

PowrSym4 User's Manual

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PowrSym4

USER MANUAL

Overview

PowrSym4 is a multi-area, multi-fuel, production-costing model in which system operation is simulated to minimize total system cost over weekly time horizons in sequential time steps of one hour (or shorter time period). In addition to simulating production cost, PowrSym4 will schedule unit maintenance and calculate system reliability statistics. Hydro operation is simulated with a load leveling routine. The operation of pumped storage units is simulated by trading high cost peak generation against low cost off-peak pumping energy to the point of no additional savings observing reservoir constraints in the process. There are both commit and dispatch types to order the non-economic operation of generating units as needed. PowrSym4 is a very robust model with much flexibility; however, all options must be understood and setup properly for the model to produce good results.

This manual is not all-inclusive. Less than half of the parameters (AIDS) available for defining a production costing study are discussed. This guide is intended to help new users of PowrSym4 to understand how to use the model and how to prepare the input files for studies. Each of the input files is discussed as well as basic control parameters.

PowrSym4 is an executable program that interacts with the user through a file called CONTROL. The program looks for this file in the current drive and directory. This does not have to be the directory where the executable file of PowrSym4 is located, but it must be in the study folder. The CONTROL file is input as 70 character records. Only the first 70 characters of a record are used. The user can use up to 70 characters for path and file name. The 32-bit version of PowrSym4 will handle long file names but because of the way the control file is input, blanks are not allowed in the file names.

PowrSym4 use is logical and intuitive for those familiar with operation of an electric utility. The same data are required for PowrSym4 as that for economic operation of the real power system. Loads, maintenance schedules, unit efficiencies and capabilities, and fuel and O&M costs are the basic ingredients for PowrSym4 and for the energy management system in the utility control center.

Additional information is needed for long term planning studies, but again the information is logical and intuitive. The cost and characteristics of expansion units must be known and input into PowrSym4 to perform such studies.

Calendar

PowrSym4 has a standard internal calendar which is the same for every year. It also has the option to use the real calendar. The following discussion pertains to the internal calendar.

Projected electric loads, maintenance records, and unit control data should all be synchronized to the same calendar. PowrSym4 uses the same calendar every year. From a planning stand point this causes the changes in simulated costs from year to year to be due only to changes in operational assumptions. The calendar on the following page was setup for a fiscal year starting with October (The fiscal year may be started any month). This is the calendar PowrSym4 uses in reporting monthly data. Because PowrSym4 is a Monte Carlo simulation model, data for an exact month **can not** be reported.

PowrSym4 allows the simulation of production costs for the same data with different assumptions on unit forced outages. Each set of assumptions is called an iteration. The results for each iteration are saved by week of the year and averaged to derive the expected operating cost for the period. Monthly reports are derived by assigning three sevenths of week five to January and four sevenths to February. When reviewing monthly reports from PowrSym4, the calendar must be kept in mind.

PowrSym4 simulates 52 weeks or 364 days per year. See the Aid, LOAD FORMAT, for number of days reported for the year.

PowrSym3 Master Calendar

Note!

JANUARY							
Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
01	01	02	03	04	05	06	07
02	08	09	10	11	12	13	14
03	15	16	17	18	19	20	21
04	22	23	24	25	26	27	28
05	29	30	31				

Note: PowrSym3's Jan. 1 is always a Monday.

JULY							
Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
26							01
27	02	03	04	05	06	07	08
28	09	10	11	12	13	14	15
29	16	17	18	19	20	21	22
30	23	24	25	26	27	28	29
31	30	31					

FEBRUARY							
Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
05				01	02	03	04
06	05	06	07	08	09	10	11
07	12	13	14	15	16	17	18
08	19	20	21	22	23	24	25
09	26	27	28				

AUGUST							
Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
31			01	02	03	04	05
32	06	07	08	09	10	11	12
33	13	14	15	16	17	18	19
34	20	21	22	23	24	25	26
35	27	28	29	30	31		

MARCH							
Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
09				01	02	03	04
10	05	06	07	08	09	10	11
11	12	13	14	15	16	17	18
12	19	20	21	22	23	24	25
13	26	27	28	29	30	31	

SEPTEMBER							
Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
35						01	02
36	03	04	05	06	07	08	09
37	10	11	12	13	14	15	16
38	17	18	19	20	21	22	23
39	24	25	26	27	28	29	30

APRIL							
Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
13							01
14	02	03	04	05	06	07	08
15	09	10	11	12	13	14	15
16	16	17	18	19	20	21	22
17	23	24	25	26	27	28	29
18	30						

OCTOBER							
Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
40	02	03	04	05	06	07	08
41	09	10	11	12	13	14	15
42	16	17	18	19	20	21	22
43	23	24	25	26	27	28	29
44	30	31					

Note: PowrSym3's October starts on the 2nd.

MAY							
Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
18		01	02	03	04	05	06
19	07	08	09	10	11	12	13
20	14	15	16	17	18	19	20
21	21	22	23	24	25	26	27
22	28	29	30	31			

NOVEMBER							
Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
44			01	02	03	04	05
45	06	07	08	09	10	11	12
46	13	14	15	16	17	18	19
47	20	21	22	23	24	25	26
48	27	28	29	30			

JUNE							
Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
22					01	02	03
23	04	05	06	07	08	09	10
24	11	12	13	14	15	16	17
25	18	19	20	21	22	23	24
26	25	26	27	28	29	30	

DECEMBER							
Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
48					01	02	03
49	04	05	06	07	08	09	10
50	11	12	13	14	15	16	17
51	18	19	20	21	22	23	24
52	25	26	27	28	29	30	31

Note: PowrSym3's Jan. 1 is always a Monday and October starts on the 2nd.

calendar.ppt/wmf

Real Calendar

If it is desired to use the real calendar option, the loads and maintenance files must be formatted to match the real calendar.

The real-time calendar uses either Load format X1=2 or X1=4. The format is the same, but the start date for week 1 and years requiring 53 weeks are different.

The format for the loads file is: (i5,i3,i1,2i3,24f8.0)

The data are: Year, week, day-of-week, month, date, 24 hourly loads.

With format 2 the years requiring 53 weeks are: 1990, 1996, 2001, 2007, 2012, 2018, 2024, 2029, 2035, 2040, 2046, 2052, 2057, 2063, 2068, 2074, 2080, 2085, 2091, 2096, 2103, 2108, 2114.

If Jan 1 is a Monday, the year requires 53 weeks, and some exceptional leap years when Jan 1 occurs on a Sunday. See also Table Z_DateFormat2 in the Analyzer.

With format 4 the years requiring 53 weeks are: 1987, 1998, 2004, 2009, 2015, 2026, 2032, 2037, 2043, 2054, 2060, 2065, 2071, 2082, 2088, 2093, 2099, 2005, 2111

If Jan 1 is a Thursday, the year requires 53 weeks and some exceptional leap years when Jan 1 occurs on Wednesday. See also Table Z_DateFormat4 in the Analyzer.

An example: All rows and columns are not shown (Format 2)

1996	527	12	29	757.	699.	665.	661.	658.	672.	710.	774.
1996	531	12	30	623.	587.	596.	602.	630.	707.	903.	1017.
1996	532	12	31	600.	589.	587.	596.	638.	755.	984.	1148.
1996	533	1	1	806.	792.	773.	751.	800.	901.	1098.	1281.
1996	534	1	2	804.	809.	804.	815.	841.	967.	1245.	1372.
1996	535	1	3	743.	719.	713.	717.	756.	855.	1098.	1253.
1996	536	1	4	885.	837.	825.	825.	834.	883.	913.	1084.
1996	537	1	5	846.	792.	777.	765.	768.	799.	821.	901.
1997	11	1	6	738.	705.	703.	719.	743.	861.	1088.	1253.
1997	12	1	7	760.	736.	718.	707.	739.	830.	1081.	1185.
1997	13	1	8	660.	621.	610.	614.	654.	751.	956.	1173.
1997	14	1	9	941.	913.	903.	918.	942.	1090.	1387.	1488.
1997	15	1	10	947.	918.	902.	900.	930.	1071.	1342.	1454.
1997	16	1	11	902.	864.	853.	855.	889.	919.	1009.	1176.
1997	17	1	12	846.	800.	795.	784.	796.	826.	888.	947.
1997	21	1	13	906.	917.	940.	971.	1030.	1198.	1400.	1522.
1997	22	1	14	1030.	980.	955.	1000.	1052.	1204.	1445.	1541.

The data for the first and last years should extend enough to include Jan 1 and Dec 31 so cy and fy reports will be complete.

Input Files

CONTROL File

A typical control file is shown on the second page following. It may be edited with any editor, notepad, em, lb, etc. PowrSym4 reads this file by record number. If a record is omitted, the files will not be connected correctly.

Record 1 is a title used as a header on all formatted printed output files. After the first record PowrSym4 searches each record starting in column 1 for the first blank character. This first part of the record is used as a file name. The rest of the record after the blank is ignored and can be used for user comments. If the first five characters match "DUMMY", the file isn't opened. DUMMY must be entered in the control file if a file is to be omitted. For example, if the weekly print file is not to be printed, line 9 of the control file must have DUMMY inserted.

The files are frequently referred to as functional files. Consequently, as an example, the weekly print file is referred to as the fun08 or f08 file. Many users use the file extension f08, or f**, although it is not necessary. Communication between users is facilitated by referring to the f08 (weekly print) or f50 (electric system data), etc.

In preparing the control file note that the title of the study is on line one, so all f** files are on line number **+1, i.e., the f08 file is listed on line 9.

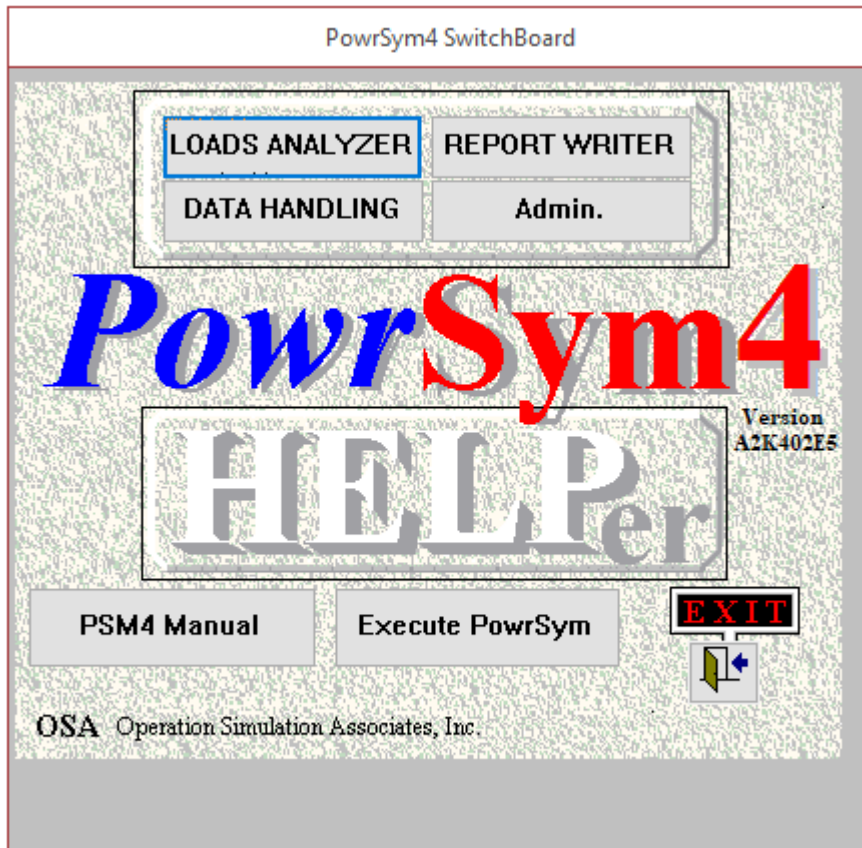
Spinning and Operating reserve information may be printed in ofc file 23. To obtain this report define file 23 in the control file.

Since there can be only one file named "control" in the study directory and since it is helpful to keep previously used control files, the user should develop a system for naming old control files. One such system uses the file name of the study plus the extension, ctl. For example, if a base case has been established for a study, files might be named base.f08, etc. The control file could be copied to or renamed to base.ctl to preserve it when creating a new control file.

PowrSym4 must have a file named "control" (without the quotes) in order to execute.

The Analyzer may be used to create the control file after all the input files have been created. Open the Analyzer and click on "Data Handling".

This brings up the "Main Menu" window. Click on "Control File" under Select a Category of Tasks. Then click on "Create Control File" under Select a Task. Click OK.



This brings up the “Main Menu” window. Click on “Control File” under Select a Category of Tasks. Then click on “Create Control File” under Select a Task. Click OK.

The control file will be placed in the study directory.

GENERIC SYSTEM SAMPLE CONTROL FILE		
SAMPLE.F01	COMMIT REPORT	FUN01
SAMPLE.F02	MARGINAL COSTS	FUN02
SAMPLE.F03	MAINTENANCE FILE	FUN03
SAMPLE.F04	LOADS FILE FOR TAREA 1	FUN04
DUMMY		FUN05
DUMMY		FUN06
DUMMY		FUN07
SAMPLE.F08	WEEKLY PRINT FILE	FUN08
DUMMY		FUN09
DUMMY		FUN10
DUMMY		FUN11
DUMMY		FUN12
SAMPLE.F13	HOURLY STATION OUTPUT (NUM STA HR OUT)	FUN13
SAMPLE.F14	HOURLY PRINT FILE	FUN14
SAMPLE.F15	DAILY PRINT FILE	FUN15
SAMPLE.F16	LOLP REPORT	FUN16
DUMMY		FUN17
DUMMY		FUN18
SAMPLE.F19	HOURLY OUTPUT FOR RELI	FUN19
DUMMY		FUN20
SAMPLE.F21	INCREMENTAL/DECREMENTAL COST OUTPUT	FUN21
SAMPLE.F22	DAY OUT FILE	FUN22
DUMMY		FUN23
SAMPLE.24	WIND/SOLAR GENERATION FILE	FUN24
DUMMY		FUN25
DUMMY		FUN26
DUMMY		FUN27
DUMMY		FUN28
DUMMY		FUN29
DUMMY		FUN30
DUMMY		FUN31
CHECKOUT.TXT	SELECTED OUTPUT	FUN32
SAMPLE.F33	HR OUT FILE	FUN33
SAMPLE.F34	WEEK OUT FILE	FUN34
SAMPLE.F35	MONTH OUT FILE	FUN35
SAMPLE.F36	CY OUT FILE	FUN36
SAMPLE.F37	FY OUT FILE	FUN37
SAMPLE.F38	MONTH PRINT FILE	FUN38
SAMPLE.F39	CY PRINT FILE	FUN39
SAMPLE.F40	FY PRINT FILE	FUN40
DUMMY		FUN41
SAMPLE.F42	COMMIT DATA INPUT (FROM PREVIOUSLY CREATED F43)	FUN42
SAMPLE.F43	COMMIT DATA OUTPUT (FOR SUBSEQUENT INPUT TO F42)	FUN43
DUMMY		FUN44
DUMMY		FUN45
DUMMY		FUN46
SAMPLE.F47	DISTRIBUTED GENERATION FILE	FUN47
DUMMY		FUN48
SAMPLE.F49	RESULTANT MAINTENANCE FILE	FUN49
SAMPLE.F50	POWER SYSTEM INPUT FILE	F50
SAMPLE.F51	EXECUTION LOG OUTPUT FILE	FUN51
SAMPLE.F52	DATA INPUT AND EXECUTION ERROR FILE	FUN52
SAMPLE.F53	INPUT PUMPED HYDRO DISPATCH SCHEDULE (PHYD DISP STEP N3)	FUN53
SAMPLE.F54	OUTPUT PUMPED HYDRO DISPATCH SCHEDULE	FUN54
DUMMY		FUN97
DUMMY		FUN98
DUMMY		FUN99
DUMMY		FUN100
TAREA2.LDS	LOAD INPUT FILE FOR TAREA2	FUN101
TAREA3.LDS	LOAD INPUT FILE FOR TAREA3	FUN102
?		
SPOT1.IDC	TRANSACTION AREA1 INCREMENTAL/DECREMENTAL COSTS	FUN191
SPOT2.IDC	TRANSACTION AREA2 INCREMENTAL/DECREMENTAL COSTS	FUN192
!		
AREAX.LDS	LOAD OUTPUT FILE FOR TAREAX	
END		

Note: Beginning with PowrSym4 v360g1 file 32 must be defined on Line 33 of the control file.

Discrete Maintenance File (F03)

PowrSym4 will read the discrete maintenance file, f03, with one of three different formats. The AID format is recommended. This format allows a unit to be scheduled on maintenance for part of a week. PowrSym4 will simulate production costs using the following options determined by the AID, MAINT CNTL:

1. Use the maintenance schedule in the maintenance file (f03), (X1=0)
2. Use no maintenance, (X1=3=default)
3. Use the maintenance scheduled in the file (f03) supplemented by additional required maintenance, (X1=2) or
4. Ignore the file and schedule maintenance for all units. (X1=1) No F03 file required.

Regardless of the maintenance option selected for a simulation, PowrSym4 writes the maintenance simulated to file 49 with the AID format. If it is desired to use this output schedule in subsequent studies, rename the file and insert that name in the CONTROL file (f03); otherwise the “f49” file will be lost when PowrSym4 is executed the next time, that is, it will be over written.

The maintenance routine is called before execution of the first week of the fiscal year. Loads for the whole year are read, and the units are scheduled for maintenance. This can cause a problem when a partial year is simulated, and the electric loads file doesn't contain 52 weeks. Consequently, the load file should contain at least one year of loads.

Below is part of a maintenance schedule in AID format. The file format is year, week of year, starting hour of week, ending hour of week, station number, station name, and the number of units on maintenance at this station.

1996	12	120	168	6	COAL3	1
1996	12	120	168	19	COAL2	1
1996	13	1	168	5	COAL1	1
1996	13	1	168	6	COAL3	1
1996	13	1	168	19	COAL2	1
1996	13	120	168	20	COALX	1
1996	14	1	168	5	COAL1	1
1996	14	1	168	6	COAL3	1
1996	14	1	168	19	COAL2	1
1996	14	1	168	20	COALX	1
1996	15	1	168	5	COAL1	1
1996	15	1	168	6	COAL3	1
1996	15	120	168	8	COAL6	1
1996	15	1	168	19	COAL2	1
1996	15	1	168	20	COALX	1
1996	16	1	168	5	COAL1	1
1996	16	1	147	6	COAL3	1
1996	16	1	168	8	COAL6	1
1996	16	1	168	19	COAL2	1
1996	16	1	168	20	COALX	1
1996	17	1	168	5	COAL1	1

The Analyzer has an option to assist in creating a maintenance schedule in the correct format.

Maintenance Schedule Analysis

Select a fun50-like table that has STA NAME records:

Select which group to view.:

Select which year to view.:

To edit a unit's outage double click its name below.
To scroll vertically, you may need to scroll horizontally first.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
HYDRO											
PHYDRO											
COAL1											
COAL3											
COAL5											
COAL6											
COAL7											

This screen will create the maintenance records from year, month, day of month, and hour of day values. In other words, the code converts calendar dates into year, week of year, and hour of week values.

PowrSym4 will schedule maintenance for a system. The various options and controls for doing this are discussed in the Maintenance section of this manual.

Electric Load File (F04)

In order to simulate production costs for an electric utility, PowrSym4 needs a set of projected hourly electric loads, f04, for the time period being studied. If the study is for a multi area model, there must be some provision for supplying projected electric loads for each area. PowrSym4 will read the projected electric loads with one of three formats. One is used primarily by European clients, a second is used by all other clients (referred to as the US format), and the third is the real calendar format. The file is composed of weekly segments, a header record with the year and week of year identifier, and twenty-one records with hourly load data. An example of a US format loads file is shown here.

1	1996	1						
2	605.	569.	577.	584.	611.	686.	874.	974.
3	888.	869.	822.	795.	788.	735.	719.	726.
4	797.	914.	985.	949.	915.	854.	774.	647.
5	582.	571.	569.	578.	619.	732.	943.	1099.
6	1045.	1031.	1047.	1068.	1043.	1045.	1036.	1042.
7	1139.	1255.	1345.	1340.	1246.	1184.	1011.	870.
8	780.	767.	749.	728.	775.	872.	1051.	1225.
9	1139.	1096.	1084.	1057.	1034.	989.	980.	983.
10	1092.	1207.	1346.	1277.	1223.	1188.	985.	865.
11	779.	784.	779.	789.	814.	929.	1190.	1312.
12	1206.	1157.	1077.	949.	899.	864.	855.	877.
13	927.	1106.	1205.	1218.	1149.	1088.	938.	800.
14	721.	698.	692.	695.	733.	827.	1051.	1199.
15	1117.	1097.	1091.	1074.	1059.	1036.	1044.	1070.
16	1136.	1264.	1307.	1253.	1194.	1127.	1053.	907.
17	857.	811.	798.	799.	807.	854.	883.	1038.
18	1163.	1272.	1320.	1300.	1287.	1239.	1170.	1177.
19	1213.	1272.	1312.	1225.	1161.	1095.	1034.	893.
20	819.	768.	753.	742.	744.	774.	795.	872.
21	1020.	1127.	1093.	1063.	1053.	1009.	938.	915.
22	957.	1033.	1141.	1070.	1066.	990.	871.	781.
23	1996	2						
24	716.	684.	683.	698.	721.	833.	1041.	1198.

The identifier record is two fields of eight. The load records are eight fields of nine. The file name for area 1 loads is in the fifth record, f04, of the control file. Areas greater than one are shown below in the bottom segment of the CONTROL file. Recall that the record count starts at zero in the control file.

SAMPLE.F50	POWER SYSTEM INPUT FILE TO POWRSYM3	FUN50
SAMPLE.F51	EXECUTION LOG OUTPUT FILE	FUN51
SAMPLE.F52	DATA INPUT AND EXECUTION ERROR FILE	FUN52
SAMPLE.F53	INPUT PUMPED HYDRO DISPATCH SCHEDULE(PHYD DISP STEP N3)	FUN53
SAMPLE.F54	OUTPUT PUMPED HYDRO DISPATCH SCHEDULE	FUN54
DUMMY		FUN97
DUMMY		FUN98
DUMMY		FUN99
DUMMY		FUN100
TAREA2.LDS	LOAD INPUT FILE FOR TAREA2	FUN101
TAREA3.LDS	LOAD INPUT FILE FOR TAREA3	FUN102
?		
SPOT1.IDC	TRANSACTION AREA1 INCREMENTAL/DECREMENTAL COSTS	FUN191
SPOT2.IDC	TRANSACTION AREA2 INCREMENTAL/DECREMENTAL COSTS	FUN192
!		
AREAX.LDS	LOAD OUTPUT FILE FOR TAREAX	
END		

Alternatively, PowrSym4 will generate hourly loads based on a pattern year of loads and projected peaks and energies. These options are discussed later in this manual under TAREA LOAD CNTL.

Electric System Data File (F50)

PowrSym4 uses the data in the electric system data file (f50) to configure the power system for simulation and to modify the configuration over the time horizon of the study. This file is time event driven. All data are not input for each week of simulation. As time is simulated, changes to the system configuration are read from the file. This file contains most inputs except for discrete maintenance and projected electric loads. The records in the f50 file set values that control over-all simulation, set station specific parameters, define transmission area parameters, define electric load modifications, and control maintenance scheduling parameters. The records in the f50 have the following format:

Field Heading	Field Location	Column Description
IYR	1-4	Calendar year for this record's data
IWK	5-7	Calendar week for this record's data
N1	8-11	Beginning of period
N2	12-15	End of period
N3	16-19	Primary data identifier
N4	20-23	Secondary data identifier
	24	Blank
AID	25-39	Alphanumeric record identifier
	40	Blank
A1	41-50	Name associated with data item
X1	51-65	Input data item for this record
	66	Blank
CLASS	67-69	Class identifier for record selection
	70	Blank
COMMENT	71-150	User comment about this record

Below is a picture of some of the system records in the database used to create the f50 file.

IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS
1996	1	0	0	0	0	COST OPR RESV	SYSTEM	100 B	NONE
1996	1	0	0	0	0	COST SPN RESV	SYSTEM	50 B	NONE
1996	1	0	0	0	0	CY OUT FILE	SYSTEM	1 CYO	NONE
1996	1	0	0	0	0	DISP INCR	SYSTEM	5 B	NONE
1996	1	0	0	0	0	ENS COST	SYSTEM	200 B	NONE
1996	1	0	0	0	0	ENS COST ESC	SYSTEM	1.03 B	NONE
1996	1	0	0	0	0	EXEC MODE	SYSTEM	0 SEQ	NONE
1996	1	0	0	0	0	EXECUTE	SYSTEM	0 B	NONE
1996	1	0	0	0	0	FY OUT FILE	SYSTEM	1 FYO	NONE
1996	1	0	0	0	0	HYDRO DISP STEP	SYSTEM	5 B	NONE
1996	1	0	0	0	0	LAST WK OF YEAR	SYSTEM	52 B	NONE

Control and Execution

These parameters control the overall operation of a PowrSym4 simulation. Some control format options of input files. Others control data saved in output files. Some interact with station parameters that control station specific simulation, and others interact with transarea parameters. Once set, some of these inputs do not change for a utility.

PowrSym4 is typically executed from the command line. If the prompt is registering the folder where the control file, f32, and executable are, the user only needs type the name of the executable. Paths to all input and output files may be specified in the control file.

As an alternative two arguments may follow the name of the executable, the first indicating the path to and name of the control file (may be any user assigned name), the second containing the path to and name of the f32 file. (The f32 file is needed if the user desires only selected output in the fixed width files.) The control file will specify the paths and names of the input and output files.

Parameters Controlling Basic Simulation

Values for these parameters should be entered only once in a f50 data file, and they should all precede the first execute record. If these parameters are changed in the middle of a simulation, the results will be difficult to analyze. Because this data file driving PowrSym4 is time event driven, there is no need to repeat records unless the parameter is changed.

LAST WK OF YEAR

This parameter controls several events in a simulation. PowrSym4 determines the first week of the fiscal year from this value. Before execution of the first week of the fiscal year, PowrSym4 reads the loads for the next fiscal year and schedules maintenance and calculates reliability statistics if required. If a partial year simulation is done that passes through the first week of the fiscal year, the electric loads files must have a full year of loads for that fiscal year. This is also the escalation trigger for cost values. This is the trigger for outputting fiscal year reports. Maintenance is scheduled optimally for the fifty-two-week period ending with this parameter. If the fiscal year corresponds to the calendar year, the X1 value for this input AID is 52.

View Input Definitions

Select the variable you want defined: Sort Variables by category:

Variable Definition

Category

Minimum

Maximum

Default

X1 is the last week of the fiscal year for reporting and input data control. The fiscal year printed file and output file are written after the execution of this week.
N1,N2,N3,N4 not used
A1 is SYSTEM

GENERIC : Table											
	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	0	0	LAST WK OF YEAR	SYSTEM	52	b	None
*	0	0	0	0	0	0			0		

LOAD FORMAT

The current version of PowrSym4 will read the electric load files with one of three formats: one typically used by European clients; one used by most others; and the real calendar. This record should be in all f50 data files with the X1 value set to the desired value. The default value for this parameter is 0. It is important that a record for this parameter is in all data files and that it precedes the first execute record.

View Input Definitions

Select the variable you want defined: Sort Variables by category:

Variable Definition

Category

Minimum

Maximum

Default

The X1 flag indicates the load input file format.
0 = Daily load input format. European format.
1 = Weekly load input format. US Format.
2 = Real calendar loads format.
N1,N2,N3,N4 not used
A1 is SYSTEM

GENERIC : Table											
	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	0	0	LOAD FORMAT	SYSTEM	1	PSM	None
	1996	1	0	0	0	0	LOAD FORMAT	SYSTEM	2	CAL	None
*	0	0	0	0	0	0			0		

In the above example two LOAD FORMAT records are shown, one for US format and one for the real calendar format. These records are in the database supported by the PowrSym4 tool, the Analyzer. When the f50 file is exported from the Analyzer, only one of these records will be exported. The user chooses which classes to export. The class field has user defined classes. Most records have a “B” in the class field. All B’s are exported plus other classes selected by the user.

Typically, PowrSym4 requires a minimum of one full year of hourly loads, but there is an option to have the loads file contain only the weeks to be executed. On the LOAD FORMAT record, set N4=the first week to be executed. The loads file must begin with this N4 week and contain as many weeks as are to be executed. To utilize this feature, X1 must equal 1 on the LOAD FORMAT record, and X1 on the MAINT CNTL record must equal 3.

MAINT FILE FLAG

The current version of PowrSym4 will read the discrete maintenance data with one of three formats. Format 2 is recommended, but 0 is used by some clients at times.

View Input Definitions

Select the variable you want defined
 MAINT FILE FLAG Show All Variables Sort Variables by category Close

Variable Definition

MAINT FILE FLAG

SYSTEM **Category**

Minimum

Maximum

Default

The X1 flag indicates which maintenance input file format to use. See section 6.2.7 for file format layouts.
 0 = Station maintenance input format. European format.
 1 = Weekly maintenance input format. Zeros and ones. Old format.
 2 = AID maintenance input format.
 "Output" file created in AID format.
 N1,N2,N3,N4 not used
 A1 is SYSTEM

GENERIC : Table											
	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	0	0	MAINT FILE FLAG	SYSTEM	2	b	None
*	0	0	0	0	0	0			0		

EXEC MODE

PowrSym4 has several options for simulating production costs: 0 for sequential and several for concurrent. One of the concurrent options must be used if energy limited fuel (elf) contracts are to be simulated.

View Input Definitions

Select the variable you want defined: **EXEC MODE** Show All Variables Sort Variables by category Close

Variable Definition

EXEC MODE

SYSTEM **Category**

Minimum

Maximum

Default

The X1 flag identifies the execution mode used in the model. This determines the solution method for the weekly execution. However, if the system has pumped hydro, the model will make a first pass in the sequential mode to schedule the pumped hydro.

0 = Sequential mode.
 1 = Concurrent mode.
 2 = Concurrent mode after sequential pass to freeze the station commitment order for the ELF pass.
 3 = Concurrent mode for both commit pass and ELF pass.
 9 = Sequential mode with a prescheduled industrial heat pass.

N1,N2,N3,N4 not used
 A1 is SYSTEM

GENERIC : Table										
	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS
▶	1996	1	0	0	0	0	EXEC MODE	SYSTEM	0	B
*	0	0	0	0	0	0			0	

DISP INCR

PowrSym4 optimizes the unit dispatch in blocks of megawatts. This parameter determines the size of that block. A small value increases the dispatch accuracy and the run time. A value of ten gives reasonable results with acceptable run times for most systems. In the example below a value of five was chosen for a small system.

GENERIC : Table										
	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS
▶	1996	1	0	0	0	0	DISP INCR	SYSTEM	5	b
*	0	0	0	0	0	0			0	

- The ENS solution method is controlled by n3 on DISP INCR
- n3=0 is the traditional cost based solution
- n3=1 solves areas with largest ENS first (distributes ENS across areas)
- n3=2 solves areas with lowest ENS first (least LOLE)
- The results for n3=0 generally fall in between #1 and #2
- n3=1 is generally the best solution when using the flow based logic

Parameters Controlling PowrSym4 Execution

There are four system data file records that control PowrSym4 execution. The EXECUTE record works in conjunction with the WEEKS TO SIM parameter. Each time a record with EXECUTE in the aid field is read, PowrSym4 will simulate the number of weeks specified by the WEEKS TO SIM parameter. It is recommended that an EXECUTE record be used for each week and that the WEEKS TO SIM parameter always be set to one.

SKIP EXEC

A non-zero value for this parameter causes PowrSym4 to skip EXECUTE records. This parameter allows the user to leave the EXECUTE records in a data file and skip to the year and week where simulation is to start. A parameter value of zero causes the next EXECUTE record to be used. Use of the combination of the EXECUTE and SKIP EXEC records causes PowrSym4 to read all the records up to the year/week the run is to start and to escalate costs, install units, etc. as appropriate before the start year/week.

EXECUTE

This parameter is hourly. PowrSym4 will start simulating production cost for the year, week, and hour of the week. The N1 value is the starting hour of the week. The N2 value is the ending hour of the week where the simulation stops. If the N1 and N2 values are zero, the entire week will be simulated.

END

When a record is read with END in the aid field, simulation stops.

WEEKS TO SIM

This parameter sets the number of weeks PowrSym4 will simulate for each EXECUTE record. It is good practice to have an EXECUTE record for each week to be simulated with one WEEKS TO SIM record with X1=1.

Typically Powrsym4 executes in weekly time increments, but also offers a monthly execution option. See MONTH FLAG in the Analyzer.

TIME V ACCURACY

Execution time of concurrent mode studies may be reduced with little loss of accuracy by setting the X1 value to around 7.0. The range is from 0.01 to 10.0, but a value around 7.0 has been found to provide good results (reduced execution time) with an insignificant loss of accuracy.

Fast Execution Option

The faster execution is invoked by x1=1 on SPEED FLAG which is a new system level input record. x1=0 or omitting the record will return to the much slower v404d3

execution mode. With the option invoked, computation time is very much faster for a large multi-area system. The results are very slightly different due to different computation order of the area flows. While the results difference is very small, always use the same option when comparing cases so as to avoid the computation differences from entering into your results. We suggest that the faster option should always be used.

Monthly Execution Option

The monthly option internally converts the weekly input data files to monthly and then executes by month. The only data change requirement is to set $x1=1$ on MONTH FLAG input record. $x1=0$ or omitting the record will return to the weekly execution mode. The ability to optimize the hydro and pumped hydro over the month horizon generally allows better use of those resources. The hour, day, month, and year output files remain as in the weekly execution option. However, the weekly output files will now also be monthly when in month mode. We attempted to recreate the week file outputs internally but it was not an easy task since weeks span month boundaries. If necessary to obtain weekly results, save the daily output files and use an external program to sum up the weeks. When comparing results between month and week execution modes, it is useful to save the monthly output files when in weekly mode and compare monthly results. Please note that random outage draws and deviation draws for load/wind/solar/other will be different between week and month options, but will converge to similar results for multiple iterations.

Minute Execution Option

The minutes option internally converts the hourly data to minutes increments and then executes in the minutes steps. The only data change requirement is to set $x1$ on TIME STEP to the number of minutes in each increment. $x1=60$ or omitting the record will return to hourly mode. The increment must be a sub-multiple of 60 minutes. Allowed values are 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, and 60 minutes. With the standard dimension of 744 time periods, only 60 is allowed in month mode and 15 or 20 or 30 or 60 allowed in weekly mode. Of course we can make the 744 dimension larger if needed, for example 4464 would allow 10 minute increments in month mode. The outputs are unchanged in minutes mode except that the hourly outputs become "time increment" outputs.

Controlling Output

PowrSym4 outputs results in two mediums. Formatted print output is ready for the printer. The data have labels and are placed on an 8.5 by 11-inch page. If these files are imported into a word processor, use a fixed character spacing font such as courier. The data are placed on the page using blanks to align the column. A proportional font will make the data almost unreadable. Below is a weekly report opened in Notepad. The data are displayed with Courier font. The black boxes in column one are carriage returns that will cause the printer to page. To save paper, the carriage returns may be deleted and blank lines inserted to space the different reports.

Operating Characteristics									
Station Report									
Year 1997 Week 1									
GENERIC SYSTEM TEST OF ENS COST (BASE CASE)									
#	Station Name	Cap Factor %	Energy GWh	Heat KMBTU (10**9)	Average HRate BTU/kWh	Starts	Oper Hours	Fuel Burn	Oper Cost \$/MWh
1	HYDRO	46.30	14.0	140.	10000.	0.	168.	140000.	1.03
3	PHYDRO	7.07	4.2	42.	10000.	7.	24.	41580.	1.20
5	COAL12	100.00	3.4	45.	13377.	0.	336.	1873.	19.11
6	COAL34	51.82	5.7	70.	12199.	0.	168.	2921.	16.64
7	COAL5	49.29	9.6	104.	10813.	0.	168.	4328.	16.29
8	COAL6	55.57	20.5	219.	10672.	0.	168.	24356.	13.94
9	COAL7	55.16	27.8	298.	10725.	0.	168.	12423.	14.54
10	COAL8	58.91	49.5	508.	10272.	0.	168.	21179.	15.55
11	CT	34.33	21.6	336.	15543.	0.	456.	57370.	62.03
20	SUDOENS	67.26	226.0	22600.	100000.	4.	113.	1076191.	515.00
	SYSTEM		382.3	24362.	63722.	11.			312.63
Cost Data									
Station Report									
Year 1997 Week 1									
04/13/99									

The other medium is for database analyses. The user can import the data into a database such as ACCESS and prepare special reports, graphics, or do further analyses. These fixed width files can also be imported directly into a spreadsheet.

Controlling Printed Output

The following AIDs control the standard print output. The X1 value is the flag that activates the report for the period. The file unit number is the record number of the output file name in the control file. The print files have the same format regardless of the period--year, month, week, day, or hour.

<u>AID</u>	<u>X1</u>	<u>File Unit Number</u>	<u>Period</u>
YEAR PRINT CNTL			
	0	40	Fiscal Year
	1	39	Calendar Year
	2	39 & 40	Both FY and CY
PERIOD PRINT			
	-1	39/40	Annual
	0	38	Month
	1	8 & 38	Week and Month
	2	8,14,38	Hour, Week, Month
PRINT OUTPUT			
	1	14	Hour
	10	15	Day
	100	8	Week
	1000	38	Month
	10000	39	CY
	100000	40	FY
XXX OUT FILE			
CY OUT FILE	1	36	CY
FY OUT FILE	1	37	FY
HR OUT FILE	1	33	HOURL
WEEK OUT FILE	1	34	WEEK
MONTH OUT FILE	1	35	MONTH
DAY OUT FILE	1	22	DAY

There is an option to eliminate files 2, 16, and 51 by setting N4=1 on the PRT UNITS FLAG record.

Controlling Fixed Width Output

User selected output may be chosen for the “out” files. There are more than 300 different values that may be obtained in the “out” files. Any one or any combination of these output aids may be selected for output using the f32 file (typically called the checkout.txt file) associated with the version of PowrSym4 being used. Using the f32 file, desired aids may be output by placing a 1 in the time period field to the left of the aid. Also, the N4 must be set to one on the appropriate out file, such as HR OUT FILE. OSA will provide the f32 file with each new version of PowrSym4.

An example of a portion of an f32 file is shown here:

1	HDWMC F AID	#	DESCRIPTION	PSM V403b8 and later
2	0000000 ASH	232	Station Ash Emission (weight)	
3	0000000 ASH COST	227	Station Ash Cost of Emissions (\$)	
4	0000000 AVAIL CAPACITY	250	Station Available Capacity by hour (HR OUT FILE, F33)	
5	0000000 AVG HEAT RATE	2	Station Average Heat Rate	
6	0000000 AVG HRATE PEAK	288	Station Average Heat Rate Peak Hours	
7	0000000 AVG HRATE OFFPK	289	Station Average Heat Rate OffPeak Hours	
8	0000000 AVG SYS HRATE	53	System Average Heat Rate	
9	0000000 AVG SYS OP COST	55	Average System Operating Cost (\$/Mwh)	
10	0000000 AVGE. LINK LOSS	104	Average link losses by link	
11	0000000 AVGE. TRANSPORT	102	Average energy transferred by link	
12	0000000 CAP FACTOR	3	Station Capacity Factor	
13	0000000 COGEN FCST ELEC	204	Fuel cost of elect generation CoGen-user defined key (K\$)	

For example if the HR OUT FILE record appears as follows:

```
2003 1 0 0 0 1 HR OUT FILE    SYSTEM          1 B None
```

The 1 in the X1 field signifies that the hourly “out” file is to be output. The 1 in the N4 field indicates that only specified output aids are to be output, and an f32 file must be prepared and placed in the data folder and listed on line 33 of the control file.

In the above example of a portion of the f32 file, none of the listed output aids will be output since there is a zero in column 1 of each record. If standard “out” file format is desired for one or more of these aids, a 1 should be placed in column 1. For example if STATION MCOST is to be output, that record in the f32 file would appear as follows:

```
100000 STATION MCOST    173 Station Marginal Cost--All Stations Hourly
```

Alternatively, if the OFC file is to have csv (comma separated variable) format, place a 2 in the appropriate column(s) before the appropriate aid(s) in the f32 file.

A third alternative with a 3 in column 1 provides csv format, but with the output aid number instead of the output aid name in the output file. The output aid numbers are listed in the f32 file, e.g., the number for CAP FACTOR is 3 as shown above.

One note of caution. To obtain correct values in the f36 and f37 files, both f39 and f40 files must be output.

Note that the first row in the f32 file provides descriptive information about the data in the columns. The first 6 columns designate which time period is to be output, hour, day, week, month, calendar year, and/or fiscal year.

COMMIT REPORT

This flag controls several reports. The -1 option produces a report of hourly generation by unit as shown below. This report is useful in that an hourly generation report is created without getting other hourly output. To view the report, a word processing program such as WORD is needed. The data are viewable when Courier

font in 8 point is used with the page set to landscape with half-inch margins on the right and left.

Hydro Stations

PowrSym4 simulates hydro generation with a load leveling routine. There are four weekly pattern variables that control the simulation. The table below shows these aids.

IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
1996	1	1	52	1	0	HYDRO ENERGY	HYDRO	14	b	None
1996	1	1	52	1	0	HYDRO MAX	HYDRO	170	b	None
1996	1	1	52	1	0	HYDRO MIN	HYDRO	5	b	None
1996	1	1	52	1	0	HYDRO PEAK	HYDRO	180	b	None

The N1 field is the starting week of the year for the X1 value and the N2 field is the ending week of the year. In this example all four parameters are set for all year, but each week can have a unique value for each of these four aids. Maximum station capability is simulated with two aids: HYDRO MAX and HYDRO PEAK. HYDRO MAX is the maximum hourly hydro dispatch. The difference between the hydro dispatch and the HYDRO PEAK value contributes to reserves. HYDRO MAX, HYDRO MIN, and HYDRO PEAK are entered as megawatts. The unit for HYDRO ENERGY is gigawatt hours. PowrSym4 will stop with a fatal error if there is not enough energy to schedule the minimum hourly dispatch for the week. (The HYDRO ENERGY is less than the HYDRO MIN value times 168.)

Alternatively, PowrSym4 has the ability to simulate cascaded hydro systems as follows:

See CHYD... definitions in the Analyzer.

Hydro Cascade Input Data

- Each hydro reservoir is assigned to a cascade group. Multiple cascades are allowed and a cascade may have multiple hydro reservoirs.
- Reservoirs have natural inflow expressed in cubic meters per second. The natural inflow may vary by week or by season.
 - Note that the natural inflow schedule may be made subject to uncertainty draws using the Monte Carlo logic.
- Reservoirs have a loss rate expressed in cubic meters per second. The loss rate may vary by week or by season. Losses may be due to some combination of evaporation, leakage into ground water, and extractions for cities, industry, thermal power plants, and agriculture.
- Reservoirs have a minimum and maximum allowed head expressed in meters. The allowed head values may vary by week or by season.
 - The beginning head level must be specified for the first week of the study.
 - For subsequent weeks, head levels are passed forward from the previous week for each reservoir.
- Reservoirs have an equation relating the cubic meters of water in the reservoir to head.
- Reservoirs have a defined tail height expressed in meters. The tail height may vary by week or by season.
 - Alternatively, the tail height may be the head height of a downstream reservoir.
- Reservoirs may be designated to receive all or a portion of the releases from an upstream reservoir. There may be multiple upstream reservoirs.
- Reservoirs have an equation relating the release rate and electric generation rate. Both the head and tail height are factors in the equation.
- Reservoirs have a minimum release rate in cubic meters per second that must be observed. The minimum release rate may vary by time of day, by week, and by season. The minimum release rate may be related to some combination of environmental, navigation, recreation, agricultural, and cooling water needs downstream.
- Reservoirs have a ramp rate expressed in (cubic meters per second) per hour that must be observed for changes in release rate.
- Reservoirs have a maximum electric capacity expressed in megawatts. If a release is more than is required for maximum electric capacity, the balance of the release will be spilled. (Note that some reservoirs may not have installed generators, in this case all releases are spilled.)
- There may be a travel time, expressed in hours, for a release from each upstream reservoir to reach the head of this reservoir.

Hydro Cascade Scheduling

Each hydro cascade group will be scheduled independently with a goal-seeking optimization using the following objective functions:

1. Move the required amount of water through the cascade over each weekly horizon.
2. Observe all reservoir constraints.
3. Minimize spill.
4. Match the hourly generation output of the cascade to electric system needs over each weekly horizon.
5. Maintain adequate operating reserves (spinning reserves and turn down reserves) as required for system needs.

Note that the hydro scheduling logic is aware of the hourly output potential of renewable resources (such as wind and solar) and will attempt to use the hydro system as a “storage battery” to maximize value of the renewable resources within the operating constraints of the hydro system. However, if it comes to a choice of reducing the renewable resource output or spilling water, the logic will choose to reduce the renewable resource.

Error! Bookmark not defined.Hydro Cascade Output Reports

These reports are available for each reservoir by hour, day, week, month, and year. Reported items include:

- Electric generation for the period.
- Minimum and maximum electric generation during the period.
- Cubic meters of water spilled during the period.
- Beginning and ending reservoir head levels
- Minimum and maximum reservoir head levels during the period.
- Minimum and maximum downstream flow rates during the period.
- Average downstream flow rates during the period.

Pumped Storage Stations

Pumped storage stations have a COMMIT TYPE value of six. These stations are connected to a reservoir where energy is stored for use in generating. These stations create a pumping load during low cost hours and supply generation during high cost hours. The following table has the pumped storage parameters for station three. The RESERVOIR NUM record points the N3 station to the X1 reservoir. In this example both stations 3 and 1 are pointing to reservoir number 1. Station 1 is a conventional hydro station and station 3 is a pumped storage station. Both types of stations point to a reservoir. Hydro and pumped storage reservoirs are numbered independently. The PHYD PUMP FLAG parameter when set to 1 switches to model the generator and pump separately. When set to 0, they are treated as a single unit. When set to 1, the PHYD NUM PUMP and PHYD FOR parameters must be set. The size of the generator is set with the POWER LEVELS aid. The PHYD PUMP MW sets the size of the pumps and the PHYD PUMP MIN sets the minimum pumping load. Pump

minimums should be set with care. The simulation is for an hour. The pump load is the integrated load on the pump over that hour and not the minimum loading on the pump. Consequently, it is conceivable for a 100 MW pump to pump only 50 MWh in an hour, i.e., the pump was online for 30 minutes during the hour.

IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
1996	1	0	0	0	1	PHYD DISP STEP	SYSTEM	10	B	None
1996	1	0	0	1	0	PHYD FOR	PHYDRO	0	B	None
1996	1	0	0	1	0	PHYD GEN EFF	PHYDRO	0.88	B	None
1996	1	0	0	1	0	PHYD NUM PUMP	PHYDRO	4	B	None
1996	1	0	0	1	0	PHYD PUMP EFF	PHYDRO	0.88	B	None
1996	1	0	0	1	0	PHYD PUMP FLAG	PHYDRO	0	B	None
1996	1	0	0	1	0	PHYD PUMP MIN	PHYDRO	0	B	None
1996	1	0	0	1	0	PHYD PUMP MW	PHYDRO	340	B	None
1996	1	0	0	1	0	PHYD RES FINAL	PHYDRO	2.4	B	None
1996	1	0	0	1	0	PHYD RES INIT	PHYDRO	2.4	B	None
1996	1	0	0	3	0	RESERVOIR NUM	PHYDRO	1	B	None
1996	1	0	0	1	0	RESERVOIR NUM	HYDRO	1	b	None
1996	1	0	0	1	0	RESERVOIR SIZE	PHYDRO	3	B	None
	0	0	0	0	0			0		

Wind Generation Stations

Any station number may be used for a wind station. Any number of wind stations may be designated. The station data are defined the same as for other stations. The COMMIT TYPE record is used to designate the station as a wind generator. Set X1=10 to designate as a wind station.

If wind generation cannot be controlled and wind does not respond to market price, set STA MIN to power level 5 or higher and set DISP TYPE to 1 or 3 (doesn't matter).

If wind generation can be controlled but wind does not respond to market price, set STA MIN = 0 and DISP TYPE = 1.

If wind can be controlled and wind does respond to market price, set STA MIN = 0 and DISP TYPE = 3.

Use the Aid, WIND GEN FMT, to define the format of the hourly wind generation file. Set X1=1 for a single or for multiple wind stations. Each row represents the data for one hour for each wind station. Each column contains the wind generation for a station. Column 1 contains the wind generation for the first wind station, the one with the lowest station number. As an example, element 3,5 contains the wind generation for the fifth wind station (the station number for the 5th wind station may be any legitimate station number) for hour 3. The format of each row is 8x,100f6.1. It is not necessary to have 100 wind stations.

Wind generation is scheduled before hydro generation since wind generation is usually taken as it occurs while hydro generation scheduling usually has some flexibility.

The user has the option to force wind/solar generation even when dump energy results or to reduce wind/solar generation to avoid increasing dumped energy. To avoid increasing dumped energy, set STA MIN for the wind/solar station to 0. To force wind/solar generation even when dumped energy is increased, set STA MIN equal to power level 5 or higher (Leave power level 1 = 0.).

If it is desired to place uncertainty on the wind generation (file), use the Aids, WIND PROB and WIND GEN DEV as described in the Analyzer. Typically, 5 values for each would be entered taking care that the sum of the probabilities equals one. As an alternative to the way WIND PROB and WIND GEN DEV are typically used, low, median, and high cases can be executed by setting WIND PROB $X1=1$ and WIND GEN DEV $X1=0.9$ (or whatever per unit value desired) for the low case; WIND GEN DEV $X1=1$ for the median case, and WIND GEN DEV $X1=1.1$ (or whatever) for the high case. WIND PROB $X1=1$ for all three cases. With this scheme the wind gen file would not need to be changed

wind generation is calculated as: $P=k*C*0.5*\rho*A*V^3$ where P =generation(kw), $k=0.000133$, C =Maximum power coefficient (0.25 to 0.45) Theoretical max=0.59, ρ =Air density, lb/ft³ (assume =0.08), A =rotor sweep area, ft² or $\pi*D^2/4$ (D =diameter in ft), V =wind speed, mph.

Solar can be treated the same as a wind station. The generation file (file 24 in the control file) may contain data for both wind and solar stations. The first column may be for the first wind station and the second column may be for the first solar station. The model makes no distinction between the two.

Distributed Generation Stations

Small generating units may be combined to form one larger unit with input from a file (file 47 in the control file) showing the hourly generation expected from this station. The file has the same format as file 24 for wind and solar stations.

Any station number may be designated as a distributed (dist) generation station. Any number of dist stations may be designated. The station data are defined the same as for other stations. The COMMIT TYPE record is used to designate the station as a dist station. Set $X1=8$ on the COMMIT TYPE record.

Since the small stations that are aggregated to form this larger dist station are not typically controlled by the utility, dist stations are given a COMMIT TYPE $X1=1$ internally in the code. However, the user has some control over generation from the dist station regarding dump energy. Set STA MIN $X1=0$ if the dist station is permitted to back down to avoid dump energy. Set STA MIN equal to POWER LEVEL 5 or greater if generation from the dist station continues even if this increases dump energy. (Leave power level 1 = 0.)

If dist generation cannot be controlled and dist does not respond to market price, set STA MIN to power level 5 or higher and set DISP TYPE to 1 or 3 (doesn't matter).

If dist generation can be controlled but dist does not respond to market price, set STA MIN = 0 and DISP TYPE = 1.

If dist can be controlled and dist does respond to market price, set STA MIN = 0 and DISP TYPE = 3.

In the input generation file each row represents the data for one hour for each dist station. Each column contains the generation for a dist station. Column 1 contains the generation for the first dist station, the one with the lowest station number. As an example, element 3,5 contains the generation for the fifth dist station (the station number for the 5th dist station may be any legitimate station number) for hour 3. The format of each row is 8x,100f6.1. It is not necessary to have 100 dist stations.

Combined Heat and Power Stations (Cogeneration)

PowrSym4™ schedules the production of both heat and power to meet the hourly load obligations of each. Some units produce only electricity, some both heat and electricity, and some only heat. The algorithm schedules operation of all three types to minimize total operating costs for meeting electric and heat loads in a combined optimization.

The heat load is specified by heat areas. Each heat area may have an hourly varying district heating load and industrial steam load. Combined heat and power units and boilers may serve either (or both) the district heat load and industrial steam load in their area.

The fuel input to a combined heat and power station is a function of both the electric and heating loads.

For each CHP station there is an allowed range of electric operation as a function of heat production and an allowed range of heat production as a function of electric production.

In addition to CHPs and heat boilers the model also allows for heat storage devices. One of the latest developments in the combined heat and power logic is the heat transport logic. This module makes it possible to connect heat areas using heat pipes with restrictions on maximum transport.

Although there are significant differences, the heat buffer logic somewhat resembles the pumped hydro storage logic.

Each heat station that is capable of producing industrial steam/hot water may be treated individually by user input. Each such unit must be assigned to an industrial heat area, and each such unit must be listed in merit order with a unique merit position. The units are loaded by merit order to meet the industrial heat load of the heat area to which the unit is assigned. Levels of heat extraction are set by the user. The Aids used to establish the merit order and heat extraction levels are: HEAT IND MERIT and HEAT EXT LVL. See the definitions in the Analyzer.

There is no interpolation between the heat border definitions. For example, a station has extraction levels of 100, 200, and 300 defined. For the range of extraction 0 to 100, the level 1 heat borders will be used. For extractions of 101 to 200, the level 2 heat borders will be used. Level 3 will be used for 201 and above.

There are numerous Aids (most designated as HEAT *) used to define heat areas and heat stations. The complete list may be viewed in the Aid definitions in the Analyzer.

Output for the heat extraction simulation is in both formatted print reports and in the ofc files. There are two reports in the formatted print files: CoGen Min/Opt Report and CoGen Cost Report. The output aids for the ofc files are listed in the f32 file and all start with COGEN. These reports are obtained by setting X1=1 on the HEAT EFF FLAG input aid.

Multi-State Stations

Generating units consisting of gas turbines and heat recovery units may be represented with the multi-state logic in PowrSym4. For example, this permits a combustion turbine to start and operate in state 1 for as long as that is the economical mode, then start the HRSG when economics dictate for state 2 operation. The logic permits up to 3 states which might include such combinations as: 2 combustion turbines and 1 HRSG: 1 combustion turbine with 1 HRSG without auxiliary firing; or 1 combustion turbine with 1 HRSG with auxiliary firing. Other combinations may be possible.

The logic permits appropriate transition rates and costs associated with movement from one state to another.

See definitions for the following AIDs in the Analyzer:

MMODE STA REF

STATE HR LVLS

STATE PWR LVLS

STRT COST 01, 12, 13, 23

DP COMMIT FLAG

DP SETUP

MIN TIME **

EFF CURVE TYPE

Generating Stations

Station parameters set the individual station characteristics that are used in the simulation of system production cost. Some station parameters that interact with system parameters have already been discussed. The N3 values on these parameters relate to the station being modeled.

At times it is desirable to permit a station to operate only if another station is unavailable, i.e., the two stations (units) may not operate simultaneously. The feature is implemented with the Aid, STA SPARE.

Station B is the spare station for Station A. B cannot operate except when A is offline. The input data must be fully entered for Station B and it may (or may not) be exactly the same as for Station A. One caveat is that the installed units for Station B must be zero so as to avoid double counting for reserves and reliability. The spare feature is set up by the input variable:

STA SPARE

n3 = station number of the spare

x1 = station number of the base unit

Number of Units

An N3 value on a station record points to a station. Each station can have up to 20 generating units. All units of a multiple unit station have the same characteristics and costs. There are several ways to change the number of units at a station during a PowrSym4 simulation.

INSTALLED UNITS

This is a weekly pattern variable. The N1 and N2 fields specify the weeks of the year that the parameter is effective. This feature is handy for modeling a station that is simulating a purchase that is only available certain weeks or months of the year.

The screenshot shows a software window titled "View Input Definitions". At the top, there is a dropdown menu labeled "Select the variable you want defined" with "INSTALLED UNITS" selected. To the right of this menu is a "Close" button. Below the menu, the text "Variable Definition" is displayed. The main area of the dialog is divided into two sections. On the left, there is a table with the following structure:

Variable	Category
INSTALLED UNITS	
STATION	
Minimum	0
Maximum	10
Default	0

On the right side of the dialog, there is a large text area containing the following text:

X1 is the number of installed units at the beginning of the study period. It is adjusted by unit additions (ADD UNITS) and retirements (REM UNITS). If the value is used to add units, maintenance is scheduled the first year the new unit is available.

N1 is begin week (0 defaults to 1)
N2 is end week (0 defaults to 52)
N3 is station number
A1 is station name
N4 not used

GENIF50 : Table											
	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
	1996	1	0	0	20	0	INSTALLED UNITS	COALX	3	EX	Example of Multi-unit Station
	1996	1	0	0	20	0	INSTALLED UNITS	COALX	1	B	None
*	0	0	0	0	0	0			0		

ADD UNITS

This parameter is the commercial operation date for an expansion unit at this station entered as YYYYWW, where YYYY is the year the expansion unit is commercial and WW is the week of the year. N4 is the unit number being added. To add more than one unit to the same station, use multiple records with the appropriate date and increasing consecutive values in the N4 field. When a unit is added to a station with the ADD UNITS parameter, PowrSym4 will not schedule maintenance for the first year or partial year of commercial operation.

	2000	1	0	0	35	1	ADD UNITS	Plan Unit	199940	B	None
	2000	1	0	0	35	2	ADD UNITS	Plan Unit	200041	B	None
	2000	1	0	0	35	3	ADD UNITS	Plan Unit	200140	B	None
	2000	1	0	0	35	4	ADD UNITS	Plan Unit	200240	B	None
	2000	1	0	0	35	5	ADD UNITS	Plan Unit	200340	B	None

REMOVE UNITS

This parameter is the retirement date for a unit at this station entered as YYYYWW, year/week. N4 is the unit number being retired. To retire more than one unit at the station, use multiple records with the appropriate date and increasing consecutive values in the N4 field.

	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	
▶	1999	1	0	0	9	1	REMOVE UNITS	XXX	200440	B	None
*	0	0	0	0	0	0			0		

Station Heat Rate

These parameters define the station operating range and efficiencies at the various loading levels.

POWER LEVELS

PowrSym4 allows up to five operating points. The N4 value points to one of these operating levels. These parameters are entered in megawatts. The normal minimum operating capability should be entered as level one. Likewise, the normal full load capability should be entered as level five. The maximum POWER LEVELS value is used to calculate capacity factor. Each power level for a station must be equal to or greater than the preceding level.

	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	6	1	POWER LEVELS	COAL3	20	B	None
	1996	1	0	0	6	2	POWER LEVELS	COAL3	40	B	None
	1996	1	0	0	6	3	POWER LEVELS	COAL3	66	B	None
	1996	1	0	0	6	4	POWER LEVELS	COAL3	66	B	None
	1996	1	0	0	6	5	POWER LEVELS	COAL3	66	B	None
*	0	0	0	0	0	0			0		

EFF CURVE TYPE

This parameter determines the method of modeling efficiency for station N3. An X1 value of zero requires the input of HEAT RATE LVLS that correspond to the average heat rate for the power level indicated by the N4 value on the POWER LEVELS record. An X1 value of one requires the input of parameters defining a single total heat input curve. An X1 value of two requires the input of parameters defining two total heat input curves--where one equation can't define the curve over its entire range.

	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	56	2	EFF CURVE TYPE	CHP1P	2	CCY	None
*	0	0	0	0	0	0			0		

HEAT RATE LVLS

These parameters are the heat rates in BTU/kWh corresponding to the POWER LEVELS indexed by the N4 values. The user should ensure the incremental heat rate implicit in these values is monotonically increasing, i.e., the incremental heat rate is always increasing. A basic assumption in economic dispatch is that the next Mw costs more than the preceding one.

	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	6	1	HEAT RATE LVLS	COAL34	14000	b	None
	1996	1	0	0	6	2	HEAT RATE LVLS	COAL34	11500	b	None
	1996	1	0	0	6	3	HEAT RATE LVLS	COAL34	11000	b	None
	1996	1	0	0	6	4	HEAT RATE LVLS	COAL34	11000	b	None
	1996	1	0	0	6	5	HEAT RATE LVLS	COAL34	11000	b	None

EFF EQ XXX

These parameters define an equation that results in the total heat required for a unit to generate given power levels. The first derivative of this equation should be monotonically increasing.

EFF EQ A1

A constant term

EFF EQ B1

The coefficient of the power level to the first power

EFF EQ C1

The coefficient of the power level squared.

EFF EQ Z1	The coefficient of the power level cubed.
EFF EQ A2	The constant term of the 2nd equation defining a dual curve
EFF EQ B2	The coefficient of the power level to the first power
EFF EQ C2	The coefficient of the power level squared.
EFF EQ Z2	The coefficient of the power level cubed.
EFF MW MAX	The MW level for switching to the second curve.

View Input Definitions

Select the variable you want defined
EFF EQ A1

Close

Variable Definition

EFF EQ A1

STATION Category

Minimum

Maximum

Default 0

X1 defines the A coefficient for the single input/output curve or first curve in the double curve input/output definition. (See EFF CURVE TYPE). The equation is:

$$\text{Heat} = A + B * PL + C * PL^2 + Z * PL^3$$

where
A,B,C,Z = Input coefficients
PL = Power level in megawatts
Heat = Millions of btu.

N3 is station number
A1 is station name
N1,N2,N4 not used

	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMME
▶	1996	1	0	0	56	0	EFF EQ A1	CHP1P	83.321	CCY	None
	1996	1	0	0	56	0	EFF EQ A2	CHP1P	112.568	CCY	None
	1996	1	0	0	56	0	EFF EQ B1	CHP1P	5.21778	CCY	None
	1996	1	0	0	56	0	EFF EQ B2	CHP1P	6.77556	CCY	None
	1996	1	0	0	56	0	EFF EQ C1	CHP1P	0.02408	CCY	None
	1996	1	0	0	56	0	EFF EQ C2	CHP1P	0.00016	CCY	None
	1996	1	0	0	56	0	EFF MW MAX	CHP1P	120	CCY	None

HEAT RATE MULT

This parameter is multiplied times each of the heat rate levels. The value should be near one. A range of 0.95 to 1.05 is reasonable. This allows the heat rates to be adjusted seasonally. The value may be entered as frequently as weekly.

View Input Definitions

Select the variable you want defined
HEAT RATE MULT

Close

Variable Definition

HEAT RATE MULT

STATION Category

Minimum

1.5 Maximum

1 Default

X1 is the adjustment multiplier for all five heat rate levels (HEAT RATE LVLS) for this station. Each of the five heat rates is increased by this multiplier. Decreases below a heat rate of 3413 Btu/kWh are not allowed. This variable may be changed as often as weekly. It may be used for seasonal effects or may be used for unit degradation with age.

(Enter 1.05 for a 5% increase)

[note: multiplier currently works only for EFF CURVE TYPE 0]

N3 is station number
A1 is station name
N1,N2,N4 not used

Station Operating Characteristics

These parameters define station-operating constraints for PowrSym4.

COMMIT TYPE

This parameter serves two functions. A value of seven defines this station as a hydro station. A value of six defines the station as an energy storage station (pumped storage). Values of one through five define the commit priority of thermal units. A value of one defines a must run unit. A value of two defines a must run unit unless dump power would occur. With a value of three the unit is committed on the basis of economics. A value of four defines a unit that is committed only if needed. A value of five defines a unit that is committed only to avoid energy not served.

	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	1	0	COMMIT TYPE	HYDRO	7	b	None
	1996	1	0	0	3	0	COMMIT TYPE	PHYDRO	6	B	None
	1996	1	0	0	5	0	COMMIT TYPE	COAL12	3	b	None
	1996	1	0	0	20	0	COMMIT TYPE	SUDOENS	5	b	None
*	0	0	0	0	0	0			0		

DISP TYPE

This parameter sets the priority for dispatching units. The ordering is the same as commit types one through five. These priorities allow the user to have PowrSym4 dispatch the system economically or as needed.

1996	1	0	0	17	0	DISP TYPE	AR2GEN	3	b	None
1996	1	0	0	18	0	DISP TYPE	CCY	3	b	None
1996	1	0	0	20	0	DISP TYPE	SUDOENS	5	b	None

MIN DOWN TIME

This parameter defines the minimum number of hours a unit must remain idle before it can be restarted.

1996	1	0	0	9	0	MIN DOWN TIME	COAL7	24	b	None
1996	1	0	0	10	0	MIN DOWN TIME	COAL8	168	b	None
1996	1	0	0	11	0	MIN DOWN TIME	CT	6	b	None
1996	1	0	0	18	0	MIN DOWN TIME	CCY	6	b	None
1996	1	0	0	20	0	MIN DOWN TIME	SUDOENS	0	b	None

MIN UP TIME

This parameter defines the minimum number of hours a unit must operate before it can be idled.

1996	1	0	0	9	0	MIN UP TIME	COAL7	24	b	None
1996	1	0	0	10	0	MIN UP TIME	COAL8	168	b	None
1996	1	0	0	11	0	MIN UP TIME	CT	6	b	None
1996	1	0	0	18	0	MIN UP TIME	CCY	6	b	None
1996	1	0	0	20	0	MIN UP TIME	SUDOENS	0	b	None

RAMP RATE

This parameter defines the maximum number of megawatts a unit can move in an hour.

1996	1	0	0	9	0	RAMP RATE	COAL7	100	b	None
1996	1	0	0	10	0	RAMP RATE	COAL8	200	B	None
1996	1	0	0	18	0	RAMP RATE	CCY	120	B	None

STA MIN

This is an hourly pattern parameter. The N1 and N2 values are the beginning and ending hours of the week this value is effective. The parameter is the minimum dispatch megawatts for this station if it is available. The parameter applies to the sum of the units at a station.

The screenshot shows a software window titled "View Input Definitions". At the top, there is a dropdown menu labeled "Select the variable you want defined" with "STA MIN" selected. To its right is a button labeled "Show All Variables" and another dropdown menu labeled "Sort Variables by category". A "Close" button is in the top right corner.

Below the top bar is the "Variable Definition" section. It contains a table with three rows for defining the variable "STA MIN":

STATION	Category
0	Minimum
1000	Maximum
0	Default

To the right of the table is a text area containing the following description: "X1 is the minimum operating level in megawatts for this station by hour. If this station is available, it must be dispatched to at least this level. Applies to the sum of the units at a multi-unit station." Below this description is a list of codes: "N1 is begin hour", "N2 is end hour", "N3 is station number", "A1 is station name", and "N4 not used".

STA PWR MIN

STA PWR MIN differs from STA MIN in that STA MIN forces commitment to meet the minimum dispatch requirement; whereas STA PWR MIN dispatches to the minimum dispatch requirement if the unit is online. STA PWR MIN does not force commitment. STA PWR MIN is an hourly weekly variable. The week is designated by the second field on the record, the week field. N1 and N2 designate the beginning and ending hours. If N4=0, values entered in a week remain in effect the following weeks until the user enters new values in a subsequent week. If N4=1, the values apply to this week only, and values must be entered for each of the 52 weeks. The entered values carry forward year-to-year. This same logic applies to STA PWR MAX and STA PWR CAP.

EMMR

This parameter is the emission rate for the emission indicated by the N4 value. The N4 value of one points to SO₂ emissions. A value of two points to NO_x emissions, and a value of three points to CO₂ emissions. The NO_x emissions can be defined with an alternative equation. See the section entitled 'Emissions' for information on other emissions that may be included.

View Input Definitions

Select the variable you want defined: Sort Variables by category:

Variable Definition

Category

Minimum

Maximum

Default

X1 is the emission rate for the emission category N4 for this station in pounds per million Btu. This value multiplied by the heat input yields the N4 emission output in pounds.
 N3 is station number
 N4 is emission category number
 A1 is station name
 N1,N2 not used

	IYR	IWH	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	1	0	5	1	EMMR	COAL12	2	b	None
	1996	1	1	0	5	2	EMMR	COAL12	2	b	None
	1996	1	1	0	5	3	EMMR	COAL12	200	b	None
	1996	1	1	0	6	1	EMMR	COAL34	2	b	None
	1996	1	1	0	6	2	EMMR	COAL34	2	b	None
	1996	1	1	0	6	3	EMMR	COAL34	200	b	None
	1996	1	1	0	7	1	EMMR	COAL5	2.5	b	None

EM EQ FLAG

This parameter determines which method PowrSym4 uses to simulate NOx emissions. With a value of zero PowrSym4 uses the constant rate per BTU of fuel burned. A value of one causes PowrSym4 to use the NOx equation.

View Input Definitions

Select the variable you want defined: Sort Variables by category:

Variable Definition

Category

Minimum

Maximum

Default

The X1 flag determines how the NOx emissions for this station will be calculated. The model can either use a constant value or find the NOx rate using an equation.
 0 = Constant value from input.
 1 = Use equation defined for this station.
 N3 is station number
 A1 is station name
 N1,N2,N4 not used

NOX XX CONSTANT

These parameters define the NOx equation explained in the PowrSym4 manual.

NOX A1 CONSTANT

NOX A2 CONSTANT

NOX A3 CONSTANT

NOX A4 CONSTANT

The screenshot shows the 'View Input Definitions' dialog box. At the top, there is a dropdown menu for 'Select the variable you want defined' with 'NOX A1 CONSTANT' selected. To the right of this dropdown is a 'Show All Variables' button and a 'Sort Variables by category' dropdown. A 'Close' button is in the top right corner. Below the dropdown is the 'Variable Definition' section. It contains a text box with the variable name 'NOX A1 CONSTANT'. To the right of this text box are three input fields for 'Minimum', 'Maximum', and 'Default' values, each with a 'Category' label. The 'Minimum' field has a value of 0, the 'Maximum' field has a value of 10, and the 'Default' field has a value of 0. To the right of these fields is a large text area containing the following text: 'X1 is the "A1" constant in the NOx equation. This equation is used if the EM EQ FLAG is set to 1. The equation is Pounds NOx = A1 + A2 * MW + A3 * e**(A4 * MW) where MW = Current dispatched megawatts for this station. N3 is station number A1 is station name'.

Station Cost

PowrSym4 uses, among others, the following to estimate station cost of operation.

FCOST

This parameter is the station fuel cost in cents per million BTU.

VAR COST

This parameter is the station variable operation and maintenance cost in dollars/MWh.

1996	1	0	0	5	0	VAR COST	COAL12	1.5	b	None
1996	1	0	0	6	0	VAR COST	COAL34	1.5	b	None
1996	1	0	0	7	0	VAR COST	COAL5	1.5	b	None
1996	1	0	0	8	0	VAR COST	COAL6	1.5	b	None
1996	1	0	0	9	0	VAR COST	COAL7	1.5	b	None
1996	1	0	0	10	0	VAR COST	COAL8	1.5	b	None
1996	1	0	0	11	0	VAR COST	CT	2.5	b	None

XXX COM MULT

FCOST COM MULT applies to FCOST values. VOM COM MULT applies to VAR COST values. These parameters are used to simulate the use of transmission penalty factors. The simulated costs are multiplied by these factors to adjust the cost for transmission losses. The adjusted costs are used only in the commit decision and are not reported.

The screenshot shows the 'View Input Definitions' dialog box. At the top, there is a dropdown menu labeled 'Select the variable you want defined' with 'FCOST COM MULT' selected. To the right of this menu is a 'Show All Variables' button and a 'Sort Variables by category' dropdown. A 'Close' button is in the top right corner. Below the dropdown menu is the 'Variable Definition' section. It contains a table with the following structure:

STATION	Category
0.5	Minimum
1.5	Maximum
1	Default

To the right of the table is a text area containing the following text:

X1 is a multiplier used to bias the fuel cost during the commit logic. A station will appear to be more expensive or less expensive when the model is determining the commit order. This factor DOES NOT affect the fuel cost for the dispatch logic or the reported fuel cost.

N3 is station number
A1 is station name
N1,N2,N4 not used

XXX DISP MULT

FCOST DISP MULT applies to FCOST values. VOM DISP MULT applies to VAR COST values. These parameters are used to simulate the use of transmission penalty factors. The simulated costs are multiplied by these factors to adjust the cost for transmission losses. The adjusted costs are only used in the dispatch decision and are not reported.

The screenshot shows the 'View Input Definitions' dialog box. At the top, there is a dropdown menu labeled 'Select the variable you want defined' with 'VOM DISP MULT' selected. To the right of this menu is a 'Show All Variables' button and a 'Sort Variables by category' dropdown. A 'Close' button is in the top right corner. Below the dropdown menu is the 'Variable Definition' section. It contains a table with the following structure:

STATION	Category
0.5	Minimum
1.5	Maximum
1	Default

To the right of the table is a text area containing the following text:

X1 is the factor used to artificially adjust the variable operating and maintenance cost during the dispatch logic. A station will appear to be more expensive or less expensive when the model is determining the dispatch order. This factor DOES NOT affect the variable operating and maintenance cost for the commit logic or the reported variable and maintenance cost.

N3 is station number
A1 is station name
N1,N2,N4 not used

EMMC

These parameters relate to an emission with the N4 value. The parameter is in dollars per unit of emission. These costs impact the commit and dispatch decisions and are reported. See the section entitled ‘Emissions’ for additional information.

View Input Definitions

Select the variable you want defined: **Show All Variables** Sort Variables by category:

Variable Definition

STATION **Category**

Minimum

Maximum

Default

X1 is the cost of the emission category specified in N4 in dollars per ton or other measuring units. This value multiplied by the calculated tons of this emission is the cost of this emission for this station.

N3 is station number
N4 is emission category number
A1 is station name
N1,N2 not used

	YR	IWF	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	1	0	5	1	EMMC	COAL12	200	b	None
	1996	1	1	0	5	2	EMMC	COAL12	0	b	None
	1996	1	1	0	5	3	EMMC	COAL12	0	b	None

FIXED COST

This parameter is the fixed O&M costs for this station in dollars per week.

View Input Definitions

Select the variable you want defined: **Show All Variables** Sort Variables by category:

Variable Definition

STATION **Category**

Minimum

Maximum

Default

X1 is the fixed operation and maintenance cost in dollars per week per unit in service for this station. This is the cost of operating the station even if there is no generation.

N3 is station number
A1 is station name
N1,N2,N4 not used

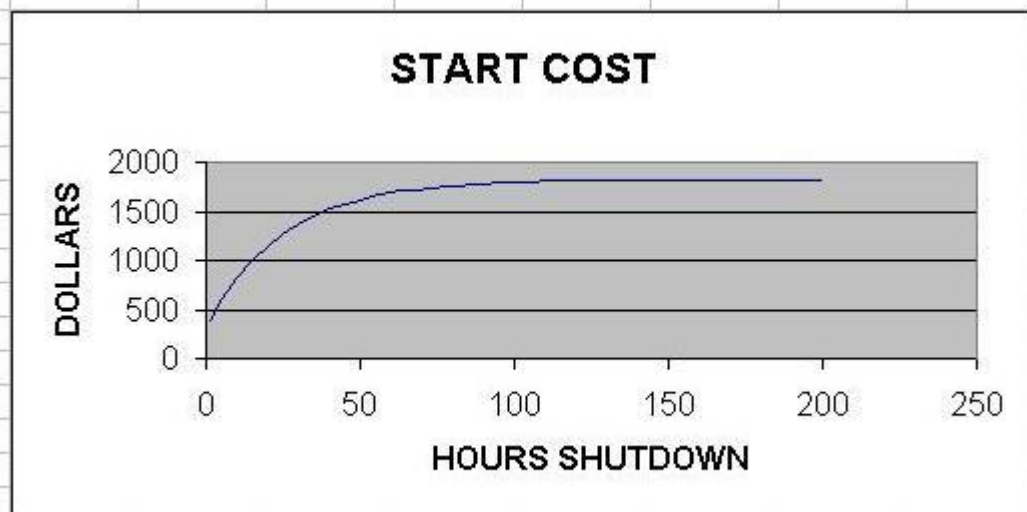
	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
►	1996	1	0	0	5	0	FIXED COST	COAL12	1900	B	None
	1996	1	0	0	6	0	FIXED COST	COAL34	6300	B	None
	1996	1	0	0	7	0	FIXED COST	COAL5	11000	B	None
	1996	1	0	0	8	0	FIXED COST	COAL6	21000	B	None
	1996	1	0	0	9	0	FIXED COST	COAL7	290000	B	None
	1996	1	0	0	10	0	FIXED COST	COAL8	24000	B	None
	1996	1	0	0	11	0	FIXED COST	CT	12000	B	None

STRT COST XXX

This is the start cost for this station in dollars per unit start. The use of the STRT COST XXX, STRT COST A, STRT COST B, STRT COST C, Etc, parameters provides a means to simulate hot and cold starts. There is a basic STRT COST that can be used that is not a function of idle time. It can represent the average start cost or the cost of a cold start depending on the users needs.

The cost of fuel used for starting a unit can be FCOST or FUEL COST by user option using the Aid, STA STRT FLAG with X1=0 for FCOST and X1=1 for FUEL COST. If X1=1, then an additional Aid, STA STRT FUEL, is required with X1 indicating which FUEL to use for starting.

Start costs may be spread over the hours operated by the unit during the week and included in the output Aid, OPER COST \$/MWH. This is controlled by the input Aid, START COST DIST with X1=1 for distribution, X1=0 for no distribution.



	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
►	1996	1	0	0	4	0	STRT COST	CAES	100	CAE	None
	1996	1	0	0	5	0	STRT COST	COAL12	1950	b	None
	1996	1	0	0	6	0	STRT COST	COAL34	3600	b	None
	1996	1	0	0	7	0	STRT COST	COAL5	3000	b	None
	1996	1	0	0	8	0	STRT COST	COAL6	5100	b	None
	1996	1	0	0	9	0	STRT COST	COAL7	23000	b	None

For multi-state units transition costs between states as well as start costs must be considered.

The start cost equation is: (for single state units)

$S = A + (\text{Fuel cost}) * (B + C * (1 - e^{-(\text{Down Time})/T}))$ where:

A = STRT COST A

B = STRT COST B

C = STRT COST C

T = STRT COST TAU

Down Time = number of hours since unit was stopped

For the multi-state situation, the following input variables are used:

STRT COST A01

STRT COST A12

STRT COST A23

STRT COST B01

STRT COST B12

STRT COST B23

STRT COST T01

STRT COST T12

STRT COST T23

If a unit starts in state 1, the equation is used with the 01 variables.

If a unit starts in state 2, the start cost is the sum of the equations using the 01 and 12 variables.

If a unit starts in state 3, the start cost is the sum of the equations using the 01, 12, and 23 variables

In all cases, if the start cost computed using the single state equation is larger, this value is used.

If a unit changes states from state 1 to state 2, the transition cost is:

$S = A12 + (\text{Fuel cost}) * B12$

If a unit changes states from state 2 to state 3, the transition cost is:

$S = A23 + (\text{Fuel cost}) * B23$

If a unit changes states from state 1 to state 3, the transition cost is the sum of 12 and 23 equations.

There is no cost for switching from higher states to lower states.

In some stations, certain transitions (such as 1 to 3) may be impossible. These transitions can be blocked by setting the minimum times to a large number. For example, setting MIN TIME 13 to 9999 will effectively block this transition without going through state 2.

FCOST ESC

This aid escalates the fuel cost entered in the first week of the FY. A three- percent escalator is entered as 1.03.

	IYR	IWH	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
►	1996	1	0	0	4	0	FCOST ESC	CAES	1.03	CAE	None
	1996	1	0	0	5	0	FCOST ESC	COAL12	1.03	b	None
	1996	1	0	0	6	0	FCOST ESC	COAL34	1.03	b	None
	1996	1	0	0	7	0	FCOST ESC	COAL5	1.03	b	None
	1996	1	0	0	8	0	FCOST ESC	COAL6	1.03	b	None
	1996	1	0	0	9	0	FCOST ESC	COAL7	1.03	b	None

STRT APPROX

An automated method to calibrate distributed start cost hours has been added to v404e3e. This method over rides the option of specifying station operating hours on n2 of VAR COST records. The automated method is implemented as follows:
Controlled by n2 on STRT APPROX

- n2 = 0 (default) no effect
- n2 = 1 run in discrete start cost mode and save the results to file fun01
- n2 = 2 run in distributed start cost mode reading the operating hours for each station by week (or month) from fun01

The strategy is to make a base case in discrete start cost mode and create fun01 (n2 = 1) and then use this file as input to following runs in distributed mode (n2 = 2)
The start costs and station energies in distributed mode will be in the same range as in discrete mode, but there will be some differences:

- The number of starts will go up since there is no longer a cost hurdle for starting or stopping units. This effect will shift some energy from stations with lower min up/down times to stations with higher up/down times.
- The linear nature of the costs will generally allow hydro optimization to find a better result.

O&M ESC

This aid escalates the variable O&M cost for this station. It escalates the cost that is effective the first week of the FY.

View Input Definitions

Select the variable you want defined: **Show All Variables** Sort Variables by category:

Close

Variable Definition

Category

Minimum

Maximum

Default

X1 is the annual escalation factor for start cost, fixed operation and maintenance cost, and variable operation and maintenance cost for this station (STRT COST, FIXED COST, and VAR COST). The escalation occurs at the beginning of each year. If a cost is entered after the beginning of a year, the escalation is not performed until the next year.
(Enter 1.05 for a 5% increase).

N4 is a flag that determines the application of the escalation rate as follows:
 0 - Escalate start, fixed, and variable costs by this value.
 1 - Escalate only start cost by this value.
 2 - Escalate only fixed cost by this value.
 3 - Escalate only variable cost by this value.

N3 is station number
 N4 is flag

EMMESC

This aid escalates the emissions cost for this station.

Generic : Table											
	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	
▶	1996	1	0	0	5	1	EMMESC	COAL1	1.03	B	NONE
	1996	1	0	0	6	1	EMMESC	COAL3	1.03	B	NONE
	1996	1	0	0	7	1	EMMESC	COAL5	1.03	b	None

Fuels

PowrSym4 has three different methods for defining the fuel cost for a generating station. The basic method requires a fuel cost for each station. The second method is for modeling energy limited fuel contracts. The third method is for modeling fuel blending and prices by hour of the week for simulation of fuels contracts. The three interact. Uncertainty may be placed on the third type of fuel modeling (See Uncertainty).

Base Fuel

The aids, FCOST and FCOST ESC, allow the user to input fuel costs for each station with an escalator for each station. These costs can be changed weekly. The last cost input before the first week of the FY is the one escalated. A value input for the first week of a subsequent year will override the escalated values. HEAT VALUE is the aid that converts the BTU burn to units such as tons for reporting. These values are reported in the station operating and cost reports. An example of base fuel records is shown here. These parameters must be set for each station.

	IYR	IWH	N1	N2	N3	N4	AID	A1	X1	CLASS	COMME
►	1996	1	0	0	6	0	FCOST	COAL34	120	b	None
	1996	1	0	0	6	0	FCOST ESC	COAL34	1.03	b	None
	1996	1	0	0	7	0	FCOST	COAL5	116	b	None
	1996	1	0	0	7	0	FCOST ESC	COAL5	1.03	b	None
	1996	1	0	0	9	0	FCOST	COAL7	118	b	None
	1996	1	0	0	9	0	FCOST ESC	COAL7	1.03	b	None

Energy Limited Fuels (ELF)

Some utilities have several contracts for fuel at one station, and each contract may have a minimum burn requirement and/or a maximum burn requirement. The default minimum burn is zero. PowrSym4 will dispatch the units using the lowest cost fuel to its maximum and then switch to the next lowest cost fuel. The spot fuel for a station is defined with the FCOST aid. This cost should be higher than any ELF fuels assigned to the station; otherwise after the minimum requirement has been met for the ELF fuel, PowrSym4 will switch to the spot fuel. With spot fuel the highest cost fuel for a station, spot fuel will be used only after all ELF fuels have been used to their limit.

The logic in the model requires use of spot fuel after an ELF fuel limit has been reached. For example, if an ELF fuel has an ELF DAILY MAX record, and the daily limit is reached, stations using this fuel will begin using spot fuel. Since all hours are solved simultaneously, spot fuel may be used any hour within the day with the elf fuel being used in hours before and after.

Annual Limits

In situations where there is an annual limit on availability of a particular fuel, the process described here may be used.

In this process a year is executed normally to determine the optimum annual usage of the particular fuel as if there were no limitation on availability of this fuel. Typically, this utilizes more fuel than permitted. A second pass is executed in which the weekly usages are scaled down to obtain the limited annual usage.

There are two options on the annual fuel limitation scheme. The first is as described above. In the second, energy limited fuels are apportioned according to user input, i.e., there may be a requirement to use 90% of one fuel and 10% of another fuel.

The inputs are: STA ELF INDEX, ELF YEAR FLAG, and ELF YEARLY MAX. There is also a batch file involved which OSA will provide on request. The inputs are described in the Analyzer.

If it is desired to minimize or eliminate spot fuel usage, the aid, NO SPOT FUEL, may be introduced. X1=1 activates the process. N4=1 is for hourly limits, and N4=2 is for daily limits. If dealing with daily limits, an iterative process is used to minimize or eliminate spot fuel usage. Spot usage cannot always be eliminated. N1 is the maximum number of iterations permitted in the process, and N2 is the approximate weekly maximum permitted spot fuel usage for this elf fuel with a daily limit. The iterations end when either the maximum permitted iterations is reached or when the spot usage is less than the weekly permitted spot usage.

IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
1999	1	0	0	1	0	ELF NAME	GAS1	0	ELF	None
1999	1	0	0	1	0	ELF COST	GAS1	218	ELF	None
1999	1	1	7	1	0	ELF DAILY MAX	GAS1	105	ELF	None
1999	1	1	13	1	0	ELF WEEKLY MAX	GAS1	720	ELF	None
1999	1	1	168	1	0	ELF HOURLY MAX	GAS1	5	ELF	None
1999	10	0	0	1	0	ELF COST	GAS1	220	ELF	None
1999	14	1	7	1	0	ELF DAILY MAX	GAS1	110	ELF	None
1999	14	1	168	1	0	ELF HOURLY MAX	GAS1	5	ELF	None
1999	14	14	17	1	0	ELF WEEKLY MAX	GAS1	730	ELF	None
1999	18	1	7	1	0	ELF DAILY MAX	GAS1	112	ELF	None
1999	18	1	168	1	0	ELF HOURLY MAX	GAS1	5	ELF	None
1999	18	18	39	1	0	ELF WEEKLY MAX	GAS1	750	ELF	None
1999	40	1	7	1	0	ELF DAILY MAX	GAS1	115	ELF	None
1999	40	1	168	1	0	ELF HOURLY MAX	GAS1	5	ELF	None
1999	40	40	43	1	0	ELF WEEKLY MAX	GAS1	760	ELF	None
1999	44	1	7	1	0	ELF DAILY MAX	GAS1	105	ELF	None
1999	44	1	168	1	0	ELF HOURLY MAX	GAS1	5	ELF	None
1999	44	44	52	1	0	ELF WEEKLY MAX	GAS1	720	ELF	None
0	0	0	0	0	0			0		

Most of the aids used to model energy limited fuels start with ELF. ELF NAME is the aid that labels the energy-limited fuel. ELF COST is the aid that sets the cost in cents per million BTU. ELF HEAT VALUE converts the BTU to units such as tons for coal for reporting purposes.

IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
1999	1	0	0	6	1	STA ELF INDEX	STA1	1	ELF	None
1999	1	0	0	7	1	STA ELF INDEX	STA2	1	ELF	None
1999	1	0	0	7	1	STA ELF INDEXC	STA2	10	ELF	None
1999	1	0	0	7	1	STA ELF TCOST	STA2	40	ELF	None

Stations are connected to an ELF fuel with the STA ELF INDEX aid. The N3 value is the station number and the X1 value is the ELF fuel number or index. The N4 value is a station reporting priority for ordering the fuels in the reports and for connecting a transportation cost adder to the ELF fuel cost. Each fuel has a unique cost defined by ELF COST. The transportation adder allows this cost to be adjusted for each station.

STA ELF TCOST

This aid sets the transportation cost adder. The N3 value is the station number. The X1 value is the cost adder. The N4 value is the station reporting priority number. This N4 value must be the same as the N4 value in the STA ELF INDEX record that points the station to the ELF fuel for which the adder is applicable.

PowrSym4 will dispatch the stations to achieve the required minimum fuel burn for each ELF fuel. After the fuel minimums have been met, the fuels for each station are ordered by cost, ELF fuels and a spot fuel cost. The spot fuel cost is entered with FCOST.

If the minimum elf requirement is not used by PowrSym4, the unused fuel is reported as “dumped”. Some contracts require payment of the transport cost even for dumped fuel. N1 on the STA ELF TCOST record is used to control payment of transport cost on dumped fuel. N1=0 is the default in which the transport cost is not paid on dumped fuel. N1=1 requires payment of the transport cost on dumped fuel.

If the user desires to use the otherwise dumped elf even though it is more costly to do so, the user may force PowrSym4 to burn the fuel for generation. This is controlled with the aid, ELF DUMP OPTION. X1=0 is the default in which dumped elf is permitted. X1=1 forces the otherwise dumped fuel to be burned to the extent possible.

PowrSym4 can simulate gas storage with appropriate limits on total storage volume, charge and extraction rates, etc. The appropriate AIDs may be found in the Analyzer listed as ELF.....

Fuel Types

This method of defining fuel costs is similar to the energy limited fuel method. Fuels are defined, and stations are indexed to a fuel. When a station points to more than one fuel, the user specifies what percent of each fuel the station burns, and the unit is dispatched with a blended fuel cost. If the user defines less than one hundred percent of the fuel mix, PowrSym4 will use the FCOST value to complete the mix. Fuel type fuels are hourly pattern values. This allows one fuel to define a purchase with pricing by hour of the week. A station can be indexed to ELF fuels and to fuel types. In this case the fuel type fuel becomes the spot fuel for the ELF logic.

FUEL NAME

This aid defines a fuel type. The N3 value is the fuel number, and the A1 value is the name. These values are used only for reporting. Below is a typical setup for modeling fuel cost with this method.

IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMI
2000	1	1	168	5	0	FUEL COST	SGAS	285	EX	None
2000	1	0	0	5	0	FUEL NAME	SGAS	0	B	None
2000	1	0	0	5	0	FUEL HEAT VALUE	SGAS	1.013	B	None
2000	1	0	0	5	0	FUEL COST ESC	SGAS	1.02	B	None
2000	1	1	168	7	0	FUEL COST	OIL	406	EX	None
2000	1	0	0	7	0	FUEL NAME	OIL	0	B	None
2000	1	0	0	7	0	FUEL HEAT VALUE	OIL	5.838	B	None
2000	1	0	0	7	0	FUEL COST ESC	OIL	1.02	B	None
2000	1	1	168	11	0	FUEL COST	COKE	127	EX	None
2000	1	0	0	11	0	FUEL NAME	COKE	0	B	None
2000	1	0	0	11	0	FUEL HEAT VALUE	COKE	22.05	B	None
2000	1	0	0	11	0	FUEL COST ESC	COKE	1.02	B	None

FUEL COST

This aid defines the fuel cost in cents per million BTU. N3 is the fuel number. X1 is the cost. The N1 value is the start hour of the week, and the N2 value is the ending hour of the week that this cost is effective.

FUEL HEAT VALUE

This aid defines the units the fuel is reported in. This value ratios the BTUs burned to units such as tons, barrels, etc.

FUEL COST ESC

This parameter serves the same purpose as FCOST ESC values. The fuel costs are multiplied by the X1 value the first week of the fiscal year.

STA FUEL MIXING

The value in the N3 field is the station number. The value in the N4 field is the fuel number. The X1 value is the ratio of the station use supplied by this fuel.

IYR	IWF	N1	N2	N3	N4	AID	A1	X1	CLASS	COMME
1996	1	0	0	5	1	STA FUEL TCOST	COAL12	55	B	None
1996	1	0	0	5	1	STA FUEL MIXING	COAL12	1	B	None
1996	1	0	0	11	10	STA FUEL TCOST	CT	-10	B	None
1996	1	0	0	11	10	STA FUEL MIXING	CT	1	B	None
1996	1	0	0	18	6	STA FUEL MIXING	CCY	0.33339	B	None
1996	1	0	0	18	11	STA FUEL MIXING	CCY	0.42516	B	None
1996	1	0	0	18	13	STA FUEL MIXING	CCY	0.20942	B	None
1996	1	0	0	18	14	STA FUEL MIXING	CCY	0.03202	B	None

Station 18 burns four different fuels, 6, 11, 13, and 14. Thirty-three percent of the burn is supplied by fuel 6, 42% by fuel 11, 21% by fuel 13, and 3% by fuel 14. PowrSym4 will calculate a weighted average fuel cost and commit and dispatch the station based on this average cost. The fuel mixing values can be changed weekly. Since each fuel has its own escalator, PowrSym4 will escalate the costs over the simulation horizon. If the STA FUEL MIXING records designate less than one hundred percent of a station's fuel burn, PowrSym4 will use FCOST values for the remaining fuel.

The logic associated with the STA FUEL MIXING uses the percentages each hour, ie, in the above example, all four fuels are reported as being used each hour the unit operates. In reality, a unit will most likely use only fuel each hour. There is an option to permit use of one fuel per hour—the lowest cost fuel for that hour. In this mode, the percentages are ignored on the STA FUEL MIXING record. To choose this mode, set N4=1 on the EXEC MODE record. N4=0 is the default which enables the use of the percentages on the STA FUEL MIXING record.

Fuel Cost Uncertainty

See the section on Uncertainty for a discussion of handling uncertainty of fuel cost for this fuel type.

Emissions

Up to 8 different emission categories may be simulated and reported. The 8 are: SO₂, NO_x, CO₂, Ash, Gypsum, Spent Nu Fuel, Waste Heat, and Miscellaneous. For the ones desired enter an EMMR and an EMMC record for each applicable station. EMMR is the emission rate usually in pounds per million btu, and EMMC is the emission cost usually in dollars per ton. The Miscellaneous category is user defined.

Station and system totals are output in the ofc (fixed width) files as requested in the checkout.txt file. The formatted print files dollar amounts include the effects of the emission costs, and SO₂, NO_x, and CO₂ are detailed in the print files.

Station dispatch costs may, or may not, include any or all emission costs. See STA EM FLAG in the Analyzer.

Simulating Out-of-Bound Operations

In simulating production costs an out-of-bound condition occurs under two conditions. One is when the projected electric loads are less than the minimum capability of the committed units. In this situation the utility is dumping power or exporting unscheduled power onto the grid. The other condition occurs when the projected electric load exceeds the capability of the system resulting in energy not served (ENS) or unscheduled imports from the grid. PowrSym4 does not simulate a system black out. The assumption is that the grid will always be able to supply needed power at some cost. Similarly, the assumption is made that excess generation during low load periods can be sold at some low price.

DUMP COST

This is a system parameter. In a single area model it is the same as TAREA DUMP COST for transarea one. This parameter is in dollars per megawatthour. The cost of producing the dumped power is in the reported production cost. For the simulation this is the price at which dump energy is sold and thus is a revenue. Care should be used in setting this value. If it is desired to collect no revenue for excess generation, set the X1 value at zero. It can be set to a negative value if it is desired to reflect excess generation as a cost in addition to the generating cost.

The screenshot shows a software window titled "View Input Definitions". At the top, there is a dropdown menu labeled "Select the variable you want defined" with "DUMP COST" selected. To its right is a "Sort Variables by category" dropdown menu. Further right are two buttons: "Show All Variables" and "Close". Below these is a section titled "Variable Definition". On the left, the variable name "DUMP COST" is entered in a text box. To its right, there are three rows of input fields: "Category" with "SYSTEM" selected, "Minimum" with "0" entered, and "Maximum" with "1000" entered. Below these are two more rows: "Default" with "0" entered. To the right of these input fields is a large text area containing the following text: "This value defines the excess generation (dumped power) price in dollars per megawatthour for weeks N1 through N2. Applied to all weeks if N1 and N2 are 0. The model multiplies this value by the dump energy to calculate money accrued. This amount is considered an income on the summary reports and is subtracted from system cost to determine the total system cost by period. NOTE: If it is desired to eliminate dump energy by reducing generation levels below Power Level 1, set N4 (for DUMP COST) to 1. Generation levels will be set to as low as 0.9 of Power Level 1. To avoid reducing a station's generation below Power Level 1, set STA PWR MIN or STA MIN for that station to Power Level 1 or greater. N3 is the tarea number N4 is a switch to eliminate dump energy if desired: =0 default-dump energy permitted =1 eliminate dump energy by reducing below power level 1 A1 is SYSTEM".

Note: Dump energy may be avoided by setting N4=1 on the DUMP COST record. (In some cases it may not be possible to avoid dump energy even when this feature is in effect. This will occur if dump energy is greater than the reduction gained by reducing output of the units to 0.9 of Power Level 1.) This option permits output of units to be as low as 0.9 of Power Level 1. For units that it is not desired to reduce below Power Level 1, input either a STA PWR MIN or STA MIN record with X1 equal to or greater than Power Level 1.

TAREA DUMP COST

In a multi-area case, dump energy can have a separate value for each area. The N3 value is the area. Do not use both DUMP COST and TAREA DUMP COST records.

The screenshot shows the 'View Input Definitions' window. At the top, there's a dropdown menu set to 'TAREA DUMP COST', a 'Show All Variables' button, a 'Sort Variables by category' dropdown, and a 'Close' button. Below this is the 'Variable Definition' section. It contains a text box with the variable name 'TAREA DUMP COST', a 'TRANSAREA' dropdown, and three input fields for 'Minimum' (0), 'Maximum' (1000), and 'Default' (0). To the right of these fields is a large text area containing the following text: 'X1 is used to price the excess generation in a transarea that cannot be avoided (dump power). The model takes this value in dollars per megawatthour multiplied by the megawatthours of excess generation to calculate the dollars accrued. This amount is considered an income on the summary reports and will therefore be subtracted from the system cost to calculate the total system cost by period. N3 is transarea number A1 is transarea name N1,N2,N4 not used'.

ENS COST

This parameter is the assumed dollars per MWh cost of buying power when the system cannot meet load. It should be higher than the highest cost generating unit or other resource. In a balanced system, there will be limited or no occasions when this cost is used since this is a rare occurrence in real system operation.

GENERIC : Table											
	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	0	0	ENS COST	SYSTEM	200	b	None
*	0	0	0	0	0	0			0		

TAREA ENS COST

In a multi-area case each area can have a separate value for energy not served. The N3 value is the area. Do not use both ENS COST and TAREA ENS COST in the same run.

ENS COST ESC

This is an escalator that is applied to all energy not served cost values. This escalator is applied to ENS COST and to TAREA ENS COST parameters. A cost escalator of five percent per year is entered as 1.05.

GENERIC : Table											
	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	0	0	ENS COST ESC	SYSTEM	1.05	b	None
*	0	0	0	0	0	0			0		

Maintenance Scheduling

PowrSym4 will schedule unit maintenance. It is scheduled before the first week of the fiscal year is simulated. The maintenance logic attempts to levelize the weekly LOLP, or to minimize cost, or a combination. The maintenance routine provides several options such as the ability to split outages between spring and fall; avoid multiple unit outages at the same station simultaneously; allow for crew recovery time between outages, etc.

MAINT PART WEEK

If the X1 for this aid is 0, maintenance is schedule in whole weeks only. A value of 1 provides for part week maintenance. For example, if a unit is to be scheduled out for 10 days, the X1=0 option would schedule only 7 days while the X1=1 option would schedule the full 10 days.

View Input Definitions

Select the variable you want defined
MAINT PART WEEK Show All Variables Sort Variables by category Close

Variable Definition

MAINT PART WEEK

SYSTEM **Category**

Minimum

Maximum

Default

X1 is the flag that allows partial week maintenance.
0 = Maintenance outages are truncated to the nearest full week
1 = Allow partial week maintenance outages
N1,N2,N3,N4 not used
A1 is SYSTEM

PMOR

This is the planned maintenance outage rate. A 5.2-week outage is entered as 0.1. Either divide the weeks of outage by 52 or the days of outage by 365. The N1 and N2 define the window in which the maintenance can be scheduled. N4 represents a period number. For example, if it were desired to break a unit's maintenance into two periods, 11 days in the spring and 7 days in the fall, two records would be required.

For the spring outage, N4=1, N1 may be 1 and N2 may be 26 although they can define a shorter period. X1 is 0.03. For the fall outage, N4=2, N1=27, N2=52, and X1=0.019.

The screenshot shows the 'View Input Definitions' window for the variable 'PMOR'. The window has a title bar 'View Input Definitions' and a toolbar with 'Select the variable you want defined', 'Show All Variables', 'Sort Variables by category', and 'Close'. The 'Variable Definition' section shows 'PMOR' as the variable name. The 'Category' is 'STATION'. The 'Minimum' is 0, 'Maximum' is 1, and 'Default' is 0. The description text on the right states: 'X1 is the planned maintenance outage rate for this station. It is only used if the model is required to schedule maintenance (MAINT CNTL is 1 or 2). It is used to determine the number of hours of maintenance to schedule for this station. (Enter 0.05 for a 5% outage rate).'. It also lists: 'N1 Starting week of the period', 'N2 Ending week of the period', 'N3 Station number', 'N4 Period number', and 'A1 is station name'. A note at the bottom says: 'Note: Truncates to full weeks unless MAINT PART WEEK is used.'

MAINT CNTL

This aid has four options controlled by X1 and four controlled by N3.

The screenshot shows the 'View Input Definitions' window for the variable 'MAINT CNTL'. The window has a title bar 'View Input Definitions' and a toolbar with 'Select the variable you want defined', 'Show All Variables', 'Sort Variables by category', and 'Close'. The 'Variable Definition' section shows 'MAINT CNTL' as the variable name. The 'Category' is 'SYSTEM'. The 'Minimum' is 0, 'Maximum' is 3, and 'Default' is 0. The description text on the right states: 'The X1 flag indicates the maintenance method to be used. 0 = Discrete maintenance file input only (File3) 1 = Internal annual maintenance scheduling 2 = Discrete maintenance file used first with the internal maintenance scheduler used to complete maintenance requirements (PMOR) 3 = No maintenance used. These maintenance options do not affect the RELY module.' It also lists: 'N1 Objective junction 0=LQLP 1=ENS 2=Total system cost 3=Total system cost subject to lqlp and ens penalties' and 'N2 Maintenance diagnostic flag 0=Disable the diagnostic,'.

View Input Definitions

Select the variable you want defined
 MAINT CNTL Show All Variables Sort Variables by category Close

Variable Definition

MAINT CNTL

SYSTEM **Category**

Minimum

Maximum

Default

0=Enable the diagnostic.
 1=Enable the diagnostic.
 N3 Schedule flag.
 0=schedules total system.
 1=schedules carea's identified with MAINT CAREA.
 2=schedules tarea's identified with MAINT TAREA.
 3=schedules carea's followed by tareas.
 4=Schedule system by multi-area costing (N1 must be set to 2)
 5=Schedule a carea with related tarease by multi-area costing(n1=2, MAINT CAREAS)
 6=Schedule system with spot-market (N1=2)
 N4 Number of times constraints released seeking feasible solution.
 A1 is SYSTEM

MAINT START HR

Many utilities start planned outages on Friday evening or Saturday morning, but since PowrSym4 starts execution at 0100 on Monday, this aid permits the user to designate the starting hour for maintenance. An entry of 120 will cause maintenance outages to start Friday at midnight. In order to use this feature, MAINT PART WEEK must be enabled.

View Input Definitions

Select the variable you want defined
 MAINT START HR Show All Variables Sort Variables by category Close

Variable Definition

MAINT START HR

SYSTEM **Category**

Minimum

Maximum

Default

X1 is the beginning hour of the week for maintenance periods scheduled by the MAINTSYM logic. If maintenance normally begins on Friday evening at hour ending midnight, this value would be 120 (last hour of Friday). Set to 1 for discreet week even if MAINT PART WEEK = 0.
 N1,N2,N3,N4 not used
 A1 is SYSTEM

MAX MAINT UNITS

This aid is useful for multi-unit stations. It limits the number of units that can be scheduled on maintenance simultaneously. N3 is the station number. X1 is the maximum number of units that may be scheduled on maintenance during a period. N1 and N2 define the period, e.g., N1=1 and N2=26 defines a period for the first half of the year. Shorter periods may be defined, but PowrSym4 may produce unexpected results. It is better to break the year into two periods, N1=1, N2=26, and N1=27, N2=52. PowrSym4 will then schedule optimally within those periods. N4 is a priority index. If PowrSym4 must relax constraints in order to schedule all maintenance, this index defines the order of relaxation. An N4 value of 0 indicates that the constraint should not be relaxed. The higher the number, the lower the priority, or the easier it is to relax the constraint.

The screenshot shows a software window titled "View Input Definitions". At the top, there is a dropdown menu with "MAX MAINT UNITS" selected, a "Show All Variables" button, a "Sort Variables by category" dropdown, and a "Close" button. Below this is a section labeled "Variable Definition". On the left, there is a table with the following structure:

Variable	Category
MAX MAINT UNITS	
STATION	
0	Minimum
10	Maximum
10	Default

On the right, there is a text area containing the following text:

This value defines the maximum number of units that may be scheduled for planned maintenance in the weeks from N1 to N2 for this station.

N1 is begin week
N2 is end week
N3 is station number
N4 Priority number for this station. This priority number is treated similarly as the procedure group priority number. A value 0 means that this constraint should not be released.
A1 is station name

Groups

The next set of three aids defines groups and associated constraints. Units may be assigned to a procedure group, such as all large coal-fired units, and constraints can be placed on that group of units.

PROC GROUP NAME

Each procedure group must be assigned a name, e.g., nuclear. The N3 value is the proc group number. The X1 value is the priority for relaxing constraints. The higher the value the lower the priority. A value of 0 indicates the constraint should not be relaxed. This aid works in conjunction with PROC GRP ACTION and STA PROC GROUP records. The constraints defined by PROC GRP ACTION records apply to all stations associated with the group assigned with STA PROC GROUP records.

The screenshot shows the 'View Input Definitions' dialog box. At the top, there is a title bar 'View Input Definitions'. Below it, a section 'Select the variable you want defined' contains a dropdown menu with 'PROC GROUP NAME' selected, a 'Show All Variables' button, a 'Sort Variables by category' dropdown, and a 'Close' button. The main area is titled 'Variable Definition' and contains a table with columns 'Variable' and 'Category'. The 'Variable' column has 'PROC GROUP NAME' and 'GROUP'. The 'Category' column has 'Minimum', 'Maximum', and 'Default'. The 'Minimum' and 'Maximum' values are set to 0. To the right of the table is a text area with the following text: 'A1 is the procedure group name for defining action limits for groups of stations. A maximum of 10 characters. X1 The group priority number. The higher the number, the lower the priority. A value 0 means that this procedure group should never be released. N3 is procedure group number. N1,N2,N4 not used'.

STA PROC GROUP

N3 is the station number and N4 is the procedure group number. A station can belong to more than one procedure group defined with PROC GROUP NAME records.

The screenshot shows the 'View Input Definitions' dialog box. At the top, there is a title bar 'View Input Definitions'. Below it, a section 'Select the variable you want defined' contains a dropdown menu with 'STA PROC GROUP' selected, a 'Show All Variables' button, a 'Sort Variables by category' dropdown, and a 'Close' button. The main area is titled 'Variable Definition' and contains a table with columns 'Variable' and 'Category'. The 'Variable' column has 'STA PROC GROUP' and 'STATION'. The 'Category' column has 'Minimum', 'Maximum', and 'Default'. The 'Minimum' value is set to 0, the 'Maximum' value is set to 10, and the 'Default' value is set to 0. To the right of the table is a text area with the following text: 'X1 is not used. N1,N2 not used. N3 is station number. N4 is procedure group number. A1 is station name'.

PROC GRP ACTION

There can be up to 3 PROC GRP ACTION records for each PROC GROUP NAME. N1 defines the priority for relaxing the constraint within the group. N2 defines the step size for relaxing a constraint. For example, if the action defines the maximum megawatts on maintenance with an X1 of 400 and the N2 value is 50, the constraint will be changed from 400 to 450 to 500 as the constraint is relaxed. The N3 value points the action to a defined group. The N4 value defines the following actions:
N4=0 = No limits

- 1 = Maximum number of units on maintenance in a single hour
- 2 = Maximum megawatts on maintenance in a single hour
- 3 = Minimum number of hours between maintenance outages

View Input Definitions

Select the variable you want defined: **Show All Variables** Sort Variables by category: **Close**

Variable Definition

GROUP	Category
<input type="text" value="0"/>	Minimum
<input type="text" value="3"/>	Maximum
<input type="text" value="0"/>	Default

X1 is the limit imposed on a procedure group for a particular action. For the action defined in field N4, the following input would be defined in the X1 field:

- 0 = No limits
- 1 = Maximum number of units on maintenance in a single hour
- 2 = Maximum megawatts on maintenance in a single hour
- 3 = Minimum number of hours between maintenance outages
- N1 The action priority number
A value 0 means that this action should never be released.
- N2 The step size for constraint release.
- N3 is procedure group number
- N4 is procedure action number
- A1 is procedure group name (optional)

Sets

Sets are similar to Groups but with different actions. The set logic can be used to specify: the minimum generating capability that must be committed for the set; the minimum generation from the set; the minimum number of units that must be online each hour for the set.

SET NAME

Each set must be assigned a name. A1 is the set name. N3 is the set number, and X1 is the set action: X1=1 for SET MIN UNITS; X1=2 for SET MIN GEN; and X1=3 for SET MIN CAP.

SET MIN UNITS

X1 specifies the minimum number of units that must be online for hours N1-N2. N3 is the set number, and A1 is the set name.

SET MIN GEN

X1 specifies the minimum generation from the set for hours N1-N2. N3 is the set number, and A1 is the set name.

SET MIN CAP

X1 specifies the minimum capability that must be committed for the set for hours N1-N2. N3 is the set number, and A1 is the set name.

STA SET NUM

X1 is the set number. N3 is the station number, and A1 is the station name.

Transmission Areas (tarea)

PowrSym4 is a multi-area model. This permits a utility to be divided into areas to simulate transmission constraints within the system or for more than one utility to be simulated. Each area modeled is defined as a separate tarea. The tareas are connected with "to" and "from" links. Each link has a transfer capability, a loss rate, and a wheeling charge.

Defining Tareas

Each tarea is given a name that is used in reports. (A name must be assigned to get optimum results.) Generating stations are assigned to tareas, and the user has control over how the electric loads for the tareas are to be modeled.

TAREA NAME

N3 is the tarea number, and A1 is the name. Each tarea should be given a name.

	IYR	IWF	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	1	0	TAREA NAME	CENTRAL	0	TRN	
	1996	1	0	0	2	0	TAREA NAME	A/C	0	TRN	

TAREA LOAD FLAG

N3 is the tarea number. X1 determines the source of the load. For X1=0 the loads are read from a file. For X1=1 the load is determined with the TAREA SYS PORT aid.

	IYR	IWF	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	1	0	TAREA LOAD FLAG	SYSTEM	1	B	NONE
	1996	1	0	0	2	0	TAREA LOAD FLAG	SYSTEM	1	TRN	NONE

TAREA SYS PORT

The N3 value is the tarea number. The meaning of the X1 value depends on the X1 value of the TAREA LOAD FLAG. If the X1 value on the TAREA LOAD FLAG is 0, then the tarea load is adjusted by the X1 value on the TAREA SYS PORT record, that is, the tarea load will be adjusted to: (Tarea load) times the X1 value. Here tarea load means hourly loads. For example, if the user wanted all hourly loads for this tarea to be increased 10%, the TAREA SYS PORT X1 value would be set to 1.1.

If the TAREA LOAD FLAG is 1, then the tarea load is a portion of the system load determined by the X1 value. The system load remains unchanged, but the load for this tarea is X1 percentage of the system load such as 25%, for example.

	IYR	IWF	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
	1996	1	0	0	2	0	TAREA SYS PORT	MARKET	0.25	TRN	

View Input Definitions

Select the variable you want defined: **Show All Variables** Sort Variables by category: **Close**

Variable Definition

Category

Minimum

Maximum

Default

A1 is transarea name (optional)
N4 not used

Note: if TAREA LOAD FLAG = 1,
Adjusted Tarea load= (system load)*(TAREA SYS PORT)+(TAREA LOAD ADJ)

if TAREA LOAD FLAG=0,
Adjusted Tarea load=(Tarea load)*(TAREA SYS PORT)+(TAREA LOAD ADJ)

STA TAREA NUM

Each station must be assigned to a tarea; however, if the record is omitted, the station will be assigned to tarea 1. N3 is the station number, and X1 is the tarea number. All stations must have a unique station number. There cannot be a station number 2 in tarea 1 and in tarea 2. Station numbers should be kept as low as possible to reduce execution time. If the PowrSym4 executable was compiled for 100 stations, no station can be numbered greater than 100. If the system has only 53 stations, PowrSym4 will execute faster if the highest station number is 53 although 100 is permitted. However, it is permissible to skip Station numbers.

1996	1	0	0	5	0	STA TAREA NUM	COAL12	1	b	None
1996	1	0	0	6	0	STA TAREA NUM	COAL34	1	b	None
1996	1	0	0	7	0	STA TAREA NUM	COAL5	1	b	None

TAREA GEN PORT

This aid specifies the portion of the load for this tarea, N3, that must be generated by generators in tarea N3. X1 is the portion that must be generated in the tarea such as 0.5 for 50%. This is an hourly pattern variable. N1 and N2 specify the beginning and ending hours of the week.

Linking Transmission Areas

PowrSym4 ties tareas using transmission links. There are two links between two tareas to accommodate transfers in each direction. The to and from link capabilities do not have to be the same. It is helpful to draw a simple diagram of tareas and links to assist in setting up the tareas. Mistakes are easy to make in setting up the links if there are several areas involved. The PowrSym4 Analyzer has a link report that is helpful in setting up and debugging the links for multi-area representation.

TAREA FROM LINK

The N3 value is the link number. The X1 value is the originating (from) tarea.

	IYR	IWH	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	1	0	TAREA FROM LINK	CENTRAL	2	TRN	
	1996	1	0	0	2	0	TAREA FROM LINK	CENTRAL	1	TRN	

TAREA TO LINK

The N3 value is the link number. The X1 value is the terminating (to) tarea.

	IYR	IWH	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	1	0	TAREA TO LINK	CENTRAL	1	TRN	
	1996	1	0	0	2	0	TAREA TO LINK	CENTRAL	2	TRN	

TAREA LINK CAP

This is the transfer capability for the link. N3 is the link number. X1 is the megawatt transfer capability for this link. This is an hourly pattern variable. N1 and N2 specify the beginning and ending hours of the week for the specified capability.

	IYR	IWH	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	1	0	TAREA LINK CAP	CENTRAL	2500	TRN	
	1996	1	0	0	2	0	TAREA LINK CAP	MARKET	2000	TRN	

TAREA LNKLOSS A

This aid specifies losses for each link. N3 is the link number. X1 is the loss factor, e.g., 0.03 for 3% losses. This is an hourly pattern variable with N1 and N2 specifying the beginning and ending hours in the week. This is useful for setting the losses higher during peak hours and lower during the off-peak hours.

	IYR	IWH	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	1	0	TAREA LNKLOSS A	CENTRAL	0	TRN	

TAREA WHEEL

This aid specifies the transmission service charge for this link. N3 is the link number. X1 is the wheeling charge in dollars/MWh. This is an hourly pattern variable with N1 and N2 specifying the beginning and ending hours of the week. This is useful for specifying a peak and an off-peak wheeling charge.

	IYR	IWH	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	1	168	1	0	TAREA WHEEL	CENTRAL	0	TRN	

Alternatively, PTDF factors may be used to represent the transmission system. See PTDF*** records in the Analyzer.

Spot Market

Interchange transactions between the central area and one or more market areas can be simulated using the spot market feature of PowrSym4. The market is represented as hourly incremental/decremental costs for blocks of power. For each hour there are 250 cost values, 125 steps that can be purchased, and 125 steps that can be displaced by a sale. The mw size for each block is specified by user input, i.e., all blocks are the same size such as 10 MW. The 125th value is system lambda for the market. Blocks below the 125th value represent the costs of resources in the market area that can be displaced by a sale to the market. Blocks above the 125th value represent resources above load that the market area can sell. The Analyzer can assist in preparing a market file. The market file is somewhat like a system incremental cost curve or table. The market file is input as file 191 in the control file. File 191 is preceded by a question mark (?) in the control file to signify that a spot market file follows.

1	1996	1	1	1	1000	0	50100.100.100.100.100.100.100.100.100.100.
2	1996	1	1	7	1000	0	50160.160.160.160.160.160.160.160.160.160.
3	1996	1	1	23	1000	0	50100.100.100.100.100.100.100.100.100.100.
4	1996	1	1	31	1000	0	50160.160.160.160.160.160.160.160.160.160.
5	1996	1	1	47	1000	0	50100.100.100.100.100.100.100.100.100.100.

1	160.160.160.160.160.250.250.250.250.250.300.300.300.300.300.300.300.
2	250.250.250.250.250.450.450.450.450.450.500.500.500.500.500.500.
3	160.160.160.160.160.250.250.250.250.250.300.300.300.300.300.300.
4	250.250.250.250.250.450.450.450.450.450.500.500.500.500.500.500.
5	260.260.260.260.260.260.260.260.260.260.300.300.300.300.300.300.
6	250.250.250.250.250.450.450.450.450.450.500.500.500.500.500.500.

In the figures above, portions of the first 5 rows are shown. In the top figure the first columns are shown for the first 5 rows. In these first columns are the year, the week, the iteration, the hour(s) represented by this row, the hourly load (1000 Mw in this example), a column of zeros, the step size (50 Mw in this case), and the costs for the first 11 steps. The costs shown in the upper figure of 100 represents \$10/Mwh.

In the lower figure the costs around lambda are shown. The cursor is just to the right of lambda which is at \$25/Mwh. So if the central system were selling into the market, the first block of 50 MW on the central system would have to be priced at less than \$25/Mwh to be attractive to the market. Similarly, the first 50 MW block that the central system could buy from the market is priced at \$30/Mwh the first hour (first row). Actually the first row represents the costs for the first 6 hours. Note that the second row has a 7 in the hour column in the upper figure. So the second row represents the costs for hours 7 through 22. (The third row starts with hour 23).

As an alternative to entering 250 values for each hour, the user may enter one value per hour, this value being the market price. With this option the market price for buying or selling is the one input value each hour. The market price does not change

with the amount of the transaction as it does when the 250 values are input. For example, the system may purchase 10 Mw or 1000 Mw from the market at the market price, if the transfer limits permit. The second price value on each row must be 999 which is the flag that indicates only one market price will be entered. Each record has the following format (same as original 250 value file):

2000 1 1 1 1000 0 50 350 999

where the 350 is the market price (\$35/Mwh). All other values have the same meaning as when entering the 250 values.

The spot market area must be set up somewhat like a Tarea with some differences. The spot market must be assigned to tarea 2. (If there is more than one spot market, then tareas 3, 4, and 5 are used.) Other regular Tareas are then assigned numbers greater than the highest spot market tarea, except that the central area must be assigned to Tarea 1. In the initial setup it is advised that the second regular tarea (not a spot market) be given tarea 6. This will allow the spot market to be setup subsequently as 2 through 5, and regular tareas will not have to be renumbered.

The following AIDs are used to setup spot market. The spot market area must be assigned a Tarea Name and a Trans Area name and number.

SPOT MARKET FLG

The X1 value turns this feature on and off. X1=0 turns the feature on, and X1=1 turns the feature off. (Caution. This is different from most PowrSym4 flags.)

MARKET COMMIT

With this feature (AID) units may be committed economically against the market without regard to loads or reserve requirements but with consideration of commit type, minimum up and down times, and start costs. Any output aids may be chosen in the Checkout.txt file, but of particular interest in this case are STATION MCOST and MCOST. X1=transaction area activates. X1=0 deactivates.

The aid, OR RESERVED MW, may be used in conjunction with the market commit option to specify reserves to be carried by specific generating units.

View Input Definitions

Select the variable you want defined: Sort Variables by category:

Variable Definition

Category

Minimum

Maximum

Default

X1 is the flag that activates the Spot Market option.
 0 = Consider Spot Market Transactions
 1 = Disable Spot Market Transactions
 N4 = 0 Non-firm transactions
 1 Firm transactions
 NOTE: When Spot Market is activated, use TAREA OR FLAG and TAREA SR FLAG and TAREA PCT or MW. Set SYS OR FLAG and SYS SR FLAG to zero.
 N1, N2, N3 not used
 A1 is SYSTEM

TRANS AREA

X1 is the Tarea that the spot market interacts with. It must be set to 1. N3 is the Tarea number assigned to the spot market and must be 2, 3, 4, or 5. A1 is the name of the spot market area. (It must also be assigned a TAREA NAME.)

View Input Definitions

Select the variable you want defined: Sort Variables by category:

Variable Definition

Category

Minimum

Maximum

Default

This parameter is used in the spot market environment. The N3 value is TAREA used by spot market. X1 is the TRANS AREA number; currently this should be one. The A1 value will over ride any TAREA NAME parameter set for the N3 TAREA.
 N3 Tarea number.
 N1, N2, N3 not used.
 A1 Trans area name.

TRANS AREA STA

Internal to PowrSym4 the spot market area has a pseudo-generating unit. A unique station number must be assigned to this pseudo-generating unit. This station number must not be used in any other Tarea.

Tarea links must be set up for the spot market area. To and From links, link caps, and link losses, if applicable.

Modifying Electric Loads in a Simulation

The user has much flexibility in dealing with loads for the system and for the areas. Since PowrSym4 reads the load files by years to schedule maintenance and to calculate reliability statistics, most load modification records should be in the first week of the FY. If execution is started in mid year, weekly load modification records are processed; however, when the first week of the fiscal year is processed, the load modification records are ignored until the start of the next year.

LOAD ADDER

This aid permits a constant Mw adjustment for the hourly loads for the weeks specified by N1 and N2. The adder can be positive or negative. All LOAD ADDER records should be read the first week of the fiscal year.

	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	7	22	0	0	LOAD ADDER	SYSTEM	500	LA	None

View Input Definitions

Select the variable you want defined
LOAD ADDER Show All Variables Sort Variables by category Close

Variable Definition

LOAD ADDER

SYSTEM **Category**

-5000 **Minimum**

5000 **Maximum**

0 **Default**

X1 is the constant megawatt adjustment to be made to all area 1 hourly loads. This adjustment is in addition to the load multiplier (LOAD MULT) adjustment. Note that this is a weekly pattern variable. The adjustments are made the first week of the fiscal year.

N1 is Start week (set to 1 if 0 entered)
N2 is End week (set to 52 if 0 entered)

N3,N4 not used

A1 is SYSTEM

LOAD MULT

This is a load multiplier applied to the hourly loads for the weeks specified by N1 and N2. The records should be read the first week of the fiscal year. The multiplier should be positive. An X1 value of zero will zero all hourly loads. An X1 of one will result in no modification. The adjusted load will be: $\text{load} * (\text{LOAD MULT}) + (\text{LOAD ADDER})$.

	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	0	0	LOAD MULT	SYSTEM	1	b	None

TAREA LOAD ADJ

This aid is similar to LOAD ADDER, but it is not a weekly pattern variable. The Mw adjustment applies to all hourly loads for the tarea specified by N3. The X1 value may be positive or negative. The record should be read the first week of the fiscal year.

The screenshot shows a software window titled "View Input Definitions". At the top, there is a dropdown menu with "TAREA LOAD ADJ" selected, a "Show All Variables" button, a "Sort Variables by category" dropdown, and a "Close" button. Below this is a "Variable Definition" section. On the left, there is a list of fields: "TAREA LOAD ADJ", "TRANSAREA", "Category", "Minimum", "Maximum", and "Default", each with a corresponding input box. The "Minimum" and "Default" boxes contain the value "0". On the right, there is a text area containing the following text: "X1 is the constant megawatt adjustment to be made to all hourly loads for this transarea. N3 is transarea number N4 not used A1 is transarea name (optional) Note: if TAREA LOAD FLAG = 1, adjusted Tarea load=(system load)*(TAREA SYS PORT) + (TAREA LOAD ADJ) if TAREA LOAD FLAG = 0, Adjusted Tarea load = (Tarea load)*(TAREA SYS PORT)+(TAREA LOAD ADJ)".

TAREA SYS PORT

This aid serves two functions. If the X1 value of TAREA LOAD FLAG is zero for this tarea, the TAREA SYS PORT is similar to LOAD MULT except that TAREA SYS PORT is not a weekly pattern variable. If the TAREA LOAD FLAG X1 is one, the X1 of TAREA SYS PORT specifies the load for this tarea as a percentage of the system load. TAREA SYS PORT records should be read the first week of the fiscal year.

TAREA LOAD FLAG

This aid is used to specify if the loads for this tarea are to come from a file or are to be determined otherwise. If the X1 value is set to one, PowrSym4 will not attempt to open a load file for this area.

View Input Definitions

Select the variable you want defined: **Show All Variables** Sort Variables by category: **Close**

Variable Definition

Category

Minimum

Maximum

Default

The X1 flag determines if there is a separate load file for this transarea or if the transarea serves a portion of the system load.

- 0 - Separate load file for this transarea.
- 1 - Transarea load is a portion of the system load (See TAREA SYS PORT).

N3 is transarea number
A1 is transarea name
N1,N2,N4 not used

Uncertainty

Uncertainty on load forecast, hydro generation, market prices, fuel costs, and unit availabilities may be addressed using the Monte Carlo feature of PowrSym4. Any one of these items may be treated with uncertainty, or any combination including all five.

PowrSym4 makes draws from a uniform distribution to determine load, hydro generation, market price, fuel cost, and unit availability. There are many draws in a game (one case), and as many games (iterations) as desired executed in one PowrSym4 run. Typically, if interested in total system results such as total production costs, a few iterations will suffice, ten or less. If the outcome for a particular unit is of interest, several iterations may be necessary 20 to 50. Seldom would as many as 100 iterations be necessary. The number of iterations is set with the Aid, MCARLO ITER. The Aid OUTAGE TYPE must be set to 3 or greater.

PowrSym4 outputs the average of the results in print files and in the ofc files for weekly, monthly, and annual reports. Results from each iteration are output in the hourly, daily, and weekly ofc files. The average of all iterations is output in the daily and weekly files. If iteration statistics are desired for monthly, cy, and fy periods, the daily values may be imported into the Analyzer and appropriate columns copied to a spreadsheet for graphing or further analyses. The COMMIT REPORT, F01, has the option to print results from all iterations or to print iteration 1 results only. N4 on the COMMIT REPORT record controls this output. N4=0 prints results of all iterations. N4=1 prints results of iteration 1 only.

Loads

This feature of PowrSym4 permits different loads to be used for each iteration of a multi-iteration study. This is useful when a range of answers is desired such as in a fuel burn study.

IYR	IWM	N1	N2	N3	N4	AID	A1	X1	CLASS	COMME
1996	1	1	52	1	1	TAREA LOAD DEV	SYSTEM	0.95	LDU	None
1996	1	1	52	1	1	TAREA LOAD PROB	SYSTEM	0.25	LDU	None
1996	1	1	52	1	2	TAREA LOAD DEV	SYSTEM	1	LDU	None
1996	1	1	52	1	2	TAREA LOAD PROB	SYSTEM	0.5	LDU	None
1996	1	1	52	1	3	TAREA LOAD DEV	SYSTEM	1.05	LDU	None
1996	1	1	52	1	3	TAREA LOAD PROB	SYSTEM	0.25	LDU	None
1996	1	1	52	1	4	TAREA LOAD DEV	SYSTEM	1	LDU	None
1996	1	1	52	1	4	TAREA LOAD PROB	SYSTEM	0	LDU	None
1996	1	1	52	1	5	TAREA LOAD DEV	SYSTEM	1	LDU	None
1996	1	1	52	1	5	TAREA LOAD PROB	SYSTEM	0	LDU	None

In this example the tarea 1 (N3) loads will be drawn for each iteration according to the TAREA LOAD PROB X1 value. In this case there are effectively 3 loads that may be drawn: The basic load having a 50% chance of being drawn; loads that are 0.95 of the basic load with a 25% chance of being drawn; and loads that are 1.05 of the basic load also with a 25% chance of being drawn. TAREA LOAD PROB is the probability of the TAREA LOAD DEV being drawn. Note that N4 associates a DEV with a PROB. The sum of the probabilities should be 1.0 for each tarea. One of the loads is drawn for each iteration. The average load will converge to the expected value in 10 to 25 iterations. Most PowrSym4 executables are dimensioned for up to 5 load probabilities and deviations. If more are needed, OSA can compile a version for the number desired.

TAREA LOAD CNTL

This aid in combination with others discussed below may be used to produce an hourly load forecast using loads from a pattern year and the forecasted peaks and energies. If the X1 value is -1, the load file with the pattern year loads is read without checking the dates. The first 8736 hourly loads are read and used as the pattern year.

IYR	IWM	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
1996	1	0	0	1	0	TAREA LOAD CNTL	SYSTEM	-10	TLC	NONE

TAREA LOAD HRS

This aid specifies the number of hours in each period to be forecasted. The period may be week, month, or year.

IYR	IWP	N1	N2	N3	N4	AID	A1	X1	CLA	COMM
1999	1	0	0	2	1	TAREA LOAD HRS	TAREA2	720	B	NONE
1999	1	0	0	2	2	TAREA LOAD HRS	TAREA2	672	B	NONE
1999	1	0	0	2	3	TAREA LOAD HRS	TAREA2	744	B	NONE
1999	1	0	0	2	4	TAREA LOAD HRS	TAREA2	720	B	NONE
1999	1	0	0	2	5	TAREA LOAD HRS	TAREA2	744	B	NONE
1999	1	0	0	2	6	TAREA LOAD HRS	TAREA2	720	B	NONE
1999	1	0	0	2	7	TAREA LOAD HRS	TAREA2	744	B	NONE
1999	1	0	0	2	8	TAREA LOAD HRS	TAREA2	744	B	NONE
1999	1	0	0	2	9	TAREA LOAD HRS	TAREA2	720	B	NONE
1999	1	0	0	2	10	TAREA LOAD HRS	TAREA2	744	B	NONE
1999	1	0	0	2	11	TAREA LOAD HRS	TAREA2	720	B	NONE
1999	1	0	0	2	12	TAREA LOAD HRS	TAREA2	744	B	NONE

In this example the hours in the X1 field are for the months beginning with January. Note that January is listed as having 720 hours instead of 744 hours because PowrSym4 simulates 52 weeks, which equals 8736 hours or 364 days. The missing day is taken from the first month of the fiscal year, January in this example. If weeks were to be represented, the X1 value would be 168. It is important that the values in TAREA LOAD HRS match the hours the energy forecast represent. TAREA LOAD HRS need to be entered only one time in a multi-year case since they do not change from year to year.

TAREA LOAD PEAK

This aid specifies the peak load for each time period defined by TAREA LOAD HRS. They are related by the N4 values.

IYR	IWP	N1	N2	N3	N4	AID	A1	X1	CLA	COMM
1999	1	0	0	2	1	TAREA LOAD PEAK	TAREA2	15662	B	NONE
1999	1	0	0	2	2	TAREA LOAD PEAK	TAREA2	14395	B	NONE
1999	1	0	0	2	3	TAREA LOAD PEAK	TAREA2	13134	B	NONE
1999	1	0	0	2	4	TAREA LOAD PEAK	TAREA2	15210	B	NONE
1999	1	0	0	2	5	TAREA LOAD PEAK	TAREA2	14792	B	NONE
1999	1	0	0	2	6	TAREA LOAD PEAK	TAREA2	17099	B	NONE
1999	1	0	0	2	7	TAREA LOAD PEAK	TAREA2	14861	B	NONE
1999	1	0	0	2	8	TAREA LOAD PEAK	TAREA2	14452	B	NONE
1999	1	0	0	2	9	TAREA LOAD PEAK	TAREA2	12439	B	NONE
1999	1	0	0	2	10	TAREA LOAD PEAK	TAREA2	14287	B	NONE
1999	1	0	0	2	11	TAREA LOAD PEAK	TAREA2	11950	B	NONE
1999	1	0	0	2	12	TAREA LOAD PEAK	TAREA2	11579	B	NONE

TAREA LOAD ENGY

This aid specifies the forecasted energies corresponding to the periods specified by TAREA LOAD HRS. They are related by the N4 values.

IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLA	COMM
1999	1	0	0	2	1	TAREA LOAD ENGY	SYSTEM	1994	B	NONE
1999	1	0	0	2	2	TAREA LOAD ENGY	SYSTEM	1738	B	NONE
1999	1	0	0	2	3	TAREA LOAD ENGY	SYSTEM	1810	B	NONE
1999	1	0	0	2	4	TAREA LOAD ENGY	SYSTEM	1973	B	NONE
1999	1	0	0	2	5	TAREA LOAD ENGY	SYSTEM	1931	B	NONE
1999	1	0	0	2	6	TAREA LOAD ENGY	SYSTEM	2121	B	NONE
1999	1	0	0	2	7	TAREA LOAD ENGY	SYSTEM	1899	B	NONE
1999	1	0	0	2	8	TAREA LOAD ENGY	SYSTEM	1754	B	NONE
1999	1	0	0	2	9	TAREA LOAD ENGY	SYSTEM	1763	B	NONE
1999	1	0	0	2	10	TAREA LOAD ENGY	SYSTEM	1749	B	NONE
1999	1	0	0	2	11	TAREA LOAD ENGY	SYSTEM	1600	B	NONE
1999	1	0	0	2	12	TAREA LOAD ENGY	SYSTEM	1595	B	NONE

The TAREA LOAD XXX records should be entered the first week of the fiscal year.

Hydro

Hydro generation varies with the amount of rainfall. The associated uncertainty may be simulated using the Aids, HYDRO PROB, HYDRO ERG DEV, HYDRO MAX DEV, and HYDRO MIN DEV.

IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMM
1996	1	1	52	1	1	HYDRO ERG DEV	SYSTEM	0.9	HYU	None
1996	1	1	52	1	1	HYDRO MAX DEV	SYSTEM	0.9	HYU	None
1996	1	1	52	1	1	HYDRO MIN DEV	SYSTEM	1	HYU	None
1996	1	1	52	1	1	HYDRO PROB	SYSTEM	0.1	HYU	None
1996	1	1	52	1	2	HYDRO ERG DEV	SYSTEM	0.95	HYU	None
1996	1	1	52	1	2	HYDRO MAX DEV	SYSTEM	0.95	HYU	None
1996	1	1	52	1	2	HYDRO MIN DEV	SYSTEM	1	HYU	None
1996	1	1	52	1	2	HYDRO PROB	SYSTEM	0.2	HYU	None
1996	1	1	52	1	3	HYDRO ERG DEV	SYSTEM	1	HYU	None
1996	1	1	52	1	3	HYDRO MAX DEV	SYSTEM	1	HYU	None
1996	1	1	52	1	3	HYDRO MIN DEV	SYSTEM	1	HYU	None
1996	1	1	52	1	3	HYDRO PROB	SYSTEM	0.4	HYU	None
1996	1	1	52	1	4	HYDRO ERG DEV	SYSTEM	1.05	HYU	None
1996	1	1	52	1	4	HYDRO MAX DEV	SYSTEM	1	HYU	None
1996	1	1	52	1	4	HYDRO MIN DEV	SYSTEM	1.05	HYU	None
1996	1	1	52	1	4	HYDRO PROB	SYSTEM	0.2	HYU	None
1996	1	1	52	1	5	HYDRO ERG DEV	SYSTEM	1.1	HYU	None
1996	1	1	52	1	5	HYDRO MAX DEV	SYSTEM	1	HYU	None
1996	1	1	52	1	5	HYDRO MIN DEV	SYSTEM	1.1	HYU	None
1996	1	1	52	1	5	HYDRO PROB	SYSTEM	0.1	HYU	None
0	0	0	0	0	0			0		

In this example there are five hydro scenarios. The expected value with N4=3 has a probability of occurrence of 0.4. There is a 20% probability of either 0.95 or 1.05 of normal occurring, and a 10% chance of either 0.9 or 1.1 of normal occurring.

Note that these are weekly pattern variables. In this example all 52 weeks have the same deviations and probabilities, but a set of values may be entered for each week or for a set of weeks representing seasonal variations for example.

Market Price

Uncertainty in market price may be simulated using the Aids, SPOT COST DEV and SPOT PROB.

1996	1	0	0	0	1	SPOT COST DEV	SPOT	0.9	SU	NONE
1996	1	0	0	0	1	SPOT PROB	SPOT	0.2	SU	NONE
1996	1	0	0	0	2	SPOT COST DEV	SPOT	0.95	SU	NONE
1996	1	0	0	0	2	SPOT PROB	SPOT	0.2	SU	NONE
1996	1	0	0	0	3	SPOT COST DEV	SPOT	1	SU	NONE
1996	1	0	0	0	3	SPOT PROB	SPOT	0.2	SU	NONE
1996	1	0	0	0	4	SPOT COST DEV	SPOT	1.05	SU	NONE
1996	1	0	0	0	4	SPOT PROB	SPOT	0.2	SU	NONE
1996	1	0	0	0	5	SPOT COST DEV	SPOT	1.1	SU	NONE
1996	1	0	0	0	5	SPOT PROB	SPOT	0.2	SU	NONE

In this example there is a 20% chance of occurrence on each of the deviations ranging from 0.9 to 1.1. These deviations are applied to the Spot Market file.

Fuel Cost

PowrSym4 has provision for entering fuel cost via three different Aids, FCOST, FUEL COST, and ELF COST. FCOST is perhaps the most straightforward. It is the fuel cost associated with the unit designated by the N3 value on the FCOST record.

ELF COST is the cost of a particular energy limited fuel. Characteristics of each are defined with appropriate Aids. Elf fuels are associated with a particular generating unit with the Aid, STA ELF INDEX.

FUEL COST is the cost of a particular fuel which characteristics are defined with appropriate Aids. Fuels are associated with generating units with the Aid, STA FUEL MIXING.

FUEL COST is the only one of the fuels that may be treated with uncertainty. The uncertainty records are FUEL COST PROB and FUEL COST DEV.

IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
1996	1	1	52	14	1	FUEL COST DEV	SPOT NG	0.9	FCU	None
1996	1	1	52	14	2	FUEL COST DEV	SPOT NG	0.95	FCU	None
1996	1	1	52	14	3	FUEL COST DEV	SPOT NG	1	FCU	None
1996	1	1	52	14	4	FUEL COST DEV	SPOT NG	1.05	FCU	None
1996	1	1	52	14	5	FUEL COST DEV	SPOT NG	1.1	FCU	None
1996	1	1	52	14	1	FUEL COST PROB	SPOT NG	0.1	FCU	None
1996	1	1	52	14	2	FUEL COST PROB	SPOT NG	0.2	FCU	None
1996	1	1	52	14	3	FUEL COST PROB	SPOT NG	0.4	FCU	None
1996	1	1	52	14	4	FUEL COST PROB	SPOT NG	0.2	FCU	None
1996	1	1	52	14	5	FUEL COST PROB	SPOT NG	0.1	FCU	None
1996	1	1	52	14	0	FUEL COST TIME	SPOT NG	1	FCU	None
1996	1	0	0	0	0	MCARLO ITER	SYSTEM	5	B	None
1996	1	0	0	0	0	OUTAGE TYPE	SYSTEM	3	B	None

The X1 value on the FUEL COST TIME record determines the frequency of draws. X1=1 for hourly; =2 for daily; and =3 for weekly.

Unit Availability

If a unit has a forced outage rate of 0.1, then it is available 0.9. Each draw the unit is either available or unavailable. The frequency of draws is set by user input with the Aid, OUTAGE TYPE.

```
1996  1    0    0    0    0 OUTAGE TYPE      SYSTEM      60 OTN None |
```

The OTN in the class column is user defined. Typically a user would use class=B. In this example draws are made at hour 1, hour 61, and hour 121, hour 120 being Friday at midnight, so that the last draw at hour 121 covers the weekend.

A separate draw is made for each station.

If OUTAGE TYPE X1=6, then the outage length may be read from the OUTAGE LENGTH record. The frequency of draws may be set by station by setting N3=the station number on the OUTAGE LENGTH record. The X1 value in this case applies to this station only. If N3=0 on the OUTAGE LENGTH record, the X1 value is a system value and applies to all stations. If an outage length is set for each station using N3=the station number, do not include an OUTAGE LENGTH record with N3=0.

Simulating Forced Outages

In simulating production cost for an electric utility, the unplanned/unscheduled outages of individual units is one of the operational characteristics that must be modeled. There are several methods for modeling forced outages. PowrSym4 uses the OUTAGE TYPE parameter to establish the method. The two most commonly used values for OUTAGE TYPE are: 1 for the derated method; and 2 for the Monte Carlo method.

FOR

This is the AID for the forced outage rate for a station in which N3 is the station number. A five percent forced outage rate is entered as 0.05. This is a weekly pattern variable. The N1 and N2 values are weeks of the year for which this parameter is applicable. N2 should always be greater than or equal to N1.

View Input Definitions

Select the variable you want defined: Sort Variables by category:

Variable Definition

Category

Minimum

Maximum

Default

X1 is the equivalent forced outage rate for this station. It is the percentage of time that the station is unavailable due to equipment failure. The value is used by the model to determine the weekly availability of the station. A weekly pattern may be applied using the N1 and N2 variables or the value will be applied to all weeks if N1 and N2 are not entered.
(Enter 0.05 for 5%)

N1 is begin week (set to 1 if 0 entered)
N2 is end week (set to 52 if 0 entered)
N3 is station number
A1 is station name

Note: Must be read first week of year.

N4 is not used

OUTAGE TYPE

PowrSym4 has several options for simulating forced outages. With the derated method the station forced outage rate, FOR, is subtracted from one and multiplied by the station capability. For example, a 100 MW unit with a 10% forced outage rate will be simulated as having 90 MW available for generation at all times. Energy output should be about the same as that from a Monte Carlo simulation with several iterations, but costs will generally be lower for the derated method than the average from Monte Carlo simulations. The Monte Carlo method makes draws from a uniform distribution to determine the state of a unit, so the unit is actually available for operation at full capability or is on forced outage. With the Monte Carlo method, a range of answers is obtained which may be useful in fuel burn studies, etc. Using the Monte Carlo method, PowrSym4 checks for unit failure each unit draw period. Each unit has a draw period that is the maximum of the outage length, the minimum down time, and the unit minimum up time. For example, if a unit has a minimum up time of 168 hours, it is only checked once per week even though the outage length might be 60 hours.

View Input Definitions

Select the variable you want defined: Sort Variables by category:

Variable Definition

Category

Minimum

Maximum

Default

The X1 flag identifies the forced outage calculation method to be used.
0 = Read a fixed outage schedule file 03, or simulate no forced outages.
1 = Derated method.(Must start execution with first week of year)
2 = Gradient derated method.
3 = Random Monte Carlo method.
4 = Selected sample Monte Carlo method.
5 = Semi-guided Monte Carlo method.
6 = Read hours between random Monte Carlo draws from OUTAGE LENGTH
7 to 168 = Number of hours between random Monte Carlo method draws[will be set to maximum of: X1, minimum up time, or minimum down time by station.

N1,N2,N3,N4 not used
A1 is SYSTEM

GENERIC : Table											
	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	0	0	OUTAGE TYPE	SYSTEM	1	B	None
*	0	0	0	0	0	0			0		

MCARLO ITER

If the OUTAGE TYPE is greater than two, this parameter determines how many times each week is simulated. Total system cost will normally converge with one iteration if draws are made every sixty hours; however, if costs for a particular unit are of interest, more iterations are required for a converged answer for that unit.

View Input Definitions

Select the variable you want defined: Sort Variables by category:

Variable Definition

Category

Minimum

Maximum

Default

X1 is the number of Monte Carlo iterations. Effective when OUTAGE TYPE is 3 or greater.
 N1 is beginning week.
 N2 is ending week.
 N3,N4 not used
 A1 is SYSTEM

Spinning and Operating Reserves

The PowrSym4 logic for spinning and operating reserves is based on guidelines established by the North American Electric Reliability Council (NERC). To qualify as spinning reserves the resource must be online. The difference between generator capability and generator output contributes to spinning reserves for online units. To qualify for operating reserves, the resource must be available within 10 minutes. Quick start units qualify as operating reserves even if not online. The difference between hydro capability and hydro generation contributes to both spinning and operating reserves. Spinning reserves are counted as operating reserves, but not vice versa in all cases.

Each station is assigned a SPIN STATUS to determine its capability for contributing to spinning and operating reserves. A SPIN STATUS of -1 (X1) designates the unit as a quick start unit. If idle, the full capability contributes to operating reserves. If online, the difference between full capability and dispatch contributes to both spinning and operating reserves.

A SPIN STATUS of 0 (X1) designates the unit as a base load unit. If idle, it contributes nothing to spinning or operating reserves. Online the difference between capability and dispatch contributes to both spinning and operating reserves.

A SPIN STATUS of 1 (X1) designates the unit as nonfirm. It contributes nothing to spinning and operating reserves regardless of its commit and dispatch status.

Spinning reserve is calculated as the difference between capability (of units with SPIN STATUS X1=0 or -1) and demand (load). Consequently, nonfirm units contribute nothing toward spinning or operating reserves.

Spinning and operating reserves may be designated by system or tarea aids but not by both. If tarea requirements are to be used, the SYS OR FLAG and SYS SR FLAG should be set to 0. Setting the SYS SR MW, SYS SR PCT and corresponding OR aids to zero does not accomplish the same as setting the flags to zero. Reserve requirements can be set for each tarea using the tarea OR and SR aids.

If it is desired to have a particular unit contribute a specified amount to operating reserves, the aids OR RESERVED MW or OR RESERVED PCT may be used. For example, if the X1 of OR RESERVED MW for station 10 (N3) is set to 50. The last 50 MW of this station will not be dispatched unless it is necessary to avoid unserved energy.

If it is desired to limit the amount a unit can contribute to operating reserves, the aids OR UNUSED MW and OR UNUSED PCT may be used. For example, if it is desired to limit the contribution of a unit to 25 MW, set the X1 value to 25 on the OR UNUSED MW record for that station. It may then contribute up to 25 MW but not more.

A PERIOD DEFINE record or records must be used with the four aids, OR RESERVED MW, OR RESERVED PCT, OR UNUSED MW, and OR UNUSED PCT. The N4 of each of these four aids indicates the pattern to be used as defined by the PERIOD DEFINE aid. Pattern 1 might be all hours in the week which would require only one PERIOD DEFINE record with N1=1 and N2=168. In the example shown below pattern 1 (X1) defines NERC off-peak hours (N1 and N2) and pattern 2 (X1) defines NERC peak hours.

PEAK/OFFPEAK : Table											
	IYR	IWM	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
	2005	1	1	6	0	0	PERIOD DEFINE	SYSTEM	1	B	NERC
	2005	1	7	22	0	0	PERIOD DEFINE	SYSTEM	2	B	NERC
	2005	1	23	30	0	0	PERIOD DEFINE	SYSTEM	1	B	NERC
	2005	1	31	46	0	0	PERIOD DEFINE	SYSTEM	2	B	NERC
	2005	1	47	54	0	0	PERIOD DEFINE	SYSTEM	1	B	NERC
	2005	1	55	70	0	0	PERIOD DEFINE	SYSTEM	2	B	NERC
	2005	1	71	78	0	0	PERIOD DEFINE	SYSTEM	1	B	NERC
	2005	1	79	94	0	0	PERIOD DEFINE	SYSTEM	2	B	NERC
	2005	1	95	102	0	0	PERIOD DEFINE	SYSTEM	1	B	NERC
	2005	1	103	118	0	0	PERIOD DEFINE	SYSTEM	2	B	NERC
	2005	1	119	126	0	0	PERIOD DEFINE	SYSTEM	1	B	NERC
	2005	1	127	142	0	0	PERIOD DEFINE	SYSTEM	2	B	NERC
	2005	1	143	168	0	0	PERIOD DEFINE	SYSTEM	1	B	NERC
*	0	0	0	0	0	0			0		

These pattern hours in combination with the records in the following table indicate when the OR RESERVED MW restrictions are in effect. For example, unit 15 (Named A) has 5 Mw reserved for operating reserves during NERC peak hours and 0 Mw reserved for operating reserves during NERC off-peak hours.

ORRESERVEDMW : Table											
	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMEI
	2005	1	0	0	15	2	OR RESERVED MW	A	5	B	None
	2005	1	0	0	32	2	OR RESERVED MW	B	10	B	None
	2005	1	0	0	46	2	OR RESERVED MW	C	15	B	None
	2005	1	0	0	47	2	OR RESERVED MW	D	20	B	None
	2005	1	0	0	66	2	OR RESERVED MW	E	25	B	None
	2005	1	0	0	68	2	OR RESERVED MW	F	30	B	None
	2005	1	0	0	69	2	OR RESERVED MW	G	35	B	None
	2005	1	0	0	70	2	OR RESERVED MW	H	40	B	None
	2005	1	0	0	74	2	OR RESERVED MW	I	45	B	None
	2005	1	0	0	15	1	OR RESERVED MW	A	0	B	None
	2005	1	0	0	32	1	OR RESERVED MW	B	0	B	None
	2005	1	0	0	46	1	OR RESERVED MW	C	0	B	None
	2005	1	0	0	47	1	OR RESERVED MW	D	0	B	None
	2005	1	0	0	66	1	OR RESERVED MW	E	0	B	None
	2005	1	0	0	68	1	OR RESERVED MW	F	0	B	None
	2005	1	0	0	69	1	OR RESERVED MW	G	0	B	None
	2005	1	0	0	70	1	OR RESERVED MW	H	0	B	None
	2005	1	0	0	74	1	OR RESERVED MW	I	0	B	None
*	0	0	0	0	0	0			0		
Record: 18 of 18											

Simulating System Reserves

The simulation of spinning and operating reserves in PowrSym4 can be very complex. PowrSym4 is a multi-area model. Transareas are the basic areas modeled. Transareas can be combined into control areas. The control area's primary purpose is for modeling reserves. System parameters control reserves for the total system. If system reserve parameters are used, transarea and control area parameters should not be used and vice versa. PowrSym4 models both spinning and operating reserves. In general, reserves are the difference between the units maximum capability and the level at which they are dispatched. Spinning reserves are defined (by NERC) as reserves that are immediately available from units online. Operating reserves are those available in 10 minutes. Spinning reserves qualify as operating reserves, but all operating reserves may not qualify as spinning reserves.

SPIN STATUS

A SPIN STATUS of -1 means the unit is a quick start unit. It can contribute to operating reserves when idle. A SPIN STATUS of 0 is assigned to base load units. They must be committed and online to contribute to operating reserves. Non-firm capacity is assigned a SPIN STATUS of 1, which does not contribute to spinning or operating reserves. N3 is the station number.

▶	1996	1	0	0	1	0	SPIN STATUS	HYDRO	-1	B	None
	1996	1	0	0	2	0	SPIN STATUS	HYDRO	-1	HY2	None
	1996	1	0	0	3	0	SPIN STATUS	PHYDRO	-1	B	None
	1996	1	0	0	4	0	SPIN STATUS	CAES	0	CAE	None
	1996	1	0	0	5	0	SPIN STATUS	COAL12	0	B	None
	1996	1	0	0	6	0	SPIN STATUS	COAL34	0	B	None
	1996	1	0	0	7	0	SPIN STATUS	COAL5	0	B	None
	1996	1	0	0	8	0	SPIN STATUS	COAL6	0	B	None
	1996	1	0	0	9	0	SPIN STATUS	COAL7	0	B	None
	1996	1	0	0	10	0	SPIN STATUS	COAL8	0	B	None
	1996	1	0	0	11	0	SPIN STATUS	CT	0	B	None
	1996	1	0	0	13	0	SPIN STATUS	PURCH1	1	B	None

SYS OR FLAG

When the X1 value is set to 1, system-operating reserves are enforced. When set to 0, system operating reserve requirements are not enforced. If it is desired to enforce TAREA or CAREA reserve requirements, the SYS OR FLAG X1 value should be set to 0 even if the SYS OR MW and SYS OR PCT values are set at 0.

	IYR	IWM	N1	N2	N3	N4	AID	A1	X1	CLASS	COMMENT
▶	1996	1	0	0	0	0	SYS OR FLAG	SYSTEM	1	B	None
	1996	1	0	0	0	0	SYS OR MW	SYSTEM	0	B	None
	1996	1	0	0	0	0	SYS OR PCT	SYSTEM	0.06	B	None

TAREA OR FLAG

The tarea indicated by N3 will have its reserve requirements enforced when X1 is 1.

CAREA OR FLAG

The carea denoted by N3 will have its reserve requirements enforced when X1 is 1.

SYS OR MW

System operating reserves are set at the value indicated by X1 if the SYS OR FLAG is in effect. Total system operating reserve requirement is the sum of SYS OR MW and SYS OR PCT. PowrSym4 attempts to meet the reserve requirements, but when resources are insufficient to meet load and reserves, there is no warning that reserves are not met; however, violations are reported in output files.

TAREA OR MW

Operating reserves for tarea N3 are set at the X1 value plus the TAREA OR PCT.

CAREA OR MW

Operating reserves for carea N3 are set at the X1 value plus the CAREA OR PCT. Carea and Tarea operating reserves may be required and enforced simultaneously.

SYS OR PCT

System operating reserves are set at the value indicated by X1 if the SYS OR FLAG is in effect. Total system operating reserves is the sum of SYS OR MW and SYS OR PCT. PowrSym4 attempts to meet the reserve requirements, but when resources are insufficient to meet load and reserves, there is no warning that reserves are not met. (Enter 0.05 for 5%).

TAREA OR PCT

Operating reserves for tarea N3 are set at the X1 value plus the TAREA OR MW.

CAREA OR PCT

Operating reserves for carea N3 are set at the X1 value plus the CAREA OR MW. Carea and Tarea operating reserves may be required and enforced simultaneously.

SYS SR FLAG

When the X1 value is set to 1, system-spinning reserve requirements are enforced. When set to 0, system spinning reserve requirements are not enforced. If it is desired to enforce TAREA or CAREA reserve requirements, the SYS OR FLAG X1 value should be set to 0 even if the SYS OR MW or SYS OR PCT values are set at 0.

TAREA SR FLAG

The tarea N3 will have its spinning reserve requirements enforced when X1 is 1.

CAREA SR FLAG

The carea N3 will have its spinning reserve requirements enforced when X1 is 1.

SYS SR MW

System spinning reserves are set at the value indicated by X1. Total system spinning reserves is the sum of SYS SR MW and SYS SR PCT. PowrSym4 attempts to meet the reserve requirements, but when resources are insufficient to meet load and reserves, there is no warning that reserves are not met.

TAREA SR MW

Spinning reserves for tarea N3 are set at the X1 value plus the TAREA SR PCT.

CAREA SR MW

Spinning reserves for carea N3 are set at the X1 value plus the CAREA SR PCT. Carea and Tarea operating reserves may be required and enforced simultaneously.

SYS SR PCT

System spinning reserves are set at the value indicated by X1. Total system operating reserves is the sum of SYS SR MW and SYS SR PCT. PowrSym4 attempts to meet the reserve requirements, but when resources are insufficient to meet load and reserves, there is no warning that reserves are not met. (Enter 0.05 for 5%).

TAREA SR PCT

Spinning reserves for tarea N3 are set at the X1 value plus the TAREA SR MW.

CAREA SR PCT

Spinning reserves for carea N3 are set at the X1 value plus the CAREA SR MW. Carea and Tarea operating reserves may be required and enforced simultaneously.

PERIOD DEFINE

This system parameter is an index that defines the hours of the week set by the N1 and N2 values. The X1 value identifies the period, i.e., period 1, period 2, etc. Other parameters point to this index to create station specific hourly pattern values. The user should take care that parameters pointing to period define indexes do not overlap.

OR RESERVED MW

This parameter is specific to station N3 and for the hours of the week defined by the PERIOD DEFINE index pointed to by the N4 value. The parameter is the megawatts at this station that are reserved to meet operating reserve requirements.

OR RESERVED PCT

This parameter is specific to station N3 and for the hours of the week defined by the PERIOD DEFINE index pointed to by the N4 value. The parameter is the per unit of full load capability at this station that is reserved to meet operating reserve requirements. If three percent of full load capability of this station is reserved to meet operating reserves, the X1 value should be entered as 0.03.

OR UNUSED MW

This parameter is specific to station N3 and for the hours of the week defined by the PERIOD DEFINE index pointed to by the N4 value. The parameter is the maximum of the non-dispatched megawatts at this station that can be used to meet operating reserve requirements. If a system is limited in the amount of non-dispatched capability that contributes to reserves, then the megawatts that a unit can ramp in a

specified period of time (usually fifteen minutes) is the value recommended for this parameter.

OR UNUSED PCT

This parameter is specific to station N3 and for the hours of the week defined by the PERIOD DEFINE index pointed to by the N4 value. The parameter is the maximum of the non-dispatched megawatts at this station that can be used to meet operating reserve requirements. This parameter is the per unit of full load capacity that can be used. A three percent requirement should be entered as 0.03.

Reliability—LOLP, LOLE

System loss-of-load probability (LOLP) is output to file 16. The standard, which is a fast approximation, is always output to file 16. If a more accurate determination of LOLP is desired, set X1=2 on the HR LOLP TYPE record. N3 determines if LOLP is calculated for the system, N3=0, system plus Careas, N3=1, or for the system plus Tareas, N3=2. CAREA LOLP FLAG and TAREA LOLP FLAG must be set appropriately. X1 of the RELI PRINT FLAG must be set to 1 to obtain the reli LOLP information in the file 16.

For one hour the reported LOLP for that hour is the per unit of the hour that load exceeds resources, but typically these hourly values are summed to obtain weekly or annual values. These values are not probabilities but are typically termed days per year, such as 1 day in 10 years failure to meet load.

LOLE is set to 1 (one) for any hour in which there is energy not served (ENS) in any tarea.

System Marginal Costs

PowrSym4 has an option to calculate and output system hourly marginal costs for a step size (Mw) chosen by the user. For example, if the user chooses a step size of a negative 10Mw, the model determines the cost of serving the top ten Mw. The two Aids required to implement this feature are:

DEM01 : Table											
	IYR	IWK	N1	N2	N3	N4	AID	A1	X1	CLASS	CO
	1996	1	0	0	1	0	MCOST FLAG	SYSTEM	2	B	None
	1996	1	0	0	0	0	MCOST STEP	SYSTEM	-10	B	None
*	0	0	0	0	0	0			0		

In this example the marginal cost for the top ten Mw will be determined and reported to file 02 (File 02 should be named in the control file.). The 2 in the X1 field of the MCOST FLAG record indicates that reports (of loads etc) should be for the original loads. A one in the X1 field indicates that the loads plus the MCOST STEP should be reported. (In this example the reported loads would be decreased by 10 Mw for reporting if X1=1.)

The N3 designates a Tarea number. The logic is that a load change in Tarea N3 yields a system marginal cost as reported for the hour.

If it is desired to obtain incremental costs for steps other than the top block as discussed above, a file of incremental/decremental costs may be obtained by setting X1=3 on the MCOST FLAG record. This produces a file of costs for 250 steps for each hour. The step size is set by the user with the PHYD DISP STEP record. If the marginal cost is defined as the cost of the last increment of load served, this incremental/decremental file contains 125 costs up to and including the marginal cost plus 125 costs above marginal cost for each hour. For example, if the step size were set at 100 Mw, for each hour the file would contain costs for 125 one hundred Mw steps below top of load and for 125 one hundred Mw steps above load. The incremental/decremental data are output to file 21 which should be named in the control file. Alternatively, the incremental/decremental data may be output in comma separated variable (csv) format by setting N4=4 on the MCOST FLAG record.

Typically, it is desired to calculate marginal costs without permitting recommitment when the MCOST STEP is applied, but at times it is desirable to permit recommitment for the adjusted load. Setting X1=5 on the MCOST FLAG permits recommitment for the loads adjusted for the MCOST STEP. The resultant file of hourly marginal costs will not be as smooth as the data obtained when recommitment is not permitted. Some marginal costs may be negative when recommitment is permitted.

Start costs for the marginal unit may be added to the marginal costs each hour with the following options:

1. Start costs are spread over the operating hours in the week for each unit. The distributed hourly start cost for the marginal unit is added to the marginal cost for the hour.
2. Start costs are spread over the current operating period (instead of over all operating hours in the week as above) then added to the marginal cost for the hour, i.e., if the marginal unit had start costs, its distributed start costs are added to the marginal costs for the hours in which this unit is the marginal unit.

The hourly marginal costs may be output to the hourly ofc file, f33, by setting N4=5 on the MCOST FLAG record. The f33 should be named in the control file. If this option is chosen, the hourly marginal costs will also be output to the f02 file. In the f32 file the MCOST output aid should have a 1 in column one for output to the f33. The aid, HR OUT FILE, should have X1=1 and N4=1.

Time Step

The default time step in PowrSym4 is 60 minutes, but the user may specify a different one with the AID, TIME STEP. The X1 value of TIME STEP may be set to any time period in minutes that divides evenly into 60, such as 10, 15, 30.

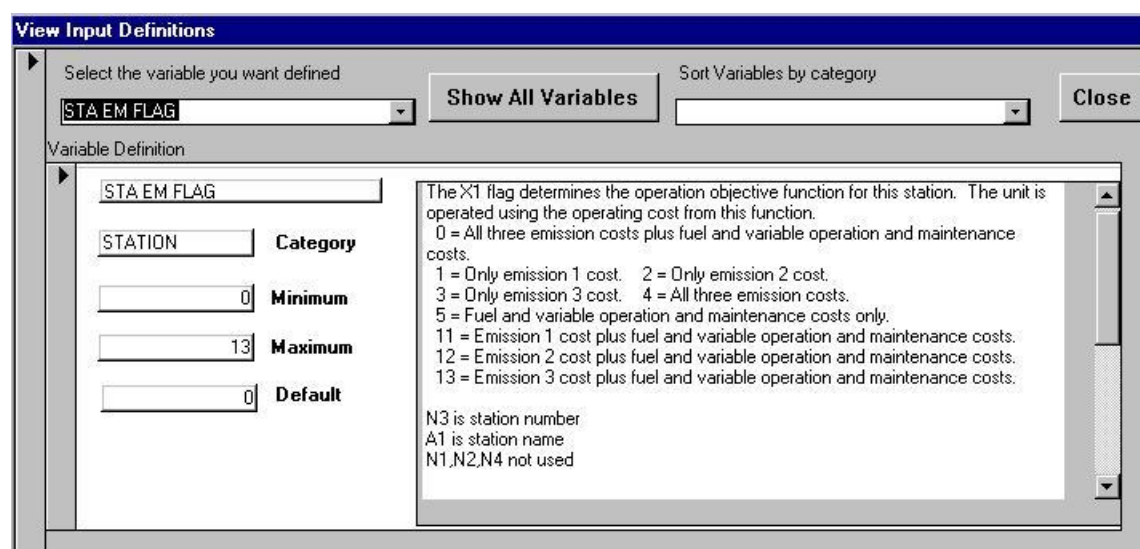
If 30 minutes is selected, for example, loads must be 30 minute values. All fun50 data may remain the same as 60-minute time step cases except for the AID, TIME STEP.

When time step is not equal to 60, the only valid output file is the f33, typically referred to as the hour out file, except that it is now reporting time step increment results. No formatted print files will be output.

Conclusion

This introduction does not cover all aspects of PowrSym4 use and usefulness. The intent is to acquaint new users with the basics of using PowrSym4. There are many AIDs not covered in this manual. Definitions for all AIDs may be found in the ANALYZER.

As an example of an area not discussed in much detail is that of emissions. PowrSym4 treats emissions in great detail, both in simulation and reporting. For example, simulated system operation can be based on emissions control instead of minimizing cost or in addition to minimizing cost. The AID, STA EM FLAG, accomplishes this.



The minimum requirements for executing PowrSym4 are:

- Control file
- Loads file
- F50

A maintenance file may be required depending on the MAINT CNTL record.

If you have difficulties or have questions concerning execution of PowrSym4, contact us at:

tj@babb.com

fax 706-965-6713
Phone 423-322-0701 or 423-488-6493

OSA, Inc.
PO Box 1129
6652 Hwy 41 North
Ringgold, GA 30736