.08928567
0.08333331	0.07738090	0.07142854	0.06547618	0.05952381
0.05357143	0.04761904	0.04166666	0.03571428	0.02976190
0.02380952	0.01785714	0.01190476	0.00595238	0.0
1.25148773	1.25148773	1.25148773	1.25148773	1.25148773
1.25148773	1.25148773	1.25148773	1.25148773	1.25148773
1.25148773	1.25148773	1.25148773	1.25148773	1.25148773
1.25148773	1.25148773	1.25148773	1.25148773	1.25148773
1.20833302	1.16666603	1.12500000	1.08333302	1.04166603
1.00000000	0.95833331	0.91666663	0.87500000	0.83333331
0.79166663	0.75000000	0.70833331	0.66666663	0.62500000
0.58333331	0.54166663	0.50000000	0.45833331	0.41666663
0.37500000	0.33333331	0.29166663	0.25000000	0.20833331
0.16666663	0.12500000	0.08333331	0.04166666	0.0
2.33482075	2.33482075	2.33482075	2.33482075	2.33482075
2.33482075	2.33482075	2.33482075	2.33482075	2.33482075
2.33482075	2.33482075	2.33482075	2.33482075	2.33482075
2.33482075	2.33482075	2.33482075	2.33482075	2.33482075
2.33482075	2.33482075	2.25148773	2.16666603	2.08333302
2.00000000	1.91666603	1.83333302	1.75000000	1.66666603
1.58333302	1.50000000	1.41666603	1.33333302	1.25000000
1.16666603	1.08333302	1.00000000	0.91666663	0.83333331
0.75000000	0.66666663	0.58333331	0.50000000	0.41666663
0.33333331	0.25000000	0.16666663	0.08333331	0.0

```
PV200 1    1  0 0
PV100 2    1  0 0
COAL4 1    4  0 0
COAL4 2    4  0 0
NUC   1    2  0 0   4 4
NUC   2    6  0 0   0 0   0 0   0 0   0 0  12 4
OIL2  1    2  0 0
OIL2  2    2  2 4
COAL2 1    2  0 0
COAL2 2    2  0 0
COAL2 3    2  0 0
COAL  1    2  0 0   3 4
COAL  2    2  0 0
OIL   1    2  1 4   0 0
CT    1    2  1 4   0 0
CT    2    2  0 0
CT    3    2  0 0   3 4
CT    4    2  0 0   3 4
CHY   1    2  2 4   0 0
CHY   2    2  0 0   4 4
CHY   3    2  1 4   0 0
CHY   4    2  0 0   0 0
CHY   5    2  0 0   0 0
PHY   1    2  2 4   0 0
PHY   2    2  0 0   3 4
PHY   3    2  0 0   0 0
PURCHAS    2  0 0   3 4
```

```
PV200 1     15 1 1973  1 2000 52  0.000  0.000  0.000  0.00   24.00 1.000
  200.0      0.000 0.010  200.0     0.000 0.010
 1   2.0
PV100 2     15 1 1973  1 2000 52  0.000  0.000  0.000  0.00   24.00 1.000
  100.0      0.000 0.010  100.0     0.000 0.010
 1   1.0
COAL4 1      3 5 1950  1 2000 52  1.020  1.420  1.010  0.10   86.40 1.000
  400.0      9.000 0.130  100.0    10.674 0.095   60.0      8.298 0.0
   80.0      8.190 0.0     80.0     8.424 0.0     80.0      8.820 0.175
COAL4 2      3 5 1950  1 2000 52  1.020  1.420  1.010  0.10   86.40 1.000
  400.0      9.000 0.130  100.0    10.674 0.095   60.0      8.298 0.0
   80.0      8.190 0.0     80.0     8.424 0.0     80.0      8.820 0.175
NUC   1      8 1 2000  1 2000 52  0.540  0.720  1.010  0.10  120.00 1.000
  700.0     10.400 0.150  700.0    10.400 0.150
NUC   2      8 1 1973  1 2000 52  0.540  0.720  1.010  0.10  120.00 1.000
  500.0     10.400 0.150  500.0    10.400 0.150
OIL2  1      5 5 2000  1 2000 52  1.750  0.280  1.010  0.10   72.00 1.000
  200.0      9.900 0.074   50.0    12.068 0.053   30.0      9.084 0.0
   40.0      8.960 0.0     40.0     9.058 0.0     40.0      9.584 0.105
OIL2  2      5 2 1969  1 2000 52  1.750  0.280  1.010  0.10   72.00 1.000
  200.0     11.322 0.079  150.0    12.068 0.053   50.0      9.084 0.105
COAL2 1      2 5 1963  1 2000 52  1.070  2.270  1.010  0.10   72.00 1.000
  200.0      9.500 0.074   50.0    11.581 0.053   30.0      8.717 0.0
   40.0      8.599 0.0     40.0     8.691 0.0     40.0      9.196 0.105
COAL2 2      2 5 1970  1 1972 52  1.070  2.270  1.010  0.10   72.00 1.000
  200.0      9.500 0.074   50.0    11.581 0.053   30.0      8.717 0.0
   40.0      8.599 0.0     40.0     8.691 0.0     40.0      9.196 0.105
COAL2 3      2 5 1958  1 1975 52  1.070  2.270  1.010  0.10   72.00 1.000
  200.0      9.500 0.074   50.0    11.581 0.053   30.0      8.717 0.0
   40.0      8.599 0.0     40.0     8.691 0.0     40.0      9.196 0.105
COAL  1      1 5 1948  1 2000 52  1.020  2.040  1.010  0.10   57.60 1.000
   50.0     11.000 0.027   12.5    13.409 0.023    7.5     10.094 0.0
   10.0      9.955 0.0     10.0    10.065 0.0     10.0     10.648 0.020
COAL  2      1 5 1942  1 2000 52  1.020  2.040  1.010  0.10   57.60 1.000
   50.0     11.000 0.027   12.5    13.409 0.023    7.5     10.094 0.0
   10.0      9.955 0.0     10.0    10.065 0.0     10.0     10.648 0.020
OIL   1      4 5 1961  1 2000 52  2.360  2.000  1.010  0.10   57.60 1.000
   50.0     11.500 0.027   12.5    14.019 0.023    7.5     10.552 0.0
   10.0     10.409 0.0     10.0    10.521 0.0     10.0     11.132 0.020
CT    1      7 1 1968  1 2000 52  2.260  1.940  1.010  0.10   48.00 1.000
   50.0     14.000 0.240   50.0    14.000 0.240
CT    2      7 1 1974  1 2000 52  2.260  1.940  1.010  0.10   48.00 1.000
   50.0     14.000 0.240   50.0    14.000 0.240
CT    3      7 1 1974  1 2000 52  2.260  1.940  1.010  0.10   48.00 1.000
   50.0     14.000 0.240   50.0    14.000 0.240
CT    4      7 1 1974  1 2000 52  2.260  1.940  1.010  0.10   48.00 1.000
   50.0     14.000 0.240   50.0    14.000 0.240
CHY   1     10 1 1962  1 2000 52  0.000  0.00   0.000  0.000  27.00 1.000
   10.0      0.000 0.012   10.0     0.000 0.012
 1680.00    1680.00
CHY   2     10 1 1962  1 2000 52  0.000  0.00   0.000  0.000  27.00 1.000
   10.0      0.000 0.012   10.0     0.000 0.012
 1680.00    1680.00
CHY   3     10 1 1962  1 2000 52  0.000  0.00   0.000  0.000  27.00 1.000
   35.0      0.000 0.012   35.0     0.000 0.012
```

```
   1200.00    1000.00
 CHY   4     10 1 1962  1 2000 52  0.000  0.00    0.000   0.000 27.00 1.000
    50.0      0.000 0.012   50.0       0.000 0.012
   1200.00    1300.00
 CHY   5     10 1 1962  1 2000 52  0.000  0.00    0.000   0.000 27.00 1.000
    25.0      0.000 0.012   25.0       0.000 0.012
    500.00     400.00
 PHY   1      9 1 1974  1 2000 52  0.000  0.00    0.000   0.000 43.00 1.000
   300.0      0.000 0.050  300.0       0.000 0.050
   200.0 0.00    1500.0 0.670
 PHY   2      9 1 1974  1 2000 52  0.000  0.00    0.000   0.000 43.00 1.000
   200.0      0.000 0.050  200.0       0.000 0.050
   200.0 0.00    1000.0 0.670
 PHY   3      9 1 1974  1 2000 52  0.000  0.00    0.000   0.000 43.00 1.000
   200.0      0.000 0.050  200.0       0.000 0.050
   150.00 0.0     600.0 0,670
 PURCHAS     10 1 1962  1 2000 52 35.000  0.00    0.000   0.000 00.00 1.000
    25.0      1.000 0.001   25.0       1.000 0.001
    100.00     100.00
```

VIII.B. SYSGEN Sample Run

```
*******************************************************************************
*                                                                             *
*                                                                             *
*                              M.I.T.                                         *
*                              SYSGEN                                         *
*                ELECTRIC POWER PRODUCTION COSTING                            *
*                               AND                                           *
*                        RELIABILITY MODEL                                    *
*                                                                             *
*                                                                             *
*                        TESTW RUN (CASE 8)                                   *
*                            HYDRO TEST                                       *
*                          MSPIN=F MLORD=T                                    *
*               MULT=T MFREQ=T MOVE=T MDLAY=T MSTOR=T                         *
*                                                                             *
*        START YEAR: 1975                               END YEAR:   1975      *
*        PERIODS:     1                                 LENGTH(HR): 1344.     *
*                     DISCOUNT RATE:    7.000 %                               *
*                                                                             *
*                        3/04/80 15*28*05.00                                  *
*                                                                             *
*******************************************************************************
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```
                              SYSGEN OPTIONS

LOADING ORDER OPTION      -  123

                           OUTPUT OPTIONS

             MGRID  -  F                    MINI   -  T
             MIDI   -  T                    MAXI   -  T
             MMAXI  -  T                    MLCAP  -  T
             MLRED  -  F

                           OPERATING OPTIONS

             MULT   -  T                    MFREQ  -  T
             MLORD  -  T                    MSPIN  -  F
             MDLAY  -  T                    MOVE   -  T
             MSTOR  -  T                    MAINT  -  F
             MSUB   -  T

                        ECONOMIC CONVERSION FACTORS

  INPUT IN  1975 DOLLARS
 OUTPUT IN  1975 DOLLARS
 CONVERSION FACTOR FROM INPUT TO OUTPUT DOLLARS = 1.000
 CPI = 0.0

                              TIME PARAMETERS

PERIODS       -     1                          HOURS/WEEK  -   168.0
SUBPERIODS    -     2                        HOURS/PERIOD  -  1344.0

WEEKS/PERIOD  -     8

SUB-PERIOD:       1   2
NO. OF WEEKS:     4   4

                           27 UNITS

                              INCLUDING
                            6 CONVENTIONAL HYDRO UNITS
                            3 STORAGE UNITS
```

LOAD DATA

NUMBER OF LOAD POINTS: 50

TIME PERIOD	SUB-PERIOD	PEAK LOAD (MW)	LOAD SHAPE
1	1	2000.0	1
	2	2000.0	2

LOAD SHAPES

LOAD SHAPE NO.	PERCENT OF TIME DEMAND EXCEEDS FRACTION OF PEAK LOAD				
1	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
	1.00000000	0.98240519	0.95272523	0.92304534	0.89336538
	0.86368549	0.83400553	0.80432564	0.77464569	0.74496579
	0.71528590	0.68560594	0.65592605	0.62624609	0.59656620
	0.56688625	0.53720635	0.50752646	0.47784656	0.44816667
	0.41848671	0.38880682	0.35912687	0.32944697	0.29976702
	0.27008718	0.24040723	0.21072733	0.18104738	0.15136749
	0.12168753	0.09200758	0.06232782	0.03264790	0.0
2	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
	1.00000000	0.97858900	0.94815427	0.92474312	0.88962632
	0.86621505	0.83109826	0.80768698	0.77257019	0.74915898
	0.71404213	0.69063097	0.65551406	0.63210285	0.59698606
	0.57357478	0.53845799	0.51504678	0.47992986	0.45651865
	0.42140186	0.39799064	0.36287385	0.33946258	0.30434573
	0.28093457	0.24581772	0.22240651	0.18728971	0.16387844
	0.12876159	0.10535038	0.07023358	0.04682244	0.0

FREQUENCY SHAPES

FREQUENCY SHAPE NO.	TIMES PER HOUR LOAD ENTERS A STATE GREATER THAN OR EQUAL TO X				
1	0.05059524	0.05059524	0.05059524	0.05059524	0.05059524
	0.05059524	0.05059524	0.05059524	0.05059524	0.05059524
	0.05059524	0.05059524	0.05059524	0.05059524	0.05059524
	0.05059524	0.05059524	0.04761904	0.04613095	0.04464285
	0.04315476	0.04166666	0.04017857	0.03869047	0.03720238
	0.03571428	0.03422619	0.03273809	0.03125000	0.02976190
	0.02827381	0.02678571	0.02529762	0.02380952	0.02232143
	0.02083333	0.01934524	0.01785714	0.01636904	0.01488095
	0.01339285	0.01190476	0.01041666	0.00892857	0.00744047
	0.00595238	0.00446428	0.00297619	0.00148810	0.0
2	0.19791663	0.19791663	0.19791663	0.19791663	0.19791663
	0.19791663	0.19791663	0.19791663	0.19791663	0.19791663
	0.19791663	0.19791663	0.19791663	0.19791663	0.19791663
	0.19791663	0.19791663	0.19047618	0.18452376	0.17857140
	0.17261904	0.16666663	0.16071427	0.15476185	0.14880949
	0.14285713	0.13690472	0.13095236	0.12500000	0.11904758
	0.11309522	0.10714281	0.10119045	0.09523809	0.08928567
	0.08333331	0.07738090	0.07142854	0.06547618	0.05952381
	0.05357143	0.04761904	0.04166666	0.03571428	0.02976190
	0.02380952	0.01785714	0.01190476	0.00595238	0.0

GENERATION CLASS DATA

CLASS INDEX	CLASS NAME	CLASS TYPE	O&M ESCALATION TABLE	FUEL ESCALATION TABLE	IMMATURE FOR TABLE
1	COAL	PEAK	1	3	1
2	COAL	INTR	1	3	1
3	COAL	BASE	1	3	1
4	OIL	PEAK	1	3	1
5	OIL	INTR	1	3	1
6	OIL	BASE	1	3	1
7	CT	PEAK	1	3	1
8	NUC	BASE	1	3	1
9	STO	PEAK	1	3	1
10	CHY	INTR	1	3	1
11	CHY	BASE	1	3	1
12	GAS	PEAK	1	3	1
13	GAS	INTR	1	3	1
14	GAS	BASE	1	3	1
15	SUN	INTR	1	3	1

IMMATURE FORCED OUTAGE RATE TABLE

MULTIPLIER SET	MULTIPLIER FOR YEAR 1	2	3	4	5	6	7	8	9	10
1	1.00									

ESCALATION RATE TABLE

ESCALATOR SET	ESCALATOR FOR YEAR 1	2	3	4	5	6	7	8	9	10
1	0.0									
2	0.01									
3	0.03									

PLANT DATA

UNIT INDEX	UNIT NAME	UNIT TYPE	INSTALL YEAR:WEEK	RETIRE YEAR:WEEK	FUEL COST ($/MBTU)	VAR O&M COST ($/MWH)	SPINNING RES COST ($/MWH)	STARTUP COST ($/START)	PENALTY FACTOR	VALVE POINT	CAPACITY (MW)	HEAT RATE (MBTU/MWH)	FORCED OUTAGE RATE	FORCED OUTAGE OCCURRENCE RATE
1	PV200 1	SUN INTR	-1: 1	25:52	0.0	0.0	0.0	0.0	1.000	1	200.0	0.0	0.010	0.00042
2	PV100 2	SUN INTR	-1: 1	25:52	0.0	0.0	0.0	0.0	1.000	1	100.0	0.0	0.010	0.00042
3	COAL4 1	COAL BASE	-24: 1	25:52	1.020	1.420	0.100	1.010	1.000	1	100.0	10.674	0.095	
										2	60.0	8.298	0.0	
										3	80.0	8.190	0.0	
										4	80.0	8.424	0.0	
										5	80.0	8.820	0.175	
										TOTAL	400.0	9.000	0.130	0.00173
4	COAL4 2	COAL BASE	-24: 1	25:52	1.020	1.420	0.100	1.010	1.000	1	100.0	10.674	0.095	
										2	60.0	8.298	0.0	
										3	80.0	8.190	0.0	
										4	80.0	8.424	0.0	
										5	80.0	8.820	0.175	
										TOTAL	400.0	9.000	0.130	0.00173
5	NUC 1	NUC BASE	26: 1	25:52	0.540	0.720	0.100	1.010	1.000	1	700.0	10.400	0.150	0.00147
6	NUC 2	NUC BASE	-1: 1	25:52	0.540	0.720	0.100	1.010	1.000	1	500.0	10.400	0.150	0.00147
7	OIL2 1	OIL INTR	26: 1	25:52	1.750	0.280	0.100	1.010	1.000	1	50.0	12.068	0.053	
										2	30.0	9.084	0.0	
										3	40.0	8.960	0.0	
										4	40.0	9.058	0.0	
										5	40.0	9.584	0.105	
										TOTAL	200.0	9.900	0.074	0.00111
8	OIL2 2	OIL INTR	-5: 1	25:52	1.750	0.280	0.100	1.010	1.000	1	150.0	12.068	0.053	
										2	50.0	9.084	0.105	
										TOTAL	200.0	11.322	0.079	0.00120
9	COAL2 1	COAL INTR	-11: 1	25:52	1.070	2.270	0.100	1.010	1.000	1	50.0	11.581	0.053	
										2	30.0	8.717	0.0	
										3	40.0	8.599	0.0	
										4	40.0	8.691	0.0	
										5	40.0	9.196	0.105	
										TOTAL	200.0	9.500	0.074	0.00111

SYSGEN

TESTW RUN (CASE 8)

PLANT DATA

UNIT INDEX	UNIT NAME	UNIT TYPE	INSTALL YEAR:WEEK	RETIRE YEAR:WEEK	FUEL COST ($/MBTU)	VAR O&M COST ($/MWH)	SPINNING RES COST ($/MWH)	STARTUP COST ($/START)	PENALTY FACTOR	VALVE POINT	CAPACITY (MW)	HEAT RATE (MBTU/MWH)	FORCED OUTAGE RATE	FORCED OUTAGE OCCURRENCE RATE
10	COAL2 2	COAL INTR	-4: 1	-3:52	1.070	2.270	0.100	1.010	1.000	1	50.0	11.581	0.053	
										2	30.0	8.717	0.0	
										3	40.0	8.599	0.0	
										4	40.0	8.691	0.0	
										5	40.0	9.196	0.105	
										TOTAL	200.0	9.500	0.074	0.00111
11	COAL2 3	COAL INTR	-16: 1	0:52	1.070	2.270	0.100	1.010	1.000	1	50.0	11.581	0.053	
										2	30.0	8.717	0.0	
										3	40.0	8.599	0.0	
										4	40.0	8.691	0.0	
										5	40.0	9.196	0.105	
										TOTAL	200.0	9.500	0.074	0.00111
12	COAL 1	COAL PEAK	-26: 1	25:52	1.020	2.040	0.100	1.010	1.000	1	12.5	13.409	0.023	
										2	7.5	10.094	0.0	
										3	10.0	9.955	0.0	
										4	10.0	10.065	0.0	
										5	10.0	10.648	0.020	
										TOTAL	50.0	11.000	0.027	0.00048
13	COAL 2	COAL PEAK	-32: 1	25:52	1.020	2.040	0.100	1.010	1.000	1	12.5	13.409	0.023	
										2	7.5	10.094	0.0	
										3	10.0	9.955	0.0	
										4	10.0	10.065	0.0	
										5	10.0	10.648	0.020	
										TOTAL	50.0	11.000	0.027	0.00048
14	OIL 1	OIL PEAK	-13: 1	25:52	2.360	2.000	0.100	1.010	1.000	1	12.5	14.019	0.023	
										2	7.5	10.552	0.0	
										3	10.0	10.409	0.0	
										4	10.0	10.521	0.0	
										5	10.0	11.132	0.020	
										TOTAL	50.0	11.500	0.027	0.00048
15	CT 1	CT PEAK	-6: 1	25:52	2.260	1.940	0.100	1.010	1.000	1	50.0	14.000	0.240	0.00658
16	CT 2	CT PEAK	0: 1	25:52	2.260	1.940	0.100	1.010	1.000	1	50.0	14.000	0.240	0.00658
17	CT 3	CT PEAK	0: 1	25:52	2.260	1.940	0.100	1.010	1.000	1	50.0	14.000	0.240	0.00658
18	CT 4	CT PEAK	0: 1	25:52	2.260	1.940	0.100	1.010	1.000	1	50.0	14.000	0.240	0.00658
19	CHY 1	CHY INTR	-12: 1	25:52	0.0	0.0	0.0	0.0	1.000	1	10.0	0.0	0.012	0.00045

PLANT DATA

UNIT INDEX	UNIT NAME	UNIT TYPE	INSTALL YEAR:WEEK	RETIRE YEAR:WEEK	FUEL COST ($/MBTU)	VAR O&M COST ($/MWH)	SPINNING RES COST ($/MWH)	STARTUP COST ($/START)	PENALTY FACTOR	VALVE POINT	CAPACITY (MW)	HEAT RATE (MBTU/MWH)	FORCED OUTAGE RATE	FORCED OUTAGE OCCURRENCE RATE
20	CHY 2	CHY INTR	-12: 1	25:52	0.0	0.0	0.0	0.0	1.000	1	10.0	0.0	0.012	0.00045
21	CHY 3	CHY INTR	-12: 1	25:52	0.0	0.0	0.0	0.0	1.000	1	35.0	0.0	0.012	0.00045
22	CHY 4	CHY INTR	-12: 1	25:52	0.0	0.0	0.0	0.0	1.000	1	50.0	0.0	0.012	0.00045
23	CHY 5	CHY INTR	-12: 1	25:52	0.0	0.0	0.0	0.0	1.000	1	25.0	0.0	0.012	0.00045
24	PHY 1	STO PEAK	0: 1	25:52	0.0	0.0	0.0	0.0	1.000	1	300.0	0.0	0.050	0.00122
25	PHY 2	STO PEAK	0: 1	25:52	0.0	0.0	0.0	0.0	1.000	1	200.0	0.0	0.050	0.00122
26	PHY 3	STO PEAK	0: 1	25:52	0.0	0.0	0.0	0.0	1.000	1	200.0	0.0	0.050	0.00122
27	PURCHAS	CHY INTR	-12: 1	25:52	35.000	0.0	0.0	0.0	1.000	1	25.0	1.000	0.001	0.0

SYSGEN

TESTW RUN (CASE 8)

PREVENTATIVE MAINTENANCE DATA

CYCLE STARTS FROM INSTALLMENT YEAR OF THE UNIT

PLANT INDEX	ID NO	YEARS IN CYCLE	SUB-PERIODS WITHIN CYCLE & CORRESPONDING WEEKS OF OUTAGE 1		2		3		4		5		6		7		85		9		10	
1	PV200 1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	PV100 2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	COAL4 1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	COAL4 2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	NUC 1	2	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	NUC 2	6	0	0	0	0	0	0	0	0	0	0	12	4	0	0	0	0	0	0	0	0
7	OIL2 1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	OIL2 2	2	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	COAL2 1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	COAL2 2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	COAL2 3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	COAL 1	2	0	0	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	COAL 2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	OIL 1	2	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	CT 1	2	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	CT 2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	CT 3	2	0	0	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	CT 4	2	0	0	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	CHY 1	2	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	CHY 2	2	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	CHY 3	2	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	CHY 4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	CHY 5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	PHY 1	2	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	PHY 2	2	0	0	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	PHY 3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	PURCHAS	2	0	0	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SORTED CONVENTIONAL HYDRO ARRAYS BY SUB-PERIOD

SUB-PERIOD 1

CHY ID	UNIT INDEX	HOURS AT PEAK CAP	RESERVOIR SIZE(MWH/WEEK)
1	19	168.0	1680.00
2	20	168.0	1680.00
3	21	34.3	1200.00
4	22	24.0	1200.00
5	23	20.0	500.00
6	27	4.0	100.00

SUB-PERIOD 2

CHY ID	UNIT INDEX	HOURS AT PEAK CAP	RESERVOIR SIZE(MWH/WEEK)
1	19	168.0	1680.00
2	20	168.0	1680.00
3	21	28.6	1000.00
4	22	26.0	1300.00
5	23	16.0	400.00
6	27	4.0	100.00

STORAGE ARRAY

STORAGE ID	UNIT INDEX	CHARGING CAPACITY (MW)	CHARGING FOR	GENERATING CAPACITY (MW)	GENERATING FOR	HOURS AT PEAK CAPACITY	RESERVOIR, SIZE(MWH/WEEK)	CYCLE EFFICIENCY
1	24	200.0	0.0	300.0	0.050	5.0	1500.00	0.670
2	25	200.0	0.0	200.0	0.050	5.0	1000.00	0.670
3	26	150.0	0.0	200.0	0.050	3.0	600.00	0.670

INITIAL CUSTOMER LOAD DURATION CURVE

TIME PERIOD 1 SUB-PERIOD 1

LOAD CURVE SPACING (MW)	MINIMUM DEMAND (MW)	MAXIMUM DEMAND (MW)	EQUIVALENT DEMAND AREA (MWH)
40.00	640.00	2000.00	893716.19

FRACTION OF TIME THAT THE EQUIVALENT DEMAND EXCEEDS THE ARRAY INDEX * SPACING:

1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000
1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000
0.9824051857	0.9527252316	0.9230453372	0.8933653831	0.8636854887	0.8340055346	0.8043256402	0.7746456861
0.7449657917	0.7152858973	0.6856059432	0.6559260488	0.6262460947	0.5965662003	0.5668862462	0.5372063518
0.5075264573	0.4778465629	0.4481666684	0.4184867144	0.3888068199	0.3591268659	0.3294469714	0.2997670174
0.2700871825	0.2404072285	0.2107273340	0.1810473800	0.1513674855	0.1216875315	0.0920075774	0.0623278208
0.0326479003	0.0						

SYSGEN

TESTW RUN (CASE 8)

TIME PERIOD 1 SUB-PERIOD 1

VALVE POINTS IN LOADING ORDER

UNIT INDEX	UNIT NAME	VALVE POINT	LOAD TYPE	MW ADDED	EXPECTED STARTUPS	MARGINAL COST ($/MWH)	EXPECTED ADDED ENERGY (MWHS)	FUEL COST (TH$)	O&M COST (TH$)	STARTUP COST (TH$)	SPINNING RESERVE COST (TH$)	TOTAL COST (TH$)	CAPACITY FACTOR	ENERGY TO STORAGE (MWH)	CAPACITY FACTOR AFTER STORAGE
19	CHY 1	1	INTR	10.0	0.0	0.0	6639.4	0.0	0.0	0.0		0.0	0.988		
20	CHY 2	1	INTR	10.0	0.0	0.0	6639.4	0.0	0.0	0.0		0.0	0.988		
6	NUC 2	1	BASE	500.0	0.0	6.34	285600.0	1603.9	205.6	0.0		1609.6	0.850	0.	0.850
3	COAL4 1	1	BASE	100.0	0.0	12.31	60816.0	662.1	86.4	0.0		748.5	0.905	0.	0.905
3	COAL4 1	2	BASE	60.0		9.88	36308.8	307.3	51.6			358.9	0.901	90.	0.903
3	COAL4 1	3	BASE	80.0		9.77	46704.4	390.2	66.3			456.5	0.869	1631.	0.899
3	COAL4 1	4	BASE	80.0		10.01	44250.3	380.2	62.8			443.1	0.823	3262.	0.884
3	COAL4 1	5	BASE	80.0		10.42	33713.5	303.3	47.9			351.2	0.627	5817.	0.735
4	COAL4 2	1	BASE	100.0	0.81	12.31	50471.5	549.5	71.7	0.00		621.2	0.751	7030.	0.856
4	COAL4 2	2	BASE	60.0		9.88	28599.5	242.1	40.6			282.7	0.709	676.	0.726
4	COAL4 2	3	BASE	80.0		9.77	36014.9	300.9	51.1			352.0	0.670	0.	0.670
4	COAL4 2	4	BASE	80.0		10.01	33388.9	286.9	47.4			334.3	0.621	0.	0.621
4	COAL4 2	5	BASE	80.0		10.42	24671.4	222.0	35.0			257.0	0.459	0.	0.459
9	COAL2 1	1	INTR	50.0	1.13	14.66	19612.3	243.0	44.5	0.00		287.5	0.584		
9	COAL2 1	2	INTR	30.0		11.60	11220.7	104.7	25.5			130.1	0.557		
9	COAL2 1	3	INTR	40.0		11.47	14322.9	131.8	32.5			164.3	0.533		
9	COAL2 1	4	INTR	40.0		11.57	13591.9	126.4	30.9			157.3	0.506		
9	COAL2 1	5	INTR	40.0		12.11	11432.5	112.5	26.0			138.4	0.425		
11	COAL2 3	1	INTR	50.0	1.19	14.66	15374.7	190.5	34.9	0.00		225.4	0.458		
11	COAL2 3	2	INTR	30.0		11.60	8667.7	80.8	19.7			100.5	0.430		
11	COAL2 3	3	INTR	40.0		11.47	10902.2	100.3	24.7			125.1	0.406		
11	COAL2 3	4	INTR	40.0		11.57	10150.9	94.4	23.0			117.4	0.378		
11	COAL2 3	5	INTR	40.0		12.11	8356.0	82.2	19.0			101.2	0.311		
8	OIL2 2	1	INTR	150.0	1.28	21.40	29572.8	624.5	8.3	0.00		632.8	0.293		
8	OIL2 2	2	INTR	50.0		16.18	6669.4	106.0	1.9			107.9	0.198		
12	COAL 1	1	PEAK	12.5	1.33	15.72	1841.0	25.2	3.8	0.00		28.9	0.219		
12	COAL 1	2	PEAK	7.5		12.34	1068.1	11.0	2.2			13.2	0.212		
12	COAL 1	3	PEAK	10.0		12.19	1381.6	14.0	2.8			16.8	0.206		
12	COAL 1	4	PEAK	10.0		12.31	1332.9	13.7	2.7			16.4	0.198		
12	COAL 1	5	PEAK	10.0		12.90	1257.3	13.7	2.6			16.2	0.187		
13	COAL 2	1	PEAK	12.5	1.36	15.72	1542.5	21.1	3.1	0.00		24.2	0.184		
13	COAL 2	2	PEAK	7.5		12.34	888.0	9.1	1.8			11.0	0.176		
13	COAL 2	3	PEAK	10.0		12.19	1140.3	11.6	2.3			13.9	0.170		
13	COAL 2	4	PEAK	10.0		12.31	1097.1	11.3	2.2			13.5	0.163		
13	COAL 2	5	PEAK	10.0		12.90	1039.0	11.3	2.1			13.4	0.155		
14*	OIL 1	1	PEAK	12.5	0.81	35.09	1240.1	41.0	2.5	0.00		43.5	0.148		
22	CHY 4	1	INTR	50.0	0.84	0.0	4730.9	0.0	0.0	0.0		0.0	0.141		
23	CHY 5	1	INTR	25.0	0.76	0.0	1976.0	0.0	0.0	0.0		0.0	0.118		
14	OIL 1	2	PEAK	7.5		26.90	599.5	14.9	1.2			16.1	0.119		
14	OIL 1	3	PEAK	10.0		26.57	777.9	19.1	1.6			20.7	0.116		
14	OIL 1	4	PEAK	10.0		26.83	753.5	18.7	1.5			20.2	0.112		

*THERMAL UNIT INTERUPTED BY THE FOLLOWING LIMITED ENERGY UNIT

SYSGEN

TESTW RUN (CASE 8)

TIME PERIOD 1 SUB-PERIOD 1

VALVE POINTS IN LOADING ORDER

UNIT INDEX	UNIT NAME	VALVE POINT	LOAD TYPE	MW ADDED	EXPECTED STARTUPS	MARGINAL COST ($/MWH)	EXPECTED ADDED ENERGY (MWHS)	FUEL COST (TH$)	O&M COST (TH$)	STARTUP COST (TH$)	SPINNING RESERVE COST (TH$)	TOTAL COST (TH$)	CAPACITY FACTOR	ENERGY TO STORAGE (MWH)	CAPACITY FACTOR AFTER STORAGE
14	OIL 1	5	PEAK	10.0		28.27	716.0	18.8	1.4			20.2	0.107		
16	CT 2	1	PEAK	50.0	0.76	33.58	2602.5	82.3	5.0	0.0		87.4	0.077		
17	CT 3	1	PEAK	50.0	0.85	33.58	2303.3	72.9	4.5	0.0		77.3	0.069		
18*	CT 4	1	PEAK	50.0	0.84	33.58	67.3	2.1	0.1	0.0		2.3	0.002		
24	PHY 1	1	PEAK	300.0	0.95	15.14	5049.5	76.5	0.0	0.0		76.5	0.025		
25	PHY 2	1	PEAK	200.0	0.41	17.50	3366.3	58.9	0.0	0.0		58.9	0.025		
26	PHY 3	1	PEAK	200.0	0.20	17.69	2280.0	40.3	0.0	0.0		40.3	0.017		
27	PURCHAS	1	INTR	25.0	0.09	35.00	53.0	1.9	0.0	0.0		1.9	0.003		

*THERMAL UNIT INTERUPTED BY THE FOLLOWING LIMITED ENERGY UNIT

TIME PERIOD 1 SUB-PERIOD 1

UNIT TOTALS IN INDEX ORDER

UNIT INDEX	UNIT NAME	UNIT TYPE		MW TOTAL	EXPECTED STARTUPS	ENERGY (MWHS)	FUEL COST (TH$)	O&M COST (TH$)	STARTUP COST (TH$)	SPINNING RESERVE COST (TH$)	TOTAL COST (TH$)	CAPACITY FACTOR	ENERGY TO STORAGE (MWH)	CAPACITY FACTOR AFTER STORAGE	EFFECTIVE CAPACITY MW	%
3	COAL4 1	COAL	BASE	400.0	0.0	221792.7	2043.1	314.9	0.0		2358.1	0.825	10802.	0.865	288.	72.1
4	COAL4 2	COAL	BASE	400.0	0.81	173146.0	1601.3	245.9	0.00		1847.1	0.644	7706.	0.673	288.	72.1
6	NUC 2	NUC	BASE	500.0	0.0	285600.0	1603.9	205.6	0.0		1809.6	0.850	0.	0.850	258.	51.7
8	OIL2 2	OIL	INTR	200.0	1.28	36242.2	730.6	10.1	0.00		740.7	0.270			177.	88.6
9	COAL2 1	COAL	INTR	200.0	1.13	70180.2	718.4	159.3	0.00		877.7	0.522			179.	89.3
11	COAL2 3	COAL	INTR	200.0	1.19	53451.5	548.3	121.3	0.00		669.6	0.398			179.	89.3
12	COAL 1	COAL	PEAK	50.0	1.33	6880.9	77.5	14.0	0.00		91.6	0.205			49.	97.1
13	COAL 2	COAL	PEAK	50.0	1.36	5706.9	64.4	11.6	0.00		76.0	0.170			49.	97.1
14	OIL 1	OIL	PEAK	50.0	0.81	4087.0	112.6	8.2	0.00		120.8	0.122			49.	97.1
16	CT 2	CT	PEAK	50.0	0.76	2602.5	82.3	5.0	0.0		87.4	0.077			37.	74.0
17	CT 3	CT	PEAK	50.0	0.85	2303.3	72.9	4.5	0.0		77.3	0.069			37.	74.0
18	CT 4	CT	PEAK	50.0	0.84	67.3	2.1	0.1	0.0		2.3	0.002			37.	74.0
19	CHY 1	CHY	INTR	10.0	0.0	6639.4	0.0	0.0	0.0		0.0	0.988			10.	98.8
20	CHY 2	CHY	INTR	10.0	0.0	6639.4	0.0	0.0	0.0		0.0	0.988			10.	98.8
22	CHY 4	CHY	INTR	50.0	0.84	4730.9	0.0	0.0	0.0		0.0	0.141			49.	98.7
23	CHY 5	CHY	INTR	25.0	0.76	1976.0	0.0	0.0	0.0		0.0	0.118			25.	98.8
24	PHY 1	STO	PEAK	300.0	0.95	5049.5	76.5	0.0	0.0		76.5	0.025			269.	89.6
25	PHY 2	STO	PEAK	200.0	0.41	3366.3	58.9	0.0	0.0		58.9	0.025			184.	92.1
26	PHY 3	STO	PEAK	200.0	0.20	2280.0	40.3	0.0	0.0		40.3	0.017			184.	92.1
27	PURCHAS	CHY	INTR	25.0	0.09	53.0	1.9	0.0	0.0		1.9	0.003			25.	99.9
SYSTEM TOTALS				3020.0		892794.4	7834.9	1100.7	0.01		8935.7	0.440	18507.			

TIME PERIOD 1 SUB-PERIOD 1

CONVENTIONAL HYDRO AND PURCHASE POWER REPORT

HYDRO ID	UNIT INDEX	CAPACITY (MW)	AVAILABILITY	MARGINAL COST ($/MWH)	AVAILABLE ENERGY (MWH)	GENERATED ENERGY (MWH)	UNUSED ENERGY (MWH)
1	19	10.0	0.988	0.0	6720.0	6639.4	80.6
2	20	10.0	0.988	0.0	6720.0	6639.4	80.6
4	22	50.0	0.988	0.0	4800.0	4730.9	69.1
5	23	25.0	0.988	0.0	2000.0	1976.0	24.0
6	27	25.0	0.999	35.00	400.0	53.0	347.0

TOTAL ENERGY AVAILABLE = 20640.0 MWH
EXPECTED UNUSED ENERGY = 601.4 MWH
ENERGY GENERATED TO LOAD = 20038.6 MWH

TIME PERIOD 1 SUB-PERIOD 1

STORAGE REPORT

STORAGE ID	UNIT INDEX	CHARGING CAPACITY (MW)	GENERATING CAPACITY (MW)	GENERATING EFFICIENCY	AVAIL	MARGINAL COST ($/MWH)	STORAGE CAPACITY (MWH)	STORED ENERGY (MWH)	GENERATED ENERGY (MWH)	UNUSED ENERGY (MWH)
1	24	200.0	300.0	0.670	0.950	15.14	6000.0	6000.0	5049.5	950.5
2	25	200.0	200.0	0.670	0.950	17.50	4000.0	4000.0	3366.3	633.7
3	26	150.0	200.0	0.670	0.950	17.69	2400.0	2400.0	2280.0	120.0

ENERGY AVAILABLE FOR STORAGE*= 72772.8 MWH
ENERGY SENT TO STORAGE = 18507.4 MWH
ENERGY LOST FROM INEFFICIENCIES = 6107.5 MWH

ENERGY STORED = 12400.0 MWH
EXPECTED UNUSED ENERGY**= 1704.2 MWH
ENERGY GENERATED FROM STORAGE = 10695.8 MWH

*TOTAL EXCESS ENERGY EXPECTED FROM BASE LOAD UNITS

**INCLUDES ENERGY UNAVAILABLE BECAUSE THE STORAGE UNIT FAILED OR BECAUSE THE STORAGE UNIT WAS DELAYED IN THE LOADING ORDER DUE TO A HIGH MARGINAL COST

FINAL EQUIVALENT DEMAND CURVE

TIME PERIOD 1 SUB-PERIOD 1

LOAD CURVE SPACING (MW)	MINIMUM DEMAND (MW)	MAXIMUM DEMAND (MW)	EQUIVALENT DEMAND AREA (MWH)
40.00	640.00	4240.00	1094989.00

FRACTION OF TIME THAT THE EQUIVALENT DEMAND EXCEEDS THE ARRAY INDEX * SPACING:

1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000
1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000
0.9983605144	0.9937459458	0.9857406438	0.9747437757	0.9617165338	0.9470496355	0.9309996870	0.9137553795
0.8955084299	0.8765385271	0.8566138061	0.8355507545	0.8133103065	0.7898857206	0.7654304373	0.7400387971
0.7138689836	0.6870977946	0.6598437258	0.6322186616	0.6042724862	0.5760548957	0.5475982875	0.5188962078
0.4899673697	0.4608509512	0.4315996333	0.4022555476	0.3728364767	0.3433557112	0.3138261829	0.2842612525
0.2546700417	0.2247788653	0.1975982174	0.1734766141	0.1530223462	0.1352457473	0.1191120637	0.1046518309
0.0914015208	0.0793634899	0.0682289078	0.0576526226	0.0482714571	0.0399823000	0.0329259273	0.0270461417
0.0221134523	0.0181371029	0.0148468614	0.0121191773	0.0098383681	0.0078847590	0.0062564564	0.0048680925
0.0037165189	0.0028195782	0.0021371562	0.0016328402	0.0012409118	0.0009310561	0.0006935066	0.0005125580
0.0003772372	0.0002718705	0.0001906905	0.0001330146	0.0000933451	0.0000659962	0.0000456789	0.0000304383
0.0000199666	0.0000130484	0.0000085646	0.0000055671	0.0000035394	0.0000022204	0.0000013551	0.0000008051
0.0000004727	0.0000002787	0.0000001654	0.0000000948	0.0000000510	0.0000000265	0.0000000140	0.0000000072
0.0000000031	0.0						

SYSTEM SUMMARY FOR TIME PERIOD 1 SUBPERIOD 1

```
                                      PEAK DEMAND =     2000.0      MW
                               AVAILABLE CAPACITY =     3020.0      MW

                           CUSTOMER ENERGY DEMAND =   893716.       MWHS
                                      LOAD FACTOR =       66.50     %
                           SYSTEM CAPACITY FACTOR =       43.992    %

                        LOSS-OF-LOAD PROBABILITY =         0.002876

                          UNSERVED ENERGY DEMAND =      269.        MWHS
                         PERCENT ENERGY UNSERVED =        0.0301    %
             AVERAGE MAGNITUDE OF LOSS OF LOAD =          0.40      MWS

                       FREQUENCY OF LOSS OF LOAD =         0.08714  TIMES/PERIOD
              AVERAGE DURATION OF LOSS OF LOAD =          0.0151    HOURS

TOTAL ENERGY GENERATED INCLUDING ENERGY LOST IN STORAGE = 911302.   MWHS

             TOTAL ENERGY GENERATED TO MEET DEMAND =  892794.       MWHS

                            SUB-PERIOD FUEL COST =     7834.926     THOUSAND DOLLARS
                             SUB-PERIOD O&M COST =     1100.736     THOUSAND DOLLARS
                           SUB-PERIOD TOTAL COST =     8935.672     THOUSAND DOLLARS

                     ERROR IN ENERGY CALCULATION =       -0.073     %

PROBABILITY(AVAILABLE RESERVES < 1000. MW) =  0.256520
PROBABILITY(AVAILABLE RESERVES <  900. MW) =  0.187045
PROBABILITY(AVAILABLE RESERVES <  800. MW) =  0.136357
PROBABILITY(AVAILABLE RESERVES <  700. MW) =  0.098855
PROBABILITY(AVAILABLE RESERVES <  600. MW) =  0.068925
PROBABILITY(AVAILABLE RESERVES <  500. MW) =  0.044645
PROBABILITY(AVAILABLE RESERVES <  400. MW) =  0.027414
PROBABILITY(AVAILABLE RESERVES <  300. MW) =  0.016698
PROBABILITY(AVAILABLE RESERVES <  200. MW) =  0.009981
PROBABILITY(AVAILABLE RESERVES <  100. MW) =  0.005649
PROBABILITY(AVAILABLE RESERVES <    0. MW) =  0.002876
PROBABILITY(AVAILABLE RESERVES < -100. MW) =  0.001461
PROBABILITY(AVAILABLE RESERVES < -200. MW) =  0.000708
PROBABILITY(AVAILABLE RESERVES < -300. MW) =  0.000331
PROBABILITY(AVAILABLE RESERVES < -400. MW) =  0.000137
PROBABILITY(AVAILABLE RESERVES < -500. MW) =  0.000057
PROBABILITY(AVAILABLE RESERVES < -600. MW) =  0.000021
PROBABILITY(AVAILABLE RESERVES < -700. MW) =  0.000007
PROBABILITY(AVAILABLE RESERVES < -800. MW) =  0.000002
PROBABILITY(AVAILABLE RESERVES < -900. MW) =  0.000001
PROBABILITY(AVAILABLE RESERVES <-1000. MW) =  0.000000
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INITIAL CUSTOMER LOAD DURATION CURVE

TIME PERIOD 1 SUB-PERIOD 2

LOAD CURVE SPACING (MW)	MINIMUM DEMAND (MW)	MAXIMUM DEMAND (MW)	EQUIVALENT DEMAND AREA (MWH)
40.00	640.00	2000.00	897743.87

FRACTION OF TIME THAT THE EQUIVALENT DEMAND EXCEEDS THE ARRAY INDEX * SPACING:

1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000
1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000
0.9785869983	0.9481542706	0.9247431159	0.8896263242	0.8662150502	0.8310982585	0.8076869845	0.7725701928
0.7491589785	0.7140421271	0.6906309724	0.6555140615	0.6321028471	0.5969860554	0.5735747814	0.5384579397
0.5150467753	0.4799298644	0.4565186501	0.4214019583	0.3979906440	0.3628738523	0.3394625783	0.3043457270
0.2809345722	0.2458177209	0.2224065065	0.1872897148	0.1638784409	0.1287615895	0.1053503752	0.0702335835
0.0468224399	0.0						

SYSGEN

TESTW RUN (CASE 8)

TIME PERIOD 1 SUB-PERIOD 2

VALVE POINTS IN LOADING ORDER

UNIT INDEX	UNIT NAME	VALVE POINT	LOAD TYPE	MW ADDED	EXPECTED STARTUPS	MARGINAL COST ($/MWH)	EXPECTED ADDED ENERGY (MWHS)	FUEL COST (TH$)	O&M COST (TH$)	STARTUP COST (TH$)	SPINNING RESERVE COST (TH$)	TOTAL COST (TH$)	CAPACITY FACTOR	ENERGY TO STORAGE (MWH)	CAPACITY FACTOR AFTER STORAGE
20	CHY 2	1	INTR	10.0	0.0	0.0	6639.4	0.0	0.0	0.0		0.0	0.988		
6	NUC 2	1	BASE	500.0	0.0	6.34	285600.0	1603.9	205.6	0.0		1809.6	0.850	0.	0.850
3	COAL4 1	1	BASE	100.0	0.0	12.31	60816.0	662.1	86.4	0.0		748.5	0.905	0.	0.905
3	COAL4 1	2	BASE	60.0		9.88	36365.4	307.3	51.6			359.4	0.902	0.	0.902
3	COAL4 1	3	BASE	80.0		9.77	46861.6	391.5	66.5			458.0	0.872	1115.	0.892
3	COAL4 1	4	BASE	80.0		10.01	44515.5	382.5	63.2			445.7	0.828	2639.	0.877
3	COAL4 1	5	BASE	80.0		10.42	33955.2	305.5	48.2			353.7	0.632	3784.	0.702
4	COAL4 2	1	BASE	100.0	3.01	12.31	50867.1	553.8	72.2	0.00		626.0	0.757	2014.	0.787
4	COAL4 2	2	BASE	60.0		9.88	28832.9	244.0	40.9			285.0	0.715	0.	0.715
4	COAL4 2	3	BASE	80.0		9.77	36392.0	304.0	51.7			355.7	0.677	0.	0.677
4	COAL4 2	4	BASE	80.0		10.01	33822.5	290.6	48.0			338.6	0.629	0.	0.629
4	COAL4 2	5	BASE	80.0		10.42	25063.7	225.5	35.6			261.1	0.466	0.	0.466
9	COAL2 1	1	INTR	50.0	3.93	14.66	19945.8	247.2	45.3	0.00		292.4	0.594		
9	COAL2 1	2	INTR	30.0		11.60	11409.8	106.4	25.9			132.3	0.566		
9	COAL2 1	3	INTR	40.0		11.47	14623.2	134.5	33.2			167.7	0.544		
9	COAL2 1	4	INTR	40.0		11.57	13856.2	128.9	31.5			160.3	0.515		
9	COAL2 1	5	INTR	40.0		12.11	11718.2	115.3	26.6			141.9	0.436		
11	COAL2 3	1	INTR	50.0	4.09	14.66	15750.0	195.2	35.8	0.00		230.9	0.469		
11	COAL2 3	2	INTR	30.0		11.60	8914.2	83.1	20.2			103.4	0.442		
11	COAL2 3	3	INTR	40.0		11.47	11213.5	103.2	25.5			128.6	0.417		
11	COAL2 3	4	INTR	40.0		11.57	10506.0	97.7	23.8			121.5	0.391		
11	COAL2 3	5	INTR	40.0		12.11	8652.6	85.1	19.6			104.8	0.322		
8	OIL2 2	1	INTR	150.0	4.21	21.40	30962.6	653.9	8.7	0.00		662.6	0.307		
8	OIL2 2	2	INTR	50.0		16.18	7122.8	113.2	2.0			115.2	0.212		
12	COAL 1	1	PEAK	12.5	4.31	15.72	1965.0	26.9	4.0	0.00		30.9	0.234		
12	COAL 1	2	PEAK	7.5		12.34	1143.4	11.8	2.3			14.1	0.227		
12	COAL 1	3	PEAK	10.0		12.19	1485.1	15.1	3.0			18.1	0.221		
12	COAL 1	4	PEAK	10.0		12.31	1439.9	14.8	2.9			17.7	0.214		
12	COAL 1	5	PEAK	10.0		12.90	1366.2	14.8	2.8			17.6	0.203		
13	COAL 2	1	PEAK	12.5	4.37	15.72	1679.4	23.0	3.4	0.00		26.4	0.200		
13	COAL 2	2	PEAK	7.5		12.34	965.9	9.9	2.0			11.9	0.192		
13*	COAL 2	3	PEAK	10.0		12.19	1050.3	10.7	2.1			12.8	0.156		
21	CHY 3	1	INTR	35.0	4.39	0.0	3884.0	0.0	0.0	0.0		0.0	0.165		
22	CHY 4	1	INTR	50.0	2.39	0.0	5137.6	0.0	0.0	0.0		0.0	0.153		
13	COAL 2	4	PEAK	10.0		12.31	902.3	9.3	1.8			11.1	0.134		
13	COAL 2	5	PEAK	10.0		12.90	851.1	9.2	1.7			11.0	0.127		
14	OIL 1	1	PEAK	12.5	2.23	35.08	1055.0	34.9	2.1	0.00		37.0	0.126		
14	OIL 1	2	PEAK	7.5		26.90	614.0	15.3	1.2			16.5	0.122		
14	OIL 1	3	PEAK	10.0		26.57	796.6	19.6	1.6			21.2	0.119		
14	OIL 1	4	PEAK	10.0		26.83	771.8	19.2	1.5			20.7	0.115		
14	OIL 1	5	PEAK	10.0		28.27	734.0	19.3	1.5			20.8	0.109		

*THERMAL UNIT INTERUPTED BY THE FOLLOWING LIMITED ENERGY UNIT

SYSGEN

TESTW RUN (CASE 8)

TIME PERIOD 1 SUB-PERIOD 2

VALVE POINTS IN LOADING ORDER

UNIT INDEX	UNIT NAME		VALVE POINT	LOAD TYPE	MW ADDED	EXPECTED STARTUPS	MARGINAL COST ($/MWH)	EXPECTED ADDED ENERGY (MWHS)	FUEL COST (TH$)	O&M COST (TH$)	STARTUP COST (TH$)	SPINNING RESERVE COST (TH$)	TOTAL COST (TH$)	CAPACITY FACTOR	ENERGY TO STORAGE (MWH)	CAPACITY FACTOR AFTER STORAGE
15	CT	1	1	PEAK	50.0	2.23	33.58	2671.0	84.5	5.2	0.0		89.7	0.079		
16*	CT	2	1	PEAK	50.0	2.33	33.58	2183.3	69.1	4.2	0.0		73.3	0.065		
23	CHY	5	1	INTR	25.0	2.43	0.0	1580.8	0.0	0.0	0.0		0.0	0.094		
17	CT	3	1	PEAK	50.0	2.13	33.58	2276.5	72.0	4.4	0.0		76.4	0.068		
18	CT	4	1	PEAK	50.0	2.09	33.58	2009.7	63.6	3.9	0.0		67.5	0.060		
25	PHY	2	1	PEAK	93.6	2.07	15.11	3800.0	57.4	0.0	0.0		57.4	0.028		
26	PHY	3	1	PEAK	80.4	1.74	17.14	2280.0	39.1	0.0	0.0		39.1	0.017		
27	PURCHAS		1	INTR	16.8	1.29	35.00	399.6	14.0	0.0	0.0		14.0	0.024		

*THERMAL UNIT INTERUPTED BY THE FOLLOWING LIMITED ENERGY UNIT

SYSGEN

TESTW RUN (CASE 8) PAGE: 25

TIME PERIOD 1 SUB-PERIOD 2

UNIT TOTALS IN INDEX ORDER

UNIT INDEX	UNIT NAME	UNIT TYPE		MW TOTAL	EXPECTED STARTUPS	ENERGY (MWHS)	FUEL COST (TH$)	O&M COST (TH$)	STARTUP COST (TH$)	SPINNING RESERVE COST (TH$)	TOTAL COST (TH$)	CAPACITY FACTOR	ENERGY TO STORAGE (MWH)	CAPACITY FACTOR AFTER STORAGE	EFFECTIVE CAPACITY MW	EFFECTIVE CAPACITY %
3	COAL4 1	COAL	BASE	400.0	0.0	222513.5	2049.4	316.0	0.0		2365.3	0.828	7538.	0.856	326.	81.5
4	COAL4 2	COAL	BASE	400.0	3.01	174978.1	1618.0	248.5	0.00		1866.4	0.651	2014.	0.658	326.	81.5
6	NUC 2	NUC	BASE	500.0	0.0	285600.0	1603.9	205.6	0.0		1809.6	0.850	0.	0.850	328.	65.6
8	OIL2 2	OIL	INTR	200.0	4.21	38085.4	767.1	10.7	0.00		777.8	0.283			180.	90.2
9	COAL2 1	COAL	INTR	200.0	3.93	71553.1	732.3	162.4	0.00		894.7	0.532			182.	90.9
11	COAL2 3	COAL	INTR	200.0	4.09	55036.3	564.3	124.9	0.00		689.3	0.409			182.	90.9
12	COAL 1	COAL	PEAK	50.0	4.31	7399.6	83.3	15.1	0.00		98.4	0.220			48.	97.0
13	COAL 2	COAL	PEAK	50.0	4.37	5449.0	62.1	11.1	0.00		73.2	0.162			48.	97.0
14	OIL 1	OIL	PEAK	50.0	2.23	3971.4	108.2	7.9	0.00		116.2	0.118			48.	97.0
15	CT 1	CT	PEAK	50.0	2.23	2671.0	84.5	5.2	0.00		89.7	0.079			37.	73.4
16	CT 2	CT	PEAK	50.0	2.33	2183.3	69.1	4.2	0.0		73.3	0.065			37.	73.4
17	CT 3	CT	PEAK	50.0	2.13	2276.5	72.0	4.4	0.0		76.4	0.068			37.	73.4
18	CT 4	CT	PEAK	50.0	2.09	2009.7	63.6	3.9	0.0		67.5	0.060			37.	73.4
20	CHY 2	CHY	INTR	10.0	0.0	6639.4	0.0	0.0	0.0		0.0	0.988			10.	98.7
21	CHY 3	CHY	INTR	35.0	4.39	3884.0	0.0	0.0	0.0		0.0	0.165			35.	98.7
22	CHY 4	CHY	INTR	50.0	2.39	5137.6	0.0	0.0	0.0		0.0	0.153			49.	98.7
23	CHY 5	CHY	INTR	25.0	2.43	1580.8	0.0	0.0	0.0		0.0	0.094			25.	98.7
25	PHY 2	STO	PEAK	200.0	2.07	3800.0	57.4	0.0	0.0		57.4	0.028			187.	93.6
26	PHY 3	STO	PEAK	200.0	1.74	2280.0	39.1	0.0	0.0		39.1	0.017			187.	93.6
27	PURCHAS	CHY	INTR	25.0	1.29	399.6	14.0	0.0	0.0		14.0	0.024			25.	99.9
SYSTEM TOTALS				2795.0		897447.6	7988.3	1120.0	0.03		9108.3	0.478	9552.			

TIME PERIOD 1 SUB-PERIOD 2

CONVENTIONAL HYDRO AND PURCHASE POWER REPORT

HYDRO ID	UNIT INDEX	CAPACITY (MW)	AVAILABILITY	MARGINAL COST ($/MWH)	AVAILABLE ENERGY (MWH)	GENERATED ENERGY (MWH)	UNUSED ENERGY (MWH)
2	20	10.0	0.988	0.0	6720.0	6639.4	80.6
3	21	35.0	0.988	0.0	4000.0	3884.0	116.0
4	22	50.0	0.988	0.0	5200.0	5137.6	62.4
5	23	25.0	0.988	0.0	1600.0	1580.8	19.2
6	27	25.0	0.999	35.00	400.0	399.6	0.4

TOTAL ENERGY AVAILABLE = 17920.0 MWH
EXPECTED UNUSED ENERGY = 278.7 MWH
ENERGY GENERATED TO LOAD = 17641.3 MWH

TIME PERIOD 1 SUB-PERIOD 2

STORAGE REPORT

STORAGE ID	UNIT INDEX	CHARGING CAPACITY (MW)	GENERATING CAPACITY (MW)	GENERATING EFFICIENCY	AVAIL	MARGINAL COST ($/MWH)	STORAGE CAPACITY (MWH)	STORED ENERGY (MWH)	GENERATED ENERGY (MWH)	UNUSED ENERGY (MWH)
2	25	200.0	200.0	0.670	0.950	15.11	4000.0	4000.0	3800.0	200.0
3	26	150.0	200.0	0.670	0.950	17.14	2400.0	2400.0	2280.0	120.0

ENERGY AVAILABLE FOR STORAGE*= 70220.0 MWH
ENERGY SENT TO STORAGE = 9552.2 MWH
ENERGY LOST FROM INEFFICIENCIES = 3152.2 MWH

ENERGY STORED = 6400.0 MWH
EXPECTED UNUSED ENERGY**= 320.0 MWH
ENERGY GENERATED FROM STORAGE = 6080.0 MWH

*TOTAL EXCESS ENERGY EXPECTED FROM BASE LOAD UNITS

**INCLUDES ENERGY UNAVAILABLE BECAUSE THE STORAGE UNIT FAILED OR BECAUSE THE STORAGE UNIT WAS DELAYED IN THE LOADING ORDER DUE TO A HIGH MARGINAL COST

FINAL EQUIVALENT DEMAND CURVE

TIME PERIOD 1 SUB-PERIOD 2

LOAD CURVE SPACING (MW)	MINIMUM DEMAND (MW)	MAXIMUM DEMAND (MW)	EQUIVALENT DEMAND AREA (MWH)
40.00	640.00	4000.00	1089607.00

FRACTION OF TIME THAT THE EQUIVALENT DEMAND EXCEEDS THE ARRAY INDEX * SPACING:

1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000
1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000	1.0000000000
0.9984156194	0.9939896865	0.9864162248	0.9751833425	0.9617997868	0.9459105666	0.9289743856	0.9104977736
0.8916331278	0.8718577058	0.8517212266	0.8302653485	0.8082161343	0.7845497787	0.7603163368	0.7346098171
0.7085869424	0.6814727345	0.6543710181	0.6264859146	0.5988168124	0.5704878459	0.5424552812	0.5137583064
0.4853512324	0.4563047573	0.4276046358	0.3983423746	0.3694856213	0.3401110785	0.3111747328	0.2817454528
0.2527721475	0.2224466578	0.1939906444	0.1679309471	0.1459879919	0.1275981777	0.1118916855	0.0982763534
0.0861686034	0.0751514957	0.0650208500	0.0551020359	0.0459673681	0.0376696409	0.0304536267	0.0244630127
0.0195404740	0.0156847662	0.0126587421	0.0102699532	0.0083513323	0.0067284956	0.0053601595	0.0041686232
0.0031348464	0.0022989955	0.0016571760	0.0011990056	0.0008729842	0.0006362495	0.0004650460	0.0003401818
0.0002496378	0.0001794602	0.0001228566	0.0000807198	0.0000519854	0.0000337531	0.0000217380	0.0000132675
0.0000076261	0.0000041653	0.0000022919	0.0000012617	0.0000006702	0.0000003365	0.0000001578	0.0000000716
0.0000000321	0.0000000140	0.0000000052	0.0				

2/80

SYSTEM SUMMARY FOR TIME PERIOD 1 SUBPERIOD 2

PEAK DEMAND =	2000.0	MW
AVAILABLE CAPACITY =	2795.0	MW
CUSTOMER ENERGY DEMAND =	897744.	MWHS
LOAD FACTOR =	66.80	%
SYSTEM CAPACITY FACTOR =	47.781	%
LOSS-OF-LOAD PROBABILITY =	0.033899	
UNSERVED ENERGY DEMAND =	4010.	MWHS
PERCENT ENERGY UNSERVED =	0.4467	%
AVERAGE MAGNITUDE OF LOSS OF LOAD =	5.97	MWS
FREQUENCY OF LOSS OF LOAD =	1.29236	TIMES/PERIOD
AVERAGE DURATION OF LOSS OF LOAD =	0.0938	HOURS
TOTAL ENERGY GENERATED INCLUDING ENERGY LOST IN STORAGE =	907000.	MWHS
TOTAL ENERGY GENERATED TO MEET DEMAND =	897448.	MWHS
SUB-PERIOD FUEL COST =	7988.312	THOUSAND DOLLARS
SUB-PERIOD O&M COST =	1119.977	THOUSAND DOLLARS
SUB-PERIOD TOTAL COST =	9108.316	THOUSAND DOLLARS
ERROR IN ENERGY CALCULATION =	0.414	%

PROBABILITY(AVAILABLE RESERVES < 1000. MW) =	0.584015
PROBABILITY(AVAILABLE RESERVES < 900. MW) =	0.513119
PROBABILITY(AVAILABLE RESERVES < 800. MW) =	0.441309
PROBABILITY(AVAILABLE RESERVES < 700. MW) =	0.368825
PROBABILITY(AVAILABLE RESERVES < 600. MW) =	0.295798
PROBABILITY(AVAILABLE RESERVES < 500. MW) =	0.221807
PROBABILITY(AVAILABLE RESERVES < 400. MW) =	0.156490
PROBABILITY(AVAILABLE RESERVES < 300. MW) =	0.111585
PROBABILITY(AVAILABLE RESERVES < 200. MW) =	0.080412
PROBABILITY(AVAILABLE RESERVES < 100. MW) =	0.054897
PROBABILITY(AVAILABLE RESERVES < 0. MW) =	0.033899
PROBABILITY(AVAILABLE RESERVES < -100. MW) =	0.019454
PROBABILITY(AVAILABLE RESERVES < -200. MW) =	0.011411
PROBABILITY(AVAILABLE RESERVES < -300. MW) =	0.006698
PROBABILITY(AVAILABLE RESERVES < -400. MW) =	0.003628
PROBABILITY(AVAILABLE RESERVES < -500. MW) =	0.001647
PROBABILITY(AVAILABLE RESERVES < -600. MW) =	0.000749
PROBABILITY(AVAILABLE RESERVES < -700. MW) =	0.000338
PROBABILITY(AVAILABLE RESERVES < -800. MW) =	0.000150
PROBABILITY(AVAILABLE RESERVES < -900. MW) =	0.000052
PROBABILITY(AVAILABLE RESERVES <-1000. MW) =	0.000017

UNIT TOTALS FOR TIME PERIOD 1

UNIT INDEX	UNIT NAME	UNIT TYPE	TOTAL CAPACITY	TOTAL EXPECTED ENERGY (MWHS)	FUEL COST ($M)	VARIABLE O&M COST ($M)	TOTAL COST ($M)	TOTAL CAPACITY FACTOR	ENERGY TO STORAGE (MWH)	CAPACITY FACTOR AFTER STORAGE	EFFECTIVE CAPACITY MW	EFFECTIVE CAPACITY %
3	COAL4 1	COAL BASE	400.0	444306.2	4.1	0.6	4.7	0.826	18339.3	0.861	307.	76.8
4	COAL4 2	COAL BASE	400.0	348124.1	3.2	0.5	3.7	0.648	9720.3	0.666	307.	76.8
6	NUC 2	NUC BASE	500.0	571200.0	3.2	0.4	3.6	0.850	0.0	0.850	293.	58.6
8	OIL2 2	OIL INTR	200.0	74327.6	1.5	0.0	1.5	0.277			179.	89.4
9	COAL2 1	COAL INTR	200.0	141733.2	1.5	0.3	1.8	0.527			180.	90.1
11	COAL2 3	COAL INTR	200.0	108487.6	1.1	0.2	1.4	0.404			180.	90.1
12	COAL 1	COAL PEAK	50.0	14280.4	0.2	0.0	0.2	0.213			49.	97.0
13	COAL 2	COAL PEAK	50.0	11155.9	0.1	0.0	0.1	0.166			49.	97.0
14	OIL 1	OIL PEAK	50.0	8058.4	0.2	0.0	0.2	0.120			49.	97.0
15	CT 1	CT PEAK	50.0	2671.0	0.1	0.0	0.1	0.040			18.	36.7
16	CT 2	CT PEAK	50.0	4785.8	0.2	0.0	0.2	0.071			37.	73.7
17	CT 3	CT PEAK	50.0	4579.8	0.1	0.0	0.2	0.068			37.	73.7
18	CT 4	CT PEAK	50.0	2076.9	0.1	0.0	0.1	0.031			37.	73.7
19	CHY 1	CHY INTR	10.0	6639.4	0.0	0.0	0.0	0.494			5.	49.4
20	CHY 2	CHY INTR	10.0	13278.7	0.0	0.0	0.0	0.988			10.	98.7
21	CHY 3	CHY INTR	35.0	3884.0	0.0	0.0	0.0	0.083			17.	49.4
22	CHY 4	CHY INTR	50.0	9868.5	0.0	0.0	0.0	0.147			49.	98.7
23	CHY 5	CHY INTR	25.0	3556.8	0.0	0.0	0.0	0.106			25.	98.7
24	PHY 1	STO PEAK	300.0	5049.5	0.1	0.0	0.1	0.013			134.	44.8
25	PHY 2	STO PEAK	200.0	7166.3	0.1	0.0	0.1	0.027			186.	92.8
26	PHY 3	STO PEAK	200.0	4560.0	0.1	0.0	0.1	0.017			186.	92.8
27	PURCHAS	CHY INTR	25.0	452.6	0.0	0.0	0.0	0.013			25.	99.9
SYSTEM TOTALS			3105.0	1790242.0	15.8	2.2	18.0	0.429	28059.7			

SYSTEM SUMMARY FOR TIME PERIOD 1

PEAK DEMAND =	2000.0	MW
AVAILABLE CAPACITY =	3105.0	MW
CUSTOMER ENERGY DEMAND =	1791460.	MWHS
LOAD FACTOR =	66.65	%
SYSTEM CAPACITY FACTOR =	42.899	%
LOSS-OF-LOAD PROBABILITY =	0.018387	
UNSERVED ENERGY DEMAND =	4279.	MWHS
PERCENT ENERGY UNSERVED =	0.2389	%
AVERAGE MAGNITUDE OF LOSS OF LOAD =	3.18	MWS
FREQUENCY OF LOSS OF LOAD =	1.37950	TIMES/PERIOD
AVERAGE DURATION OF LOSS OF LOAD =	0.0544	HOURS
TOTAL ENERGY GENERATED INCLUDING ENERGY LOST IN STORAGE =	1818301.	MWHS
TOTAL ENERGY GENERATED TO MEET DEMAND =	1790242.	MWHS
TIME PERIOD FUEL COST =	15.823	MILLION DOLLARS
TIME PERIOD O&M COST =	2.221	MILLION DOLLARS
TIME PERIOD TOTAL COST =	18.044	MILLION DOLLARS
AVERAGE ABSOLUTE ERROR IN ENERGY CALCULATION =	0.243	%

GIGABTU OF FUEL CONSUMED BY EACH PLANT CLASS
INCLUDING ENERGY SENT TO STORAGE

CLASS NAME		MBTU/10**3
COAL	PEAK	2817.103
COAL	INTR	23955.695
COAL	BASE	229321.437
OIL	PEAK	103083.509
OIL	INTR	9558.293
OIL	BASE	0.0
CT	PEAK	1975.908
NUC	BASE	59404.773
STO	PEAK	0.0
CHY	INTR	4.526
CHY	BASE	0.0
GAS	PEAK	0.0
GAS	INTR	0.0
GAS	BASE	0.0
SUN	INTR	0.0
TOTAL		429121.062

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