GE Energy Consulting

Multi-Area Reliability Simulation Program

MARS

User's Manual

A Proprietary Software Product of
General Electric Company

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Chapter 1

General Overview

The Multi-Area Reliability Simulation program (MARS) enables the electric utility planner to quickly and accurately assess the ability of a power system, comprised of any number of interconnected areas, to adequately satisfy customer load requirements.

A sequential Monte Carlo simulation forms the basis for MARS, which was jointly developed by General Electric and Associated Power Analysts. The Monte Carlo method provides a fast, versatile, and easily-expandable program that can be used to fully model many different types of generation and demand-side options.

MARS calculates, on an area and pool basis, the standard indices of daily and hourly LOLE (days/year and hours/year) and expected unserved energy (LOEE in MWh/year). The use of sequential Monte Carlo simulation allows for the calculation of time-correlated measures such as frequency (outages/year) and duration (hours/outage). To model the impact of emergency operating procedures, the program also calculates the expected number of days per year at specified positive and negative margin states.

In addition to calculating the expected values for the reliability indices, MARS produces a multitude of statistics and system summaries that can be used to understand the behavior of the modeling and yearly variations in reliability that the system could be expected to experience. These datasets are easily accessible through the GE MAPS and MARS User Interface or through snappy, a python-based library.

1.1 Monte Carlo Simulation for Reliability Evaluations

In determining the reliability of a utility system, there are several types of randomly occurring events that must be taken into consideration. Among these are the forced outages of generating units, the forced outages of transmission capacity, and deviations from in the forecasted loads. Monte Carlo simulation is a widely-accepted technique for modeling the effects of such random events.

Monte Carlo simulation approaches can be categorized as "non-sequential" and "sequential". A non-sequential simulation process does not move through time chronologically or sequentially, but rather considers each hour to be independent of every other hour. Because of this, it cannot accurately model issues that involve time correlations, such as unit starting times or unplanned outages which cannot be postponed, and cannot be used to calculate time-related indices such as frequency and duration.

A sequential Monte Carlo simulation, the approach used by MARS, steps through the year chronologically, recognizing the fact that the status of a piece of equipment is not independent of its status in adjacent hours. Equipment forced outages are modeled by taking the equipment out of service for contiguous hours, with the length of the outage period being determined from the equipment's mean time to repair. The sequential simulation can model issues of concern that involve time correlations, and can be used to calculate indices such as frequency and duration.

1.2 Convergence and Interpretation of Results

An important issue in Monte Carlo simulation programs is the number of years of artificial history which must be created to achieve an acceptable level of statistical convergence in the reliability indices (expected values) of interest. The degree of statistical convergence of a reliability index (expected value) is measured by the standard deviation of the estimate of the reliability index that is calculated from the simulation data. This can be expressed mathematically as follows.

Let $I_i =$ the value of the reliability index obtained from simulation data for year i

and $N =$ number of times the year has been simulated

Then $\bar{I} = \sum_{i=1}^{N} \frac{I_i}{N} =$ estimate of the expected value of the index I.

and $S\bar{I} = \sqrt{\frac{S^2}{N}} =$ standard deviation of the estimate $\bar{I}$

Where $S^2 = \sum_{i=1}^{N} \frac{(I_i - \bar{I})^2}{N}$

Note that $S\bar{I}$, the standard deviation of the estimate $\bar{I}$, varies directly as S and inversely as $\sqrt{N}$. Here S, the standard deviation of I, is a measure of the year-to-year variation in I, and N is the number of simulations for the year. It follows that the number of years of simulated history required to achieve a given degree of statistical convergence in an expected value reliability index is a function of the year-to-year variability of the index as expressed by S. S will tend to be low for systems which are characterized by:

- many generators, all of which are small in comparison to the load,
- a strong transmission network which allows mutual assistance, with few limitations, between areas,
- relatively low capacity reserve levels, implying relatively low system reliability.

Conversely, S will tend to be high for systems whose reliability performance is dominated by a few large units (in comparison to the load), with weak interconnections between areas, and which have high capacity reserve levels, implying high system reliability.

No variance reduction procedures have been incorporated into MARS. Therefore, the simulation results reflect the general year-to-year variability that would be experienced by the actual system itself. In this light, it seems appropriate to measure system reliability performance by the statistical variation about the expected value of the reliability index, as well as by the expected value of the index.

If the variance about the expected value is large, it is evident that no one, consumers or utilities, will be able to detect small to moderate variations in the expected value of the reliability index. This suggests that a confidence interval, say ninety percent, on the reliability index may be a more physically meaningful measure of reliability than a point estimate (expected value) of the reliability index itself.

In practice, alternatives which yield substantially overlapping confidence intervals would be viewed as yielding levels of reliability which are indistinguishable for all practical purposes. In view of this, it is evident that extremely accurate estimates of the expected values of reliability indices are rarely needed or warranted. Historically, the wide acceptance of expected value reliability measures is based on the fact that this is the only information that can be easily obtained from the analytical models that are usually used.

The standard deviation of the estimated mean, also known as the standard error, has the same physical units (e.g., days/year) as the index being estimated, and thus its magnitude is a function of the type of index being estimated. Because the standard deviation can assume a wide range of values, the degree of convergence is often measured by the standard error expressed as a per unit of the mean:

$$\text{Standard error of } \bar{I} = \frac{S\bar{I}}{\bar{I}}$$

Chapter 2

Program Description

2.1 Summary of Program Features

MARS provides for the detailed representation of the utility system required to accurately assess the reliability of the generation system. In addition, the program has been written so its dimensions (number of areas, pools, units, etc.) can be easily changed to fit the program to the system being studied.

The following is a brief description of the way in which MARS models the different aspects of the utility system. Each of these is described in greater detail in the remainder of the section.

2.1.1 Loads

The loads in MARS are modeled on an hourly, chronological basis for each area being studied. The program has the option to modify the input hourly loads through time to meet specified annual or monthly peaks and energies. Uncertainty on the annual peak load forecast and hourly profile can also be modeled.

2.1.2 Generation

MARS has the capability to model the following different types of resources:

- Thermal
- Energy limited
- Energy storage
- Cogeneration
- Hourly modifiers

For each unit modeled, the user specifies the installation and retirement dates and planned maintenance requirements. Other data such as maximum rating, available capacity states, state transition rates, and net modification of the hourly loads are input depending on the unit type.

2.1.3 Contracts

Scheduled interchanges between areas are modeled through the use of firm and curtailable contracts. Each contract is defined by specifying the sending and receiving areas, the interchange path used for delivering the contracts and the hourly rating, in MW. Alternatively, contract rating can be tied to the capacity and availability of one or more units in the system.

2.1.4 Transmission System

The transmission system is modeled through transfer limits on the interfaces between pairs of interconnected areas. Separate transfer capabilities can be specified for the tie in each direction. Simultaneous transfer limits can also be specified on groups of two or more interfaces. The transfer limits on the interfaces and groups of interfaces can vary hourly based on the availability of the specified units and the value of area loads.

2.1.5 Resource Allocations Among Areas

The user can also specify the order in which areas with excess reserves will provide assistance to deficient areas, or the excess reserves can be shared among the deficient areas in proportion to their shortfalls. A priority ordering for the sharing of reserves between the areas in different pools can also be modeled.

2.1.6 Emergency Operating Procedures

The need for a utility to begin emergency operating procedures is modeled by evaluating the daily and hourly loss-of-load expectation (LOLE) and loss-of-energy expectation (LOEE) at specified positive and negative margin states. The user specifies these margin states for each of the areas in the system in terms of the operating reserve requirements and the actual benefit available from each of the EOPs. The staggered implementation of EOPs between areas as well as the limits on the number of days each EOP is implemented can be modeled.

2.2 Simulation Event Calendar

The Monte Carlo simulation models the system by stepping through time chronologically. As the program moves through the year, events take place just as they do in real life: units are installed and retired, they are taken out of service for planned maintenance, and their available capacity changes as a result of random forced outages.

In order to keep track of the events that will take place during the simulation, the program employs a sophisticated filing structure to maintain a calendar of pending events. Included in the event calendar is information that identifies the type of event and the time at which it is to occur. Through a system of pointers, the program always knows the time of the next event that is to take place.

The proper timing of events is maintained by the program through the use of an internal clock. This clock is incremented as the simulation progresses through the year. At the end of a replication year, the clock is not reset to zero but continues to be incremented. For example, the clock is set to simulation hour 8761 for the first hour of the second replication year. This method makes it easier to schedule events that cross over from one replication to the next.

At the beginning of the simulation for a given study year, several events are filed for each unit being modeled. If the unit is being installed or retired during the year, events are recorded so that this will occur at the proper time. Events to model the beginning of the planned outage periods are put into the calendar. The first random outage of each unit is also placed in the event calendar.

Whenever an event occurs, the event is removed from the calendar and a new event is filed. Different types of new events will be filed depending on the time of event that just occurred

If an event to install a unit has just taken place, two future events will be scheduled. The first new events will put the unit into service at the same time during the replication of the study year. The time for this new event is determined by adding to the current clock time the number of hours in the year (8760 or 8784). The second event filed will be the first random outage of the unit.

If the event retired a unit in mid-year, the new event that is put into the event calendar will schedule the retirement to occur at the same time during the next replication of the year.

Two pending events will be scheduled if the current event begins a planned outage period for a unit. First, the event will be scheduled to begin the planned outage at the same time next replication. The event marking the end of the planned outage period will also be filed. Every unit entering the planned outage state already has a random outage event on the event calendar. Since that random outage will now not occur, that event is removed from the calendar. When a unit is returned to service following a planned outage, a new random outage event will be created and filed.

Whenever a unit makes a random transition from one capacity state to another, the next random state transition for the unit will be determined and put into the event calendar.

The event calendar is also used to control the operation of the program. An event is scheduled to occur each hour to the subroutine that computes the area margins and collects the statistics needed to calculate the reliability indices.

2.3 Program Overview

MARS consists of two major modules: an input data processor and the Monte Carlo simulation. The input processor reads and checks the study data, and arranges it into a format that allows the Monte Carlo module to quickly and efficiently access the data as needed for the simulation. The Monte Carlo module reads the data from the input processor and performs the actual simulation, replicating the year until the stopping criterion is satisfied.

Figure 2.1 provides an overview of the entire program. The process begins with the reading of the General Data. This is the data that will not be changed during the entire study period. It includes the list of all of the units that may be in service at some time during the study, the assignment of units to areas and areas to pools, the definition of the interfaces between areas, and the convergence stopping criteria.

After the General Data has been read, the program enters the annual loop on study years. There is no limit to the length of the study period that can be considered in a single run of the program. The program also allows for the skipping of years during the study period.

The annual loop begins with the reading of any data that is being overridden on an annual basis. (This includes monthly overrides occurring in January.) The annual data includes the planned maintenance requirements for the units, the unit transition rates, the priority list for the allocation of excess resources among the areas and pools, and load data.

The load data for the year is processed next. A set of hourly load data in EEI (Edison Electric Institute) format must be input for each area for the first year of the study, and can be optionally input for subsequent years. The program will then modify the input load shapes to match the monthly of annual peaks and energies specified by the user. Each year, the program checks the data for completeness and consistency and will stop if any serious problems are detected.

After the load data has been processed, MARS schedules the annual planned maintenance for the generating units. The user can specify the starting and stopping dates of the maintenance periods, or can specify the required outage time (in weeks per year or as a per unit planned outage rate) and allow the program to automatically schedule the maintenance. The program schedules maintenance to levelize reserves on an area, pool, or system basis.

The next step in the annual loop involves creating the list of units to be modeled by the Monte Carlo simulation. This list includes all of the units that are in service at some time during the year. To speed the calculations, the units are sorted by area and then by type (thermal, Type 1 energy-limited, type 2 cogeneration) within an area.

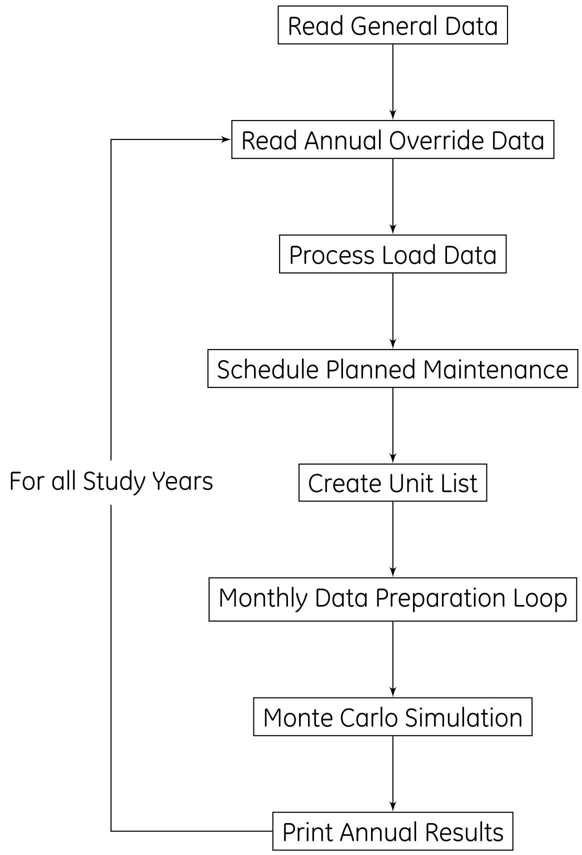

Figure 2.1: Overview of MARS

The final step in the input processor is the monthly data preparation loop. This loop sets up the data that can change on a monthly basis and writes it to an interface file that will then be read each month by the Monte Carlo simulation.

The details of the monthly data preparation loop are shown in figure 2.2. This loop begins with the reading of the input data that can be overridden monthly. This includes the unit ratings, ratings of the firm contracts, transfer limits between areas, the cogeneration unit load profiles, and the load modifications associated with the energy-storage and demand-side management units.

The area loads are then modified to account for the different types of units that are modeled as load modifiers. These include the type 1 cogeneration units, the Type 2 energy-limited units (that are being scheduled deterministically rather than on an as-needed basis during the Monte Carlo simulation) and the hourly modifiers.

The final step in the monthly data preparation loop is to write the monthly data to an interface file that will then be read by the Monte Carlo module. This loop is repeated for the twelve months of the year currently being studied before moving on to the Monte Carlo simulation itself.

Figure 2.3 provides an overview of the Monte Carlo simulation module of the program. The first step is to initialize data for the study year. The master seed for the random number generator is used to determine a random number seed for each unit on the system. Events to model mid-year installations and retirements and the beginning of planned outages are scheduled and stored in the event calendar. The initial capacity state of each generating unit is also determined at this time.

At this point, the program begins the actual Monte Carlo simulation. This consists of modeling the year repeatedly until the stopping criterion is met. The simulation is done chronologically on an hourly basis. Because much data can be changed on a monthly basis, the hourly loop is inside of a monthly loop. The first step in the monthly loop

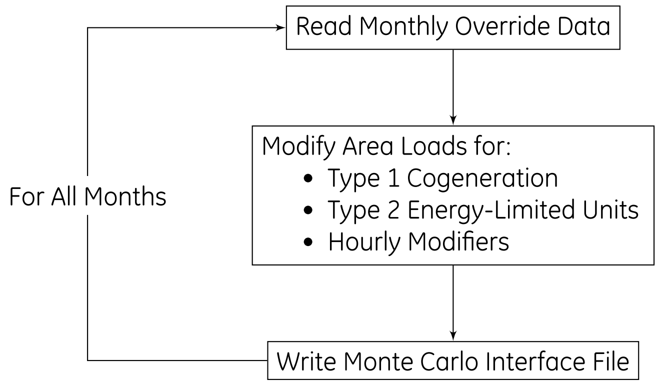

Figure 2.2: Monthly Data Preparation Loop

is to read the interface file that was written during the monthly data preparation loop.

The calculations are then done for each hour of the month. Based on the initial capacity state of each unit and the unit transition rates, operating histories are randomly generated for each unit on the system. From those operating histories, the capacity available from each unit can be determined for each hour.

At the beginning of each hour, the firm contracts between areas are scheduled. The area interface transfer limits are adjusted to account for the contract flow on the ties, and the total contract capacity is accumulated for each area.

The unit capacities are then summed to give the total available capacity in each area. The area load is subtracted from the area capacity to determine the margin in each isolated area for the hour, and the area margins are adjusted to account for the firm contracts. If any of the areas have a negative margin, the program collects statistics from which the isolated indices will be computed.

The curtailable contracts between areas are then scheduled and the area margins and interface transfer limits are adjusted accordingly. If any of the areas have a negative margin, a transportation algorithm is used to move resources from the areas with excess capacity (positive margins) to the areas that are deficient. The available reserves are allocated among the deficient areas either according to a user-specified priority list or on a shared basis in proportion to the area shortfalls.

If an area that is supplying curtailable contracts has a negative margin at this point, the contracts will be curtailed to the extent necessary to bring the area margin to zero and the assistance between areas will be recalculated. The program continues through this process until all of the necessary contract curtailments have been made.

Once the usage emergency operating procedures has been determined, the program will dispatch EL3 and ES units, if necessary. This is performed after each EOP. After the resulting interface flows and area margins have been calculated, the program collects the statistics from which the indices on an interconnected basis will be computed.

If energy storage (ES) units is present in the system, the program will determine if there is sufficient capacity (and transmission availability) to charge said units without causing a system shortage. This step is performed right before the program moves on to the next hour.

If load forecast uncertainty is being modeled, the reliability at each of the specified load levels will be determined for the hour before moving on to the next hour.

MARS calculates the daily LOLE based on all of the hours of day. If an area is deficient during one or more hours of the day, regardless of when those hours occur, the area will be counted as in a loss-of-load state for the day.

This process is repeated for all of the hours in the month and all of the months in the year. At the end of the replication year, the annual indices are calculated and tested for convergence. If the simulation has converged, the program will print annual summaries and proceed to the next study year. If the simulation has not converged, the program will return to the beginning of the annual Monte Carlo loop and simulate the year again. The program

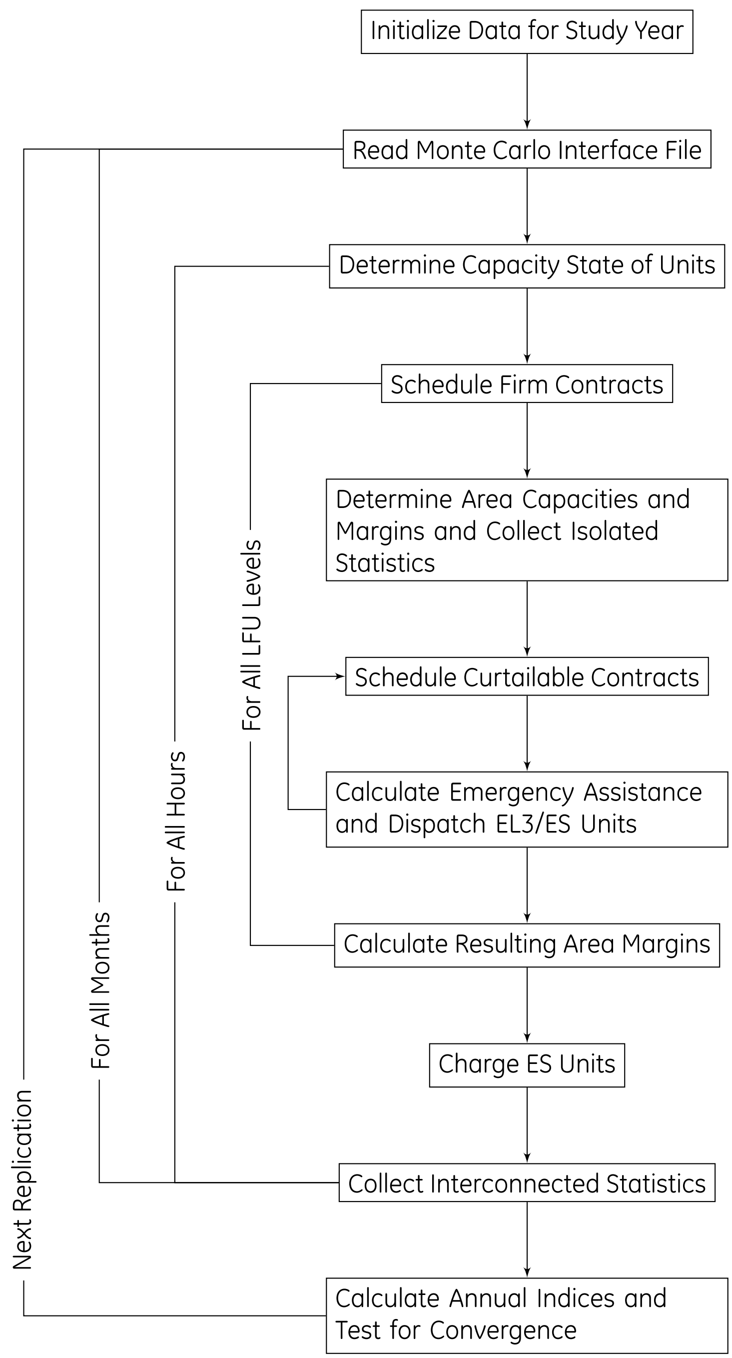

Figure 2.3: Overview of Monte Carlo Simulation Module

wraps around from one replication year to the next, with the units starting a new replication year in the same capacity state as they were in at the end of the previous replication.

2.4 Description of Program Models

The previous section provided a general overview of MARS. This section will now discuss in more detail how the program models the different portions of the utility system.

2.4.1 Loads

Chronological hourly load data for each area in the system must be input for the first year of the study, and can optionally be provided for subsequent years. If new EEI data is not input for a subsequent year, the program will begin from the load data used in the previous year.

Load forecast uncertainty (LFU) is a critical component of reliability calculations. The uncertainty is typically related to weather conditions in the near term and economic factors in the longer term. To model the near-term uncertainty, MARS allows you to input a different hourly load profile for each LFU load level, typically used to represent different weather conditions. Longer-term LFU is discussed below.

LFU load shapes do not have to be used for all of the study areas, but if the shapes are being used for an area, a shape must be input for each of the LFU load levels being modeled. In addition to inputting a profile for each load level, you can also input a profile for the base or expected load shape. The base shape will be used for the maintenance scheduling and to schedule the Type 2 Energy-Limited Units if being modeled on a deterministic basis. If the base shape is not input, MARS will create it from the LFU shapes and the corresponding probabilities.

The program has an internal calendar which is used to determine the day of the week on which the year begins. If the day-type of the first day of load data does not match the day-type of the first day of the year, the program will shift the loads accordingly. If the study year is a leap year but the hourly data is specified for only 365 days, day 366 will be created by copying the loads from the day one week earlier, thus maintaining the same day-type.

The program checks the input hourly load data for the following errors and stops if an error is encountered:

- data not input for all areas for the first year,
- improper header line or invalid area name in header,
- annual data input out of sequence,
- negative loads.

The program also checks the load data for zero loads and for loads that vary from hour to hour by more than the input per unit tolerance. A warning is printed, but program execution continues.

After the load data has been read, MARS can automatically modify the input hourly load data to develop a load model with the specified peak and energy. The data can be specified on a monthly or annual basis. If just the peak is specified, all of the hourly loads will be adjusted proportionately, and the load factor will be unchanged. Several options are available for adjusting the energy.

The first method maintains the monthly peak while adjusting the remaining hourly loads in the month to give the specified energy. With this method, the lowest loads will be adjusted the most with the amount of adjustment decreasing as you approach the peak load. The second method maintains both the monthly peak and valley, with the loads mid-way between the peak and valley changing the most. If the target energy is specified on an annual basis, it will be allocated to the months in proportion to the original monthly energies.

The third method changes the loads on a daily basis, maintaining the daily peak and adjusting the remaining loads during the day. The total monthly energy will be allocated to the individual days in proportion to the original daily energies.

After the load data for an area and year has been processed, it is written to a binary direct-access file. This allows the load data for an area to be read a month at a time by the monthly data preparation loop and written to the Monte Carlo interface file.

The longer-term uncertainty in the peak load forecast can be modeled during the Monte Carlo simulation by specifying up to ten per unit multipliers on the peak load and the associated probabilities of each load level occurring. This data can be input separately for each area and can be overridden on a monthly basis. MARS will compute the reliability indices at each of the load levels, as determined by the LFU load shapes and the peak load multipliers, and will calculate weighted-average values based on the input probabilities. Testing for simulation convergence will be based on the weighted-average value of the specified index.

2.4.2 Generation

MARS can model the following types of generation:

- Thermal
- Energy limited
- Energy storage
- Cogeneration
- Hourly modifiers

An energy-limited unit can be modeled stochastically as a thermal unit with an energy probability distribution (Type 1 energy-limited unit), or as a unit with a specified capacity and available monthly energy (Type 2/3 energy-limited unit). Cogeneration units are modeled as thermal units with an associated hourly load demand. Hourly-based profile units are modeled as load modifiers. Charging and discharging of energy storage units is determined during the Monte Carlo solutions. Type 2 energy-limited units and demand-side management units can also be used to model contracts. Because Type 1 energy-limited units and cogeneration are modeled as thermal units with additional characteristics, any discussion relative to the input data or modeling of thermal units also pertains to these other two types.

For each unit on the system, the user inputs the unit name, the name of the area in which the unit is located, the installation and retirement dates, the unit type, and planned maintenance requirements. Additional data is required depending on the unit type.

The non-thermal unit types can be thought of as being input on a plant basis. The user can then specify the number of identical units to be used in modeling that plant. The program will schedule the automatic maintenance separately for each unit at a plant, although all of the input data is specified by plant, with the exception of fixed daily maintenance, which can be input by individual unit. It is best to include in the unit list all of the units that will be modeled at some time during the study, even though they may not be needed for the current run. The reason for this is that the program assigns to each unit in the unit list a seed for that unit's random number generator. If the unit list is not changed, the same seeds will be assigned to the units each run, thus improving the repeatability between runs. The units being modeled in a given run can be controlled through the installation and retirement dates.

Maintenance Scheduling

The planned outages for all types of units in MARS can be specified by the user or automatically scheduled by the program on a weekly basis. The program schedules planned maintenance to levelize reserves on either an area, pool, or system basis as shown in figure 2.4. The units are scheduled in order of decreasing capacity or decreasing product of capacity times weeks of maintenance.

If the outage periods are specified through fixed daily maintenance, the thermal units (including those types of energy-limited and cogeneration units that are modeled as thermal units) are limited to five maintenance

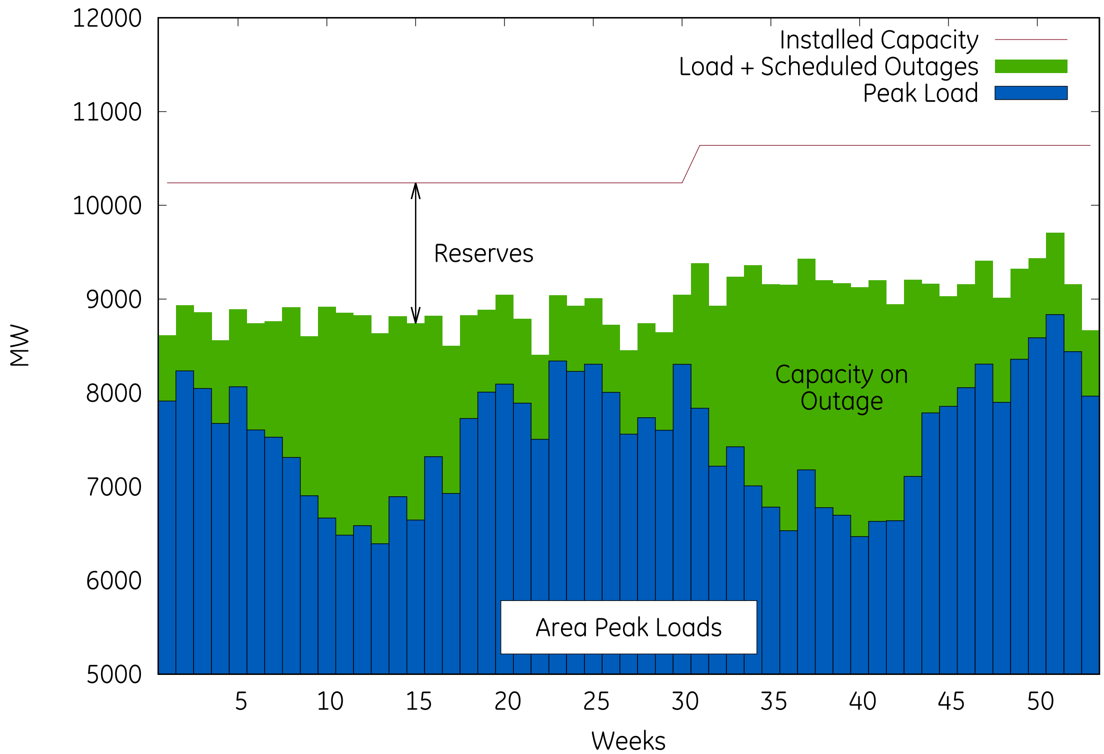

Figure 2.4: Maintenance Scheduled on an Area Basis

periods during the year. There is no limit on the number of planned maintenance periods for the other types of units. Automatic maintenance is scheduled as a single outage period only during the full weeks in the year, although fixed daily maintenance can be specified for the partial weeks at the beginning and end of the year. If the maintenance requirements for a unit is not a whole number of weeks, the fractional week of automatic maintenance will be in the week following the maintenance period.

The program does not schedule automatic maintenance on any units that are installed or retired during the year, or for which fixed daily maintenance was specified, or if the unit's capacity is zero. The program also does not schedule automatic maintenance on units representing contracts, and does not include the capacity of these units in the automatic maintenance calculations. However, fixed daily maintenance can be specified for these units. The maintenance schedule is developed based on the capacity of the units at the start of the year. For energy storage and demand-side management units, the user inputs a rating to be used for maintenance scheduling. If the modifier has a negative rating, the absolute value will be used for scheduling maintenance although the actual value will be used in adjusting the capacity on maintenance and calculating the reserves.

For units being modeled in the Monte Carlo simulation, the planned outages are modeled in the simulation as events that begin on a certain hour and last for a certain number of hours. For the other unit types that are modeled by modifying the load shapes (such as Type 2/3 energy-limited units, Type 1 cogeneration, and demand-side management), the average daily availability of each unit is calculated from the maintenance schedule. This recognizes the scheduled outages in determining the amount of load modification. Similar logic is used for the energy storage units except the availability is calculated on a weekly basis (this assumes a weekly refill cycle). MARS also has the option of reading a maintenance schedule developed by a previous run and modifying it as specified by the user through any of the maintenance input data. This schedule can then be saved for use by subsequent runs.

Thermal Units

In addition to the data described previously, thermal units (including Type 1 energy-limited units and cogeneration) require data describing the available capacity states in which the unit can operate. This is input by specifying the maximum rating of each unit and the rating of each capacity state as a per unit of the unit's maximum rating. A maximum of eleven capacity states are allowed for each unit. The unit is considered to be fully available in state 1, with the other states representing decreasing amounts of available capacity as governed by the outages of various unit components.

Planned outages on thermal units are modeled by removing the unit from service for the specified periods of time. A maximum of five maintenance periods per year are allowed for each unit. Following its outage period, the unit returns to service in the fully available state. If a unit is on full forced outage at the time that its planned outage period is scheduled to begin, the planned outage will be postponed until the end of the forced outage period. If this delay causes the planned outage periods to overlap, the second planned outage will begin right after the first outage ends.

To model the impact of ambient conditions on some types of generation, MARS can derate unit capacities based on area loads, which can serve as an indicator of ambient temperature. For each unit to be derated, you input the area load to be monitored, and up to five per unit capacity multipliers that will be applied to the unit's maximum capacity to determine its derated rating when the specified area load is above the corresponding value.

Type 1 Energy-Limited Units

Type 1 energy-limited units are modeled as thermal units whose capacity is limited on a random basis for reasons other than the forced outages on the unit. In other words, the maximum capacity available from the unit at a given time may be less than that determined by the unit's current capacity state. If the limit on a unit's operation is a fixed amount rather than a random function, it can be modeled by simply changing the unit's maximum rating through time.

This unit type can be used to model a thermal unit whose operation may be restricted due to the unavailability of fuel, or a hydro unit with limited water availability. It can also be used to model technologies such as wind or solar; the capacity may be available but the energy output is limited by weather conditions.

The information to describe the random nature of the energy limits is supplied through a cumulative probability density function for each Type 1 energy-limited unit. The density function gives the probability of the unit being at or below a given capacity level. An example is shown in figure 2.5.

The frequency with which the capacity limit is calculated depends on the type of energy-limited unit being modeled. The program allows it to be calculated either daily or monthly. The daily calculation would be used for modeling a technology such as wind or solar where the available energy would change quite often, depending on the weather. A monthly calculation would more accurately represent fuel or water limitations that may be changing over a longer period of time.

At the beginning of each day or month, the program determines the maximum possible capacity available from the unit, recognizing its energy limits. This is done by randomly generating a probability value and using the cumulative probability density function to find the capacity associated with that probability.

As an example, assume that a 400 MW unit has the density function shown in figure 2.5. This is a representation of the probability density function for `UNIT-10B` in the example table on page 90. If a random probability value of 0.37 is generated for the unit, the maximum capacity actually available from the unit, recognizing the energy limits, will be $(0.5) * (400 \text{ MW}) = 200$ MW. If the unit is in a capacity state greater than 200 MW, its available capacity will be restricted to the 200 MW limit.

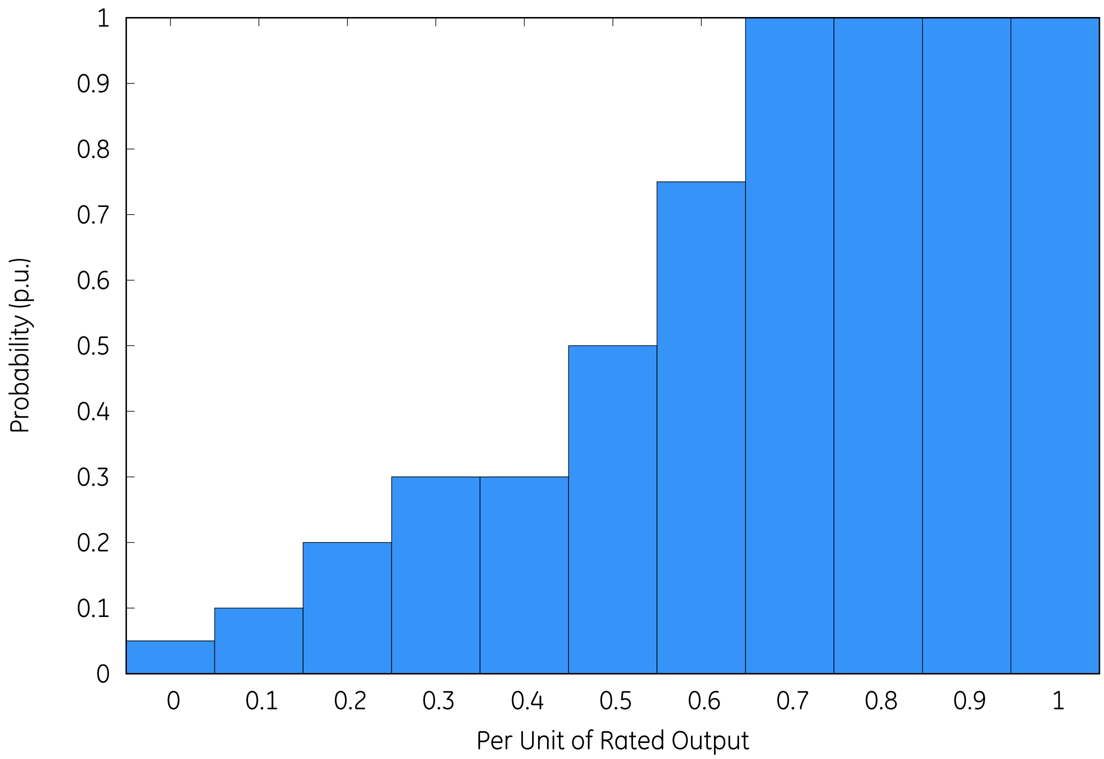

Figure 2.5: Cumulative Probability Density Function for Type 1 Energy-Limited Unit

Type 2 Energy-Limited Units

Type 2 energy-limited units are typically used to model conventional hydro units for which the available water is assumed to be known with little or no uncertainty. This type can also be used to model certain types of contracts. These units area scheduled as deterministic load modifiers.

Type 2 energy-limited units are described by specifying a maximum rating, a minimum rating and a monthly available energy. All of this data can be updated on a monthly basis. The loads against which the unit will be scheduled can be specified as a combination of area and pool loads. The specified loads will already have been modified for Type 1 cogeneration units and previously scheduled modifiers. Even though a combination of area and pool loads is used to develop the operational schedule of the unit, only the loads in the unit's area will actually be modified.

Each unit is scheduled on a monthly basis. The first step is to dispatch the unit's minimum rating for all of the hours in the month. A one-week example of this for a unit with a 150 MW minimum rating is shown in figure 2.6. For the scheduling, the remaining capacity and energy is then scheduled so as to reduce the peak loads as much as possible, as is also shown in figure 2.6. The unit's area loads are then modified to reflect the unit's operation for the month.

Type 3 (as-needed) Energy-Limited Units

Type 3 energy-limited units can be used to model hydro or other resources for which the availability of energy is known. For Type 2 energy-limited units the dispatch is performed against input loads and their profiles is locked across all simulations of the Monte Carlo. Type 3 energy-limited units are dispatched on an as-needed basis during the Monte Carlo simulation and their generation profile usually changes from one replication to another.

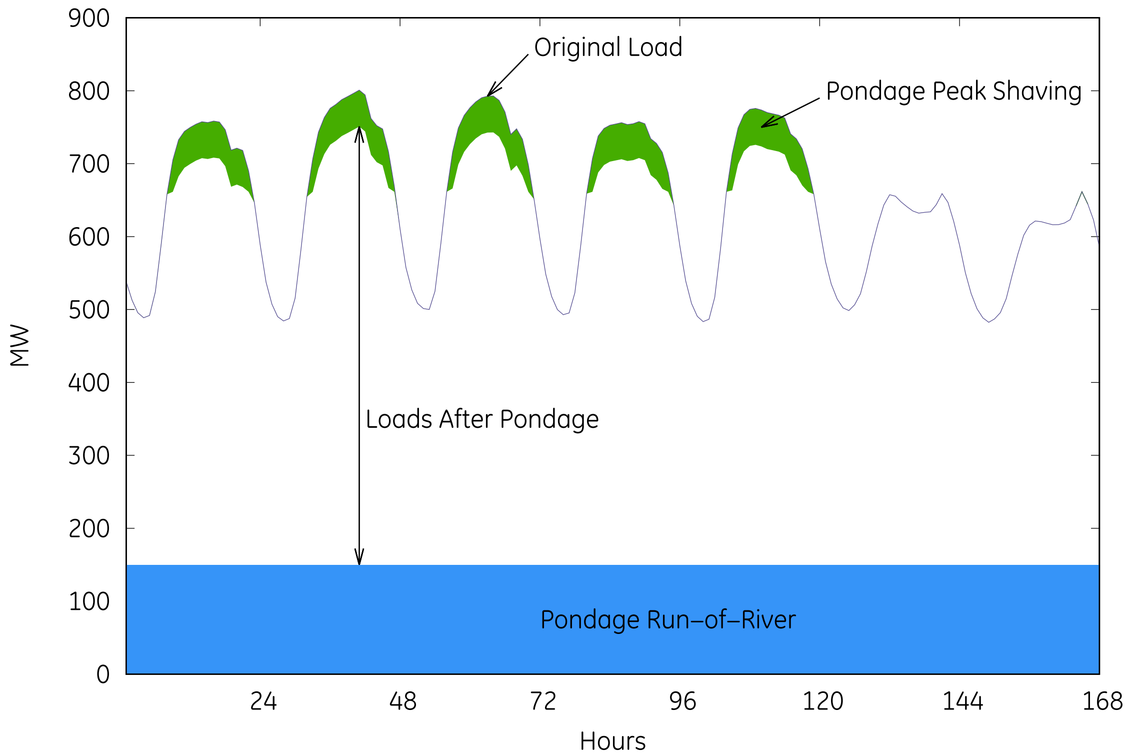

Figure 2.6: Dispatch of Type 2 Energy-Limited Unit

With this approach, the Type 3 energy-limited units are used only if the thermal capacity is not sufficient to serve the load. If there is sufficient thermal capacity in a given hour, the energy of the Type 3 energy-limited units will be saved for use in some future hour when it is needed. Any energy that is not used in a given month can be carried forward into the next month (but not from year to year), up to the maximum storage specified by the user. The minimum rating, which would represent the run-of-river portion of the unit, would be dispatched deterministically as described above and shown in figure 2.6.

Three options are available for scheduling the Type 3 energy-limited units on an as-needed basis. In the first option, these units are used to cover shortfalls only in the area in which they are located; a unit in one area will not be dispatched to meet a deficiency in another area.

In the next option, the units are first scheduled on an isolated basis as in the first option. If, after the emergency assistance calculations have been done, an area is still deficient because of a lack of available thermal capacity on the system, the program will attempt to cover this shortfall with Type 3 energy-limited units that are in another area.

In the third option, the units are scheduled only on an interconnected basis. The units are used only if one or more areas are deficient after the emergency assistance has been calculated. This option optimizes the use of the available energy in the sense that it is used to improve the interconnected indices as much as possible. The isolated indices, on the other hand, are computed as though the peak-shaving portion of the Type 3 energy-limited units is not available.

The units are dispatched by area, starting with the units with the greatest number of hours of full-load operation remaining, based on their capacity and remaining available energy. By spreading the usage across the units in this manner, the program attempts to maximize the total capacity available from the units given their monthly energy limits. Alternatively, the user can defined the order in which these units are dispatched.

If using the option to dispatch the peak shaving portion of the Type 3 energy-limited units on an interconnected-only basis, the Type 3 energy-limited units in multiple areas can be dispatched as a single group. The Type 3 energy-limited units in the areas that are assigned to groups will be scheduled first, based on their group numbers and recognizing the transfer limits between the areas. The resulting schedules will be locked in and then all of the areas (including any remaining capacity in areas that are in groups) will be scheduled, and dispatched by areas, to cover any remaining shortages.

The frequency of usage of the on-demand portion of Type 3 energy-limited units can be constrained to model more complex situations or special resources, such as demand response limited to a number of calls per year. Any combination of the following constraints can be applied and the limits can be changed on a monthly basis. More information is available in MOD-ELMW.

- Number of days per year
- Number of days per month
- Number of hours per year
- Number of hours per month
- Number of hours per day
- Energy per day

Energy Storage Units

Energy storage units can be used to represent resources that are operated by filling or charging energy into a reservoir and drawing from that energy when there are shortages in the system. This model can be used to represent units such as batteries of pumped-hydro storage. The charge/discharge cycles happen entirely within each replication in the Monte Carlo simulation.

The parameters that define a storage unit can be updated monthly and include the following. More information is available in MOD-ESMW.

- Storage size: Maximum amount of energy (in MWh) that can be stored
- Generation rating: Maximim capacity (in MW) that the unit can generate in an hour
- Chargin rating: Maximim capacity (in MW) that the unit can charge in an hour (optional, defaults to the generation rating).
- Round-trip efficiency: To represent losses in a charge/discharge cycle (optional, defaults to 1)

The discharge of energy storage and Type 3 energy-limited units is considered in the same step and the same principles apply. The program will attempt to dispatch the units that have energy available to generate for the largest amount of hours first, although the user can define the specific order in which all these units are dispatched.

Cogeneration

MARS models cogeneration as a thermal unit with an associated load demand. The difference between the unit's available capacity and its load requirements represents the amount of capacity that the unit can contribute to the system. The load demand is input by specifying the hourly loads for a typical week (168 hourly loads for Monday through Sunday). This load profile can be changed on a monthly basis.

Two types of cogeneration are modeled in the program, the difference being whether or not the system provides back-up generation when the unit is unable to meet its native load demand. Type 1 cogeneration units are used to model those units for which the system will provide back-up if the unit is on outage and not able to meet its load demand. To model this type of unit, the cogeneration load demand is added to the area's hourly loads, and the unit is modeled as a thermal unit.

Type 2 cogeneration is used to model units for which the system does not provide back-up; if the available capacity of the cogeneration unit is less than its load demand, a portion of its load will not be served for that hour. Modeling this type of unit requires that the cogeneration loads be kept separate from the area loads. Each hour, the unit's available capacity is compared to its native load requirements; if the capacity exceeds the load, the difference will go towards meeting the area load demand. If the capacity is less that its load, a portion of the cogeneration load will not be served, and the net contribution of the cogeneration unit to the system will be zero.

Hourly Modifier Units

Hourly modifier units are modeled as deterministic load modifiers. In early versions of MARS this unit type was referred to as "demand-side management" units and that term is still maintained in certain parts of the code (e.g., the short-name for this unit type is "DS"). For each such unit, the user specifies a net hourly load modification based on hourly data for a typical week or for all hours of the year.

If modeling values for for a typical week the user supplies 168 hourly values (for Monday through Sunday). The typical week profile can be updated each month, if necessary. The input load modification is subtracted from the hourly loads for the unit's area; hence, positive values decrease the area loads, negative values increase the loads. Negative values would be used to model the recharging cycle of an energy-storage unit, while positive values would represent the discharge or generating cycle.

The net hourly load modification of an hourly modifier unit can also be calculated by the program from a combination of different hourly shapes. The hourly impact of each shape (e.g., demand side controls on water heaters and air conditioners, or metered production of wind or solar plants) can be input for all of the hours in the year through the shapes file, which can either be similar in format to the EEI load data file or a binary HDF5 file. The user then specifies the shapes, and associated penetration levels, to be combined to form a particular hourly unit's profile. This option can also be used to model variable resources such as wind and solar for which the expected output has been projected from historical weather data.

MARS can introduce a degree of randomness in the simulation of resources that are modeled with hourly shapes. MARS has several options for randomly choosing the day-shape to use in modeling a given day in a given replication. When using this method, the random selection is limited to a specific day, and the shape within the day is maintained. This is based on the definite patterns of output observed during a course of the day in actual data.

The three options for the random selection are:

- Random selection or shift of data:
  - You can choose to randomly select from days in the same month. This causes a random day from within the current simulation month to be selected during each simulation day. The random day selected is redrawn each simulation day.
  - You can choose to randomly select from the days within a user-specified window for a given shape. Like the first option, this method redraws the random day selected each simulation day. This method removes the artificial boundaries imposed by months and recognizes the fact that the wind pattern for May 31 is probably more closely related to that of June 1 than it is to May 1. Although you could specify the options such that any day-shape in the year could be used to model any study day, a review of actual data for intermittent resources reveals a definite seasonal pattern, and using a wind profile from March when modeling July may not be very realistic.
- A random shape can be selected at the beginning of each replication. For a given random selection group, multiple shape sets can be assigned to the group with a probability for each shape (with the sum of the probabilities for the shape sets totalling 1.0) through MOD-RAND. Each unit then can assign shapes to each random selection group through MOD-SHAP-03. For each random group, the shape set selected is redrawn at the start of each replication.

Modifier Priority List

If the user is modeling any units as load modifiers (Type 2/3 energy-limited units, energy storage or hourly modifiers), a modifier priority list must be input. This list shows the order in which the different load modifiers are to be scheduled. Since the Type 2 energy-limited units are the only units that are actually scheduled by the program (the schedule for the others is input by the user), and the modified loads are used in developing this schedule, they are the only units whose operation will be impacted by this priority list.

Type 2 energy-limited units and hourly modifiers that are being used to model contracts must also be included in this list. For developing the hourly contract ratings, these units are scheduled in the order specified but do not modify the area loads. Within the Monte Carlo simulation, the contracts will be dispatched in the order in which they are input.

2.4.3 Contracts

Contracts are used to model scheduled interchanges of capacity between areas in the system. These interchanges are separate from those that are scheduled by the program as one area with excess capacity in a given hour provides emergency assistance to a deficient area.

The data for calculating the hourly rating of a contract is input as a Type 2 energy-limited unit or a demand-side management unit. Units that actually represent contracts are identified as such in the input unit list by specifying CONTRACT for the area in which the unit is located. Additional data, such as the sending and receiving areas and the area interfaces over which the contract is delivered, are input on a separate data table.

Alternatively, a contract can depend on the status of one or more units in the system, to represent cases in which a contract should not be considered if certain units are unavailable. This capability allows to combine the capacity and availability of multiple units and consider their full output or just a portion as part of the contract.

Each contract can be identified as either firm or curtailable. Firm contracts will be scheduled regardless of whether or not the sending area has sufficient resources on an isolated basis, but they can be curtailed because of interface transfer limits. Curtailable contracts will be scheduled only to the extent that the sending area has the necessary resources on its own or can obtain them as emergency assistance from other areas.

The firm contracts are scheduled first, in the order in which they appear in the FCT-DATA table. The isolated area indices include the effects of firm contracts only; the curtailable contracts are scheduled, in their input order, as part of the calculation of the interconnected indices.

If an area's margin is negative after the curtailable contracts have been scheduled, the contracts for which this area is the sending area will be curtailed in proportion to the area's total shortfall. After all of the contracts have been curtailed as necessary, the process is repeated with the contracts being rescheduled based on their curtailed ratings. The area margins will then be checked and the curtailment process repeated as necessary up to a total of four times through the curtailment logic.

The user must also specify which area interfaces are to be used to deliver the contract from the sending area to the receiving area. (The program will not check that the path specified actually connects the sending and receiving areas.) When the contract is scheduled, the limits on these interfaces and related interface groups will be adjusted accordingly. For each contract, the user can specify that the limits be changed in both directions or only in the direction of actual flow. If a contract causes an interface to exceed its limit, only the portion of the contract that can be accommodated by the interface will be scheduled, and the MW that could not be delivered will be accumulated for the contracts curtailment summary.

2.4.4 Transmission System

The transmission system between interconnected areas is modeled with interface transfer limits. The user identifies the interfaces that join areas that are interconnected. Each interface consists of two ties: one from the first area to the second (positive direction), the other from the second area to the first (negative direction). In addition to limiting the flows on individual interfaces, the program can model simultaneous transfer limits by limiting the total flow on groups of two or more interfaces.

A separate transfer capability, in MW, is specified for each direction of each interface and interface group. The system configuration, as defined by the interconnection of areas, cannot change during the study, but the maximum transfer capability of the ties can change monthly. The actual transfer limits can vary hourly based on the availability of specified units and the value of the area loads. Condition sets are defined in terms of whether specified units are available (which includes being on partial forced outage) or unavailable, whether the specified area loads are greater than or less than a specified value, and the number of conditions that must be met for the condition set to be satisfied. If satisfied, the ratings of the associated interfaces and interface groups will be adjusted accordingly.

If an interface is being used for scheduling contracts but not for non-firm emergency assistance, the tie limits can be set to zero before doing the non-firm assistance calculations.

2.4.5 State Transition Rates

Because MARS is based on a sequential Monte Carlo simulation, it uses state transition rates, rather than state probabilities, to describe the random forced outages of the thermal units. State probabilities give the probability of a unit being in a given capacity state at any particular time, and can be used if you assume that the unit's capacity state for a given hour is independent of its state at any other hour. Sequential Monte Carlo simulation recognizes the fact that a unit's capacity state in a given hour is dependent on its state in previous hours and influences it state in future hours. It thus requires the additional information that is contained in the transition rate data.

For each unit, a transition rate matrix is input that shows the transition rates to go from each capacity state to each other capacity state. The transition rate from state A to state B is defined as the number of transitions from A to B per unit of time, in hours, in state A:

$$\text{TR (A to B)} = \frac{\text{Number of Transitions from A to B}}{\text{Total Time in State A (hours)}}$$

Table 2.1 shows the calculation of the state transition rates from historical data for one year. The Time-in-State Data shows the amount of time that the unit spent in each of the available capacity states during the year; in this example, the unit was on planned outage for the remaining 760 hours. The Transition Data shows the number of times that the unit transitioned from each state to each other state during the year.

The State Transition Rates can be calculated from this data. For example, the transition rate from state 1 to state 2 equals the number of transitions from 1 to 2 divided by the total time spent in state 1:

$$\text{TR (1 to 2)} = \frac{\text{10 transitions}}{\text{5,000 hours}} = 0.002 \text{ transitions per hour}$$

If detailed transition rate data for the units is not available, MARS can approximate the transition rates from the partial forced outage rates and an assumed number of transitions between pairs of capacity states. The user can input transition matrices (similar to the Transition Data table above) for typical units with differing numbers of capacity states. A transition matrix is then assigned to each unit. The program will use the partial forced outage rates to determine the amount of time in each capacity state, and then combine this with the number of transitions to compute the transition rates. The time-in-state is calculated from the partial forced outage rates (PFOR) as follows:

State 1 Time-in-state $= (1.0 - \text{PFOR}_1) * 8760$ hours

State n Time-in-state $= (\text{PFOR}_{n-1} - \text{PFOR}_n) * 8760$ hours

Transition rates calculated in this manner will give accurate results for LOLE and LOEE, but it is important to remember that the assumed number of transitions between states will have an impact on the time-correlated indices such as frequency and duration. From the state transition rates for a unit, the program calculates the

Table 2.1: Example of State Transition Rates

Time-in-state Data

State	MW	Hours
1	200	5,000
2	100	2,000
3	0	1,000

Transition Data

	To State		
From State	1	2	3
1	0	10	5
2	6	0	12
3	9	8	0

State Transition Rates

	To State		
From State	1	2	3
1	0.000	0.002	0.001
2	0.003	0.000	0.006
3	0.009	0.008	0.000

two primary quantities that are needed to model the random forced outages on the unit: the average time that the unit resides in each capacity state, and the probability of the unit transitioning from each state to each other state.

Mean Time-in-State

For reliability calculations, it is often assumed that the time that a component spends in a particular state is a random variable with an exponential distribution having the following probability density function: $f(x) = \frac{1}{\beta}e^{-x/\beta}$ where β is the mean of the distribution and $x > 0$.

The cumulative density function can be found by integrating $f(x)$ from 0 to x resulting in: $F(x) = 1 - e^{-x/\beta}$

If the random number, R, is the probability that the time in state is equal to T, then $R = 1 - e^{-T/\beta}$.

Solving for the time in state, T, as a function of the random number R:

$$e^{-T/\beta} = 1 - R$$

$$ln(e^{-T/\beta}) = ln(1 - R)$$

$$-T/\beta = ln(1 - R)$$

We can replace $(1 - R)$ by R since we are only interested in choosing a random time, T, giving: $T = -ln(R) * \beta$.

The mean time-in-state, β, can be calculated from the state transition rates. The sum of the transition rates out of a particular state is equal to the total number of transitions from the state per unit of time. The reciprocal of this sum is the average time in the particular state per transition out of the state, or the mean time-in-state, β.

Probability of Transitioning to a State

The state transition rates are also used to compute the probability of a unit transitioning from each state to each other possible state. The probability of transitioning from state A to state B is calculated as:

$$\text{Prob (A to B)} = \frac{\text{Transition Rate from A toB}}{\text{Sum of Transition Rates from A}}$$

This probability function is then converted to a cumulative density function to be used with a random number to determine the state to which the unit will transition at the end of its time in the current state. Using the transition rates in the example in table 2.1, the mean time-in-state, β, and the probability of transitioning from each state to each other state would be calculated as shown in tables 2.2 and 2.3.

Table 2.2: Mean Time in State

State	$\sum$ of Transition Rates Out	β
1	0.003	333.3
2	0.009	111.1
3	0.017	58.8

Table 2.3: Probability of Transitioning from State to State

	To State		
From State	1	2	3
1	0.000	0.667	0.333
2	0.333	0.000	0.667
3	0.529	0.471	0.000

Whenever a unit changes capacity states, two random numbers are generated. The first is used to calculate the amount of time that the unit will spend in the current state; it is assumed that the time in a state is exponentially distributed, with a mean computed from the transition rates as explained above. This time in state is added to the current simulation time to calculate when the next random state change will occur. The second random number is combined with the state transition probabilities to determine the state to which the unit will transition when it leaves its current state. The program thus knows for every unit on the system, its current state, when it will be leaving that state, and the state to which it will go next.

Assume that the unit in the example above just entered state 2 and that the random numbers generated were 0.72 and 0.26. The amount of time that the unit will spend in state 2 will be: $T = -ln(0.72) * 111.1 = 36.5$ hours, at which time the unit will transition to state 1, since 0.26 is less than 0.333, the probability of transitioning from state 2 to state 1.

Each time a unit changes state as a result of random state changes, the beginning or ending of planned outages, or mid-year installations or retirements, the total capacity available in the unit's area is updated to reflect the change in the unit's available capacity. This total capacity is then used in computing the area margins each hour.

Perfect Units

Starting with version 3.26.1338, MARS supports 1-state units. Capacity for these units are always available unless it is undergoing scheduled maintenance. More information is available in UNT-CAPS.

Non-thermal Units

With the release of version 4.14.2163 , MARS has added support to model forced outages for type 3 energy-limited (EL3) and energy storage (ES) units.

Data for capacity states, transition rates or forced outage rates is entered in the program with the same tables used for thermal units, as explained above. If no data is entered for a unit, it is considered to have perfect availability, to ensure backwards compatibility.

2.4.6 Resource Allocation Among Areas

The first step in calculating the reliability indices is to compute the area margins on an isolated basis for each hour. This is done by subtracting from the total available capacity in the area for the hour the load demand for the hour:

Margin = (Total Available Capacity) - (Load Demand)

At this point, the total available capacity has been adjusted for the net firm contracts involving this area. If an area has a positive or zero margin, then it has sufficient capacity to meet its load. If the area margin is negative, the load exceeds the capacity available to serve it, and the area is in a loss-of-load situation.

If there are any areas that have a negative margin after the isolated area margins have been adjusted for curtailable contracts, the program will attempt to satisfy those deficiencies with capacity from areas that have positive margins. Two methods are available for determining how the reserves from areas with excess capacity are allocated among the areas that are deficient.

In the first approach, the user specifies the order in which an area with excess resources provides assistance to areas that are deficient. This is a single priority list which applies to all of the areas in the system, rather than a separate assistance priority specified for each individual area. The program attempts to provide the first deficient area in the list with all of the assistance that it needs before moving on to the next area. With this approach, the areas at the beginning of the list will tend to receive a disproportionate level of assistance at the expense of those areas lower in the list.

When using the priority list approach, the user can specify that areas within a pool will have priority over outside areas. In this case, an area will assist all deficient areas within its pool, regardless of the order of areas in the priority list, before assisting areas outside of the pool.

The second method shares the available excess reserves among the deficient areas in proportion to the size of their shortfalls. As with the priority list approach, preference can be given to areas within the same pool. The initial allocation takes into account the transfer limits into and out of each area to determine the maximum import for each negative area and the maximum export for each positive area. The effects of transfer limitations are further considered by grouping together those areas with the same sign (positive or negative margins) that are directly interconnected. If the transportation calculations (described below) indicate that an area is unable to receive all of its allocation due to transfers limitations elsewhere in the system, the allocation will be adjusted and the process repeated until all of the available assistance that can be delivered to deficient areas is delivered.

Whether using the priority list or reserve sharing, there are three passes that the program goes through in attempting to cover the shortfall in deficient areas. In the first pass, areas within a pool attempt to assist deficient areas within the same pool. This is the pool priority pass referred to above. In this pass, you can limit the flow to only those interface paths within each pool, or you can allow assistance to flow through outside pools. The second pass considers the pool sharing arrangements that have been defined in the data. This input identifies the order in which pools with excess capacity will provide assistance to deficient areas in other pools. Once again, you can control whether to allow flow through pools that are not part of the particular pool sharing arrangement. The final pass is done on a system-wide basis, without regard to the pools to which the areas have been assigned.

MARS uses a transportation model to determine if areas with negative margins can be served by areas having positive margins, while being constrained by the capacity transfer limits between areas. This is accomplished by assigning one “cost” for using a path between areas, and another “cost” for not serving the load in a particular area. The “cost” is in fact an artificial value that is used in a complex search routine to determine the “cheapest” way of distributing capacity throughout the system without exceeding any of the interface transfer limits. At the heart of the logic is a "nearest neighbor policy" which implies that if an area is deficient in capacity, it will look for assistance by way of the shortest path possible.

An area will provide assistance to other areas only up to the limit of its excess resources. No "loss sharing" is modeled in which an area would share in the loss of another area by allowing its margin to become negative so that it could provide additional assistance to a deficient area.

2.4.7 Emergency Operating Procedures

Emergency operating procedures are steps undertaken by a utility system as the reserve conditions on the system approach critical levels. They consist of load control and generation supplements which can be implemented before load has to be actually disconnected. Load control measures could include disconnecting interruptible loads, public appeals to reduce demand, and voltage reductions. Generation supplements could include overloading units, emergency purchases, and reducing operating reserves. The frequency with which various emergency operating procedures are initiated provides a physically meaningful measure of the reliability of the system.

MARS models emergency operating procedures by evaluating the daily LOLE at specified positive and negative margin states. (If the daily LOLE is being calculated based on all of the hours in the day, the hourly LOLE and LOEE will also be computed for each margin state.) Rather than comparing the area margin (capacity minus load) to a value of zero MW, the program computes the expected number of days per year that the margin falls below the specified positive and negative margins. The first positive margin state typically represents the desired operating reserves since the emergency measures would be implemented as soon as the available reserves dropped below this level.

The user can define up to twenty margin states for each of the areas in the system. The data is input as the operating reserve requirements and the actual benefit available from each of the EOPs. The benefit of each EOP can be input as the sum of a fixed MW value, a per unit of the hourly load for the area, and a per unit of the available capacity in the area. In addition, you can limit the number of days that an EOP will be implemented each month, and you can specify whether the EOP will be implemented for the benefit of the area only, for the benefit of other areas within the same pool, or for the benefit of any areas in the system.

Assume that a system has an operating reserve requirement of 1,200 MW and that the following emergency operating procedures are available:

Procedure	MW Benefit
Emergency Ratings	800
Interruptible Loads	1,000
Voltage Reductions	300
Customer Appeals	400
Reduce Operating Reserves	700

The program would compute the daily LOLE at the following margin states:

Margin State	MW
1	1,200
2	400
3	-600
4	-900
5	-1,300
6	-2,000

For example, the daily LOLE for the first margin state would give the expected number of days during the year that units would have to be operated at emergency ratings because the operating reserves had fallen below the desired level. The daily LOLE for margin state two would indicate the frequency of disconnecting interruptible loads. The daily LOLE for the fourth margin states would indicate the number of days during the year in which appeals would be made to the customers to have them reduce demand.

MARS assumes that all of the areas move through the EOPs together. In other words, all of the areas initiate the first step at the same time, then move to the second step together, and so on. The program also has the option to stagger the implementation of EOPs, which would simulate the requirement that deficient areas must implement a specific number of EOPs before the other areas that are not deficient begin their EOPs. For each area you specify the number of EOPs that the deficient area must implement before the named area begins its EOPs. This data is input separately for areas in the same pool and for areas in outside pools. Using the load forecast uncertainty option to vary the installed reserves, MARS can calculate in a single run the need for initiating emergency operating procedures for several different levels of installed reserves, resulting in a set of curves similar to that shown in figure 2.7.

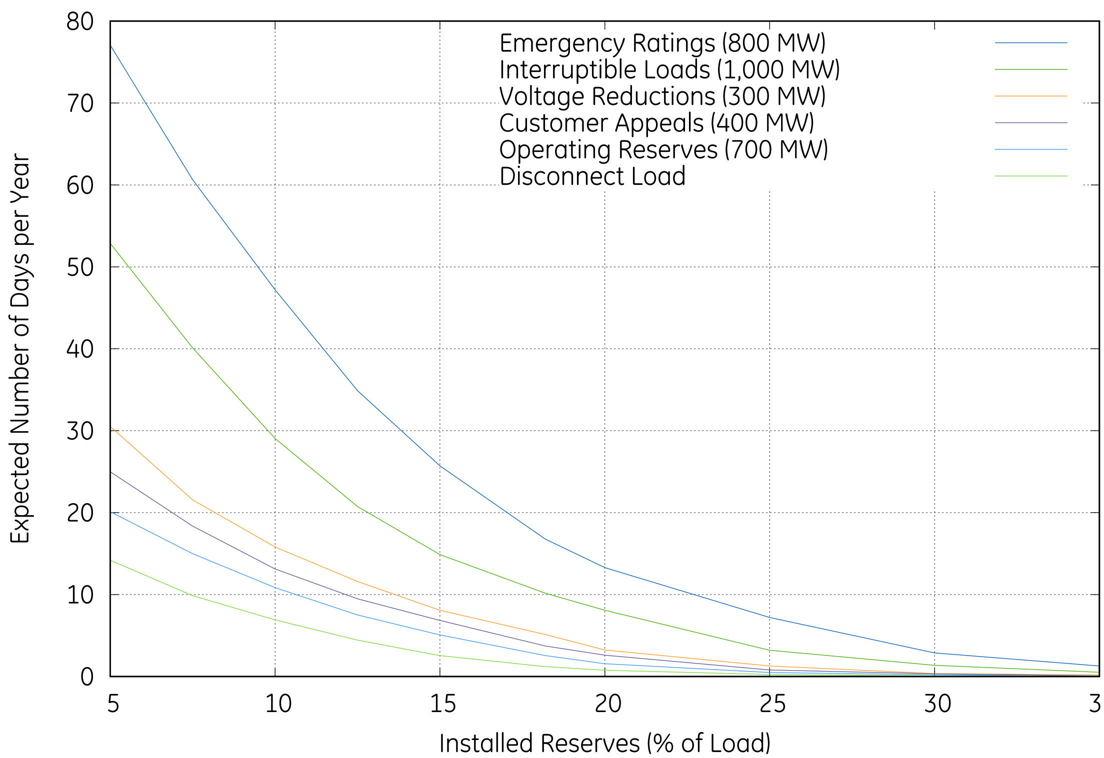

Figure 2.7: Expected Need for Emergency Operating Procedures

2.4.8 Dynamic Conditions

Dynamic conditions in MARS enable hour-by-hour modeling of interactions that depend on system conditions, when the availability of one element of the system depends on the status of another. The classic example is modifying the rating of interface lines based on the availability of certain units. This was the first dynamic condition implemented in MARS, but the capability is much more powerful.

Conceptually, dynamic conditions have two components as shown in Figure 2.8: triggers and consequences. For every hour in the simulation MARS will evaluate the status of all the triggers and determine which ones are active. For instance, MARS will check whether certain units are available or on outage. If the right triggers are activated, MARS will then apply the right consequence, such as reducing the transfer capacity between the areas if a key unit is not available.

Figure 2.8: The components of dynamic conditions

Condition triggers are organized by identifiers called condition set numbers. These identifiers are common across all the input tables that define condition triggers. If the same condition set number is used across multiple tables, all of the events will be evaluated and will need to be true for the condition set to be triggered. There are currently three types of triggers:

- Unit availability (UNT-COND): define a trigger that depends on whether one or more units are symultaneously available or unavailable
- Modifier generation (MOD-COND): define a trigger that is activated when the generation from an EL2 or DS unit is above and/or below certain thresholds
- Load (LOD-COND): define a trigger that is activated when the demand in an area, pool or whole system is above and/or below certain thresholds
- Date windows (DAT-COND): define a trigger that is activated for certain periods of the year
- Load forecast uncertainty (LFU) level (LFU-COND): define a trigger only valid for some LFU levels

Consequences are activated if the right combination of triggers are active. Each consequence is define by a unique identifier. Unlike, triggers, these identifiers are not shared across tables, so identifier number 1 in one table is independent of identifier 1 in another. The following tables can be used to define consequences:

- Modify interface limits (INF-DLIM): update the transfer limits for interfaces and interface groups
- Modify unit capacity (UNT-DCAP): modify the capacity of thermal units

All the consequece tables use the same mechanics to connect to triggers, with the last few columns in the table. We inclue an example below for table INF-DLIM. The second-to-last column specifies the number of conditions that need to be true. The following values can be provided:

- A positive number indicates the exact number that conditions that must be met
- Zero (0) when all the conditions need to be met
- A negative number indicates that at least that number of conditions must be met (for example, -2 means that at least two conditions must be met for the consequence to be activated)

After that column, enter all the condition set numbers that should be considered. Positive set numbers will apply the set as defined, negative set numbers will return the complement. For example, if set 7 were defined as units A and B available, -7 would be true if either A, B, or both was unavailable.

```
&INF-DLIM-00     DLM    CONTINUATION
*                                            INTERFACE-DYNAMIC-LIMITS
*-----------------------------------------------------------------------------------------------------------
*      EFFECTIVE    LIMIT   INTERFACE OR   LIMIT     POSITIVE       NEGATIVE      NUMBER OF      CONDITION SETS
*        DATE        SET     INTERFACE     ACTIVE    DIRECTION      DIRECTION    CONDITIONS TO
*                   NUMBER   GROUP NAME                LIMIT          LIMIT        BE TRUE
*-----------------------------------------------------------------------------------------------------------
*
*-----------------------------------------------------------------------------------------------------------
*       MMMYYYY      III      AAAAAAAA      Y/N     #########      #########        III        III  III  III  III
*       -------      ---      --------      ---     ---------      ---------        ---        ---  ---  ---  ---
                      1      'ONE2TWO '      Y            100           9999          1          1    2   -3

;;;; END OF INF-DLIM-00 ;;;;
```

The documentation of the individual input tables includes additional details on how to implement dynamic conditions. Please contact MARS support with suggestions to further improve the functionality.

2.5 Repeatability Between Cases

When running a computer model to evaluate the sensitivity of the results to a given input, it is desirable to be able to hold everything else in the study constant. With the Monte Carlo simulation, that means being able to duplicate between runs the stream of random events generated for each unit.

In MARS, a separate random number generator is used for each unit, interface, or group of random hourly resources. One master random number seed is input by the user and is used to generate the seed for each unit's or interface's random number generator. If the order of the units in the input data, the units' type, and the master seed are not changed between runs, each unit's seed will be the same as in previous runs, thus producing duplicate streams of random events.

If you are doing a study where repeatability between runs is important, one unit list should be used throughout the study. Units can be removed from service in going from run to run by changing the installation and retirement dates, and have no impact on the random events for the other units.

Similarly, units added at the end of the unit list will not impact the random seeds of the preceding units.

Chapter 3

Hourly Input Data

The data required by the MARS program is input through three data files. The first file contains the hourly load data in and the second file is used to input hourly data for hourly modifier units. The remaining study data is input through a series of tables in the third input file, referred to as the Master Input File.

3.1 Hourly Load Data

MARS requires chronological hourly load data for each area for each year being studied. Additional load profiles can be input to model the effects of load forecast uncertainty (LFU). The hourly load data must be input for the first year of the study, and can be optionally provided for subsequent years. The load data can either be in the standard EEI format (see page 35), or provided as an HDF5 File.

3.2 Units Based on Hourly Shapes

The net hourly load modification of an hourly modifier unit can either be specified through hourly values for a typical week (table MOD-MDMW), or it can be calculated by the program from a combination of different hourly shapes. The hourly impact of each shape (e.g., demand side controls on water heaters and air conditioners) can be input for all of the hours in the year through the shapes file (file code 17). The devices to be combined to form a particular DSM program are specified on this table. The associated penetration factors are input on table MOD-PENE.

The hourly data for all of the shapes is input on file code 17 in either standard EEI format (see page 35) or in an HDF5 File.

3.3 HDF5 File Format for Hourly Input

If the input filename for either file code 2 or file code 17 ends in `.h5`, MARS will interpret it using the HDF5 file format.

For the users who wish to integrate this file format into their own processes, a description of the format follows. The snappy python API also provides convenience functions for converting in02 / in17 files into this format.

Both the hourly loads and hourly modifier files follow similar structures, with small variations to accommodate the additional meta data required for the hourly loads.

There are three datasets which are common between the two file formats:

- Both hourly loads and hourly modifier files contain a dataset called `SchemaVersion`, which is a 1x1 integer array containing the version of the file format. MARS will verify this version and use it to determine how to proceed with reading the file. The Schema Version is currently 1 for both hourly loads and hourly modifiers, but may increase in the future as enhancements are made to the model.
- The `ShapeData` dataset is an integer array, where the size of the array is the number of shapes. The value for each item in the array is the day of the week that the hourly shape starts on. This is the same number that previously was stored in the day of week column of the EEI shape data.
- The `HourlyValues` dataset is a double precision floating point matrix, the same length as `ShapeData` and either 8760 or 8784 columns wide, depending on if a leap year is modeled. Hourly values are stored horizontally, which is not immediately intuitive but is optimal when using the HDF5 file format.

The two unique datasets to the hourly loads files are:

- The `AreaNames` dataset is an array of eight character strings, where the size of the array will be the number of area, year, load level combinations being read into the model. For example, with five areas, and three areas having shapes for four load levels, this array would have a length of fourteen. These strings may either be padded on the right with spaces or null terminated.
- The `AreaData` dataset is an integer matrix of the same length as `AreaNames` and a width of three. The first column is the effective year of the shape. This is the same year that was previously entered in the header of the EEI format. The second column is the load level that the shape is assigned to, or zero to assign the shape to the base load level. The third column is the shape's zero-based index in the `ShapeData` and `HourlyValues` datasets. This allows for the reuse of the same shape data for multiple load levels or areas. As a comparison to the EEI format, any row in `AreaNames` and `AreaData` contains all of the information from the header of an area's load shape.

Like the hourly loads file, the hourly modifier file has two unique datasets as well:

- The `HRMShapeNames` dataset is an array of eight character strings, where the size of the array will be the number shapes being read into the model. These strings may either be padded on the right with spaces or null terminated.
- The `HRMShapeData` dataset is an integer array of the same length as `HRMShapeNames`. The only data needed is the shape's zero-based index in the `ShapeData` and `HourlyValues` datasets.

3.4 EEI Format

The data is listed in an 80-character line with twelve hourly loads in chronological order on each line. The data is entered according to the following format:

Column	Contents
1-2	Month. 01 = January, 12 = December
3-4	Day of the month. 01 through 31.
5-6	Year. Ignored by program.
7	A.M. or P.M. 1 = A.M., 2 = P.M.
8-9	Company number. Ignored by program.
10-15	Blank.
16	Day-type. 1 = Monday, 7 = Sunday, 8 = Holiday.
17-20	Blank.
21-80	Twelve hourly load values, input as five-digit integers, right-justified.

Load Data

All of the load data for the study is input through a single input file. This file is accessed by the program through file code 02. The load data is input sequentially by year; for a given year, the areas and load forecast uncertainty load levels can be input in any order. The load data for each area must begin with the following header line, beginning in column 1:

```
 **  AREANAME  YEAR  LL
```

where

****** must be in columns 1 and 2,

AREANAME is the eight-character area name and must begin in column 5,

YEAR is the four-digit year and must begin in column 15, and

LL is the LFU load level and must be in columns 21 and 22. If these columns are blank or do not contain a value that can be read as an integer, the program will assume that the data is for the base load shape. A value of 0 will be assigned to the base load shape, 1 through the number of load levels will be assigned to the specified load level, and any other value will cause an error during the data read.

The year code that is input in columns five and six of the EEI data is ignored, and the year from the header line is used to define the first study year for which the data will be used.

Hourly Shapes

The data for each shape begins with a header line, beginning in column 1:

```
 **         AAAAAAAA                    ###.##
```

where

****** must be in columns 1 and 2,

AAAAAAAA is the eight character shape name and must begin in column 11, and

###.## is a scale factor and must be in columns 33 through 38. The decimal point can appear anyplace within the field.

Because the values read from the shapes file must be integers, the scale factor on the header line is used to convert the input values to the actual MW. For example, if 1,000 water heater controls reduce the load by a total of 500 kW, a value of 500 is input on the shapes file with a scale factor of 0.001 to convert from kW to MW. The hourly value section of the EEI file follows the same format as described above.

Chapter 4

Input Data Tables

The remaining study data is input through a third file which consists of a series of data tables. This file is referred to as the Master Input File and is accessed by the program through file code 05.

Different types of input tables are used depending on the format of the data being input. Record tables are used for data that can be arranged in columns, such as unit characteristics. Data items within a row must be separated by one or more blanks. The colon table is used to input single items of data, such as the starting year of the study. Each data item is input following the colon on the line; if a value is not supplied, the program will assign a default value. The colon array table is used to input data that can be viewed as an array, such as data that is specified on a monthly basis.

Each table has a unique name that is recognized by the program and is used in assigning input data to program variables. Each table begins with an ampersand (&) in column one or two, followed by the table name. A semi-colon (;) in column one or two indicates the end of the table. Comments and blank lines can be inserted anywhere in a table except within a continuation line; a comment line begins with an asterisk (*) in column one or two.

Each unit, area, interface, etc. in a system that is being studied must be given a unique name by the user. This name is then used throughout the data tables to associate the data items with the appropriate unit, area, interface, etc. These key names are first established in specific driver tables, and the program will flag any names found in subsequently read tables that do not match the names in the driver tables.

Within the Master Input File, data tables can be arranged in any order, with the exception that the *GEN-CASE table must be first*. The program will scan the Master Input File and first read the driver tables that establish the key names. It will then read the remaining data tables in the order in which they are input. If a table appears more than once, data in the subsequent table will override data that was previously read.

Much of the input data can be overridden on a monthly or annual basis. The tables containing data that can be overridden include a column where you specify the effective date for that data. The format of the effective data column indicates whether the data can be overridden monthly (`MMMYYYY`) or annually (`YYYY`). Data without an effective date is assumed to remain constant for the entire study.

chapter 8 discusses the Master Input File (MIF) in more detail and outlines the rules that govern the data tables. One important rule up front, *do not use tabs in your MIF.*

4.1 General Study Data

4.1.1 Case Identification and Study Options (GEN-CASE)

```
&GEN-CASE-00     CIN
*                                              CASE-INFORMATION
*--------------------------------------------------------------------------------------------------------------------------------
*                                                      AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
  IDENTIFICATION 1   (.IDENT1.)                     : "TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA  "
*                                                      AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
  IDENTIFICATION 2   (.IDENT2.)                     : "REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS"
*                                                      AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
  IDENTIFICATION 3   (.IDENT3.)                     : "WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS "

  JOB IDENTIFIER   (.JOBNUM.)               AAAAAA :  165443
  DATE FOR OUTPUT LISTING  (.KDATE.)      AAAAAAAA :  07022012

  FIRST YEAR OF STUDY   (.NSTART.)            YYYY :  2015
  LAST YEAR OF STUDY    (.NSTOP.)             YYYY :  2018

*                                                      AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
  SYSTEM NAME        (.NMSYST.)                     : "MARS TEST SYSTEM "

  P.U. TOLERANCE FOR CHECKING LOADS  (.TOLER.)    # :0.2

  UNIT FORCED OUTAGES SPECIFIED THROUGH
    STATE TRANSITION RATES (0) OR FORCED
    OUTAGE RATES (1)  (.INPFOR.)                  I :  0

  DISPATCH OPTION FOR TYPE 3 ENERGY-LIMITED UNITS
    0  =  DETERMINISTIC LOAD MODIFIERS BEFORE
          THE MONTE CARLO SIMULATION
    1  =  AS NEEDED DURING THE MONTE CARLO
          SIMULATION (ISOLATED ONLY)
    2  =  AS NEEDED DURING THE MONTE CARLO
          SIMULATION (ISOLATED AND INTERCONNECTED)
    3  =  AS NEEDED DURING THE MONTE CARLO
          SIMULATION (INTERCONNECTED ONLY)
    (.IEL2MC.)                                    I :  3

 OPTION TO MODEL FORCED OUTAGES ON THE
    INTERFACE TIES (.IOUTIE.)   Y/N             AAA :  N

 OPTION TO WRITE OR READ AVAILABLE
    HOURLY CAPACITY BY AREA   (.ICAPRW.)          A :  N
      W  =  WRITE
      R  =  READ
      N  =  NEITHER

  FIRST REPLICATION TO CALCULATE WHEN
    USING THE OPTION TO RUN ON MULTIPLE
    PROCESSORS   (.INTVAL(12).)                IIII :
      0 = DO NOT USE THE OPTION (DEFAULT)
      1 = BEGIN CASE WITH REPLICATION 1.
          SAME AS NOT USING THE OPTION BUT
          CREATES THE BINARY FILE WITH THE
          INTERMEDIATE RESULTS.
      N = BEGIN CASE WITH REPLICATION N.
          SIMULATION WILL GO FROM N TO MAXREP.

  OPTION TO WRITE OR READ BINARY INPUT DATA
    FILE   (.INTVAL(17).)                         A : N
      W  =  WRITE
      R  =  READ
      N  =  NEITHER (DEFAULT)

;;;; END OF &GEN-CASE-00 ;;;;
```

Identification 1-3

Three lines of text information can be input to identify the case being run. Each line can be up to 72 characters long. This information will print on each page of program output.

Job Identifier

A six-character job identifier can be input. If not input, it will be provided by the computer system.

Date for Output Listing

An eight-character date can also be specified. If not input, it will be provided by the computer system.

First and Last Year of Study

The study period is defined by inputting the first and last years of the study. The calculations for years within the study period can be skipped (see table GEN-TIME).

System Name

Input a 48-character name of the system being modeled

P.U. Tolerance for Checking Loads

The program will check consecutive hourly loads and print a warning for those hours in which the per unit change exceeds the input tolerance. The default value is 0.20.

Unit Forced Outages Specified Through State Transition Rates (0) or Forced Outage Rates (1)

Deprecated This value used to control if unit forced outage data was controlled through state transition rates or partial forced outage rates and the number of transitions between states. A combination of transition rates for some units and forced outage rates for other units is now allowed.

Dispatch Option for Type 3 Energy-Limited Units

Deprecated This option used to control how as-needed unit were dispatched. Now they are always dispatched only during interconnected calculations.

Option to Model Forced Outages on the Interface Ties

Enter Y to model forced outages on the interface ties between areas. If using this option, capacity state and forced outage data must be input on the UNT-CAPS and either the UNT-TRNS or UNT-FORS tables for the interfaces.

The default is N which models the interface transfer capability as being fully available.

Option to Write or Read Available Hourly Capacity by Area

The amount of thermal capacity available in each area for each hour of an initial simulation can be written to file code 04. This capacity can then be read in by a subsequent simulation for specified areas (identified on GEN-AREA), thus eliminating the need to simulate the outages on the thermal units in those areas.

Enter W to write the information to file code 04. Enter R to read the hourly capacities from a previous run.

The default is N.

First Replication to Calculate

This input is used for running a single case on multiple processors. With this option, a case can be broken up into several cases with a range of replications simulated on each processor. Input the first replication to calculate in a specific case.

MARS will open and write a binary file named results-n.bin where n is number of the first replication in this case. (No changes to mars.ctl are required; the program automatically names and opens this file if the option is on.)

A separate post-processor, MARS-OUT, reads the results of the multiple cases and combines them to produce the MARS output files equivalent to those from running the cases as a single run. MARS-OUT is described in chapter 6.

0 Do not use option (default)

1 Begin case with replication 1. Same as not using the option but creates the binary file with the intermediate results.

n Begin case with replication n. Simulation will go from n to `MAXREP`.

Option to Write or Read Binary Input Data File

Enable the option to write certain data to a binary file.

W Write the binary file

R Read the binary file

N Do not interface with the binary file

The binary input data file is described in detail in chapter 5

This should always be the first table in your file.

4.1.2 Pool Identification (GEN-POOL)

```
&GEN-POOL-00     PID
*                            POOL-IDENTIFICATION
*--------------------------------------------------------------------------------
*    ABBREVIATED
*     POOL NAME                                  FULL POOL NAME
*--------------------------------------------------------------------------------
*     .NMPOOL.                                      .NMP048.
*--------------------------------------------------------------------------------
*     AAAAAAAA                  AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
*    ---------                  -------------------------------------------------
     "POOL 1"                   "POOL 1  -  AREAS A, B, AND C"
     "POOL 2"                   "POOL 2  -  AREAS D AND E"

;;;; END OF &GEN-POOL-00 ;;;;
```

Abbreviated Pool Name

Enter a unique name (maximum of eight characters) for each pool in the system. Pool Name, when referred to in other input tables, corresponds to this eight-character name.

Full Pool Name

Enter the full name (up to 48 characters long) of each pool being modeled.

4.1.3 Area Identification (GEN-AREA)

```
&GEN-AREA-00     AID
*                                              AREA-IDENTIFICATION
*-----------------------------------------------------------------------------------------------------------------
*                                                          READ              BLOCK BINARY
*    ABBREVIATED             FULL                      HOURLY THERMAL      INPUT UNIT DATA      GROUP FOR   MODEL AS
*       AREA                 AREA              POOL     CAPACITY FROM     FROM BEING MODIFIED    EL3 UNIT    DUMMY
*       NAME                 NAME           ASSIGNMENT  PREVIOUS RUN ?    IN SUBSEQUENT RUN ?    DISPATCH     AREA
*-----------------------------------------------------------------------------------------------------------------
*    .NMAREA.              .NMAR24.           .KPOOLA.     .IRDCAP.            .IBLKDT.            .IEL2GP.
*-----------------------------------------------------------------------------------------------------------------
*    AAAAAAAA     AAAAAAAAAAAAAAAAAAAAAAAA    AAAAAAAA       Y/N                 Y/N/U               III        Y/N
*    --------     ------------------------    --------       ---                 -----               ---        ---
     AREA-A     " IEEE-RTS AREA-A        "    "POOL 1"        =                    U                  =          =
     AREA-B     " IEEE-RTS AREA-B        "    "POOL 1"        =                    Y                  =          =
     AREA-C     " IEEE-RTS AREA-C        "    "POOL 1"        =                    Y                  =          =
     AREA-D     " IEEE-RTS AREA-D        "    "POOL 2"        =                    U                  1          =
     AREA-E     " IEEE-RTS AREA-E        "    "POOL 2"        =                    Y                  1          Y

;;;; END OF &GEN-AREA-00 ;;;;
```

Abbreviated Area Name

Enter a unique name (maximum of eight characters) for each area in the system. Area Name, when referred to in other input tables, corresponds to this eight-character name.

Full Area Name

Enter the full name (up to 24 characters long) of each area being modeled.

Pool Assignment

Enter the abbreviated name of the pool to which the area belongs.

Read Hourly Thermal Capacity From Previous Run?

If the amount of thermal capacity available hourly in each area has been saved from a previous simulation, you can specify the areas for which to read this data for the current simulation. Enter Y to read the data.

The default is N.

Note: Review related input on GEN-CASE.

Block Binary Input Unit Data From Being Modified in Subsequent Run?

If using the option to write some of the input data to a binary file, you can specify whether the data for units in the area can be blocked from modification in subsequent runs. You can also specify whether the output summaries showing the capacity by area are to be blocked from being written.

Y Block the unit data from being modified and block the writing of area capacity summaries (default).

N Do not block the unit data from being modified.

U Block the unit data from being modified, but allow the area capacity summaries to be written.

The option is controlled through the GEN-CASE table, and this data is used only in the case that is writing the binary data file.

Group for EL3 Unit Dispatch

You can specify on this table that the as-needed EL2 units in a group of areas be scheduled together, rather than by individual area. Input the number of the group to which the area is assigned. Group numbers should be consecutive integers beginning with 1. All EL3 units in this area will be dispatched as part of the same group.

Model as Dummy Area

Using areas as "dummy" areas is a common modeling practice with MARS. Previously, load shapes had to be included in the EEI file for all areas in the system, including areas where no load was being modeled. By enabling this option for an area, MARS will automatically set its load to a value smaller than the tolerance entered in Tolerance - Negative Margins.

Additionally, areas marked as a dummy area do not need to have EOP steps specified, and will be automatically initialized to 0 MW benefit.

4.1.4 Area Group Definition (GEN-ARGP)

The program computes reliability indices for each area and pool in the study system. You can also define other groupings of areas for which the indices will be calculated. The area groups defined here are used only for summary purposes and do not affect the reliability calculations. The calculated indices will be written to the various output reports following the area and pool indices.

```
&GEN-ARGP-00     AGP        CONTINUATION
*                                            AREA-GROUP-DEFINITION
*-----------------------------------------------------------------------------------------------------------------------
*    ABBREVIATED
*    AREA GROUP             FULL AREA
*       NAME                GROUP NAME                    ABBREVIATED NAMES OF AREAS INCLUDED IN THE AREA GROUP
*-----------------------------------------------------------------------------------------------------------------------
*     .NMARGP.               .NMAG24.                                              .IARGRP.
*-----------------------------------------------------------------------------------------------------------------------
*     AAAAAAAA      AAAAAAAAAAAAAAAAAAAAAAAA       AAAAAAAA    AAAAAAAA    AAAAAAAA    AAAAAAAA    AAAAAAAA    AAAAAAAA
*     --------      ------------------------       --------    --------    --------    --------    --------    --------
      AREA-AB      'AREAS A AND B'                 AREA-A      AREA-B
      SYSTEM       'ENTIRE SYSTEM '                AREA-A      AREA-B      AREA-C      AREA-D      AREA-E

;;;; END OF &GEN-ARGP-00 ;;;;
```

Abbreviated Area Group Name

Enter a unique name (maximum of eight characters) for each area group for which reliability indices are to be computed.

Full Area Group Name

Enter the full name (up to 24 characters long) of each area group being modeled.

Abbreviated Names of Areas Included in the Area Group

Input the abbreviated area name of each area to be included in the area group. Note that an area can be included in more than one area group.

4.1.5 Unit Summary Type (GEN-UNTY)

```
&GEN-UNTY-00      UTY
*             UNIT-SUMMARY-TYPE-IDENTIFICATION
*----------------------------------------------------
*                    GENERAL UNIT TYPE
*    UNIT TYPE          T = THERMAL
*      NAME             N = NON-THERMAL
*----------------------------------------------------
*    .NMUNTY.              .IUNTMD.
*----------------------------------------------------
*    AAAAAAAA                A
*    --------               ---
     NUCLEAR                 T
     FOSSIL-S                T
     FOSSIL-L                T
     C.T.                    T
     COGEN                   T
     HYDRO                   N
     E.S.                    N
     SHAPE                   N
     WIND                    N
     CONTRACT                N

;;;; END OF &GEN-UNTY-00 ;;;;
```

Unit Type Name

Input an eight-character name for each unit summary type to be used

General Unit Type

T Thermal

N Non-Thermal

Indicate whether the type will be assigned to thermal units (which include Type 1 energy-limited units and co-generation) or non-thermal units (which include Type 2/3 energy-limited, energy storage, and hourly shapes).

4.1.6 Years to Study and Annual Output Options (GEN-TIME)

```
&GEN-TIME-00     STU
*                                       STUDY-TIME-PERIOD-AND-ANNUAL-OUTPUT
*------------------------------------------------------------------------------------------------------------------------------------
*                                  PRINT SUMMARY                                                             PRINT        PRINT      PRINT
*              STUDY      PRINT      FOR EVERY      PRINT        WRITE        PRINT        PRINT     WEEKLY/MONTHLY  HOURLY     HOURLY
*  EFFECTIVE    THE       ANNUAL      III'TH        HOURLY     HISTOGRAM   LOAD MODEL   SUMMARY BY   SUMMARIES BY     FLOW      MODIFER
*     YEAR     YEAR ?    OUTPUT ?   REPLICATION    OUTPUT ?     FILE ?      OUTPUT ?   UNIT TYPE ?  LOAD LEVEL ?   OUTPUT ?   OUTPUT
*------------------------------------------------------------------------------------------------------------------------------------
*            .IYRSTD.  .KPRINT(2).  .KPRINT(3). .KPRINT(4). .KPRINT(5). .KPRLDS.  .KPRINT(6).  .KPRINT(7).  .KPRINT(8).
*------------------------------------------------------------------------------------------------------------------------------------
*     YYYY     Y/N         Y/N          III          AAA          Y/N        Y/N/S        Y/N         N/W/M/B        Y/N        Y/N/S
*     ----     ---         ---          ---          ---          ---         ---         ---         -------        ---         ---
               Y           Y            1            N            Y           Y           Y             N            N           Y
@     2016     N           Y            1            N            Y           Y           Y             N            N           =
@     2018     Y           Y            1            N            Y           Y           Y             N            N           =

;;;; END OF &GEN-TIME-00 ;;;;
```

Study the Year?

The study period is defined in table GEN-CASE. Within the study period, years can be skipped by entering N. The default is Y (study the year).

Print Annual Output?

The annual output includes:

- Reliability indices for the areas and pools on both an isolated (zero ties between areas) and interconnected (using the input tie ratings) basis;
- Interface flow summaries;
- Summary of contract curtailments.

This output is written to file 09. If load forecast uncertainty is being modeled (table LOD-UNCY (System)), a similar summary for each load level is written to file code 11.

The default is Y.

Print Summary for Every III'th Replication

Deprecated This value is not needed anymore because no data is saved by replication outside the HDF5 file.

Print Hourly Output

Detailed hourly output showing area margin information can be written to file 10. The file is only written as a comma-separated value (CSV) file and the format has change slightly from the MARS 3 series. The following options are available to control the output written:

A Isolated & Interconnected (same as Y)

E Interconnected only

G Interconnected, last margin state

N No hourly output will be written

With option A (isolated and interconnected), if any area is deficient on an isolated basis, the isolated and interconnected area margins are written for all of the areas. With option E (interconnected only), the area margins are written only if at least one area is deficient on an interconnected basis. With option G, the margins are written only if at least one area is deficient on an interconnected basis after its last margin state.

Caution This option can result in a very large output file and should be used only for runs with a limited number of replications.

Write Histogram File?

Deprecated This value used to control whether data was saved into file 12 and 13 to create histograms, which is no longer available.

Print Load Model Output?

Enter Y to print the summary which shows for each area the monthly peaks, energies, and load factors for the input load model and for the load model after adjustments to meet the specified peaks and energies. Enter S to print these summaries only in years which have "Study The Year" set to Y. The default is S.

Print Summary by Unit Type?

Enter Y to print a summary to file 09 which shows, on a monthly basis, the installed capacity by user-defined unit types. The unit types are defined in table GEN-UNTY. The default is N.

This summary is printed only if the year is being studied.

Print Weekly/Monthly Summaries by Load Level?

If weekly or monthly indices are being calculated (see table CNV-CRIT), they will be printed on file code 08. This input controls whether these indices are also to be printed by load forecast uncertainty load on file code 11.

N Do not print (default)

W Print weekly indices only

M Print monthly indices only

B Print both weekly and monthly indices

Print Hourly Flow Output?

For each hour in which the interface flow calculations are done or for only those hours for which hourly area output was written to file code 10 (see page 45, the program will print the MW flow on each of the interface ties. This summary is written in CSV (comma separated values) format to file code 16.

A Write flows for all hours (same as Y)

B Write flows and limits for all hours

C Write flows for only those hours that the area margins are written to file 10

D Write flows and limits for only those hours that the area margins are written to file 10

N Do not write this output

The limits written out are the actual interface limits for the hour, which take into account interface forced outages and dynamic limits. If there are no dynamic limits, and thus the limits apply to all load levels, the limits are listed once for the hours with a load level value of 0. A negative value of load level indicates that the limits apply to only that load level, and could vary between load levels because of the dynamic interface limits.

The default is N.

Caution This option can result in a very large output file and should be used only for runs with a limited number of replications.

Print Hourly Modifier Output?

Enter Y to print the report, in CSV format, of the hourly output of all hourly modifiers which are specified through shapes. When enabled, this report will be created in the working directory as hourly-modifiers.csv. Enter S to print this report only in years which have "Study the Year" set to Y. The default is N.

4.1.7 Simulation Convergence Criteria (CNV-CRIT)

The study year is simulated repeatedly by the Monte Carlo simulation until the measure of convergence falls within a specified tolerance or until the year has been simulated for the maximum specified number of times. In this table, you identify the index and tolerance to be tested for convergence.

```
&CNV-CRIT-00     CNC
*                                           CONVERGENCE-CRITERIA
*---------------------------------------------------------------------------------------------------------------

  AREA OR POOL TO DETERMINE HOUR OF DAILY PEAK  (.IPKARP.)                   AAAAAAAA : ALL

  AREA OR POOL TO CHECK FOR CONVERGENCE  (.ICNARP.)                          AAAAAAAA : "POOL 1"

  CONVERGENCE INDEX     1  =  LOEE (MWH/YR)        (.KVSTAT.)                       I : 3
                        2  =  LOLE (HOURS/YR)
                        3  =  LOLE (DAYS/YR)

  BASIS FOR CALCULATING CONVERGENCE INDEX   1  =  INTERCONNECTED   (.KVWHEN.)       I : 1
                                            2  =  ISOLATED

  CONVERGENCE TOLERANCE  (per unit)  (.CVPARM.)                                    #  : .05

  MARGIN STATE TO CALCULATE CONVERGENCE INDEX  (.KVEOP.)                           I  :  6

  MINIMUM NUMBER OF REPLICATIONS   (.MINREP.)                                      I  : 500

  MAXIMUM NUMBER OF REPLICATIONS   (.MAXREP.)                                      I  : 500

  ASSISTANCE PRIORITY WITHIN POOL ?   (.IPRIPL.)   Y/N                           AAA  : YES

  SEED FOR RANDOM NUMBER GENERATOR   (.ISEED.)                                     I  : 1340983

  INDICES TO CALCULATE       A  =  ALL                          (.ICALC.)        AAA  :  A
                             I  =  INTERCONNECTED ONLY
                             D  =  DAILY INTERCONNECTED ONLY

  CALCULATE WEEKLY OR MONTHLY INDICES    N  =  NEITHER (ANNUAL ONLY)  (.ICWKMN.)   AAA :  B
                                         W  =  WEEKLY
                                         M  =  MONTHLY
                                         B  =  BOTH WEEKLY AND MONTHLY

  SHARE EXCESS RESERVES AMONG DEFICIENT AREAS ?   (.ILOSHR.)   Y/N                AAA :  YES

;;;; END OF &CNV-CRIT-00 ;;;;
```

Area or Pool to Determine Hour of Daily Peak

Deprecated The program computes the daily LOLE for each area based on all of the hours in the day (ALL). This option used to allow calculating it by only using one hour per day, but that is not available anymore.

Area, Pool, or Area Group to Check for Convergence

In testing for convergence of the simulation, the specified index for the given area, pool, or area group will be monitored; all of the indices for all of the pools and areas will be calculated, but only the one will be checked for convergence.

Convergence Index

Specify the index to be tested for convergence of the simulation:

1 Loss-of-energy expectation (LOEE) (MWh/year)

2 Hourly loss-of-load expectation (LOLE) (hours/year)

3 Daily loss-of-load expectation (LOLE) (days/year)

Basis for Calculating Convergence Index

1 Interconnected

2 Isolated

Indicate whether the index used to test for convergence is to be calculated on an interconnected basis (recognizing the ties between areas) or on an isolated basis (ignoring the ties between areas).

Convergence Tolerance (per unit)

Enter the standard error of the mean, as a per unit of the cumulative mean, to be used in testing for convergence. A discussion of the standard error can be found in Section 1 of this manual.

Margin State to Calculate Convergence Index

Input the margin state (table EOP-DATA-01) for which to calculate the index being tested for convergence.

Minimum Number of Replications

Enter the minimum number of times that the year is to be simulated before testing for convergence.

Maximum Number of Replications

Enter the maximum number of times that the year is to be simulated. If convergence has not been reached at this point, the output for the current year will be printed and the program will move on to the next study year.

Assistance Priority Within Pool?

Areas that are deficient in capacity receive assistance from areas with excess resources according to the input priority list (table RES-PRIO). By entering Y you can specify that areas providing assistance must first assist all deficient areas within the same pool before assisting areas outside of the pool.

Seed for Random Number Generator

The Monte Carlo simulation uses a random number generator to determine the availability of units through time. The seed for the random number generator should be a six- to eight-digit integer ending in 1, 3, 7, or 9.

This seed will be used to generate the seeds used by the random number generators assigned to the individual generating units.

Indices to Calculate

A All

I Interconnected Only

D Interconnected Daily Only

Specify the group of indices that you want the program to calculate: all indices (isolated and interconnected), interconnected indices only, or interconnected daily indices only. The default is A.

The index to be tested for convergence must be one of those being calculated.

Calculate Weekly or Monthly Indices

In addition to annual indices, the program can also calculate daily LOLE, hourly LOLE, and unserved energy (LOEE) on a weekly or monthly basis.

N Do not calculate (default)

W Calculate weekly indices only

M Calculate monthly indices only

B Calculate both weekly and monthly indices

If calculated, the weekly and monthly indices and monthly interface flows will be printed on file code 08. Printing of the weekly and monthly indices and the interface flow summaries by load forecast uncertainty load level is controlled through table GEN-TIME.

Share Excess Reserve Among Deficient Areas?

In calculating the non-firm emergency assistance from areas with excess reserves to areas that are deficient, two methods of allocation are available. In the first method, the allocation will be done either according to a user-specified priority list (table RES-PRIO). The alternate approach is to share the excess reserves among the deficient areas in proportion to their shortfall. The default is N (use the priority list).

4.1.8 MARS H5 Output File (GEN-HDF5)

Enables output data into the HDF5-formated file Mars.h5. To read the information in the file, please use the snappy library, a python library that is a companion to MARS. The MAPS and MARS User Interface and also be used to read this data.

```
&GEN-HDF5-00
*                        HDF5-OUTPUT-OPTIONS
*---------------------------------------------------------------------

  WRITE H5?                                        Y/N :

  WRITE HOURLY FLOWS TO H5?                        Y/N :

  WRITE HOURLY THERMAL CAPACITY STATES           0/1/2 :

  WRITE AS-NEEDED ENERGY LIMITED UNIT USAGE        Y/N :
                                                         A/B/C/D/E/F/N
  WRITE AREA MARGINS                                   :

  WRITE EOP USAGE                                  Y/N :

  WRITE CONTRACT CURTAILMENT                       Y/N :

;;;; END OF GEN-HDF5-00 ;;;;
```

Write H5

Enable output of data into the H5 output file (Y). Default is no output (N)

Write Hourly Flows

If Y write flow by interface, replication, load level and hour for the last margin state. This dataset can be very large. Default is N.

This option also accepts a positive integer to indicate that the flows at a given margin state should be saved. For instance, a value of 3 will only save flows for the third margin state.

Write Hourly Thermal Capacity States

If 0 or N, do not write the capacity states by thermal unit, by replication, and by hour. If 1 or Y, the dataset is written as a series of characters with the hexadecimal representation of the state (uses less disk space). If 2, the data is saved as 32-bit integers (uses more disk space). Default is 0.

Write Hourly as Needed Energy Limited Unit Usage

If Y write as-needed energy limited unit usage, by replication, by load level, and by hour. This dataset can be very large. Default is N.

Write Area Margins

If enabled, write area margins by replication, by load level, and by hour. This dataset can be very large. Default is N. Valid options are:

A Save all (isolated & interconnected) margins

B Save all negative margins

C Save only interconnected margins

D Save only isolated margins

E Save only negative interconnected margins

F Save only negative isolated margins

N Do not save margins

Write Emergency Operating Procedure Usage

If Y write EOP usage by replication, by load level, and by hour. This dataset can be very large.

Write Contract Curtailment

If Y write contract curtailment by load level, and by hour. This dataset can be very large.

4.1.9 General Program Options (GEN-OPTN)

```
&GEN-OPTN-00     OPT
*                                            GENERAL-PROGRAM-OPTIONS
*-------------------------------------------------------------------------------------------------------------------
*                                                  FIRST      LAST     LAST EOP FOR WHICH          SELF      SYSTEM
*             ZERO TIE LIMITS     ALLOW FLOW       MONTH      MONTH    TIE LIMITS ARE ZEROED    ASSISTANCE    WIDE
*  EFFECTIVE  BEFORE NON-FIRM      THROUGH          TO         TO      FOR INITIAL NON-FIRM     DURING P-P   RESERVE
*    YEAR      ASSISTANCE ?    OUTSIDE POOLS ?   SIMULATE   SIMULATE   AND EOP CALCULATIONS     ASSISTANCE   SHARING
*-------------------------------------------------------------------------------------------------------------------
*                .LZERTI.         .IFLOPL.       .MNSTRT.   .MNSTOP.         .ISOEOP.            .IFLPSF.   .IFLPSY.
*-------------------------------------------------------------------------------------------------------------------
*    YYYY          Y/N              Y/N            AAA        AAA              III                 Y/N        Y/N
*    ----          ---              ---            ---        ---              ---                 ---        ---
                    N                N              =          =                0                   Y          Y

;;;; END OF &GEN-OPTN-00 ;;;;
```

Zero Tie Limits Before Non-Firm Assistance and EOP Calculations?

If an interface is to be used for scheduling firm contracts but not for non-firm emergency assistance, the tie limits can be set to zero before doing the non-firm assistance calculations. The ties to be zeroed are specified on table INF-TRLM.

The default is N.

Allow Flow Through Outside Pools?

If priority is being given to assisting areas within the same pool, you can allow this assistance to flow through outside pools or restrict the flow to ties within the pool.

First and Last Month to Simulate

If the hourly area capacities are being read for all areas (GEN-CASE and GEN-AREA), you can specify the portion of the year to be simulated. This can be helpful in reducing run-times if you are focusing on just part of the year. Enter the three-character names for the first and last months to be simulated.

The defaults are JAN and DEC.

Last EOP for Which Tie Limits are Zeroed for Initial Non-Firm and EOP Calculations

To model the case in which a group of areas would provide assistance (including implementing emergency operating procedures) to each other before turning to outside areas for additional assistance, you can effectively isolate portions of the system by setting specified tie limits to zero during the initial stages of the interconnected calculations.

Enter the number of the last EOP (margin state) for which the specified tie limits will be set to 0 for the initial non-firm and EOP calculations. The ties to be zeroed are specified in table INF-TRLM.

If it is set to 0, then all interface ties capacities will not be zeroed for non-firm assistance and EOP calculations regardless what are specified in table INF-TRLM.

If it is set to value other than 0, then this value represents the last margin state that all interface ties, which have their last EOP margin states specified in table INF-TRLM ¿ 0, will be zeroed for the initial non-firm assistance and EOP calculation at least up to this margin state.

The default is 0.

By default, the ties limits will be force to zero with this option. However, a fraction of the tie capacities can be enabled instead by entering a value in RELVAL(3) in INT-ONLY-00.

Allow/Disallow Self Assistance During Pool-to-Pool Assistance?

This option allows the sending pool to assist itself during the pool to pool assistance phase.

.IFLPSF. 6th column of GEN-OPTN-00 - self assistance during the pool-to-pool assistance stage is allowed/disallowed. Default = Y or blank.

Allow/Disallow System-Wide Sharing?

This option allows the user to turn off system-wide sharing after the pool to pool assistance stage. This can be used after disallowing the self assistance option during pool-to-pool stage to determine if additional assistance would be provided from other pools in the system.

.IFLPSY. 7th column of GEN-OPTN-00 - system wide sharing is allowed/disallowed. Default = Y or blank.

4.1.10 Annual Output Options (MNT-AOPT)

```
&MNT-AOPT-00      MTO
 *                                                       ANNUAL-OUTPUT-OPTIONS
 *-----------------------------------------------------------------------------------------------------------------
 *                PRINT WEEKLY          PRINT           FILLER          PRINT           PRINT
 *                  CAPACITY         ANNUAL UNIT      CHARACTERS      SUMMARY OF      SUMMARY OF      MONTH FOR
 *                  SUMMARY ?        MAINTENANCE         FOR          MAINTENANCE     UNIT INPUT      SEASONAL
 *    EFFECTIVE      (FC07)           SCHEDULE ?      MAINTENANCE       DATES ?         DATA ?         RATINGS
 *      YEAR       POOL  AREA          (FC07)           SUMMARY         (FC07)          (FC07)       WINTER  SUMMER
 *------------------------------------------------------------------------------------------------------------------
 *                  .KPRCAP.           .KPRMNT.        .MTBLNK.        .KPRMT2.        .KPRUNT.        .MNSEAS.
 *------------------------------------------------------------------------------------------------------------------
 *      YYYY       Y/N   Y/N             Y/N              AA             Y/N             Y/N          AAA     AAA
 *      ----       ---   ---             ---              --             ---             ---          ---     ---
                    Y     Y               Y               --              Y               Y           JAN     JUL

 ;;;; END OF &MNT-AOPT-00 ;;;;
```

Print Weekly Capacity Summary for Pool or Area?

The program will print a summary showing, on a weekly basis: peak load, installed capacity, capacity on scheduled maintenance, reserves in MW, and reserves as a percent of peak load. The default is N.

This summary is written to file code 07 and can be requested for the pools and/or areas. If this summary is written for the areas, the area groups will also be output. If this summary is printed for the areas or pools, a summary for the entire system will also be printed.

Print Annual Unit Maintenance Schedule

Enter Y to print a summary which shows for each unit on the system the weeks during the year in which the unit was on maintenance and the type of maintenance (user-specified or scheduled by the program). The default is N.

This summary is written to file code 07.

Filler Characters for Maintenance Summary

To help make the annual unit maintenance schedule summary easier to read, the user can specify up to two characters to be printed in those weeks for which no maintenance is scheduled. This input should be enclosed in single quotes. The default is two blanks.

Print Summary of Maintenance Dates?

A summary listing for each unit the actual dates of maintenance (in `DDMMM` format) and the type of maintenance for each period can be printed by specifying Y. The default is N.

This summary is written to file code 07.

Print Summary of Unit Input Data?

Summaries of the unit input data can be written to file code 07 for each year. The summary for thermal units lists the unit's type, installation and retirement dates, two seasonal ratings, planned outage time in weeks, equivalent forced outage rate, and forced outage rate by capacity state.

The summary for the non-thermal units shows the same information with the exception of the annual energy in place of the forced outages rates. Enter Y to print these summaries The default is N.

Months for Seasonal Ratings?

Enter the 3-character abbreviations of the two months to be used in determining the seasonal ratings in the previous summary. The default months are `JAN` and `JUL`.

4.1.11 Infrequently Used Program and Output Options (INT-ONLY-00)

Over time, several program and output options have been added to MARS to satisfy specific requests from users. This table contains the input for these options as well as some program default values that the user would not typically change unless directed to by MARS support personnel.

```
&INT-ONLY-00      INT
*                               FOR INTERNAL USE - ADDITIONAL INPUT VALUES
*-------------------------------------------------------------------------------
     TRACE LEVEL                 (.ITRACE.)                 I : 0
     TRACE LEVEL FOR FUTURE USE  (.MTRACE.)                 I :
     HOUR FOR DETAILED OUTPUT    (.IHRTRC.)                 I : 0
     DELAYED TRACE LEVEL         (.INTVAL( 1).)             I :
     FREQ OF CONV CHK PRINT      (.INTVAL( 2).)             I :
     HOURLY LOADS OR HOUR OF PEAK (.INTVAL( 3).)            I : 0
     OLD FORMAT FOR OT10 FILE    (.INTVAL( 4).)             I :
     WRITE/READ FOR M.C. BINARY  (.INTVAL( 5).)             I :
     # OF AREAS FOR REP. OUTPUT  (.INTVAL( 6).)             I :
     TIMES THRU RESERVE SHARING  (.INTVAL( 7).)             I : 15
     SAME SEED FOR MULTI-YEAR    (.INTVAL( 8).)             I : 0
     CURTAILMENT ITERATIONS      (.INTVAL( 9).)             I : 4
     ALLOW SKIPPING LOWER LOADS  (.INTVAL(10).)             I :
     DIGITS TO RIGHT OF DECIMAL  (.INTVAL(11).)             I : 3
     FIRST REPLICATION TO CALC   (.INTVAL(12).)             I :
     BYPASS LP SPEEDUP LOGIC     (.INTVAL(13).)             I :
     DETAILED DERATION OUTPUT    (.INTVAL(14).)             I : 0
     DELAY HOURLY OUTPUT REPL    (.INTVAL(15).)             I :
     COST OF TIES BTW. POOLS     (.INTVAL(16).)             I :
     READ/WRITE MASKED DATA      (.INTVAL(17).)             I :
     EL2 WARNINGS AND OUTPUT     (.INTVAL(18).)             I : 0
     LOADS FOR DYN. INTER. LIMITS (.INTVAL(19).)            I :
     ENABLE OLD MLS PEAK LOGIC   (.INTVAL(20).)             I :

     TOLERANCE - NEG. MARGINS    (.RELVAL( 1).)             # : 0.01
     PRINT RANDOM GROUP SET ASGN (.RELVAL( 2).)             # :
     AMOUNT OF ASSISTANCE IN TIES (.RELVAL( 3).)            # :
                                 (.RELVAL( 4).)             # :
                                 (.RELVAL( 5).)             # :
                                 (.RELVAL( 6).)             # :
                                 (.RELVAL( 7).)             # :
                                 (.RELVAL( 8).)             # :
                                 (.RELVAL( 9).)             # :
                                 (.RELVAL(10).)             # :

 ;;;; END OF &INT-ONLY-00 ;;;;
```

Trace Level

Option to print varying levels of trace output.

Hour for Detailed Output

Clock hour (from 1 to 8760*number of replications) at which time to begin printing detailed hourly output of area margins (file 10) and hourly interface flows (file 16).

The hourly area margins will be written in ASCII format so the GEN-TIME table must have an A for that column in the general data (data without an override date), which would then be set to N for the first year of the study.

Delayed Trace Level

This trace level will be copied to `ITRACE` when the hour in `IHRTRC` is reached.

Frequency of Convergence Check Printing

Frequency of printing convergence checks to file code 06. Default is every 100,000 replications (effectively not printed).

Hourly Loads or Hour of Peak

Switch to write out the hourly loads, after adjustment for the input peaks and energies, in EEI or .csv format. Also used to write the hour of daily peak for each area.

0 Do not write (default)

¿0 Write hourly loads in .csv format to file hourly-loads.csv, base or expected load shape only

¡0 Write hourly loads in .csv format to file hourly-loads.csv, all LFU load levels

There is no need to change the MARS control file; the program will automatically open the necessary output file in the directory in which the program is being run.

Old Format for OT10 File

This option enables writing the data to file code 10 in an older fixed width format instead of a CSV format. Any non-zero value will enable this behavior.

Write/Read for Monte Carlo Binary

Switch to speed up writing and reading of data on the Monte Carlo binary interface file.

0 Write and read entire load arrays (default)

1 Write and read load arrays only for number of areas being modeled.

If the number of areas being modeled is close to the program dimension for number of areas, setting `INTVAL(5)` = 0 will result in the faster writing and reading of the interface. If the number of areas is somewhat less than the program dimension, `INTVAL(5)` = 1 will be faster.

The value of `INTVAL(5)` to use is best determined by comparing the running times of two runs that are identical except for their value of `INTVAL(5)`.

Times Thru Reserve Sharing

Input the number of iterations through the reserve sharing logic to better account for the transfer limits in the allocation of reserves to areas. The default is 15.

Same Seed for Multi-Year

Input 1 to use the same random number generator seed for each year of a multi-year study. Otherwise, a new random seed will be generated for each year. The default is 0.

Curtailment Iterations

Enter the number of iterations through the logic for modeling curtailable contracts. The default is 4.

Allow Skipping Lower Load Levels

When set to a non-zero value, MARS will skip lower load levels, assuming no loss of load events at a higher load level will also mean no events at lower levels. Default is 0, evaluate all load levels.

This logic is bypassed if multiple load shapes are read in from the EEI file.

Digits to Right of Decimal

Input the number of digits to the right of the decimal point to be written for the calculated reliability indices. You may only increase the number of digits written (currently at three); an input value of less than three will be reset to three.

This option affects the weekly and monthly output (file 08), the annual summary (file 09), the output by load forecast uncertainty load level (file 11), and the files containing the replication output.

First Replication to Calc

Please see the description for the GEN-CASE table on page 40.

Bypass LP Speedup Logic

Setting this switch to a non-zero value bypasses changes to the LP logic for simultaneous interface limits introduced in 2002.

Detailed Deration Output

Set to 1 to print detailed output of the unit deration calculations. The default is 0.

Delay hourly output replication

Once the replication in this variable is reached, MARS will reset `KPRINT(4)` (hourly output to file code 10) to the `A` option (ASCII Isolated & Interconnected Daily & Hourly).

Cost of ties between pools

This value is used to tweak the LP when it is solving the transportation model. The default is 1.

Read/Write masked data

Please see the chapter Binary Input Data File on page 134.

EL2 Warnings and Output

Options related to Type 2 energy limited units.

0 Write warnings but not debug output (default)

1 Bypass warnings to file 06 about too much energy being input

2 Write debug output to file 06 showing when EL2 units being dispatched on an "as needed" basis hit their energy limits

The default is 0 (write warnings but not debug output).

Loads for Dynamic Interface Limits

Specify whether the base loads or those that have been adjusted for the load forecast uncertainty shapes and multipliers are to be used for determining dynamic interface limits in LOD-COND.

0 Use the adjusted loads (default)

1 Use the base loads that have not been adjusted for load forecast uncertainty

Enable old MLS Peak Logic

Versions of MARS prior to 3.18 only considered the base shape when determining the hour of daily peak. Starting in version 3.18, the daily peak for each load level was determined independently. Setting this option to 1 reverts to the old logic.

Tolerance - Negative Margins

Input the round-off tolerance for area margins. An area's margin will be considered to be negative if it is less than `-RELVAL(1)`. The default is 0.01 MW.

Print random group set assignment

Setting this to a value greater than zero will cause the random group set selected for each random group during the replication to be printed to the OT06 file.

Amount of assistance

To model the case in which a group of areas would provide assistance (including implementing emergency operating procedures) to each other before turning to outside areas for additional assistance, you can effectively isolate portions of the system by setting specified tie limits to zero during the initial stages of the interconnected calculations. This option is controlled through the ISOEOP option in table GEN-OPTN.

This value controls the amount of tie capacity that is allowed when the ISOEOP option is enabled. The default value is 0, so the tie capacity is forced to zero. Enter a value between 0 and 1 to enable a certain amount of capacity. For instance, a value of 0.5 will allow half of the tie capacity to remail in the initial EOP stages.

4.1.12 Infrequently Used Program and Output Options (INT-ONLY-01)

Over time, several program and output options have been added to MARS to satisfy specific requests from users. This table contains the input for these options as well as some program default values that the user would not typically change unless directed to by MARS support personnel.

```
&INT-ONLY-00     INT
*                                FOR INTERNAL USE - ADDITIONAL INPUT VALUES
*--------------------------------------------------------------------------------
     TRACE LEVEL                 (.ITRACE.)                I : 0
     TRACE LEVEL FOR FUTURE USE  (.MTRACE.)                I :
     HOUR FOR DETAILED OUTPUT    (.IHRTRC.)                I : 0
     DELAYED TRACE LEVEL         (.INTVAL( 1).)            I :
     FREQ OF CONV CHK PRINT      (.INTVAL( 2).)            I :
     HOURLY LOADS OR HOUR OF PEAK (.INTVAL( 3).)           I : 0
     OLD FORMAT FOR OT10 FILE    (.INTVAL( 4).)            I :
     WRITE/READ FOR M.C. BINARY  (.INTVAL( 5).)            I :
     # OF AREAS FOR REP. OUTPUT  (.INTVAL( 6).)            I :
     TIMES THRU RESERVE SHARING  (.INTVAL( 7).)            I : 15
     SAME SEED FOR MULTI-YEAR    (.INTVAL( 8).)            I : 0
     CURTAILMENT ITERATIONS      (.INTVAL( 9).)            I : 4
     ALLOW SKIPPING LOWER LOADS  (.INTVAL(10).)            I :
     DIGITS TO RIGHT OF DECIMAL  (.INTVAL(11).)            I : 3
     FIRST REPLICATION TO CALC   (.INTVAL(12).)            I :
     BYPASS LP SPEEDUP LOGIC     (.INTVAL(13).)            I :
     DETAILED DERATION OUTPUT    (.INTVAL(14).)            I : 0
     DELAY HOURLY OUTPUT REPL    (.INTVAL(15).)            I :
     COST OF TIES BTW. POOLS     (.INTVAL(16).)            I :
     READ/WRITE MASKED DATA      (.INTVAL(17).)            I :
     EL2 WARNINGS AND OUTPUT     (.INTVAL(18).)            I : 0
     LOADS FOR DYN. INTER. LIMITS (.INTVAL(19).)           I :
     ENABLE OLD MLS PEAK LOGIC   (.INTVAL(20).)            I :
     SET FIRST DAY DAYTYPE       (.INTVAL(21).)            I :
     SET LEAP YEAR               (.INTVAL(22).)            I :
     USE EXACT DYNAMIC LIMIT     (.INTVAL(23).)            I :
     DISPATCH ORDER FOR EL3/ES   (.INTVAL(24).)            I :
     SINGLE AREA MODE            (.INTVAL(25).)            I :

     TOLERANCE - NEG. MARGINS    (.RELVAL( 1).)            # : 0.01
     PRINT RANDOM GROUP SET ASGN (.RELVAL( 2).)            # :
     AMOUNT OF ASSISTANCE IN TIES (.RELVAL( 3).)           # :
                                 (.RELVAL( 4).)            # :
                                 (.RELVAL( 5).)            # :
                                 (.RELVAL( 6).)            # :
                                 (.RELVAL( 7).)            # :
                                 (.RELVAL( 8).)            # :
                                 (.RELVAL( 9).)            # :
                                 (.RELVAL(10).)            # :

 ;;;; END OF &INT-ONLY-00 ;;;;
```

Trace Level

Option to print varying levels of trace output.

Hour for Detailed Output

Clock hour (from 1 to 8760*number of replications) at which time to begin printing detailed hourly output of area margins (file 10) and hourly interface flows (file 16).

The hourly area margins will be written in ASCII format so the GEN-TIME table must have an A for that column in the general data (data without an override date), which would then be set to N for the first year of the study.

Delayed Trace Level

This trace level will be copied to `ITRACE` when the hour in `IHRTRC` is reached.

Frequency of Convergence Check Printing

Frequency of printing convergence checks to file code 06. Default is every 100,000 replications (effectively not printed).

Hourly Loads or Hour of Peak

Switch to write out the hourly loads, after adjustment for the input peaks and energies, in EEI or .csv format. Also used to write the hour of daily peak for each area.

0 Do not write (default)

¿0 Write hourly loads in .csv format to file hourly-loads.csv, base or expected load shape only

¡0 Write hourly loads in .csv format to file hourly-loads.csv, all LFU load levels

There is no need to change the MARS control file; the program will automatically open the necessary output file in the directory in which the program is being run.

Old Format for OT10 File

This option enables writing the data to file code 10 in an older fixed width format instead of a CSV format. Any non-zero value will enable this behavior.

Write/Read for Monte Carlo Binary

Switch to speed up writing and reading of data on the Monte Carlo binary interface file.

0 Write and read entire load arrays (default)

1 Write and read load arrays only for number of areas being modeled.

If the number of areas being modeled is close to the program dimension for number of areas, setting `INTVAL(5)` = 0 will result in the faster writing and reading of the interface. If the number of areas is somewhat less than the program dimension, `INTVAL(5)` = 1 will be faster.

The value of `INTVAL(5)` to use is best determined by comparing the running times of two runs that are identical except for their value of `INTVAL(5)`.

Times Thru Reserve Sharing

Input the number of iterations through the reserve sharing logic to better account for the transfer limits in the allocation of reserves to areas. The default is 15.

Same Seed for Multi-Year

Input 1 to use the same random number generator seed for each year of a multi-year study. Otherwise, a new random seed will be generated for each year. The default is 0.

Curtailment Iterations

Enter the number of iterations through the logic for modeling curtailable contracts. The default is 4.

Allow Skipping Lower Load Levels

When set to a non-zero value, MARS will skip lower load levels, assuming no loss of load events at a higher load level will also mean no events at lower levels. Default is 0, evaluate all load levels.

This logic is bypassed if multiple load shapes are read in from the EEI file.

Digits to Right of Decimal

Input the number of digits to the right of the decimal point to be written for the calculated reliability indices. You may only increase the number of digits written (currently at three); an input value of less than three will be reset to three.

This option affects the weekly and monthly output (file 08), the annual summary (file 09), the output by load forecast uncertainty load level (file 11), and the files containing the replication output.

First Replication to Calc

Please see the description for the GEN-CASE table on page 40.

Bypass LP Speedup Logic

Setting this switch to a non-zero value bypasses changes to the LP logic for simultaneous interface limits introduced in 2002.

Detailed Deration Output

Set to 1 to print detailed output of the unit deration calculations. The default is 0.

Delay hourly output replication

Once the replication in this variable is reached, MARS will reset `KPRINT(4)` (hourly output to file code 10) to the `A` option (ASCII Isolated & Interconnected Daily & Hourly).

Cost of ties between pools

This value is used to tweak the LP when it is solving the transportation model. The default is 1.

Read/Write masked data

Please see the chapter Binary Input Data File on page 134.

EL2 Warnings and Output

Options related to Type 2 energy limited units.

0 Write warnings but not debug output (default)

1 Bypass warnings to file 06 about too much energy being input

2 Write debug output to file 06 showing when EL2 units being dispatched on an "as needed" basis hit their energy limits

The default is 0 (write warnings but not debug output).

Loads for Dynamic Interface Limits

Specify whether the base loads or those that have been adjusted for the load forecast uncertainty shapes and multipliers are to be used for determining dynamic interface limits in LOD-COND.

0 Use the adjusted loads (default)

1 Use the base loads that have not been adjusted for load forecast uncertainty

Enable old MLS Peak Logic

Versions of MARS prior to 3.18 only considered the base shape when determining the hour of daily peak. Starting in version 3.18, the daily peak for each load level was determined independently. Setting this option to 1 reverts to the old logic.

Set Start Day Daytype

Force the simulation to start in a given day of the week (1=Monday), overriding the logic in MARS. The default (0) uses the MARS logic.

Set Leap Year

Force the simulation year to not be a leap year (option 1), or to be a leap year (option 2). If this option is not set, or set to 0, the number of days / hours in each year will be determined from the simulation year.

Use Exact Dynamic Limits

Determines whether the last applicable dynamic limit is applied (1) or the minimum applicable (0).

Dispatch Order for EL3/ES Units

By default (0), EL3 and ES units that are in the same area are dispatched based on how many "hours" of capability they have left (by comparing actual hourly limits or calculating the ratio of energy left divided by capacity). For charging, ES units with the fewest available get charged first.

There are two alternative ways of dividing the capacity to be generated or charged for units in the same area:

- Based on the order in which they are entered in MOD-PRIO (value of 1)
- Proportionally, so that units are dispatched or charged depending on how much energy they have left or are able to charge, repectively (value of 2)

Single area mode

This option provides a quick way to model all load and resources in a single area, which should be equivalent to a simulation without transmission contracts (i.e., copper sheet) but much faster.

When activated (value of 1), all load and resources will be placed on the first area listed in GEN-AREA right before margin calculations are performed. Output files (plain-text and H5) may not reflect this change when reporting load and unit data.

This option is experimental and is not recommended with certain advanced modeling functions, such as binary data masking, EOP use limits (beyond availability in MW and p.u. of load), contracts, multi-pool systems, any interface limits (they will be ignored), or reserve sharing. Most other features should work as they do in normal area mode.

Tolerance - Negative Margins

Input the round-off tolerance for area margins. An area's margin will be considered to be negative if it is less than `-RELVAL(1)`. The default is 0.01 MW.

Print random group set assignment

Setting this to a value greater than zero will cause the random group set selected for each random group during the replication to be printed to the OT06 file.

Amount of assistance

To model the case in which a group of areas would provide assistance (including implementing emergency operating procedures) to each other before turning to outside areas for additional assistance, you can effectively isolate portions of the system by setting specified tie limits to zero during the initial stages of the interconnected calculations. This option is controlled through the ISOEOP option in table GEN-OPTN.

This value controls the amount of tie capacity that is allowed when the ISOEOP option is enabled. The default value is 0, so the tie capacity is forced to zero. Enter a value between 0 and 1 to enable a certain amount of capacity. For instance, a value of 0.5 will allow half of the tie capacity to remail in the initial EOP stages.

4.2 Load Data

4.2.1 Annual Area Load Data (LOD-DATA)

MARS will automatically modify the input hourly load data to develop a load model with the specified peak and energy. This data can be specified by area on a monthly (table LOD-MTAR) or annual basis. The program will also grow the peaks and energies through time by the input growth multipliers.

The load adjustment is done in two steps. The first step adjusts all of the hourly loads by the same percentage to meet the specified annual peak load, while maintaining the original load factor. In the second step, the hourly loads are further modified to meet the specified monthly target energy.

```
&LOD-DATA-01     AL1
*                                              AREA-LOAD-DATA
*----------------------------------------------------------------------------------------------------------------------
*                                                                                                  LOAD ADJUSTMENT TO
*                                                                                                MEET SPECIFIED ENERGY ?
*                                                                                                 N = NO ADJUSTMENT
*                                                                                                 P = HOLD MONTHLY PEAK
*                                   LFU     -----  ANNUAL PEAK  -----      --  ANNUAL TARGET ENERGY  --      V = HOLD MONTHLY PEAK
*     EFFECTIVE        AREA        LOAD                    GROWTH                            GROWTH                & VALLEY
*       YEAR           NAME        LEVEL       (MW)       RATE (P.U.)          (MWH)        RATE (P.U.)      D = HOLD DAILY PEAK
*------------------------------------------------------------------------------------------------------------------
*                                           .ANPEAK.       .GRMW.            .ANTENG.       .GRMWH.              .KENANN.
*------------------------------------------------------------------------------------------------------------------
*       YYYY         AAAAAAAA       I           #              #                 #              #                   A
*       ----         --------      ---      ---------      ---------       -------------    ---------             -----
                      AREA-A         =         2800          1.025                =            1.03                 V
                      AREA-A         1         2884          1.03                 =            1.03                 V
                      AREA-A         2         2850          1.03                 =            1.03                 V
                      AREA-A         3         2800          1.025                =            1.03                 V
                      AREA-A         4         2716          1.03                 =            1.03                 V
                      AREA-A         5         2680          1.03                 =            1.03                 V
                      AREA-B         =         1700          1.04           9350000            1.04                 P
                      AREA-B         1         1751          1.03           9630500            1.04                 P
                      AREA-B         2         1730          1.04           9500000            1.03                 P
                      AREA-B         3         1700          1.04           9350000            1.04                 P
                      AREA-B         4         1649          1.04           9069500            1.04                 P
                      AREA-B         5         1600          1.04           8750000            1.03                 P
                      AREA-C         =         2100          1.00          10300000            1.00                 D
                      AREA-D         =         1650          1.03           9700000            1.03                 P
                      AREA-E         =          900          1.03           4960000            1.03                 N

@       2016          AREA-C         =         2200          1.02          10700000            1.021                V

;;;; END OF &LOD-DATA-00 ;;;;
```

Area Name

Enter the abbreviated area name.

LFU Load Level

If you are using different load shapes to model the effects of load forecast uncertainty, specify the LFU load level for which the data applies. If inputting data for the base or expected load model, input a load level of 0 (default).

Annual Peak (MW)

Enter the annual peak load, in MW, for the area. If an annual peak load is not input, the program will use the peak from the hourly load data, but will not grow it through time.

If an annual peak load of -1 is input, the program will use the peak from the hourly load data for the current year and grow it at the input growth rate to calculate the peak for subsequent years. Re-inputting -1 in subsequent years will cause a new base value to be determined from the hourly load data for that year.

Annual Peak Growth Rate (p.u.)

Input the annual peak load growth rate multiplier, in per unit, for the area. This growth rate will be used to calculate the peak for subsequent years. The default is 1.0.

Annual Target Energy (MWh)

Enter the annual target energy for the area in MWh. If the load adjustment option is used, the input load shape will be modified to produce a load model with the specified energy. The annual energy will be allocated to the months in proportion to the monthly energies on the original load model.

If an annual target energy of -1 is input, the program will use the energy from the hourly load data for the current year and grow it at the input growth rate to calculate the energy for subsequent years. Re-inputting -1 in subsequent years will cause a new base value to be determined from the hourly load data for that year.

If the input energy is 0, the loads will be adjusted to meet the specified peak but no energy adjustment will be done. The annual energy will grow at the same rate as the peak load, and the load factor will not change.

If both annual and monthly target energies are input (table LOD-MTAR), the annual value will be used and the monthly targets will be ignored.

Annual Target Energy Growth Rate (p.u.)

Input the annual peak energy growth rate multiplier, in per unit, for the area. This growth rate will be used to calculate the energy for subsequent years. If monthly energy targets are input (table LOD-MTAR), they will also be grown at this rate. The default is 1.0.

Load Adjustment to Meet Specified Energy

Enter the code for the option to be used in adjusting the loads to meet the target energy. The default is N.

N No adjustment

P Hold the monthly peak

V Hold the monthly peak and valley

D Adjust the daily loads while holding the daily peak

4.2.2 Area Month-to-Annual Ratios (LOD-MTAR)

```
&LOD-MTAR-01      MAR
 *                      MONTH-TO-ANNUAL-RATIOS
 *--------------------------------------------------------------
 *
   EFFECTIVE YEAR                          YYYY :

   AREA NAME                           AAAAAAAA  : AREA-C
   LFU LOAD LEVEL                             I  : =

   USE FOLLOWING RATIOS TO CALCULATE
   MONTHLY PEAK LOADS ?  (.INTRAT.)        Y/N  :  Y
 *
 *--------------------------------------------------
 *        MONTH TO           MONTHLY
 *      ANNUAL RATIO      TARGET ENERGY
 *         (P.U.)            (MWH)
 *--------------------------------------------------
 *        .RATIO.            .TARENG.
 *--------------------------------------------------
 *           #                   #
 *       ---------         -----------
   JAN :      0.900              0.000
   FEB :      0.800              0.000
   MAR :      0.700              0.000
   APR :      0.800              0.000
   MAY :      0.900              0.000
   JUN :      0.950              0.000
   JUL :      1.000              0.000
   AUG :      0.850              0.000
   SEP :      0.800              0.000
   OCT :      0.750              0.000
   NOV :      0.800              0.000
   DEC :      0.850              0.000

 ;;;; END OF &LOD-MTAR-00 ;;;;
```

Area Name

Enter the abbreviated area name.

LFU Load Level

If you are using different load shapes to model the effects of load forecast uncertainty, specify the LFU load level for which the data applies. If inputting data for the base or expected load model, input a load level of 0 (default).

Monthly Peak Load?

Enter Y to have the program use the month-to-annual ratios input on this table to calculate the monthly peak loads. If N is input, the program will ignore the ratios on this table and use the ratios from the input hourly loads. The default is N.

Month to Annual Ratio (P.U.)

Input the per unit month-to-annual ratios to use to calculate the monthly peak loads from the annual peak.

Monthly Target Energy (MWh)

Enter the monthly target energies in MWh. If both the annual (table LOD-DATA) and monthly targets are input, the annual values will be used and the monthly targets will be ignored. Input 0 for the annual values to use the monthly values.

If the input energy is 0, the loads will be adjusted to meet the specified peak but no energy adjustment will be done. The monthly energy will grow at the same rate as the peak load, and the load factor will not change.

4.2.3 Load Forecast Uncertainty, System Basis (LOD-UNCY-00)

MARS will include the effects of load forecast uncertainty (LFU) by calculating the reliability measures for up to 10 different load levels and computing a weighted-average value based on the input probabilities. Convergence testing will be based on the weighted-average value of the specified measure. Only the weighted-average value of the measures will be written to the histogram files.

If you are using the option to specify hourly load profiles by LFU load level, the LFU multipliers will be applied to the corresponding LFU load shapes.

```
&LOD-UNCY-00      LDU
 *                LOAD-FORECAST-UNCERTAINTY
 *---------------------------------------------------
 *                   LOAD
 *   LOAD         MULTIPLIER          PROBABILITY
 *   LEVEL          (P.U.)              (P.U.)
 *---------------------------------------------------
 *                 .PULODX.            .PRBLDX.
 *---------------------------------------------------
 *                    #                   #
 *                 --------            --------
       1 :           1.03                0.25
       2 :           1.00                0.50
       3 :           0.97                0.25
       4 :
       5 :
       6 :
       7 :
       8 :
       9 :
      10 :

;;;; END OF &LOD-UNCY-00 ;;;;
```

Load Multiplier (p.u.)

Input the per unit multipliers for computing the loads for which to calculate the reliability measures. The default is 1.0 for the first load level and 0.0 for the remaining load levels.

Probability (p.u.)

Enter the per unit probability of the load level occurring. The probabilities must sum to 1.0. The default is 1.0 for the first load level and 0.0 for the remaining load levels.

4.2.4 Load Forecast Uncertainty, Area Basis (LOD-UNCY-01)

This table can be used to specify load forecast uncertainty by area and month. A single set of probabilities applies to the per-unit variations in load of all of the areas. Unlike the multipliers that can change monthly, the probabilities can be overridden only at the start of the year. As with the previous table, the probabilities must sum to 1.0. Also, the per-unit load multipliers must be in descending order. The number of load levels being modeled is determined from the last non-zero probability in the general data (data without an override date) and cannot change during the study.

If probabilities are not input on this table (LOD-UNCY (Area)), the program will use the values (if any) from the previous table (LOD-UNCY (System)). If per unit multipliers for the load levels were not input on this table for a given area, the program will assign to that area the values (if any) from the previous table.

If you are using the option to specify hourly load profiles by LFU load level, the LFU multipliers will be applied to the corresponding LFU load shapes.

```
&LOD-UNCY-01      LU1
 *                                                     LOAD-FORECAST-UNCERTAINTY
 *
 *     To specify the probabilities associated with each load level, input PROB for the AREA NAME
 *
 *                  AREA
 *  EFFECTIVE       NAME        - - - - - - - - - - - - - LOAD MULTIPLIER OR LOAD LEVEL PROBABILITY (PU) - - - - - - - - - - - -
 *    DATE        OR 'PROB'        1         2         3         4         5         6         7         8         9        10
 *-----------------------------------------------------------------------------------------------------------------------------
 *                                                                      .PULOAD.    .PROBLD.
 *-----------------------------------------------------------------------------------------------------------------------------
 *   MMMYYYY       AAAAAAAA        #         #         #         #         #         #         #         #         #         #
 *   -------       --------     -------   -------   -------   -------   -------   -------   -------   -------   -------   -------
                   PROB          0.06      0.24      0.40      0.24      0.06

                   AREA-A        1.02      1.01      1.00      0.99      0.98
                   AREA-B        1.02      1.01      1.00      0.99      0.98
                   AREA-C        1.05      1.03      1.00      0.97      0.94
                   AREA-D        1.06      1.04      1.00      0.96      0.92
                   AREA-E        1.06      1.04      1.00      0.96      0.92

 ;;;; END OF &LOD-UNCY-01 ;;;;
```

Area Name or `PROB`

Enter the abbreviated are name for which the load multipliers are to be input. If you are entering the probabilities associated with the load level, input the word `PROB`.

Load Multiplier or Load Level Probability (p.u.)

If an area name was entered in the previous column, input the per unit multipliers for this area for computing the loads for which to calculate the reliability measures. The default is 1.0 for the first load level and 0.0 for the remaining load levels.

If `PROB` was input in the previous column, enter the per unit probability of the load level occurring. The probabilities must sum to 1.0. The default is 1.0 for the first load level and 0.0 for the remaining load levels.

Probabilities cannot be overridden through time, and attempting to do so will cause a warning to be printed.

4.2.5 Load Forecast Uncertainty, Hourly Basis (LOD-UNCH-00)

This table can be used to specify load forecast uncertainty (LFU) multipliers by area, month, and hour of day. The values entered in this table will override any data entered in table LOD-UNCY-01 for a specific area and LFU level combination.

Probability values for LFU levels need to be entered in table LOD-UNCY (Area).

```
&LOD-UNCH-00      LUH     CONTINUATION     ASTERISK
*                    LOAD-FORECAST-UNCERTAINTY-WITH-HOURLY-VALUES
*-------------------------------------------------------------------------------------
*     EFFECTIVE DATE    AREA NAME      LFU         LOAD MULTIPLIER OR LOAD LEVEL
*                                     LEVEL              PROBABILITY (P.U.)
*-------------------------------------------------------------------------------------
*                                                            .PRBLDX.
*-------------------------------------------------------------------------------------
*        MMMYYYY        AAAAAAAA       III     ######## ######## ######## ########
*        -------        --------       ---     -------- -------- -------- --------
                        AREA-A          1       12*1.00   8*1.02   4*1.00
                        AREA-A          2       12*1.00   8*1.01   4*1.00
                        AREA-A          3       12*1.00   8*1.00   4*1.00
                        AREA-A          4       12*1.00   8*1.99   4*1.00
                        AREA-A          5       12*1.00   8*1.98   4*1.00

                        AREA-B          1       12*1.00   8*1.02   4*1.00
                        AREA-B          2       12*1.00   8*1.01   4*1.00
                        AREA-B          3       12*1.00   8*1.00   4*1.00
                        AREA-B          4       12*1.00   8*1.99   4*1.00
                        AREA-B          5       12*1.00   8*1.98   4*1.00

;;;; END OF LOD-UNCH-00 ;;;;
```

Area Name

Enter the abbreviated area name. In addition to area name, you may also enter a valid pool or area group name.

In case of multiple rows being applicable to a given area, MARS will first attempt to find the data provided with the area name. If none is available, MARS will look for data for the pool. If that is not available, MARS will look for all the area groups that include the area and select the first one that matches (the order is determined by the entries in GEN-ARGP).

If no valid entries are found, the data defaults to the values in the LOD-UNCY (Area) table for all hours of the year.

LFU Level

Enter the LFU level number. It may not be empty or zero.

Load Multiplier or Load Level Probability (p.u.)

Input the per unit multipliers for a given area and LFU combination. Any missing data will default to the values assumed in the LOD-UNCY (Area) table.

The values can be entered for a typical day (24 hourly values) or for a typical week (168 hourly values). Please use one option (either typical day or typical week) for each area.

4.3 Unit Data

All of the units on the system, except for the firm contracts, are listed in this table. It is a good practice to include in this list all of the units that you may want to model at some time during the study, even if they are not all needed for a particular run. MARS uses a random number generator for each thermal unit to determine the availability of the unit through time. Keeping this list constant for the duration of a study allows for repeatability between runs by ensuring that each unit whose outage characteristics have not been changed will experience the same stream of random events as in previous runs.

Additional data from other tables will be read depending on the unit type. Data describing the thermal units are input on tables UNT-MXCP, MNT-UNOP-00, and MNT-FIXD. Type 1 energy-limited units and cogeneration (described below) are modeled as thermal units and require the data included in these tables.

Data for unit forced outage data are input on tables UNT-CAPS, UNT-TRNS, and UNT-FORS. This data is required for thermal units and optional for non-thermal units.

If you are modeling forced outages on the interface ties between areas (as defined on table INF-DATA), the interface capacity states are also input on table UNT-CAPS, and the forced outage rate data is input on table UNT-TRNS or UNT-FORS.

Energy-limited units can be modeled in one of two ways. A Type 1 energy-limited unit is modeled as a thermal unit with an outage probability distribution that describes the energy limit. For this type of unit, you must supply all of the data required for a thermal unit as well as the outage probability distribution (table ELU-DIST and, optionally, table ELU-STEP).

For a Type 2 and 3 energy-limited unit, you specify a minimum rating, a maximum rating, and a monthly energy (table MOD-ELMW). The program will deterministically schedule the energy for Type 2 energy-limited units against the user-specified loads (table MOD-ELLD).

Cogeneration is modeled as a thermal unit with an associated hourly load demand (table MOD-CGMW-00). Type 1 cogeneration units are those for which the system will provide back-up if the unit is not able to meet its own load demand. Type 2 cogeneration units receive no system back-up, and so the cogeneration load will not be met if the unit itself cannot serve it.

Energy storage units are modeled through charge/discharge cycles of energy into a reservoir. The parameters are entered in table MOD-ESMW.

Hourly profile units are modeled as a net hourly load modification specified for a typical week (table MOD-MDMW). Demand-side management units can also be constructed from a combination of input hourly shapes (tables MOD-SHAP-03 and MOD-PENE).

Type 2 energy-limited units and hourly profile units are also used for modeling contracts between areas. With the exception of identifying these units as contracts by inputting `CONTRACT` as the area name, the data for these contract units would be specified the same as for other units of these types. Additional contract-related data, such as the sending and receiving areas and the assigned transfer paths, are input on table FCT-DATA.

Contracts can also be tied to the status and capacity of other units in the system, by using the table FCT-UNIT.

4.3.1 General Unit Data (UNT-DATA)

```
&UNT-DATA-00     UGD
*                                              UNIT-GENERAL-DATA
*------------------------------------------------------------------------------------------------------------------------------
*                                                                    UNIT TYPE
*                                                                 TH  = THERMAL
*                                                                 EL1 = TYPE 1 ENERGY-LTD
*                                                                 EL2 = TYPE 2 ENERGY-LTD
*                                                                 CG1 = TYPE 1 COGEN         NUMBER OF UNITS
*                                                                 CG2 = TYPE 2 COGEN            IN PLANT           UNIT
*      UNIT          AREA          INSTALLATION       RETIREMENT  ES  = ENERGY STORAGE      (EL2, ES, AND DS      SUMMARY
*      NAME          NAME              DATE              DATE     DS  = DEMAND-SIDE           UNITS ONLY)          TYPE
*-------------------------------------------------------------------------------------------------------------------------------
*    .NAMES.       .IAREA.       .INSTDY..INSTYR.  .IRETDY..IRETYR.        .IUNTYP.             .NUNPD..NUNPS..NUNHM.     .IUNSUM.
*-------------------------------------------------------------------------------------------------------------------------------
*    AAAAAAAA      AAAAAAAA         DDMMMYYYY        DDMMMYYYY              AAA                        III               AAAAAAAA
*    --------      --------         ---------        ---------              ---                        ---               --------
     UNIT-5A       AREA-A             JAN1980          JAN2050              CG1                        =                 COGEN
     UNIT-7A       AREA-A           15JUN2016          JAN2050              TH                         =                 C.T.
     UNIT-9A       AREA-A             JAN1980          JAN2050              EL2                        3                 HYDRO

     UNIT-1B       AREA-B             JAN1980          DEC2015              TH                         =                 C.T.
     UNIT-10B      AREA-B             JAN1980          JAN2050              EL1                        1                 FOSSIL-S

     UNIT-2C       AREA-C             JAN1980        01OCT2017              TH                         =                 C.T.
     UNIT-7C       AREA-C             JAN1980          JAN2050              CG2                        =                 COGEN
     UNIT-8C       AREA-C             JAN1980          JAN2050              EL2                        4                 HYDRO
     UNIT-9C       AREA-C             JAN1980          JAN2050              EL1                        =                 FOSSIL-S

     UNIT-5D       AREA-D             JAN1980          JAN2050              ES                         1                 E.S.

     UNIT-1E       AREA-E             JAN1980          JAN2050              DS                         1                 DSM

     CONT-C-D      CONTRACT           JAN1980          JAN2050              DS                         1                 CONTRACT

     WIND-01       AREA-A           15MAY2014          JAN2050              DS                         1                 WIND

;;;; END OF &UNT-DATA-00 ;;;;
```

Unit Name

Enter a unique name (maximum of eight characters) for each unit in the system. Unit Name, when referred to in other input tables, corresponds to this eight-character name.

Area Name

Enter the abbreviated name of the area in which the unit is located. If the unit is being used to model a contract between areas (it's type must be DS or EL2), enter `CONTRACT` for the area name. Additional contract data will be input on table FCT-DATA.

Installation Date

Input the date (`DDMMMYYYY` format) on which the unit is installed. The default is 0 which indicates that the unit is installed before the start of the study.

Retirement Date

Input the date (`DDMMMYYYY` format) on which the unit is retired. The default is 0 which indicates that the unit is retired before the start of the study.

Note A unit is removed from service at the beginning, not the end, of its retirement date, and will not be available on its retirement date.

Unit Type

Enter the two- or three-character code which describes the unit's type.

TH Thermal

EL1 Type 1 energy-limited (probabilistic)

EL2 Type 2 energy-limited (deterministic)

EL3 Type 3 energy-limited (as needed)

CG1 Type 1 cogeneration (system back-up)

CG2 Type 2 cogeneration (no system back-up)

ES Energy storage

DS Demand-side management (i.e., hourly profiles)

Number of Units in Plant (EL2, EL3, ES and DS Units Only)

For maintenance scheduling, non-thermal unit types (Type 2 and Type 3 energy-limited, energy storage, and demand-side management)will be split into identical units based on the number of units in each plant. All other data will be input on a plant basis with the exception of fixed daily maintenance which is specified by unit (table MNT-FDMD).

Enter the number of units into which each plant is to be split. The default is 1.

This input is not used for the thermal units (including Type 1 energy-limited and cogeneration); however, an entry should be made in this column (1 or =).

Unit Summary Type

Units can be grouped by unit summary types that are defined by the user on table GEN-UNTY. This unit type is used only for generating the summaries of installed capacity by month that appear on file code 07 and should not be confused with the unit type used to identify a unit as thermal, Type 1 energy-limited, etc. Enter the unit summary type from table GEN-UNTY associated with each unit. If a unit is not assigned a type, it will assigned to the last available (not necessarily defined) unit type and a warning will be written to file 06.

4.3.2 Additional Unit Information (UNT-INFO)

```
&UNT-INFO-00     UIF
*                                                 ADDITIONAL-UNIT-INFORMATION
*--------------------------------------------------------------------------------------------------------------------------
*     UNIT NAME                  LONG NAME                     PIVOT TYPE           LOCATION         LATITUDE     LONGITUDE
*--------------------------------------------------------------------------------------------------------------------------
*
*--------------------------------------------------------------------------------------------------------------------------
*      AAAAAAAA      AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA      AAAAAAAAAAAAAAA      AAAAAAAAAAAAAAA      ########      ########
*      --------      --------------------------------      ---------------      ---------------      --------      --------
      "UNIT-5A "    "THIS IS UNIT 5 A                "    "COMB. CYCLE    "    "NEW YORK       "      42.8099      -73.9560

;;;; END OF UNT-INFO-00 ;;;;
```

Unit Name

Enter the name of the unit.

Long Name

Optionally, enter the long name for the unit, up to 32 characters.

Pivot type

Optionally, enter a character to identify the unit type. This is merely for reporting and completely separate from the unit summary set in UNT-DATA. The string can be up to 15 characters long.

Location

Optionally, enter a string to describe the location of a unit, up to 15 characters.

Latitude

Optionally, enter the unit's latitude (defaults to 0).

Longitude

Optionally, enter the unit's longitude (defaults to 0).

4.4 Thermal Unit Data

4.4.1 Thermal Unit Maximum Capacity (UNT-MXCP)

```
&UNT-MXCP-00      UMC
*              UNIT-MAXIMUM-CAPACITY-DATA
*--------------------------------------------------
*                                 MAXIMUM
*  EFFECTIVE         UNIT         RATING
*    DATE            NAME          (MW)
*--------------------------------------------------
*                                  .CAP.
*--------------------------------------------------
*   MMMYYYY        AAAAAAAA          #
*   -------        --------      ---------
                   UNIT-1A           36
                   UNIT-21A         200
                   UNIT-22A         350
                   UNIT-23A         400
                   UNIT-24A         200

;;;; END OF &UNT-MXCP-00 ;;;;
```

Name

Enter the name of the thermal unit (this includes Type 1 energy-limited and cogeneration units).

Maximum Rating (MW)

Input the maximum capacity of the unit in MW.

4.4.2 Thermal Unit Capacity Derations (UNT-DERT)

A unit's maximum capacity can be derated as a function of the hourly area load (as adjusted by the load forecast uncertainty multipliers), which can serve as an indicator of ambient temperature. Up to five pairs of loads and capacity multipliers can be input for each unit.

```
&UNT-DERT-00      UDR
*                                                     UNIT-CAPACITY-DERATIONS
*-----------------------------------------------------------------------------------------------------------------------------
*                                       *******************  Unit Capacity Adjustment as Function of Load  *******************
*  EFFECTIVE     UNIT        AREA                CAP.                CAP.                CAP.                CAP.                CAP.
*    DATE        NAME        NAME       LOAD    MULT.       LOAD    MULT.       LOAD    MULT.       LOAD    MULT.       LOAD    MULT.
*-----------------------------------------------------------------------------------------------------------------------------
*   MMMYYYY    AAAAAAAA    AAAAAAAA    ######  ######      ######  ######      ######  ######      ######  ######      ######  ######
*                                                                         .DRTLD.    .DRTMLT.
*------------------------------------------------------------------------------------------------------------------------------
*   MMMYYYY    AAAAAAAA    AAAAAAAA    ######  ######      ######  ######      ######  ######      ######  ######      ######  ######
*   -------    --------    --------    ------  ------      ------  ------      ------  ------      ------  ------      ------   ------
               UNIT-1A     AREA-A        4500    0.95        4750    0.90        5000    0.85

;;;; END OF &UNT-DERT-00 ;;;;
```

Name

Enter the name of the thermal unit (this includes Type 1 energy-limited and cogeneration units).

Area Name

Enter the name of the area whose hourly load will be used to determine the amount of deration.

Load

Enter the load in MW or per unit above which the corresponding capacity multiplier will apply. (A value less than 2 will be interpreted as a per unit value.) The loads must be input in increasing order.

Capacity Multiplier (Cap. Mult.)

Enter the per unit capacity multiplier that will be applied to the unit's maximum capacity to determine its derated rating when the specified area load is above the corresponding value.

Up to five pairs of loads and capacity multipliers can be specified for each unit.

Note The units for which derations will be calculated and the number of deration levels for each unit is determined at the beginning of the run from the general data (data without an override date).

4.5 Unit and Interface Outage data

4.5.1 Capacity States (UNT-CAPS)

```
&UNT-CAPS-00      UCS
*                                                   CAPACITY-STATE-DATA
*------------------------------------------------------------------------------------------------------------------------
*                            RATING OF EACH CAPACITY STATE IN PER UNIT OF MAXIMUM RATING (STATE 1 IS THE FULLY UP STATE)
*            NAME            1        2        3        4        5        6        7        8        9        10       11
*------------------------------------------------------------------------------------------------------------------------
*                                                              .STATPU.
*------------------------------------------------------------------------------------------------------------------------
*  YYYY     AAAAAAAA         #        #        #        #        #        #        #        #        #        #        #
*  ----     --------      -------  -------  -------  -------  -------  -------  -------  -------  -------  -------  -------
            UNIT-1A       1.0000   0.00000
            UNIT-21A      1.0000   0.50000  0.00000
            UNIT-22A      1.0000   0.65000  0.30000  0.00000
            UNIT-23A      1.0000   0.80000  0.60000  0.30000  0.00000
            UNIT-24A      1.0000   0.50000  0.00000
            UNITPERF      1.0000

;;;; END OF &UNT-CAPS-00 ;;;;
```

Name

Enter the name of the unit or interface. This data is required for thermal units (this includes Type 1 energy-limited and cogeneration units) and is optional for non-thermal units (only EL3 and ES units are currently supported).

Rating of Each Capacity State in Per Unit of Maximum Rating

For each unit or interface, enter the ratings of its capacity states as a per unit of the its maximum capacity. The capacity states must be in descending order, with the unit or interface being fully available in state 1. A maximum of 11 capacity states is allowed.

Perfect units can be defined by entering a single state, with full availability.

4.5.2 Transition Rates (UNT-TRNS)

MARS uses transition rates to model the forced outages on the generating units and interface ties. The transition rate gives the number of transitions from one state to any other state per unit of time in the originating state. A more detailed description of transition rates can be found in the discussion on units in Section 2 of this manual.

```
&UNT-TRNS-00     UTR    CONTINUATION
*                                                   TRANSITION-RATE-DATA
*----------------------------------------------------------------------------------------------------------------------------------
*                  NUMBER
* EFFECTIVE           OF    FROM   - - - - - - - - - - - - - - -    TRANSITION RATE TO STATE    - - - - - - - - - - - - - - - - -
*   DATE     NAME   STATES  STATE    1        2        3        4        5        6        7        8        9       10       11
*----------------------------------------------------------------------------------------------------------------------------------
*                                                                             .TRNSRT.
*----------------------------------------------------------------------------------------------------------------------------------
*  MMMYYYY AAAAAAAA   I      I       #        #        #        #        #        #        #        #        #        #        #
*  ------- -------- ---    ---   -------  -------  -------  -------  -------  -------  -------  -------  -------  -------  -------
           UNIT-1A    2      1      0.0     .000340
+                            2     .016667    0.0
           UNIT-21A   3      1     0.0     0.00125   0.00125
+                            2     0.0     0.0       0.00667
+                            3     0.04    0.0       0.0
           UNIT-22A   4      1     0.0     0.00111   0.00111   0.00111
+                            2     0.0     0.0       0.00571   0.00571
+                            3     0.0     0.01      0.0       0.01
+                            4     0.04    0.0       0.0       0.0
           UNIT-23A   5      1     0.0     0.00125   0.00125   0.0    0.00125
+                            2     0.0     0.0       0.005     0.0    0.005
+                            3     0.0     0.0       0.0       0.01   0.01
+                            4     0.0     0.02      0.0       0.0    0.02
+                            5     0.03    0.0       0.0       0.01   0.0

;;;; END OF &UNT-TRNS-00 ;;;;
```

Name

Enter the name of the unit or interface.

Number of States

Input the number of capacity states being used to model the unit or interface. This must be consistent with the data in table UNT-CAPS. You must input for each unit or interface as many rows and columns of data as the number of states being modeled.

From State

Enter the originating state for the transition rates which follow on this line. The FROM states must be input in ascending order.

Transition Rate to State...

Input the transition rates to go from the FROM state to each of TO states. The name and number of states is entered once for each unit or interface. Subsequent rows for the unit or interface are entered with a continuation character (+) in the line-zone (column 1 or 2), followed by the From state and the associated transition rates.

If overriding this data, you must re-enter all of the data for the unit or interface; you cannot override just selected rows.

4.5.3 Forced Outage Rates (UNT-FORS)

If state transition rates are not available, MARS will calculate approximate transition rates from the partial forced outage rates for the units or interfaces and a matrix that contains the number of transitions between pairs of states (table GEN-CASE). The assumed number of transitions between states will have an impact on the frequency and duration indices calculated by the program.

```
&UNT-FORS-00     UFO    CONTINUATION     ASTERISK
*                                                    FORCED-OUTAGE-RATE-DATA
*----===---------------------------------------------------------------------------------------------------------------------------
*  EFFECTIVE               TRANSITION   - - - - - - - - - - - - PARTIAL FORCED OUTAGE RATE FOR CAPACITY STATE - - - - - - - - - - - - - -
*    DATE          NAME      MATRIX        1        2        3        4        5        6        7        8        9       10       11
*----===---------------------------------------------------------------------------------------------------------------------------
*                           .ITRNSM.                                                      .FORSEC.
*---===----------------------------------------------------------------------------------------------------------------------------
*    MMMYYYY    AAAAAAAA       I           #        #        #        #        #        #        #        #        #        #        #
*    -------    --------      ---       -------  -------  -------  -------  -------  -------  -------  -------  -------  -------  -------
               UNIT-15D        1         0.04
               UNIT-16D        1         0.04
               UNIT-17D        2         0.20     0.05
               UNIT-18D        2         0.20     0.05
               UNIT-19D        3         0.28     0.14     0.06

;;;; END OF &UNT-FORS-00 ;;;;
```

Name

Enter the name of the unit or interface.

Transition Matrix

Input the number of the transition matrix from table NUM-TRNS to be used in computing the transition rates for the unit or interface.

Partial Forced Outage Rate for Capacity State

Enter the partial forced outage rate (in per unit) for each capacity state being modeled for the unit or interface. The partial forced outage rates must be greater than zero for all capacity states except for the last one. The partial forced outage rate for a state must be less than or equal to that of the previous state.

Section 2.4.5 includes an example showing the calculation of partial forced outage rates from data on the amount of time that a unit spends in each capacity state.

4.5.4 Number of State Transitions (NUM-TRNS)

To calculate state transition rates from partial forced outage rates (table GEN-CASE), the program needs the number of transitions that occur between pairs of capacity states during the year. On this table you can define up to 25 matrices showing the number of transitions between pairs of states for typical units with differing numbers of capacity states.

```
&NUM-TRNS-00      NTR     CONTINUATION
*                                                   STATE-TRANSITION-DATA
*-----------------------------------------------------------------------------------------------------------------------------
*                              NUMBER
*  EFFECTIVE      TRANSITION     OF        FROM          - - - - - - - - - - - -  NUMBER  OF  TRANSITIONS  TO  STATE  - - - - - - - - - - - -
*    DATE           MATRIX     STATES      STATE          1       2       3       4       5       6       7       8       9      10      11
*-----------------------------------------------------------------------------------------------------------------------------
*                                                                                     .NUMTRN.
*-----------------------------------------------------------------------------------------------------------------------------
*   MMMYYYY            I           I          I           I       I       I       I       I       I       I       I       I       I       I
*   -------          -----       -----      -----       -----   -----   -----   -----   -----   -----   -----   -----   -----   -----   -----
                       1           2          1           0       7
+                                             2           7       0

                       2           3          1           0       3       3
+                                             2           0       0       3
+                                             3           6       0       0

                       3           4          1           0       2       2       4
+                                             2           0       0       3       3
+                                             3           0       2       0       3
+                                             4           8       2       0       0

;;;; END OF &NUM-TRNS-00 ;;;;
```

Transition Matrix

Enter the identification number which is used to assign this transition matrix to a specific unit (table UNT-FORS). The number must be from 1 to 25.

Number of States

Input the number of capacity states being modeled by this transition matrix. You must input as many rows and columns of data as the number of states being modeled.

From State

Enter the originating state for the transition values which follow on this line. The FROM states must be input in ascending order.

Number of Transitions to State...

Enter the number of transitions per year from the FROM state to each of the TO states.

The transition matrix number and number of states is entered once for each matrix. Subsequent rows for the unit are entered with a continuation character (+) in the line-zone (column 1 or 2), followed by the From state and the associated number of transitions.

If overriding this data, you must re-enter all of the data for the matrix; you cannot override just selected rows.

4.6 Maintenance Data

4.6.1 Unit Maintenance Data and Options (MNT-UNOP-00)

The amount of planned maintenance time required by the units can be specified in several ways. Maintenance cycles which vary the maintenance requirements from year to year can be input (tables MNT-PLOR-00 and MNT-WEEK-00) and assigned to the individual units. The number of weeks of maintenance can also be specified by unit. A final option uses the maintenance schedule developed by a previous run of the program (table MNT-OPTN), which can then be modified for specific units using any of the maintenance options.

```
&MNT-UNOP-00     UMO
*                                                  UNIT-MAINTENANCE-OPTIONS
*------------------------------------------------------------------------------------------------------------
*                                                MAINTENANCE
*                                                 WEEKS OR
*                                                   CYCLE          STARTING        MAINT       MAINT
*                           OVERRIDE MAINT.    0 = NO MAINT.      POSITION IN     WINDOW      WINDOW
*   EFFECTIVE      UNIT       SCHED. FROM     <0 = # OF WEEKS    MAINT. CYCLE     START       STOP
*     YEAR         NAME       INTERFACE ?     >0 = CYCLE #          (1-7)         DATE        DATE
*------------------------------------------------------------------------------------------------------------
*                             .NMAINT.          .MCYCLM.          .MPOSM.        .WIND1.     .WIND2.
*                             .NMNTPS.          .MCYCPS.          .MPSMPS.       .W1DTPS.    .W2DTPS.
*                             .NMNTHM.          .MCYCHM.          .MPSMHM.       .W1DTHM.    .W2DTHM.
*                             .NMNTPD.          .MCYCPD.          .MPSMPD.       .W1DTPD.    .W2DTPD.
*------------------------------------------------------------------------------------------------------------
*     YYYY      "AAAAAAAA"       Y/N               III               I            DDMMM       DDMMM
*     ----       --------        ---               ---              ---           -----       -----
                 UNIT-3A          N                 0                1              =           =
                 UNIT-8A          N                 2                1              =           =
                 UNIT-9A          N                 5                2            01JUL       15AUG
                 UNIT-10A         N                 6                1              =           =
                 UNIT-11A         N                 3                1            01SEP       31OCT
                 UNIT-12A         N                 3                1              =           =
                 UNIT-13A         N                 3                1            01MAR       30APR
                 UNIT-24A         N                -6                1              =           =
                 UNIT-4C          N                 5                3              =           =
                 UNIT-24C         N                -5                1              =           =

;;;; END OF &MNT-UNOP-00 ;;;;
```

Unit Name

Enter the name of the unit.

Override Maintenance Schedule from Interface?

If the maintenance schedule from a previous run is being read, you may wish to override the schedule for selected units. If so, enter Y. The default is N.

Maintenance Weeks or Cycle

0 No Maintenance

<**0** Number of Weeks

>**0** Cycle Number

Enter 0 to indicate that no automatic maintenance will be scheduled for the unit.

Enter a number less than 0 to indicate the number of weeks of maintenance to be scheduled during the year. For example, if you input -4, the program will schedule 4 weeks of maintenance for the unit.

Enter a number greater than 0 to indicate the maintenance cycle to be used. Table MNT-OPTN specifies whether the planned outage rate cycles (MNT-PLOR-00 or MNT-PLOR-01) or weeks of maintenance cycles (MNT-WEEK-00 or MNT-WEEK-01) are to be used.

Note The program does not schedule automatic maintenance on units representing contracts, and does not include the capacity of these units in the automatic maintenance calculations. However, fixed daily maintenance can be specified for these units.

Starting Position in Maintenance Cycle

Each planned outage and weekly maintenance cycle can be up to seven years long. Enter a number from 1 to 7 to indicate the unit's position in the cycle at the start of the study. The default is 1.

Maintenance Window Start Date

A maintenance window, which is the time period during which automatic maintenance will be scheduled by the program, may be designated for each unit. Enter the first day of the maintenance window in `DDMMM` format.

Maintenance Window Stop Date

Enter the last day of the maintenance window in `DDMMM` format.

4.6.2 Unit Maintenance Data and Options (MNT-UNOP-01)

The amount of planned maintenance time required by the units can be specified in several ways. Maintenance cycles which vary the maintenance requirements from year to year can be input (tables MNT-PLOR-00 and MNT-WEEK-00) and assigned to the individual units. The number of weeks of maintenance can also be specified by unit. A final option uses the maintenance schedule developed by a previous run of the program (table MNT-OPTN), which can then be modified for specific units using any of the maintenance options.

```
&MNT-UNOP-00     UMO
*                                                 UNIT-MAINTENANCE-OPTIONS
*-------------------------------------------------------------------------------------------------------------------
*                                               MAINTENANCE
*                                                WEEKS OR
*                                                  CYCLE        NUMBER     STARTING        MAINT        MAINT
*                            OVERRIDE MAINT.    0 = NO MAINT.     OF      POSITION IN      WINDOW       WINDOW
*   EFFECTIVE      UNIT        SCHED. FROM     <0 = # OF WEEKS            MAINT. CYCLE     START        STOP
*     YEAR         NAME        INTERFACE ?     >0 = CYCLE #    OUTAGES       (1-7)          DATE         DATE
*-------------------------------------------------------------------------------------------------------------------
*                              .NMAINT.          .MCYCLM.                  .MPOSM.        .WIND1.      .WIND2.
*                              .NMNTPS.          .MCYCPS.                  .MPSMPS.       .W1DTPS.     .W2DTPS.
*                              .NMNTHM.          .MCYCHM.                  .MPSMHM.       .W1DTHM.     .W2DTHM.
*                              .NMNTPD.          .MCYCPD.                  .MPSMPD.       .W1DTPD.     .W2DTPD.
*-------------------------------------------------------------------------------------------------------------------
*     YYYY      "AAAAAAAA"       Y/N               III            III         I            DDMMM        DDMMM
*     ----       --------        ---               ---            ---        ---           -----        -----
                 UNIT-3A          N                 0              1          1              =            =
                 UNIT-8A          N                 2              1          1              =            =
                 UNIT-9A          N                 5              1          2            01JUL        15AUG
                 UNIT-10A         N                 6              3          1              =            =
                 UNIT-11A         N                 3              1          1            01SEP        31OCT
                 UNIT-12A         N                 3              1          1              =            =
                 UNIT-13A         N                 3              1          1            01MAR        30APR
                 UNIT-24A         N                -6              2          1              =            =
                 UNIT-4C          N                 5              1          3              =            =
                 UNIT-24C         N                -5              1          1              =            =

;;;; END OF &MNT-UNOP-00 ;;;;
```

Unit Name

Enter the name of the unit.

Override Maintenance Schedule from Interface?

If the maintenance schedule from a previous run is being read, you may wish to override the schedule for selected units. If so, enter Y. The default is N.

Maintenance Weeks or Cycle

0 No Maintenance

$<$**0** Number of Weeks

$>$**0** Cycle Number

Enter 0 to indicate that no automatic maintenance will be scheduled for the unit.

Enter a number less than 0 to indicate the number of weeks of maintenance to be scheduled during the year. For example, if you input -4, the program will schedule 4 weeks of maintenance for the unit.

Enter a number greater than 0 to indicate the maintenance cycle to be used. Table MNT-OPTN specifies whether the planned outage rate cycles (MNT-PLOR-00 or MNT-PLOR-01) or weeks of maintenance cycles (MNT-WEEK-00 or MNT-WEEK-01) are to be used.

Note The program does not schedule automatic maintenance on units representing contracts, and does not include the capacity of these units in the automatic maintenance calculations. However, fixed daily maintenance can be specified for these units.

Number of Outages

If maintenance cycle or weeks is < 0, the outage weeks specified will be divided by the number of outages. For example, -6 (6 weeks of maintenance) with 2 outages specified per year will be scheduled as 2 distinct 3 week outages.

If maintenance cycle or weeks > 0, and the cycle is defined in MNT-PLOR-00 or MNT-WEEK-00, the duration of the outages in the maintenance cycle will be divided by the number of outages. If MNT-PLOR-01 or MNT-WEEK-01 are used and the Outage number specified is 0, the cycle will be divided by the number of outages. If multiple outage numbers are specified in MNT-PLOR-01 or MNT-WEEK-01 and the number of outages associated with the cycle is less than that specified here, the number of outages here will be used. If the number of outages associated with the cycle is less than the number specified here, the number of outages of the cycle will be used.

Starting Position in Maintenance Cycle

Each planned outage and weekly maintenance cycle can be up to seven years long. Enter a number from 1 to 7 to indicate the unit's position in the cycle at the start of the study. The default is 1.

Maintenance Window Start Date

A maintenance window, which is the time period during which automatic maintenance will be scheduled by the program, may be designated for each unit. Enter the first day of the maintenance window in `DDMMM` format.

Maintenance Window Stop Date

Enter the last day of the maintenance window in `DDMMM` format.

4.6.3 Thermal Unit Fixed Daily Maintenance (MNT-FIXD)

For each unit being modeled as a thermal unit (including Type 1 energy-limited and cogeneration units), a maximum of five periods of planned outage can be specified during the year. The planned outage periods cannot coincide or overlap. In other words, there must be at least one day between the date that the first period ends and the date that the next period begins.

If fixed daily maintenance is specified for a unit, the program will not schedule any automatic maintenance for the unit. If maintenance is not being scheduled by the program (table MNT-OPTN), the fixed daily maintenance will still be modeled.

```
&MNT-FIXD-00      FMD
*                                       FIXED-DAILY-MAINTENANCE--THERMAL-UNITS
*-----------------------------------------------------------------------------------------------------------
*                               PERIOD 1         PERIOD 2         PERIOD 3         PERIOD 4         PERIOD 5
*  EFFECTIVE      UNIT        START   STOP     START   STOP     START   STOP     START   STOP     START   STOP
*    DATE         NAME        DATE    DATE     DATE    DATE     DATE    DATE     DATE    DATE     DATE    DATE
*-----------------------------------------------------------------------------------------------------------
*                                                           .MSTART. .MSTOP.
*-----------------------------------------------------------------------------------------------------------
*      YYYY     AAAAAAAA      DDMMM  DDMMM     DDMMM  DDMMM     DDMMM  DDMMM     DDMMM  DDMMM     DDMMM  DDMMM
*      ----     --------      -----  -----     -----  -----     -----  -----     -----  -----     -----  -----
                UNIT-24C      19MAR  15APR     01OCT  14OCT     01DEC  10DEC
                UNIT-11D      14MAY  03JUN
                UNIT-10E      19FEB  18MAR     01NOV  08NOV

;;;; END OF &MNT-FIXD-00 ;;;;
```

Unit Name

Enter the name of the thermal unit (this includes Type 1 energy-limited and cogeneration units).

Start Date

Enter the starting date of the maintenance period in DDMMM format.

Stop Date

Enter the stopping date of the maintenance period in DDMMM format. A unit is on outage on its stop date; it returns to service the following day.

4.6.4 Non-Thermal Unit Fixed Daily Maintenance (MNT-FDMD)

While most of the maintenance data for the non-thermal units (Type 2 energy-limited, energy storage, and demand-side management) is input by plant (table MNT-UNOP-00), the fixed daily maintenance can be specified separately for the individual units at a plant.

Unlike the thermal units that were limited to five planned outage periods, there is no limit on the number of maintenance periods for non-thermal units. If fixed daily maintenance is specified for a unit, the program will not schedule any automatic maintenance for the unit. If maintenance is not being scheduled by the program (table MNT-OPTN), the fixed daily maintenance will still be modeled.

```
&MNT-FDMD-00     FDM      CONTINUATION
*                                        FIXED-DAILY-MAINTENANCE--NON-THERMAL-UNITS
*--------------------------------------------------------------------------------------------------------------
*  EFFECTIVE    PLANT         UNIT          START   STOP        START   STOP        START   STOP        START   STOP
*     YEAR      NAME          NUMBER        DATE    DATE        DATE    DATE        DATE    DATE        DATE    DATE
*--------------------------------------------------------------------------------------------------------------
*              .NMPSH.     .LFXUPS.                             .MSTAPS.     .MSTOPS.     .LFXPPS.
*              .NMHRM.     .LFXUHM.                             .MSTAHM.     .MSTOHM.     .LFXPHM.
*              .NMPOND.    .LFXUPD.                             .MSTAPD.     .MSTOPD.     .LFXPPD.
*--------------------------------------------------------------------------------------------------------------
*     YYYY     AAAAAAAA       III           DDMMM   DDMMM       DDMMM   DDMMM       DDMMM   DDMMM       DDMMM   DDMMM
*     ----     --------       ---           -----   -----       -----   -----       -----   -----       -----   -----
               UNIT-8C         1            10JUN   23JUN
               UNIT-8C         2            24JUN   01JUL
               UNIT-1E         1            01APR   07APR       01AUG   08AUG       01NOV    08NOV

;;;; END OF &MNT-FDMD-00 ;;;;
```

Plant Name

Enter the plant name of the unit.

Unit Number

Enter the number of the unit within the plant. The number of identical units in each plant was input on table UNT-DATA.

Start Date

Enter the starting date of the maintenance period in DDMMM format.

Stop Date

Enter the stopping date of the maintenance period in DDMMM format. A unit is on outage on its stop date; it returns to service the following day.

4.6.5 Hourly Profile Capacities for Maintenance Scheduling (MNT-MDCP)

```
&MNT-MDCP-00      MDC
*          HOURLY-PROFILE-CAPACITY-FOR-MAINTENANCE-SCHEDULING
*-------------------------------------------------------------------
*   EFFECTIVE          UNIT          CAPACITY TO USE FOR
*     YEAR             NAME        MAINT. SCHEDULING (MW)
*-------------------------------------------------------------------
*                                    .CAPMES.    .CAPMDS.
*-------------------------------------------------------------------
*     YYYY           AAAAAAAA                #
*     ----           --------            ---------
                     UNIT-5D                50
                     UNIT-1E                10
                     UNIT-11E                0


;;;; END OF &MNT-MDCP-00 ;;;;
```

Unit Name

Enter the name of the hourly profile unit.

Capacity to use for Maintenance Scheduling (MW)

Enter the total plant capacity, in MW, to be used for maintenance scheduling. This capacity will be used to determine the capacity of the individual units at this plant, based on the number of units at the plant (table UNT-DATA)

4.6.6 Maintenance Scheduling Options (MNT-OPTN)

```
&MNT-OPTN-00      MOP
*                                                  MAINTENANCE-OPTIONS
*-----------------------------------------------------------------------------------------------------------------
*               READ/WRITE
*               MAINT. FILE                      SCHEDULE     USE PLANNED                 MAINTENANCE
*                N = NO        MAINTENANCE      MAINT. BY    OUTAGE RATE     ORDER       LOAD OPTION      ZERO OUT
*   EFFECTIVE    R = READ       SCHEDULED       AREA, POOL      CYCLE        MAINT.     O = ORIG. LOAD   FIXED MAINT.
*     YEAR       W = WRITE     BY PROGRAM ?      OR SYS.      MATRIX ?      BY MW ?    S = SPEC. LOAD     DATA ?
*-----------------------------------------------------------------------------------------------------------------
*                 .NTAPEM.      .NSCHED.         .MTACSW.       .MOPT.       .KSKED.       .INTRD.        .IZEROF.
*-----------------------------------------------------------------------------------------------------------------
*     YYYY           A            Y/N              AAAA          Y/N           Y/N           A              Y/N
*     ----           -            ---              ----          ---           ---           -              ---
                     N             Y               AREA           N             Y            O               Y


;;;; END OF &MNT-OPTN-00 ;;;;
```

Read/Write Maintenance File

N No

R Read

W Write

B Both

The maintenance schedule developed by the program (which includes fixed daily maintenance) can be written to a file (file code 15) for use by a subsequent run. An existing maintenance schedule can be read by the program (file code 14) and modified using any of the maintenance options, and a new maintenance schedule written out. You can specify on a unit basis whether the maintenance schedule that was read in is to be modified (table MNT-UNOP-00). The default is N.

Maintenance Scheduled by the Program

Enter Y to have the program automatically schedule the planned maintenance. If maintenance is not being scheduled by the program, the program will still read in and model the fixed daily maintenance from the input file along with the specified maintenance file. The default is Y.

Scheduled Maintenance by Area, Pool, or System

The program will schedule maintenance to levelize reserves on an area, pool, or system basis. Enter `AREA`, `POOL`, or `SYS`.

Use Planned Outage Rate Cycle Matrix?

Enter Y to have the program use the planned outage rate cycles (table MNT-PLOR-00) to determine the maintenance requirements for the units on table MNT-UNOP-00. Enter N to use the weeks of maintenance cycles (table MNT-UNOP-00). The default is N.

Order Maintenance by MW

The order in which the units will be scheduled for maintenance will be based on either the ratings of the units (enter Y) or the ratings times the required number of weeks of maintenance (enter N). The default is N.

Maintenance Load Option

O Original Load

S Specified Load

To schedule the maintenance, the program will use either the weekly peak loads from the original load model, or it will use a load model developed specifically for the maintenance scheduling (tables MNT-ANPK, MNT-RATI). The default is S.

Zero Out Fixed Maintenance Data

If you wish to input a new schedule of fixed daily maintenance each year, enter Y to specify that this data be cleared each year. The default is Y.

Note in versions prior to 3.18.4, the fixed maintenance data is zeroed only after a year has been modeled. So data in place at the beginning of the first year, even if it was override data from the previous year, will be used.

4.6.7 Cycles for Per Unit Planned Outage Rates (MNT-PLOR-00)

Planned outage rate cycles can be used to model the cyclic nature of the planned maintenance requirements of generating units. This table is used to define the cycles to be used. The cycles are assigned to individual units on table MNT-UNOP-00 or MNT-UNOP-01.

Whether the program uses the planned outage rate cycles or the weeks of maintenance cycles (table MNT-WEEK-00 or MNT-WEEK-01) is controlled through table MNT-OPTN.

```
&MNT-PLOR-00      POC
*                                                  PLANNED-OUTAGE-RATE-CYCLES
*------------------------------------------------------------------------------------------------------------
*                                                   PER UNIT PLANNED OUTAGE RATE
*           CYCLE          CYCLE YEAR   CYCLE YEAR   CYCLE YEAR   CYCLE YEAR   CYCLE YEAR   CYCLE YEAR   CYCLE YEAR
*             #                1            2            3            4            5            6            7
*------------------------------------------------------------------------------------------------------------
*                                                             .PORCYC.
*------------------------------------------------------------------------------------------------------------
*            III               #            #            #            #            #            #            #
*            ---           ---------    ---------    ---------    ---------    ---------    ---------    ---------
              1               0.1          0.1          0.15
              2               0.05
              3               0.083        0.083        0.083        0.167


 ;;;; END OF &MNT-PLOR-00 ;;;;
```

Cycle Number

Enter a number to identify the planned outage rate cycle. The program can model as many cycles as there are units.

Per Unit Planned Outage Rate

Enter the per unit planned outage rate for each year of the cycle. Each cycle can be up to seven years in length.

4.6.8 Cycles for Per Unit Planned Outage Rates (MNT-PLOR-01)

Planned outage rate cycles can be used to model the cyclic nature of the planned maintenance requirements of generating units. This table is used to define the cycles to be used. The cycles are assigned to individual units on table MNT-UNOP-00 or MNT-UNOP-01.

Whether the program uses the planned outage rate cycles or the weeks of maintenance cycles (table MNT-WEEK-00 or MNT-WEEK-01) is controlled through table MNT-OPTN.

```
&MNT-PLOR-01     POC
*                                                    PLANNED-OUTAGE-RATE-CYCLES
*-------------------------------------------------------------------------------------------------------------------------
*                                                           PER UNIT PLANNED OUTAGE RATE
*          CYCLE    OUTAGE     CYCLE YEAR   CYCLE YEAR   CYCLE YEAR   CYCLE YEAR   CYCLE YEAR   CYCLE YEAR   CYCLE YEAR
*            #      NUMBER         1            2            3            4            5            6            7
*-------------------------------------------------------------------------------------------------------------------------
*                                                                    .PORCYC.
*-------------------------------------------------------------------------------------------------------------------------
*           III       III          #            #            #            #            #            #            #
*           ---       ---      ---------    ---------    ---------    ---------    ---------    ---------    ---------
             1         0         0.05           =            =            =            =            =            =
             2         1         0.1          0.1          0.15           =            =            =            =
+                      2         0.2          0.2          0.05           =            =            =            =
             3         1         0.083        0.083        0.083        0.167            =            =            =
+                      2         0.167        0.083        0.083        0.083            =            =            =
+                      3         0.083        0.167        0.083        0.083            =            =            =

;;;; END OF &MNT-PLOR-01 ;;;;
```

Cycle Number

Enter a number to identify the planned outage rate cycle. The program can model as many cycles as there are units.

Outage Number

Enter a number to identify the planned outage number within the year. If the number of outages is specified as 0, the Planned Outage Rate will be evenly divided by the number of outages specified in MNT-UNOP-01. If the outage number is non-zero and more outages are specified in MNT-UNOP-01 than are specified in the cycle definition then the number of outages in the cycle will be used. If there are more outages in the cycle than there are specified in MNT-UNOP-01, the number of outages specified in MNT-UNOP-01 will be used.

The program can model as many cycles as there are units and up to 52 outages per cycle.

Per Unit Planned Outage Rate

Enter the per unit planned outage rate for each year of the cycle. Each cycle can be up to seven years in length.

4.6.9 Cycles for Weeks of Planned Maintenance (MNT-WEEK-00)

The cyclic nature of the planned maintenance requirements of generating units can also be input through cycles that specify the actual number of weeks of maintenance required during each year of the cycle. These cycles are defined in this table. The cycles are assigned to individual units on table MNT-UNOP-00 or MNT-UNOP-01. Whether the program uses the weeks of maintenance cycles or the planned outage rate cycles (table MNT-PLOR-00 or MNT-PLOR-01) is controlled through table MNT-OPTN.

```
&MNT-WEEK-00      WMC
*                                    WEEKS-OF-MAINTENANCE-CYCLES
*---------------------------------------------------------------------------------------------------------
*                                             NUMBER OF WEEKS OF MAINTENANCE
*       CYCLE     CYCLE YEAR   CYCLE YEAR   CYCLE YEAR   CYCLE YEAR   CYCLE YEAR   CYCLE YEAR   CYCLE YEAR
*         #            1            2            3            4            5            6            7
*---------------------------------------------------------------------------------------------------------
*                                                         .CYCLEM.
*---------------------------------------------------------------------------------------------------------
*        III           #            #            #            #            #            #            #
*        ---       --------     --------     --------     --------     --------     --------     --------
          1            1
          2            2
          3            3
          4            4
          5            1            2            3            4
          6            5            6            7            8


;;;; END OF &MNT-WEEK-00 ;;;;
```

Cycle Number

Enter a number to identify the planned outage rate cycle. The program can model as many cycles as there are units.

Number of Weeks of Maintenance

Enter the number of weeks of maintenance required during each year of the cycle. Each cycle can be up to seven years in length.

4.6.10 Cycles for Weeks of Planned Maintenance (MNT-WEEK-01)

The cyclic nature of the planned maintenance requirements of generating units can also be input through cycles that specify the actual number of weeks of maintenance required during each year of the cycle. These cycles are defined in this table. The cycles are assigned to individual units on table MNT-UNOP-00 or MNT-UNOP-01. Whether the program uses the weeks of maintenance cycles or the planned outage rate cycles (table MNT-PLOR-00 or MNT-PLOR-01) is controlled through table MNT-OPTN.

```
&MNT-WEEK-01      WM1
*                                           WEEKS-OF-MAINTENANCE-CYCLES
*------------------------------------------------------------------------------------------------------------------------
*                                                            NUMBER OF WEEKS OF MAINTENANCE
*       CYCLE  OUTAGE    CYCLE YEAR   CYCLE YEAR   CYCLE YEAR   CYCLE YEAR   CYCLE YEAR   CYCLE YEAR   CYCLE YEAR
*         #    NUMBER        1            2            3            4            5            6            7
*------------------------------------------------------------------------------------------------------------------------
*                                                                        .CYCLEM.
*------------------------------------------------------------------------------------------------------------------------
*        III     III         #            #            #            #            #            #            #
*        ---     ---     --------     --------     --------     --------     --------     --------     --------
          1       0          1            =            =            =            =            =            =
          2       1          2            =            =            =            =            =            =
+                 2          3            =            =            =            =            =            =
+                 3          4            =            =            =            =            =            =
          3       1          1            2            3            4            =            =            =
+                 2          5            6            7            8            =            =            =

 ;;;; END OF &MNT-WEEK-01 ;;;;
```

Cycle Number

Enter a number to identify the planned outage rate cycle. The program can model as many cycles as there are units.

Outage Number

Enter a number to identify the planned outage number within the year. If the Number of outages is specified as 0, the Planned Outage weeks are evenly divided by the number of outages specified in MNT-UNOP-01. If the outage number is non-zero and more outages are specified in MNT-UNOP-01 than are specified in the cycle definition then the number of outages in the cycle will be used. If there are more outages in the cycle than there are specified in MNT-UNOP-01, the number of outages specified in MNT-UNOP-01 will be used.

The program can model as many cycles as there are units and up to 52 outages per cycle.

Number of Weeks of Maintenance

Enter the number of weeks of maintenance required during each year of the cycle. Each cycle can be up to seven years in length.

4.6.11 Annual Peaks for Maintenance Load Model (MNT-ANPK)

Referring to table MNT-OPTN, if S was entered under Maintenance Load Option, this table is used to input the annual peaks to be multiplied by the week-to-annual ratios from table MNT-RATI to create the load model for maintenance scheduling. The data entered here must be consistent with whether maintenance is being scheduled by areas, pools, or system (table MNT-OPTN).

```
&MNT-ANPK-00      APL
*                      MAINTENANCE-LOAD-ANNUAL-PEAK
*-----------------------------------------------------------
*            FOR MAINTENANCE LOAD MODEL ONLY
*
*  EFFECTIVE      AREA OR POOL NAME            ANNUAL PEAK
*    YEAR           (0 = SYSTEM)                LOADS (MW)
*-----------------------------------------------------------
*                                               .AREAPK.
*-----------------------------------------------------------
*    YYYY             AAAAAAAA                     #
*    ----             --------                   -----
                       AREA-A                    3000
                       AREA-D                    2250


;;;; END OF &MNT-ANPK-00 ;;;;
```

Area or Pool Name (0 = System)

Enter the Abbreviated Area or Pool Name (or 0 for the system).

Annual Peak Loads (MW)

Input the annual peak load, in MW, for the specified area, pool, or system.

4.6.12 Weekly Ratios for Maintenance Load Model (MNT-RATI)

If S was entered under Maintenance Load Option on table MNT-OPTN, input on this table the week-to-annual ratios to be combined with the annual peaks on table MNT-ANPK in creating the load model for maintenance scheduling. The data entered here must be consistent with whether maintenance is being scheduled by areas, pools, or system (table MNT-OPTN).

```
&MNT-RATI-00      MPR      CONTINUATION      ASTERISK
*                                        MAINTENANCE-LOAD-RATIOS
*-------------------------------------------------------------------------------------------------------------
*                                     FOR MAINTENANCE LOAD MODEL ONLY
*                 AREA OR
*  EFFECTIVE     POOL NAME
*    YEAR       (0 = SYSTEM)                              WEEK PEAK/ANNUAL PEAK RATIO
*--------------------------------------------------------------------------------------------------------------
*                                                                 .RATIOX.
*--------------------------------------------------------------------------------------------------------------
*  YYYY          AAAAAAAA         #             #           #           #           #           #           #
*  ----          --------     ---------     ---------   ---------   ---------   ---------   ---------   ---------
                 AREA-A        13*0.60       13*0.65     13*0.70     13*0.65

;;;; END OF &MNT-RATI-00 ;;;;
```

Area or Pool Name (0 = System)

Enter the Abbreviated Area or Pool Name (or 0 for the system).

Week Peak / Annual Peak Ratio

Input the ratio of the weekly peak load to the annual peak load, in per unit, for the specified area, pool, or system. A value should be input for each of the 52 weeks in the year.

4.6.13 Capacity Adjustments for Maintenance Scheduling (MNT-FIXC)

An adjustment to the total installed capacity used to schedule maintenance can be input on a weekly basis. This MW value is added to the capacity of the specified area, pool, or system. The data input here must be consistent with whether maintenance is being scheduled by areas, pool, or system (table MNT-OPTN).

This input can be used to cause the program to schedule more or less maintenance during certain weeks of the year. For example, entering a large, negative number for a week will reduce the available reserves in that week and thus discourage the program from scheduling any maintenance during that week.

```
&MNT-FIXC-00     MFC     CONTINUATION     ASTERISK
*                                                 MAINTENANCE-FIXED-CAPACITY-MODIFIER
*-----------------------------------------------------------------------------------------------------------------
*                  AREA OR
*   EFFECTIVE     POOL NAME
*     YEAR       (0 = SYSTEM)                          FIXED MW CAPACITY MODIFIER
*-----------------------------------------------------------------------------------------------------------------
*                                                                .FIXCAP.
*-----------------------------------------------------------------------------------------------------------------
*     YYYY         AAAAAAAA        #           #           #           #           #           #           #
*     ----         --------    ---------   ---------   ---------   ---------   ---------   ---------   ---------
                   AREA-C        15*0        22*100      15*0
                   AREA-D        10*-50      10*0        12*50       10*0        10*-50


;;;; END OF &MNT-FIXC-00 ;;;;
```

Area or Pool Name (0 = System)

Enter the Abbreviated Area or Pool Name (or 0 for the system).

Fixed MW Capacity Modifier

Input the capacity modifier, in MW, for the specified area, pool, or system. A value should be input for each of the 52 weeks in the year.

4.7 Type 1 Energy-Limited Units

4.7.1 Unit Outage Distributions (ELU-DIST)

Type 1 energy-limited units are modeled as thermal units whose capacity is limited on a random basis for reasons other than the forced outages on the unit. The unit's operation may be restricted due to the unavailability of fuel, or a lack of water if it is a hydro unit; the capacity is available but the energy is not.

This table is used to input the cumulative probability density function that is used to determine the maximum available capacity of a unit, recognizing its energy limits. A discussion of Type 1 energy-limited units and an example of the cumulative probability density function for `UNIT-10B` below are found in section 2.4.2 of this manual.

```
&ELU-DIST-00      ELD
*                                           ENERGY-LIMITED-UNIT-OUTAGE-DISTRIBUTION
*------------------------------------------------------------------------------------------------------------------------------
*                         DRAW
*                        RANDOM
*                       CAPACITY
* EFFECTIVE     UNIT   D = DAILY            PROBABILITY OF BEING AT OR BELOW A GIVEN PERCENT OF RATED OUTPUT  (P.U.)
*   DATE        NAME   M = MONTHLY  0        10        20        30        40        50        60        70        80        90        100
*------------------------------------------------------------------------------------------------------------------------------
*                       .IDRELU.                                                        .ELUPRB.
*------------------------------------------------------------------------------------------------------------------------------
*  MMMYYYY    AAAAAAAA     A       #         #         #         #         #         #         #         #         #         #         #
*  -------    --------    ---   -------   -------   -------   -------   -------   -------   -------   -------   -------   -------   -------
              UNIT-10B     D       0.05      0.1       0.2       0.3       0.3       0.5       0.75      1.0       1.0       1.0       1.0
              UNIT-9C      M       0.1       0.2       0.3       0.4       0.5       0.6       0.7       0.8       0.9       1.0       1.0

;;;; END OF &ELU-DIST-00 ;;;;
```

Unit Name

Enter the name of the Type 1 energy-limited unit.

Draw Random Capacity

D Daily

M Monthly

The effect of the energy limits on the available capacity of the unit can be determined on a daily or monthly basis. Default is D.

Probability of Being at or Below a Given Percent of Rated Output (p.u.)

Input, in per unit, the cumulative probability density function that describes the probability of the unit being at or below the specified percent of the rated output.

For example, `UNIT-10B` has a 0.75 probability that its maximum output will be restricted to 60% of rated output because of energy limits. If `UNIT-10B` is rated at 100 MW but is derated this day to 80 MW because of partial forced outages, there is a 0.75 probability that it will be further restricted to 60 MW because of the energy limits.

Default is that the unit does not have energy limits.

4.7.2 Unit Outage Distributions (ELU-STEP)

This table is used to override the distribution steps associated with the probabilities in ELU-DIST. The default is for the 11 steps to be evenly spaced between 0% and 100% in 10% increments.

This table is used to input the cumulative probability density function that is used to determine the maximum available capacity of a unit, recognizing its energy limits. A discussion of Type 1 energy-limited units and an example of the cumulative probability density function for UNIT-10B below are found in section 2.4.2 of this manual.

```
&ELU-STEP-00      ELT
*                                        ENERGY-LIMITED-UNIT-OUTAGE-DISTRIBUTION-STEPS
*-----------------------------------------------------------------------------------------------------------------------------
*      EFFECTIVE     UNIT NAME                STEPS IN THE DISTRIBUTION AS A PERCENT OF RATED OUTPUT (P.U.)
*        DATE                      0       10       20       30       40       50       60       70       80       90      100
*-----------------------------------------------------------------------------------------------------------------------------
*                                                                            .ELUPRB.
*-----------------------------------------------------------------------------------------------------------------------------
*       MMMYYYY       AAAAAAAA    ######   ######   ######   ######   ######   ######   ######   ######   ######   ######   ######
*       -------       --------    ------   ------   ------   ------   ------   ------   ------   ------   ------   ------   ------

                      UNIT-10B     0.00     0.10     0.20     0.30     0.40     0.50     0.60     0.70     0.80     0.90     1.00
                      UNIT-9C      0.00     0.05     0.10     0.20     0.30     0.45     0.55     0.67     0.85     0.95     1.00

;;;; END OF ELU-STEP-00 ;;;;
```

Unit Name

Enter the name of the Type 1 energy-limited unit.

Steps in the Distribution as a Percent of Rated Output (p.u.)

Input, in per unit, the capacity associated to the corresponding breaks in ELU-DIST. The default values are equally divided between 0 and 1 in 0.1 increments.

For example, UNIT-10B has the same steps as in the default assumptions. UNIT-9C has 0.55 in this table and 0.7 in ELU-DIST in the seventh position. This means that UNIT-9C has a a 0.7 probability that its maximum output will be restricted to 55% of rated output because of energy limits. If UNIT-9C is rated at 100 MW but is derated this day to 80 MW because of partial forced outages, there is a 0.7 probability that it will be further restricted to 55 MW because of the energy limits.

4.8 Cogeneration Units

4.8.1 Cogeneration Unit Hourly Load Demand (MOD-CGMW-01)

Cogeneration units are modeled as thermal units with an associated load demand. This load demand is specified by inputting hourly data for a typical week. This data can be overridden on a monthly basis. Cogeneration units are described in greater detail in section 2.4.2.

```
&MOD-CGMW-01      CG1     CONTINUATION     ASTERISK
*                                 COGENERATION-UNIT-HOURLY-LOAD-DEMAND
*-----------------------------------------------------------------------------------------------------
*     EFFECTIVE     UNIT NAME      APPLY    COGENERATION UNIT HOURLY LOAD DEMAND FOR TYPICAL WEEK (MW)
*        DATE                       LFU
*-----------------------------------------------------------------------------------------------------
*                                                                  .COGMOD.
*-----------------------------------------------------------------------------------------------------
*      MMMYYYY       AAAAAAAA       Y/N       #########       #########       #########       #########
*      -------       --------       ---       ---------       ---------       ---------       ---------
                    "UNIT-5A "       Y           8*0.00        12*40.00         12*0.00        12*40.00
+                                               12*0.00        12*40.00         12*0.00        12*40.00
+                                               12*0.00        12*40.00         52*0.00
                    "UNIT-7C "       N        168*30.00

;;;; END OF MOD-CGMW-01 ;;;;
```

Unit Name

Enter the name of the cogeneration unit.

Apply LFU?

If selected (Y), load forecast uncertainty multipliers for the unit's area will be applied to the the data in this table for each load level. The default is N.

Cogeneration Unit Hourly Load Demand for Typical Week (MW)

Input the cogeneration unit's associated hourly load demand, in MW, for a typical week (168 hourly values).

4.8.2 Cogeneration Unit Hourly Load Demand (MOD-CGMW-00)

Cogeneration units are modeled as thermal units with an associated load demand. This load demand is specified by inputting hourly data for a typical week. This data can be overridden on a monthly basis. Cogeneration units are described in greater detail in section 2.4.2.

```
&MOD-CGMW-00      CGM      CONTINUATION      ASTERISK
*                                                COGENERATION-MOD-MW
*---------------------------------------------------------------------------------------------------
*     EFFECTIVE      UNIT
*       DATE         NAME          COGENERATION UNIT HOURLY LOAD DEMAND FOR TYPICAL WEEK (MW)
*---------------------------------------------------------------------------------------------------
*                                                            .COGMOD.
*---------------------------------------------------------------------------------------------------
*     MMMYYYY      AAAAAAAA        #            #            #            #            #
*     -------      --------    ---------    ---------    ---------    ---------    ---------
                   UNIT-5A     8*0 12*40 4*0    8*0 12*40 4*0   8*0 12*40 4*0   8*0 12*40 4*0
+                              8*0 12*40 4*0   48*0

                   UNIT-7C     168*30


;;;; END OF &MOD-CGMW-00 ;;;;
```

Unit Name

Enter the name of the cogeneration unit.

Cogeneration Unit Hourly Load Demand for Typical Week (MW)

Input the cogeneration unit's associated hourly load demand, in MW, for a typical week (168 hourly values).

4.9 Non-Thermal Units and Load Modifiers

4.9.1 Ratings for Type 2 Energy-Limited Units (MOD-ELMW)

Type 2 energy-limited units are modeled as deterministic load modifiers that are scheduled on a monthly basis. The minimum rating, which can be thought of as the run-of-river portion of a hydro unit, is dispatched across all of the hours in the month. The remaining capacity and energy is then used in a peak-shaving mode, either as a deterministic load modifier or as needed during the Monte Carlo simulation (table GEN-CASE). Type 2 and 3 energy-limited units are discussed in more detail in section 2.4.2.

The limits of number of days per year/month, hours per year/month/day or energy per day only apply to "as-needed" basis (EL3). For those units, the minimum rating of the plant is always dispatched, if set to a number greater than zero. The limits on the frequency of usage of a unit only applies to the amoung of power between the maximum and minimum rating. For example, a unit with 100-MW of minimum rating, 300 MW of maximum and a 5 hours per year would be dispatched at 100 MW for all hours of the year, plus an additional 200 MW for (at most) 5 hours.

Type 2 energy-limited units will respect the energy per day limit when dispatching the unit, if a value is entered.

```
&MOD-ELMW-00      ELM
*                                  RATINGS-FOR-TYPE-2-AND-TYPE-3-ENERGY-LIMITED-UNITS
*----------------------------------------------------------------------------------------------------------------------
*     EFFECTIVE     UNIT NAME      MINIMUM     MAXIMUM      ENERGY      STORAGE      DAYS    DAYS    HOURS   HOURS   HOURS    ENERGY
*       DATE                        (MW)        (MW)        (MWH)       (MWH)        PER     PER     PER     PER     PER     PER DAY
*                                                                                    YEAR    MONTH   YEAR    MONTH   DAY
*----------------------------------------------------------------------------------------------------------------------
*                                 .ELUMIN.    .ELUMAX.    .ELUENG.    .EL2STR.   .IEL2MD..IEL2MD..IEL2YH..IEL2MH..IEL2DH. .EE12DH.
*----------------------------------------------------------------------------------------------------------------------
*      MMMYYYY       AAAAAAAA     ########    ########    ########    ########    III     III     IIII    III     III     ######
*      -------       --------     --------    --------    --------    --------    ---     ---     ----    ---     ---     ------
@      JAN2010**    "UNIT-9A "        15.0        75.0       25000        1000      =       =        =      =       =          =
@      JUN2010**    "UNIT-9A "        15.0        75.0       20000        1000      =       =        =      =       =          =
@      NOV2010**    "UNIT-9A "        15.0        75.0       25000        1000      =       =        =      =       =          =
                    "UNIT-8C "         0.0        50.0       20000           0      =       =        =      =       =          =
                    "CONT-B-E"         0.0        50.0       15000           0      =       =        =      =       =          =

 ;;;; END OF &MOD-ELMW-00 ;;;;
```

Unit Name

Enter the name of the Type 2 energy-limited unit.

Minimum (MW)

Input the minimum rating of the plant, in MW.

Maximum (MW)

Input the maximum rating of the plant, in MW.

If the maximum rating is negative, the schedule will be developed as if it were positive, but it will be added to, rather than subtracted from, the area loads.

Units with a negative maximum rating will always be scheduled deterministically, even if the option is chosen to dispatch the Type 2 energy-limited units as needed during the Monte Carlo simulation (table GEN-CASE).

Energy (MWh)

Enter the total amount of energy, in MWh, available from the plant during the month.

If the input energy is greater than the maximum amount that can be used in the month:

- if being scheduled deterministically (EL2), the input energy will be set equal to the maximum possible usage;
- if being scheduled on an "as-needed" basis (EL3), the input energy will not be reset, and the excess will be carried forward subject to the storage limits.

Storage (MWh)

Input the maximum unused energy that can be carried from one month to the next. Unused energy will not be carried from one study year to the next.

Number of Days Per Year

Input the number of days during the year that this unit can be initiated. Implementation multiple times during a day counts as a single day.

Number of Days Per Month

Input the number of days during the month that this unit can be initiated. Implementation multiple times during a day counts as a single day. Once the limit has been reached, this Unit will not be available again for use until the beginning of the next month.

Number of Hours Per Year

Input the number of hours during the year that this Unit can be initiated.

Number of Hours Per Month

Input the number of hours during the Month that this Unit can be initiated. Once the limit has been reached, this Unit will not be available again for use until the beginning of the next month.

Number of Hours Per Day

Input the number of hours during the day that this Unit can be initiated. Once the limit has been reached, this Unit will not be available again for use until the beginning of the next day.

Energy Per Day

Input the energy (MWh) during the day that this unit can be initiated. Once the limit has been reached, this unit will not be available again for use until the beginning of the next day. This limit can be applied to Type 2 units.

4.9.2 Daily Overrides for As-Needed Units (MOD-ELDY)

Use this table to override the limits of energy by day of number of hours by day for single days. This will override the values entered in MOD-ELMW.

```
&MOD-ELDY-00      EDY
*             DAILY-OVERRIDES-FOR-AS-NEEDED-UNITS
*-------------------------------------------------------------
*      EFFECTIVE      UNIT NAME       DATE    ENERGY PER    HOURS
*         YEAR                                    DAY      PER DAY
*-------------------------------------------------------------
*         YYYY         AAAAAAAA      DDMMM    ########     IIIIII
*         ----         --------      -----    --------     ------
@         2010        "UNIT-9A "     04JAN      100.00        =
@         2010        "UNIT-9A "     15APR      150.00        =

@         2010        "UNIT-8C "     04JAN           =        0
@         2010        "UNIT-8C "     15APR           =        4

;;;; END OF MOD-ELDY-00 ;;;;
```

Unit Name

Enter the name of the type 3 energy-limited (EL3) or storage (ES) unit.

Date

Enter the date for which the data is to be overriden in DDMMM format.

Energy Per Day

Override the energy (MWh) per day limit entered in MOD-ELMW for a single unit in a single day.

Number of Hours Per Day

Override the number of hours per day limit entered in MOD-ELMW for a single unit in a single day.

4.9.3 Loads for Scheduling Type 2 Energy-Limited Units (MOD-ELLD)

Type 2 energy-limited units can be scheduled against the system loads or a combination of area and pool loads. The default is to use the loads of the area in which the unit is located. The loads that are used have been modified for contracts, Type 1 cogeneration units, and previously scheduled hourly profile units and Type 2 energy-limited units.

The loads specified on this table are used only in developing the dispatch schedule of the unit. This dispatch schedule will then be used to modify the loads of the area in which the unit is located. Units being used to represent contracts are scheduled against the specified loads to determine the hourly contract ratings but do not modify any area loads.

```
&MOD-ELLD-00      ELS      CONTINUATION
*                                               ENERGY-LIMITED-UNIT-SCHED
*-------------------------------------------------------------------------------------------------------------
*                               - - - - - - - - - -   LOADS TO SCHEDULE AGAINST  - - - - - - - - - - - - -
*                                AREA OR      P.U.         AREA OR      P.U.          AREA OR      P.U.
*  EFFECTIVE       UNIT         POOL NAME      OF          POOL NAME     OF           POOL NAME     OF
*    DATE          NAME        (0 = SYSTEM)   LOAD        (0 = SYSTEM)  LOAD         (0 = SYSTEM)  LOAD
*-------------------------------------------------------------------------------------------------------------
*                                              .SCHDAR.    .SCHDPL.
*-------------------------------------------------------------------------------------------------------------
*    YYYY      AAAAAAAA          AAAAAAAA       #           AAAAAAAA      #              AAAAAAAA      #
*    ----      --------          --------    -------        --------   -------           --------   -------
               UNIT-9A           AREA-A      1.0
               UNIT-8C          "POOL 1"     1.0           "POOL 2"      0.5
               CONT-B-E          AREA-E      1.0

;;;; END OF &MOD-ELLD-00 ;;;;
```

Unit Name

Enter the name of the Type 2 energy-limited unit.

Area or Pool (0 = System)

Input the abbreviated name of the area or pool to be included in creating the composite loads to be used for scheduling the unit. Enter 0 to schedule against the system loads.

P.U. Of Load

Enter the per unit portion of the area, pool, or system load to be included in the composite load model.

The default is to schedule the unit against the loads of the area in which it is located.

If overriding the data in this table, you must zero the input for the areas or pools whose loads are no longer to be included. To zero the system input from a previous year, input 0 for each pool.

4.9.4 Ratings for Storage Units (MOD-ESMW)

Storage units are modeled as units that hold a certain amount of energy reserves that get deployed on an as-needed basis, i.e., their capacity is used if there is a shortage in the system. Each replication may result in a different dispatch of the unit. The unit is limited by the amount of energy stored, its generating rating and the ability of providing power to the areas with shortages through interfaces.

If there is a surplus of capacity in the system, storage units will attempt to fill (or charge) their energy reservoirs without causing shortfalls in the system. The charging of storage units is limited to its charging capacity, the amount of room in the reservoir and the ability of the system to deliver excess capacity to the areas where storage units are located.

Internally, type 3 energy-limited units and storage units are very similar. Both types generate on an as-needed basis when there are shortages in the system and are limited to the available energy in the reservoir. The main difference between the two is that storage units have the ability to refill the reservoir each hour, while EL3 units have a given amount of energy that is updated on a monthly basis.

```
&MOD-ESMW-00      ESM
*                                RATINGS-FOR-STORAGE-UNITS
*------------------------------------------------------------------------------------------
*     EFFECTIVE    UNIT NAME    GENERATION   STORAGE    ROUND-TRIP  RATING FOR   INITIAL
*       DATE                    MAX (MW)     (MWH)      EFFICIENCY  CHARGING     ENERGY
*                                                          (PU)        (MW)       (MWH)
*------------------------------------------------------------------------------------------
*                               .ELUMAX.    .EL2STR.
*------------------------------------------------------------------------------------------
*      MMMYYYY      AAAAAAAA    ########    ########    ########    ########    ########
*      -------      --------    --------    --------    --------    --------    --------
                   "BATTERY "     100.00      400.00     0.90000           =           =

;;;; END OF MOD-ESMW-00 ;;;;
```

Unit Name

Enter the name of the storage unit unit.

Generation maximum (MW)

Input the maximum rating of the plant for generation, in MW..

Storage (MWh)

Maximum energy that can be stored by the unit, in MWh. The default is 0.

Round-trip efficiency (PU)

Input the round-trip efficiency (in per unit) for the unit. The efficiency is applied during the charging process. As an example, if we have a unit with an efficiency of 0.9 the unit will store 9 MWh of energy for every 10 MW charged in an hour.

Rating for charging (MW)

Input the maximum rating for the unit during charging. It defaults to the generation rating.

Initial Energy (MWh)

Enter the energy available for the storage unit in the first hour of each replication. The smallest of this value and Storage will be used. The default is for the unit to start each replication in a fully-charged state.

4.9.5 Constrain calls for as-needed units (MOD-CALL)

This table allows the user to impose constraints on the calls to type 3 energy-limited and storage units. A call is define as a period of one or more consecutive hours when a unit is generating. For instance, if a unit is generating at 1, 2 and 3 p.m., that generation pattern counts as three hours, but only one call.

This table complements the limits on hour and days of operation that are present in MOD-ELMW.

```
&MOD-CALL-00      ELM
*                                CONSTRAIN-CALLS-FOR-AS-NEEDED-UNITS
*-------------------------------------------------------------------------------------------
*      EFFECTIVE     UNIT NAME       MINIMUM       MAXIMUM      ENERGY     CALLS     CALLS    CALLS
*         DATE                       DURATION      DURATION    PER CALL     PER       PER      PER
*                                                                          YEAR      MONTH     DAY
*-------------------------------------------------------------------------------------------
*
*-------------------------------------------------------------------------------------------
*       MMMYYYY       AAAAAAAA         III           III        ######      III       III      III
*       -------       --------         ---           ---        ------      ---       ---      ---

                      DR                2             8            =         25        =        =

;;;; END OF MOD-CALL-00 ;;;;
```

Unit Name

Enter the name of the type 3 energy-limited or energy storage units.

Minimum duration

Minimum duration for a call, in hours. The default is 1.

Maximum duration

Maximum duration for a call, in hours. The default is unlimited.

Energy Per Call

Maximum energy to be used per call, in MWh. The default is unlimited.

Calls Per Year

Number of calls per year to limit the unit's operations.

Calls Per Month

Number of calls per month to limit the unit's operations.

Calls Per Day

Number of calls per year to limit the unit's operations.

4.9.6 Limit or Delay As-Needed Units Usage (MOD-DLAY)

Dispatch of Type 3 energy-limited and storage units is considered several times during a Monte Carlo simulation: before the any EOP is taken into and count and after each available EOP is applied. This table limits how often each unit is considered by optionally defining the first and/or last EOPs at which the unit could be dispatched.

```
&MOD-DLAY-00      MDL
*                 LIMIT-OR-DELAY-AS-NEEDED-UNITS-USAGE
*-----------------------------------------------------------------------
*      UNIT NAME      FIRST EOP      LAST EOP      ASSIST      DISPATCH
*                        FOR            FOR         OTHER        GROUP
*                     DISPATCH       DISPATCH       POOLS
*-----------------------------------------------------------------------
*       AAAAAAAA         III            III         A/P/S         III
*       --------         ---            ---         -----         ---

      "DR       "         =              4            S             =
      "BATTERY  "         2              5            P             =
      "PUMPHYDR"          =              =            =             1

;;;; END OF MOD-DLAY-00 ;;;;
```

Unit Name

Enter the name of the Type 3 energy-limited or energy storage units

First EOP for dispatch

First EOP after which the unit dispatched is considered for dispatch. The default is 0, i.e., the unit can be dispatched before any EOP step is considered. If the value entered exceeds the number of EOPs, the unit will not be dispatched.

Last EOP for dispatch

Last EOP after which the unit dispatched is considered. The default is the number of EOPs in the model.

Assist other pools

By default EL3 and ES units are considered for dispatch when there are shortages in their own area, their own pool and the rest of the system (in that order). This option removes the ability of any units to be used outside its own area or outside its own pool.

The available options are:

A Dispatch unit for shortages in its own area only

P Dispatch unit for shortages in its own area or pool only

S Dispatch unit for shortages anywhere in the system

The default value is S.

Dispatch group

By using this option, you can consider selected EL3 and ES units to be scheduled together, in a coordinated way. Input the number of the group to which the unit is assigned. Group numbers should be consecutive integers beginning with 1.

To assign all the units in an area to a group, use the available option in GEN-AREA. The values provided in this table will superseed any group value entered in GEN-AREA.

Dispatch groups will be dispatched first, starting with group 1. Once all groups have been dispatched, MARS will consider all units without a dispatch group. The table **??** can be used to introduce forecast errors in the dispatching of individual groups, to represent situations when decisions are made with imperfect information.

4.9.7 Limit Generation and Charging Status (MOD-STAT)

This table is used to limit when energy-limited type 3 (EL3) and storage (ES) units are allowed to generate and/or charge.

```
&MOD-STAT-00     MWH    CONTINUATION    ASTERISK
*                              LIMIT-GENERATION-AND-CHARGING
*-------------------------------------------------------------------------------------------
*     EFFECTIVE    UNIT NAME                         HOURLY STATUS
*        DATE
*-------------------------------------------------------------------------------------------
*
*-------------------------------------------------------------------------------------------
*      MMMYYYY      AAAAAAAA      B/G/C/N       B/G/C/N       B/G/C/N       B/G/C/N
*      -------      --------      -------       -------       -------       -------

                   "UNIT    "        12*N           6*G            6*C

;;;; END OF MOD-STAT-00 ;;;;
```

Unit Name

Enter the name of the Type 3 energy-limited or energy storage units

Hourly status

Input a valid character to indicate whether the unit is allowed to charge or generate at each hour. The values can be entered for a typical day (24 hourly values) or for a typical week (168 hourly values). Please use one option (either typical day or typical week) for each unit.

The available options are:

B Both generation and charging is allowed

G Only generation is allowed this hour

C Only charging is allowed this hour

N Unit cannot charge or generate

R A ES unit storage is reset to zero going at the beginning of the hour, so charging becomes the only option

The default value is B.

In the example above, the unit is not allowed to generate or charge for the first 12 hours in the day. The unit can only generate in the next 6 hours and it is only allowed to charge in the last 6 hours of the day.

4.9.8 Load Forecast Error (LOD-FERR-00)

MARS can apply load forecast errors during the dispatch of as-needed energy limited (EL3) and energy storage (ES) units. The goal is to simulate certain conditions when those resources have to be committed ahead of time, with imperfect information.

To use this feature, the EL3/ES units to be affected need to be added to a dispatch group, matching the group listed in this table.

Forecast errors for pools are divided amongst the pool areas proportional to the area load for the hour. If an area is both given a forecast error and is in a pool with a forecast error, both values will be added together.

```
&LOD-FERR-00      LFE
*                                              LOAD-FORECAST-ERROR
*-------------------------------------------------------------------------------------------------------------
*    EFFECTIVE    DISPATCH   AREA OR POOL    UPDATE    APPLY    DISTRIB                PARAMETERS
*       DATE        GROUP        NAME       FREQUENCY   LFU?     UTION          PARAM1                 PARAM2
*-------------------------------------------------------------------------------------------------------------
*      MMMYYYY       III       AAAAAAAA       H/D/N      Y/N       N       ##############      ##############
*      -------       ---       --------       -----      ---       -       --------------      --------------
                      1       "AREA-A  "        H         Y        N                0.000             100.000
                      1       "AREA-B  "        H         Y        N                0.000              35.000
                      2       "AREA-A  "        D         N        N                0.000              50.000
                      1       "POOL-1  "        D         N        N                0.000             200.000

;;;; END OF LOD-FERR-00 ;;;;
```

Effective Date

Use this field to enter data overrides.

Dispatch Group

Dispatch group for as-needed energy limited (EL3) and energy storage units (ES) for which the forecast error is applied. Each dispatch group needs to be included in this table, otherwise it is assumed that there is no forecast error applied.

Area or Pool Name

Enter the abbreviated area or pool name.

Update Frequency

Define how oftern the forecast error needs to be updated: for each hour, once a day, or not all (to disable the forecast error). The available options are:

H Create a different forecast error for each hour

D Maintain the same forecast error for all hours in a day

N Disable the load forecast error (the default value)

Apply LFU?

Should load forecast uncertainty (LFU) multipliers be applied to the forecast error? The values should be either Y or N (default).

Distribution

Select distribution to be used for the distribution error. For the time being, the normal distribution is the only option (N).

Parameters

Parameters to be used, which depend on the distribution being used. For a normal distribution, the parameters are the average and standard deviation.

4.9.9 Hourly Profile Net Hourly Load Modification (MOD-MDMW)

```
&MOD-MDMW-00     ESD     CONTINUATION     ASTERISK
*                                            HOURLY-PROFILE-MOD-MW
*------------------------------------------------------------------------------------------------------------------
*    EFFECTIVE      UNIT                     NET HOURLY LOAD MODIFICATION FOR TYPICAL WEEK (MW)
*      DATE         NAME                                 FOR HOURLY PROFILE UNITS
*------------------------------------------------------------------------------------------------------------------
*                                                         .ESUMOD.     .DSMMOD.
*------------------------------------------------------------------------------------------------------------------
*    MMMYYYY     AAAAAAAA            #             #             #             #             #             #
*    -------     --------        ---------     ---------     ---------     ---------     ---------     ---------
                 UNIT-5D         6*-55 6*0 6*50 4*0 2*-55   6*-55 6*0 6*50 4*0 2*-55   6*-55 6*0 6*50 4*0 2*-55
+                                6*-55 6*0 6*50 4*0 2*-55   6*-55 6*0 6*50 4*0 2*-55   6*-55 6*0 6*50 4*0 2*-55
+                                6*-55 6*0 6*50 4*0 2*-55

                 UNIT-1E         120*10  48*0

                 CONT-C-D        168*20
@    APR2010**   CONT-C-D        168*-20
@    OCT2010**   CONT-C-D        168*20


;;;; END OF &MOD-MDMW-00 ;;;;
```

Unit Name

Enter the name of the Hourly Profile unit.

Net Hourly Load Modification for Typical Week (MW)

Input the net hourly load modification, in MW, for a typical week (168 hourly values). The input modification is subtracted from the load; hence, positive values decrease the load, negative values increase the load.

4.9.10 Hourly Modifier Shapes with Random Shape Selection (MOD-SHAP-03)

The net hourly load modification of a variable resource like wind or solar can either be specified through hourly values for a typical week (table MOD-MDMW), or it can be calculated by the program from a combination of different hourly shapes. The hourly impact of each shape (e.g., controls on water heaters and air conditioners, or metered production for a wind farm) can be input for all of the hours in the year through the shapes file (file code 17). The shapes to be combined to form a particular hourly modifier are specified on this table. The associated penetration factors are input on table MOD-PENE.

For variable resources such as wind and solar that are being modeled with an annual hourly shape, MARS has the option to randomly pick the day whose input data will be used to model the output of the unit for that study day. As a result, the output of these units will randomly change from one replication to the next. The day used can be randomly chosen from a specified window centered on the current study day or can be limited to days within the same month.

By limiting the random selection of the day, the program will capture the seasonality of these resources (the wind in one month may be different from that in another month), but will allow you to eliminate the correlation with the loads that may be implied by modeling the days sequentially and thus linking the hourly shapes to the hourly loads. The selection is made daily rather than hourly to preserve the daily pattern that is often observed. The day selected applies to all resources grouped together so that a consistent weather pattern can be applied to all units in a region.

If, for example, multiple years of hourly production data are available for a resource, these shapes can be entered as multiple sets for a random group, and a probability of occurrence can be entered for these sets in MOD-RAND.

The hourly data for all of the shapes are input on file code 17 in either standard EEI format or provided in an HDF5 File (see page 34).

```
&MOD-SHAP-03      MS3         CONTINUATION
*                                  HOURLY-PROFILE-SHAPE-RELATION
*-----------------------------------------------------------------------------------------------------------------------------
*                  GROUP NUMBER    MAX. NUMBER    SET NAME
*                   FOR RANDOM      OF DAYS     FOR RANDOM
*    UNIT NAME      SELECTION      FOR SHIFT      DRAW                                 SHAPE NAMES
*-----------------------------------------------------------------------------------------------------------------------------
*                    .IMDGRP.       .MDSHFT.                                        .SHMDNM.
*-----------------------------------------------------------------------------------------------------------------------------
*    AAAAAAAA          III            III        AAAAAAAA      AAAAAAAA      AAAAAAAA      AAAAAAAA      AAAAAAAA      AAAAAAAA
*    --------          ---            ---        --------      --------      --------      --------      --------      --------
     UNIT-11E           0              0            =         "WTR HTR"     "AIR COND"
     WIND-01            0              0            =          WINDSHP1
     WIND-02            1              0            =          WINDSHP2
     WIND-03            2              7            =          WINDSHP3
     WIND-04            2              7            =          WINDSHP4
     WIND-05            3              =         PRODYR11      WIND0511
     WIND-05            3              =         PRODYR12      WIND0512
     WIND-05            3              =         PRODYR13      WIND0513

 ;;;; END OF &MOD-SHAP-03 ;;;;
```

Unit Name

Enter the name of the hourly modifier unit to be modeled with data from the shapes input file.

Group Number for Random Selection

Assign each unit to a consecutively numbered group. The randomly selected day will apply to all units in a group. A group of 0 indicates that the day shape for that unit will not be randomly chosen, but will be used as input in the shapes data.

Maximum Number of Days for Shift

To have the day shape randomly chosen from within a window centered on the current day, input the maximum number of days for the shift, which will be applied in each direction. A negative number will keep the same shift for all the days in a replications. A maximum number of days for the shift of 0 indicates that the day will be randomly chosen from within the current study month (assuming that the group number is not 0).

Set Name for Random Draw

Optionally input the set name for this collection of shapes. For each replication, each group will have a random set selected for that replication based on the probabilities specified in MOD-RAND.

Shape Names

Input the names of the shapes to be combined in forming this hourly modifier. The names must match with the names specified on the header lines in the shapes file.

4.9.11 Hourly Modifier Shapes with Random Selection within Windows (MOD-SHAP-02)

The net hourly load modification of an hourly modifier can either be specified through hourly values for a typical week (table MOD-MDMW), or it can be calculated by the program from a combination of different hourly profiles. The hourly impact of each profile (e.g., controls on water heaters and air conditioners) can be input for all of the hours in the year through the shapes file (file code 17). The devices to be combined to form a particular hourly modifier are specified on this table. The associated penetration factors are input on table MOD-PENE.

For resources such as wind and solar that are being modeled with an annual hourly shape, MARS has the option to randomly pick the day whose input data will be used to model the output of the unit for that study day. As a result, the output of these units will randomly change from one replication to the next. The day used can be randomly chosen from a specified window centered on the current study day or can be limited to days within the same month.

By limiting the random selection of the day, the program will capture the seasonality of these resources (the wind in one month may be different from that in another month), but will allow you to eliminate the correlation with the loads that may be implied by modeling the days sequentially and thus linking the hourly shapes to the hourly loads. The selection is made daily rather than hourly to preserve the daily pattern that is often observed. The day selected applies to all resources grouped together so that a consistent weather pattern can be applied to all units in a region.

The hourly data for all of the shapes are input on file code 17 in either standard EEI format or provided in an HDF5 File (see page 34).

```
&MOD-SHAP-02      MS2         CONTINUATION
*                                    HOURLY-PROFILE-SHAPE-RELATION
*------------------------------------------------------------------------------------------------------------------------------
*                  GROUP NUMBER   MAX. NUMBER
*                   FOR RANDOM      OF DAYS
*    UNIT NAME      SELECTION      FOR SHIFT                                      SHAPE NAMES
*------------------------------------------------------------------------------------------------------------------------------
*                    .IMDGRP.       .MDSHFT.                                   .SHMDNM.
*------------------------------------------------------------------------------------------------------------------------------
*    AAAAAAAA           III            III          AAAAAAAA      AAAAAAAA      AAAAAAAA      AAAAAAAA      AAAAAAAA      AAAAAAAA
*    --------           ---            ---          --------      --------      --------      --------      --------      --------
     UNIT-11E           0              0           "WTR HTR"     "AIR COND"
     WIND-01            0              0            WINDSHP1
     WIND-02            1              0            WINDSHP2
     WIND-03            2              7            WINDSHP3
     WIND-04            2              7            WINDSHP4

 ;;;; END OF &MOD-SHAP-00 ;;;;
```

Unit Name

Enter the name of the hourly modifier unit to be modeled with data from the shapes input file.

Group Number for Random Selection

Assign each unit to a consecutively numbered group. The randomly selected day will apply to all units in a group. A group of 0 indicates that the day shape for that unit will not be randomly chosen, but will be used as input in the shapes data.

Maximum Number of Days for Shift

To have the day shape randomly chosen from within a window centered on the current day, input the maximum number of days for the shift, which will be applied in each direction. A negative number will keep the same shift for all the days in a replications. A maximum number of days for the shift of 0 indicates that the day will be randomly chosen from within the current study month (assuming that the group number is not 0).

Shape Names

Input the names of the shapes to be combined in forming this hourly modifier. The names must match with the names specified on the header lines in the shapes file.

4.9.12 Hourly Modifier Shapes with option for Monthly Selection (MOD-SHAP-01)

The net hourly load modification of an hourly modifier can either be specified through hourly values for a typical week (table MOD-MDMW), or it can be calculated by the program from a combination of different hourly profiles. The hourly impact of each profile (e.g., controls on water heaters and air conditioners) can be input for all of the hours in the year through the shapes file (file code 17). The devices to be combined to form a particular hourly modifier are specified on this table. The associated penetration factors are input on table MOD-PENE.

For resources such as wind and solar that are being modeled with an annual hourly shape, MARS has the option to randomly pick the day whose input data will be used to model the output of the unit for that study day. As a result, the output of these units will randomly change from one replication to the next. The day used will be randomly chosen from a day within the same study month.

By limiting the random selection of the day, the program will capture the seasonality of these resources (the wind in one month may be different from that in another month), but will allow you to eliminate the correlation with the loads that may be implied by modeling the days sequentially and thus linking the hourly shapes to the hourly loads. The selection is made daily rather than hourly to preserve the daily pattern that is often observed. The day selected applies to all resources grouped together so that a consistent weather pattern can be applied to all units in a region.

The hourly data for all of the shapes are input on file code 17 in either standard EEI format or provided in an HDF5 File (see page 34).

```
&MOD-SHAP-01      MS1         CONTINUATION
*                                       HOURLY-PROFILE-SHAPE-RELATION
*-------------------------------------------------------------------------------------------------------------------------
*                   GROUP  NUMBER
*                    FOR  RANDOM
*     UNIT  NAME       SELECTION                                             SHAPE  NAMES
*-------------------------------------------------------------------------------------------------------------------------
*                      .IMDGRP.                                           .SHMDNM.
*-------------------------------------------------------------------------------------------------------------------------
*     AAAAAAAA           III           AAAAAAAA      AAAAAAAA      AAAAAAAA      AAAAAAAA      AAAAAAAA      AAAAAAAA
*     --------           ---           --------      --------      --------      --------      --------      --------
      UNIT-11E            0           "WTR  HTR"    "AIR  COND"
      WIND-01             0            WINDSHP1
      WIND-02             1            WINDSHP2
      WIND-03             2            WINDSHP3
      WIND-04             2            WINDSHP4

 ;;;;  END  OF  &MOD-SHAP-00  ;;;;
```

Unit Name

Enter the name of the hourly modifier unit to be modeled with data from the shapes input file.

Group Number for Random Selection

Assign each unit to a consecutively numbered group. The randomly selected day from the current simulation month will apply to all units in a group. A group of 0 indicates that the day shape for that unit will not be randomly chosen, but will be used as input in the shapes data.

Shape Names

Input the names of the shapes to be combined in forming this hourly modifier. The names must match with the names specified on the header lines in the shapes file.

4.9.13 Hourly Modifier Shapes with no Random Selection (MOD-SHAP-00)

The net hourly load modification of an hourly modifier can either be specified through hourly values for a typical week (table MOD-MDMW), or it can be calculated by the program from a combination of different hourly profiles. The hourly impact of each profile (e.g., controls on water heaters and air conditioners) can be input for all of the hours in the year through the shapes file (file code 17). The devices to be combined to form a particular hourly modifier are specified on this table. The associated penetration factors are input on table MOD-PENE.

The hourly data for all of the shapes are input on file code 17 in either standard EEI format or provided in an HDF5 File (see page 34).

```
&MOD-SHAP-00                CONTINUATION
*                                    HOURLY-PROFILE-SHAPE-RELATION
*----------------------------------------------------------------------------------------------------
*
*
*    UNIT NAME                                        SHAPE NAMES
*----------------------------------------------------------------------------------------------------
*                                                  .SHMDNM.
*----------------------------------------------------------------------------------------------------
*    AAAAAAAA        AAAAAAAA      AAAAAAAA      AAAAAAAA      AAAAAAAA      AAAAAAAA      AAAAAAAA
*    --------        --------      --------      --------      --------      --------      --------
     UNIT-11E       "WTR HTR"     "AIR COND"
     WIND-01         WINDSHP1
     WIND-02         WINDSHP2
     WIND-03         WINDSHP3
     WIND-04         WINDSHP4

 ;;;; END OF &MOD-SHAP-00 ;;;;
```

Unit Name

Enter the name of the hourly modifier unit to be modeled with data from the shapes input file.

Shape Names

Input the names of the shapes to be combined in forming this hourly modifier. The names must match with the names specified on the header lines in the shapes file.

4.9.14 Hourly Modifier Shape Penetration Factors (MOD-PENE)

```
&MOD-PENE-00      MPE      CONTINUATION
*                                    HOURLY-PROFILE-PENETRATION
*---------------------------------------------------------------------------------------------
*     EFFECTIVE       UNIT
*       DATE          NAME                             PENETRATION  FACTORS
*---------------------------------------------------------------------------------------------
*                                                           .SHMDPN.
*---------------------------------------------------------------------------------------------
*      MMMYYYY      AAAAAAAA        #          #          #          #          #          #
*      -------      --------    --------   --------   --------   --------   --------   --------
                    UNIT-11E       2.5        4.0
@      JAN2017      UNIT-11E       3.5        4.2
                    WIND-01        0.9
@      JUN2018      WIND-01        1.7
                    WIND-02        1.0
                    WIND-03        2.0
                    WIND-04        1.3

;;;; END OF &MOD-PENE-00 ;;;;
```

Unit Name

Enter the name of the hourly modifer unit.

Penetration Factors

Input the penetration factors to be used in constructing this hourly modifier from the individual shapes. These factors correspond to the shapes assigned in table MOD-SHAP-03.

The modification for an hour is calculated as:

Value * Scale Factor * Penetration Factor

where the Scale Factor was input in the header line in the shapes file. The amount of modification is subtracted from the load: hence, positive values decrease the load, and negative values increase the load.

4.9.15 Definition of Random Sets and Probabilities (MOD-RAND)

```
&MOD-RAND-00     MRD      CONTINUATUIN
*            HOURLY MODIFER RANDOM DRAW
*-------------------------------------------------------
*    RANDOM GROUP       SET         P.U. OF
*      NUMBER           NAME       RANDOM DRAW
*-------------------------------------------------------
*       III           AAAAAAAA        #
*       ---           --------     -------
         3            PRODYR11       0.50
+                     PRODYR12       0.25
+                     PRODYR13       0.25

;;;; END OF &MOD-RAND-00 ;;;;
```

Group Number for Random Selection

For all groups where random set names are specified in MOD-SHAP-03, include the group number here.

Set Name for Random Draw

For each of the sets that make up the group in MOD-SHAP-03, enter them here. Note that this column and p.u. of Random Draw are intended to be used as a continuation table as pictured in the example above.

P.U. Of Random Draw

Provide a probability for each set. The sum of the probabilities for a group must equal 1.0.

4.9.16 Priority Order for Scheduling Non-Thermal Units and Load Modifiers (MOD-PRIO)

```
&MOD-PRIO-00     MPL      CONTINUATION
*                                 MODIFIER-PRIORITY-LIST
*---------------------------------------------------------------------------------------------------------
*                                PRIORITY ORDER FOR SCHEDULING LOAD MODIFIERS
*                                         (LOAD MODIFIER NAMES)
*---------------------------------------------------------------------------------------------------------
*                                                .IPRMOD.
*---------------------------------------------------------------------------------------------------------
*  AAAAAAAA     AAAAAAAA     AAAAAAAA     AAAAAAAA     AAAAAAAA     AAAAAAAA     AAAAAAAA     AAAAAAAA
*  --------     --------     --------     --------     --------     --------     --------     --------
   WIND-01      WIND-02      WIND-03      WIND-04      UNIT-9A      UNIT-8C      UNIT-5D      UNIT-1E
+  UNIT-11E     CONT-C-D     CONT-B-E     CONT-A-E


;;;; END OF &MOD-PRIO-00 ;;;;
```

Priority Order for Scheduling Load Modifiers

Input the names of the non-thermal units and load modifiers (Type 2 energy-limited units, energy storage units, and demand-side management devices), including units being used to represent contracts, in the order in which they are to be dispatched. Each non-thermal unit and load modifier must appear in this list once.

For developing the hourly ratings, contract units are scheduled in the order specified but do not modify area loads. Within the Monte Carlo simulation, the contracts will be dispatched according to their input order.

4.9.17 Non-thermal Units and Load Levels (MOD-UNCY)

```
&MOD-UNCY-00      MUC
*                                        NON-THERMAL-UNITS-AND-LOAD-LEVELS
*---------------------------------------------------------------------------------------------------------------
*     EFFECTIVE     UNIT NAME      APPLY                          UNIT AVAILABILITY BY LOAD LEVEL
*        DATE                       LFU      1       2       3       4       5       6       7       8       9      10
*---------------------------------------------------------------------------------------------------------------
*      MMMYYYY       AAAAAAAA       Y/N     Y/N     Y/N     Y/N     Y/N     Y/N     Y/N     Y/N     Y/N     Y/N     Y/N
*      -------       --------       ---     ---     ---     ---     ---     ---     ---     ---     ---     ---     ---
                    "UNT-MULT"       Y       =
                    "UNT-LL1 "       =       Y       N       N       N       N
                    "UNT-LL2 "       =       N       Y       N       N       N
                    "UNT-LL3 "       =       N       N       Y       N       N
                    "UNT-LL4 "       =       N       N       N       Y       N
                    "UNT-LL5 "       =       N       N       N       N       Y

;;;; END OF MOD-UNCY-00 ;;;;
```

Unit Name

Enter the name of the hourly shape, energy-limited type 3 (EL3), or energy storage (ES) unit.

Apply LFU

If selected (Y), load forecast uncertainty multipliers for the unit's area will be applied to the the data in this table for each load level. The default is N.

This value only applies to hourly shape units.

Unit availability by load level

Input whether the unit is avaliable for to each load level. The default is to include the shape (Y).

4.10 Contracts

4.10.1 Contract Data (FCT-DATA)

```
&FCT-DATA-00     FCD     CONTINUATION
*                                                      CONTRACT-DATA
*----------------------------------------------------------------------------------------------------------------------
*                           CONTRACT                                MODIFY TIE   *****  ASSIGNED PATH  *****    *****  ASSIGNED PATH  *****
*                             TYPE        SENDING    RECEIVING       RATINGS               DIRECTION                       DIRECTION
* EFFECTIVE    CONTRACT     F = FIRM        AREA        AREA          B = BOTH    INTERFACE   P = POS.              INTERFACE   P = POS.
*   DATE         NAME     C = CURTAIL.      NAME        NAME        A = ACTUAL      NAME      N = NEG.   P.U.         NAME      N = NEG.   P.U.
*----------------------------------------------------------------------------------------------------------------------
*            .NAMECT.      .ICTTYP.     .ICTSND.   .ICTREC.                            .IDTICT.    .PUCTRT.
*----------------------------------------------------------------------------------------------------------------------
*   YYYY     AAAAAAAA          A        AAAAAAAA   AAAAAAAA           A        AAAAAAAA       A        #       AAAAAAAA       A        #
*   ----     --------         ---       --------   --------          ---       --------      ---     -----     --------      ---     -----
             CONT-C-D          F        AREA-C     AREA-D             B        C-TO-D         P       1.00
             CONT-B-E          C        AREA-B     AREA-E             B        B-TO-C         P       1.00     C-TO-E         P       1.00
             CONT-A-E          F        AREA-A     AREA-E             A        A-TO-C         P       1.00     C-TO-E         P       1.00

;;;; END OF &FCT-DATA-00 ;;;;
```

Contract Name

Enter the eight-character name of the Type 2 energy-limited or demand-side management unit being used to model the contract.

Contract Type

F Firm

C Curtailable

Enter the code to indicate whether the contract is firm (F) or curtailable (C). The default is F. A description of firm and curtailable contracts is found in section 2.4.3 of this manual.

Sending Area Name

Input the abbreviated name of the area which is supplying the contract.

Receiving Area Name

Enter the abbreviated name of the area which is receiving the contract.

Modify Tie Ratings

B Both

A Actual

When the contract is scheduled, the limits on the assigned path interfaces on which the contract flows are adjusted accordingly. Enter the code to indicate whether to change the limits in both directions (B) or only in the direction of the actual flow (A). The default is B.

Assigned Path: Interface Name, Direction, and P.U.

The user specifies which area interfaces are to be used to deliver the contract from the sending are to the receiving area. (The program will not check that the path specified actually connects the sending and receiving areas.) Enter the eight-character name of the interface, the code to indicate whether the flow is in the positive (P) or negative (N) direction, and the per unit portion of the contract that flows on this path. (Default for per unit portion is 0.0.)

Additional assigned path data can be specified on the next line by using the continuation character (+) in the line-zone (column 1 or 2).

Note The names of all of the contracts to be included during the study must be input in the general data (data without an override date). If the contract is not actually in place until later in the study, this can be specified through the installation and retirement dates of the unit being used to model the contract.

If the Assigned Path data is being overridden through time, all of the data must be re-input.

4.10.2 Contracts Tied to Other Units (FCT-UNIT)

```
&FCT-UNIT-00      FCU     CONTINUATION
*              CONTRACTS-TIED-TO-OTHER-UNITS
*-----------------------------------------------------------
*     EFFECTIVE      CONTRACT      OTHER UNIT      P.U. OF
*        DATE          NAME           NAME       OTHER UNIT
*-----------------------------------------------------------
*
*-----------------------------------------------------------
*      MMMYYYY       AAAAAAAA       AAAAAAAA       ########
*      -------       --------       --------       --------
                    "CONTRACT"    "UNIT-1   "      1.000000
+                                 "UNIT-2   "      0.500000

;;;; END OF FCT-UNIT-00 ;;;;
```

Contract Name

Enter the eight-character name of the Type 2 energy-limited or demand-side management unit being used to model the contract.

Other Unit

Enter the eight-character name of the unit to be tied to the contract.

P.U. of other unit capacity

Enter the multiplier to be applied to the other unit capacity. In the example, the CONTRACT unit capacity is calculated as the combination of 1.0 times the capacity of UNIT-1 and 0.5 times the capaciyt of UNIT-2.

4.11 Area Interfaces

4.11.1 Definition of Area Interfaces (INF-DATA)

Interfaces are defined between pairs of areas that are interconnected. Each interface is modeled by a pair of ties: one from the FROM area to the TO area (referred to as being in the positive direction), and the other from the TO area to the FROM area (negative direction). Ratings for each tie in an interface are input on table INF-TRLM.

To model forced outages on the interface ties, the interface capacity states are input on table UNT-CAPS, and the interface forced outage rate data is input on table UNT-TRNS or UNT-FORS. The capacity state and forced outage data apply to both ties in the interfaces, and both ties go on outage at the same time. The option to model forced outages on interface ties is controlled through table GEN-CASE.

```
&INF-DATA-00      IDT
*                          INTERFACE-IDENTIFICATION
*------------------------------------------------------------------------------
*     ABBREVIATED                                          FROM          TO
*      INTERFACE                                           AREA         AREA
*        NAME            FULL INTERFACE NAME               NAME         NAME
*------------------------------------------------------------------------------
*       .NMTIE.                 .NMTIEL.                 .LTIEB.       .LTIEE.
*------------------------------------------------------------------------------
*      AAAAAAAA        AAAAAAAAAAAAAAAAAAAAAAAA         AAAAAAAA      AAAAAAAA
*      --------       --------------------------        --------      --------
       A-TO-B         'AREA-A TO AREA-B'                AREA-A        AREA-B
       A-TO-C         'AREA-A TO AREA-C'                AREA-A        AREA-C
       B-TO-C         'AREA-B TO AREA-C'                AREA-B        AREA-C
       C-TO-D         'AREA-C TO AREA-D'                AREA-C        AREA-D
       C-TO-E         'AREA-C TO AREA-E'                AREA-C        AREA-E
       D-TO-E         'AREA-D TO AREA-E'                AREA-D        AREA-E


;;;; END OF &INF-DATA-00 ;;;;
```

Abbreviated Interface Name

Enter an eight-character name for each interface.

Full Interface Name

Input a 24-character name for each interface.

From Area Name

Enter the name of the area in which the interface begins.

To Area Name

Enter the name of the area in which the interface ends.

Note Do not define two interfaces between the same two areas.

4.11.2 Definition of Interface Groups (INF-GRPS)

Simultaneous transfer limits are modeled by limiting the total flow on groups of two or more interfaces. The interface groups are defined in terms of the individual interfaces and the portion of the flow on the interface that is counted in the total flow for the group.

```
&INF-GRPS-00     IGP      CONTINUATION
*                                              INTERFACE-GROUP-IDENTIFICATION
*-----------------------------------------------------------------------------------------------------------------------------------
*    ABBREVIATED                                  ABBREVIATED                  ABBREVIATED                  ABBREVIATED
*     INTERFACE                                    INTERFACE     PER UNIT       INTERFACE     PER UNIT       INTERFACE     PER UNIT
*    GROUP NAME    FULL INTERFACE GROUP NAME         NAME       MULTIPLIER        NAME       MULTIPLIER        NAME       MULTIPLIER
*-----------------------------------------------------------------------------------------------------------------------------------
*     .NMINTF.              .NMINTL.              .INTGRP.      .XGRPPU.       .INTGRP.      .XGRPPU.       .INTGRP.      .XGRPPU.
*-----------------------------------------------------------------------------------------------------------------------------------
*     AAAAAAAA      AAAAAAAAAAAAAAAAAAAAAAAA       AAAAAAAA         #          AAAAAAAA         #          AAAAAAAA         #
*     --------     -------------------------       --------        ---         --------        ---         --------        ---
      P1-TO-P2    'POOL 1 TO POOL 2  POS  '        C-TO-D          1.0         C-TO-E          1.0

      A-IMPORT    'NET IMPORTS INTO A     '        A-TO-B         -1.0         A-TO-C         -1.0

      C-EXPORT    'NET EXPORTS FROM C     '        A-TO-C         -1.0         B-TO-C         -1.0         C-TO-D          1.0
+                                                  C-TO-E          1.0


;;;; END OF &INF-GRPS-00 ;;;;
```

Abbreviated Interface Group Name

Enter an eight-character name for each interface group.

Full Interface Group Name

Input a 24-character name for each interface group.

Abbreviated Interface Name

Enter the abbreviated name of one of the interfaces that is part of this interface group.

Per Unit Multiplier

Input the per unit portion of the flow on the named interface that is included in the total flow for the interface group. Note that the sign must take into account the direction of the named interface as originally defined in INF-DATA.

4.11.3 Identification of Closed Interface Groups (INF-CLSD)

To speed up the calculations related to the flows on interface groups, the program uses special logic for closed interface groups. A closed interface group is one that completely encircles a portion of the system. In the reserve sharing calculations, if a closed interface is limiting, the area margins within that interface will be adjusted to reflect the transfer limits on that interface group. The closed interfaces will be processed in the order in which they are listed, so if a closed interface is enclosed by another closed interface, it is recommended that they be listed from the inside out.

```
&INF-CLSD-00     ICD
*                          IDENTIFICATION-OF-CLOSED-INTERFACES
*-----------------------------------------------------------------------------------------------------
*    ABBREVIATED      DIRECTION OF
*     INTERFACE       POSTIVIE FLOW
*    GROUP NAME       I=IN  O=OUT        ABBREVIATED NAMES OF AREAS WITHIN THE CLOSED INTERFACE
*-----------------------------------------------------------------------------------------------------
*     .NMINTF.          .IDIRGP.                              .IARGRP.
*-----------------------------------------------------------------------------------------------------
*     AAAAAAAA             A            AAAAAAAA     AAAAAAAA     AAAAAAAA     AAAAAAAA     AAAAAAAA
*     --------             -            --------     --------     --------     --------     --------


;;;; END OF &INF-CLSD-00 ;;;;
```

Abbreviated Interface Group Name

Enter the abbreviated name of the interface group that is closed. Be sure that each closed interface group is only listed once.

Direction of Positive Flow

Indicate whether the positive flow of the interface group as defined in INF-GRPS is into (I) or out of (O) the closed interface group.

Abbreviated Names of Areas Within the Closed Interface

Enter the abbreviated name of the areas that are contained within this closed interface group.

4.11.4 Interface Transfer Limits (INF-TRLM)

```
&INF-TRLM-00      ITL
*                           INTERFACE-TRANSFER-LIMITS
*----------------------------------------------------------------------------------------------------------------
*               INTERFACE     POSITIVE     NEGATIVE                         ZERO TIE LIMITS      ALLOW OUTPUTING
*                  OR         DIRECTION    DIRECTION     ZERO TIE LIMITS      FOR INITIAL        OF FLOWS WHEN
*    EFFECTIVE  INTF. GROUP   TIE LIMIT    TIE LIMIT     BEFORE NON-FIRM    NON-FIRM AND EOP     MASKING INPUT
*      DATE        NAME         (MW)         (MW)         ASSISTANCE ?      CALCULATIONS ?         DATA ?
*----------------------------------------------------------------------------------------------------------------
*                             .TIEMW.      .TIEMW.         .LIMZER.            .ITIEOP.           .ITIEOT.
*----------------------------------------------------------------------------------------------------------------
*     MMMYYYY     AAAAAAAA       #            #               Y/N                 Y/N                Y/N
*     -------     --------    -------      -------            ---                 ---                ---
                     A-TO-B     100          100               Y                   N                  Y
                     A-TO-C     200          200               3                   N                  Y
                     B-TO-C     150          160               4                   N                  Y
                     C-TO-E      50           50               N                   N                  N
                     C-TO-D      50           50               N                   N                  N
                     D-TO-E     100          100               N                   N                  N

                     P1-TO-P2    90           90               N                   N                  N
                     A-IMPORT   250          250               N                   N                  Y
                     C-EXPORT   300          300               N                   N                  N

;;;; END OF &INF-TRLM-00 ;;;;
```

Interface Name

Enter the abbreviated interface or interface group name.

Positive Direction Tie Limit (MW)

Enter the maximum amount of power, in MW, that the interface or interface group can transfer in the positive direction.

Negative Direction Tie Limit (MW)

Input the maximum amount of power, in MW, that the interface or interface group can transfer in the negative direction.

Zero Tie Limits before Non-Firm Assistance?

If an interface is being used for scheduling contracts but not for non-firm emergency assistance, the tie limits can be set to zero before doing the non-firm assistance calculations. This option is controlled through table GEN-OPTN.

The default is N.

This input does not apply to interface groups.

Zero Tie Limits for Initial Non-Firm and EOP Calculations?

To model the case in which a group of areas would provide assistance (including implementing emergency operating procedures) to each other before turning to outside areas for additional assistance, you can effectively isolate portions of the system by setting specified tie limits to zero during the initial stages of the interconnected calculations. This option is controlled through table GEN-OPTN.

If the entry for an interface is "N" or 0, they will not be zeroed regardless of what the control option in table GEN-OPTN. If the entry is "Y", the entry is considered as zeroing the interface limit up to specified margin state 1. Other values, up to the maximum number of EOP margin states, can be entered.

The interface control option specified in table GEN-OPTN will still have control on the minimum EOP margin states that the interface ratings will be zeroed. For example, if ISOEOP specified in table GEN-OPTN is 5, all interfaces which have entries other than "N" or "0" will still be zeroed at least up to EOP margin state 5. If an individual interface has EOP switch higher than the ISOEOP value, it will continue to be zeroed until after that margin is reached.

By default, the ties limits will be force to zero with this option. However, a fraction of the tie capacities can be enabled instead by entering a value in RELVAL(3) in INT-ONLY-00.

The default is N.

This input does not apply to interface groups.

Allow Output of Flows When Masking Input Data?

If you are using the option to write portions of the input data to a binary file to facilitate the sharing of confidential data between users, you can specify the interfaces and interface groups for which the flow summaries will be written in the case using the masked data. The default is Y, which will allow the summaries to be written.

4.12 Dynamic Conditions

4.12.1 Unit Triggers for Dynamic Conditions (UNT-COND)

This table is used to define the unit-based triggers to be considered in dynamic condition. Each condition set is described in terms of whether specified units are available (which includes being on partial forced outage) or unavailable (retired, not installed, on planned maintenance, or on full forced outage) or in a specified capacity state. For each condition set, you also specify either the exact or minimum number of conditions that must be met for the condition set to be satisfied. For more information, please refer to the Dynamic Conditions section.

```
&UNT-COND-00      UCD     CONTINUATION
*                         DYNAMIC LIMIT UNIT CONDITIONS
*--------------------------------------------------------------------------------
*     CONDITION     NUMBER OF       UNIT OR         STATUS: A - AVAILABLE; U -
*        SET      CONDITIONS TO    INTERFACE     UNAVAILABLE; +# - < THIS STATE;
*       NUMBER       BE TRUE         NAME                -# - >= THIS STATE
*--------------------------------------------------------------------------------
*
*--------------------------------------------------------------------------------
*        III           III          AAAAAAAA                    AAA
*        ---           ---          --------                    ---
           1             2         'UNIT1    '                    A
+                                  'UNIT2    '                    U
+                                  'UNIT3    '                    3
+                                  'UNIT4    '                   -2

;;;; END OF UNT-COND-00 ;;;;
```

Condition Set Number

Enter a unique number for each condition set. This condition set number serves as the identifier to be used in condition consequence tables. If this same set number is used in LOD-COND, MOD-COND, LFU-COND, or DAT-COND, all the events will be evaluated to determine if the dynamic limit is to be applied.

Number of Conditions

Specify the number of unit conditions within the set which must be met for the set to be met. A positive number indicates that exact number of conditions must be met, zero (0) indicates that all conditions must be met, and a negative number indicates that at least that number of conditions must be met.

Unit Name

Enter the abbreviated name of each unit that is part of this condition set. May be a unit of type TH, CG1, CG2, or EL1, or an interface if outages are modeled on interfaces.

Status

Input the status of the unit required for the condition set to be met:

A the unit must be available (either fully available or on partial forced outage)

U the unit must be unavailable (on planned or full forced outage)

$>$**0** the unit is strictly at at state less than the state specified

$<$**0** the unit is in a state equal to or greater than the state specified

4.12.2 Modifier Triggers for Dynamic Conditions (MOD-COND)

This table is used to define the modifier-based triggers to be considered when defining dynamic limits. Each condition set is described in terms of whether the generation from EL2 or DS units are greater than or less than a specified value. For each condition set, you also specify either the exact or minimum number of conditions that must be met for the condition set to be satisfied. For more information, please refer to the Dynamic Conditions section.

```
&MOD-COND-00      MCD     CONTINUATION
*                      DYNAMIC-LIMIT-MODIFIER-CONDITIONS
*-----------------------------------------------------------------------------
*    CONDITION     NUMBER OF      EL2 OR DS      LT / GT             MW
*       SET      CONDITIONS TO       UNIT
*       NUMBER      BE TRUE
*-----------------------------------------------------------------------------
*       III           III           AAAAAAAA       LT/GT       ###############
*       ---           ---           --------       -----       ---------------
         2             -1          "UNIT 1  "        GT                   0.00
+                                  "UNIT 1  "        LT                 100.00

;;;; END OF MOD-COND-00 ;;;;
```

Condition Set Number

Enter a unique number for each condition set. This condition set number serves as the identifier to be used in condition consequence tables. If this same set number is used in LOD-COND, UNT-COND, LFU-COND, or DAT-COND, all the events will be evaluated to determine if the dynamic limit is to be applied.

Number of Conditions

Specify the number of unit conditions within the set which must be met for the set to be met. A positive number indicates that exact number of conditions must be met, zero (0) indicates that all conditions must be met, and a negative number indicates that at least that number of conditions must be met.

EL2 or DS unit

Enter the abbreviated name of each EL2 or DS unit that is part of this condition set.

LT / GT

Indicate whether the generation must be less than (LT) or greater than (GT) the specified value for the condition set to be met.

MW

Input the EL2 or DS unit generation, in MW, to be used in determining whether or not the condition set is met.

4.12.3 Load Triggers for Dynamic Conditions (LOD-COND)

This table is used to define the load-based triggers to be considered when defining dynamic limits. Each condition set is described in terms of whether loads are greater than or less than a specified value. For each condition set, you also specify either the exact or minimum number of conditions that must be met for the condition set to be satisfied. For more information, please refer to the Dynamic Conditions section.

```
&LOD-COND-00      LCD     CONTINUATION
*                         DYNAMIC-LIMIT-LOAD-CONDITIONS
*---------------------------------------------------------------------------
*    CONDITION     NUMBER OF      AREA, AREA     LT / GT             MW
*       SET      CONDITIONS TO   GROUP, POOL
*      NUMBER       BE TRUE        NAME OR
*                                   SYSTEM
*---------------------------------------------------------------------------
*
*---------------------------------------------------------------------------
*       III           III          AAAAAAAA       LT/GT       ###############
*       ---           ---          --------       -----       ---------------
          2            -1         'AREA 1  '         LT                  1000
+                                 'AREA 2  '         GT                  5000

;;;; END OF LOD-COND-00 ;;;;
```

Condition Set Number

Enter a unique number for each condition set. This condition set number serves as the identifier to be used in condition consequence tables. If this same set number is used in UNT-COND, MOD-COND, LFU-COND, or DAT-COND, all the events will be evaluated to determine if the dynamic limit is to be applied.

Number of Conditions

Specify the number of unit conditions within the set which must be met for the set to be met. A positive number indicates that exact number of conditions must be met, zero (0) indicates that all conditions must be met, and a negative number indicates that at least that number of conditions must be met.

Area Name, Pool Name, or `SYSTEM`

Enter the abbreviated name of each load area, area group, or pool that is part of this condition set, or enter `SYSTEM` to use the system load.

LT / GT

Indicate whether the load must be less than (LT) or greater than (GT) the specified value for the condition set to be met.

MW

Input the area, area group, pool, or system load, in MW, to be used in determining whether or not the condition set is met. By default, the forecast area loads, after adjustment for load forecast uncertainty, are used in the calculations. To use the base or expected loads before adjustment for load forecast uncertainty, input 1 for INTVAL(19) on the INT-ONLY-00 table as described on page 57.

4.12.4 Date Triggers for Dynamic Conditions (DAT-COND)

This table is used to define date-based triggers for dynamic conditions. Each condition set is described in terms of whether a day in the simulation falls within the periods specified in the table. For more information, please refer to the Dynamic Conditions section.

```
&DAT-COND-00      DCD     CONTINUATION
*           DYNAMIC-LIMIT-DATE-CONDITIONS
*-----------------------------------------------------
*     YEAR    CONDITION SET   START DATE   STOP DATE
*                NUMBER
*-----------------------------------------------------
*     YYYY         III           DDMMM        DDMMM
*     ----         ---           -----        -----

;;;; END OF DAT-COND-00 ;;;;
```

Condition Set Number

Enter a unique number for each condition set. This condition set number serves as the identifier to be used in condition consequence tables. If this same set number is used in UNT-COND, MOD-COND, LFU-COND, or LOD-COND, all the events will be evaluated to determine if the dynamic limit is to be applied.

Start date

Enter the starting date for the period in which the condition is active, in DDMMM format.

Stop date

Enter the stopping date for the period in which the condition is active in DDMMM format. The condition will be active in its stop date.

4.12.5 Dynamic Limit LFU Conditions (LFU-COND)

```
&LFU-COND-00      LFC
*                              DYNAMIC-LIMIT-LFU-CONDITIONS
*------------------------------------------------------------------------------------
*    CONDITION                         CONDITION BY LOAD LEVEL
*       SET       1      2      3      4      5      6      7      8      9      10
*      NUMBER
*------------------------------------------------------------------------------------
*       III      Y/N    Y/N    Y/N    Y/N    Y/N    Y/N    Y/N    Y/N    Y/N    Y/N
*       ---      ---    ---    ---    ---    ---    ---    ---    ---    ---    ---
         1        Y      N      Y

;;;; END OF LFU-COND-00 ;;;;
```

Condition Set Number

Enter a unique number for each condition set. This condition set number serves as the identifier to be used in condition consequence tables. If this same set number is used in either UNT-COND, MOD-COND, or LOD-COND, all the events will be evaluated to determine if the dynamic limit is to be applied.

Condition by load level

If selected (Y), load forecast uncertainty multipliers for the unit's area will be applied to the the data in this table for each load level. The default is N.

This value only applies to hourly shape units.

Condition by load level

Input whether the condition set is active for each LFU level. The default is to include the shape (Y).

4.12.6 Dynamic Interface Transfer Limits (INF-DLIM)

The interface and interface group transfer limits can be varied hourly based on the status of condition triggers. This table is used to define the limits to be used if the the condition sets are satisfied, the ratings of the interfaces and interface groups associated with that condition set will be modified accordingly. For more information, please refer to the Dynamic Conditions section.

The adjustment to the ratings is specified as either a MW value or a per unit multiplier (if less than 1.0) on the rating input on the INF-TRLM table. If INTVAL(23) in INT-ONLY-01 is equal to zero (0), the most restrictive condition set in terms of interface ratings applies, and so the largest value that the rating will ever assume should be input on the INF-TRLM table. If INTVAL(23) is equal to one (1), the last applicable set will be applied.

```
&INF-DLIM-00      DLM     CONTINUATION
*                                                INTERFACE-DYNAMIC-LIMITS
*-------------------------------------------------------------------------------------------------------------------
*      EFFECTIVE     LIMIT   INTERFACE OR   LIMIT      POSITIVE        NEGATIVE      NUMBER OF        CONDITION SETS
*        DATE         SET     INTERFACE     ACTIVE     DIRECTION       DIRECTION    CONDITIONS TO
*                   NUMBER   GROUP NAME                  LIMIT           LIMIT        BE TRUE
*-------------------------------------------------------------------------------------------------------------------
*
*-------------------------------------------------------------------------------------------------------------------
*       MMMYYYY       III       AAAAAAAA      Y/N      #########       #########         III          III  III  III  III
*       -------       ---       --------      ---      ---------       ---------         ---          ---  ---  ---  ---
                       1       'ONE2TWO '      Y             100            9999           1            1    2   -3

;;;; END OF INF-DLIM-00 ;;;;
```

Limit Set Number

Enter a unique set number for each limit set to be applied.

Interface or Interface Group Name

Enter the abbreviated name of the interface or interface group whose limits are to be reset based on this limit set.

Limit Active (Y/N)

Enter whether the limit should be applied or not.

Positive Direction Limit (MW)

Input the transfer limits to apply in the positive direction if the condition set is met. Values between 0 and 1.0 will be treated as per unit multipliers to be applied to the limits input in INF-TRLM.

Negative Direction Limit (MW)

Input the transfer limits to apply in the negative direction if the condition set is met. Values between 0 and 1.0 will be treated as per unit multipliers to be applied to the limits input in INF-TRLM.

Number of Conditions

Specify the number of unit condition sets which must be met for the limit to be applied. A positive number indicates that exact number of conditions must be met, zero (0) indicates that all conditions must be met, and a negative number indicates that at least that number of conditions must be met.

Condition Sets

Specify the condition sets which must be evaluated to determine if the limits are applied. Positive set numbers will apply the set as defined, negative set numbers will return the complement. For example, if set 7 were defined as units A and B available, -7 would be true if either A, B, or both was unavailable.

4.12.7 Dynamic Unit Capacity (UNT-DCAP)

The rating of all units can be varied hourly based on the status fo condition triggers. This table is used to define the update values that unit capacity will take. if the the condition sets are satisfied, the unit maximum capacities associated with that condition set will be modified accordingly. For more information, please refer to the Dynamic Conditions section.

The adjustment to the maximum capacity is specified as either a MW value or a per unit multiplier (if less than 1.0) when applied to individual units. When applying to unit summary types, the value is always assumed to be a per-unit multiplier.

For thermal units, the modifications are applied to the ratin input given in the UNT-MXCP table.

For energy-limited type 2 (EL2) or hourly shape (DS) units, the value is used as a maximum limit or a per-unit multiplier to the generation in each hour. The energy curtailed by the dynamic limit is lost.

For energy-limited type 3 (EL3) or energy storage (ES) units, the value is applied to the maximum generation capacity provided in MOD-ELMW or MOD-ESMW. The limit applies to the combination of fixed dispatch (determined by the minimum generation) and as-needed generation (the remained up to the total capacity). The energy not used because of a dynamic limit can be carried to the following hour.

Modifications to the maximum capacity (such as capacity state or derate for EL1 units) are applied to the new value. For example, if this table forces the maximum capacity for EL1 Unit A to be 100 MW, but the unit output is derated by 60%, the unit capacity will be 60 MW for that hour.

```
&UNT-DCAP-00      DCP     CONTINUATION
*                                        UNIT-DYNAMIC-CAPACITY
*----------------------------------------------------------------------------------------------------
*     EFFECTIVE   CAPACITY  UNIT NAME OR   LIMIT       CAPACITY      NUMBER OF      CONDITION SETS
*       DATE        SET       UNIT TYPE    ACTIVE                  CONDITIONS TO
*                  NUMBER                                             BE TRUE
*----------------------------------------------------------------------------------------------------
*      MMMYYYY      IIII       AAAAAAAA      Y/N       #########        III        III  III  III  III
*      -------      ----       --------      ---       ---------        ---        ---  ---  ---  ---
                       1      "UNIT 1   "     Y              100          1          1    2   -3

;;;; END OF UNT-DCAP-00 ;;;;
```

Capacity Set Number

Enter a unique set number for each limit set to be applied.

Unit Name or Unit Type

Enter the abbreviated name of the unit for which the capacity is to be reset based on this limit set. You may also enter the abbreviated name for a unit summary type, to affect all the units of said type at once.

In case of conflict, the limits are applied in increasing capacity set number order.

Limit Active (Y/N)

Enter whether the limit should be applied or not.

Capacity (MW or P.U.)

Input the capacity to apply to the unit or unit summary type if the condition sets are met.

If this row is applied to a single unit, this value represents the new capacity (for values greater than 1) or per-unit multipliers (for values between 0 and 1). If this row is applied across a unit summary type, this value is interpreted as a per-unit multiplier.

Per-unit multipliers are a applied to the capacity input in UNT-MXCP.

Number of Conditions

Specify the number of unit condition sets which must be met for the capacity to be applied. A positive number indicates that exact number of conditions must be met, zero (0) indicates that all conditions must be met, and a negative number indicates that at least that number of conditions must be met.

Condition Sets

Specify the condition sets which must be evaluated to determine if the capacity is applied. Positive set numbers will apply the set as defined, negative set numbers will return the complement. For example, if set 7 were defined as units A and B available, -7 would be true if either A, B, or both was unavailable.

4.13 Resource Allocation

4.13.1 Priority Order for Allocating Resources Among Areas (RES-PRIO)

```
&RES-PRIO-00     RPL      CONTINUATION
*                             RESOURCE-ALLOCATION-PRIORITY-LIST
*----------------------------------------------------------------------------------------------------------
*
*                  AREAS LISTED IN THE ORDER IN WHICH THEY RECEIVE ASSISTANCE
*----------------------------------------------------------------------------------------------------------
*                                    .IALLOC.
*----------------------------------------------------------------------------------------------------------
*
*  AAAAAAAA     AAAAAAAA     AAAAAAAA     AAAAAAAA     AAAAAAAA     AAAAAAAA     AAAAAAAA     AAAAAAAA
*  --------     --------     --------     --------     --------     --------     --------     --------
    AREA-A       AREA-B        AREA-C       AREA-D       AREA-E

;;;; END OF &RES-PRIO-00 ;;;;
```

Areas Listed in the Order in Which They Receive Assistance

Input the areas in the order in which they receive assistance from an area with excess resources. This is a system-wide list and applies regardless of which area has surplus. Each area must appear in this list once.

On table CNV-CRIT, you can specify that areas with excess must first assist all of the areas within that pool before providing assistance to outside areas.

This list defaults to the order in which the areas are input on table GEN-AREA.

4.13.2 Pool Reserve Sharing Data (RES-POOL)

```
&RES-POOL-00     RSP      CONTINUATION
*                                                   POOL-RESERVE-SHARING-DATA
*------------------------------------------------------------------------------------------------------------------------
*                                           ALLOW FLOW
*  EFFECTIVE     PRIORITY      POOL WITH      THROUGH
*    DATE         ORDER         EXCESS      OUTSIDE POOLS ?    - - - - - - - -  POOLS RECEIVING ASSISTANCE   - - - - - - - -
*------------------------------------------------------------------------------------------------------------------------
*                              .IPLSND.        .IFLPLP.                                         .IPLREC.
*------------------------------------------------------------------------------------------------------------------------
*
*    YYYY         III          AAAAAAAA          Y/N          AAAAAAAA     AAAAAAAA     AAAAAAAA     AAAAAAAA     AAAAAAAA
*    ----         ---          --------          ---          --------     --------     --------     --------     --------


;;;; END OF &RES-POOL-00 ;;;;
```

Priority Order

Input the priority order of the reserve sharing arrangement. The priority order values, which must range from 1 to the number of arrangements being specified, do not have to be in sequence. If a priority order value is repeated, that data will override the data previously input with the same priority order.

Pool With Excess

Enter the eight-character name of the pool with excess that is providing assistance. A given pool may be listed multiple times if, for example, it provides assistance to some pools, then another pool provides assistance, then the first provides assistance to others, etc.

Allow Flow Through Outside Pools?

Indicate whether flow through outside pools is allowed with this reserve sharing arrangement. The default is Y.

Pools Receiving Assistance

Enter the eight-character name of each pool receiving assistance under this reserve sharing arrangement. If using reserve sharing (table CNV-CRIT), the areas in the pools listed will share the excess reserves of the pool with excess in proportion to their deficiencies. Otherwise, the areas in the pools receiving assistance will receive it according to the area priorities from table RES-PRIO.

4.14 Emergency Operating Procedures

4.14.1 Margin State Data for Modeling Emergency Operating Procedures (EOP-DATA-01)

MARS evaluates the need for implementing emergency operating procedures by calculating the expected number of days per year that the system is at specified positive and negative margin states. If you are calculating the daily LOLE based on all of the hours in the day, the hourly LOLE and unserved energy (LOEE) will also be calculated for each margin state.

Up to twenty margin states can be input for each area on the system. More details on the modeling of emergency operating procedures can be found in section 2.4.7.

```
&EOP-DATA-01     EP1
*                                             EMERGENCY-OPERATING-PROCEDURE-DATA
*----------------------------------------------------------------------------------------------------------------------------------
*                                                                                                                   USE EOP FOR
*                                                                           ORIGINAL OR     P.U. OF     NUMBER OF    A - AREA ONLY
*  EFFECTIVE     AREA      EOP                                     P.U. OF   MODIFIED     AVAILABLE   TIMES PER    P - POOL ONLY
*   DATE         NAME       #        EOP NAME          MW          LOAD       LOAD ?      CAPACITY     MONTH       S - SYSTEM
*----------------------------------------------------------------------------------------------------------------------------------
*                                     .NMEOP.        .EOPMW.     .EOPLOD.   .IEOPLD.     .EOPCAP.     .IEOPLM.     .IEOPBN.
*----------------------------------------------------------------------------------------------------------------------------------
*  MMMYYYY      AAAAAAAA    I       AAAAAAAAAAAA        #           #          O/M          #            I           A/P/S
*  -------      --------   ---      ------------      -----       -----        ---        -----         ---          -----
                AREA-A      1      'OPER. RESRVS'     -300          =           =           =            =             S
                AREA-A      2      'EMRG RATINGS'      100          =           =           =            =             S
                AREA-A      3      'INTRPT LDS 1'      100          =           =           =            =             S
                AREA-A      4      'VOLTAGE RED.'      100          =           =           =            =             S
                AREA-A      5      'CUST. APPEAL'      100          =           =           =            =             S
                AREA-A      6      'REDUCE O.R. '      100          =           =           =            =             S

                AREA-B      1      'OPER. RESRVS'     -100          =           =           =            =             S
                AREA-B      2      'EMRG RATINGS'       30          =           =           =            =             S
                AREA-B      3      'INTRPT LDS 1'       20          =           =           =            =             S
                AREA-B      4      'VOLTAGE RED.'       50          =           =           =            =             S
                AREA-B      5      'CUST. APPEAL'       50          =           =           =            =             S
                AREA-B      6      'REDUCE O.R. '       50          =           =           =            =             S

                AREA-C      1      'OPER. RESRVS'     -200          =           =           =            =             S
                AREA-C      2      'EMRG RATINGS'      100          =           =           =            =             S
                AREA-C      3      'INTRPT LDS 1'       50          =           =           =            =             S
                AREA-C      4      'VOLTAGE RED.'       50          =           =           =            =             S
                AREA-C      5      'CUST. APPEAL'       50          =           =           =            =             S
                AREA-C      6      'REDUCE O.R. '       50          =           =           =            =             S

                AREA-D      1      'OPER. RESRVS'     -200          =           =           =            =             S
                AREA-D      2      'EMRG RATINGS'       50          =           =           =            =             S
                AREA-D      3      'INTRPT LDS 1'       50          =           =           =            =             S
                AREA-D      4      'VOLTAGE RED.'      100          =           =           =            =             S
                AREA-D      5      'CUST. APPEAL'      100          =           =           =            =             S
                AREA-D      6      'REDUCE O.R. '      100          =           =           =            =             S

                AREA-E      1      'OPER. RESRVS'     -100          =           =           =            =             S
                AREA-E      2      'EMRG RATINGS'       50          =           =           =            =             S
                AREA-E      3      'INTRPT LDS 1'       25          =           =           =            =             S
                AREA-E      4      'VOLTAGE RED.'       25          =           =           =            =             S
                AREA-E      5      'CUST. APPEAL'       25          =           =           =            =             S
                AREA-E      6      'REDUCE O.R. '       25          =           =           =            =             S

;;;; END OF &EOP-DATA-01 ;;;;
```

Area Name

Enter the abbreviated area name.

EOP data must be specified in the general data (data without an override date) although it can be overridden during the study.

EOP

Input a number from 1 to 10 to indicate the order in which the procedures are initiated. The EOPs with a given number are implemented for all of the areas at the same time. If data for a given EOP number is not input, that EOP is assumed to have a 0 MW value.

EOP Name

Input a 12-character name for the EOP being modeled.

MW

Enter the value of the EOP as a fixed MW amount. The default is 0. Negative values can be entered for this input and the per unit of load and capacity multipliers to represent requirements such as operating reserves. The negative EOP must be first in the list and the first positive EOP must be in the same position for all of the areas.

P.U. Of Load

Enter the value of the EOP as a per unit of the area hourly load. The default is 0.

Original or Modified Load?

Specify whether the original (O) or modified (M) area load is to be used to compute the EOP's value. The original or modified loads will have been adjusted by the load forecast uncertainty load multipliers.

The default is O.

P.U. Of Available Capacity

Enter the value of the EOP as a per unit of the available capacity (not on outage) in the area. The default is 0.

Number of Days Per Month

Input the number of days during the month that this EOP can be initiated. Implementation multiple times during a day counts as a single day. Once the limit has been reached, this EOP will not be available again for use until the beginning of the next month. Negative EOP cannot have a limit. The default is 9999.

Use EOP for Area Only, Pool Only, or System

Indicate whether the EOP is to be initiated for the benefit of only the area itself (A), to assist other areas in the same pool (P), or to assist all deficient areas, regardless of the pool to which they belong (S). The default is S (assist all areas, regardless of pool).

4.14.2 Margin State Data for Modeling Emergency Operating Procedures (EOP-DATA-02)

MARS evaluates the need for implementing emergency operating procedures by calculating the expected number of days per year that the system is at specified positive and negative margin states. If you are calculating the daily LOLE based on all of the hours in the day, the hourly LOLE and unserved energy (LOEE) will also be calculated for each margin state.

Up to twenty margin states can be input for each area on the system. More details on the modeling of emergency operating procedures can be found in section 2.4.7.

```
&EOP-DATA-02    EP2
*                                    MARGIN-STATE-DATA-FOR-MODELING-EMERGENCY-OPERATING-PROCEDURES
*--------------------------------------------------------------------------------------------------------------------------------
*       DATE    AREA NAME   EOP      EOP NAME        EOP MW   P.U. OF   ORIG.    P.U. OF  NUMBER  NUMBER  NUMBER    ENERGY   USE EOP
*                            #                                 LOAD      OR      AVAIL.     OF      OF      OF     PER DAY    FOR
*                                                                       MOD.    CAPACITY   DAYS    DAYS   HOURS     (MWH)     AREA
*                                                                       LOAD?               PER     PER     PER               ONLY,
*                                                                                          YEAR   MONTH    DAY                POOL
*                                                                                                                             ONLY,
*                                                                                                                              OR
*                                                                                                                            SYSTEM
*--------------------------------------------------------------------------------------------------------------------------------
*                                   .NMEOP.       .EOPMW.   .EOPLOD. .IEOPLD. .EOPCAP. .IEOPLY..IEOPLM..IEOPLD.  .IEOPLE.  .IEOPBN.
*--------------------------------------------------------------------------------------------------------------------------------
*     MMMYYYY    AAAAAAAA    I    AAAAAAAAAAAA    #######    ######    O/M      ######    III     III     III    #######    A/P/S
*     -------    --------    -    ------------    -------    ------    ---      ------    ---     ---     ---    -------    -----
                "AREA-A  "   1   'OPER. RESRVS'      -300         =      =           =      =       =       =          =        S
                "AREA-A  "   2   'EMRG RATINGS'       100         =      =           =      =       =       =          =        S
                "AREA-A  "   3   'INTRPT LDS 1'       100         =      =           =      =       =       =          =        S
                "AREA-A  "   4   'VOLTAGE RED.'       100         =      =           =      =       =       =          =        S
                "AREA-A  "   5   'CUST. APPEAL'       100         =      =           =      =       =       =          =        S
                "AREA-A  "   6   'REDUCE O.R. '       100         =      =           =      =       =       =          =        S

                "AREA-B  "   1   'OPER. RESRVS'      -100         =      =           =      =       =       =          =        S
                "AREA-B  "   2   'EMRG RATINGS'        30         =      =           =      =       =       =          =        S
                "AREA-B  "   3   'INTRPT LDS 1'        20         =      =           =      =       =       =          =        S
                "AREA-B  "   4   'VOLTAGE RED.'        50         =      =           =      =       =       =          =        S
                "AREA-B  "   5   'CUST. APPEAL'        50         =      =           =      =       =       =          =        S
                "AREA-B  "   6   'REDUCE O.R. '        50         =      =           =      =       =       =          =        S

                "AREA-C  "   1   'OPER. RESRVS'      -200         =      =           =      =       =       =          =        S
                "AREA-C  "   2   'EMRG RATINGS'       100         =      =           =      =       =       =          =        S
                "AREA-C  "   3   'INTRPT LDS 1'        50         =      =           =      =       =       =          =        S
                "AREA-C  "   4   'VOLTAGE RED.'        50         =      =           =      =       =       =          =        S
                "AREA-C  "   5   'CUST. APPEAL'        50         =      =           =      =       =       =          =        S
                "AREA-C  "   6   'REDUCE O.R. '        50         =      =           =      =       =       =          =        S

                "AREA-D  "   1   'OPER. RESRVS'      -200         =      =           =      =       =       =          =        S
                "AREA-D  "   2   'EMRG RATINGS'        50         =      =           =      =       =       =          =        S
                "AREA-D  "   3   'INTRPT LDS 1'        50         =      =           =      =       =       =          =        S
                "AREA-D  "   4   'VOLTAGE RED.'       100         =      =           =      =       =       =          =        S
                "AREA-D  "   5   'CUST. APPEAL'       100         =      =           =      =       =       =          =        S
                "AREA-D  "   6   'REDUCE O.R. '       100         =      =           =      =       =       =          =        S

                "AREA-E  "   1   'OPER. RESRVS'      -100         =      =           =      =       =       =          =        S
                "AREA-E  "   2   'EMRG RATINGS'        50         =      =           =      =       =       =          =        S
                "AREA-E  "   3   'INTRPT LDS 1'        25         =      =           =      =       =       =          =        S
                "AREA-E  "   4   'VOLTAGE RED.'        25         =      =           =      =       =       =          =        S
                "AREA-E  "   5   'CUST. APPEAL'        25         =      =           =      =       =       =          =        S
                "AREA-E  "   6   'REDUCE O.R. '        25         =      =           =      =       =       =          =        S

 ;;;; END OF &EOP-DATA-02 ;;;;
```

Area Name

Enter the abbreviated area name.

EOP data must be specified in the general data (data without an override date) although it can be overridden during the study.

EOP

Input a number from 1 to 10 to indicate the order in which the procedures are initiated. The EOPs with a given number are implemented for all of the areas at the same time. If data for a given EOP number is not input, that EOP is assumed to have a 0 MW value.

EOP Name

Input a 12-character name for the EOP being modeled.

MW

Enter the value of the EOP as a fixed MW amount. The default is 0. Negative values can be entered for this input and the per unit of load and capacity multipliers to represent requirements such as operating reserves. The negative EOP must be first in the list and the first positive EOP must be in the same position for all of the areas.

P.U. Of Load

Enter the value of the EOP as a per unit of the area hourly load. The default is 0.

Original or Modified Load?

Specify whether the original (O) or modified (M) area load is to be used to compute the EOP's value. The original or modified loads will have been adjusted by the load forecast uncertainty load multipliers.

The default is O.

P.U. Of Available Capacity

Enter the value of the EOP as a per unit of the available capacity (not on outage) in the area. The default is 0.

Number of Days Per Year

Input the number of days during the year that this EOP can be initiated. Implementation multiple times during a day counts as a single day. Negative EOP cannot have a limit. The default is9999.

Number of Days Per Month

Input the number of days during the month that this EOP can be initiated. Implementation multiple times during a day counts as a single day. Once the limit has been reached, this EOP will not be available again for use until the beginning of the next month. Negative EOP cannot have a limit. The default is 9999.

Number of Hours Per Day

Input the number of hours during the day that this EOP can be initiated. Once the limit has been reached, this EOP will not be available again for use until the beginning of the next day. Negative EOP cannot have a limit. The default is 9999.

Number of Energy Per Day

Input the energy (MWh) during the day that this EOP can be initiated. Once the limit has been reached, this EOP will not be available again for use until the beginning of the next day. Negative EOP cannot have a limit. The default is 9999.

Use EOP for Area Only, Pool Only, or System

Indicate whether the EOP is to be initiated for the benefit of only the area itself (A), to assist other areas in the same pool (P), or to assist all deficient areas, regardless of the pool to which they belong (S). The default is S (assist all areas, regardless of pool).

4.14.3 Data for Staggering Emergency Operating Procedures (EOP-DLAY)

MARS assumes that all of the areas move through the EOPs together. In other words, all of the areas initiate the first step at the same time, then move to the second step together, and so on. The program also has the option to stagger the implementation of EOPs, which would simulate the requirement that deficient areas must implement a specific number of EOPs before the other areas that are not deficient begin their EOPs. For each area you specify the number of EOPs that the deficient area must implement before the named area begins its EOPs. This data is input separately for areas in the same pool and for areas in outside pools.

```
&EOP-DLAY-00      EPD
*                     EMERGENCY-OPERATING-PROCEDURE-DELAY
*----------------------------------------------------------------------
*                              NUMBER OF EOPS DEFICIENT AREA MUST
*                            IMPLEMENT BEFORE NAMED AREA BEGINS EOPS
*
*  EFFECTIVE      AREA        DEFICIENT AREA         DEFICIENT AREA
*    DATE         NAME         IN SAME POOL          IN OUTSIDE POOL
*----------------------------------------------------------------------
*                                           .IEOPDL.
*----------------------------------------------------------------------
*   MMMYYYY     AAAAAAAA            I                     I
*   -------     --------           ---                   ---

;;;; END OF &EOP-DLAY-00 ;;;;
```

Area Name

Enter the abbreviated area name.

Number of EOPs Deficient Area Must Implement Before Named Area Begins EOPs

Enter the number of emergency operating procedures (EOPs) that a deficient area must implement before the named area will begin implementing its EOPs to provide assistance. Input separate values for areas in the same pool as the area named, and for areas in outside pools.

The default is 0, which results in all areas moving through their EOPs together. Large value (greater than number of possible EOPs) will result in an area never using its EOPs to assist other areas.

Chapter 5

Binary Input Data File

To facilitate the sharing of confidential input data between users, MARS has an option that allows you to write selected unit and contract data and interface transition rates to a binary data file. Specifically, data from the following MIF tables is written to the binary file: MNT-UNOP-00, MNT-FIXD, MNT-FDMD, UNT-MXCP, UNT-CAPS, UNT-TRNS, MOD-CGMW-01, MOD-PENE, FCT-DATA, EOP-DATA-01, EOP-DATA-02, MOD-MDMW, MOD-PENE, MOD-SHAP-00, MOD-SHAP-01, MOD-SHAP-02, and MOD-SHAP-03. Except as described below, this data can then be deleted from the MIF, and the resulting MIF can be used with the binary file for subsequent runs. Additionally, shapes entere in file 17 are also added to be binary file and can be omitted in new runs.

Set this input to W to write the file, set it to R to read the file. If you are using this option, the program will automatically open a file named input-data.bin; you do not need to change your control file. Since the program does not read the file name from the control file, and thus you cannot specify a directory path, the file must be copied into the directory in which you are running if you are reading the file from a previous run.

When the file is first written, you can control the data that can be modified in subsequent runs that use it. A column on GEN-AREA allows you to specify whether or not the binary input data that is being read for units in that area is to be blocked from modification in the subsequent run. (The program will ignore this column in the MIF for the run in which the file is being read.) Even if data for a blocked unit is input, the program will ignore it and use the values read from the binary file. This is intended to keep someone from trying to back into the data for units other than those to which they have been given access.

The program compares the names of the units contained on the binary input file with those in the current MIF, and writes to file 06 a message regarding any mismatches. If units have been deleted in the current MIF, the program will terminate since this would result in data being assigned to the wrong units. In your current MIF you can retire units that were on the binary input file, but they must be left in the unit list.

If you want to add units to those that are on the binary input file, they must be added to the end of the unit list, which is determined by the UNT-DATA table. All new units will be listed in the maintenance and unit data summaries, even if they are in an area for which changing data on the existing units was blocked. The program will assign the random number seeds to the new units in such a way that the units on the binary data file will have the same seeds as in the original case. If you add units to the list, but give them an installation date so that they are not present during the study, you should get results identical to those from the original case that wrote the binary input file.

The binary input file contains the transition rate data for the units and interfaces, even if the program option to input forced outage rates was selected. The case that reads this file can use either forced outage rates or transition rates for input for the units that can be modified.

In the maintenance summaries and the summary of unit input data at the end of file 07, only those units that were added to the MIF or those whose data is not being read from the binary file will be listed; the units whose data is being blocked are not printed. You can also identify the areas for which summaries of area capacity are to be blocked from being written.

The data for all of the contracts will be blocked. The units used to model the contracts must be left in the UNT-DATA list, although all of their other data may be deleted from the case reading the binary file. Likewise, the contract names, in the original order, must appear in the FCT-DATA table, although the remainder of the data in that table can be deleted.

If you wish to add contracts, the units used to model the contracts must be added to the end of UNT-DATA, and the contracts must be added to the end of FCT-DATA.

You can also specify on the INF-TRLM table the interfaces and interface groups for which the flow summaries are not to be written in a case that uses masked input data.

All emergency operating procedures (EOP) data is read from the binary file and data in EOP-DATA-01 and EOP-DATA-02 is ignored.

All the data used to represent hourly shape (DS) units is ignored from the MIF and read from the binary file. This includes tables MOD-MDMW, MOD-PENE, MOD-SHAP-00, MOD-SHAP-01, MOD-SHAP-02, and MOD-SHAP-03, along with shapes entered in file 17. Additional DS units can be modeled, as long as they are added at the end of UNT-DATA. New units cannot be associated with hourly shapes in the binary file and any shapes they use need to be entered in file 17.

Chapter 6

Multiple Processor Post-Processor - MARS-OUT

MARS has an option to allow a case to be split into pieces and run on multiple processors, thus reducing the elapsed time required to complete the run. The results of the multiple simulations are then combined through the MARS-OUT post-processor to produce the same weekly, monthly, annual, and replication results output summaries as if the case had been run as a single simulation.

When using this option, each simulation should be run to a fixed endpoint as specified by setting the minimum and maximum number of replications (table CNV-CRIT) to the same value. Testing on the standard error in a given simulation could produce misleading results since each simulation contains only a portion of the replications for the overall case.

This option is controlled through input INTVAL(12) on the INT-ONLY-00 MIF table (and is also available in GEN-CASE):

0 Begins the simulation at replication 1 and does not write the binary file with the intermediate results (default)

1 Begins the simulation at replication 1 and writes the binary file with the intermediate results

N Begins the simulation at replication N and writes the binary file with the intermediate results

No changes to the MARS control file are required. If the option is turned on, MARS will automatically open a binary file for writing the intermediate results of that simulation. The file will be named results-n.bin, where n is the number of the first replication for that run.

Once all of the simulations have completed, the MARS-OUT post-processor is run to combine the results from the individual simulations and produce consolidated MARS output reports.

To run a 1,000 replication case as four simulations of 250 replications each, the data in the MIF would be modified as follows:

Simulation	INTVAL(12)	MINREP/MAXREP	Intermediate Results File
1	1	250	results-1.bin
2	251	500	results-251.bin
3	501	750	results-501.bin
4	751	1000	results-751.bin

MARS-OUT requires a control file that lists the names of the input and output files. An example is shown below.

MARS writes a summary of some of the input data at the beginning of file 09. Since this data is not written on the intermediate results files read by MARS-OUT, MARS-OUT reads file 09 written by one of the simulations and copies the input data summary to the file 09 that it writes. The MARS output file used for this is specified on the second line of the MARS-OUT control file.

6.1 Example MARS-OUT Control File

```
mars-out.ot06              /*  Warnings and messages from MARS-OUT
../run1/mars.ot09          /*  mars.ot09 file to use for summary of input data
../run1/results-1.bin      /*  Intermediate binary results from first MARS case
../run2/results-251.bin    /*  Intermediate binary results from second MARS case
../run3/results-501.bin    /*  Intermediate binary results from third MARS case
../run4/results-751.bin    /*  Intermediate binary results from fourth MARS case
END OF INPUT FILES         /*  Line to indicate end of files with intermediate results
mars.ot08                  /*  Weekly and monthly indices
mars.ot09                  /*  Annual output
mars.ot11                  /*  Summaries by load level
```

Chapter 7

Output Reports

MARS calculates the following reliability indices:

- Daily LOLE (days/year)
- Hourly LOLE (hours/year)
- LOEE (MWh/year)
- Frequency (outages/year)
- Duration (hours/outage)

The program also calculates the daily LOLE at different margin states to evaluate the need for initiating various emergency operating procedures. All of these indices are calculated for each of the areas, pools, and area groups in the system, on both an isolated and interconnected basis. All of these calculations can be made at several different load levels to model the effects of load forecast uncertainty.

MARS produces many output reports that summarize the results of the reliability calculations. This information is available on a weekly, monthly, or annual basis, for the individual replications of the study year, and on an hourly basis during the replications. Other reports summarize the load models used for the simulation, the maintenance schedule developed by the program, and the input data for the generating units.

This section contains samples of the output reports that are available from MARS.

7.1 Program Execution Summaries

File code 06 begins with a summary of the study dimensions, listing the number of area, units, etc. in the study data. This file also contains a summary that tracks the progress of the program as it is executing. If any problems are detected in the data or during the program execution, the warning or error messages will print on this summary.

The user should always check this summary. If the program did not run successfully, this summary will contain information that can help in fixing the problem. If the program did run, this summary will warn the user of potential problems that should possibly be given further consideration.

7.1.1 Program Dimension Summary

```
                              MULTI-AREA RELIABILITY SIMULATION   Version  3.15              Run Date:   07022012
                                COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY               Job Number:   165443

TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                        Output Section   6
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                           Page             2
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS




                                        PROGRAM DIMENSION SUMMARY

                       QUANTITY                                    MAXIMUM ALLOWED            NUMBER USED
                       --------                                    ---------------            -----------

                       AREAS                                            125                       5

                       POOLS                                             15                       2

                       THERMAL UNITS                                  10000                      87

                       TYPE 1 ENERGY-LIMITED (PROBABILISTIC)            100                       2

                       TYPE 2 ENERGY-LIMITED (DETERMINISTIC)            700                       3

                       TYPE 1 COGENERATION (SYSTEM BACK-UP)              20                       1

                       TYPE 2 COGENERATION (NO BACK-UP)                  20                       1

                       ENERGY-STORAGE                                    20                       1

                       DEMAND-SIDE MANAGEMENT                           700                       8

                       UNIT TYPES                                       100                      10

                       AREA INTERFACES                                  150                       6

                       AREA INTERFACE GROUPS                             70                       3

                       LOAD FORECAST UNCERTAINTY LOAD LEVELS             10                       5

                       CONTRACTS                                        100
                            FIRM                                                                  2
                            CURTAILABLE                                                           1
```

7.1.2 Program Progress Summary

```
                                   MULTI-AREA RELIABILITY SIMULATION   Version  3.15              Run Date:    07022012
                                    COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY                Job Number:    165443

TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                            Output Section    6
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                               Page              3
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS



    MODIFIER SHAPE DATA FOR WTR HTR  BEING READ.

    MODIFIER SHAPE DATA FOR AIR COND BEING READ.

    MODIFIER SHAPE DATA FOR WINDSHP1 BEING READ.

    MODIFIER SHAPE DATA FOR WINDSHP2 BEING READ.

    MODIFIER SHAPE DATA FOR WINDSHP3 BEING READ.

    MODIFIER SHAPE DATA FOR WINDSHP4 BEING READ.

    EEI DATA FOR AREA AREA-A   BEING READ FOR 2015 FOR LOAD LEVEL   3.

    EEI DATA FOR AREA AREA-A   BEING READ FOR 2015 FOR LOAD LEVEL   1.

    EEI DATA FOR AREA AREA-A   BEING READ FOR 2015 FOR LOAD LEVEL   2.

    EEI DATA FOR AREA AREA-A   BEING READ FOR 2015 FOR LOAD LEVEL   4.

    EEI DATA FOR AREA AREA-A   BEING READ FOR 2015 FOR LOAD LEVEL   5.

    EEI DATA FOR AREA AREA-B   BEING READ FOR 2015 FOR LOAD LEVEL   3.

    EEI DATA FOR AREA AREA-B   BEING READ FOR 2015 FOR LOAD LEVEL   2.

    EEI DATA FOR AREA AREA-B   BEING READ FOR 2015 FOR LOAD LEVEL   4.

    EEI DATA FOR AREA AREA-B   BEING READ FOR 2015 FOR LOAD LEVEL   5.

    EEI DATA FOR AREA AREA-C   BEING READ FOR 2015 FOR LOAD LEVEL   6.

    EEI DATA FOR AREA AREA-D   BEING READ FOR 2015 FOR LOAD LEVEL   6.

    EEI DATA FOR AREA AREA-E   BEING READ FOR 2015 FOR LOAD LEVEL   6.

    *** WARNING - EEI LOAD DATA FOR BASE LOAD SHAPE NOT INPUT FOR AREA AREA-A   FOR 2015.
                  SHAPE WILL BE DEVELOPED FROM LOAD FORECAST UNCERTAINTY LOAD SHAPES AND PROBABILITIES.

    *** WARNING - BASE LOAD SHAPE FOR AREA AREA-A   FOR 2015 BEING DEVELOPED FROM LOAD FORECAST
                  UNCERTAINTY LOAD SHAPES AND PROBABILITIES.

    *** WARNING - EEI LOAD DATA FOR BASE LOAD SHAPE NOT INPUT FOR AREA AREA-B   FOR 2015.
                  SHAPE WILL BE DEVELOPED FROM LOAD FORECAST UNCERTAINTY LOAD SHAPES AND PROBABILITIES.

    *** WARNING - BASE LOAD SHAPE FOR AREA AREA-B   FOR 2015 BEING DEVELOPED FROM LOAD FORECAST
                  UNCERTAINTY LOAD SHAPES AND PROBABILITIES.

    MAINTENANCE SCHEDULING COMPLETED FOR YEAR 2015.

    RANDOM NUMBER GENERATOR SEED FOR 2015 IS        1340983.

    SIMULATION STOPPED AFTER     500 REPLICATIONS.

    RELIABILITY CALCULATIONS COMPLETED FOR 2015.
    .
    .
    .
    MAINTENANCE SCHEDULING COMPLETED FOR YEAR 2018.

    RANDOM NUMBER GENERATOR SEED FOR 2018 IS     1359236617.

    SIMULATION CONVERGED AFTER     500 REPLICATIONS.
    STANDARD ERROR =     0.0496   CONVERGENCE TOLERANCE =     0.0661

    RELIABILITY CALCULATIONS COMPLETED FOR 2018.
```

7.2 Annual Summaries

For each year that is studied, the program writes several annual summaries. This output appears on file code 09 and begins with a summary of the program options for the current year, and also includes a brief summary of some of the input data such as the interface tie ratings and area capacities and peak loads. More detailed summaries of the input data can be found on file code 07.

File code 09 also includes a summary of the calculated quantities such as annual reliability indices, interface flows, energy usage for Type 2 energy-limited units, and contract curtailments. If load forecast uncertainty is being modeled, a summary of the calculated quantities, by load level, appears on file code 11.

7.2.1 Program Options Summary

```
                                  MULTI-AREA RELIABILITY SIMULATION   Version  3.15               Run Date:   07022012
                                    COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY                Job Number:   165443

TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                             Output Section   9
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                                Page             1
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                                         PROGRAM OPTION SUMMARY FOR 2015


                   CONVERGENCE INDEX -- INTERCONNECTED DAILY LOLE FOR POOL POOL 1

                   CONVERGENCE TOLERANCE -- 0.0500 PER UNIT

                   MARGIN STATE FOR CALCULATING CONVERGENCE --   6

                   DAILY LOLE CALCULATED FOR ALL HOURS IN THE DAY

                   NUMBER OF REPLICATIONS -- MINIMUM     500      MAXIMUM     500      FIRST       0

                   RANDOM NUMBER GENERATOR SEED --      1340983

                   NON-FIRM ASSISTANCE BASED ON RESERVE SHARING (ADDITIONAL ITERATIONS -- 15)

                   ASSISTANCE PRIORITY TO AREAS WITHIN A POOL -- YES

                   ALLOW FLOW THROUGH OUTSIDE POOLS IN POOL-PRIORITY PASS -- YES

                   PRIORITY ORDER FOR ALLOCATING ASSISTANCE AMONG AREAS
                        AREA-A     AREA-B     AREA-C     AREA-D     AREA-E

                   NUMBER OF RESERVE SHARING ARRANGEMENTS BETWEEN POOLS --   0

                   MODELING FORCED OUTAGES ON INTERFACE TIES -- NO

                   ZERO SPECIFIED TIE LIMITS BEFORE SCHEDULING NON-FIRM ASSISTANCE -- NO

                   TYPE 2 ENERGY-LIMITED UNITS DISPATCHED AS-NEEDED ON AN INTERCONNECTED BASIS USING GROUPS

                   NUMBER OF HOURLY RESOURCE GROUPS FOR RANDOM SCHEDULING --   2

                   UNIT FORCED OUTAGE RATES SPECIFIED THROUGH STATE TRANSITION RATES

                   UNIT MAINTENANCE SCHEDULED BY AREA AGAINST ORIGINAL LOAD MODEL

                   NUMBER OF CONDITION SETS FOR DYNAMIC TRANSFER LIMITS --   1

                   NUMBER OF CLOSED INTERFACE GROUPS  --   0

                   NUMBER OF UNITS WITH DERATION OPTION  --    0

                   LAST EOP FOR WHICH TIE LIMITS ARE ZEROED FOR THE INITIAL NON-FIRM AND EOP CALCULATIONS --  0

                   MONTHS SIMULATED  --  JAN THROUGH DEC
```

7.2.2 Interface Rating Summary

```
                                  MULTI-AREA RELIABILITY SIMULATION   Version  3.15               Run Date:   07022012
                                    COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY                Job Number:   165443

TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                             Output Section   9
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                                Page             2
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                                        INTERFACE RATING DATA FOR 2015


                                                                                         *** TIES ZEROED FOR ***
                                                             POSITIVE          NEGATIVE      NON-FIRM      INITIAL
  INTERFACE OR INTERFACE GROUP      FROM AREA     TO AREA    DIRECTION (MW)    DIRECTION (MW)  ASSISTANCE     EOPS
  ----------------------------      ---------     -------    --------------    --------------  ----------    -------
  AREA-A TO AREA-B                  AREA-A        AREA-B        100.00            100.00          N            N
  AREA-A TO AREA-C                  AREA-A        AREA-C        200.00            200.00          N            N
  AREA-B TO AREA-C                  AREA-B        AREA-C        150.00            160.00          N            N
  AREA-C TO AREA-D                  AREA-C        AREA-D         50.00             50.00          N            N
  AREA-C TO AREA-E                  AREA-C        AREA-E         50.00             50.00          N            N
  AREA-D TO AREA-E                  AREA-D        AREA-E        100.00            100.00          N            N

  POOL 1 TO POOL 2  POS                                          90.00             90.00
  NET IMPORTS INTO A                                            250.00            250.00
  NET EXPORTS FROM C                                            300.00            300.00
```

The interface ratings between areas and for interface groups are as of the beginning of the year. Monthly overrides made during the year are not reflected in this summary.

7.2.3 Summary of Area Capacities and Loads

MULTI-AREA RELIABILITY SIMULATION Version 3.15
COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY

Run Date: 07022012
Job Number: 165443

TEST CASE - 5 AREAS 2 POOLS BASED ON IEEE RTS DATA
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS

Output Section 9
Page 3

AREA CAPACITIES AND LOADS FOR 2015

AREA	INSTALLED CAPACITY (MW)	-- PEAK LOAD (MW) -- ORIGINAL	MODIFIED
AREA-A	3265.00	2789.68	2811.53
AREA-B	2062.00	1692.02	1692.02
AREA-C	2590.00	2100.00	2100.00
AREA-D	1940.00	1650.00	1650.00
AREA-E	985.00	900.00	890.00

NOTE: The installed capacity on this summary includes only the thermal units (which include EL1 and cogeneration) that are in service at some time during the year. It is based on the unit ratings as of the first month of the year, and does not reflect subsequent monthly overrides to the unit ratings.

The installed capacity of the areas is based on the ratings of the thermal, cogeneration, and Type 1 energy-limited units as of the start of the year (including the overrides for January), but does not reflect subsequent monthly overrides made to the ratings during the year. It includes all thermal units that will be in service at some time during the year even if not installed until mid-year. Summaries of the installed capacity by month, which includes overrides to ratings during the year, can be found on file code 07.

The modified peak load includes the effects of load modifiers such as Type 2 energy-limited units, Type 1 cogeneration units, energy storage devices, and demand-side management, but does not include units that are being used to model contracts.

7.2.4 Summary of Annual Indices

MULTI-AREA RELIABILITY SIMULATION Version 3.15
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Run Date: 07022012
Job Number: 165443

TEST CASE - 5 AREAS 2 POOLS BASED ON IEEE RTS DATA
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS

Output Section 9
Page 4

CALCULATED INDICES FOR 2015

	ISOLATED					INTERCONNECTED				
AREA OR POOL	LOLE (days/yr)	LOLE (hrs/yr)	LOEE (MWh/yr)	FREQUENCY (outg/yr)	DURATION (hrs/outg)	LOLE (days/yr)	LOLE (hrs/yr)	LOEE (MWh/yr)	FREQUENCY (outg/yr)	DURATION (hrs/outg)
AREA-A	1.750	42.511	4800.5	10.323	4.118	0.092	3.146	272.9	0.962	3.272
AREA-B	3.624	53.274	5260.9	10.494	5.077	0.489	7.218	610.3	1.710	4.221
AREA-C	1.335	18.151	1498.1	4.839	3.751	0.013	0.295	16.7	0.115	2.559
AREA-D	1.203	68.008	5439.7	15.559	4.371	0.177	13.941	950.9	3.919	3.557
AREA-E	22.030	286.007	20294.1	42.959	6.658	2.284	33.491	1737.0	7.089	4.724
POOL 1	6.602	111.061	11559.5	24.654	4.505	0.592	10.458	899.9	2.701	3.872
POOL 2	23.099	347.386	25733.8	56.435	6.156	2.419	43.811	2687.9	9.870	4.439
AREA-AB	5.313	94.070	10061.3	20.251	4.645	0.581	10.248	883.2	2.624	3.906
SYSTEM	28.868	441.966	37293.3	76.131	5.805	2.995	53.844	3587.8	12.398	4.343

NOTE: Daily LOLE was calculated for margin state 6.
All other indices were calculated for the zero margin state.
Isolated indices include firm contracts.

The annual indices are printed for the areas and pools on both an isolated (zero ties between areas) and interconnected (using the input tie ratings) basis.

The daily LOLE (days/year) is calculated for the margin state specified on input table CNV-CRIT. The other two indices are calculated for the zero MW margin state. The isolated indices include the effects of firm contracts between areas. The firm and curtailable contracts are included in the interconnected indices.

If load forecast uncertainty is being modeled, the indices on this summary are the averages of the values for the individual load levels, weighted by the input probabilities (table LOD-UNCY (System) or LOD-UNCY (Area)). The indices by load level are written to file code 11.

7.2.5 Expected Number of Days per Year at Specified Margin States

The expected number of days per year that each area and pool is at the given margin state is summarized on an isolated (zero ties between areas) and interconnected (using the input tie ratings between areas) basis. The different margin states are input by area in table EOP-DATA-01.

If the daily LOLE calculations are based on all of the hours in the day (CNV-CRIT), these summaries will also be printed for the hourly LOLE (hours/year) and LOEE (MWh/year).

If load forecast uncertainty is being modeled, the indices on this summary are the averages of the values for the individual load levels, weighted by the input probabilities (table LOD-UNCY (System) or LOD-UNCY (Area)). The indices by load level are written to file code 11.

Isolated - days/year

```
                                          MULTI-AREA RELIABILITY SIMULATION    Version  3.15                  Run Date:   07022012
                                            COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY                    Job Number:   165443

TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                                         Output Section    9
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                                            Page              5
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                               EXPECTED NUMBER OF DAYS PER YEAR AT SPECIFIED MARGIN STATES FOR 2015
                                                       ON AN ISOLATED BASIS


                                                   MARGIN STATE
     AREA OR POOL            1         2         3         4         5         6
     ------------         --------  --------  --------  --------  --------  --------
       AREA-A              51.859    30.493    16.656     8.480     4.021     1.750
       AREA-B              20.794    16.270    13.758     8.853     5.686     3.624
       AREA-C              23.693    10.354     6.485     3.956     2.349     1.335
       AREA-D              64.751    45.183    30.417    12.287     4.188     1.203
       AREA-E              94.918    59.916    45.811    35.787    28.534    22.030

       POOL 1              83.235    51.908    34.387    20.317    11.714     6.602
       POOL 2             138.015    94.805    70.533    46.095    32.164    23.099

       AREA-AB             67.211    44.008    28.988    16.770     9.510     5.313
       SYSTEM             175.913   125.009    93.438    61.676    41.906    28.868
```

Interconnected - days/year

```
                                          MULTI-AREA RELIABILITY SIMULATION    Version  3.15                  Run Date:   07022012
                                            COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY                    Job Number:   165443

TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                                         Output Section    9
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                                            Page              8
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                               EXPECTED NUMBER OF DAYS PER YEAR AT SPECIFIED MARGIN STATES FOR 2015
                                                    ON AN INTERCONNECTED BASIS


                                                   MARGIN STATE
     AREA OR POOL            1         2         3         4         5         6
     ------------         --------  --------  --------  --------  --------  --------
       AREA-A              10.804     4.909     2.136     0.826     0.282     0.092
       AREA-B               5.109     3.096     2.431     1.447     0.846     0.489
       AREA-C               2.598     0.615     0.246     0.091     0.034     0.013
       AREA-D              30.206    16.607     9.613     3.031     0.785     0.177
       AREA-E              30.019    14.916     9.763     5.865     3.664     2.284

       POOL 1              15.251     7.860     4.552     2.303     1.152     0.592
       POOL 2              47.584    26.856    16.998     8.193     4.281     2.419

       AREA-AB             14.407     7.591     4.416     2.238     1.122     0.581
       SYSTEM              57.856    33.055    20.875    10.308     5.382     2.995
```

Interconnected - MWh/year

```
                          MULTI-AREA RELIABILITY SIMULATION   Version  3.15              Run Date:    07022012
                            COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY               Job Number:    165443

TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                    Output Section    9
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                       Page             10
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                    EXPECTED UNSERVED ENERGY (MWH) PER YEAR AT SPECIFIED MARGIN STATES FOR 2015
                                            ON AN INTERCONNECTED BASIS


                                        MARGIN STATE
     AREA OR POOL          1         2         3         4         5         6
     ------------      --------  --------  --------  --------  --------  --------
       AREA-A            6280.1    2371.5     850.5     273.6      80.2      21.6
       AREA-B            2231.7    1438.0    1106.3     609.8     332.1     175.7
       AREA-C             823.6     160.5      55.1      16.3       5.0       1.8
       AREA-D           16161.3    7710.0    3880.5     944.1     196.4      36.6
       AREA-E           13253.5    5443.7    3224.2    1743.5     980.4     562.9

       POOL 1            9335.4    3970.1    2011.9     899.7     417.3     199.1
       POOL 2           29414.8   13153.8    7104.7    2687.6    1176.8     599.5

       AREA-AB           8511.8    3809.6    1956.8     883.4     412.3     197.3
       SYSTEM           38750.2   17123.9    9116.6    3587.3    1594.1     798.6
```

7.2.6 Interface Flows

```
                          MULTI-AREA RELIABILITY SIMULATION   Version  3.15              Run Date:    07022012
                            COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY               Job Number:    165443

TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                    Output Section    9
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                       Page             18
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                                                        INTERFACE FLOWS FOR 2015


                                ***********  POSITIVE DIRECTION  ***********       ***********  NEGATIVE DIRECTION  ***********
                                ---------  MW  ---------   ----  HOURS  ----       ---------  MW  ---------   ----  HOURS  ----
 INTERFACE OR INTERFACE GROUP    LIMIT  MAXIMUM  AVERAGE    AT LIMIT    TOTAL       LIMIT  MAXIMUM  AVERAGE    AT LIMIT    TOTAL
 ----------------------------    -----  -------  -------    --------    -----       -----  -------  -------    --------    -----
AREA-A TO AREA-B                100.0    100.0     34.8       114.7     180.5      100.0    100.0     33.4       238.5     318.4
 AREA-A TO AREA-C                200.0    200.0     81.2        11.0     128.0      200.0    200.0    108.7        56.7     268.3
 AREA-B TO AREA-C                150.0    150.0     46.4        24.2    3846.3      160.0    160.0     83.0        21.0      97.4
 AREA-C TO AREA-D                 50.0     50.0     21.1        80.9    4494.0       50.0     50.0     20.2        26.5    4265.5
 AREA-C TO AREA-E                 50.0     50.0     45.1      3024.6    3892.3       50.0     50.0     24.0         5.4      64.6
 AREA-D TO AREA-E                100.0    100.0     56.6       144.1     547.7      100.0    100.0     61.2       136.3     432.5

 POOL 1 TO POOL 2  POS            90.0     90.0     37.7       126.3    6189.8       90.0     90.0     19.9         9.1    2562.5
 NET IMPORTS INTO A              250.0    250.0    117.5        13.7     335.7      250.0    250.0     57.8         0.5     282.7
 NET EXPORTS FROM C              300.0    300.0     27.8         6.2    4529.0      300.0    300.0     22.4         4.1    4226.0


       NOTE:  Limits shown are as of the beginning of the year.
              Because all load levels and/or margin states may not have been calculated (in order to speed
              up the calculations), the quantities in this summary may not be completely accurate.
```

This summary shows, for both directions of each interface between the interconnected areas and interface group, the limit (as of the beginning of the year), the maximum flow (in MW) in that direction, the average flow (in MW) for the year, the number of hours that the tie was at its limit, and the number of hours during the year for which there was flow on the tie. The average flow is based on the number of hours during the year for which there was flow on the tie, and not on the total number of hours in the year.

If load forecast uncertainty is being modeled, the quantities on this summary are the averages of the values for the individual load levels, weighted by the input probabilities. Because of this averaging, it is possible that the flow was limited at some time during the year even though the average maximum flow is less than the tie limit. The details by load level are written to file code 11.

7.2.7 Energy Usage for Peaking Portion of Type 2 Energy-Limited Units

```
                                         MULTI-AREA RELIABILITY SIMULATION    Version  3.15                Run Date:    07022012
                                           COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY                  Job Number:    165443

TEST CASE - 5 AREAS   2 POOLS    BASED ON IEEE RTS DATA                                                    Output Section    9
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                                         Page             19
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                           ENERGY USAGE (MWH) FOR PEAKING PORTION OF TYPE 2 ENERGY-LIMITED UNITS FOR 2015


          AVAILABLE                                    MARGIN STATE
  UNIT       MWH      HOURLY      1         2         3         4         5         6
--------  ---------   ------   -------   -------   -------   -------   -------   -------
UNIT-9A    148640.0    264.7    4244.2       0.0       0.0       0.0       0.0       0.0
UNIT-8C    240000.0     30.9    1091.3       0.0       0.0       0.0       0.0       0.0


       NOTE:  The hourly value is calculated at the 0 MW margin state for all of the hours in the year.
              The margin state values are calculated at the time of daily peak load.
              EL2 units dispatched on interconnected basis only.
```

If the program option was chosen to dispatch the peaking portion of the Type 2 energy-limited units as needed during the Monte Carlo simulation, this report summarizes the amount of energy produced by each unit for peak shaving; this summary does not include the energy associated with the dispatch of the unit's minimum rating. The hourly value is calculated at the 0 MW margin state for all of the hours in the year; the margin state values are calculated only for the hours of daily peak load. The last line of the note indicates the dispatch option chosen (isolated only, interconnected only, or both).

If load forecast uncertainty is being modeled, the quantities on this summary are the averages of the values for the individual load levels, weighted by the input probabilities. The details by load level are written to file code 11.

7.2.8 Contract Curtailments

```
                                         MULTI-AREA RELIABILITY SIMULATION    Version  3.15                Run Date:    07022012
                                           COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY                  Job Number:    165443

TEST CASE - 5 AREAS   2 POOLS    BASED ON IEEE RTS DATA                                                    Output Section    9
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                                         Page             20
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                                                   ANNUAL CONTRACT CURTAILMENTS FOR 2015


                                                                       CONTRACT        ****  CURTAILMENT  ****
                              CONTRACT      FROM AREA     TO AREA     ENERGY (MWH)     HOURS       ENERGY (MWH)
                              --------      ---------     -------     ------------     -----       ------------
                              CONT-C-D      AREA-C        AREA-D           -480.00       0.0               0.00
                              CONT-B-E      AREA-B        AREA-E         180000.56      26.3            1196.39
                              CONT-A-E      AREA-A        AREA-E              0.00       0.0               0.00
```

This summary lists all of the contracts (firm and curtailable) being modeled in the current year. For each contract it shows the total contract energy available for the year, the number of hours that the scheduled contract amount could not be delivered either because of transfer limits or insufficient resources in the sending area (if the contract is curtailable), and the amount of energy not delivered.

If load forecast uncertainty is being modeled, the quantities on this summary are the averages of the values for the individual load levels, weighted by the input probabilities. The details by load level are written to file code 11.

7.2.9 EOP Usage

```
                                           MULTI-AREA RELIABILITY SIMULATION   Version  3.15                Run Date:   07022012
                                             COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY                 Job Number:   165443

TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                                      Output Section   9
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                                          Page            21
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                                           ANNUAL EOP USAGE ON INTERCONNECTED BASIS FOR 2015
                                                   (EXPECTED NUMBER OF DAYS PER YEAR)


                                   EMERGENCY OPERATING PROCEDURE

         AREA              2          3          4          5          6
       --------         --------   --------   --------   --------   --------
       AREA-A           53.354     22.421      8.899      3.155      0.990
                         1.485      0.560      0.162      0.029      0.002
                         0.194      0.069      0.009      0.002      0.000
       AREA-B           25.788     16.051     12.551      7.167      4.063
                         1.007      0.372      0.110      0.027      0.005
                         0.008      0.020      0.007      0.001      0.000
       AREA-C            9.951      2.151      0.813      0.285      0.099
                         3.297      0.883      0.240      0.051      0.011
                         2.505      0.264      0.040      0.005      0.000
       AREA-D          179.769     90.981     48.957     13.309      3.061
                        11.169      7.534      4.264      1.503      0.384
                         0.509      0.156      0.027      0.003      0.000
       AREA-E          202.762     90.438     56.602     33.052     19.830
                        31.422     13.288      3.296      0.710      0.118
                         0.726      0.202      0.049      0.010      0.001


       NOTE:  Line 1 - Number of times EOP initiated by area to meet its own deficiency.
              Line 2 - Number of times EOP initiated to assist other areas in the same pool.
              Line 3 - Number of times EOP initiated to assist areas in other pools.
```

This summary shows the expected number of times per year that each area initiates each of its EOPs for its own benefit, for the benefit of other areas in the same pool, and for areas in outside pools. This summary, by load forecast uncertainty load level, appears in file code 11.

7.3 Annual Indices by Load Forecast Uncertainty Load Levels

MARS models the impact of uncertainty in the load forecast by calculating the reliability indices at several input load levels in a single run. The following summaries show the details by load level of the annual indices, interface flows, energy usage for Type 2 energy-limited units, and contract curtailments that were shown on the previous summaries on a weighted-average basis. This output is written to file code 11.

If the load forecast uncertainty multipliers were input by area (LOD-UNCY (Area)), the values shown for the pool and area group summaries are merely placeholders and have no significance.

7.3.1 Annual Indices

```
MULTI-AREA RELIABILITY SIMULATION   Version  3.15                 Run Date:    07022012
COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY                    Job Number:   165443

TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA              Output Section  11
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS Page             1
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS
```

CALCULATED INDICES FOR 2015

AREA OR POOL	LOAD MULT. (pu)	ISOLATED LOLE (days/yr)	ISOLATED LOLE (hrs/yr)	ISOLATED LOEE (MWh/yr)	ISOLATED FREQUENCY (outg/yr)	ISOLATED DURATION (hrs/outg)	INTERCONNECTED LOLE (days/yr)	INTERCONNECTED LOLE (hrs/yr)	INTERCONNECTED LOEE (MWh/yr)	INTERCONNECTED FREQUENCY (outg/yr)	INTERCONNECTED DURATION (hrs/outg)
AREA-A	1.02	4.432	96.440	11948.1	21.836	4.417	0.312	9.564	897.2	2.786	3.433
	1.01	2.848	66.022	7733.1	15.512	4.256	0.164	5.482	486.4	1.632	3.359
	1.00	1.582	39.666	4343.1	9.874	4.017	0.076	2.606	214.2	0.830	3.140
	0.99	0.610	18.098	1784.1	4.820	3.755	0.014	0.790	62.0	0.260	3.038
	0.98	0.360	11.152	1036.8	3.054	3.652	0.008	0.416	30.3	0.142	2.930
AREA-B	1.02	6.670	99.096	10207.9	19.178	5.167	1.082	15.946	1410.6	3.606	4.422
	1.01	5.038	74.338	7479.3	14.612	5.087	0.756	11.016	938.0	2.584	4.263
	1.00	3.580	52.000	5142.1	10.262	5.067	0.450	6.740	572.0	1.614	4.176
	0.99	2.130	31.520	2919.1	6.254	5.040	0.238	3.420	268.2	0.854	4.005
	0.98	1.186	18.706	1599.3	3.844	4.866	0.100	1.678	122.6	0.380	4.416
.											
.											
.											
POOL 1	1.00	13.778	226.230	25754.4	48.072	4.706	1.426	25.600	2381.9	6.412	3.993
	1.00	9.818	163.638	17640.6	35.652	4.590	0.940	16.648	1458.0	4.254	3.913
	1.00	6.246	105.696	10785.2	23.784	4.444	0.534	9.454	794.9	2.482	3.809
	1.00	3.368	57.842	5369.0	13.380	4.323	0.254	4.244	332.9	1.126	3.769
	1.00	1.870	34.232	2964.4	8.132	4.210	0.110	2.112	153.7	0.534	3.955
POOL 2	1.00	35.136	552.374	46406.2	87.736	6.296	4.934	94.276	6503.9	20.716	4.551
	1.00	30.886	466.924	37584.4	73.690	6.336	3.818	70.412	4587.1	15.550	4.528
	1.00	22.834	338.668	24306.0	54.516	6.212	2.178	38.946	2255.1	8.914	4.369
	1.00	15.936	238.140	15233.5	41.158	5.786	1.236	20.910	1096.6	4.868	4.295
	1.00	10.326	159.356	9179.3	30.012	5.310	0.650	10.976	525.9	2.680	4.096
AREA-AB	1.00	10.860	189.996	22156.0	39.310	4.833	1.386	24.910	2307.8	6.154	4.048
	1.00	7.768	137.324	15212.4	29.130	4.714	0.918	16.274	1424.4	4.120	3.950
	1.00	5.126	90.294	9485.2	19.670	4.590	0.526	9.286	786.1	2.422	3.834
	1.00	2.726	49.210	4703.1	10.928	4.503	0.252	4.198	330.2	1.106	3.796
	1.00	1.544	29.736	2636.1	6.842	4.346	0.108	2.094	152.9	0.522	4.011
SYSTEM	1.00	46.578	732.134	72160.6	122.336	5.985	6.298	118.158	8885.8	26.432	4.470
	1.00	39.222	601.914	55224.9	100.804	5.971	4.732	86.250	6045.1	19.474	4.429
	1.00	28.412	430.838	35091.2	74.184	5.808	2.698	48.128	3050.0	11.288	4.264
	1.00	19.038	290.660	20602.5	52.828	5.502	1.484	25.078	1429.5	5.964	4.205
	1.00	12.094	191.410	12143.7	37.430	5.114	0.760	13.076	679.7	3.204	4.081

NOTE: Daily LOLE was calculated for margin state 6.
All other indices were calculated for the zero margin state.
Isolated indices include firm contracts.

7.3.2 Expected Number of Days per Year at Margin States - Isolated

MULTI-AREA RELIABILITY SIMULATION Version 3.15
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Run Date: 07022012
Job Number: 165443

TEST CASE - 5 AREAS 2 POOLS BASED ON IEEE RTS DATA
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS

Output Section 11
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EXPECTED NUMBER OF DAYS PER YEAR AT SPECIFIED MARGIN STATES FOR 2015
ON AN ISOLATED BASIS

AREA OR POOL	LOAD MULT. (pu)	PROB. (pu)	MARGIN STATE 1	2	3	4	5	6
AREA-A	1.020	0.060	87.294	55.416	32.786	17.922	9.256	4.432
	1.010	0.240	70.070	42.778	24.204	12.760	6.256	2.848
	1.000	0.400	51.766	30.106	16.180	8.094	3.752	1.582
	0.990	0.240	32.016	17.188	8.574	3.968	1.676	0.610
	0.980	0.060	23.578	12.234	5.842	2.542	1.020	0.360
AREA-B	1.020	0.060	34.592	28.096	24.160	15.992	10.318	6.670
	1.010	0.240	27.878	22.222	18.922	12.180	7.874	5.038
	1.000	0.400	20.916	16.202	13.588	8.706	5.576	3.580
	0.990	0.240	13.204	9.972	8.416	5.372	3.428	2.130
	0.980	0.060	8.212	6.276	5.198	3.304	2.070	1.186
AREA-C	1.050	0.060	40.412	19.810	13.064	8.336	5.184	3.094
	1.030	0.240	32.740	15.114	9.746	5.998	3.666	2.140
	1.000	0.400	22.846	9.730	5.922	3.620	2.114	1.148
	0.970	0.240	15.344	5.956	3.622	2.090	1.148	0.652
	0.940	0.060	9.832	3.616	2.068	1.118	0.616	0.332
AREA-D	1.060	0.060	104.028	76.794	54.086	24.246	9.378	2.962
	1.040	0.240	89.456	63.918	44.606	19.180	7.004	2.128
	1.000	0.400	62.934	43.588	28.962	11.320	3.630	1.002
	0.960	0.240	42.562	28.188	17.740	6.266	1.840	0.432
	0.920	0.060	27.530	17.238	10.400	3.286	0.838	0.174
AREA-E	1.060	0.060	125.554	89.206	69.224	51.660	40.376	32.608
	1.040	0.240	115.542	78.432	60.060	44.540	36.214	29.028
	1.000	0.400	95.528	58.648	43.676	35.268	28.468	21.922
	0.960	0.240	75.306	42.850	33.926	27.682	21.348	15.534
	0.920	0.060	56.168	33.288	27.172	20.784	15.148	10.162
POOL 1	1.000	0.060	130.344	89.240	62.794	39.248	23.556	13.778
	1.000	0.240	109.338	71.360	48.568	29.212	17.172	9.818
	1.000	0.400	83.778	51.550	33.580	19.636	11.184	6.246
	1.000	0.240	55.468	31.358	19.846	11.186	6.188	3.368
	1.000	0.060	39.170	21.352	12.796	6.872	3.684	1.870
POOL 2	1.000	0.060	185.198	143.032	110.178	71.052	48.140	35.136
	1.000	0.240	170.212	125.292	95.002	60.220	42.118	30.886
	1.000	0.400	138.946	93.246	67.776	44.910	31.696	22.834
	1.000	0.240	107.368	66.486	49.268	33.270	23.052	15.936
	1.000	0.060	78.432	48.308	36.446	23.844	15.940	10.326
AREA-AB	1.000	0.060	108.590	76.270	53.026	32.278	18.898	10.860
	1.000	0.240	89.172	60.464	40.732	23.966	13.776	7.768
	1.000	0.400	67.726	43.868	28.530	16.322	9.170	5.126
	1.000	0.240	43.150	26.204	16.532	9.188	5.070	2.726
	1.000	0.060	30.798	18.068	10.844	5.788	3.078	1.544
SYSTEM	1.000	0.060	228.156	183.512	144.784	97.998	66.438	46.578
	1.000	0.240	211.210	161.510	124.214	81.444	55.876	39.222
	1.000	0.400	179.226	124.998	91.410	60.476	41.202	28.412
	1.000	0.240	139.720	88.876	64.788	42.748	28.618	19.038
	1.000	0.060	105.170	65.102	47.112	30.000	19.332	12.094

7.3.3 Expected Number of Days per Year at Margin States - Interconnected

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                                        MULTI-AREA RELIABILITY SIMULATION   Version  3.15                       Run Date:    07022012
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TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                                            Output Section  11
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                                               Page             5
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                              EXPECTED NUMBER OF DAYS PER YEAR AT SPECIFIED MARGIN STATES FOR 2015
                                                     ON AN INTERCONNECTED BASIS

  AREA OR      LOAD      PROB.                          MARGIN STATE
   POOL     MULT. (pu)   (pu)       1         2         3         4         5         6
 --------   ----------   ----   --------  --------  --------  --------  --------  --------

AREA-A       1.020     0.060    619.680   357.724   192.690    96.440    45.620    19.850
              1.010     0.240    476.410   264.236   136.774    66.022    29.716    12.290
              1.000     0.400    332.494   175.612    86.308    39.666    16.812     6.362
              0.990     0.240    190.046    92.952    42.632    18.098     6.906     2.282
              0.980     0.060    134.144    63.496    27.784    11.152     4.030     1.250

 AREA-B       1.020     0.060    240.264   187.384   157.222    99.096    62.118    38.892
              1.010     0.240    186.256   142.656   118.840    74.338    46.328    28.834
              1.000     0.400    134.654   101.244    83.724    52.000    32.410    20.000
              0.990     0.240     81.940    61.310    50.568    31.520    19.376    11.156
              0.980     0.060     49.406    37.022    30.542    18.706    10.752     5.916

 AREA-C       1.050     0.060    252.898   108.440    67.234    40.546    23.846    13.520
              1.030     0.240    196.998    79.862    48.410    28.582    16.362     9.044
              1.000     0.400    130.252    48.854    28.534    16.166     8.890     4.718
              0.970     0.240     83.080    28.876    16.294     8.826     4.630     2.558
              0.940     0.060     50.878    16.450     8.860     4.562     2.476     1.176

 AREA-D       1.060     0.060    849.220   577.052   377.248   145.774    48.010    13.450
              1.040     0.240    702.134   465.544   300.474   110.168    34.778     9.370
              1.000     0.400    461.404   295.398   181.056    60.724    17.366     4.290
              0.960     0.240    291.224   177.140   103.206    31.632     8.106     1.680
              0.920     0.060    174.076   100.884    56.662    15.672     3.616     0.622

 AREA-E       1.060     0.060   1290.482   764.932   565.772   425.378   327.906   252.902
              1.040     0.240   1144.690   655.848   488.708   368.992   287.398   216.662
              1.000     0.400    874.720   479.962   363.706   283.164   212.454   152.326
              0.960     0.240    640.754   358.042   277.484   208.340   147.950   100.304
              0.920     0.060    462.546   272.614   205.544   144.322    96.818    61.100


 POOL 1       1.000     0.060    975.304   598.914   390.998   226.230   128.122    71.226
              1.000     0.240    773.414   454.504   289.268   163.638    90.774    49.672
              1.000     0.400    553.178   310.310   191.934   105.696    57.474    30.958
              1.000     0.240    337.674   177.852   107.382    57.842    30.790    15.948
              1.000     0.060    226.808   114.824    66.430    34.232    17.212     8.332

 POOL 2       1.000     0.060   1890.616  1230.376   885.280   552.374   370.956   265.130
              1.000     0.240   1663.360  1042.534   748.366   466.924   318.978   225.326
              1.000     0.400   1242.222   737.380   525.664   338.668   228.706   156.366
              1.000     0.240    886.590   517.588   372.594   238.140   155.682   101.896
              1.000     0.060    616.298   366.166   259.020   159.356   100.274    61.688


 AREA-AB      1.000     0.060    802.558   516.088   335.066   189.996   105.720    58.124
              1.000     0.240    626.936   389.528   247.020   137.324    75.068    40.838
              1.000     0.400    447.906   268.106   166.028    90.294    48.804    26.294
              1.000     0.240    264.714   151.282    91.842    49.210    26.212    13.408
              1.000     0.060    180.362    99.202    57.806    29.736    14.754     7.166

 SYSTEM       1.000     0.060   2363.126  1598.740  1157.946   732.134   480.576   328.452
              1.000     0.240   2075.850  1343.450   961.860   601.914   398.296   270.236
              1.000     0.400   1592.580   970.114   681.538   430.838   280.904   185.258
              1.000     0.240   1130.370   663.400   465.474   290.660   184.506   117.166
              1.000     0.060    797.772   465.996   318.992   191.410   116.800    69.826
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7.3.4 Interface Flows

MULTI-AREA RELIABILITY SIMULATION Version 3.15
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Run Date: 07022012
Job Number: 165443

TEST CASE - 5 AREAS 2 POOLS BASED ON IEEE RTS DATA
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS

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INTERFACE FLOWS FOR 2015

INTERFACE OR GROUP	LOAD MULT. (pu)	PROB. (pu)	POSITIVE DIRECTION MW LIMIT	MAXIMUM	AVERAGE	HOURS AT LIMIT	TOTAL	NEGATIVE DIRECTION MW LIMIT	MAXIMUM	AVERAGE	HOURS AT LIMIT	TOTAL
AREA-A TO AREA-B	1.00	0.060	100.0	100.0	31.8	194.7	289.5	100.0	100.0	31.3	442.5	569.2
	1.00	0.240	100.0	100.0	33.2	154.7	237.3	100.0	100.0	32.3	340.1	444.7
	1.00	0.400	100.0	100.0	35.3	115.3	182.5	100.0	100.0	33.7	234.8	314.4
	1.00	0.240	100.0	100.0	37.8	71.8	119.8	100.0	100.0	36.0	129.5	182.9
	1.00	0.060	100.0	100.0	39.9	43.1	73.8	100.0	100.0	38.2	89.5	130.9
AREA-A TO AREA-C	1.00	0.060	200.0	200.0	83.5	19.9	223.2	200.0	200.0	113.3	121.0	513.1
	1.00	0.240	200.0	200.0	82.6	16.2	180.1	200.0	200.0	110.6	86.1	387.0
	1.00	0.400	200.0	200.0	80.6	10.3	122.7	200.0	200.0	108.1	54.3	262.2
	1.00	0.240	200.0	200.0	78.9	6.6	80.6	200.0	200.0	102.7	25.4	141.6
	1.00	0.060	200.0	200.0	75.8	3.5	49.5	200.0	200.0	99.9	15.5	95.5
AREA-B TO AREA-C	1.00	0.060	150.0	150.0	47.7	63.1	3758.3	160.0	160.0	84.3	41.3	186.9
	1.00	0.240	150.0	150.0	47.0	41.3	3805.7	160.0	160.0	83.4	30.2	138.8
	1.00	0.400	150.0	150.0	46.2	20.8	3848.1	160.0	160.0	82.8	20.7	95.3
	1.00	0.240	150.0	150.0	45.8	8.4	3889.6	160.0	160.0	82.0	11.1	53.9
	1.00	0.060	150.0	150.0	45.7	3.8	3912.3	160.0	160.0	79.8	5.7	31.0
AREA-C TO AREA-D	1.00	0.060	50.0	50.0	22.2	150.0	4606.2	50.0	50.0	20.4	60.0	4152.8
	1.00	0.240	50.0	50.0	21.7	121.7	4561.7	50.0	50.0	20.3	41.6	4197.6
	1.00	0.400	50.0	50.0	21.0	76.2	4484.9	50.0	50.0	20.2	24.8	4274.7
	1.00	0.240	50.0	50.0	20.6	44.6	4435.8	50.0	50.0	20.1	11.2	4324.0
	1.00	0.060	50.0	50.0	20.3	24.4	4404.9	50.0	50.0	20.0	5.8	4355.0
AREA-C TO AREA-E	1.00	0.060	50.0	50.0	44.6	2904.3	3850.0	50.0	50.0	25.7	11.7	120.6
	1.00	0.240	50.0	50.0	44.8	2960.0	3870.9	50.0	50.0	24.6	8.7	94.9
	1.00	0.400	50.0	50.0	45.1	3029.8	3892.5	50.0	50.0	23.6	4.9	62.2
	1.00	0.240	50.0	50.0	45.3	3086.7	3915.2	50.0	50.0	22.6	2.4	35.5
	1.00	0.060	50.0	50.0	45.5	3120.1	3927.7	50.0	50.0	21.5	1.2	20.3
AREA-D TO AREA-E	1.00	0.060	100.0	100.0	55.7	219.9	817.3	100.0	100.0	62.1	234.8	732.2
	1.00	0.240	100.0	100.0	56.3	192.0	709.6	100.0	100.0	61.8	198.1	615.7
	1.00	0.400	100.0	100.0	57.4	143.8	532.9	100.0	100.0	61.2	130.9	416.3
	1.00	0.240	100.0	100.0	56.7	98.5	403.3	100.0	100.0	59.9	81.0	268.8
	1.00	0.060	100.0	100.0	53.7	62.5	306.3	100.0	100.0	58.4	47.3	163.6
POOL 1 TO POOL 2 POS	1.00	0.060	90.0	90.0	38.9	287.9	6149.3	90.0	90.0	20.5	23.0	2595.9
	1.00	0.240	90.0	90.0	38.4	214.0	6173.4	90.0	90.0	20.1	15.0	2574.9
	1.00	0.400	90.0	90.0	37.6	109.1	6191.9	90.0	90.0	19.8	8.2	2560.9
	1.00	0.240	90.0	90.0	37.2	52.4	6207.3	90.0	90.0	19.6	3.2	2548.7
	1.00	0.060	90.0	90.0	37.0	23.3	6212.9	90.0	90.0	19.5	1.3	2544.8
NET IMPORTS INTO A	1.00	0.060	250.0	250.0	123.0	24.4	610.3	250.0	250.0	60.2	0.9	448.3
	1.00	0.240	250.0	250.0	120.1	19.0	471.6	250.0	250.0	59.3	0.7	374.9
	1.00	0.400	250.0	250.0	116.8	13.6	330.9	250.0	250.0	56.9	0.5	282.2
	1.00	0.240	250.0	250.0	110.8	8.0	189.6	250.0	250.0	56.4	0.3	190.7
	1.00	0.060	250.0	250.0	108.1	6.0	134.0	250.0	250.0	55.7	0.1	119.3
NET EXPORTS FROM C	1.00	0.060	300.0	300.0	34.7	16.4	4672.0	300.0	300.0	24.5	7.5	4078.9
	1.00	0.240	300.0	300.0	31.1	10.2	4605.4	300.0	300.0	23.5	6.0	4147.6
	1.00	0.400	300.0	300.0	27.6	5.4	4523.6	300.0	300.0	22.2	4.0	4231.2
	1.00	0.240	300.0	300.0	24.1	2.0	4453.1	300.0	300.0	21.4	2.3	4304.2
	1.00	0.060	300.0	300.0	22.6	0.9	4419.4	300.0	300.0	20.8	1.2	4339.2

NOTE: Limits shown are as of the beginning of the year.

7.3.5 Energy Usage for Peaking Portion of Type 2 Energy-Limited Units

MULTI-AREA RELIABILITY SIMULATION Version 3.15 Run Date: 07022012
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TEST CASE - 5 AREAS 2 POOLS BASED ON IEEE RTS DATA Output Section 11
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS Page 9
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS

ENERGY USAGE (MWH) FOR PEAKING PORTION OF TYPE 2 ENERGY-LIMITED UNITS FOR 2015

UNIT	AVAILABLE MWH	LOAD MULT. (pu)	HOURLY	MARGIN STATE 1	2	3	4	5	6
UNIT-9A	148640.0	1.000	786.6	10247.3	0.0	0.0	0.0	0.0	0.0
		1.000	455.2	6742.1	0.0	0.0	0.0	0.0	0.0
		1.000	222.4	3847.4	0.0	0.0	0.0	0.0	0.0
		1.000	71.6	1711.5	0.0	0.0	0.0	0.0	0.0
		1.000	35.3	1025.9	0.0	0.0	0.0	0.0	0.0
UNIT-8C	240000.0	1.000	122.1	3476.5	0.0	0.0	0.0	0.0	0.0
		1.000	58.1	1979.5	0.0	0.0	0.0	0.0	0.0
		1.000	20.8	825.6	0.0	0.0	0.0	0.0	0.0
		1.000	5.0	294.8	0.0	0.0	0.0	0.0	0.0
		1.000	1.4	110.5	0.0	0.0	0.0	0.0	0.0

NOTE: The hourly value is calculated at the 0 MW margin state for all of the hours in the year.
The margin state values are calculated at the time of daily peak load.
EL2 units dispatched on interconnected basis only.

7.3.6 Contract Curtailments

MULTI-AREA RELIABILITY SIMULATION Version 3.15 Run Date: 07022012
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TEST CASE - 5 AREAS 2 POOLS BASED ON IEEE RTS DATA Output Section 11
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS Page 10
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS

ANNUAL CONTRACT CURTAILMENTS FOR 2015

CONTRACT	LOAD MULT. (pu)	PROB. (pu)	FROM AREA	TO AREA	CONTRACT ENERGY (MWH)	**** CURTAILMENT HOURS	ENERGY (MWH) ****
CONT-C-D	1.00	0.060	AREA-C	AREA-D	-480.00	0.0	0.00
	1.00	0.240				0.0	0.00
	1.00	0.400				0.0	0.00
	1.00	0.240				0.0	0.00
	1.00	0.060				0.0	0.00
CONT-B-E	1.00	0.060	AREA-B	AREA-E	180000.56	62.1	2787.26
	1.00	0.240				40.6	1842.79
	1.00	0.400				24.1	1104.17
	1.00	0.240				11.7	538.54
	1.00	0.060				5.8	266.09
CONT-A-E	1.00	0.060	AREA-A	AREA-E	0.00	0.0	0.00
	1.00	0.240				0.0	0.00
	1.00	0.400				0.0	0.00
	1.00	0.240				0.0	0.00
	1.00	0.060				0.0	0.00

7.3.7 EOP Usage

```
                                          MULTI-AREA RELIABILITY SIMULATION    Version  3.15                 Run Date:   07022012
                                            COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY                   Job Number:   165443

TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                                        Output Section  11
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                                           Page            11
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                                              ANNUAL EOP USAGE FOR 2015 FOR LOAD LEVEL  1
                                                  (EXPECTED NUMBER OF DAYS PER YEAR)
                                                    ( 1.000 pu, 0.060 probability)


                                  EMERGENCY OPERATING PROCEDURE

         AREA              2          3          4          5          6
       --------        --------   --------   --------   --------   --------
       AREA-A          127.696     56.936     24.504      9.598      3.386
                         5.422      1.994      0.772      0.182      0.034
                         0.702      0.278      0.068      0.014      0.002
       AREA-B           60.182     34.776     26.702     15.770      9.176
                         4.086      1.572      0.570      0.116      0.028
                         0.036      0.098      0.042      0.000      0.000
       AREA-C           31.448      7.558      3.054      1.100      0.432
                        12.200      3.570      1.114      0.274      0.064
                         9.432      1.196      0.240      0.034      0.006
       AREA-D          382.700    203.586    115.186     35.264      9.040
                        26.502     18.140     11.082      4.392      1.292
                         2.176      0.712      0.146      0.028      0.000
       AREA-E          363.694    174.552    112.608     66.990     40.582
                        80.146     37.162     10.034      2.326      0.488
                         3.016      0.894      0.254      0.056      0.010
```

7.4 Weekly and Monthly Summaries

In addition to the annual indices, MARS also calculates daily LOLE, hourly LOLE, and unserved energy (LOEE) on a weekly and monthly basis. As with the annual indices, the weekly and monthly results are available for all of the areas, pools, and area groups on an isolated and interconnected basis. The daily LOLE is also available by margin state. The weekly and monthly indices are written to file code 08.

If load forecast uncertainty is being modeled, the indices on file code 08 are the averages of the indices for the individual load levels, weighted by the input probabilities. The details by load level are written to file code 11.

The calculation of weekly and monthly indices is controlled through input table CNV-CRIT. The printing of the weekly and monthly indices by load forecast uncertainty load level is controlled through table GEN-TIME.

7.4.1 Weekly Indices

MULTI-AREA RELIABILITY SIMULATION Version 3.15
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Run Date: 07022012
Job Number: 165443

TEST CASE - 5 AREAS 2 POOLS BASED ON IEEE RTS DATA
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS

Output Section 8
Page 1

WEEKLY INDICES FOR AREA-A FOR 2015
ON AN ISOLATED BASIS

WEEK	LOLE (days)	LOLE (hours)	LOEE (MWh)	WEEK	LOLE (days)	LOLE (hours)	LOEE (MWh)
1	0.010	0.228	27.983	28	0.024	1.015	91.687
2	0.015	0.410	42.108	29	0.043	1.128	137.232
3	0.054	1.269	147.468	30	0.087	2.095	270.678
4	0.017	0.456	48.475	31	0.011	0.312	30.154
5	0.042	1.085	120.149	32	0.011	0.244	21.608
6	0.046	1.243	134.981	33	0.022	0.472	49.172
7	0.046	1.106	125.095	34	0.009	0.248	25.412
8	0.037	0.788	96.156	35	0.003	0.187	13.618
9	0.000	0.059	2.670	36	0.009	0.170	19.317
10	0.005	0.111	11.530	37	0.013	0.339	30.028
11	0.004	0.125	10.263	38	0.006	0.224	15.834
12	0.001	0.053	3.704	39	0.011	0.241	23.649
13	0.003	0.093	7.225	40	0.039	0.955	99.630
14	0.010	0.288	24.848	41	0.014	0.384	32.241
15	0.006	0.182	14.794	42	0.013	0.408	37.740
16	0.050	1.021	114.940	43	0.036	0.791	84.907
17	0.025	0.398	43.660	44	0.028	0.707	75.618
18	0.019	0.501	48.316	45	0.026	0.596	66.326
19	0.059	1.580	164.344	46	0.023	0.527	51.770
20	0.062	1.575	205.629	47	0.057	1.268	137.008
21	0.046	1.157	136.500	48	0.023	0.681	71.127
22	0.012	0.386	38.779	49	0.063	1.406	162.390
23	0.076	1.826	224.424	50	0.137	2.778	355.242
24	0.018	0.701	69.943	51	0.188	3.927	495.231
25	0.027	0.729	86.247	52	0.098	2.272	262.210
26	0.039	0.970	113.022	53	0.008	0.192	16.998
27	0.019	0.603	60.381				

NOTE: Daily LOLE was calculated for margin state 6.
All other indices were calculated for the zero margin state.
Isolated indices include firm contracts.

Similar summaries are available by area, pool, and area group on an interconnected basis.

7.4.2 Weekly Indices - Daily LOLE by Margin State

```
                                    MULTI-AREA RELIABILITY SIMULATION   Version  3.15                Run Date:    07022012
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TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                                Output Section   8
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                                   Page            19
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                              EXPECTED NUMBER OF DAYS AT SPECIFIED MARGIN STATES FOR AREA-A   FOR 2015
                                                        ON AN ISOLATED BASIS
```

	MARGIN STATE					
WEEK	1	2	3	4	5	6
1	0.422	0.232	0.115	0.053	0.021	0.010
2	0.754	0.413	0.206	0.099	0.044	0.015
3	1.402	0.832	0.452	0.250	0.129	0.054
4	0.889	0.468	0.225	0.103	0.047	0.017
5	1.220	0.770	0.458	0.228	0.103	0.042
6	1.423	0.865	0.488	0.253	0.116	0.046
7	1.244	0.744	0.423	0.219	0.104	0.046
8	0.991	0.573	0.313	0.156	0.074	0.037
9	0.432	0.188	0.071	0.023	0.003	0.000
10	0.382	0.176	0.067	0.022	0.009	0.005
11	0.583	0.252	0.094	0.034	0.012	0.004
12	0.503	0.210	0.068	0.016	0.003	0.001
13	0.391	0.168	0.067	0.028	0.010	0.003
14	0.609	0.319	0.153	0.074	0.028	0.010
15	0.559	0.283	0.120	0.050	0.023	0.006
16	1.157	0.702	0.400	0.216	0.111	0.050
17	0.781	0.418	0.203	0.096	0.047	0.025
18	0.784	0.436	0.210	0.097	0.045	0.019
19	1.344	0.853	0.509	0.279	0.137	0.059
20	1.321	0.802	0.465	0.250	0.128	0.062
21	1.209	0.731	0.402	0.217	0.105	0.046
22	0.739	0.388	0.191	0.090	0.034	0.012
23	1.560	0.969	0.560	0.311	0.160	0.076
24	0.824	0.471	0.257	0.130	0.057	0.018
25	0.839	0.488	0.254	0.128	0.062	0.027
26	1.190	0.695	0.363	0.179	0.088	0.039
27	0.900	0.512	0.263	0.120	0.050	0.019
28	1.313	0.767	0.408	0.187	0.074	0.024
29	1.256	0.746	0.388	0.189	0.085	0.043
30	1.497	0.968	0.600	0.340	0.176	0.087
31	0.467	0.276	0.148	0.069	0.028	0.011
32	0.614	0.318	0.151	0.069	0.029	0.011
33	0.793	0.439	0.217	0.109	0.052	0.022
34	0.829	0.438	0.198	0.074	0.030	0.009
35	0.678	0.335	0.150	0.051	0.014	0.003
36	0.437	0.205	0.095	0.038	0.017	0.009
37	0.606	0.329	0.165	0.080	0.037	0.013
38	0.699	0.364	0.169	0.062	0.017	0.006
39	0.440	0.242	0.122	0.058	0.025	0.011
40	1.296	0.745	0.397	0.198	0.093	0.039
41	0.831	0.474	0.235	0.098	0.040	0.014
42	0.839	0.470	0.240	0.112	0.044	0.013
43	1.140	0.676	0.379	0.195	0.088	0.036
44	0.938	0.558	0.308	0.152	0.071	0.028
45	1.022	0.577	0.293	0.136	0.058	0.026
46	0.974	0.555	0.278	0.125	0.055	0.023
47	1.477	0.909	0.509	0.267	0.129	0.057
48	0.905	0.526	0.288	0.141	0.057	0.023
49	1.358	0.855	0.503	0.278	0.139	0.063
50	2.075	1.386	0.861	0.508	0.281	0.137
51	2.634	1.872	1.237	0.728	0.392	0.188
52	1.988	1.324	0.819	0.445	0.219	0.098
53	0.302	0.181	0.102	0.048	0.022	0.008

If the daily LOLE calculations are based on all of the hours in the day (CNV-CRIT), these summaries will also be printed for the hourly LOLE (hours/year) and LOEE (MWh/year). Similar summaries are available by area, pool, and area group on an interconnected basis.

7.4.3 Monthly Indices

MULTI-AREA RELIABILITY SIMULATION Version 3.15
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Run Date: 07022012
Job Number: 165443

TEST CASE - 5 AREAS 2 POOLS BASED ON IEEE RTS DATA
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS

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MONTHLY INDICES FOR 2015
ON AN ISOLATED BASIS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
AREA-A												
LOLE (days)	0.134	0.134	0.014	0.091	0.198	0.170	0.174	0.046	0.043	0.117	0.138	0.491
LOLE (hrs)	3.314	3.319	0.400	1.946	5.134	4.577	4.803	1.185	1.103	2.936	3.284	10.511
LOEE (MWh)	375.1	369.5	33.8	202.5	588.8	526.6	557.2	112.6	101.8	297.1	349.2	1286.5
AREA-B												
LOLE (days)	0.271	0.296	0.192	0.254	0.333	0.231	0.236	0.260	0.211	0.264	0.353	0.721
LOLE (hrs)	3.977	4.617	2.899	3.293	5.417	3.898	3.879	3.667	3.202	3.787	4.566	10.072
LOEE (MWh)	373.5	423.3	259.1	325.2	519.3	369.5	404.6	327.9	278.0	375.5	445.1	1160.0
AREA-C												
LOLE (days)	0.057	0.027	0.012	0.030	0.562	0.148	0.238	0.058	0.036	0.070	0.040	0.057
LOLE (hrs)	0.670	0.430	0.193	0.315	7.631	1.926	2.588	0.604	0.382	1.735	0.671	1.007
LOEE (MWh)	51.2	27.7	10.0	21.1	677.8	172.4	254.3	46.8	25.7	90.5	42.8	77.8
AREA-D												
LOLE (days)	0.045	0.035	0.004	0.026	0.155	0.213	0.224	0.099	0.023	0.043	0.088	0.249
LOLE (hrs)	2.604	2.235	0.782	2.947	9.189	11.962	10.856	6.331	2.205	2.945	4.261	11.692
LOEE (MWh)	187.3	177.1	38.6	185.0	761.4	984.9	971.4	474.1	137.1	209.3	339.2	974.3
AREA-E												
LOLE (days)	1.517	1.678	2.765	1.490	2.466	1.605	1.120	1.740	1.414	1.620	1.910	2.705
LOLE (hrs)	19.345	21.502	39.424	18.015	36.671	20.134	15.359	20.682	17.502	19.481	22.825	35.067
LOEE (MWh)	1313.1	1616.6	2211.1	1206.5	2930.9	1442.0	985.3	1410.9	1181.0	1268.8	1738.6	2989.5
POOL 1												
LOLE (days)	0.457	0.454	0.217	0.372	1.062	0.544	0.633	0.364	0.289	0.444	0.525	1.240
LOLE (hrs)	7.825	8.238	3.472	5.501	17.419	10.182	10.878	5.403	4.650	8.306	8.329	20.859
LOEE (MWh)	799.8	820.5	302.9	548.9	1785.9	1068.4	1216.0	487.2	405.5	763.1	837.1	2524.3
POOL 2												
LOLE (days)	1.557	1.712	2.769	1.515	2.601	1.802	1.323	1.828	1.433	1.660	1.992	2.908
LOLE (hrs)	21.761	23.564	40.098	20.789	44.801	31.215	25.362	26.572	19.443	22.210	26.701	44.872
LOEE (MWh)	1500.4	1793.6	2249.7	1391.5	3692.2	2426.8	1956.7	1885.1	1318.1	1478.1	2077.8	3963.7
AREA-AB												
LOLE (days)	0.402	0.427	0.206	0.342	0.526	0.399	0.404	0.306	0.254	0.374	0.487	1.186
LOLE (hrs)	7.190	7.825	3.290	5.192	10.349	8.378	8.502	4.821	4.271	6.625	7.703	19.924
LOEE (MWh)	748.6	792.8	292.9	527.7	1108.1	896.1	961.7	440.4	379.8	672.5	794.2	2446.5
SYSTEM												
LOLE (days)	1.973	2.114	2.953	1.858	3.504	2.279	1.898	2.162	1.698	2.072	2.458	3.899
LOLE (hrs)	28.948	30.837	42.950	25.798	58.790	40.006	34.840	31.404	23.651	29.836	34.115	60.791
LOEE (MWh)	2300.1	2614.2	2552.6	1940.4	5478.1	3495.3	3172.7	2372.3	1723.6	2241.2	2914.9	6488.0

NOTE: Daily LOLE was calculated for margin state 6.
All other indices were calculated for the zero margin state.
Isolated indices include firm contracts.

Similar summaries are available by area, pool, and area group on an interconnected basis.

7.4.4 Monthly Indices - Daily LOLE by Margin State

```
                                        MULTI-AREA RELIABILITY SIMULATION   Version  3.15                Run Date:   07022012
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TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                                    Output Section   8
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                                       Page            75
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                              EXPECTED NUMBER OF DAYS AT SPECIFIED MARGIN STATES FOR AREA-A   FOR 2015
                                                          ON AN ISOLATED BASIS


                                          MARGIN STATE
        MONTH          1         2         3         4         5         6
        -----      --------  --------  --------  --------  --------  --------
         JAN         4.455     2.571     1.376     0.696     0.328     0.134
         FEB         4.279     2.499     1.369     0.685     0.311     0.134
         MAR         1.934     0.837     0.309     0.106     0.037     0.014
         APR         3.240     1.790     0.905     0.446     0.213     0.091
         MAY         5.232     3.126     1.741     0.921     0.444     0.198
         JUN         4.809     2.861     1.561     0.812     0.397     0.170
         JUL         5.002     3.019     1.679     0.843     0.384     0.174
         AUG         3.052     1.594     0.740     0.312     0.129     0.046
         SEP         2.358     1.239     0.606     0.268     0.108     0.043
         OCT         4.582     2.659     1.417     0.685     0.305     0.117
         NOV         4.673     2.745     1.470     0.721     0.321     0.138
         DEC         8.246     5.553     3.484     1.987     1.044     0.491
```

If the daily LOLE calculations are based on all of the hours in the day (CNV-CRIT), these summaries will also be printed for the hourly LOLE (hours/year) and LOEE (MWh/year). Similar summaries are available by area, pool, and area group on an interconnected basis.

7.4.5 Monthly Interface Flows

MULTI-AREA RELIABILITY SIMULATION Version 3.15 Run Date: 07022012
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TEST CASE - 5 AREAS 2 POOLS BASED ON IEEE RTS DATA Output Section 8
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WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS

INTERFACE FLOWS FOR 2015

		*********** POSITIVE DIRECTION ***********					*********** NEGATIVE DIRECTION ***********				
		MW			HOURS		MW			HOURS	
INTERFACE OR GROUP	MONTH	LIMIT	MAXIMUM	AVERAGE	AT LIMIT	TOTAL	LIMIT	MAXIMUM	AVERAGE	AT LIMIT	TOTAL
AREA-A TO AREA-B	JAN	100.0	100.0	23.8	10.4	13.7	100.0	100.0	26.2	21.8	26.8
	FEB	100.0	100.0	31.1	11.3	15.8	100.0	100.0	28.9	20.8	26.4
	MAR	100.0	100.0	55.7	5.1	14.2	100.0	100.0	52.9	3.6	8.5
	APR	100.0	100.0	45.1	6.9	12.9	100.0	100.0	42.3	11.1	17.4
	MAY	100.0	100.0	25.1	13.4	18.1	100.0	100.0	27.2	29.5	36.7
	JUN	100.0	100.0	24.5	9.9	13.2	100.0	100.0	26.9	26.9	32.9
	JUL	100.0	100.0	33.2	7.8	11.6	100.0	100.0	33.8	27.5	35.5
	AUG	100.0	100.0	57.3	5.8	13.4	100.0	100.0	59.4	7.1	14.9
	SEP	100.0	100.0	47.4	6.8	15.5	100.0	100.0	54.3	6.3	11.8
	OCT	100.0	100.0	37.2	8.0	14.1	100.0	100.0	46.6	16.4	25.8
	NOV	100.0	100.0	24.1	10.6	13.9	100.0	100.0	26.9	21.9	27.1
	DEC	100.0	100.0	23.8	18.8	24.2	100.0	100.0	26.3	45.5	54.7
AREA-A TO AREA-C	JAN	200.0	200.0	77.8	0.4	5.6	200.0	200.0	108.6	5.3	24.1
	FEB	200.0	200.0	73.5	0.3	4.8	200.0	200.0	110.3	5.3	23.3
	MAR	200.0	200.0	68.9	0.2	3.5	200.0	200.0	84.5	0.3	4.5
	APR	200.0	200.0	70.4	0.2	4.3	200.0	200.0	104.5	2.5	13.0
	MAY	200.0	200.0	87.6	4.5	42.6	200.0	200.0	104.5	5.8	30.9
	JUN	200.0	200.0	84.3	1.2	11.5	200.0	200.0	110.2	6.5	29.0
	JUL	200.0	200.0	88.4	1.1	10.5	200.0	200.0	109.6	6.3	29.2
	AUG	200.0	200.0	80.7	0.4	5.7	200.0	200.0	91.7	0.7	8.7
	SEP	200.0	200.0	79.0	0.3	3.9	200.0	200.0	96.3	0.9	7.9
	OCT	200.0	200.0	71.8	1.2	23.0	200.0	200.0	101.4	2.9	19.1
	NOV	200.0	200.0	77.3	0.5	6.2	200.0	200.0	108.0	5.2	24.3
	DEC	200.0	200.0	83.9	0.6	6.5	200.0	200.0	119.7	14.9	54.1
.											
.											
.											
POOL 1 TO POOL 2 POS	JAN	90.0	90.0	40.2	5.6	742.8	90.0	90.0	55.7	0.4	1.2
	FEB	90.0	90.0	42.4	6.1	670.9	90.0	90.0	53.3	0.2	1.0
	MAR	90.0	90.0	40.4	10.3	743.8	90.0	87.4	44.2	0.0	0.2
	APR	90.0	90.0	29.5	4.6	304.7	90.0	90.0	19.5	0.2	414.6
	MAY	90.0	90.0	31.6	15.2	302.3	90.0	90.0	20.4	3.7	439.3
	JUN	90.0	90.0	32.6	13.2	301.8	90.0	90.0	20.0	1.0	417.2
	JUL	90.0	90.0	30.3	9.4	304.9	90.0	90.0	19.8	1.5	437.8
	AUG	90.0	90.0	29.2	8.0	311.6	90.0	90.0	19.3	0.3	431.0
	SEP	90.0	90.0	30.1	6.2	305.1	90.0	90.0	19.5	0.1	414.4
	OCT	90.0	90.0	40.1	6.4	741.7	90.0	90.0	59.1	0.9	2.2
	NOV	90.0	90.0	41.0	10.3	718.9	90.0	90.0	55.6	0.3	1.1
	DEC	90.0	90.0	40.7	30.8	741.4	90.0	90.0	50.4	0.5	2.5
NET IMPORTS INTO A	JAN	250.0	250.0	116.7	0.7	28.3	250.0	248.2	41.4	0.0	18.0
	FEB	250.0	250.0	118.0	0.8	28.2	250.0	248.6	42.9	0.0	19.4
	MAR	250.0	250.0	91.6	0.5	9.0	250.0	250.0	60.1	0.0	17.1
	APR	250.0	250.0	113.3	1.0	18.3	250.0	250.0	53.6	0.0	16.3
	MAY	250.0	250.0	114.0	1.0	36.5	250.0	250.0	77.5	0.2	53.1
	JUN	250.0	250.0	119.0	1.1	34.1	250.0	248.2	55.7	0.0	22.6
	JUL	250.0	250.0	119.6	1.4	36.4	250.0	250.0	63.9	0.0	19.8
	AUG	250.0	250.0	106.2	1.4	15.7	250.0	250.0	66.9	0.1	18.0
	SEP	250.0	250.0	110.7	1.1	12.5	250.0	250.0	55.9	0.0	18.5
	OCT	250.0	250.0	114.4	2.0	27.2	250.0	250.0	62.4	0.1	34.4
	NOV	250.0	250.0	116.2	0.7	28.7	250.0	250.0	42.7	0.0	18.6
	DEC	250.0	250.0	129.3	1.9	60.7	250.0	248.6	39.4	0.0	26.9

NOTE: Because all load levels and/or margin states may not have been calculated (in order to speed up the calculations), the quantities in this summary may not be completely accurate.

7.5 Load Model Summaries

Hourly load data, in EEI format, must be input for each area in the system for the first year of the study. If using the option to model load forecast uncertainty through different hourly load profiles, this data must also be input for the first year of the study for any areas for which the option is chosen. Additional sets of EEI load data can optionally be input for subsequent years; if not input, the program will start from the load model used in the previous year. The program will automatically adjust the input load model to meet the specified annual or monthly peaks and energies (input tables LOD-DATA and LOD-MTAR).

```
                                         MULTI-AREA RELIABILITY SIMULATION    Version  3.15                Run Date:   07022012
                                           COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY                  Job Number:   165443

TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                                      Output Section   7
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                                        Page            14
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                               LOAD MODEL STATISTICS FOR GROUP AREA-AB  FOR 2015 FOR LOAD LEVEL  3

              ************  INPUT LOAD MODEL DATA  ************              ***********  ADJUSTED LOAD MODEL DATA  ***********

    MONTH       PEAK       VALLEY       ENERGY        LOAD FACTOR              PEAK       VALLEY       ENERGY        LOAD FACTOR
                (MW)        (MW)        (MWH)           (P.U.)                 (MW)        (MW)        (MWH)           (P.U.)
   -------      ----       ------       ------        -----------              ----       ------       ------        -----------

        1     2510.7     1116.9     1364191.5        0.7303              2510.7     1116.9     1364191.5        0.7303
        2     2357.3     1080.0     1158780.1        0.7315              2357.3     1080.0     1158780.1        0.7315
        3     2055.4      972.4     1126805.5        0.7369              2055.4      972.4     1126805.5        0.7369
        4     2231.7      957.5     1138060.9        0.7083              2231.7      957.5     1138060.9        0.7083
        5     2454.9     1086.0     1340051.5        0.7337              2454.9     1086.0     1340051.5        0.7337
        6     2510.7     1052.1     1319288.5        0.7298              2510.7     1052.1     1319288.5        0.7298
        7     2454.9      979.4     1255139.9        0.6872              2454.9      979.4     1255139.9        0.6872
        8     2231.7      981.4     1182685.9        0.7123              2231.7      981.4     1182685.9        0.7123
        9     2175.9      945.5     1084398.5        0.6922              2175.9      945.5     1084398.5        0.6922
       10     2457.9      984.4     1202897.0        0.6578              2457.9      984.4     1202897.0        0.6578
       11     2622.3     1179.6     1366863.5        0.7240              2622.3     1179.6     1366863.5        0.7240
       12     2789.7     1192.6     1473824.6        0.7101              2789.7     1192.6     1473824.6        0.7101

   ANNUAL     2789.7      945.5    15012987.0        0.6143              2789.7      945.5    15012987.0        0.6143

   NOTE:  BASE LOADS WERE COMPUTED FROM LOAD FORECAST UNCERTAINTY LOAD SHAPES
```

This summary shows, on a monthly and annual basis for the given area or area group, the peak load, valley load, energy, and load factor for the input load model, and for the load model that results from the adjustments made by the program to meet the specified monthly or annual peaks and energies. This summary will also be written for both the base shape, and each load forecast uncertainty load level for which data was input, if applicable.

This output is written to file code 07 and is controlled through input table GEN-TIME.

7.6 Maintenance Summaries

The maintenance scheduling portion of MARS writes two types of output summaries. The first one summarizes the maintenance schedule by unit; the second shows the weekly reserves by area, area group, pool, and for the entire system. This output is written to file code 07 and is controlled through input on table MNT-AOPT.

7.6.1 Unit Outage Summary

```
                                   MAINTENANCE AND OUTAGE SCHEDULE FOR 2015                     < KPRMNT >


                                                    WEEK
  ID  NAME         1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27
   1  UNIT-1A     --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
   2  UNIT-2A     --  --  --  --  --  --  --  --  --  SM  SM  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
   3  UNIT-3A     --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
   4  UNIT-4A     --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  SM  SM  --  --  --  --  --
   5  UNIT-6A     --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
   6  UNIT-7A     NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI
   7  UNIT-8A     --  --  --  --  --  --  SM  SM  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
   8  UNIT-10A    --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
   9  UNIT-11A    --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
  24  UNIT-1B     --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
  87  UNIT-10E    --  --  --  --  --  --  --  --  --  SM  SM  SM  SM  --  --  --  --  --  --  --  --  --  --  --  --  --  --
  88  UNIT-10B    --  --  --  --  --  --  --  --  --  SW  SW  SW  SW  SW  SW  --  --  --  --  --  --  --  --  --  --  --  --
  89  UNIT-9C     --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  PF  FD  FD  PF  --  --  --  --

... Continued on next page...
                                   MAINTENANCE AND OUTAGE SCHEDULE FOR 2015                     < KPRMNT >


                                                    WEEK
  ID  NAME        28  29  30  31  32  33  34  35  36  37  38  39  40  41  42  43  44  45  46  47  48  49  50  51  52  53       TOTAL
   1  UNIT-1A     --  --  --  SW  SW  SW  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --    3.00
   2  UNIT-2A     --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --    2.00
   3  UNIT-3A     --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --    0.00
   4  UNIT-4A     --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --    2.00
   5  UNIT-6A     --  --  --  --  SM  SM  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --    2.00
   6  UNIT-7A     NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  NI  --   52.14
   7  UNIT-8A     --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --    2.00
   8  UNIT-10A    --  --  --  --  --  --  --  --  --  --  --  SM  SM  SM  SM  SM  --  --  --  --  --  --  --  --  --  --  --    5.00
   9  UNIT-11A    --  --  --  --  --  --  --  --  --  --  SW  SW  SW  --  --  --  --  --  --  --  --  --  --  --  --  --  --    3.00
  24  UNIT-1B     --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  PF  RE  RE  RE  RE  --    4.43
  87  UNIT-10E    --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --    4.00
  88  UNIT-10B    --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --    6.00
  89  UNIT-9C     --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --    3.00

                               ** MAINTENANCE AND OUTAGE CODE DEFINITIONS **
                FD = FIXED DAILY MAINTENANCE      SM = SCHEDULED MAINTENANCE        NI = UNIT NOT YET INSTALLED
                PF = PARTIAL FIXED MAINTENANCE    SW = SCHED. MAINT. IN WINDOWS     RE = UNIT RETIRED
                                                  PS = PARTIAL SCHED. MAINT.        -- = NO OUTAGE THIS WEEK
```

This summary shows, for each unit on the system (including the individual units of the non-thermal plants), the weeks during the year that the unit was on outage and the type of outage. The units are listed in the following order: thermal, Type 1 energy-limited, Type 2 cogeneration, Type 1 cogeneration, Type 2 energy limited, energy storage, and demand-side management.

The total outage time recognizes the partial weeks at the beginning and end of the year.

7.6.2 Maintenance and Outage Dates

```
                                          MULTI-AREA RELIABILITY SIMULATION   Version  3.15                Run Date:    07022012
                                            COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY                 Job Number:   165443

TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                                      Output Section   7
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                                         Page            24
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                        MAINTENANCE AND OUTAGE DATES FOR 2015                                                   < KPRMT2 >


       ID      NAME          START DATE     STOP DATE      TYPE OF OUTAGE
       --      ----          ----------     ---------      --------------
        1      UNIT-1A         27JUL          16AUG        Scheduled Maintenance in Windows
        2      UNIT-2A         02MAR          15MAR        Scheduled Maintenance
        3      UNIT-3A         -----          -----        Unit Not on Outage This Year
        4      UNIT-4A         18MAY          31MAY        Scheduled Maintenance
        5      UNIT-6A         03AUG          16AUG        Scheduled Maintenance
        6      UNIT-7A         01JAN          31DEC        Unit Not Yet Installed
        7      UNIT-8A         09FEB          22FEB        Scheduled Maintenance
        8      UNIT-10A        21SEP          25OCT        Scheduled Maintenance
        9      UNIT-11A        14SEP          04OCT        Scheduled Maintenance in Windows
        .
        .
       24      UNIT-1B         01DEC          06DEC        Fixed Daily Maintenance
        .
        .
       87      UNIT-10E        02MAR          29MAR        Scheduled Maintenance
       88      UNIT-10B        02MAR          12APR        Scheduled Maintenance in Windows
       89      UNIT-9C         14MAY          03JUN        Fixed Daily Maintenance
       90      UNIT-7C         19FEB          18MAR        Fixed Daily Maintenance
                               07MAY          01JUN        Fixed Daily Maintenance
                               01NOV          08NOV        Fixed Daily Maintenance
       91      UNIT-5A         30MAR          12APR        Scheduled Maintenance in Windows
       92      UNIT-9A         03AUG          16AUG        Scheduled Maintenance in Windows
       93      UNIT-9A         06JUL          19JUL        Scheduled Maintenance in Windows
       94      UNIT-9A         03AUG          16AUG        Scheduled Maintenance in Windows
       95      UNIT-8C         10JUN          23JUN        Fixed Daily Maintenance
       96      UNIT-8C         24JUN          01JUL        Fixed Daily Maintenance
       97      UNIT-8C         02FEB          15FEB        Scheduled Maintenance
       98      UNIT-8C         24AUG          06SEP        Scheduled Maintenance
       99      CONT-B-E        -----          -----        Unit Not on Outage This Year
      100      UNIT-5D         09MAR          05APR        Scheduled Maintenance in Windows
      101      UNIT-1E         01APR          07APR        Fixed Daily Maintenance
                               01AUG          08AUG        Fixed Daily Maintenance
                               01NOV          08NOV        Fixed Daily Maintenance
      102      UNIT-11E        01JAN          31DEC        Unit Not Yet Installed
      103      CONT-C-D        -----          -----        Unit Not on Outage This Year
      104      CONT-A-E        -----          -----        Unit Not on Outage This Year
      105      WIND-01         -----          -----        Unit Not on Outage This Year
      106      WIND-02         01JAN          30SEP        Unit Not Yet Installed
                               28SEP          30SEP        Fixed Daily Maintenance
```

This summary lists all of the units on the system with the starting and stopping dates of all of the periods during the year in which the unit in on maintenance or scheduled outage, along with the type of outage. A unit is still on outage on its stop date; it returns to service on the following day.

7.6.3 Summary of Weekly Reserves

```
                                        MULTI-AREA RELIABILITY SIMULATION   Version  3.15              Run Date:   07022012
                                          COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY               Job Number:   165443

TEST CASE - 5 AREAS   2 POOLS   BASED ON IEEE RTS DATA                                                 Output Section    7
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                                     Page             25
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                                     WEEKLY RESERVES SUMMARY (MW) FOR AREA AREA-A   FOR 2015                       < KPRCAP >
                                            (MAINTENANCE SCHEDULED ON AN AREA BASIS)


                       INSTALLED    SCHED.    **  RESERVES  **                            INSTALLED    SCHED.    **  RESERVES  **
  WEEK   PEAK LOAD     CAPACITY    OUTAGES      MW        %            WEEK   PEAK LOAD    CAPACITY    OUTAGES      MW        %
  ----   ---------    ---------    -------   --------   ------         ----   ---------   ---------    -------   --------   ------
    1       2405.1       3340.0        0.0      934.9    38.87           28      2276.6      3340.0      375.0      688.4    30.24
    2       2510.7       3340.0        0.0      829.3    33.03           29      2234.7      3340.0      375.0      730.3    32.68
    3       2448.9       3340.0      150.0      741.1    30.26           30      2454.9      3340.0      200.0      685.1    27.91
    4       2326.4       3340.0      150.0      863.6    37.12           31      2308.5      3340.0      236.0      795.5    34.46
    5       2454.9       3340.0      150.0      735.1    29.94           32      2165.0      3340.0      336.0      839.0    38.75
    6       2346.3       3340.0      250.0      743.7    31.70           33      2231.7      3340.0      286.0      822.3    36.84
    7       2320.4       3340.0      250.0      769.6    33.17           34      2097.2      3340.0      500.0      742.8    35.42
    8       2248.7       3340.0      250.0      841.3    37.41           35      2025.5      3340.0      500.0      814.5    40.21
    9       2113.2       3340.0      400.0      826.8    39.13           36      1966.7      3340.0      500.0      873.3    44.40
    .
    .
    .
   19       2427.0       3340.0      200.0      713.0    29.38           46      2536.6      3340.0        0.0      803.4    31.67
   20       2454.9       3340.0      150.0      735.1    29.94           47      2622.3      3340.0        0.0      717.7    27.37
   21       2388.2       3340.0      190.0      761.8    31.90           48      2482.8      3340.0        0.0      857.2    34.52
   22       2261.6       3340.0      190.0      888.4    39.28           49      2628.3      3340.0        0.0      711.7    27.08
   23       2510.7       3340.0      150.0      679.3    27.06           50      2706.0      3340.0        0.0      634.0    23.43
   24       2474.8       3340.0        0.0      865.2    34.96           51      2789.7      3340.0        0.0      550.3    19.73
   25       2499.8       3340.0        0.0      840.2    33.61           52      2655.2      3340.0        0.0      684.8    25.79
   26       2402.1       3340.0      150.0      787.9    32.80           53      2495.8      3340.0        0.0      844.2    33.83
   27       2258.6       3340.0      350.0      731.4    32.38


    NOTE:  The installed capacity on this summary is based on the ratings of the units at
           the start of the year and reflects mid-year installations and retirements but
           does not reflect monthly overrides made to the unit ratings during the year.
           This summary does not include units that are being used to model contracts.
```

This summary shows, for each week in the year, the peak load, installed capacity, capacity on scheduled outage, and reserves in MW and as a percent of the peak load. The installed capacity is based on the ratings of the units at the start of the study and includes mid-year installations and retirements, but does not reflect any monthly overrides made during the year. It also includes the capacity adjustments that were specified on MNT-FIXC. (Area adjustments are also included in the corresponding area groups.)

The capacity on outage recognizes the number of days of outage during the week and the number of days in the week. For example, if a 100 MW unit is on outage for three days during the first week of the year which begins on Wednesday (and thus contains only five days), the scheduled outage will be 60 MW.

This output can be requested for the areas and/or pools. If it is requested for the areas, it will also be written for the area groups. If it is requested for the areas or pools, it will also be printed for the system.

If the option to schedule automatic maintenance has been disabled in MNT-OPTN, this summary will not be printed.

7.7 Installed Capacity Summaries

```
                              MULTI-AREA RELIABILITY SIMULATION    Version  3.15              Run Date:    07022012
                                COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY                Job Number:    165443

TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                         Output Section    7
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                            Page             35
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS
```

INSTALLED CAPACITY (MW) BY UNIT TYPE FOR AREA AREA-A FOR 2015

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
NUCLEAR	750.00	750.00	750.00	750.00	750.00	750.00	750.00	750.00	750.00	750.00	750.00	750.00	750.00
FOSSIL-S	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
FOSSIL-L	1936.00	1936.00	1936.00	1936.00	1936.00	1936.00	1936.00	1936.00	1936.00	1936.00	1936.00	1936.00	1936.00
C.T.	229.00	229.00	229.00	229.00	229.00	229.00	229.00	229.00	229.00	229.00	229.00	229.00	229.00
COGEN	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
HYDRO	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
E.S.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DSM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WIND	46.17	46.17	46.17	46.17	45.99	45.81	44.64	41.94	45.90	46.17	46.08	46.17	46.17
CONTRACT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	3386.17	3386.17	3386.17	3386.17	3385.99	3385.81	3384.64	3381.94	3385.90	3386.17	3386.08	3386.17	3386.17

AVAILABLE ENERGY (MWH) BY NON-THERMAL UNIT TYPE FOR AREA AREA-A FOR 2015

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
HYDRO	25000.	25000.	25000.	25000.	25000.	20000.	20000.	20000.	20000.	20000.	25000.	25000.	275000.
E.S.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DSM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
WIND	13437.	11765.	11548.	8675.	10628.	5165.	6985.	6333.	7843.	9024.	12002.	11681.	115086.
CONTRACT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL	38437.	36765.	36548.	33675.	35628.	25165.	26985.	26333.	27843.	29024.	37002.	36681.	3900

These reports summarize the installed capacity of each area, area group, pool, and the system on a monthly basis by user-specified unit types. For the non-thermal unit types (such as Type 2 energy-limited units, energy storage, and demand-side management), these summaries also list the energy available for the month.

A unit is included in the monthly capacity if it is installed at any time during the month. Units being used to model contracts are added to the capacity of the receiving area (and related area groups and pools) and subtracted from the capacity of the sending area.

The unit types are specified through input table GEN-UNTY and are assigned to individual units on table UNT-DATA. These summaries are written to file code 07 and are controlled through table GEN-TIME.

7.8 Unit Data Summaries

Summaries of the unit input data can be written to file code 07 for each year. This is controlled through input on the MNT-AOPT table. The summary for thermal units lists the unit's type, installation and retirement dates, two seasonal ratings (for specified months of the year), planned outage time in weeks, equivalent forced outage rate, forced outage rate by capacity state, and the mean time-in-state (in hours) for each capacity state.

The summary for the non-thermal units shows the same information with the exception of the annual energy in place of the forced outages rates.

7.8.1 Thermal Units

MULTI-AREA RELIABILITY SIMULATION Version 3.15
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Run Date: 07022012
Job Number: 165443

TEST CASE - 5 AREAS 2 POOLS BASED ON IEEE RTS DATA
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS

Output Section 7
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THERMAL UNIT SUMMARY FOR 2015

ID	UNIT NAME	AREA	SUMMARY TYPE	INSTALLED	RETIRED	RATING JAN (MW)	RATING JUL (MW)	PLANNED (WEEKS)	EFOR (P.U.)	# OF STATES	CAP. ST. (P.U.)	ST. FOR (P.U.)	MTIS (HOURS)
1	UNIT-1A	AREA-A	FOSSIL-L	01JAN1980	01JAN2050	36.00	36.00	3.00	0.0200	2	1.0000	0.0200	2941.2
											0.0000	0.0000	60.0
2	UNIT-2A	AREA-A	C.T.	01JAN1980	01JAN2050	24.00	24.00	2.00	0.0167	2	1.0000	0.0167	2941.2
											0.0000	0.0000	50.0
3	UNIT-3A	AREA-A	C.T.	01JAN1980	01JAN2050	40.00	40.00	0.00	0.1000	2	1.0000	0.1000	450.0
											0.0000	0.0000	50.0
4	UNIT-4A	AREA-A	C.T.	01JAN1980	01JAN2050	40.00	40.00	2.00	0.1000	2	1.0000	0.1000	450.0
											0.0000	0.0000	50.0
5	UNIT-6A	AREA-A	C.T.	01JAN1980	01JAN2050	50.00	50.00	2.00	0.0100	2	1.0000	0.0100	1980.2
											0.0000	0.0000	20.0
6	UNIT-7A	AREA-A	C.T.	15JUN2016	01JAN2050	50.00	50.00	52.14	0.0100	2	1.0000	0.0100	1980.2
											0.0000	0.0000	20.0
7	UNIT-8A	AREA-A	FOSSIL-L	01JAN1980	01JAN2050	150.00	150.00	2.00	0.0100	2	1.0000	0.0100	1980.2
											0.0000	0.0000	20.0
8	UNIT-10A	AREA-A	C.T.	01JAN1980	01JAN2050	75.00	75.00	5.00	0.0200	2	1.0000	0.0200	1960.8
											0.0000	0.0000	40.0
9	UNIT-11A	AREA-A	FOSSIL-L	01JAN1980	01JAN2050	150.00	150.00	3.00	0.0200	2	1.0000	0.0200	1960.8
											0.0000	0.0000	40.0
.													
.													
.													
17	UNIT-19A	AREA-A	FOSSIL-L	01JAN1980	01JAN2050	200.00	200.00	4.00	0.1250	3	1.0000	0.1999	400.0
											0.5000	0.0500	149.9
											0.0000	0.0000	25.0
18	UNIT-20A	AREA-A	FOSSIL-L	01JAN1980	01JAN2050	200.00	200.00	4.00	0.1250	3	1.0000	0.1999	400.0
											0.5000	0.0500	149.9
											0.0000	0.0000	25.0
19	UNIT-21A	AREA-A	FOSSIL-L	01JAN1980	01JAN2050	200.00	200.00	4.00	0.1250	3	1.0000	0.1999	400.0
											0.5000	0.0500	149.9
											0.0000	0.0000	25.0
20	UNIT-22A	AREA-A	NUCLEAR	01JAN1980	01JAN2050	350.00	350.00	5.00	0.1649	4	1.0000	0.2799	300.3
											0.6500	0.1399	87.6
											0.3000	0.0600	50.0
											0.0000	0.0000	25.0

7.8.2 Non-Thermal Units

MULTI-AREA RELIABILITY SIMULATION Version 3.15
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Run Date: 07022012
Job Number: 165443

TEST CASE - 5 AREAS 2 POOLS BASED ON IEEE RTS DATA
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS

Output Section 7
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NON-THERMAL UNIT SUMMARY FOR 2015

ID	UNIT NAME	AREA	UNIT TYPE	SUMMARY TYPE	INSTALLED	RETIRED	RATING JAN (MW)	RATING JUL (MW)	PLANNED (WEEKS)	ANNUAL ENERGY (MWH)
92	UNIT-9A	AREA-A	EL2	HYDRO	01JAN1980	01JAN2050	75.00	75.00	2.00	275000.000
93	UNIT-8C	AREA-C	EL2	HYDRO	01JAN1980	01JAN2050	50.00	50.00	1.79	240000.000
94	CONT-B-E	CONTRACT	EL2	CONTRACT	01JAN1980	01JAN2050	50.00	50.00	0.00	180000.000
95	UNIT-5D	AREA-D	ES	E.S.	01JAN1980	01JAN2050	50.00	50.00	4.00	-51100.000
96	UNIT-1E	AREA-E	DS	DSM	01JAN1980	01JAN2050	10.00	10.00	3.29	62640.000
97	UNIT-11E	AREA-E	DS	DSM	01JAN2016	01JAN2050	0.00	0.00	52.14	0.000
98	CONT-C-D	CONTRACT	DS	CONTRACT	01JAN1980	01JAN2050	20.00	-20.00	0.00	-480.000
99	CONT-A-E	CONTRACT	DS	CONTRACT	01JAN1980	01JAN2050	0.00	0.00	0.00	0.000
100	WIND-01	AREA-A	DS	WIND	15MAY2014	01JAN2050	46.17	44.64	0.00	115086.320
101	WIND-02	AREA-B	DS	WIND	01OCT2015	01JAN2050	0.00	0.00	39.00	95373.000
102	WIND-03	AREA-D	DS	WIND	15MAY2016	01JAN2050	0.00	0.00	52.14	0.000
103	WIND-04	AREA-E	DS	WIND	15MAY2018	01JAN2050	0.00	0.00	52.14	0.000

7.9 Interface Data Summary

Summaries of the interface input data will be written to file code 07 if the unit input data, as controlled through input on the MNT-AOPT table, was written out. The summary lists the "from" and "to" areas, two seasonal ratings for both directions (for specified months of the year), equivalent forced outage rate, forced outage rate by capacity state, and the mean time-in-state (in hours) for each capacity state.

```
                                          MULTI-AREA RELIABILITY SIMULATION    Version  3.15                Run Date:    07022012
                                            COPYRIGHT 1988-2012 - GENERAL ELECTRIC COMPANY                  Job Number:    165443

TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA                                                       Output Section   7
REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS                                          Page            52
WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS


                                                  INTERFACE SUMMARY FOR 2015


                                                         POS. DIRECTION    NEG. DIRECTION     EFOR   # OF  CAP. ST. ST. FOR   MTIS
  NAME     FULL INTERFACE NAME       FROM      TO      JAN (MW) JUL (MW) JAN (MW) JUL (MW)  (P.U.) STATES  (P.U.)   (P.U.)  (HOURS)
-------- ------------------------  -------- --------  -------- -------- -------- --------  ------ ------ -------- ------- -------
A-TO-B   AREA-A TO AREA-B          AREA-A   AREA-B      100.00   100.00   100.00   100.00  0.0000    1     1.0000  0.0000 999999.9
A-TO-C   AREA-A TO AREA-C          AREA-A   AREA-C      200.00   200.00   200.00   200.00  0.0000    1     1.0000  0.0000 999999.9
B-TO-C   AREA-B TO AREA-C          AREA-B   AREA-C      150.00   150.00   160.00   160.00  0.0000    1     1.0000  0.0000 999999.9
C-TO-D   AREA-C TO AREA-D          AREA-C   AREA-D       50.00    50.00    50.00    50.00  0.0000    1     1.0000  0.0000 999999.9
C-TO-E   AREA-C TO AREA-E          AREA-C   AREA-E       50.00    50.00    50.00    50.00  0.0000    1     1.0000  0.0000 999999.9
D-TO-E   AREA-D TO AREA-E          AREA-D   AREA-E      100.00   100.00   100.00   100.00  0.0000    1     1.0000  0.0000 999999.9
```

Chapter 8

Using the Master Input File

MARS uses the Master Input File (MIF) to input all of the study data except for the hourly loads and the DSM shapes. This section describes the general format of the Master Input File and the rules that govern its use.

The MIF is a set of input tables. With the exception of table GEN-CASE, which should always be the first table, the order in which the tables appear in the MIF is irrelevant. Each line can be up to 132 characters long.

8.1 How Tables are Recognized in the MIF

Tables are recognized in the following way. The MIF is scanned for special characters in columns 1-2 (the "line zone"). An ampersand (&) in the line-zone indicates the beginning of a table. A semicolon (;) in the line-zone indicates the end of a table.

```
1234567890 ...                  ----------> (132 characters)


    You may use the space between tables
    and the space before the first table
    and after the last table for
    free-form comments.


 &Table-X



 ;End-of-TableX



   *** This is a comment ***

       User comment ...


 &Table-Z




 ;End-of-TableZ




 &Table-Y





 ;End-of-TableY



##### This is another comment #####
```

Each of the tables in the MIF has comments within it which are there to help you fill in the input values. A convention that is followed is that at each place a value may be inserted there is a "value-type-indicator" which lets you know what type of value is expected. The "value-type-indicators" which are in the MIF are of the following formats: #, I's (a string of 1 one or more I's), A's (a string of one or more A's), DDMMMYYYY (a date), Y/N or YES/NO.

8.1.1 Value Type Indicators

#

A real value is expected. A real value will read as a number which may be signed, followed by a maximum of 12 digits for the whole part of the number, followed by a decimal point, followed by a maximum of 10 digits for the decimal part of the number. No embedded blanks are allowed between the sign, the whole part digits, the decimal point, and the decimal part digits.

Table 8.1: Valid Real Values

- `1.0`
- `+1.`
- `0`
- `0.0004`
- `.0004`
- `-.0004`
- `+.0004`
- `-900`
- `999999999999.9999999999` (largest possible real value)
- `-999999999999.9999999999` (smallest possible real value)

Table 8.2: Invalid Real Values

- `- 5.5` (no spaces allowed)
- `+5.  0`

I

An integer value is expected. An integer value may be signed and have up to eight digits. There may not be any blanks between the sign and the digits.

Table 8.3: Valid Integer Values

- `+1`
- `1277`
- `-888`
- `99999999` (largest integer value)
- `-99999999` (smallest integer value)

Table 8.4: Invalid Integer Values

- `+ 23` (no spaces allowed)
- `1.` (decimal not allowed)

A

An alpha-numeric character string value is expected (or a string of A's). If there are no embedded blanks in the string then the string does not need to be enclosed in quotes.

The number of A's indicates the allowed length of the string value. For instance, `AAAAAAAA` indicates that a string of up to eight characters is allowed for a particular value. It is not necessary to fill in all eight positions. The value will be right filled with blanks when it is used by the program. If you use more than the allowed positions then the string is truncated, from the right, to the number of allowed characters.

Table 8.5: Valid String Values

- `9MILE`
- `"9MILE"`
- `'9MILE'` (single or double quotes may be used as string delimiters)
- `'9MILE '`
- `"BLUE BAY"`
- `BLUE-BAY`
- `"BLUE'S BAY"`

Table 8.6: Invalid String Values

- `BLUE BAY`
- `BLUE-BAY"` (beginning and ending delimiter must be consistent)

YYYY, MMMYYYY, DDMMMYYY

A date is required for input.

YYYY A year value is required.

MMMYYYY A month and a year value is required. The months are indicated by these three character strings: JAN, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEPT, OCT, NOV, DEC.

DDMMMYYYY A day, month, and year value is required.

Table 8.7: Valid Dates

- `1998`
- `FEB1991`
- `02JUN1992`
- `2JUN1992`

Table 8.8: Invalid Dates

- `FEB 1991` (no spaces allowed)
- `01Jun1999` (month must be in uppercase)

Y/N

A Yes or a No value is required. Either YES or Y may be used for YES. Either NO or N may be used for NO.

8.1.2 The Spaces Between Tables

The lines in the MIF between tables and above the first table and below the last table may be used by you for commenting purposes. You may insert comments in free format with the only exception being that an & or a ; may not appear in the line-zone (columns 1-2) of any comment line. Blank lines may be inserted anywhere in the MIF (between tables or within tables).

8.1.3 Comment and Blank Lines Within a Table

The lines within a table which have an asterisk (*) in the line-zone are comment lines. They are there to help you in filling in the input values. They may be deleted or modified. You may insert additional comment lines or blank lines anywhere within any table.

8.2 Types of Tables

In designing the MIF structure, three table types were developed to handle different types of input data. All tables in the MIF to conform to one of these three table types. The three types of MIF tables are:

1. The Record Table
2. The Colon Table
3. The Colon Array Table

Two special features were developed to help exceptional data (such as large arrays) conveniently fit into one of the table types. The two special features allowed in some of the tables are:

1. The Continuation Feature
2. The Asterisk Feature

8.2.1 The Record Table

A record table is a table which organizes data into fixed columns and rows. Unless there is only one row in the table, the first column in a record table may be thought of as a "key" in that it will be unique for each row of the table.

Record Table Format

Data can be filled into the columns of a record table in free format. That is, the column values can appear anywhere on a line as long as they are in the correct order. Any number of spaces is allowed between the values. In the sample record table the columns were lined up with the headings in the comment lines to lend neatness and readability to the table. As part of the comments in each record table we have provided a "guide-line" to aid you in filling in the values. Refer to the preceding section, "Input Value Types" for an explanation of the "guide-line".

Sample Record Table - Multiple Rows

In this table each of the "unit names" is unique. It must appear only once in the "UNIT NAME" column. The number of rows of input values is dependent upon your data.

```
&UNT-DATA-00     UGD
*                                                  UNIT-GENERAL-DATA
*------------------------------------------------------------------------------------------------------------------------
*                                                                            UNIT TYPE
*                                                                         TH  = THERMAL
*                                                                         EL1 = TYPE 1 ENERGY-LTD
*                                                                         EL2 = TYPE 2 ENERGY-LTD
*                                                                         CG1 = TYPE 1 COGEN
*                                                                         CG2 = TYPE 2 COGEN          NUMBER OF UNITS
*                                                                         ES  = ENERGY STORAGE            IN PLANT              UNIT
*      UNIT          AREA         INSTALLATION          RETIREMENT        DS  = DEMAND-SIDE          (EL2, ES, AND DS        SUMMARY
*      NAME          NAME             DATE                 DATE                                         UNITS ONLY)           TYPE
*-------------------------------------------------------------------------------------------------------------------------
*    .NAMES.       .IAREA.      .INSTDY..INSTYR.  .IRETDY..IRETYR.          .IUNTYP.            .NUNPD..NUNPS..NUNHM.     .IUNSUM.
*-------------------------------------------------------------------------------------------------------------------------
*    AAAAAAAA      AAAAAAAA        DDMMMYYYY          DDMMMYYYY                AAA                        III             AAAAAAAA
*    --------      --------        ---------          ---------                ---                        ---             --------
     UNIT-5A       AREA-A            JAN1980            JAN2050                CG1                         =              COGEN
     UNIT-7A       AREA-A          15JUN2016            JAN2050                TH                          =              C.T.
     UNIT-9A       AREA-A            JAN1980            JAN2050                EL2                         3              HYDRO

     UNIT-1B       AREA-B            JAN1980            DEC2015                TH                          =              C.T.
     UNIT-10B      AREA-B            JAN1980            JAN2050                EL1                         1              FOSSIL-S

     UNIT-2C       AREA-C            JAN1980          01OCT2017                TH                          =              C.T.
     UNIT-7C       AREA-C            JAN1980            JAN2050                CG2                         =              COGEN
     UNIT-8C       AREA-C            JAN1980            JAN2050                EL2                         4              HYDRO
     UNIT-9C       AREA-C            JAN1980            JAN2050                EL1                         =              FOSSIL-S

     UNIT-5D       AREA-D            JAN1980            JAN2050                ES                          1              E.S.

     UNIT-1E       AREA-E            JAN1980            JAN2050                DS                          1              DSM

     CONT-C-D      CONTRACT          JAN1980            JAN2050                DS                          1              CONTRACT

     WIND-01       AREA-A          15MAY2014            JAN2050                DS                          1              WIND

;;;; END OF &UNT-DATA-00 ;;;;
```

Sample Record Table - Single Row

In this table there is no "key" column. The table requires a single row of input values.

```
&MNT-OPTN-00     MOP
*                                                  MAINTENANCE-OPTIONS
*----------------------------------------------------------------------------------------------------------
*               READ/WRITE
*               MAINT. FILE                        SCHEDULE       USE PLANNED                  MAINTENANCE
*                 N = NO        MAINTENANCE       MAINT. BY      OUTAGE RATE      ORDER        LOAD OPTION       ZERO OUT
*  EFFECTIVE      R = READ       SCHEDULED        AREA, POOL        CYCLE         MAINT.     O = ORIG. LOAD   FIXED MAINT.
*    YEAR         W = WRITE     BY PROGRAM ?        OR SYS.        MATRIX ?      BY MW ?     S = SPEC. LOAD      DATA ?
*----------------------------------------------------------------------------------------------------------
*                 .NTAPEM.       .NSCHED.          .MTACSW.         .MOPT.        .KSKED.        .INTRD.        .IZEROF.
*----------------------------------------------------------------------------------------------------------
*     YYYY           A             Y/N               AAAA             Y/N           Y/N             A              Y/N
*     ----           -             ---               ----             ---           ---             -              ---
                     N              Y                AREA              N             Y              O               Y


;;;; END OF &MNT-OPTN-00 ;;;;
```

8.2.2 The Colon Table

A colon table is a table which allows one input value per line. An input value follows a colon on a line.

Colon Table Format

There is a fixed number of input values which may be placed in a colon table. If a value is not placed after the colon a default value will be assigned. Any number of spaces may be inserted between the colon and the value. Blank lines and comment lines may be inserted anywhere in the table. On a line containing a colon you may alter the information preceding the colon. It is there to guide you in filling in the table. The colon is the only required information on a line.

Sample Colon Table

```
&GEN-CASE-00     CIN
*                                              CASE-INFORMATION
*--------------------------------------------------------------------------------------------------------------------------------
*                                                      AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
  IDENTIFICATION 1   (.IDENT1.)                     : "TEST CASE - 5 AREAS  2 POOLS   BASED ON IEEE RTS DATA  "
*                                                      AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
  IDENTIFICATION 2   (.IDENT2.)                     : "REVISED LIMITS BETWEEN AREAS WITHIN POOL, 50 MW TIES BETWEEN POOLS"
*                                                      AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
  IDENTIFICATION 3   (.IDENT3.)                     : "WITH LFU SHAPES FOR A AND B WITH MULTIPLIERS "

  JOB IDENTIFIER   (.JOBNUM.)              AAAAAA :  165443
  DATE FOR OUTPUT LISTING  (.KDATE.)     AAAAAAAA :  07022012

  FIRST YEAR OF STUDY   (.NSTART.)           YYYY :  2015
  LAST YEAR OF STUDY    (.NSTOP.)            YYYY :  2018

*                                                      AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
  SYSTEM NAME        (.NMSYST.)                     : "MARS TEST SYSTEM "

  P.U. TOLERANCE FOR CHECKING LOADS  (.TOLER.)    # :0.2

  UNIT FORCED OUTAGES SPECIFIED THROUGH
    STATE TRANSITION RATES (0) OR FORCED
    OUTAGE RATES (1)  (.INPFOR.)                  I :  0

  DISPATCH OPTION FOR TYPE 3 ENERGY-LIMITED UNITS
    0  =  DETERMINISTIC LOAD MODIFIERS BEFORE
          THE MONTE CARLO SIMULATION
    1  =  AS NEEDED DURING THE MONTE CARLO
          SIMULATION (ISOLATED ONLY)
    2  =  AS NEEDED DURING THE MONTE CARLO
          SIMULATION (ISOLATED AND INTERCONNECTED)
    3  =  AS NEEDED DURING THE MONTE CARLO
          SIMULATION (INTERCONNECTED ONLY)
    (.IEL2MC.)                                    I :  3

 OPTION TO MODEL FORCED OUTAGES ON THE
    INTERFACE TIES (.IOUTIE.)   Y/N             AAA :  N

 OPTION TO WRITE OR READ AVAILABLE
    HOURLY CAPACITY BY AREA  (.ICAPRW.)           A :  N
      W  =  WRITE
      R  =  READ
      N  =  NEITHER

  FIRST REPLICATION TO CALCULATE WHEN
    USING THE OPTION TO RUN ON MULTIPLE
    PROCESSORS  (.INTVAL(12).)               IIII :
      0 = DO NOT USE THE OPTION (DEFAULT)
      1 = BEGIN CASE WITH REPLICATION 1.
          SAME AS NOT USING THE OPTION BUT
          CREATES THE BINARY FILE WITH THE
          INTERMEDIATE RESULTS.
      N = BEGIN CASE WITH REPLICATION N.
          SIMULATION WILL GO FROM N TO MAXREP.

  OPTION TO WRITE OR READ BINARY INPUT DATA
    FILE  (.INTVAL(17).)                          A : N
      W  =  WRITE
      R  =  READ
      N  =  NEITHER (DEFAULT)

;;;; END OF &GEN-CASE-00 ;;;;
```

8.2.3 The Colon Array Table

A colon array table is similar to a colon table. It also uses the colon to indicate where input values may be placed. The difference between a colon table and a colon array table is that some of the lines in a colon array table allow more than one input value to be placed after a colon. The colon array table allows you to conveniently input data which can be viewed as an array. Non-array values (i.e., lines on which only one value would be placed after a colon) are often part of a colon array table.

Colon Array Table Format

Values are input similarly to the values in a colon table. Spacing is flexible and values must be placed after the colons. Just as in a colon table the order of the values is field. Comments are placed on the table to aid you in filling in the values. As with all tables blank lines and comment lines may be inserted anywhere in the table.

Sample Colon Array Table

```
&LOD-MTAR-01      MAR
 *                      MONTH-TO-ANNUAL-RATIOS
 *--------------------------------------------------------------
 *
   EFFECTIVE YEAR                          YYYY :

   AREA NAME                          AAAAAAAA  : AREA-C
   LFU LOAD LEVEL                            I  : =

   USE FOLLOWING RATIOS TO CALCULATE
   MONTHLY PEAK LOADS ?  (.INTRAT.)        Y/N  :  Y
 *
 *--------------------------------------------------
 *        MONTH TO          MONTHLY
 *      ANNUAL RATIO     TARGET ENERGY
 *         (P.U.)            (MWH)
 *--------------------------------------------------
 *        .RATIO.           .TARENG.
 *--------------------------------------------------
 *           #                  #
 *       ---------        -----------
   JAN :      0.900              0.000
   FEB :      0.800              0.000
   MAR :      0.700              0.000
   APR :      0.800              0.000
   MAY :      0.900              0.000
   JUN :      0.950              0.000
   JUL :      1.000              0.000
   AUG :      0.850              0.000
   SEP :      0.800              0.000
   OCT :      0.750              0.000
   NOV :      0.800              0.000
   DEC :      0.850              0.000

 ;;;; END OF &LOD-MTAR-00 ;;;;
```

8.2.4 Special Features

Because some of the input data might not conveniently fit into one of the three table types (record, colon, or colon array) two special features were created, the continuation feature and the asterisk feature.

The Continuation Feature

The continuation feature allows a row (or line) of input values to be continued on the following line. For example, suppose that in a record table or the array part of a colon array table it would be convenient to allow many values to be placed across a line in the MIF. But, there is a limitation of 132 characters per line in the MIF. To get around this the continuation feature was created.

Continuation is accomplished by inserting a plus sign (+) in the line-zone (columns 1-2) of the succeeding line and continuing to input the values. If the continuation feature is allowed in a table the word CONTINUATION will appear on the beginning-of-table line (the & line).

Sample Record Table with Continuation Feature

In this table, all of the data for C-EXPORT does not conveniently fit on one line; so the data is continued on the next line.

```
&INF-GRPS-00     IGP     CONTINUATION
*                                               INTERFACE-GROUP-IDENTIFICATION
*-----------------------------------------------------------------------------------------------------------------------------------
*    ABBREVIATED                                  ABBREVIATED                 ABBREVIATED                 ABBREVIATED
*     INTERFACE                                    INTERFACE    PER UNIT       INTERFACE    PER UNIT       INTERFACE    PER UNIT
*    GROUP NAME     FULL INTERFACE GROUP NAME        NAME       MULTIPLIER       NAME       MULTIPLIER       NAME       MULTIPLIER
*-----------------------------------------------------------------------------------------------------------------------------------
*     .NMINTF.               .NMINTL.              .INTGRP.     .XGRPPU.       .INTGRP.     .XGRPPU.       .INTGRP.     .XGRPPU.
*-----------------------------------------------------------------------------------------------------------------------------------
*     AAAAAAAA      AAAAAAAAAAAAAAAAAAAAAAAA       AAAAAAAA        #           AAAAAAAA        #           AAAAAAAA        #
*     --------     -------------------------       --------       ---          --------       ---          --------       ---
      P1-TO-P2     'POOL 1 TO POOL 2  POS  '       C-TO-D         1.0          C-TO-E         1.0

      A-IMPORT     'NET IMPORTS INTO A     '       A-TO-B        -1.0          A-TO-C        -1.0

      C-EXPORT     'NET EXPORTS FROM C     '       A-TO-C        -1.0          B-TO-C        -1.0          C-TO-D         1.0
+                                                  C-TO-E         1.0


;;;; END OF &INF-GRPS-00 ;;;;
```

The Asterisk Feature

The asterisks feature allows you to use a repeat factor with an asterisk (*). It is useful when you want to assign successive input items the same value.

The following two lines of input produce the same assignments:

```
101 101 424 103 103 103 103 103 110 601 601
2*101 424 5*103 110 601 601
```

There cannot be any spaces between the repeat factor, the asterisk, and the value.

The following examples show invalid use of the repeat feature:

```
2 *101
12* 110
```

If the asterisk feature is allowed in a table the word ASTERISK will appear on the beginning-of-table line (the & line).

Sample Record Table with Asterisk Feature

This table assigns input data values using the continuation feature.

```
&MNT-FIXC-00     MFC     CONTINUATION     ASTERISK
*                                                    MAINTENANCE-FIXED-CAPACITY-MODIFIER
*-------------------------------------------------------------------------------------------------------------------
*                 AREA OR
*  EFFECTIVE     POOL NAME
*    YEAR       (0 = SYSTEM)                                FIXED MW CAPACITY MODIFIER
*-------------------------------------------------------------------------------------------------------------------
*                                                                     .FIXCAP.
*-------------------------------------------------------------------------------------------------------------------
*    YYYY         AAAAAAAA        #            #            #            #            #            #            #
*    ----         --------    ---------    ---------    ---------    ---------    ---------    ---------    ---------
                  AREA-C        15*0         22*100       15*0
                  AREA-D        10*-50       10*0         12*50        10*0         10*-50


;;;; END OF &MNT-FIXC-00 ;;;;
```

8.3 Overriding Input Values

Most of the data input through the MIF is read by the program at the start of the study and remains in effect for the entire study. This data is referred to as General Data. However, most of the MIF tables also provide the means of having the input values in the table overridden during the study, that is, updated by the program over some period of time (such as annually, monthly, or daily). Data that is changed through time is referred to as Override

Data. You can determine what data may be overridden by looking at the template of each table. For data in a record table, if the first column is titled EFFECTIVE DATE then all the data in that table may be overridden.

For data in a colon array table if the first value allowed is entitled EFFECTIVE DATE then all of the data in that table may be overridden.

If the EFFECTIVE DATE field is missing in the template of a table, then none of the data in that table may be overridden.

8.3.1 Determining Time Basis For Overrides

For any table in which overrides are an option, a guide within the comments for the EFFECTIVE DATE lets you know on what time basis the values in that table may be updated. The guides are one of the following:

YYYY Values may be updated annually

MMMYYYY Values may be updated monthly

DDMMMYYYY Values may be updated daily

The format for inputting these dates is identical to the format for inputting date values. Refer to the section entitled "Input Value Types" for an explanation of inputting dates.

8.3.2 Overriding Data in a Record Table

In a record table input values are updated by adding a line in the table with an at sign (@) in the line-zone, followed by an effective date, followed by values for each of the succeeding columns.

Sample Record Table with Overrides

```
&GEN-TIME-00     STU
*                                       STUDY-TIME-PERIOD-AND-ANNUAL-OUTPUT
*-----------------------------------------------------------------------------------------------------------------------------------
*                                   PRINT SUMMARY                                                         PRINT        PRINT     PRINT
*              STUDY      PRINT      FOR EVERY     PRINT      WRITE      PRINT      PRINT      WEEKLY/MONTHLY HOURLY     HOURLY
*  EFFECTIVE   THE       ANNUAL      III'TH       HOURLY    HISTOGRAM  LOAD MODEL  SUMMARY BY  SUMMARIES BY   FLOW       MODIFER
*    YEAR      YEAR ?   OUTPUT ?   REPLICATION   OUTPUT ?    FILE ?    OUTPUT ?   UNIT TYPE ?  LOAD LEVEL ?  OUTPUT ?   OUTPUT
*-----------------------------------------------------------------------------------------------------------------------------------
*            .IYRSTD.  .KPRINT(2).  .KPRINT(3). .KPRINT(4). .KPRINT(5). .KPRLDS.  .KPRINT(6).  .KPRINT(7).  .KPRINT(8).
*-----------------------------------------------------------------------------------------------------------------------------------
*    YYYY      Y/N       Y/N          III          AAA         Y/N       Y/N/S       Y/N        N/W/M/B        Y/N       Y/N/S
*    ----      ---       ---          ---          ---         ---        ---        ---        -------        ---        ---
               Y         Y            1            N           Y          Y          Y           N             N          Y
@    2016      N         Y            1            N           Y          Y          Y           N             N          =
@    2018      Y         Y            1            N           Y          Y          Y           N             N          =

;;;; END OF &GEN-TIME-00 ;;;;
```

In the example above, the switch for "Study the Year" was changed from no to yes in 2018.

Shorthand Updating Method

There is a shorthand method which may be used for inputting overrides that may "flip-flop". Let's look at the following table to illustrate this point.

```
&MOD-ELMW-00      ELM
*                                  RATINGS-FOR-TYPE-2-AND-TYPE-3-ENERGY-LIMITED-UNITS
*-------------------------------------------------------------------------------------------------------------------------
*     EFFECTIVE     UNIT NAME      MINIMUM      MAXIMUM      ENERGY       STORAGE      DAYS     DAYS    HOURS    HOURS    HOURS     ENERGY
*       DATE                        (MW)         (MW)        (MWH)        (MWH)        PER      PER      PER      PER      PER     PER DAY
*                                                                                      YEAR     MONTH    YEAR     MONTH    DAY
*-------------------------------------------------------------------------------------------------------------------------
*                                 .ELUMIN.     .ELUMAX.     .ELUENG.     .EL2STR.    .IEL2MD..IEL2MD..IEL2YH..IEL2MH..IEL2DH.  .EE12DH.
*-------------------------------------------------------------------------------------------------------------------------
*      MMMYYYY      AAAAAAAA      ########     ########     ########     ########      III      III      IIII     III      III      ######
*      -------      --------      --------     --------     --------     --------      ---      ---      ----     ---      ---      ------
@      JAN2010**   "UNIT-9A "         15.0         75.0        25000         1000        =        =         =        =        =           =
@      JUN2010**   "UNIT-9A "         15.0         75.0        20000         1000        =        =         =        =        =           =
@      NOV2010**   "UNIT-9A "         15.0         75.0        25000         1000        =        =         =        =        =           =
                   "UNIT-8C "          0.0         50.0        20000            0        =        =         =        =        =           =
                   "CONT-B-E"          0.0         50.0        15000            0        =        =         =        =        =           =

 ;;;; END OF &MOD-ELMW-00 ;;;;
```

Locate `@ JAN2010**` in the table. This entry indicates that hourly modifier "UNIT-9A" will begin with 25,000 MWh of energy per month starting the first day of January 2010. The trailing two asterisks direct the program to make this override each year until the conclusion of the study period.

Below `@ JAN2010**` is `@ JUN2010**`. This entry indicates that beginning in June 2010, the monthly energy for "UNIT-9A" will drop from 25,000 MWh to 20,000 MWh. Because of the two asterisks the program will make this override each year of simulation until the end of the study period.

In January, the energy returns to the original value of 25,000 MWh. The use of these two overrides for "UNIT-9A" will cause the program to alternate between 25,000 MWh and 20,000 MWh on January 1 and June 1 for each year of the study.

Additional overrides could have been inserted in the table below for "UNIT-9A" so that instead of "flip-flopping" between two overrides you can instruct the program to "rotate" among several overrides.

For example, if an additional override had been included in the table below such as `@ NOV2010**` for "UNIT-9A" then the data for this unit would have changed three times a year (in January, June, and November).

You can also specify a cap on the number of times that you want an override to be effective. An asterisk followed by a number indicates that you want the override repeated for as many years as is indicated by that number. If you had entered `@ APR2015*2` instead of `@ APR2015**`, this would cause this particular override to occur in 2015 and 2016, two years only, and not thereafter.

8.3.3 Overriding Data in a Colon Array Table

In a colon array table input values are updated by fully reproducing the table within the MIF and inputting an effective date. If you want the data in a colon array table to be read as general data (that is, at the beginning of the study period before the first year of simulation) then leave the effective date field blank. If you want to override any of the values in the table at some point in the simulation then you would reproduce the table, fill in the effective date value, and change the values you want to override at the time of the effective date.

Colon Array Table with General Data (No Effective Date Input)

```
&LOD-MTAR-01      MAR
 *                      MONTH-TO-ANNUAL-RATIOS
 *-------------------------------------------------------------
 *
   EFFECTIVE YEAR                             YYYY :

   AREA NAME                             AAAAAAAA  : AREA-C
   LFU LOAD LEVEL                               I  : =

   USE FOLLOWING RATIOS TO CALCULATE
   MONTHLY PEAK LOADS ?  (.INTRAT.)         Y/N   :  Y
 *
 *-------------------------------------------------
 *        MONTH TO          MONTHLY
 *      ANNUAL RATIO      TARGET ENERGY
 *         (P.U.)            (MWH)
 *-------------------------------------------------
 *        .RATIO.           .TARENG.
 *-------------------------------------------------
 *           #                  #
 *       ---------          -----------
   JAN :      0.900               0.000
   FEB :      0.800               0.000
   MAR :      0.700               0.000
   APR :      0.800               0.000
   MAY :      0.900               0.000
   JUN :      0.950               0.000
   JUL :      1.000               0.000
   AUG :      0.850               0.000
   SEP :      0.800               0.000
   OCT :      0.750               0.000
   NOV :      0.800               0.000
   DEC :      0.850               0.000

 ;;;; END OF &LOD-MTAR-00 ;;;;
```

Colon Array Table With Override Data (Effective Date Is Input)

Assuming that the table in the previous page and the table below are both in the same MIF, then, in 2015 the month to annual ratios will be changed in January and June, and the monthly target energy will be changed in June.

```
&LOD-MTAR-01      MAR
 *                      MONTH-TO-ANNUAL-RATIOS
 *-------------------------------------------------------------
 *
@  EFFECTIVE YEAR                             YYYY : 2015

   AREA NAME                             AAAAAAAA  : AREA-C
   LFU LOAD LEVEL                               I  : =

   USE FOLLOWING RATIOS TO CALCULATE
   MONTHLY PEAK LOADS ?  (.INTRAT.)         Y/N   :  Y
 *
 *-------------------------------------------------
 *        MONTH TO          MONTHLY
 *      ANNUAL RATIO      TARGET ENERGY
 *         (P.U.)            (MWH)
 *-------------------------------------------------
 *        .RATIO.           .TARENG.
 *-------------------------------------------------
 *           #                  #
 *       ---------          -----------
   JAN :      0.900               0.000
   FEB :      0.800               0.000
   MAR :      0.700               0.000
   APR :      0.800               0.000
   MAY :      0.900               0.000
   JUN :      0.950               0.000
   JUL :      1.000               0.000
   AUG :      0.850               0.000
   SEP :      0.800               0.000
   OCT :      0.750               0.000
   NOV :      0.800               0.000
   DEC :      0.850               0.000

 ;;;; END OF &LOD-MTAR-00 ;;;;
```

8.4 Uses of the Equals Sign

The equals sign (=) may be used in place of any piece of data in a table when a value is to assume the default value assigned by the application program or retain its current value if it has already been assigned a value by the user. The = may be used in general data or override data. In most record tables and colon array tables there are a fixed number of values that must be assigned. The equals sign = can be used to reserve a value's position.

The = is particularly handy when inputting overrides. You can use the = for all the values in the override except the value(s) which you want to change. The table below illustrates the use of = in Override Data in a Record Table.

```
&HST-DATA-00    HST
*                                               HISTOGRAM-PROGRAM-DATA
*------------------------------------------------------------------------------------------------------------------------
*                             INDEX TO PROCESS    MARGIN
*                                  DLOLE          STATE
*                                  HLOLE           FOR
*                                  LOEE           DLOLE,
*  EFFECTIVE     AREA OR           FREQ           HLOLE,      INTERCONNECTED = 1      MINIMUM      MAXIMUM      CELL
*    DATE       POOL NAME          DUR             LOEE       ISOLATED       = 2       VALUE        VALUE       WIDTH
*------------------------------------------------------------------------------------------------------------------------
*                                .INDEX.          .MARST.          .INTISO.           .CELMIN.     .CELMAX.     .CELWID.
*------------------------------------------------------------------------------------------------------------------------
*    YYYY       AAAAAAAA          AAAAA              I                 I                  #            #            #
*------------------------------------------------------------------------------------------------------------------------
                AREA-A            DLOLE              4                 2                 0.0         10.0          1.0
                AREA-D            HLOLE              =                 2                 0.0        200.0          5.0
                AREA-A            DLOLE              4                 1                 0.0          1.0          0.25
               'POOL 1'           LOEE               =                 2                 0.0      20000.0       1000.0
               'POOL 1'           LOEE               =                 1                 0.0       5000.0        500.0
@   2018        AREA-A            DLOLE              4                 2                 0.0         10.0          0.5
@   2018       'POOL 1'           LOEE               =                 2              5000.0      20000.0        500.0


;;;; END OF &HST-DATA-00 ;;;;
```

8.5 MIF Reserved Characters

Listed below is a summary of the special characters used by the MIF.

8.5.1 Line-Zone Reserved Characters

& Begining of table indicator

; End of table indicator

***** Comment line (within a table)

@ Override data (within a record or colon array table)

+ Continuation line (within a table)

8.5.2 Non-Line-Zone Reserved Characters

= A value will not be changed. It will keep the value it was last assigned, either the program default value or the user assigned value.

***** Repeat factor in tables with the asterisk feature. Used to assign the same value to successive input items.

8.6 Warning and Error Messages

Listed below is a summary of the warning and error messages printed by the program while the MIF is being read. In addition to the message, the program prints the line of data being processed at the time to help in identifying the cause of the problem.

****ERROR - INVALID TABLE *** table-name

Table name in MIF does not match any of the tables used by the program. Most likely caused by error in spelling of table name.

<**> ERROR: FATAL ERROR IN CREATING INDEX, TABLE table-name

Problem encountered in setting up the driver tables, usually caused by duplicate names on driver tables or attempting to input more areas, units, etc. than the maximum number allowed by the program. Check previous error messages on output for specific causes of this message.

<**> ERROR: REQUIRED TABLE table-name NOT FOUND.

One of the input tables that is required by the program was not supplied. Required tables for MARS are: GEN-CASE, GEN-POOL, GEN-AREA, CNV-CRIT, UNT-DATA, UNT-CAPS, and UNT-MXCP.

<**> WARNING: INCORRECT NUMBER OF ROWS, TABLE table-name

Colon or colon array table contains fewer rows than program expects. Program assumes that the last entries in table are missing and will assign default values to those inputs.

<**> WARNING: INCORRECT NUMBER OF COLUMNS, TABLE table-name

Table contains few columns than program expects. Program assumes that the last columns on the row are missing and will assign default values to those inputs.

<**> WARNING: INCORRECT NUMBER OF TOP COLUMNS, TABLE table-name

Colon array table contains fewer rows at top of table than program expects. Program assumes that the last rows are missing and will assign default values to those inputs.

<**> ERROR: TABLE table-name ASSIGNMENT FAILURE: string

Data could not be assigned to an input variable. Most likely causes include a name that could not be matched to the names on the driver tables, data that was not within the acceptable range (e.g., negative unit ratings or maximum ratings that are less than the minimum rating), or data with an invalid value (e.g., value other than YES or NO).

<**> ERROR: ENTRY TOO LONG, TABLE table-name

Character data string exceeds maximum allowable length of 80 characters. Check for missing single or double quote at end of string and that ending delimiter is the same kind as the beginning delimiter.

PROBLEM CONVERTING string TO INTEGER.

Check string, which program is expecting to be an integer, for invalid characters or a decimal point.

<**> ERROR: MORE THAN 12 CHARACTERS IN WHOLE PART OF VALUE. string

Real values cannot have more than 12 characters to the left of the decimal point.

<**> ERROR: MORE THAN 10 CHARACTERS IN DECIMAL PART OF VALUE. string

Real values cannot have more than 10 characters to the right of the decimal point.

<**> ERROR: ILLEGAL CHARACTER IN VALUE string

Check string, which program expects to be a real number, for invalid characters.

<**> ERROR: PARSING DATE OF OVERRIDE, TABLE table-name

Check that an effective date is specified for data with @ in the line-zone, indicating this is override data, and that the date is in the format indicated by the effective date on the table heading.

Chapter 9

Program File Codes

This section describes the file codes that are used by the MARS program.

9.1 Input Data

9.1.1 File Code 02

Load data in EEI format for each area for the first year of the study. This data call also be optionally input for subsequent study year. Details on the format for this data can be found in Section 3.

9.1.2 File Code 05

Master Input File containing input data tables.

9.1.3 File Code 17

Demand-side management hourly shapes in EEI format. The hourly shapes are read only at the beginning of the study and cannot be overridden through time. Details on the format for this data can be found in Section 3.

9.2 Output Reports

9.2.1 File Code 06

Program dimension and trace summaries and error messages.

9.2.2 File Code 07

Listing of Master Input File, load model output, maintenance schedule summaries, and unit type summaries.

9.2.3 File Code 08

Weekly and monthly reliability indices.

9.2.4 File Code 09

Annual output summaries showing the following reliability indices by area, pool, and area group:

- daily LOLE (days/year)
- hourly LOLE (hours/year)
- LOEE (MWh/year)
- frequency (outages/year)
- duration (hours/outage)
- expected number of days per year at the specified margin states

Annual summaries of:

- Interface flows
- Energy usage for Type 2 energy-limited units
- Contract curtailments

9.2.5 File Code 11

Annual, monthly, and weekly output summaries by load forecast uncertainty load level.

9.3 Binary Files

9.3.1 File Code 14

Existing maintenance schedule file to be read by the program (see input table MNT-OPTN).

9.3.2 File Code 15

File to which the maintenance schedule of the current run will be written (see input table MNT-OPTN).

9.4 Temporary Files

9.4.1 File Code 01

Binary file containing monthly data required by the Monte Carlo simulation.

9.4.2 File Code 03

Direct access binary file used in processing the load data.

9.4.3 File Code 04

Direct access binary file used in processing the load data.

9.4.4 File Code 18

Direct access binary file for the hourly shapes data.

9.4.5 File Code 19

Scratch file used in processing the input tables.

9.4.6 File Code 20

Scratch file used in processing the input tables.

9.5 Summary of MARS File Codes

01 Monte Carlo simulation monthly interface file (binary).

02 EEI load data.

03 Temporary file for processing load data (binary).

04 Temporary file for processing load data (binary).

05 Master Input File.

06 Program dimension and trace summaries and error messages.

07 Listing of MIF, load model output, maintenance schedule summaries, and unit type summaries.

08 Weekly and monthly reliability indices.

09 Annual summary of reliability indices, interface flows, Type 2 energy-limited unit energy usage, and contract curtailments.

10 Detailed hourly output - area margins.

11 Annual, monthly, and weekly summaries by load level.

12 (*Deprecated*) General and annual records for histogram program (binary).

13 (*Deprecated*) Replication records for histogram program (binary).

14 Input maintenance schedule (binary).

15 Output maintenance schedule (binary).

16 Detailed hourly output - interface flows.

17 Hourly shapes data.

18 Temporary file for proccessing hourly shapes data (binary).

19 Scratch file for processing input tables (binary).

20 Scratch file for processing input tables (binary).

21 - 50 (*Deprecated*) Replication output - isolated.

51 - 80 (*Deprecated*) Replication output - interconnected.

Chapter 10

Quick Start Guide

This quick start guide is based on the "mars-quickstart.zip" archive which is provided by MARS Support. If you did not receive this archive, please contact support at mars-support@ge.com.

It is recommended that you review and familiarize yourself with General Overview and Program Description, then return to this guide to perform your first MARS simulation.

10.1 Getting Started with MARS

The first step is to extract the quick start archive to your project directory on your machine. When you do this, you should end up with a file listing like the one shown in figure 10.1. The "MARS-Manual.pdf" file (the filename may differ if it includes the version number and release date) is this document. The "Executables" directory contains the actual MARS model, in a 32 and a 64 bit configuration (the version you choose will depend on your platform). Finally, the "TestCase" directory contains a small sample case which we will use for the remainder of this guide.

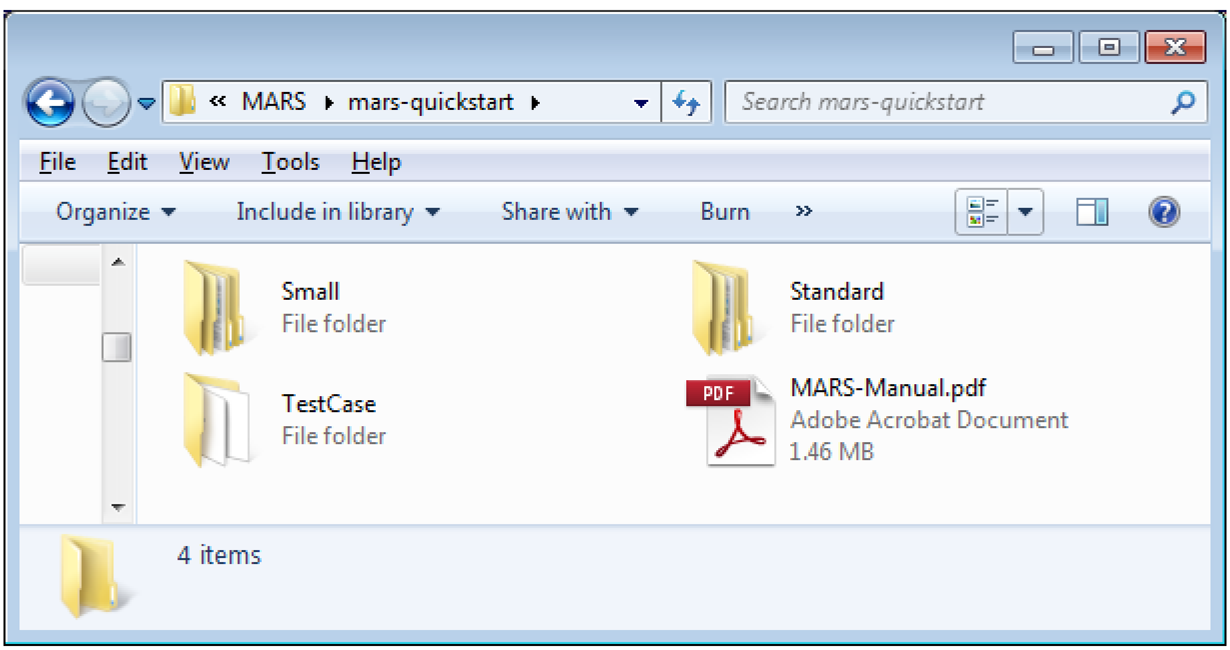

Figure 10.1: Quick start archive contents

10.1.1 License File Configuration

MARS requires a license file to run. The model currently looks for the license in two locations:

1. `C:\Progra~1\GEMARS\MARS-LIC` (`Progra~1` is typically `C:\Program Files`)
2. The current working directory

For a machine where MARS will be run frequently, it is easiest to copy the license to the first directory. To do this, open a new Windows Explorer window and type `C:\PROGRA~1` into the address bar, and hit enter, as shown in figure 10.2. This should redirect you to `C:\Program Files`. Within this directory, create a new directory called `GEMARS`. Finally, within the `GEMARS` directory you just created, you can copy your license file that was provided by GE, ensuring it keeps the name `MARS-LIC`. These steps may require Administrator permissions to perform, as Windows protects this directory. After this point though, MARS should no longer require elevated permissions.

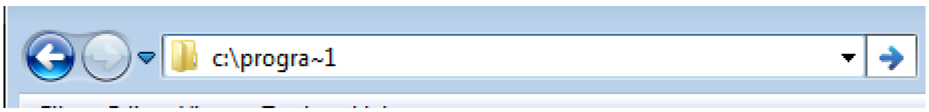

Figure 10.2: Entry of `C:\PROGRA~1` into Windows Explorer

If you have any issues configuring the license, please feel free to reach out to GE MARS Support at mars-support@ge.com.

10.1.2 First Simulation

Within the "TestCase" directory, you should see a batch file named "run32bit.bat". Double clicking this file will launch the 32 bit version of MARS using the sample database. In almost all cases, the 32 bit version of MARS should run, but if your machine is 64 bit, you may find increased performance by using "run64bit.bat" instead of "run32bit.bat" throughout the rest of this guide.

After double clicking on which ever batch file you choose, MARS should launch. Once MARS has completed, your window should look like the example shown in figure 10.3.

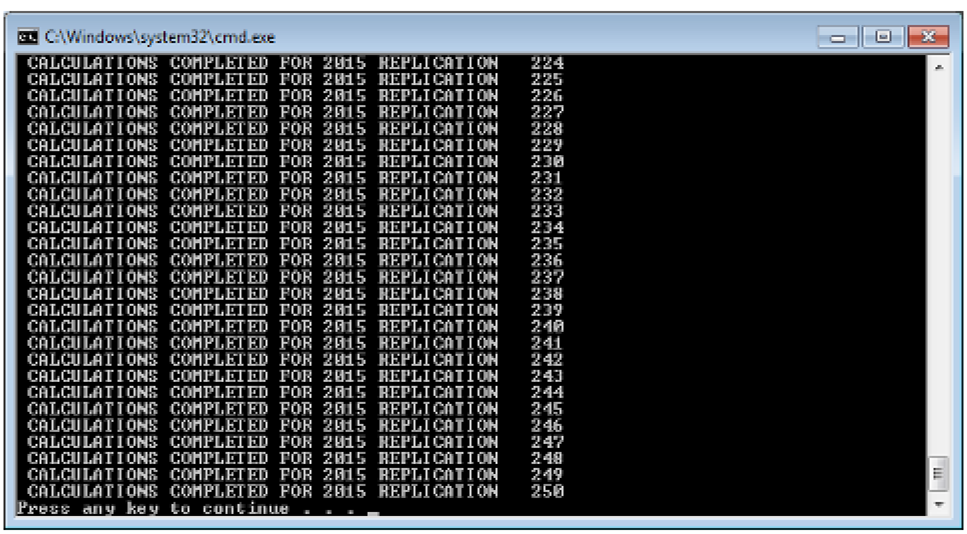

Figure 10.3: Example of MARS run

10.1.3 Reviewing Results

After MARS has completed, the output files will be located within the "run" directory. These output files are described in detail in Output Reports. **The contents of this directory will be overwritten by default when using the "run32bit.bat" file**, so if you would like to compare results from run to run, you may want to copy the necessary files out of this folder before starting your next run.

Almost all of the output files from MARS are human readable text documents, and can be opened in any text editor, including Windows Notepad.

The first file to review after the completion of any run is the "6 file" . In the quick start database, this file will be called "mars.ot06". Any warnings or errors from MARS will be printed to this file, and it is a good practice to review this file after each run to verify that there were no unexpected messages.

The next file to review is the "7 file" ("mars.ot07"). This file contains a summary of various input data to the model, including loads, unit data, and interface data. It also will provide a summary of the maintenance schedule that the model used, based on user input and the model's automatic scheduling. When reviewing the maintenance model data, note that the reserves calculation shown in the "Weekly Reserves Summary" is based on the values used within the maintenance model, and not necessarily the actual load or capacity modeled.

Annual reliability indices are located in the "9 file" ("mars.ot09"), in a table titled "Calculated Indices For <year>". On the left are the isolated indices, which represent each area's own ability to meet its load. On the right are the interconnected indices, which take into account the ability for areas to share reserves among themselves.

Weekly and Monthly indices are available in the "8 file" ("mars.ot08"), and the values broken down for each load level modeled (if any) are located in the "11 file" ("mars.ot11").

10.2 Making Data Changes

Now that you have reviewed the results of your first run, it is time to change model and evaluate the impacts of that change. At this point, it is recommended that you review Using the Master Input File before continuing.

To edit the input data, open "mars.in05" from the "TestCase" directory in your text editor.

10.2.1 Retiring a Unit

For our first data modification, we will study the impacts of retiring the nuclear unit `UNIT-19D`. To do this, first search for the table UNT-DATA, which should be located around line 835 of the MIF. When you look at the table header, you'll notice that the fourth column in this table represents the retirement date. Now find `UNIT-19D`. Change its retirement date from `JAN2020` to `JAN2014`. This will tell the model to remove the unit from service on January 1, 2014.

Save your changes to the MIF, and double click "run32bit.bat". After MARS completes, you can review the output files and determine the impact that this retirement had on your LOLE. Open the 9 file in your text editor, and scroll to the table titled "CALCULATED INDICES FOR 2015". The index we are interested in is the Interconnected LOLE in (days/yr), which is highlighted in figure 10.4. You may want to record the daily LOLE values for the various areas, or save a copy of the 9 file for comparison with future runs.

10.2.2 Increasing Interface Limit

For our second modification, we will increase the transfer capability from Area E to Area D.

CALCULATED INDICES FOR 2015

AREA OR POOL	ISOLATED LOLE (days/yr)	ISOLATED LOLE (hrs/yr)	ISOLATED LOEE (MWh/yr)	ISOLATED FREQUENCY (outg/yr)	ISOLATED DURATION (hrs/outg)	INTERCONNECTED LOLE (days/yr)	INTERCONNECTED LOLE (hrs/yr)	INTERCONNECTED LOEE (MWh/yr)	INTERCONNECTED FREQUENCY (outg/yr)	INTERCONNECTED DURATION (hrs/outg)
AREA-A	0.425	16.333	1613.0	4.358	3.748	0.031	2.187	152.4	0.735	2.976
AREA-B	14.679	341.668	28804.4	63.635	5.369	0.104	4.204	227.9	1.230	3.418
AREA-C	0.396	7.206	535.5	2.159	3.338	0.007	0.418	27.4	0.156	2.679
AREA-D	5.544	551.069	45063.8	110.163	5.002	0.499	92.396	6264.3	23.596	3.916
AREA-E	2.461	51.553	2795.9	10.353	4.980	0.162	6.376	280.5	1.766	3.610
POOL 1	15.380	359.468	30952.9	68.205	5.270	0.132	5.141	407.7	1.550	3.317
POOL 2	7.932	593.365	47859.7	117.278	5.059	0.632	95.024	6544.7	24.182	3.930
AREA-AB	15.034	354.072	30417.4	66.679	5.310	0.128	5.044	380.3	1.509	3.343
SYSTEM	22.434	854.428	78812.6	157.363	5.430	0.7[illegible]0	99.183	6952.4	25.319	3.917

Figure 10.4: Location of Interconnected Daily LOLE index in MARS results

First, locate the INF-DATA table in the MIF (around line 2300). From this table, we will look up the interface name we will need to modify. Note that the interface `D-TO-E` connects the two areas we are interested in, but the tie limit we want to increase will be for the negative direction.

Now, locate the INF-TRLM table (around line 2375). Find the tie limit for the `D-TO-E` interface in the negative direction and increase it to 200 MW, representing transmission upgrades between the areas for example. Again, save your MIF and re-run MARS.

10.2.3 Changing Unit Rating

To replace some of the capacity we retired in Area D (the location of `UNIT-19D`), we will now uprate units `UNIT-17D` and `UNIT-18D` by 100 MW each. Because these are thermal units, their capacity is specified in UNT-MXCP, which should be located around line 1123. Locate the entries for the two units of interest in this table, and adjust both of their ratings to be 300 MW. Save and run the model.

At this point, if you have made the three changes above, your `SYSTEM` LOLE should be 0.314 days/year on an interconnected basis.

10.3 Going Forward

From here, you can add units, retire units, adjust load forecasts etc. This manual is an excellent resource, and you can also contact MARS Support at mars-support@ge.com.

Chapter 11

Release Notes

11.1 MARS Version 4.0.1723

- As-needed energy limited (type 3, EL3) units
  - **Breaking change**: As-needed energy limited (type 3) units are only dispatched during interconnected calculations and the IEL2MC option in GEN-CASE is deprecated.
  - **Modeling change**: Type 3 (EL3) energy-limited units are now first dispatched during margin state 0 (before EOPs). Previously, the first dispatch was considered after margin state 1.
  - The new tables MOD-CALL, MOD-DLAY and MOD-STAT allow users to define when each type 3 (EL3) energy-limited or energy storage unit could be dispatched.
  - Data for type 2 (EL2) and type 3 (EL3) energy-limited units is now separated in the H5 output file
- Energy storage (ES) units
  - **Breaking change**: Energy storage (ES) units are now modeled as dynamic units.
  - The type for units modeled as legacy ES units should now be modeled as DS units, by changing the unit type in UNT-DATA
  - The description and parameters for the new energy storage modeling is summarized in MOD-ESMW
  - Energy storage parameters can also be entered in table MOD-ELMW
- Contracts
  - New table FCT-UNIT can be used to tie a contract to the status and capacity of other units in the system. This modeling approach can replace the use of curtailable contracts in some situations, leading to faster solution times.
  - All features in DS units can be used when modeling a contract unit, including using hourly shapes, random shape draws and random shifts
- Margin states
  - **Modeling change**: MARS now always models margin state 0 (before any EOPs are considered. The output is included in the H5 file, but not in the plain text files. Please use snappy or the MAPS/MARS User Interface to access the data.
  - The margin to check for convergence (KVEOP) will default to the last margin, if left empty. Margin state 0 can now also be used an as option.
- Error checking and output

- Errors and warnings raised during the simulation are now written to the H5 output file. They will also display prominently in the run log when using the snappy server and the user interface.
- MARS now always creates an H5 output file. If the H5 output is not requested in GEN-HDF5, the H5 file will only include errors and warnings and will not be readable by snappy.
- Fixed checks for unit transition and number of states data.
- Transition matrices for thermal units and interfaces are written to the H5 output file
- Disable writing file code 10 (hourly margins by replication), file code 16 (hourly flows by replication), hourly-loads.csv and hourly-modifiers.csv because this data can be accessed by enabling the H5 output in GEN-HDF5.
- MARS will attempt to clean the bn01 at the end of the execution
- Improved reporting of flows and margins per replication (all margin states now show the correct flows and margins not just the ones that MARS actually solved)

- Other
  - **Breaking change**: Tables MOD-PRIO and RES-PRIO do not support overrides in the input. That capability did not properly work in the past, so it is not expected to cause issues. Date overrides may need to be removed for existing databases.
- Known issues
  - Writing and reading the binary file has been disabled, but will be re-enabled in the next release.

11.2 MARS Version 4.1.1749

- **Deprecation warning** Table INF-DYLM will be removed from MARS in early 2022. Please use tables UNT-COND, LOD-COND and INF-DLIM instead and contact mars-support@ge.com if you have any questions.
- New table DAT-COND adds the option to control transmission limits based on conditions on certain periods of the year
- Energy limited Type 2 (EL2) units now respect the "energy per day" limit, if provided in table MOD-ELMW
- Enable RELVAL(3) in INT-ONLY-00 to control the amount of capacity available across ties to enable a fraction of external assistance prior to the EOP state determined by ISOEOP.
- Statistics for interface and interface groups are now saved in the H5 output file
- Re-enable writing file code 10 (hourly margins by replication), file code 16 (hourly flows by replication), hourly-loads.csv and hourly-modifiers.csv, reverting the change in the previous version. Some of the options to write these files has been streamlined and the formatting of the first few lines has been simplified.
- **Minor breaking change**: The flow-by-replication datasets are now saved for a single margin. This reduces the size of the H5 output file and improves performance when merging cases with that dataset. Please refer to the documentation for table GEN-HDF5 for a description of the option.
- Avoid errors printed on screen when the H5 output file is not enabled
- Improve warning check when the number of shapes and the numbers of multipliers for a DS unit do not match
- Fixed error in the dispatch of EL3 and ES units located in areas with shortages, for databases with curtailable contracts

11.3 MARS Version 4.2.1764

- Restored ability to read/write binary files. Binary files from previous MARS versions are not compatible with this release.
- Fixed error with model that used DS units but no shapes (i.e., units that only use MOD-MDMW)
- Ignore minimum generation entered for energy storage units (a warning will be printed)
- Identify dummy areas in the output H5 file
- Fixed an error that cause MARS to ignore dynamic limits dependent solely on entries in DAT-COND

11.4 MARS Version 4.3.1796

- Fix bug from the previous version that prevented overrides in MOD-MDMW from working properly
- Fix bug that would cause DS shapes to be calculated incorrectly for multi-year runs
- Fix calculation of system, pool and area group loads in multi-year runs. This only affected the load summary output in file code 7 and may change results in cases with dynamic limits that depend on loads for simulations with multiple years
- Support use of table MOD-DLAY with models with ISOEOP = 0
- Correctly print elapsed time in seconds for skipped iterations
- Add warning for thermal units with zero capacity
- Avoid incorrect warning for number of columns for MOD-ESMW, MOD-DLAY and MOD-CALL
- Avoid execution error if the MIF has duplicated names
- Add checks for "nan" data in load and shape EEI files
- Rating for DS units in file code 7 is now reported as the largest absolute value, instead of the maximum value
- **Minor breaking change**: Internal changes may have an small effect on flow calculations

11.5 MARS Version 4.4.1803

- Fix potential issues if a user enters more than 20 entries in a row in table MOD-RAND
- Stop MARS if the load or shape files have errors

11.6 MARS Version 4.5.1814

- When reading from a binary file, allow non-contract unit data to be read from MOD-MDMW in the MIF (contract data will be read from the MIF)

11.7 MARS Version 4.6.1878

This new version introduces many improvements to the way dynamic conditions are handled in MARS. To better reflect and explain this mechanism, a new section has been added to the manual (please see Dynamic Conditions). The changes related to dynamic limits include:

- **Breaking change** Table INF-DYLM has been removed from MARS. Please use UNT-COND, LOD-COND and INF-DLIM instead.
- Overrides for INF-DLIM don't require data in all columns anymore
- Fix handling of overrides for DAT-COND
- Add table UNT-DCAP to modify capacity from thermal units based on dynamic coditions

Other changes include:

- Add new option INT-ONLY-01 under "INTVAL(24)" to dispatch EL3 and ES units proportionally based on their available energy and charge ES units based on maximum charge
- Small fix to ES charging logic, which can affect results
- Rewrite the handling of metrics in the ot files (H5 results remain unchanged). This produces a reduction of memory usage of 200 MB and more consistency between the values reported in the ot files and the H5.
- Restore printing of retired units in the unit summary table in file code 7
- Fix errors that could occur when running two years in the same simulation
- Detect incorrect day of the week input in load and shape H5 files
- Fix application of Cogen Type 2 loads to area margins
- Fix accounting of EOP usage for areas with no EOPs (affects ot files, not H5)
- Enable saving maintenance schedules in the H5 if a time window is used in MNT-UNOP-00

11.8 MARS Version 4.7.1889

- Fix error that prevented the EL3 minimum generation values to be counted towards monthly energy limits

11.9 MARS Version 4.8.1904

- Fix the documentation of the "status" column in UNT-COND and fix error that would happen when the last thermal unit is used in that table
- Fix error did not activate dynamic conditions in UNT-COND and LOD-COND if the "number of conditions to be true" column was set to 0
- Fix error that would make MARS fail when the last area or last pool is selected in the table LOD-COND
- Added the ability to consider forecast errors when dispatching as-needed energy limited (EL3) or energy storage (ES) units. This can be used to simulate how certain resources may be dispatched ahead of time, with imperfect information. To use this feature, assign the resources to a dispatch group (in table MOD-DLAY) and define the forecast error (in table LOD-FERR).

11.10 MARS Version 4.9.2019

- Add support for forced outages for hourly shape (DS), Type 3 energy limited (EL3), and energy storage (ES) units. The default is for this units to have perfect availability (the same as in previous versions). To enable this behavior please add the unit to the UNT-CAPS table and then to either UNT-TRNS or UNT-FORS.
- Add table MOD-UNCY, which provides the ability to control the behavior of hourly shapes for different load levels
- Add support to apply dynamic capacity changes by unit summary type in UNT-DCAP
- Fix error that could prevent derates in UNT-DCAP from being applied
- Fix crash in cases with no DS units, but `KPRINT(9)` is enabled
- Add EL3/ES unit to the binary masking. Masked binaries for this version are incompatible with previous releases
- Add option to run MARS in single area mode. Please refer to the description of `INTVAL(25)` in INT-ONLY-01
- Double the maximum number of dynamic limit to 160
- Updated logo in the plain text files

11.11 MARS Version 4.10.2035

Note: Because some of the changes listed below, this MARS version is likely to affect the results of most models with EL3 and/or ES units.

- Add option to MOD-STAT to reset the stored energy of a ES unit
- Improve stability of the routine that determines the order in which EL3 and ES units generate energy (only affects the default dispatch method)
- Fix bug that would prevent some ES units from charging under certain conditions
- Fix bug when setting `ISOEOP` above 2, `ITIEOP` for one or more interfaces as **Y**, and using the minimum EOP for any EL3/ES unit in MOD-DLAY as 2
- Avoid crash when the the maximum number of units, areas, etc. is exceeded

11.12 MARS Version 4.11.2051

- Implement new table MOD-COND to define dynamic conditions based on generation output from EL2 and DS units
- Fix bug that forced MARS from complete a simulation after an error was found while reading load shapes

11.13 MARS Version 4.12.2091

- Allow entering load forecast uncertainty multipliers on an hourly basis with table LOD-UNCH.
- Add the ability to set the initial energy for energy storage (ES) units in MOD-ESMW.
- Allow energy-limited type 3 (EL3) and energy storage (ES) units to be disabled by load forecast uncertainty level through the existing table MOD-UNCY.

- Fix how hourly shape unit data saved in the H5 when the same shape is used more than once in MOD-SHAP so that snappy can correctly reconstruct the replication-level generation.
- Fix the calculation flows and contract curtailment in certain cases with curtailable contracts.
- Fix crash that would happen with cases with fixed maintenance in years not being studied.

Due to internal changes, masked binaries for this version are incompatible with previous releases.

11.14 MARS Version 4.13.2129

- Allow overriding daily limits for energy per day and hours per day for type 3 energy-limited (EL3) and energy storage (ES) units with table MOD-ELDY.
- Expand table UNT-DCAP so that dynamic capacity can be applied to non-thermal units.
- Fix detection of state for perfect units in UNT-COND when selecting the status to be `A` or `U`.
- Fix tracking of contract curtailment in both plain-text and H5 output files

Due to these changes, masked binaries for this version are incompatible with previous releases.

11.15 MARS Version 4.14.2163

- Add table LFU-COND to enable or disable dynamic conditions by LFU level
- Fix indexing error with hourly (DS) units
- Fix recording on per-replication margins in the H5 file for certain cases

Due to these changes, masked binaries for this version are incompatible with previous releases.

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