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SOLAR TOTAL ENERGY SYSTEMS (STES)
SIMULATION PROGRAM USER'S GUIDE

January 4, 1979

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ABSTRACT

This document describes a computer program which simulates the operations of a STES facility and evaluates its annualized costs and energy displacement. The program contains a dynamic model which simulates the interaction of the insolation and electrical and thermal demands on an hourly basis. The program is flexible enough to allow thousands of different configurations to be simulated under a wide variety of conditions. Moreover, with this program, the sizes of the STES components can be adjusted to maximize the return on invested capital or the savings in fossil fuels. The program can also be used to simulate conventional fossil fuel Total Energy (TE) systems and solar thermal energy systems for comparison with STES. The program is written in Fortran for the FTN compiler on The Aerospace Corporation's CDC 7600 computer. It consists of 9 routines and approximately 1300 cards, including comments.

This document contains a description of the program, its inputs and its outputs. Examples of program input and output as well as a sample deck structure are provided. A source listing appears in the appendix.

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1. Introduction

A STES facility is characterized by the use of solar energy for on-site generation of electricity, with recovery and reuse of turbine waste heat to meet thermal demands such as process heat, space heating and cooling, and water heating.

This document describes a computer program developed by The Aerospace Corporation to study STES facilities. A block diagram of the major subsystems of the simulation is shown in Figure 1-1. The program allows multiple cases to be run. This permits the major subsystems of the model to be modified to simulate different sizes and operational characteristics of collectors, turbines, and low and high temperature storage, and enables the user to optimize the design of the STES facility being studied. The model dynamically simulates the interaction of time-varying solar insolation, electric and thermal demand for the application selected, and the time-lag effects of thermal storage. System operation is simulated in one-hour increments. The simulation is based on hourly insolation and demand data for 365 day operation. The thermal input to the generator, the electrical output and thermal exhaust are assumed to be constant during any hourly period of operation. Any shortage of on-site electrical and thermal energy is assumed purchased from the utilities.

The STES simulation program gives outputs of several technical and economic parameters by daily, yearly and plant life cycle basis (c.f. Section 4 - STES Outputs). Some of the important parameters include Equivalent Cost Ratio (ECR), a parameter which is used to measure the STES economic performance, and the fraction of electric, thermal and total fuel displacement by solar radiation from the operation of a given STES. Definitions of these and many other parameters are given in Section 2.2. The total fuel displacement (FD) is especially important in that it can be used along with ECR to rank order STES applications and aggregate by industry and/or region to obtain estimates of national STES market potential.

The STES simulation program has been utilized in the analysis of the technical and economic performance associated with an idealized STES application, i.e., an application which utilizes all the turbine waste heat to meet the thermal demand with minimum high temperature storage capacity and

collector area. The analysis has highlighted the fact that such an application can be quite cost competitive with fossil fuel alternatives and produce significant fossil fuel displacement. Further analysis has indicated that the technical and economic performance of STES can be attractive for a wide variety of applications if the ratio of annual thermal demand to annual electric demand is above 1.5, and turbine inlet temperature exceeds 450°F.

The more recent studies have concentrated primarily on industrial STES applications. STES economics and fuel displacement as a function of region, based on the amount of insolation which a given region receives, have been determined for 34 different cities. (References 2 and 5) Data on fossil fuel and electricity prices have been analyzed and used in determining the effect of regional price variations on STES economics. An in-depth study based on STES simulation has been made which shows how phasing patterns, annual thermal to electric demand ratio and cooling requirements affect the economics and fuel displacement of STES applications. Results of the study are documented in reference 1.

Finally the STES simulation program has been used in determining the possible STES penetration of industrial markets. In this effort, the output of the STES simulation program was utilized by two other computer programs, the STES Application Model (SAM) and the Market Penetration Model (MPM), both developed by The Aerospace Corporation. User's guides for these programs are forthcoming. Development and application of these models are documented in references 2 and 3.

This user's guide is intended to furnish all of the information needed for an experienced programmer to run the STES simulation program, given the source deck and input tapes. Section 2 contains a discussion of the program structure, functions, equations, size, time requirements and limitations. Section 3 contains a description of the contents and formats of each input file along with input variable names, their defaults and units. Sample input is also included. Section 4 contains a description of the contents and format of each output report along with samples of the reports. Section 5 contains a sample deck structure and a description of each of the control cards and their parameters. The well-commented source listing appears in the appendix.

Figure 1-1. STES Simulation Block Diagram

2. STES Description

The following paragraphs provide information on the STES simulation program structure, functions, equations, computer resource requirements and limitations.

2.1 STES Structure and Functions

The STES simulation program consists of a main program and eight subroutines. A flow chart complete with routine names appears in Figure 2-1.

The main program contains all of the COMMON blocks used in the program. They appear in alphabetical order at the beginning of the program.

The main program contains the definition of the NAMELIST group FIXNAME which identifies all of the variables and arrays that are in NAMELIST.

The main program contains, via DATA statements, default values for all of the variables and arrays in NAMELIST as well as initial values for several other variables used elsewhere in the program.

The main program also acts as a driver program. After initializing variables, it reads in the NAMELIST data on TAPE 5 - the input stream. The values assigned to the variables read in override the default values assigned via the DATA statements. The main program prints out on Tape 6 - the output file - the values of the NAMELIST variables and arrays that will be used by the program in the set of cases they define. The main program then calls subroutine YEAR to simulate for one year the operations of each of the STES cases defined by the NAMELIST data.

After all of the cases defined by NAMELIST data have been modeled and reported, the main program branches back to reinitialize variables and read in the next set of NAMELIST input data. This cycle is repeated until an end-of-file is encountered in the input stream.

Subroutine YEAR models the operation of a STES facility for one year. For each day of the year: Subroutine SUN is called to get the daily insolation, subroutine DEMAND is called to get the daily thermal and electrical energy demand, and subroutine DAY is called to perform the daily energy balance. At the end of the year, subroutine REPORT is called to generate the output reports for this case.

Subroutine SUN accesses either the solar insolation data from Tape 2 or the test data read in via NAMELIST. The indicator that determines the source of the insolation data is ISOLOPT. If ISOLOPT=0, the insolation data is read in from Tape 2. If ISOLOPT=1, the NAMELIST data is used.

When ISOLOPT=0 (and IFLG=0) the hourly solar insolation data for 365 days is read in and stored in the LCM (large core memory) array SUNLCM on the first day of the year. On subsequent days, the hourly insolation for the day is merely transferred from LCM to SCM (small core memory) and stored in arrays QDTSUN1 (direct insolation) and QDTSUN2 (total hemispheric insolation). LCM and SCM are defined in more detail in Reference 4.

The advantage of using LCM to store a years insolation data becomes obvious when a set of cases is considered where the location, and consequently the insolation data, does not change. Then, instead of rewinding a tape and rereading files for each case modeled, the program merely accesses the data already stored in LCM. This results in a considerable savings in job execution time.

When ISOLOPT=1, subroutine SUN accesses the hourly insolation data in the NAMELIST arrays TSTESOL and TSTTSOL. When this option is used it is assumed that the year is composed of a number of intervals each possessing a unique pattern of hourly insolation data. Subroutine SUN first determines which interval the day belongs to and then stores the hourly insolation data pattern for that interval in QDTSUN1 (direct insolation) and QDTSUN2 (total hemispheric insolation).

Subroutine DEMAND accesses the thermal and electrical demand either from the NAMELIST data or from Tape 2 - the energy demand data tape. There are four options for calculating the demands. The value of IDEMOPT determines which option is used.

If IDEMOPT=1, the thermal and electrical demands are calculated from data in the NAMELIST arrays QBAWH, QDOTA, QDOTB and QDOTW.

If IDEMOPT=2, the thermal and electrical demands are calculated from data in the NAMELIST arrays TSTDEME and TSTDENT. This option is used when there are ITDEMI demand intervals into which the year is divided. The demand pattern remains the same for all of the days in an interval. For each day, the interval that the day belongs to is determined and then the demand data for that interval is accessed and stored in QDOTE (electrical demand) and QDOTSP (thermal demand).

If IDEMOPT=3, the thermal and electrical demands are calculated from the data in the NAMELIST arrays TSTDEME and TSTDENT, similar to when IDEMOPT=2. This option is used when there are ITDEMI demand patterns which are cyclically repeated.

If IDEMOPT=4, the thermal and electric demands are calculated from data read in from Tape 3 - the energy demand data tape. As with the insolation data tape, the demand data tape is actually read only on the first call to subroutine DEMAND (if IDFILE=0) and then the hourly electrical heating and cooling loads for 365 days are read in and stored in the LCM array DEMLCM. On this and all subsequent days the days hourly electrical and thermal demands are calculated from the hourly loads.

Function MONTH returns the number of the month (January=1, December=12) which the current day is a member of.

Subroutine HEADER writes out headings on the annual reports written on Tape 6 and on the special report written on Tape 1.

Subroutine REPORT generates the annual report and the special report for a case. It prints the annual report on Tape 6 and the special report on Tape 1.

Subroutine DAY performs the STES energy balance for one day. This routine, along with subroutine ITURBNE, contains the heart of the STES simulation. The essence of this routine is described by the equations which appear in the following section.

Function ITURBNE controls the turbine operation.

If ITRBOPT=1, then the turbine is turned on at KTSTART and off at KTSTOP, independent of insolation.

If ITRBOPT=2, then ITURBNE uses perfect insolation prediction to approximately center turbine operation about a specified peak time KP. Any shortfall in energy needed to operate the turbine for an integral number of hours is made up by burning fossil fuel. Under this option the turbine will not be turned on if there is zero electric demand. The turbine will be turned off if the energy in high temperature storage is fully depleted. If the throttling mode option has been selected (IBYPASS=1), the turbine will be turned off when there is zero electric demand.

Figure 2-1. Flow Chart of STES Routines

2.2 STES Equations

The notation used in the model is:

Δ	step size increment of one hour
$Q_{\text{sun1}}(k)$	direct insolation power density (at hour $k-1$)
$Q_{\text{sun2}}(k)$	total hemispheric insolation power density (at hour $k-1$)
A_1	concentrating solar collector area
E_{sun1}	efficiency of insolation-to-heat conversion of high temperature collectors
$Q_{\text{s1}}(k)$	energy in high temperature storage (at hour $k-1$)
Q_{m1}	high temperature storage capacity
E_{s1}	efficiency of high temperature storage (fraction of heat energy retained at the end of one hour)
E_{f1}	efficiency of high temperature auxiliary heater
$\dot{Q}_g$	maximum electrical generating capacity of turbine generator
E_g	maximum efficiency of heat-to-electricity conversion for turbine generator
$\dot{Q}_s(k)$	process steam demand
E_u	fossil fuel-to-electricity conversion efficiency of utility
$C_{\text{f1}}(k)$	cumulative cost of make up makeup fuel for electrical demand
$R_{\text{f}}(k)$	annualized fuel price per energy unit (variable peak demand pricing allowed in model)
$\dot{Q}_e(k)$	electrical power demand
$C_e(k)$	cumulative cost of electricity to make up demand/supply power difference
$R_e(k)$	annualized electric power price per power unit (variable demand pricing allowed in model)
A_2	flat plate solar collector area
E_{sun2}	efficiency of insolation-to-heat conversion in low temperature cycle

$Q_{s2}(k)$	energy in low temperature storage (at hour k-1)
Q_{m2}	low temperature storage capacity
E_{s2}	efficiency of low temperature storage (fraction of energy retained at the end of one hour)
E_{hr}	efficiency of low temperature recovery
$\dot{Q}_{sp}(k)$	space heating/cooling power demand
E_{f2}	efficiency of low temperature auxiliary heater
$C_{f2}(k)$	cumulative cost of makeup fuel for thermal demand
K_{start}	turbine generator start index
K_{stop}	turbine generator stop index
Y	operational life of STES plant
$RATE$	fixed charge rate
S_1	capital cost of concentrating collectors per unit area
S_2	capital cost of flat plate collectors per unit area
T_1	capital cost of high temperature storage per energy unit
T_2	capital cost of low temperature storage per energy unit
G	capital cost of installed generating capacity per unit power

The concentrating solar collector/storage model is

$$Q_1(k) = E_{s1}Q_{s1}(k) + \Delta [E_{sun1}(Q_{sun1}(k), k)A_1 Q_{sun1}(k) - \dot{Q}_g(k)/E_g(k) - \dot{Q}_s(k)] \quad (2-1)$$

$$Q_{s1}(k+1) = \begin{cases} 0 & ; Q_1(k) \leq 0 \\ Q_1(k) & ; 0 \leq Q_1(k) \leq Q_{m1} \\ Q_{m1} & ; Q_{m1} \leq Q_1(k) \end{cases} \quad (2-2)$$

where $Q_{s1}(1)$ is determined from the steady state solution of the daily model where $Q_{s1}(1) = Q_{s1}(25)$.

The generator efficiency may be constant or variable. If excess electricity can be fed into the utility line, then the generator efficiency is held constant. Otherwise, the generator is throttled to match the load. As the electric load decreases below turbine capacity the generator efficiency is decreased. A simple model is assumed for a throttling turbine. The output is set equal to the demand up to the maximum capacity of the turbine.

$$\dot{Q}_g(k) = \begin{cases} \dot{Q}_e(k); & \dot{Q}_e(k) \leq \dot{Q}_g(k), K_{start} \leq k \leq K_{stop} \\ \dot{Q}_g(k); & \dot{Q}_e(k) > \dot{Q}_g(k), K_{start} \leq k \leq K_{stop} \\ 0 & ; K_{stop} < k < K_{start} \end{cases} \quad (2-3)$$

The efficiency of the turbine is assumed to vary linearly with the output up to the maximum efficiency.

$$E_g(k) = \begin{cases} E_g(k) \dot{Q}_e(k) / \dot{Q}_g(k); & \dot{Q}_e(k) \leq \dot{Q}_g(k) \\ E_g(k) & ; \dot{Q}_e(k) > \dot{Q}_g(k) \end{cases} \quad (2-4)$$

The cumulative hourly cost of the makeup fuel for the high temperature auxiliary heater is

$$C_{f1}(k+1) = \begin{cases} C_{f1}(k) & ; Q_1(k) \geq 0 \\ C_{f1}(k) - R_f(k) Q_1(k) / E_{f1}; & Q_1(k) < 0 \end{cases} \quad (2-5)$$

Note that the fuel cost may vary on an hourly basis.

The cumulative hourly cost of purchased electricity is:

$$C_e(k+1) = C_e(k) - R_e(k) [\dot{Q}_g(k) - \dot{Q}_e(k)] \quad (2-6)$$

$$C_e(1) = 0 \quad (2-7)$$

The amount of high temperature storage overflow for possible low temperature storage is:

$$Q_{10VRFL}(k) = \begin{cases} 0 & ; Q_1(k) \leq Q_{m1} \\ Q_1(k) - Q_{m1} & ; Q_1(k) \geq Q_{m1} \end{cases} \quad (2-8)$$

The thermal model for low temperature storage is:

$$Q_2(k) = E_{s2}Q_{s2}(k) + E_{sun2}A_2Q_{sun2}(k) + ((1 - E_g(k))/E_g(k)) E_{hr}\dot{Q}_g(k) - \dot{Q}_{sp}(k) + Q_{10VRFL}(k) \quad (2-9)$$

$$Q_{s2}(k+1) = \begin{cases} 0 & ; Q_2(k) < 0 \\ Q_2(k) & ; 0 \leq Q_2(k) \leq Q_{m2} \\ Q_{m2} & ; Q_{m2} \leq Q_2(k) \end{cases} \quad (2-10)$$

where $Q_{s2}(1)$ is determined from the steady state solution of the daily model
where $Q_{s2}(1) = Q_{s2}(25)$.

The cumulative hourly STES cost of the makeup fuel to meet the thermal demand is:

$$C_{f2}(k+1) = \begin{cases} C_{f2}(k) & ; Q_2(k) \geq 0 \\ C_{f2}(k) - R_f(k)Q_2(k)/E_{f2} & ; Q_2(k) < 0 \end{cases} \quad (2-11)$$

The daily cost of off-site electrical energy for a conventional system is:

$$DC_1 = \sum_{k=1}^{24} R_e(k) \dot{Q}_e(k) \quad (2-12)$$

The daily cost of off-site thermal energy for a conventional system is:

$$DC_2 = \sum_{k=1}^{24} R_f(k) \dot{Q}_{sp}(k)/E_{f2} \quad (2-13)$$

The daily cost of all off-site energy for a conventional system is:

$$DC = DC_1 + DC_2 \quad (2-14)$$

The daily STES cost of purchased electricity is:

$$DS_1 = C_e(25) \quad (2-15)$$

The daily STES cost of makeup fuel for electrical energy is:

$$DS_3 = C_{f1}(25) \quad (2-16)$$

The daily STES cost of makeup fuel for thermal energy is:

$$DS_2 = C_{f2}(25) \quad (2-17)$$

The daily STES cost of all on-site energy is:

$$DS = DS_1 + DS_2 + DS_3 \quad (2-18)$$

Note: Subroutine YEAR accumulates the above seven (7) daily costs (Equations (2-12) through (2-18)) into annual costs, using the same variable names. When these variables appear in the subsequent equations that follow, they are to be interpreted as annual costs.

The daily fossil fuel requirement for off-site electrical energy for a conventional system is:

$$WD_e = \sum_{k=1}^{24} \dot{Q}_e(k)/E_u \quad (2-19)$$

The daily fossil fuel requirement for off-site thermal energy for a conventional system is:

$$WD_{sp} = \sum_{k=1}^{24} \dot{Q}_{sp}(k)/E_{f2} \quad (2-20)$$

The daily fossil fuel requirement for purchased electrical energy for STES is:

$$W_e = \sum_{k=1}^{24} (\dot{Q}_e(k) - \dot{Q}_g(k))/E_u \quad (2-21)$$

The daily fossil fuel requirement for makeup fuel for the high temperature auxiliary boiler to generate electrical energy for STES is:

$$W_{f1} = \sum_{k=1}^{24} (C_{f1}(k+1) - C_{f1}(k))/R_f(k) \quad (2-22)$$

The daily fossil fuel requirement for makeup thermal energy for STES is:

$$W_{f2} = \sum_{k=1}^{24} (C_{f2}(k+1) - C_{f2}(k))/R_f(k) \quad (2-23)$$

Note: Subroutine YEAR accumulates the above five (5) daily fossil fuel requirements into annual fossil fuel requirements, using the same variable names. When these variables appear in the subsequent equations, they are to be interpreted as annual costs.

The daily total insolation is:

$$W_{sun} = \sum_{k=1}^{24} A_1 Q_{sun1}(k) + A_2 Q_{sun2}(k) \quad (2-24)$$

The ratio of the fossil fuel requirement of STES to a conventional system's fossil fuel requirement is:

$$P = (W_e + W_{f1} + W_{f2})/(WD_e + WD_{sp}) \quad (2-25)$$

The total system efficiency is:

$$EFF = \begin{cases} 0 & ; W_{sun} = 0 \\ ((WD_e - W_e)E_u + (WD_{sp} - W_{f2})E_{f2})/(W_{sun} + W_{f1}); & \text{otherwise} \end{cases} \quad (2-26)$$

The daily amount of direct insolation per unit area is:

$$Q_{sun1s} = \sum_{k=1}^{24} Q_{sun1}(k) \quad (2-27)$$

The daily amount of total hemispheric insolation per unit area is:

$$Q_{\text{sun2s}} = \sum_{k=1}^{24} Q_{\text{sun2}}^{(k)} \quad (2-28)$$

The ratio of the annual purchased electrical energy demand to the annual off-site electrical energy demand is:

$$P_e = W_e / W_{De} \quad (2-29)$$

The ratio of the annual makeup fuel demand to the annual off-site thermal energy demand is:

$$P_{sp} = (W_{f1} + W_{f2}) / W_{Dsp} \quad (2-30)$$

The ratio of the annual thermal demand to the annual electrical demand is:

$$\text{TERAT} = W_{Dsp} E_{f2} / (W_{De} E_u) \quad (2-31)$$

The total STES capital cost is:

$$C = S_1 A_1 + S_2 A_2 + T_1 Q_{m1} + T_2 Q_{m2} + G \dot{Q}_g \quad (2-32)$$

The annualized total STES capital cost is:

$$CW = C \cdot \text{RATE} \quad (2-33)$$

The break even collector cost is:

$$CC = ((DC - DS) / \text{RATE} - (T_1 Q_{m1} + G \dot{Q}_g + T_2 Q_{m2})) / A_1 \quad (2-34)$$

The break even fixed charge rate is:

$$\text{FCR} = (DC - DS) \cdot 100 / C \quad (2-35)$$

The equivalent cost ratio (ECR) is:

If IC00L = 1, i.e. vapor compression cooling is modeled:

$$ECR = CW/(DC - DS) \quad (2-36)$$

If IC00L = 0, i.e. absorption cooling is modeled:

$$ECR = \begin{cases} 9.999 & ; \text{ OSTEICI} = DS \\ CW/(\text{OSTEICI} - DS) & ; \text{ OSTEICI} > DS \\ -9.999 & ; \text{ OSTEICI} < DS \end{cases} \quad (2-37)$$

The break even competing energy cost is:

$$CEC = (ECR - 1) 100 \quad (2-38)$$

The cost benefit ratio (CBR) is:

If IC00L = 1:

$$CBR = (DS + CW)/DC \quad (2-39)$$

If IC00L = 0:

$$CBR = (DS + CW)/\text{OSTEICI} \quad (2-40)$$

The thermal/electric energy displacement ratio is:

$$\text{RATIO} = [(\text{WD}_{sp} - \text{W}_{f2})/(\text{WD}_e - \text{W}_e)] E_{f2}/E_u \quad (2-41)$$

The thermal/electric energy displacement net ratio is:

$$\text{RN} = (\text{WD}_{sp} - \text{W}_{f2} - \text{W}_{f1})/(\text{WD}_e - \text{W}_e) E_{f2}/E_u \quad (2-42)$$

The annualized cost of the on-site fixed expenses in thousands of dollars is:

$$CW = CW/1000 \quad (2-43)$$

The annualized cost of the on-site fuel expenses in thousands of dollars is:

$$DSFW = (DS_2 + DS_3)/1000 \quad (2-44)$$

The annualized cost of the purchased electricity in thousands of dollars is:

$$DSEW = DS_1/1000 \quad (2-45)$$

The annualized cost of the on-site expenses subtotal (makeup fuel and purchased electricity) in thousands of dollars is:

$$DSW = DSFW + DSEW \quad (2-46)$$

The annualized cost of the total on-site expenses in thousands of dollars is:

$$DTOT = DSW + CW \quad (2-47)$$

The annualized cost of the off-site thermal energy in thousands of dollars is:

$$DCFW = DC_2/1000 \quad (2-48)$$

The annualized cost of the off-site electrical energy in thousands of dollars is:

$$DCEW = DC_1/1000 \quad (2-49)$$

The annualized cost of the total off-site expenses in thousands of dollars is:

$$DCW = DCFW + DCEW \quad (2-50)$$

The annualized cost of the equivalent of STES supplied electricity is:

$$REQ = [(CW-DC_2+DS_2+DS_3)/(E_u(WD_e-W_e))] 3.413 \times 10^6 \quad (2-51)$$

The annualized cost of the utility supplied electricity is:

$$RU = [DC_1/(WD_e E_u)] 3.413 \times 10^6 \quad (2-52)$$

The fraction of electrical energy displaced by STES is:

$$ONEP_e = 1 - P_e \quad (2-53)$$

The fraction of thermal energy displaced by STES is:

$$ONEPSP_2 = 1 - W_{f2} / WD_{sp} \quad (2-54)$$

The fraction of thermal energy used for electricity generation is:

$$PF = W_{f1} / WD_{sp} \quad (2-55)$$

To accurately compare different types of collectors (distributed, central receiver, etc.) the collection efficiency is specified as a function of incident insolation and solar elevation.

The model for collector efficiency is:

$$E_{sun1}(Q_{sun1}, k) = \max(0, F(Q_{sun1}, k)) \quad (2-56)$$

$$F(Q_{sun1}, k) = P_1(1/P_2 - 1/Q_{sun1}) / (1/P_2)(P_3 \cos(((K-13)/P_4)\pi/2)) \quad (2-57)$$

where

- P_1 = efficiency at maximum insolation with no shading
- P_2 = insolation at which net energy collected is zero
- P_3 = maximum shading efficiency
- P_4 = hour that shading efficiency is zero

The parameters used in the simulation are listed below:

Type	P ₁	P ₂	P ₃	P ₄
Central Receiver	.792	17	1	6
Distributed Collectors	.67	45	1	6

2.3 STES Requirements and Limitations

The STES simulation program was written in Fortran for the FTN compiler on the Aerospace Corporation CDC 7600 computer. It consists of 9 routines and approximately 1300 cards, including comments.

As presently structured, the programs memory requirements are as follows: 7,504 words of small core memory (SCM) and 52,560 words of large core memory (LCM). If necessary, the LCM requirements could be eliminated by restructuring the program so that the hourly insolation data from tape 2 and the hourly demand data from tape 3 are stored in SCM. This restructuring would result in considerably longer running times, however.

The program is relatively fast. At the Aerospace Corporation STES takes approximately 15 seconds to run a set of 30 cases. This accounts for approximately 3 computing units (CUs) which currently cost \$1.30/CU so that it costs approximately \$4.00 to run 30 cases or 13¢/case. As a general guide in estimating job time, STES takes 2 seconds to compile and approximately 1/2 sec/case to execute. So, for example, a safe estimate to run a set of 30 cases would be $2 + 30 \times 1/2 = 17$ seconds.

Because the program was written for the FTN compiler for a CDC 7600 computer, it has certain non-ANSI Fortran features. A (perhaps incomplete) list of the non-ANSI features includes: a PROGRAM statement, 7-character variable names, a LEVEL 2 statement indicating storage in LCM, and non-ANSI format DATA statements.

3. STES Inputs

The STES simulation program has up to 3 input files. Tape 5 - the input stream - contains all of the variables in the NAMELIST group FIXNAME. Tape 2, when used, contains the hourly insolation data. Tape 3, when used, contains the hourly electrical and thermal demand data.

3.1 Tape 5 - The Input Stream

The STES simulation program uses NAMELIST data. The data for a set of cases is organized into one NAMELIST group with the group name FIXNAME.

NAMELIST data must be in the following format:

Data groups begin with \$ group name and end with \$.

Variables are defined as follows: variable = constant,

Arrays are defined as follows: array name = constant, . . ., constant,

For additional information concerning NAMELIST, refer to the CDC Fortran Extended Reference Manual (Reference 4).

The program has default values stored for all of the input variables. When a variable is redefined, the new value is stored replacing the default value. It is possible to redefine a variable several times; each time the new value is stored and replaces the previously defined value. In execution, the program uses the last value stored.

After the program reads the \$ defining the end of a data group, the program executes the set of cases indicated by the data. When the program completes processing of the indicated set of cases it branches back to read in additional data cards. This process continues until all the data cards have been read in. The program terminates when an end-of-file (or 6-7-8-9 card) is encountered.

The names of all of the input variables in FIXNAME, along with brief descriptions, default values and units, follows. Array dimensions are shown in parentheses.

ACOP For IDEMOPT=4, coefficient of performance for absorption cooling.
(default = .6)

A1(50) concentrating solar collector area (sq. ft.)
(default = 25.E3,50.E3,75.E3,100.E3,46*0.)

A2(50) flat plate solar collector area (sq. ft.)
(default = 50*0.)

CA For IDEMOPT = 1, ratio of coefficient of performance of vapor
compression cooling to that of absorption cooling, used in electrical
and thermal demand calculations in subroutine DEMAND.
(default = 3.)

CONLTD For IDEMOPT = 4, a multiplier indicating the number of buildings
having the electric, cooling and heating loads read in from Tape 3.
This constant scales up the electric, cooling and heating loads read
in from Tape 3.
(default = 200.)

EF1 efficiency of high temperature auxiliary heater
(default = .8)

EF2 efficiency of low temperature auxiliary heater
(default = .8)

EG maximum turbine heat-to-electricity efficiency conversion
(default = .18)

EHR efficiency of low temperature recovery
(default = .8)

ESUN1 efficiency of insolation-to-heat conversion of high temperature
collectors
(default = .5)

ESUN2 efficiency of insolation-to-heat conversion of low temperature
collectors
(default = .4)

ES1 efficiency of high temperature storage
(fraction of heat energy retained at the end of one hour)
(default = .998)

ES2 efficiency of low temperature storage
(fraction of heat energy retained at the end of one hour)
(default = .998)

EU fossil fuel-to-electricity conversion efficiency of utility
(default = .3)

FA For IDEMOPT = 1, fraction of cooling load supplied by absorption
cooling, used in electrical and thermal demand calculations in
subroutine DEMAND.
(default = 0.)

G capital cost of installed generating capacity per unit power
 (\$/Btu/hr)
 (default = .1173)

IBYPASS If IBYPASS = 0, turbine always operates at full capacity.
 If IBYPASS = 1, turbine operates at less than full capacity when
 electric demand is less than turbine capacity. The turbine operates
 at full capacity when electric demand is greater than or equal to
 turbine capacity.
 (default = 1)

ICHAR (12,4) For IDEMOPT=1, ICHAR is used to determine which value of QBAWH is
 used in the calculations of QDOTE and QDOTSP in subroutine DEMAND.
 (listing has default values)

ICOOOL cooling option indicator
 If ICOOOL = 0, absorption cooling is modeled.
 If ICOOOL = 1, vapor compression cooling is modeled.
 (default = 1)

IDEM For IDEMOPT = 1, IDEM defines application type.
 If IDEM=1; residential application
 If IDEM=2; commercial application
 (default = 1)

IDEMOPT electrical and thermal demand option indicator
 For IDEMOPT = 1, demand is obtained from data in arrays QBAWH, QDOTB,
 QDOTA, and QDOTW and computations made in subroutine DEMAND.
 For IDEMOPT = 2, demand is obtained for interval I from TSTDEME (*,I)
 for electric and TSTDENT (*,I) for thermal. Interval I includes days
 ITDEMD (I-1) + 1 to ITDEMD(I). The number of intervals is ITDEMI.
 Variables ITDEMI, ITDEMD, TSTDEME and TSTDENT must be set for this
 option to operate. ITDEMI defines the number of different demand
 intervals. ITDEMD is an array which defines the last day in each
 demand interval. There must be ITDEMI values defined for ITDEMD.
 TSTDEME and TSTDENT are arrays containing the daily demand sets for
 electric and thermal demand respectively. There must be 25*ITDEMI
 values defined for both TSTDEME and TSTDENT.
 For IDEMOPT = 3, demand is obtained for day I from TESDEME
 (*,I+IDMBIAS - ((I + IDMBIAS - 1)/ITDEMI)*ITDEMI) for electric and
 TESDEMT(*,I+IDMBIAS-((I+IDMBIAS-1)/ITDEMI)*ITDEMI) for thermal.
 Variables ITDEMI, IDMBIAS, TSTDEME and TSTDENT must be set for this
 option to operate. ITDEMI defines the number of days in the demand
 cycle. IDMBIAS defines which cycle days demand will be used for day
 1 of the year. TSTDEME and TSTDENT are arrays containing the daily
 demand sets for electric and thermal demand respectively. There must
 be 25*ITDEMI values defined for both TSTDEME and TSTDENT.
 For IDEMOPT = 4, the electrical and thermal loads are obtained from
 Tape 3. Tape 3 contains hourly heating, cooling and electric loads
 in KWH. Variables IDFILE, ICOOOL and CONLTD must be set for this
 option to operate. IDFILE defines which file on Tape 3 is to be
 read. ICOOOL indicates whether absorption cooling or vapor
 compression cooling is to be simulated. CONLTD scales the loads to
 fit the size of turbine specified in QDOTG.
 (default = 3)

IDFILE For IDEMOPT = 4, IDFILE indicates the number of the file on the demand tape (Tape 3) to be read for this set of cases.
(default = 0)

IDINYR number of times subroutine DAY is called
(default = 365)

IDMBIAS For IDEMOPT = 3, used to bias demand cycle. IDMBIAS defines which day in the demand cycle will be used for first day of the year.
(default = 0)

IFLG For ISOLOPT = 0, flag indicating whether or not insolation data tape should be read in for this set of cases.
if 0; yes
if 1; no
(default = 0, but automatically set to 1 after tape read in)

ILOC For IDEMOPT = 1, ILOC defines application location.
If 1; southwest US
If 2; southeast US
If 3; northeast US
If 4; Fort Hood, TX
(default = 4)

IPRNT print flag
if 0; special print only
if 1; annual and special print only
if 2; daily, annual and special print
if 3, special print and annual when equivalent cost ratio reaches new low
(default = 1)

ISOLOPT Insolation option indicator.
If ISOLOPT = 0, insolation is obtained from tape. IDINYR must be set to 365.
If ISOLOPT = 1, insolation is obtained for interval I from TSTESOL(*,I) for direct and TSTTSOL (*,I) + 1 for total hemispheric. Interval I includes day ITSOLD(I-1) + 1 to ITSOLD(I). The number of intervals is ITSOLI. Variables ITSOLI, ITSOLD, TSTESOL, AND TSTTSOL must be set on this option to operate.
ITSOLI defines the number of daily insolation sets to used, i.e., the number of different insolation intervals. ITSOLD is an array which defines the last day in each insolation interval. There must be ITSOLI values defined for ITSOLD. TSTESOL AND TSTTSOL are arrays containing the daily insolation set for direct and total hemispheric insolation respectively. There must be 24*ITSOLI values defined for both TSTESOL and TSTTSOL.
(default = 0)

ITDEMD (12) For IDEMOPT = 2, ITDEMD defines the last day in each demand interval. There must be ITDEMI values defined for ITDEMD.
(default = 2)

ITDEMI For IDEMOPT = 2, ITDEMI defines the number of demand intervals.
For IDEMOPT = 3, ITDEMI defines the number of days in demand cycle.
(default = 1)

ITRBOPT Turbine control option indicator.
If ITRBOPT = 1, the turbine algorithm turns the turbine on at KTSTART and off at KTSTOP, independent of insolation.
If ITRBOPT = 2, the turbine control law uses perfect insolation prediction to approximately center turbine operation about time KP (in ITURBNE). Any shortfall in energy needed to operate the turbine for an integral number of hours is made up by burning fossil fuel. Under this option the turbine will not be turned on if there is zero electric demand. The turbine will be turned off if throttling has been selected (IBYPASS=1) when there is zero electric demand. Also, the turbine will be turned off if the energy in high temperature storage is fully depleted.
(default = 2)

ITSOLD For ISOLOPT = 1, ITSOLD defines the last day in each insolation interval. There must be ITSOLI values defined for ITSOLD.
(12) (default = 6)

ITSOLI For ISOLOPT = 1, ITSOLI defines the number of insolation intervals.
(default = 1)

KP expected peak electric demand time
(default = 11)

KTSTART For ITRBOPT = 1, turbine generator start index.
(default = 6)

KTSTOP For ITRBOPT = 1, turbine generator stop index.
(default = 20)

NFILE For ISOLOPT = 0, number of file on insolation tape (TAPE 2) to be read.
(default = 1)

NHITC Number of high temperature collector size values input in array A1.
(default = 4, maximum = 50)

NHITS Number of high temperature storage size values input in array QM1.
(default = 4, maximum = 50)

NLOTC Number of low temperature collector size values input in array A2.
(default = 1, maximum = 50)

NLOTS Number of low temperature storage size values input in array QM2.
(default = 3, maximum = 50)

NMGP Number of turbine size values input in array TRBKWH.
(default = 1, maximum = 50)

OSTEIC1 For IC00L = 0, off-site total expenses from IC00L = 1 run used to modify equivalent cost ratio and cost benefit ratio.
(default = 1.E20)

PAR1-4 PAR1-PAR4 are parameter values used in defining the efficiency of insolation-to-heat conversion in high temperature cycle for different types of concentrating collectors (c.f. Equations (2-61) and (2-62)).

PAR1	(default = .792)	} used to model	.67	} used to model	
PAR2	(default = 17.)		central		45.
PAR3	(default = 1.)		receiver		1.
PAR4	(default = 6.)				6.

QBAWH For IDEMPT=1,
(4,5,4) QBAWH(1,ITY,ILOC) = daily electric load not including air conditioning
QBAWH(2,ITY,ILOC) = daily air conditioning electric load assuming 100% vapor compression cooling
QBAWH(3,ITY,ILOC) = daily water heating load
QBAWH(4,ITY,ILOC) = daily space heating load
(listing has default values)

QDOTA For IDEMPT=1, normalized air conditioning electric load profile
(25,2) (listing has default values)

QDOTB For IDEMPT=1, normalized electric load profile not including air conditioning
(25,2) (listing has default values)

QDOTH For IDEMPT=1, normalized space heating load profile
(25,2) (listing has default values)

QDOTS hourly demand for process steam (Btu/hr)
(25) (default 25* 0.)

QDOTW For IDEMPT=1, normalized water heating load profile
(25,2) (listing has default values)

QM1(50) high temperature storage capacity (Btu)
(default = 1.E6,5.E6,10.E6,25.E6,46*0.)

QM2(50) low temperature storage capacity (Btu)
(default = 10.E6,20.E6,50.E6,46*0.)

RATE fixed charge rate i.e., annual capital related cost as a fraction of capital
(default = .15)

RE(25) electrical power price per power unit (variable demand pricing allowed in model) (\$/Btu)
(default = 25*.1289E-4)

RF(25) fuel price per energy unit (variable demand pricing allowed in model)
 (\$/Btu)
 (default = 25×10^{-5})

S1 capital cost of concentrating collectors per unit area (\$/sq. ft.)
 (default = 14.)

S2 capital cost of flat plate collectors per unit area (\$/sq. ft.)
 (default = 13.7)

TRBKWH Turbine generator capacity (KW)
 (50) (default = 500.,49*0.)

TSTDEME For IDEMOPT = 2 and 3, TSTDEME defines the electrical demand by
 (25,12) hour for all demand intervals. There must be 25*ITDEMI values
 defined for TSTDEME. (Btu/hr)
 (default = $6 \times 10^{-14} \times 1706.5 \times 10^3, 280 \times 0$.)

TSTDEMT For IDEMOPT = 2 and 3, TSTDEMT defines the thermal demand by hour
 (25,12) for all demand intervals. There must be 25*ITDEMI values defined for
 TSTDEMT. (Btu/hr)
 (default = $6 \times 10^{-14} \times 6219.24 \times 10^3, 280 \times 0$.)

TSTESOL For ISOLOPT = 1, TSTESOL defines the direct insolation by hour for
 (24,12) all insolation intervals. There must be 24*ITSOLI values defined for
 TSTESOL. (Btu/hr/ft²)
 (default = $7 \times 10^{-2} \times 110., 2 \times 270., 3 \times 320.2 \times 270., 2 \times 110., 270 \times 0$.)

TSTTSOL For ISOLOPT = 1, TSTTSOL defines total hemispheric insolation
 (24,12) by hour for all insolation intervals. There must be 24*ITSOLI
 values defined for TSTTSOL. (Btu/hr/ft²)
 (default = $7 \times 10^{-2} \times 110., 2 \times 270., 3 \times 320., 2 \times 270., 2 \times 110., 270 \times 0$.)

T1 capital cost of high temperature storage per energy unit (\$/Btu)
 (default = $.45 \times 10^{-2}$)

T2 capital cost of low temperature storage per energy unit (\$/Btu)
 (default = $.1 \times 10^{-2}$)

VCOP For IDEMOPT = 4, coefficient of performance for vapor compression
 cooling.
 (default = 1.7)

Y The operational life of the STES plant. (years)
 (default = 30.)

3.2 Tape 2 - The Hourly Insolation Data

This tape contains the 1962 hourly direct and total hemispheric insolation data for 365 days for 34 locations or stations throughout the United States. The tape was created from the insolation data base at The Aerospace Corporation established by Dr. Charles Randall. This insolation data base is described in detail in reference 5. The tape has 34 files, one station per file. The first record in each file is a header record of 30 characters (station name, year of data, and station number). During execution, this header record is printed out at the top of each case summary to ensure that the appropriate file has been processed. The remaining 365 records in each file contain the total hemispheric insolation, direct insolation and temperature for each hour of the day. The temperature data is not used by the program. At the end of each file there is an end-of-file mark. Table 3-1 is a listing of the file header records indicating the order in which the insolation data has been stored on the tape.

As indicated in Section 3.1, Tape 2 is an optional input. When ISOLOPT = 0 the hourly insolation data values are read in from Tape 2, as described above. When ISOLOPT = 1, however, the hourly insolation values input via NAMELIST in arrays TSTESOL and TSTTSOL are used.

3.3 Tape 3 - The Hourly Demand Data

This tape contains the hourly electrical, cooling and heating loads for 365 days for 8 types of buildings in 9 locations throughout the United States. The tape has 72 files, one building type in one location per file. The first record in each file is a header record of 30 characters (building type and location). During execution this header record is printed out at the top of each case summary to ensure that the appropriate file has been processed. The remaining 53 records each contain the hourly electrical, cooling and heating loads for 7 days (except the last record which contains the hourly values for 1 day - the 365th day of the year). When the STES program reads in the tape in subroutine DEMAND, the program converts the

hourly electrical, cooling and heating loads into electrical and thermal demands (c.f. Section 2.1). At the end of each file there is an end-of-file mark.

In fact, there are two hourly demand data tapes: one containing hourly load data for commercial buildings and one containing hourly load data for residential buildings.

The tape containing hourly load data for commercial buildings was created from the Commercial Buildings Energy Demand (CBED) model developed at The Aerospace Corporation. This program is described in detail in Appendix A of reference 2.

The tape containing hourly load data for residential buildings was created from the tapes generated by IGT (Institute of Gas Technology). This data is also described in reference 2 and 6.

Table 3-2 is a listing of the file header records of the tape containing hourly load data for commercial buildings. The listing indicates the types of buildings and locations included on the tape as well as the order in which the data has been stored on the tape. Table 3-3 shows the correspondence between the commercial building type numbers and their verbal descriptions.

Table 3-4 is a listing of the file header records of the tape containing hourly demand data for residential buildings. The listing indicates the types of buildings and locations included on the tape as well as the order in which the data has been stored on the tape. Table 3-5 shows the correspondence between the residential building type numbers and their verbal descriptions.

As indicated in Section 3.1, Tape 3 is an optional input. When IDEMOPT = 4, the hourly load values are read in from tape 3 as described above. Otherwise, the hourly demands are input via NAMELIST in the arrays TSTDME and TSTDEMT when IDEMOPT = 2 and 3, and in the arrays QBAWH, QDOTB, QDOTA and QDOTW when IDEMOPT = 1.

Table 3-1. File Headers of the Insolation Data Tape - Tape 2

<u>File Number</u>	<u>HEADER</u>		
	<u>Station Name</u>	<u>Year</u>	<u>Station Number</u>
1	Albuquerque, NM	1962	23050
2	Inyokern, CA	1962	93104
3	Yuma, AZ	1962	23195
4	Edwards AFB, CA	1962	23114
5	Riverside, CA	1962	23119
6	LACC, CA	1962	93134
7	LAX, CA	1962	23174
8	San Diego, CA	1962	23188
9	Santa Maria, CA	1962	23273
10	Fresno, CA	1962	93193
11	Tucson, AZ	1962	23160
12	Salt Lake City, UT	1962	24127
13	Phoenix, AZ	1962	23183
14	Ely, NV	1962	23154
15	Grand Junction, CO	1962	23066
16	Omaha, NE	1962	94918
17	Fort Worth, TX	1962	03927
18	Dodge City, KS	1962	13985
19	Midland, TX	1962	23023
20	El Paso, TX	1962	23044
21	Charleston, SC	1962	12880
22	Sterling, VA	1962	93734
23	Miami, FL	1962	12839
24	Nashville, TN	1962	13897
25	Lake Charles, LA	1962	03937
26	Boise, ID	1962	24131
27	Great Falls, MT	1962	24143
28	Medford, OR	1962	24225
29	Seattle, WA	1962	24233
30	Blue Hill, MA	1962	14753
31	Bismarck, ND	1962	24011
32	Madison, WS	1962	14837
33	Cleveland, OH	1962	14820
34	Columbia, MO	1962	13983

Table 3-2. File Headers of the Commercial Demand Data Tape-Tape 3

File	Header		File	Header	
1	Building Type 1	Los Angeles, CA	37	Building Type 5	Nashville, TN
2	Building Type 2	Los Angeles, CA	38	Building Type 6	Nashville, TN
3	Building Type 3	Los Angeles, CA	39	Building Type 7	Nashville, TN
4	Building Type 4	Los Angeles, CA	40	Building Type 8	Nashville, TN
5	Building Type 5	Los Angeles, CA	41	Building Type 1	Omaha, NE
6	Building Type 6	Los Angeles, CA	42	Building Type 2	Omaha, NE
7	Building Type 7	Los Angeles, CA	43	Building Type 3	Omaha, NE
8	Building Type 8	Los Angeles, CA	44	Building Type 4	Omaha, NE
9	Building Type 1	Miami, FL	45	Building Type 5	Omaha, NE
10	Building Type 2	Miami, FL	46	Building Type 6	Omaha, NE
11	Building Type 3	Miami, FL	47	Building Type 7	Omaha, NE
12	Building Type 4	Miami, FL	48	Building Type 8	Omaha, NE
13	Building Type 5	Miami, FL	49	Building Type 1	Seattle, WA
14	Building Type 6	Miami, FL	50	Building Type 2	Seattle, WA
15	Building Type 7	Miami, FL	51	Building Type 3	Seattle, WA
16	Building Type 8	Miami, FL	52	Building Type 4	Seattle, WA
17	Building Type 1	Albuquerque, NM	53	Building Type 5	Seattle, WA
18	Building Type 2	Albuquerque, NM	54	Building Type 6	Seattle, WA
19	Building Type 3	Albuquerque, NM	55	Building Type 7	Seattle, WA
20	Building Type 4	Albuquerque, NM	56	Building Type 8	Seattle, WA
21	Building Type 5	Albuquerque, NM	57	Building Type 1	Madison, WS
22	Building Type 6	Albuquerque, NM	58	Building Type 2	Madison, WS
23	Building Type 7	Albuquerque, NM	59	Building Type 3	Madison, WS
24	Building Type 8	Albuquerque, NM	60	Building Type 4	Madison, WS
25	Building Type 1	Ft. Worth, TX	61	Building Type 5	Madison, WS
26	Building Type 2	Ft. Worth, TX	62	Building Type 6	Madison, WS
27	Building Type 3	Ft. Worth, TX	63	Building Type 7	Madison, WS
28	Building Type 4	Ft. Worth, TX	64	Building Type 8	Madison, WS
29	Building Type 5	Ft. Worth, TX	65	Building Type 1	Blue Hill, MA
30	Building Type 6	Ft. Worth, TX	66	Building Type 2	Blue Hill, MA
31	Building Type 7	Ft. Worth, TX	67	Building Type 3	Blue Hill, MA
32	Building Type 8	Ft. Worth, TX	68	Building Type 4	Blue Hill, MA
33	Building Type 1	Nashville, TN	69	Building Type 5	Blue Hill, MA
34	Building Type 2	Nashville, TN	70	Building Type 6	Blue Hill, MA
35	Building Type 3	Nashville, TN	71	Building Type 7	Blue Hill, MA
36	Building Type 4	Nashville, TN	72	Building Type 8	Blue Hill, MA

Table 3-3. Commercial Building Types

<u>Building Type</u>	<u>Description</u>
1	conventional large shopping center
2	conventional small shopping center
3	conventional large retail store
4	conventional low-rise office building
5	energy conservation large shopping center
6	energy conservation small shopping center
7	energy conservation large retail store
8	energy conservation low-rise office building

Table 3-4. File Headers of the Residential Demand Data Tape-Tape 3

<u>File</u>	<u>Header</u>	<u>File</u>	<u>Header</u>
1	NASH-BUILD1	37	NASH-BUILD5
2	NASH-BUILD2	38	NASH-BUILD6
3	NASH-BUILD3	39	NASH-BUILD7
4	NASH-BUILD4	40	NASH-BUILD8
5	BOST-BUILD1	41	BOST-BUILD5
6	BOST-BUILD2	42	BOST-BUILD6
7	BOST-BUILD3	43	BOST-BUILD7
8	BOST-BUILD4	44	BOST-BUILD8
9	CHIC-BUILD1	45	CHIC-BUILD5
10	CHIC-BUILD2	46	CHIC-BUILD6
11	CHIC-BUILD3	47	CHIC-BUILD7
12	CHIC-BUILD4	48	CHIC-BUILD8
13	DALL-BUILD1	49	DALL-BUILD5
14	DALL-BUILD2	50	DALL-BUILD6
15	DALL-BUILD3	51	DALL-BUILD7
16	DALL-BUILD4	52	DALL-BUILD8
17	MIAM-BUILD1	53	MIAM-BUILD5
18	MIAM-BUILD2	54	MIAM-BUILD6
19	MIAM-BUILD3	55	MIAM-BUILD7
20	MIAM-BUILD4	56	MIAM-BUILD8
21	PHOE-BUILD1	57	PHOE-BUILD5
22	PHOE-BUILD2	58	PHOE-BUILD6
23	PHOE-BUILD3	59	PHOE-BUILD7
24	PHOE-BUILD4	60	PHOE-BUILD8
25	RALE-BUILD1	61	RALE-BUILD5
26	RALE-BUILD2	62	RALE-BUILD6
27	RALE-BUILD3	63	RALE-BUILD7
28	RALE-BUILD4	64	RALE-BUILD8
29	ALBU-BUILD1	65	ALBU-BUILD5
30	ALBU-BUILD2	66	ALBU-BUILD6
31	ALBU-BUILD3	67	ALBU-BUILD7
32	ALBU-BUILD4	68	ALBU-BUILD8
33	LOS -BUILD5	69	LOS -BUILD5
34	LOS -BUILD6	70	LOS -BUILD6
35	LOS -BUILD7	71	LOS -BUILD7
36	LOS -BUILD8	72	LOS -BUILD8

Table 3-5. Residential Building Types

<u>Building Type</u>	<u>Description</u>
1	conventional single family dwelling
2	conventional townhouse
3	conventional low-rise apartment
4	conventional high-rise apartment
5	energy conservation single family dwelling
6	energy conservation townhouse
7	energy conservation low-rise apartment
8	energy conservation high-rise apartment

4. STES Outputs

In addition to the printback of the NAMELIST input, the STES simulation program has three types of printed output - daily, annual and special printouts. The special printout always appears, but the daily and annual printouts are optional (c.f. discussion of IPRNT in Section 3.1).

4.1 NAMELIST Printback

In order to provide a permanent record of the values and options used in a STES run, the names and values of all of the variables in the NAMELIST group FIXNAME are always printed out for each set of cases run. An example of part of the NAMELIST printback for a set of cases appears in Figure 4-1.

4.2 STES Daily Printout

If requested, (c.f. discussion of IPRNT in Section 3.1) the daily values of some of the key "working variables" appears as a separate report in the printout. This daily printout has been especially useful to check out the program when modifications to the program are being made. With production runs, however, the daily printout is normally suppressed as it quickly produces an unmanageable amount of printout. An example of part of the daily printout for a case appears in Figure 4-2. A brief description of each of the variables in the daily printout follows:

DAY	day of the year
TSTART	hour of the day that the turbine generator was turned on
TSTOP	hour of the day that the turbine generator was turned off
QSUN1S	amount of direct insolation per unit area received during day (c.f. Equation (2-27))
QSUN2S	amount of total hemispheric insolation per unit area received during day (c.f. Equation (2-28))
WDE	amount of fossil fuel required to meet daily electrical demand without TE system (c.f. Equation (2-19))
WDSP	amount of fossil fuel required to meet daily thermal demand without TE system (c.f. Equation (2-20))

WF1	amount of fossil fuel required to meet daily on-site generated electrical demand with TE system (c.f. Equation (2-22))
WE	amount of fossil fuel required to meet daily off-site generated electrical demand with TE system (c.f. Equation (2-21))
WF2	amount of fossil fuel required to meet daily thermal demand with TE system (c.f. Equation (2-23))
P	ratio of amount of fossil fuel required to meet daily total energy demand with TE system to amount of fossil fuel required to meet daily total energy demand without TE system (c.f. Equation (2-25))
EFF	plant efficiency; ratio of amount of thermal and electric energy produced in a day to amount of solar insolation energy and high-temperature makeup fuel used in day (c.f. Equation (2-26))

4.3 STES Annual Printout

The annual printout of a case has "everything you'd ever want to know about that case." An example of the annual printout for a case appears in Figure 4-3.

The header includes the case number, the source of the insolation data, the source of the energy demand data and the type of cooling.

The sizes, unit costs, and capital costs in thousands of dollars of the five major subsystems of a STES (high temperature collectors, high temperature storage, turbine generator, low temperature collectors, and low temperature storage) are given. The capital cost of each subsystem is computed as the product of the subsystem size and the subsystem unit cost. The total STES capital cost is also given (c.f. Equation (2-32)).

The per unit rates paid for electricity (when demand exceeds supply) and makeup fossil fuel are given. The operational life in years of the STES plant is given.

The annual costs in thousands of dollars for purchased electricity, for makeup fuel for electrical energy, for makeup fuel for thermal energy as well as total on-site energy costs are given (c.f. Equations (2-15), (2-16), (2-17), and (2-18)).

The ratio of the annual purchased electrical energy demand to off-site electrical energy demand is given as FR-ELECT (c.f. Equation (2-29)). The ratio of the annual makeup fuel demand to off-site thermal demand is given as FR-SPACE (c.f. Equation (2-30)). The ratio of the annual total on-site energy demand to the total off-site energy demand is given as FR-TOTAL (c.f. Equation (2-25)). The amount of total energy displaced annually (1 minus FR-TOTAL) is given as FUEL DSP.

The annual electrical and thermal energy demands in appropriate units are given as is the ratio of the thermal demand to the electrical demand - T/E RATIO (c.f. Equations (2-19), ((2-20) and (2-31)).

The annual off-site electrical, thermal and total energy costs in thousands of dollars are given (c.f. Equations (2-12), (2-13) and (2-14)).

The cost in dollars per square foot that concentrating collectors would have to be in order for this STES to break even ($ECR = 1.0$) with a conventional power plant is given as COLL COST (c.f. Equation (2-34)). The break even fixed charge rate or the annualized charge rate that results in break even ($ECR=1$) STES is given as FCR (c.f. Equation (2-35)). The percent increase or decrease in conventional energy costs for break even ($ECR=1$) STES is given as COMP ENERGY (c.f. Equation (2-38)).

The equivalent cost ratio, cost benefit ratio, T/E energy displacement ratio and T/E energy displacement net ratio are given (c.f. Equations (2-36), (2-37), (2-39), (2-40), (2-41) and (2-42)).

The annualized cost of the various on-site expenses, in thousands of dollars, is given (c.f. Equations (2-43), (2-44), (2-45), (2-46) and (2-47)).

The annualized cost of the various off-site expenses, in thousands of dollars, is given (c.f. Equations (2-48), (2-49) and (2-50)).

The annualized cost of the equivalent electricity cost of TE system and the annualized cost of utility supplied electricity are given as REQ and RU, respectively (c.f. Equations (2-51) and (2-52)).

The fraction of electrical energy displaced (1 minus FR-ELECT), the fraction of thermal energy displaced, and the fraction of thermal energy used for electricity generation are given. Note that one minus the difference between the fraction of thermal energy displaced and the fraction of thermal energy used for electric generation is FR-SPACE (c.f. Equations (2-30), (2-54), and (2-55)).

A histogram showing the number of days and what fraction of the days in a year that the turbine was on for n hours, where n varies from 0 to 24, is given.

A histogram showing the number of days and what fraction of the days in a year when $250 \cdot n$ units of direct insolation per unit area occurred, where n varies from 1 to 14, is given.

4.4 STES Special Printout

The STES Special Printout always appears as part of the STES Output. It provides a one line summary of the key parameters and performance indicators for each case in the set of cases run. The STES Special Printout thus provides a concise yet informative look at each case run. Often this is all that is necessary. The actual practice at The Aerospace Corporation has been to select print option IPRNT=3 (c.f. discussion of IPRNT in Section 3.1) so that the output includes the one line special printout for all cases run and receives the full page annual printout only for those cases where a new low ECR was recorded. This practice can significantly reduce the amount of printout produced by a run. A sample STES Special Printout appears in Figure 4-4.

The STES Special Printout contains a header much like that of the annual printout, without the case number. The header includes the source of the insolation data, the source of the energy demand data and the type of cooling.

For each case modeled, the following data is reported:

CASE	the case number
COLLECT SIZE	size in square feet of the concentrating collector area
STORAGE SIZE LOW	size in millions of BTUs of the low temperature storage area
STORAGE SIZE HIGH	size in millions of BTUs of the high temperature storage area
ECR	equivalent cost ratio (c.f. Equations (2-36) and (2-37)).
FUEL DISPL	fraction of off-site fossil fuel displaced by STES with this configuration
RATIO	thermal/electrical energy displacement ratio (c.f. Equation (2-41)).
BECC	break even collector cost (c.f. Equation (2-34)).
FCR	break even fixed charge rate (c.f. Equation (2-35)).
CEC	break even competing energy costs (c.f. Equation (2-38)).
NET RATIO	thermal/electrical energy displacement net ratio (c.f. Equation (2-42)).
CBR	cost benefit ratio (c.f. Equations (2-39) and (2-40)).

Figure 4-1. Sample of Partial NAMELIST Printback

```
$FIXNAME
ESUN1    = .5E+00,
ES1      = .998E+00,
EF1      = .8E+00,
EG       = .18E+00,
ESUN2    = .4E+00,
ES2      = .998E+00,
.
.
.
ITSOLD    = 6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
ITDEMD    = 2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
.
.
.
IDFILE    = 0,
OSTEIC1   = .1E+21,
ACOP      = .6E00,
VCOP      = .17E01,
$END
```

Figure 4-2. Sample of Partial STES Daily Printout

DAY	TSTART	TSTOP	QSUN1S	QSUN2S	WDE	WDSP	WF1	WE	WF2	P	EFF
1	8	18	2645.	1141.	.80E+08	.11E+09	.11E+08	.23E+08	.23E+08	.301	.409
2	8	18	2658.	1150.	.80E+08	.11E+09	.95E+07	.23E+08	.31E+07	.188	.487
3	8	17	2306.	1001.	.80E+08	.11E+09	.31E+07	.28E+08	.73E+07	.207	.548
4	8	17	2541.	1131.	.80E+08	.11E+09	.25E+07	.28E+08	.23E+08	.288	.434
5	8	17	2563.	1146.	.80E+08	.11E+09	.22E+07	.28E+08	.13E+08	.229	.475
6	8	16	2128.	999.	.80E+08	.11E+09	.27E+06	.34E+08	.24E+08	.311	.508
7	8	17	2439.	1120.	.80E+08	.11E+09	.29E+07	.28E+08	.21E+08	.279	.460
8	8	17	2420.	1143.	.80E+08	.11E+09	.54E+07	.28E+08	.14E+08	.255	.488
9	8	17	2484.	1147.	.80E+08	.11E+09	.22E+07	.28E+08	.13E+08	.233	.487
10	8	17	2547.	1180.	.80E+08	.11E+09	.16E+07	.28E+08	.14E+08	.236	.472
11	8	17	2674.	1239.	.80E+08	.11E+09	.49E+06	.28E+08	.12E+08	.213	.463
12	8	18	2569.	1177.	.80E+08	.11E+09	.96E+07	.23E+08	.58E+07	.203	.492
13	8	18	2661.	1238.	.80E+08	.11E+09	.95E+07	.23E+08	.78E+07	.213	.468
14	8	18	2658.	1257.	.80E+08	.11E+09	.12E+08	.23E+08	.15E+07	.190	.488
15	8	17	2287.	1095.	.80E+08	.11E+09	.59E+07	.28E+080.		.182	.577
16	8	17	1976.	984.	.80E+08	.11E+09	.54E+07	.34E+08	.34E+08	.392	.477
17	8	17	2341.	1253.	.80E+08	.11E+09	.41E+07	.28E+08	.23E+08	.296	.430
18	9	16	2097.	1097.	.80E+08	.11E+09	.64E+07	.40E+08	.94E+07	.295	.559
19	8	17	2214.	1092.	.80E+08	.11E+09	.17E+07	.28E+08	.27E+08	.303	.482
20	24	24	1354.	743.	.80E+08	.11E+090.		.80E+08	.44E+08	.658	.508
21	9	10	910.	210.	.80E+08	.11E+09	.58E+07	.74E+08	.10E+09	.959	0.000
22	9	10	910.	643.	.80E+08	.11E+09	.48E+07	.74E+08	.65E+08	.763	.502
23	8	18	2674.	1360.	.80E+08	.11E+09	.11E+08	.23E+08	.20E+08	.286	.416
24	8	18	2712.	1385.	.80E+08	.11E+09	.10E+08	.23E+080.		.175	.488
25	9	18	2538.	1318.	.80E+08	.11E+09	.11E+08	.28E+080.		.210	.508
26	8	18	2582.	1337.	.80E+08	.11E+09	.11E+08	.23E+080.		.178	.509
27	8	18	2557.	1347.	.80E+08	.11E+09	.12E+08	.23E+080.		.182	.512
28	9	18	2547.	1359.	.80E+08	.11E+09	.11E+08	.28E+080.		.210	.506
29	9	18	2572.	1380.	.80E+08	.11E+09	.11E+08	.28E+080.		.209	.502
30	9	18	2569.	1395.	.80E+08	.11E+09	.11E+08	.28E+080.		.210	.502
31	9	18	2576.	1410.	.80E+08	.11E+09	.11E+08	.28E+080.		.208	.502
32	9	18	2553.	1410.	.80E+08	.11E+09	.11E+08	.28E+080.		.209	.506
33	9	18	2569.	1428.	.80E+08	.11E+09	.11E+08	.28E+080.		.209	.503
34	9	18	2560.	1437.	.80E+08	.11E+09	.11E+08	.28E+080.		.208	.503
35	9	18	2558.	1443.	.80E+08	.11E+09	.11E+08	.28E+080.		.209	.507
36	9	18	2411.	1371.	.80E+08	.11E+09	.11E+08	.28E+080.		.209	.534
37	9	16	1431.	1004.	.80E+08	.11E+09	.86E+07	.40E+08	.28E+08	.404	.663
38	24	24	650.	608.	.80E+08	.11E+090.		.80E+08	.80E+08	.849	.468
39	9	10	146.	385.	.80E+08	.11E+09	.58E+07	.74E+08	.99E+08	.949	.563
40	9	10	587.	604.	.80E+08	.11E+09	.59E+07	.74E+08	.73E+08	.823	.571
41	9	10	127.	342.	.80E+08	.11E+09	.58E+07	.74E+08	.10E+09	.959	.517
42	9	10	609.	618.	.80E+08	.11E+09	.52E+07	.74E+08	.78E+08	.832	.523
43	9	18	2128.	1309.	.80E+08	.11E+09	.10E+08	.28E+08	.24E+08	.332	.490
44	9	17	1963.	1209.	.80E+08	.11E+09	.42E+07	.34E+08	.30E+08	.364	.506
45	9	16	2487.	1547.	.80E+08	.11E+09	.12E+08	.28E+08	.23E+08	.344	.417
46	8	17	2255.	1485.	.80E+08	.11E+09	.14E+07	.34E+08	.79E+07	.230	.554
47	8	18	2658.	1644.	.80E+08	.11E+09	.10E+08	.23E+08	.72E+07	.213	.470
48	9	18	2579.	1611.	.80E+08	.11E+09	.10E+08	.28E+080.		.205	.503
49	9	17	2277.	1446.	.80E+08	.11E+09	.12E+07	.34E+080.		.187	.586
50	24	24	311.	415.	.80E+08	.11E+090.		.80E+08	.10E+09	.952	.312
51	8	18	2534.	1616.	.80E+08	.11E+09	.10E+08	.23E+08	.20E+08	.282	.439
52	8	18	2731.	1730.	.80E+08	.11E+09	.93E+07	.23E+08	.38E+07	.190	.472
53	8	18	2937.	1732.	.80E+08	.11E+09	.54E+07	.23E+080.		.150	.461
54	9	18	3036.	1803.	.80E+08	.11E+09	.40E+07	.28E+080.		.172	.442
55	8	18	2671.	1735.	.80E+08	.11E+09	.10E+08	.23E+080.		.175	.495
56	8	18	2731.	1811.	.80E+08	.11E+09	.11E+08	.23E+080.		.181	.482

Figure 4-3. Sample of STES Annual Printout

CASE 21

INSOLATION SOURCE DATA : INYOKERN, CA 1962

ENERGY DEMAND SOURCE DATA: INPUT

TYPE OF COOLING : VAPOR COMPRESSION

UNIT COSTS

HI-COLL: 14.00 D/FT2
 HI-STOR: 4.50 D/THOUSAND BTU
 GEN: 400.34 D/KWH
 LO-COLL: 13.70 D/FT2
 LO-STOR: 1.00 D/THOUSAND BTU

ELECT RATE: 44. MILS/KWH
 FUEL RATE: 516. CENTS/1000 CU. FT.
 PLANT LIFE: 30. YEARS

ELECT DEMAND: .26E+04 MWH
 THERMAL DEMAND: .32E+02 BTU
 T/E RATIO: 3.6444

PERFORMANCE ANALYSIS

EQUIVALENT COST RATIO: .804090
 COST BENEFIT RATIO: .844586
 T/E ENERGY DSP RATIO: 5.236320
 T/E ENERGY DSP NET RATIO: 4.945805

CAPITAL COST

HI-COLL: 1050.
 HI-STOR: 23.
 GEN: 200.
 LO-COLL: 0.
 LO-STOR: 50.
 TOTAL: 1323.

ANNUAL ON-SITE ENERGY COSTS

FUEL-HI: 10228.
 ELECT: 39792.
 FUEL-LO: 14271.
 TOTAL: 64291.

ANNUAL OFF-SITE ENERGY COSTS

ELECT: 112404.
 FUEL: 198627.
 TOTAL: 311031.

ANNUALIZED COST ANALYSIS

ON-SITE
 FIXED: 198.
 EXPENSES
 FUEL: 24.
 ELECT: 40.
 SUB: 64.
 TOTAL: 263.

SIZE

75. THOUSAND SQ. FT.
 5. MILLION BTU
 500. KW
 0. THOUSAND SQ. FT.
 50. MILLION BTU

FR-ELECT: .35
 FR-SPACE: .12
 FR-TOTAL: .22
 FUEL DSP: .78

BREAK EVEN SCENARIOS

COLL COST: 18.3
 FCR: 18.7
 COMP ENERGY: -20.

OFF-SITE
 EXPENSES
 FUEL: 199.
 ELECT: 112.
 TOTAL: 311.

REQ: .1471E+02 MILLS/KWH
 RU: 43.9936 MILLS/KWH

FR-ELECT ENERGY DSP: .646
 FR-THERMAL ENERGY DSP: .928
 FR-THERMAL ENERGY USED FOR ELECT GEN: .051

TURBINE HISTOGRAM

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
.01	.03	.01	.01	.00	.00	.01	.03	.06	.19	.65	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

INSOLATION HISTOGRAM (TIMES 250.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
.01	.01	.00	.01	.01	.01	.01	.03	.05	.18	.09	.11	.16	.31

Figure 4-4. Sample STES Special Printout

INSOLATION SOURCE DATA : INYOKERN, CA 1962
 ENERGY DEMAND SOURCE DATA: INPUT
 TYPE OF COOLING : VAPOR COMPRESSION

CASE	COLLECT SIZE	STORAGE LOW	SIZES HIGH	ECR	FUEL DISPL	RATIO	BECC	FCR	CEC	NET RATIO	CBR
1	25.	10.	5.	1.061	.246	19.675	12.7	14.1	6.	19.102	1.016
2	25.	20.	5.	1.079	.246	19.675	12.3	13.9	8.	19.102	1.021
3	25.	50.	5.	1.134	.246	19.675	11.1	13.2	13.	19.102	1.035
4	25.	10.	10.	1.100	.254	8.761	11.8	13.6	10.	8.420	1.027
5	25.	20.	10.	1.118	.254	8.761	11.4	13.4	12.	8.420	1.031
6	25.	50.	10.	1.173	.254	8.761	10.2	12.8	17.	8.420	1.046
7	25.	10.	25.	1.217	.268	3.689	9.2	12.3	22.	3.328	1.058
8	25.	20.	25.	1.235	.268	3.689	8.8	12.1	24.	3.328	1.063
9	25.	50.	25.	1.289	.268	3.689	7.6	11.6	29.	3.328	1.077
10	50.	10.	5.	.833	.535	4.450	17.8	18.0	-17.	4.227	.910
11	50.	20.	5.	.840	.536	4.462	17.6	17.9	-16.	4.238	.913
12	50.	50.	5.	.867	.536	4.462	17.0	17.3	-13.	4.238	.928
13	50.	10.	10.	.849	.543	3.852	17.4	17.7	-15.	3.580	.918
14	50.	20.	10.	.858	.543	3.854	17.2	17.5	-14.	3.582	.923
15	50.	50.	10.	.885	.543	3.854	16.6	17.0	-12.	3.582	.937
16	50.	10.	25.	.909	.545	3.682	16.1	16.5	-9.	3.425	.950
17	50.	20.	25.	.917	.545	3.682	15.9	16.4	-8.	3.425	.955
18	50.	50.	25.	.944	.545	3.682	15.3	15.9	-6.	3.425	.970
19	75.	10.	5.	.886	.693	4.393	16.2	16.9	-11.	4.103	.921
20	75.	20.	5.	.821	.749	4.938	17.8	18.3	-18.	4.647	.864
21	75.	50.	5.	.804	.779	5.236	18.3	18.7	-20.	4.946	.845
22	75.	10.	10.	.867	.723	4.256	16.7	17.3	-13.	3.922	.903
23	75.	20.	10.	.812	.773	4.712	18.1	18.5	-19.	4.378	.853
24	75.	50.	10.	.817	.784	4.818	18.0	18.4	-18.	4.483	.855
25	75.	10.	25.	.861	.747	4.019	16.9	17.4	-14.	3.774	.893
26	75.	20.	25.	.860	.753	4.070	17.0	17.4	-14.	3.824	.892
27	75.	50.	25.	.879	.753	4.070	16.6	17.1	-12.	3.825	.906

5. STES Deck Structure and Control Cards

Although each facility may have unique peculiarities which result in differences in the control cards, a sample deck structure with the control cards used at The Aerospace Corporation is shown in Figure 5-1.

As shown in Figure 5-1, there are two control cards, the \$PGMR4 card and the \$PARAM card which appear at the front of every batch-submitted job at The Aerospace Corporation. These two cards are used to identify the job, the programmer, the account number to which the computing charges are applied, the number of tapes and the amount of time requested by the job. Although these cards may be unique to The Aerospace Corporation in format, each facility has cards which perform similar functions which can be substituted in their place.

A STAGE card is required for each tape that is requested by the job. The STAGE card included in Figure 5-1 requests that the operators mount tape number 36614 and assign it the logical file name of TAPE2. This tape is the hourly insolation data tape referred to in Section 3.2 and read in by subroutine SUN.

In the deck structure in Figure 5-1 it was assumed that the demand data was input via NAMELIST. If the demand data were input via tape, a STAGE card requesting that a tape be mounted and assigned to TAPE3 would be necessary.

The FTN card calls the FTN compiler to compile the source deck and create the object module LGO. R=3 is an optional parameter request for a long symbolic reference map. PL=17500 is an optional parameter request for a print line limit of 17500 lines.

The LGO card causes the LGO file to be executed. During execution, the program writes the special printout on TAPE1.

The REWIND card causes the file with the logical file name of TAPE1 to be rewound, or, when TAPE1 is actually a disk file, causes control to be transferred to the first record on the file.

The COPY card causes the information on TAPE1 to be transferred to the OUTPUT file, i.e., the printer.

The EXIT card and the REWIND and COPY cards which follow it are optional control cards which, if present, cause the information on TAPE1 to be printed even when the program abnormally terminates.

```
$PGMR4 } Aerospace Peculiar  
$PARAM }
```

```
STAGE(TAPE2,VSN=36614)
```

```
FTN(R=3,PL=17500)
```

```
LGO.
```

```
REWIND(TAPE1)
```

```
COPY(TAPE1,OUTPUT)
```

```
EXIT.
```

```
REWIND(TAPE1)
```

```
COPY(TAPE1,OUTPUT)
```

```
789
```

```
SOURCE DECK
```

```
789
```

```
NAMelist DATA
```

```
6789
```

Figure 5-1. Sample STES Deck Structure and Control Cards

6. Bibliography

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4. Control Data Corporation Fortran Extended Reference Manual, Publication Number 60497800, Revision B, March 5, 1976.
5. Insolation Data Base, The Aerospace Corporation, ATR-76(7523-11)-9, December 1976.
6. Application Analysis of Solar Total Energy to the Residential Sector, Institute of Gas Technology, Quarterly Technical Status Report, October 1 - December 31, 1977, IGT Project Number 8987, January 1978.

Appendix - STES Source Listing

```

1      PROGRAM STES (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,
      *      TAPE1,TAPE2,TAPE3)
      C
      C      BEGIN COMMON BLOCKS.
      C
5      COMMON /AVERAGE/
      *      DC1,DC2,DS1,DS2,DS3,DS,DC,WSUN,WDE,WDSP,WE,WF1,WF2
      C
10     COMMON /BTUPAR/
      *      QDTSUN1(25),QDTSUN2(25),QDOTE(25),RE(25),QDOTSP(25),
      *      RF(25),QDOTS(25),KP,
      *      QDOTB(25,2),QDOTA(25,2),QDOTH(25,2),QDOTW(25,2),QBAWH(4,5,4),
      *      ICHAR(12,4),STATION(3),ICDOL,CONLTD,IDFILE,NDF,TATLE(3)
15     *      ,OSTEIC1,IDELOPT,ISOLOPT,ACOP,VCOP,PERIOD(25),HSUN(14)
      C
      COMMON /DEMBLK/
      *      IDEM,ILOC,FA,CA
      C
20     COMMON /FIXED/
      *      ESUN1,ES1,EF1,EG,ESUN2,ES2,EF2,EHR,S1,S2,T1,T2,G,Y
      *      ,RATE,KTSTART,KTSTOP,IBYPASS
      *      ,PAR1,PAR2,PAR3,PAR4,QS1(25),QS2(25),ICASE,EU
      C
25     COMMON /LCMBLK/
      *      SUNLCM(3,24,365),DEMLCM(3,24,365)
      *      LEVEL 2,SUNLCM,DEMLCM
      C
30     COMMON /OPTPAR/
      *      A1(50),QM1(50),A2(50),QM2(50),QDOTG(50),TRBKWH(50)
      C
      COMMON /TEST/
      *      ITSOLI,ITDEMI,ITSOLD(12),ITDEMD(12),TSTDEME(25,12)
      *      ,TSTDEMT(25,12),TSTESOL(24,12),TSTTSOL(24,12),IDINYR
35     *      ,IDMBIAS,KL,IFLG,NF,NFILE,KHEADF,IDAYPR,CBREF
      C
      C      BEGIN NAMELIST DEFINITION.
      C
40     NAMELIST /FIXNAME/
      *      ESUN1,ES1,EF1,EG,ESUN2,ES2,EF2,EHR,S1,S2,T1,T2,
      *      G,Y,KTSTART,KTSTOP,RATE,IBYPASS
      *      ,PAR1,PAR2,PAR3,PAR4
      *      ,ITSOLI,ITDEMI,ITSOLD,ITDEMD,TSTDEME,TSTDEMT,TSTESOL,TSTTSOL
      *      ,IDINYR,IDMBIAS,IFLG,NFILE
45     *      ,A1,QM1,A2,QM2,QDOTG,TRBKWH
      *      ,QDTSUN1,QDTSUN2,RE,RF,QDOTS,KP
      *      ,QDOTB,QDOTA,QDOTH,QDOTW,QBAWH,ICHAR
      *      ,IPRNT,IDELOPT,ISOLOPT,ITRBOPT,NHITS,NLOTS
      *      ,NMGP,NLOTC,EU
50     *      ,IDEM,ILOC,FA,CA
      *      ,ICDOL,CONLTD,IDFILE
      *      ,OSTEIC1,ACOP,VCOP
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55      C      BEGIN DATA STATEMENTS.
      C
      DATA IDEM /1/
      *      , ILOC /4/
      *      , FA /0./
      *      , CA /3./
60      *      , ICOOL /1/
      *      , OSTEIC1 /1.E20/, ACP /0.6/, VCP /1.7/
      *      , CONLTD /200./
      *      , IDFILE /0/, NDF /1/
      *      , IDAYPR /0/
65      DATA IPRNT /1/
      *      , IDENOPT /3/
      *      , ISOLOPT /0/
      *      , ITRBOPT /2/
      *      , NHITC /4/
70      *      , NHITS /4/
      *      , NLOTS /3/
      *      , NMGP /1/
      *      , NLOTG /1/
      DATA A1 /25.E3, 50.E3, 75.E3, 100.E3, 46*0./
75      *      , OM1 /1.E6, 5.E6, 10.E6, 25.E6, 46*0./
      *      , A2 /50*0./
      *      , OM2 /10.E6, 20.E6, 50.E6, 47*0./
      *      , TRBKW4 /500., 49*0./
      DATA QDTSUN1 /25*0./
80      *      , QDTSUN2 /25*0./
      *      , RE /25*.1289E-4/
      *      , RF /25*.5E-5/
      *      , QDOTS /25*0./
      *      , KP /11/
85      DATA ESUN1 /1.5/
      *      , ES1 /1.998/
      *      , EF1 /1.8/
      *      , EG /1.8/
      *      , ESUN2 /1.4/
90      *      , ES2 /1.998/
      *      , EF2 /1.8/
      *      , EHR /1.8/
      *      , S1 /14./
      *      , S2 /13.7/
95      *      , T1 /1.45E-2/
      *      , T2 /1.1E-2/
      *      , G /1173/
      *      , Y /30./
      *      , KTSTART /6/
100      *      , KTSTOP /20/
      *      , RATE /1.15/
      DATA IBYPASS /1/
      *      , PAR1 /1.792/
      *      , PAR2 /17./
105      *      , PAR3 /1./
      *      , PAR4 /6./

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* DATA ,EU /,3/
DATA ,ITSOLI /1/
* ,ITDEMI /1/
110 * ,ITSOLI /6,11*0/
* ,ITDEMI /2,11*0/
* ,ITSTDEME /6*0.,14*1706.5E3,280*0./
* ,ITSTDEMT /6*0.,14*6219.24E3,280*0./
* ,ITSTESOL /5*0.,2*70.,2*200.,7*300.,2*200.,2*70.,268*0./
115 * ,ITSTISOL /7*0.,2*110.,2*270.,3*320.,2*270.,2*110.,270*0./
* ,IDINYS /365/
* ,IDMBIAS /0/
* ,KL /13/
* ,IFLG /0/
120 * ,NFILE /1/
* ,NF /1/
* ,KHEADF /0/
DATA QDOT8 /,033.,031,3*.03.,031.,036.,039.,043.,046,3*.047.,046,
2 3*.045.,047.,051.,05.,048.,045.,039.,033,
125 3 .015,4*.013.,016.,017.,019.,021,3*.07.,1.,08,4*.07.,06.,043.,027,
4 .023.,019.,017.,015,
DATA QDOTA /,022.,016.,008.,002,4*0.0.,002.,014.,032.,056.,062,
2 .078.,082,3*.092.,088.,078.,062.,052.,042.,032.,022,
3 6*0.,04.,05.,056.,061.,063.,068.,071.,072,2*.075.,072.,07.,067,
130 4 .065.,053.,04,3*0.0 /
DATA QDOTH /,042.,041.,04.,041,2*.042.,043.,044,2*.045.,044.,043,
2 .042.,04.,039.,038.,039.,04,2*.041,5*.042,
3 6*0.0.,014.,039.,048.,068.,074,2*.076.,077,3*.079.,077.,067.,052,
135 4 .051.,04.,004,2*0.0 /
DATA QDOTW /,027.,026.,025.,026.,027.,03.,035.,04.,047.,05.,053,
2 .055.,053.,051.,05.,049.,048.,049.,051.,052.,047.,042.,036.,031,
3 .027,
140 4 6*0.0.,014.,039.,048.,068.,074,2*.076.,077,3*.079.,077.,067.,052,
5 .051.,04.,004,2*0.0 /
DATA QBAWH /6E7,0.,5E7,63E7,6E7,0.,5E7,38E7,6E7,0.,5E7,0.,6E7,11E7,
2 5E7,0.,6E7,16E7,5E7,0.,
145 3 6E7,0.,5E7,75E7,6E7,0.,5E7,5E8,6E7,0.,5E7,0.,2*6E7,5E7,0.,6E7,
4 12E7,5E7,0.,
5 6E7,0.,5E7,1E9,6E7,0.,5E7,5E8,6E7,0.,5E7,0.,6E7,2*5E7,0.,6E7,8E7,
6 5E7,0.,
7 23E6,0.,33E6,150E6,2*23E6,33E6,34E6,8*-1E9,23E6,56E6,33E6,0. /
DATA ICHAR /1,2*2,3,2*4,2*5,4,3,2,1,
2 1,2*2,3,2*4,2*5,4,3,2,1,
150 3 2*1,2*2,3,4,5,4,3,2*2,1,
4 2*1,3*2,4*5,2*2,1 /
      BEGIN EXECUTABLE CODE.
155 10 CONTINUE
      INITIALIZE CASE COUNTER TO ZERO.
      ICASE=0

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160      C      SET SPECIAL PRINT HEADER FLAG
      C      KHEADF=1
165      C      SET DAILY REPORT HEADER FLAG.
      C      IDAYPR=0
      C      INITIALIZE CBREF
170      C      CBREF=1.E6
      C      READ IN NAMELIST INPUT FOR NEXT SET OF CASES.
      C      IF THERE IS NO DATA, TERMINATE PROGRAM.
175      C      READ(5, FIXNAME)
      C      IF (EOF(5)) 20,30
20      C      STOP
30      C      CONTINUE
180      C      COMPUTE QDOTG FROM TRBKWH
      C      DO 40 K=1,50
      C      QDOTG(K)=TRBKWH(K)*3413.
185      C      40 CONTINUE
      C      WRITE OUT NAMELIST VARIABLES AND VALUES USED FOR THIS
      C      SET OF CASES.
190      C      WRITE (6, FIXNAME)
      C      CALL SUBROUTINE YEAR FOR EACH CASE MODELED.
      C      DO 50 I=1,NHITC
      C      DO 50 J=1,NHITS
195      C      DO 50 K=1,NMGP
      C      DO 50 L=1,NLOTC
      C      DO 50 M=1,NLOTS
      C      CALL SUBROUTINE YEAR TO MODEL CASE DESCRIBED BY ARGUMENTS
      C      AND VARIABLES IN COMMON.
200      C      CALL YEAR (I,J,K,L,M,IPRNT,ITRBOPT)
      C      50 CONTINUE
205      C      GO TO 10 TO READ IN NAMELIST INPUT FOR NEXT SET OF CASES.
      C      GO TO 10
      C      END
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1      SUBROUTINE DAY (I,J,N,L,M,IPRNT,IDAY,ITRBOPT)
      C
      C      SUBROUTINE DAY PERFORMS THE STES ENERGY BALANCE FOR ONE DAY.
      C
5      COMMON /AVERAGE/
      * DC1,DC2,DS1,DS2,DS3,DS,DC,WSUN,WDE,WDSP,WE,WF1,WF2
      C
      COMMON /BTUPAR/
10     * QDTSUN1(25),QDTSUN2(25),QDOTE(25),RE(25),QDOTSP(25),
      * RF(25),QDOTS(25),KP,
      * QDOT8(25,2),QDOTA(25,2),QDOTH(25,2),QDOTW(25,2),QBAWH(4,5,4),
      * ICHAR(12,4),STATION(3),ICOOL,CONLTD,IDFILE,NDF,TATLE(3)
      * ,OSTEIC1,IDELOPT,ISOLOPT,ACDP,VCOP,PERIOD(25),HSUN(14)
15     C
      COMMON /DEMBLK/
      * IDEM,ILOC,FA,CA
      C
      COMMON /FIXED/
20     * ESUN1,ES1,EF1,EG,ESUN2,ES2,EF2,EHR,S1,S2,T1,T2,G,Y
      * ,RATE,KTSTART,KTSTOP,IBYPASS
      * ,PAR1,PAR2,PAR3,PAR4,QS1(25),QS2(25),ICASE,EU
      C
      COMMON /OPTPAR/
25     * A1(50),QM1(50),A2(50),QM2(50),QDOTG(50),TRBKWH(50)
      C
      COMMON /TEST/
      * ITTSOLI,ITDEMI,ITSOLD(12),ITDEMD(12),TSTDEME(25,12)
30     * ,TSTDENT(25,12),TSTESOL(24,12),TSTTSOL(24,12),IDINYR
      * ,IDMBIAS,KL,IFLG,NF,NFILE,KHEADF,IDAYPR,CBREF
      C
      DIMENSION
      * EP(24),Q1(25),Q2(25),CF1(25),CF2(25),CE(25),Q1OVRFL(25)
      C
35     INTEGER
      * PERIOD
      C
      C      DEFINE FUNCTION ESUN1F.
      C
40     ESUN1F(Q,KI)=AMAX1(0.,PAR1*PAR3*COS(FLOAT(K-13)*1.5707963868/PAR4
      -)*(1.-(PAR2/(Q+1.E-100))))
      C
      C      IF THIS IS FIRST DAY (IDAY=1), INITIALIZE ARRAYS.
      C
45     IF(IDAY.NE.1) GO TO 30
      DO 10 K=1,14
      HSUN(K)=0.
10    CONTINUE
      DO 20 K=1,25
      QS1(K)=0.
50     QS2(K)=0.
      PERIOD(K)=0.
20    CONTINUE

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55      30 CONTINUE
      C      IF ITRBOPT=1, SET KSTART AND KSTOP SO THAT SUBROUTINE
      C      ITURBNE TURNS THE TURBINE ON AT KSTART AND OFF AT KSTOP,
      C      INDEPENDENT OF INSOLATION.
60      IF (ITRBOPT.EQ. 2) GO TO 40
      KSTART=KTSTART+1
      KSTOP=KTSTOP+1
      GO TO 50
      C
65      IF ITRBOPT=2, SET KSTART AND KSTOP SO THAT SUBROUTINE
      C      ITURBNE CONTROLS OPERATION OF TURBINE AS FUNCTION OF
      C      INSOLATION AND ENERGY DEMAND.
70      40 CONTINUE
      KSTART=25
      KSTOP=25
      C
      INITIALIZE DAYS CUMULATIVE COST FOR PURCHASED ELECTRICITY.
75      50 CONTINUE
      CE(1)=0.0
      C
      INITIALIZE AMOUNT OF ENERGY IN HIGH TEMP STORAGE AT START OF
80      DAY TO BE AMOUNT OF ENERGY IN HIGH TEMP STORAGE AT END OF
      C      PREVIOUS DAY.
      QS1(1)=QS1(25)
      C
      START OF LOOP
85      DO 80 K=1,24
      C
      C      INITIALLY, SET EFFICIENCY OF TURBINE AT HOUR K TO MAXIMUM
      C      EFFICIENCY OF TURBINE GENERATOR.
90      EP(K)=EG
      C
      C      INITIALLY, SET AMOUNT OF ELECTRICITY GENERATED THIS HOUR TO 0.
95      QDOTGT=0.0
      C
      IF TURBINE HAS ALREADY BEEN TURNED ON, GO TO 60.
      IF (K.GT. KSTART) GO TO 60
100      TURBINE HAS NOT YET BEEN TURNED ON, USE FUNCTION ITURBNE TO
      C      DETERMINE WHETHER TURBINE SHOULD BE TURNED ON THIS HOUR. IF
      C      RETURN FROM ITURBNE WITH ITURBNE=0, THEN DO NOT TURN ON
      C      TURBINE THIS HOUR.
105      IF (0.EQ. ITURBNE(K, QS1(K), QM1(J), QDOTG(N), A1(I), ITRBOPT))

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      *      GO TO 70
110      C      ITURBNE=1 SO TURN TURBINE ON THIS HOUR.
      C      KSTART=K
      C      IF TURBINE HAS BEEN TURNED OFF, GO TO 70.
115      60 CONTINUE
      C      IF (K .GE. KSTOP) GO TO 70
      C      TURBINE IS ON THIS HOUR, DETERMINE AMOUNT OF ELECTRICITY
120      C      GENERATED THIS HOUR.
      C      QDOTGT=IBYPASS*AMIN1(QDOTG(N),QDOTE(K))+
      1      (1-IBYPASS)*QDOTG(N)
      C      IF TURBINE OPERATING IN THROTTLING MODE, COMPUTE TURBINE
125      C      EFFICIENCY.
      C      IF (QDOTG(N).NE.0.0 .AND. IBYPASS.EQ.1 .AND. QDOTGT.NE.0.0)
      C      -EP(K)=EG*QDOTGT/QDOTG(N)
130      C      FOR QDOTGT=0 AND IBYPASS=1 SET EP(K) TO A SMALL NONZERO VALUE
      C      RATHER THEN ZERO SO HEAT STORAGE FORMULAS WILL COMPUTE.
      C      IF (QDOTGT.EQ.0.0 .AND. IBYPASS.EQ.1) EP(K)=1.E-100
      C      COMPUTE COST OF ELECTRICAL ENERGY BOUGHT (OR SOLD) THIS HOUR
135      C      AND ACCUMULATE.
      C      70 CONTINUE
      C      C1=RE(K)*(QDOTGT-QDOTE(K))
      C      CF(K+1)=CE(K)- C1
140      C      COMPUTE AMOUNT OF ENERGY AVAILABLE FOR HIGH TEMPERATURE
      C      STORAGE AT THIS HOUR.
      C      Q1(K)=ES1*QS1(K)-QDOTGT/EP(K) - QDOTS(K)+A1(I)*QDOTSUN1(K)
145      2      *ESUN1F(QDOTSUN1(K),K)
      C      COMPUTE AMOUNT OF ENERGY IN HIGH TEMPERATURE STORAGE AT THIS
      C      HOUR.
150      C      QS1(K+1)=AMAX1(AMIN1(Q1(K),QM1(J)),0.0)
      C      SAVE HIGH TEMPERATURE STORAGE OVERFLOW FOR POSSIBLE LOW
      C      TEMPERATURE STORAGE
155      C      Q1OVRFL(K)=AMAX1(Q1(K)-QM1(J),0.0)
      C      IF ITRBOPT=1, TURBINE TURNS OFF AT KSTOP AS DETERMINED BY
      C      INPUT VARIABLE KTSTOP SO GO TO 80.
      C      IF (ITRBOPT .EQ. 1) GO TO 80

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160      ITRBOPT=2, TURBINE CONTROL LOGIC FUNCTION OF INSOLATION AND
      ENERGY DEMAND.
165      INDICATE TURBINE AS HAVING BEEN TURNED OFF IN THE THROTTLING
      MODE WHEN ELECTRIC DEMAND GOES TO 0.
      IF(Q1(K).LT.0.0 .AND. K.LT.KSTOP) KSTOP=K+1
170      TURN TURBINE OFF IF NO ENERGY AVIALABLE FOR HIGH TEMPERATURE
      STORAGE AT THIS HOUR.
      IF (QDOTGT.EQ.0. .AND. IBYPASS.EQ.1 .AND. K.LT.KSTOP .AND.
      -K.GT.KSTART) KSTOP=K
175      SPACE HEATING/COOLING MODEL
80 CONTINUE
      INITIALIZE AMOUNT OF ENERGY IN LOW TEMP STORAGE AT START OF
180      DAY TO BE AMOUNT OF ENERGY IN LOW TEMP STORAGE AT END OF
      PREVIOUS DAY.
      QS2(1)=QS2(25)
185      LOOP FOR LOW TEMPERATURE CYCLE.
      DO 90 K=1,24
      DETERMINE AMOUNT OF ELECTRICITY GENERATED THIS HOUR.
190      QDOTGT=IBYPASS*AMIN1(QDOTG(N),QDOTE(K))
      + (1-IBYPASS)*QDOTG(N)
      IF(K.LE.KSTART.OR.K.GT.KSTOP) QDOTGT=0.
195      COMPUTE AMOUNT OF ENERGY AVAILABLE FOR LOW TEMPERATURE
      STORAGE.
      Q2(K)=ES2*QS2(K)+ESUN2*A2(L)*QDOTSUN2(K)
      -EHR*(1.-EP(K))/EP(K)*QDOTGT-QDOTSP(K)+Q10VRFL(K)
200      COMPUTE AMOUNT OF ENERGY IN LOW TEMPERATURE STORAGE AT THIS
      HOUR.
      QS2(K+1)=Q2(K)
205      IF(Q2(K).LE.0.) QS2(K+1)=0.
      IF(Q2(K).GT.QM2(M)) QS2(K+1)=QM2(M)
90 CONTINUE
      COMPUTE CUMULATIVE COSTS OF DAYS MAKEUP FUEL FOR ELECTRICAL
210      AND THERMAL ENERGY.
      CF1(1)=0.1

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215      CF2(1)=0.
      DO 100 K=1,24
      CF1(K+1)=CF1(K)
      IF(Q1(K).LT.0.)CF1(K+1)=CF1(K)-RF(K)*Q1(K)/EF1
      CF2(K+1)=CF2(K)
      IF(Q2(K).LT.0.)CF2(K+1)=CF2(K)-RF(K)*Q2(K)/EF2
100    CONTINUE
220      C
      C      COMPUTE CUMULATIVE COSTS OF DAYS OFF-SITE ELECTRICAL AND
      C      THERMAL ENERGY.
      C
      DC1=0.
      DC2=0.
      DO 110 K=1,24
      DC1=DC1+RF(K)*QDOTTE(K)
      DC2=DC2+RF(K)*QDOTSP(K)/EF2
110    CONTINUE
230      C
      C      ASSIGN DS1 THE COST OF DAYS PURCHASED ENERGY.
      C      ASSIGN DS2 THE COST OF DAYS MAKEUP FUEL FOR THERMAL ENERGY.
      C      ASSIGN DS3 THE COST OF DAYS MAKEUP FUEL FOR ELECTRICAL ENERGY.
      C      COMPUTE DC THE DAYS COST OF ALL OFF-SITE ENERGY.
      C      COMPUTE DS THE DAYS COST OF ALL ON-SITE ENERGY.
235      C
      DS1=CE(25)
      DS2=CF2(25)
      DS3=CF1(25)
      DC=DC1+DC2
      DS=DS1+DS2+DS3
240      C
      C      COMPUTE WDE THE DAYS FOSSIL FUEL REQUIREMENT FOR OFF-SITE ELE
      C      COMPUTE WE THE DAYS FOSSIL FUEL REQUIREMENT FOR PURCHASED
245      C      ELECTRICAL ENERGY.
      C      COMPUTE WDSP THE DAYS FOSSIL FUEL REQUIREMENT FOR OFF-SITE
      C      THERMAL ENERGY.
      C      COMPUTE WF1 THE DAYS FOSSIL FUEL REQUIREMENT FOR MAKEUP
      C      ELECTRICAL ENERGY.
250      C      COMPUTE WF2 THE DAYS FOSSIL FUEL REQUIREMENT FOR MAKEUP
      C      THERMAL ENERGY.
      C      COMPUTE WSUN THE DAYS TOTAL INSOLATION.
255      WF1=0.
      WF2=0.
      WE=0.
      WDE=0.
      WDSP=0.
      WSUN=0.0
260      DO 120 K=1,24
      WDE=WDE+QDOTTE(K)/EU
      QDOTGT=IBYPASS*AMINI(QDOTG(N),QDOTTE(K))
      + (1-IBYPASS)*QDOTG(N)
      IF(K.LE.KSTART.OR.K.GT.KSTOP)QDOTGT=0.
265      WE=WE+(QDOTTE(K)-QDOTGT)/EU

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Line	Code	Statement	Address
270	CCCC	WDSP=WDSP+QDOTSP(K)/EF2	00000475
		WF1=WF1 + (CF1(K+1)-CF1(K))/RF(K)	00000476
		WF2=WF2 + (CF2(K+1)-CF2(K))/RF(K)	00000477
120		WSUN=WSUN+A1(I)*QDTSUN1(K)+A2(L)*QDTSUN2(K)	00000478
		CONTINUE	00000479
	CCCC	COMPUTE P THE RATIO OF ONSITE TOTAL ENERGY TO OFF-SITE	00000480
		TOTAL ENERGY.	00000481
		COMPUTE EFF THE PLANT EFFICIENCY.	00000482
275		P=(WE+WF2+WF1) / (WDE+WDSP)	00000483
		EFF=0.0	00000484
		IF(WSUN.NE.10.0)	00000485
280		* EFF=((WDE-WE)*EU+(WDSP-WF2)*EF2) / (WSUN+WF1)	00000486
	CCCC	COMPUTE QSUN1S THE DAYS DIRECT INSOLATION PER UNIT AREA.	00000487
		COMPUTE QSUN2S THE DAYS TOTAL HEMISPHERIC INSOLATION PER	00000488
		UNIT AREA.	00000489
285		COMPUTE QDOTES THE DAYS ELECTRICAL DEMAND.	00000490
		COMPUTE QDOTSPS THE DAYS THERMAL DEMAND.	00000491
		QSUN1S=QSUN2S=QDOTES=QDOTSPS=0.0	00000492
		DO 130 K=1,24	00000493
290		QSUN1S=QSUN1S+QDTSUN1(K)	00000494
		QSUN2S=QSUN2S+QDTSUN2(K)	00000495
		QDOTES=QDOTES+QDOTE(K)	00000496
		QDOTSPS=QDOTSPS+QDOTSP(K)	00000497
130		CONTINUE	00000498
295	CCCC	COMPUTE K THE NUMBER OF HOURS TURBINE OPERATED THIS DAY.	00000499
		INCREMENT COUNTER OF NUMBER OF DAYS TURBINE OPERATED K HOURS.	00000500
		COMPUTE K THE AMOUNT OF DAYS DIRECT INSOLATION PER UNIT AREA.	00000501
300		INCREMENT COUNTER OF NUMBER OF DAYS WITH K UNITS OF DIRECT	00000502
		INSOLATION PER UNIT AREA.	00000503
		K=KSTOP-KSTART+1	00000504
		PERIOD(K)=PERIOD(K)+1	00000505
305		K=MAX(1,MIN(INT(.5+QSUN1S/250.),14))	00000506
		HSUN(K)=HSUN(K)+1.0	00000507
		IF IPRNT .NE. 2, THEN DAILY PRINTOUT NOT REQUESTED SO RETURN.	00000508
310		IF (IPRNT .NE. 2) RETURN	00000509
		IF FIRST DAY, PRINT OUT DAILY PRINTOUT HEADER.	00000510
		IF (IDAYPR .NE. 0) GO TO 150	00000511
315		IDAYPR=1	00000512
		WRITE (6,140)	00000513
140		FORMAT(*1IDAY TSTART TSTOP QSUN1S QSUN2S WDE WDSP WF1	00000514
		2 WE WF2 P EFF*)	00000515
		PRINT DAILY PRINTOUT ON OUTPUT FILE.	00000516

SUBROUTINE DAY

76/75

OPT=1

FTN 4.6+4288

08/22/78 19.12.113

```

320      C 150 CONTINUE
          WRITE(6,160)IDAY,KSTART-1,KSTOP-1,QSUN1S,QSUN2S,WDE,WDSP,WF1
          $,WE,WF2,P,EFF
          160 FORMAT(I5,I7,I6,2F7.0,5E8.2,2F6.3)
          RETURN
325      END

```

```

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SYMBOLIC REFERENCE MAP (R=3)

ENTRY	POINTS	DEF	LINE	REFERENCES					
3	DAY	1		309	324				
VARIABLES	SN	TYPE	RELOCATION						
1005 ACOP		REAL	BTUPAR	R	FS	9			
0 A1		REAL	ARRAY	OPTPAR		24	106	143	269
144 A2		REAL	ARRAY	OPTPAR		24	198	269	
3 CA		REAL	DEMBLK			16			
2272 CBREF		REAL	TEST			27			
744 CE		REAL	ARRAY			32	138	237	DEFINED 76
662 CF1		REAL	ARRAY			32	215	216	239 2*267
				DEFINED		212	215	216	
713 CF2		REAL	ARRAY			32	217	218	238 2*268
				DEFINED		213	217	218	
774 CONLTD		REAL	BTUPAR			9			
541 C1		REAL				138	DEFINED	137	
6 DC		REAL	AVERAGE			6	DEFINED	240	
0 DC1		REAL	AVERAGE			6	227	240	DEFINED 224
1 DC2		REAL	AVERAGE			6	228	240	DEFINED 225
5 DS		REAL	AVERAGE			6	DEFINED	241	
2 DS1		REAL	AVERAGE			6	241	DEFINED	237
3 DS2		REAL	AVERAGE			6	241	DEFINED	238
4 DS3		REAL	AVERAGE			6	241	DEFINED	239
543 EFF		REAL				321	DEFINED	277	278
2 EF1		REAL	FIXED			19	216		
6 EF2		REAL	FIXED			19	218	228	266 278
3 EG		REAL	FIXED			19	91	127	
7 EHR		REAL	FIXED			19	198		
550 EPP		REAL	ARRAY			32	143	2*198	DEFINED 91
0 ESUN1		REAL	FIXED			19			
4 ESUN2		REAL	FIXED			19	198		
1 ES1		REAL	FIXED			19	143		
5 ES2		REAL	FIXED			19	198		
111 EU		REAL	FIXED			19	261	265	278
2 FA		REAL	DEMBLK			16			
14 G		REAL	FIXED			19			
1040 HSUN		REAL	BTUPAR			9			
0 I		INTEGER	F.P.			106	304	DEFINED 47	304
21 IBYPASS		INTEGER	FIXED			19	143	269	DEFINED 131 172
							2*121	127	

```

1      SUBROUTINE DEMAND (IDAY)
2
3      THIS SUBROUTINE ACCESSES THE THERMAL AND ELECTRICAL DEMAND
4      EITHER FROM THE DATA READ IN VIA NAMELIST OR FROM TAPE 2.
5      THERE ARE FOUR OPTIONS FOR CALCULATING THE DEMANDS. THE
6      VALUE OF IDEMOPT DETERMINES WHICH OPTION IS USED.
7
8
9
10     COMMON /BTUPAR/
11     * QDTSUN1(25),QDTSUN2(25),QDOTE(25),RE(25),QDOTSP(25),
12     * RF(25),QDOTS(25),KP,
13     * QDOTB(25,2),QDOTA(25,2),QDOTH(25,2),QDOTW(25,2),QBAWH(4,5,4),
14     * ICHAR(12,4),STATION(3),ICool,CONLTD,IDFILE,NDF,TATLE(3)
15     * ,OSTEIC1,IDEMOPT,ISOLOPT,ACOP,VCOP,PERIOD(25),HSUN(14)
16
17     COMMON /DEMBLK/
18     * IDEM,ILOC,FA,CA
19
20     COMMON /LCMBLK/
21     * SUNLCM(3,24,365),DEMLCM(3,24,365)
22     LEVEL 2,SUNLCM,DEMLCM
23
24     COMMON /TEST/
25     * ITSOLI,ITDEMI,ITSOLD(12),ITDEMD(12),TSTDEME(25,12)
26     * ,TSTDENT(25,12),TSTESOL(24,12),TSTTSOL(24,12),IDINYR
27     * ,IDMBIAS,KL,IFLG,NF,NFILE,KHEADF,IDAYPR,CBREF
28
29     DETERMINE WHICH OPTION OF IDEMOPT IS USED AND BRANCH TO THE
30     APPROPRIATE SECTION OF CODE.
31
32     GO TO (10,50,30,90) IDEMOPT
33
34     IF IDEMOPT EQ 1, THE THERMAL AND ELECTRIC DEMANDS ARE
35     CALCULATED FROM DATA IN ARRAYS QBAWH, QDOTA, QDOTB AND QDOTW.
36
37 10  CONTINUE
38     PRE-SET CONDITIONS
39
40     ITY=ICAR(MONTH(IDAY),ILOC)
41     ONEMFA=1.0-FA
42     CAFA=CA*FA
43
44     LOAD QDOTE AND QDOTSP
45
46     DO 20 K=1,25
47     QDOTE(K)=QBAWH(1,ITY,ILOC)*QDOTB(K,IDEM)+ ONEMFA*QBAWH(2,ITY,ILOC)
48     *QDOTA(K,IDEM)
49     QDOTSP(K)=QBAWH(3,ITY,ILOC)*QDOTW(K,IDEM)+QBAWH(4,ITY,ILOC)*
50     *QDOTH(K,IDEM)+ CAFA*QBAWH(2,ITY,ILOC)*QDOTA(K,IDEM)
51 20  CONTINUE
52     RETURN
53
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55      C      IF IDEMOPT EQ 3, THE THERMAL AND ELECTRIC DEMANDS ARE      00000588
      C      CALCULATED FROM DATA IN ARRAYS TSTDEME AND TSTDEMT.      00000589
      C      THIS OPTION IS USED WHEN THERE ARE ITDEMI DEMAND PATTERNS      00000590
      C      WHICH ARE CYCLICALLY REPEATED.      00000591
      C
      C      30 CONTINUE      00000592
      C      IDMINDX=(IDAY+IDMBIAS)-(((IDAY+IDMBIAS-1)/ITDEMI)*ITDEMI)      00000593
      C      DO 40 K=1,25      00000594
      C      QDOTTE(K)=TSTDEME(K,IDMINDX)      00000595
      C      QDOTSP(K)=TSTDEMT(K,IDMINDX)      00000596
      C      40 CONTINUE      00000597
      C      RETURN      00000598
      C
      C      IF IDEMOPT EQ 2, THE THERMAL AND ELECTRIC DEMANDS ARE      00000599
      C      CALCULATED FROM DATA IN ARRAYS TSTDEME AND TSTDEMT.      00000600
      C      THIS OPTION IS USED WHEN THERE ARE ITDEMI DEMAND INTERVALS      00000601
      C      INTO WHICH THE YEAR IS DIVIDED. THE DEMAND PATTERN REMAINS      00000602
      C      THE SAME FOR ALL OF THE DAYS IN AN INTERVAL. THE INTERVAL      00000603
      C      THAT DAY IDAY BELONGS TO IS DETERMINED AND THEN THE DEMAND      00000604
      C      DATA FOR THAT INTERVAL IS ACCESSED.      00000605
      C
      C      50 CONTINUE      00000606
      C      DO 60 J=1,ITDEMI      00000607
      C      IF (IDAY .LE. ITDEMD(J)) GO TO 70      00000608
      C      IF DAY FALLS WITHIN INTERVAL J IT WILL BE LESS THAN OR EQUAL TO      00000609
      C      THE LAST DAY OF THE INTERVAL AND EXECUTION WILL LEAVE THE LOOP.      00000610
      C
      C      60 CONTINUE      00000611
      C      70 CONTINUE      00000612
      C      DO 80 K=1,25      00000613
      C      USE TEST DATA TO SET THE DAYES INSOLATION      00000614
      C      QDOTTE(K)=TSTDEME(K,J)      00000615
      C      QDOTSP(K)=TSTDEMT(K,J)      00000616
      C      80 CONTINUE      00000617
      C      RETURN      00000618
      C
      C      IF IDEMOPT=4, THE THERMAL AND ELECTRIC DEMANDS ARE      00000619
      C      CALCULATED FROM DATA READ IN FROM TAPE 3.      00000620
      C
      C      90 CONTINUE      00000621
      C
      C      THE DEMAND DATA IS ON TAPE 3. IF THIS IS THE FIRST CALL TO      00000622
      C      SUBROUTINE DEMAND THIS CASE, THEN IDFILE INDICATES FILE TO      00000623
      C      BE READ FROM TAPE 3. IF THIS IS NOT THE FIRST CALL TO SUB-      00000624
      C      ROUTINE DEMAND THIS CASE, THEN IDFILE=0 AND THE DEMAND DATA      00000625
      C      HAS ALREADY BEEN READ INTO LCM SO GO TO 180 AND BYPASS THE      00000626
      C      SECTION OF CODE WHERE TAPE 3 IS READ.      00000627
      C
      C      100 IF (IDFILE .EQ. 0) GO TO 180      00000628
      C
      C      IDFILE INDICATES FILE WE WANT TO READ.      00000629
      C      NDF INDICATES FILE WE ARE POSITIONED TO READ.      00000630
      C      IF IDFILE EQ NDF, THEN WE ARE POSITIONED TO READ FILE WE WANT.      00000631
      C      IF IDFILE LT NDF, THEN WE ARE BEYOND FILE WE WANT SO MUST GO      00000632
      C
      C      105      00000633
      C      00000634
      C      00000635
      C      00000636
      C      00000637
      C      00000638
      C      00000639
      C      00000640

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```

C      TO 100 WHERE WE REWIND TAPE 3.
C      IF IDFILE GT NDF, THEN WE ARE NOT YET TO FILE WE WANT SO MUST
C      GO TO 110 WHERE WE READ OVER THIS FILE.
110      IF (IDFILE-NDF) 100,140,110
100      REWIND 3
      NDF=1
      GO TO 90
115      DO 130 I=1,54
120      READ (3)
      IF (EOF(3)) 120,130
130      CONTINUE
      NDF=NDF+1
      GO TO 90
120      C
      C      WE ARE AT RIGHT FILE. READ IN TITLE. PRINT BACK TITLE.
      C
125      140 CONTINUE
      READ (3) TATLE(1)
      IF (EOF(3)) 140,150
150      CONTINUE
      WRITE (6,160) TATLE(1)
130      160 FORMAT (1X,3A10)
      C
      C      READ HOURLY DEMAND DATA FOR 365 DAYS INTO DEMLCM.
      C
      DO 170 M=1,365,7
      IDAYL=M+6
135      IF (M.EQ. 365) IDAYL=365
      READ (3)((DEMLCM(I,J,K),I=1,3),J=1,24),K=M,IDAYL)
170      CONTINUE
      NDF=NDF+1
      IDFILE=0
140      180 CONTINUE
      C
      C      STORE HOURLY DEMAND DATA IN QDOT (ELECTRICAL DEMAND) AND
      C      QDOTSP (THERMAL DEMAND). IF ICOOL=1, THEN HAVE VAPOR
      C      COMPRESSION COOLING. IF ICOOL=0, THEN HAVE ABSORPTION COOLING.
145      DO 200 IHCUR=1,24
      IF (ICOOL.EQ. 1) GO TO 190
      QDOT (IHCUR)=DEMLCM(2,IHCUR,IDAY)*CONLTD
      QDOTSP(IHCUR)=(DEMLCM(1,IHCUR,IDAY)/ACOP+DEMLCM(3,IHCUR,IDAY))
150      *CONLTD
      GO TO 200
190      CONTINUE
      QDOT (IHCUR)=(DEMLCM(2,IHCUR,IDAY)+DEMLCM(1,IHCUR,IDAY)/VCOP)
      *CONLTD
155      QDOTSP(IHCUR)=DEMLCM(3,IHCUR,IDAY)*CONLTD
200      CONTINUE
      RETURN
      END

```

```

1      SUBROUTINE HEADER(I)                                00000693
C      SUBROUTINE HEADER WRITES OUT HEADER INFORMATION ON FILE I. 00000694
C      SUBROUTINE HEADER WRITES OUT HEADER INFORMATION ON FILE I. 00000695
5      COMMON /BTJPAR/                                       00000696
C      COMMON /BTJPAR/                                       00000697
C      * QDTSUN1(25),QDTSUN2(25),QDOTE(25),RE(25),QDOTSP(25), 00000698
C      * RF(25),QDOTS(25),KP,                                00000699
C      * QDOTB(25,2),QDOTA(25,2),QDOTH(25,2),QDOTW(25,2),QBAWH(4,5,4), 00000700
10     * ICHAR(12,4),STATION(3),ICOOL,CONLTD,IDFILE,NDF,TATLE(3) 00000701
C      * ,OSTE IC1, IDEMOPT, ISOLOPT, ACOP, V COP, PERIOD(25),HSUN(14) 00000702
C      * ,OSTE IC1, IDEMOPT, ISOLOPT, ACOP, V COP, PERIOD(25),HSUN(14) 00000703
C      COMMON /TEST/                                         00000704
C      * ITSOLI,ITDEMI,ITSOLD(12),ITDEMD(12),TSTDEME(25,12) 00000705
15     * ,TSTDEMT(25,12),TSTESOL(24,12),TSTISOL(24,12),IDINYNR 00000706
C      * ,IDMBIAS,KL,IFLG,NF,NFILE,KHEADF,IDAYPR,CBREF        00000707
C      * ,IDMBIAS,KL,IFLG,NF,NFILE,KHEADF,IDAYPR,CBREF        00000708
C      IF I=1, SKIP TO TOP OF NEXT PAGE.                    00000709
C      IF (I.EQ. 1) WRITE (I,140)                            00000710
C      WRITE OUT SOURCE OF INSOLATION DATA.                  00000711
C      IF (ISOLOPT.EQ. 0) GO TO 20                             00000712
20     WRITE (I,10)                                           00000713
C      10 FORMAT (1H0,5X,*INSOLATION SOURCE DATA : INPUT*) 00000714
C      GO TO 40                                                00000715
C      20 CONTINUE                                             00000716
C      WRITE (I,30) STATION                                    00000717
30     30 FORMAT (1H0,5X,*INSOLATION SOURCE DATA : *,2A10,A5) 00000718
C      WRITE OUT SOURCE OF DEMAND DATA.                       00000719
C      40 CONTINUE                                             00000720
C      IF (IDEMOPT.EQ. 4) GO TO 60                             00000721
35     WRITE (I,50)                                           00000722
C      50 FORMAT (1H0,5X,*ENERGY DEMAND SOURCE DATA: INPUT*) 00000723
C      GO TO 80                                                00000724
C      60 CONTINUE                                             00000725
C      WRITE (I,70) TATLE(1)                                   00000726
40     70 FORMAT (1H0,5X,*ENERGY DEMAND SOURCE DATA: *,3A10) 00000727
C      WRITE OUT TYPE OF COOLING MODELED.                     00000728
C      80 CONTINUE                                             00000729
C      IF (ICOOL.EQ. 1) GO TO 100                             00000730
45     WRITE (I,90)                                           00000731
C      90 FORMAT (1H0,5X,*TYPE OF COOLING : ABSORPTION*,//) 00000732
C      GO TO 120                                                00000733
50     100 CONTINUE                                           00000734
C      WRITE (I,110)                                           00000735
110    110 FORMAT (1H0,5X,*TYPE OF COOLING : VAPOR COMPRESSION*,//) 00000736
C      110 FORMAT (1H0,5X,*TYPE OF COOLING : VAPOR COMPRESSION*,//) 00000737
C      110 FORMAT (1H0,5X,*TYPE OF COOLING : VAPOR COMPRESSION*,//) 00000738
C      110 FORMAT (1H0,5X,*TYPE OF COOLING : VAPOR COMPRESSION*,//) 00000739
C      110 FORMAT (1H0,5X,*TYPE OF COOLING : VAPOR COMPRESSION*,//) 00000740
C      110 FORMAT (1H0,5X,*TYPE OF COOLING : VAPOR COMPRESSION*,//) 00000741
C      110 FORMAT (1H0,5X,*TYPE OF COOLING : VAPOR COMPRESSION*,//) 00000742
C      110 FORMAT (1H0,5X,*TYPE OF COOLING : VAPOR COMPRESSION*,//) 00000743
C      110 FORMAT (1H0,5X,*TYPE OF COOLING : VAPOR COMPRESSION*,//) 00000744
C      110 FORMAT (1H0,5X,*TYPE OF COOLING : VAPOR COMPRESSION*,//) 00000745

```

SUBROUTINE HEADER

76/76

OPT=1

FTN 4.6+4288

08/22/78 19.12.113

```

55      C      IF I=1, WRITE OUT COLUMN HEADINGS.
      C
      120 CONTINUE
          IF (I.EQ. 6) RETURN
          WRITE (I,130)
      130 FORMAT (///,7X,*COLLECT STORAGE SIZES*,11X,*FUEL*,33X,*NET*,/
          * ,* CASE SIZE LOW HIGH ECR DISPL RATIO *
          * ,*BECC FCR CEC RATIO CBR*)
      C
      C      RESET SPECIAL PRINT HEADER FLAG SO THAT NO MORE HEADERS
      C      ARE PRINTED THIS CASE.
      C
      65      KHEADF=0
      140 FORMAT (1H1,/)
          RETURN
          END

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SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS DEF LINE REFERENCES
3 HEADER 1 57 68

VARIABLES	SN	TYPE	RELOCATION	REFS	6	57	DEFINED	1	I/O REFS
1005 ACOP		REAL	BTUPAR	REFS	6				
2272 CBREF		REAL	TEST	REFS	13				
774 CONLTD		REAL	BTUPAR	REFS	6				
1040 HSUN		REAL	BTUPAR	REFS	6				
0 I		INTEGER	F.P.	REFS	20	57	DEFINED	51	58
					36	40	47		
710 ICHAR		INTEGER	ARRAY	REFS	6				
773 ICOCL		INTEGER	BTUPAR	REFS	6	46			
2271 IDAYPR		INTEGER	TEST	REFS	13				
1003 IDEMOPT		INTEGER	BTUPAR	REFS	6	35			
775 IDFILE		INTEGER	BTUPAR	REFS	6				
2262 IDINYN		INTEGER	TEST	REFS	13				
2263 IDMBIAS		INTEGER	TEST	REFS	13				
2265 IFLG		INTEGER	TEST	REFS	13				
1004 ISOLOPT		INTEGER	BTUPAR	REFS	6	24			
16 ITDFMD		INTEGER	ARRAY	REFS	13				
1 ITDEMI		INTEGER	TEST	REFS	13				
2 ITSLO		INTEGER	ARRAY	REFS	13				
0 ITSOLI		INTEGER	TEST	REFS	13				
2270 KHEADF		INTEGER	TEST	REFS	13	DEFINED	66		
2264 KL		INTEGER	TEST	REFS	13				
257 KP		INTEGER	BTUPAR	REFS	6				
776 NDF		INTEGER	BTUPAR	REFS	6				
2266 NF		INTEGER	TEST	REFS	13				
2267 NFILE		INTEGER	TEST	REFS	13				
1002 OSTEIC1		REAL	BTUPAR	REFS	6				

```

1      FUNCTION ITURBNE (K, QS, QM1, QDOTG, A1, ITRBOPT)
      C
      C      FUNCTION ITURBNE CONTROLS THE TURBINE OPERATION.
      C
5     COMMON /BTUPAR/
      C      * QDOTSUN1(25), QDOTSUN2(25), QDOTG(25), RE(25), QDOTSP(25),
      C      * RF(25), QDOTS(25), KP,
      C      * QDOTB(25,2), QDOTA(25,2), QDOTH(25,2), QDOTW(25,2), QBAWH(4,5,4),
10     * ICHAR(12,4), STATION(3), ICOOL, CONLTD, IDFILE, NDF, TATLE(3)
      C      * , OSTEIC1, IDEMOPT, ISOLOPT, ACOP, VCOP, PERIOD(25), HSUN(14)
      C
      C      COMMON /FIXED/
      C      * ESUN1, ES1, EF1, EG, ESUN2, ES2, EF2, EHR, S1, S2, T1, T2, G, Y
15     * , RATE, KTSTART, KTSTOP, IBYPASS
      C      * , PAR1, PAR2, PAR3, PAR4, QS1(25), QS2(25), ICASE, EU
      C
      C      DEFINE FUNCTION ESUN1F.
      C
20     ESUN1F(Q, K) = AMAX1(0., PAR1*PAR3*COS(FLOAT(K-13)*1.5707963868/PAR4
      C      -)*(1.-(PAR2/(Q+1.E-100))))
      C
      C      IF ITRBOPT=1, THEN THE TURBINE IS TURNED ON AT KTSTART
      C      AND OFF AT KTSTOP, INDEPENDENT OF INSOLATION.
25     IF (ITRBOPT.EQ. 2) GO TO 10
      C      ITURBNE=0
      C      IF (K.EQ.KTSTART+1) ITURBNE=1
      C      RETURN
30
      C      IF ITRBOPT=2, THEN ITURBNE USES PERFECT INSOLATION
      C      PREDICTION TO APPROXIMATELY CENTER TURBINE OPERATION
      C      ABOUT TIME KP. ANY SHORTFALL IN ENERGY NEEDED TO
      C      OPERATE THE TURBINE FOR AN INTEGRAL NUMBER OF HOURS
35     IS MADE UP BY BURNING FOSSIL FUEL. UNDER THIS OPTION
      C      THE TURBINE WILL NOT BE TURNED ON IF THERE IS ZERO
      C      ELECTRIC DEMAND. THE TURBINE WILL BE TURNED OFF IF
      C      THROTTLING HAS BEEN SELECTED (IBYPASS=1) WHEN THERE
      C      IS ZERO ELECTRIC DEMAND. ALSO, THE TURBINE WILL BE
40     TURNED OFF IF THE ENERGY IN HIGH TEMPERATURE STORAGE
      C      IS FULLY DEPLETED.
      C
10    CONTINUE
      C      ITURBNE=0
45
      C      IF PAST PEAK TIME, DO NOT TURN TURBINE ON.
      C
      C      IF (K.GE.KP) RETURN
      C
      C      IF THERE IS ZERO ELECTRIC DEMAND, DO NOT TURN ON TURBINE.
50     IF (QDOTG(K).EQ.0) RETURN
      C
      C

```

FUNCTION ITURBNE

76/76

OPT=1

FTN 4.6+428B

08/22/78 19.12.113

```

55      C      CALCULATE NUMBER OF HOURS TO RUN TURBINE.
      C
      NSTAR=(KP-K)+MINO(KP-K,25-KP)
      C
      C      PREDICT INTERVAL IF TURNED ON NOW.
      C
60      QT=QS
      I26MK=26-K
      KM1=K-1
      DO 30 N=1,I26MK
      IF (QT.GT. 0.) GO TO 20
65      IF(N.GE.NSTAR) ITURBNE=1
      RETURN
      C
      C      USE ACTUAL INSOLATION DATA FOR BEST POSSIBLE
      C      ESTIMATE OF TURBINE TURN ON TIME.
70      C
      20 CONTINUE
      QT=AMIN1(QM1,(ES1*QT+QDTSUN1(KM1+N)*ESUN1F(QDTSUN1(KM1+N),
      - (KM1+N))*A1-(QDOTG/EG)))
      30 CONTINUE
75      ITURBNE=1
      RETURN
      END

```

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```

SYMBOLIC REFERENCE MAP (R=3)

ENTRY	POINTS	DEF	LINE	REFERENCES	48	52	66	76
4	ITURBNE	1	29					
VARIABLES	SN	TYPE	RELOCATION					
1005	ACOP	REAL	BTUPAR				6	
0	A1	REAL	F.P.				72	DEFINED
774	CONLTD	REAL	BTUPAR				6	
2	EF1	REAL	FIXED				13	
6	EF2	REAL	FIXED				13	
3	EG	REAL	FIXED				13	72
7	HR	REAL	FIXED				13	
0	ESUN1	REAL	FIXED				13	
4	ESUN2	REAL	FIXED				13	
1	ES1	REAL	FIXED				13	72
5	ES2	REAL	FIXED				13	
111	EU	REAL	FIXED				13	
14	G	REAL	FIXED				13	
1040	HSUN	REAL	BTUPAR	ARRAY			6	
21	IBYPASS	INTEGER	FIXED				13	
110	ICASE	INTEGER	FIXED				13	
710	ICHR	INTEGER	BTUPAR	ARRAY			6	
773	ICOCL	INTEGER	BTUPAR				6	

FUNCTION MONTH

76/75

OPT=1

FTN 4.6+428B

08/22/78 19.12.11\$

```

1      FUNCTION MONTH(IDAY)                                00000839
      C      FUNCTION MONTH RETURNS THE NUMBER OF THE MONTH (JAN=1,DEC=12) 00000840
      C      OF WHICH DAY IDAY IS A MEMBER.                    00000841
5      C      DIMENSION ISTART(12)                             00000842
      C      STARTING DAY OF EACH MONTH FOR NON-LEAP YEAR      00000843
      C      DATA ISTART /1,32,60,91,121,152,182,213,244,274,305,335/ 00000844
10     MONTH=12                                                00000845
      DO 10 K=1,11                                             00000846
      IF(ISTART(K).LE.IDAY .AND. IDAY.LT.ISTART(K+1)) MONTH=K 00000847
15     10 CONTINUE                                           00000848
      RETURN                                                  00000849
      END                                                    00000850

```

SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS	DEF LINE	REFERENCES
4 MONTH	1	15

VARIABLES	SN	TYPE	RELOCATION	REFS	2*13	DEFINED	DEFINED	10
0 IDAY		INTEGER	F.P.	REFS	6	2*13	DEFINED	
23 ISTART		INTEGER	ARRAY	REFS	3*13	DEFINED	12	
22 K		INTEGER		REFS	11	DEFINED	13	
21 MONTH		INTEGER		DEFINED				

STATEMENT LABELS	DEF LINE	REFERENCES
0 10	14	12

LOOPS	LABEL	INDEX	FROM-TO	LENGTH	PROPERTIES
12	10	K	12 14	58	INSTACK

STATISTICS	PROGRAM LENGTH	378	31

```

1      SUBROUTINE REPORT (I,J,N,L,M,IPRNT)
2
3      SUBROUTINE REPORT GENERATES OUTPUT REPORTS FOR THIS CASE.
4
5      COMMON /AVERAGE/
6      *   DC1,DC2,DS1,DS2,DS3,DS,DC,WSUN,WDE,WDSP,WE,WF1,WF2
7
8      COMMON /BTUPAR/
9      *   QDTSUN1(25),QDTSUN2(25),QDOTE(25),RE(25),QDOTSP(25),
10     *   RF(25),QDOTS(25),KP,
11     *   QDOTB(25,2),QDOTA(25,2),QDOTH(25,2),QDOTW(25,2),QBAWH(4,5,4),
12     *   ICHAR(12,4),STATION(3),ICQOL,CONLTD,IDFILE,NDF,TATLE(3)
13     *   ,OSTEIC1,IDEMOPT,ISOLOPT,ACOP,VCOP,PERIOD(25),HSUN(14)
14
15     COMMON /DEMBLK/
16     *   IDEM,ILOC,FA,CA
17
18     COMMON /FIXED/
19     *   ESUN1,ES1,EF1,EG,ESUN2,ES2,EF2,EHR,S1,S2,T1,T2,G,Y
20     *   ,RATE,KTSTART,KTSTOP,IBYPASS
21     *   ,PAR1,PAR2,PAR3,PAR4,QS1(25),QS2(25),ICASE,EU
22
23     COMMON /OPTPAR/
24     *   A1(50),QM1(50),A2(50),QM2(50),QDOTG(50),TRBKWH(50)
25
26     COMMON /TEST/
27     *   ITSOLI,ITDEMI,ITSOLD(12),ITDEMD(12),TSTDEME(25,12)
28     *   ,TSTDGMT(25,12),TSTESOL(24,12),TSTTSOL(24,12),IDINYR
29     *   ,IDMBIAS,KL,IFLG,NF,NFILE,KHEADF,IDAYPR,CBREF
30
31     DIMENSION
32     *   PERIOD(25)
33
34     INTEGER
35     *   PERIOD
36
37     CAPITAL COST.
38
39     C=S1*A1(I) +S2*A2(L) +T1*QM1(J) +T2*QM2(M) +G*QDOTG(N)
40
41     ANNUALIZED COST OF CAPITAL.
42
43     CW=C*RATE
44
45     ELECTRICAL COST ON SITE AND FOR UTILITY.
46
47     REQ=(CW-DC2+DS2+DS3) /(EU*(WDE-WE+1.E-100)) *3.413E6
48     RU=DC1/(WDE*EU+1.E-100)*3.413E6
49
50     CONVERT OUTPUT VARIABLES TO PROPER UNITS FOR PRINTOUT.
51
52     CW=CW/1000.

```

```

55      DCFW=DC2/1000.
      DSFW=(DS2+DS3)/1000.
      DSEW=DS1/1000.
      DCEW=DC1/1000.
      DCW=DCEW+DCFW
      DSW=DSEW+DSFW
60      P=(WE+WF2+WF1)/(WDE+WDSP)
      P1=1.0-P
      PE=WE/(WDE+1.E-100)
      PSP=(WF1+WF2)/(WDSP+1.E-100)
      PSP2=WF2/(WDSP+1.E-100)
65      PF=WF1/(WDSP+1.E-100)
      ONEPE=1.-PE
      ONEPSP2=1.-PSP2
      RATIO=(WDSP-WF2)/(WDE-WE+.001)*EF2/EU
      RN=(WDSP-WF2-WF1)/(WDE-WE+.001)*EF2/EU
70      TERAT=(WDSP*EF2)/(WDE*EU+1.E-100)
      ECR=CW/(DCW-DSW+1.E-9)
      CBR=(DSW+CW)/DCW
      GQDOTG=G*QDOTG(N)
      S1A1=S1*A1(I)
75      S2A2=S2*A2(L)
      T1QM1=T1*QM1(J)
      T2QM2=T2*QM2(M)
      S1A1Y=S1A1/1000.
      S2A2Y=S2A2/1000.
      T1QM1Y=T1QM1/1000.
80      T2QM2Y=T2QM2/1000.
      GQDOTGY=GQDOTG/1000.
      A1SC=A1(I)/1000.
      T2SC=T2*1000.
85      T1SC=T1*1000.
      QM1SC=QM1(J)/1E6
      GSC=G*3413.0
      QDOTSC=QDOTG(N)/3413.0
      A2SC=A2(L)/1000.
90      QM2SC=QM2(M)/1E6
      RESC=RE(1)*3.413E6
      RFSC=RF(1)*1.031E8
      WDE=EU*WDE/3.413E6
      WDSP=EF2*WDSP/1.E9
95      C=C/1000.
      ICASE=ICASE+1
      CC=((DCW-DSW)/RATE-(T1QM1Y+GQDOTGY+T2QM2Y))/A1SC
      FCR=(DCW-DSW)*100./C
100      C
      C
      C
      DTOT=DSW+CW
      IF(ICOO1.EQ.1) GO TO 30
      CBR=CBR*(DCW/OSTEIC1)
105      IF(OSTEIC1.LT.DSW) GO TO 10
      IF(OSTEIC1.EQ.DSW) GO TO 20

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      ECR=CW/(OSTEIC1-DSW)
      GO TO 30
110  CONTINUE
      ECR=-9.999
      GO TO 30
20  CONTINUE
      ECR= 9.999
115  CONTINUE
      CEC=(ECR-1.0)*100.

      PRINT OUTPUT

      IF(IPRNT.EQ.3) GO TO 40
      GO TO 60
120  CONTINUE
      IF (ECR.GT. CBREF) GO TO 400
      CBREF=ECR
      CONTINUE
125  IF (IPRNT.EQ.0) GO TO 400
      WRITE (6,73) ICASE
130  FORMAT (1H1,5X,*CASE*,I6)

      CALL SUBROUTINE HEADER TO PRINTOUT HEADER INFORMATION ON
      FILE 6.

      CALL HEADER (6)
      WRITE (6,80)
135  FORMAT (12,*UNIT COSTS*,T53,*CAPITAL COST*,T81,*SIZE*)
      WRITE (6,90) S1,S1A1Y,A1SC
      FORMAT (1/* HI-COLL:*,F9.2,* D/FT2*,T53,*HI-COLL:*,F9.0,T81,F6.0,
      * * THOUSAND SO. FT.*)
      WRITE (6,100) T1SC,T1QM1Y,QM1SC
140  FORMAT (1/* HI-STOR:*,F9.2,* D/THOUSAND BTU*,T53,*HI-STOR:*,F9.0,
      * T81,F6.0,* MILLION BTU*)
      WRITE (6,110) GSC,GQDOTGY,QDOTSC
      FORMAT (* GEN:*,F13.2,* D/KWH*,T53,*GEN: *,F9.0,T81,F6.0,* KW*)
110  WRITE (6,120) S2,S2A2Y,A2SC
      FORMAT (1/* LO-COLL:*,F9.2,* D/FT2*,T53,*LO-COLL:*,F9.0,T81,F6.0,
      * * THOUSAND SO. FT.*)
145  WRITE (6,130) T2SC,T2QM2Y,QM2SC
      FORMAT (1/* LO-STOR:*,F9.2,* D/THOUSAND BTU*,T53,*LO-STOR:*,F9.0,
      * T81,F6.0,* MILLION BTU*)
      WRITE (6,140) C
150  FORMAT (1T53,*TOTAL: *,F9.0/ )
      WRITE (6,150)
      FORMAT (1T53,*ANNUAL ON-SITE ENERGY COSTS* )
150  WRITE (6,160) RESC,DS3,PE
      FORMAT (1/* ELECT RATE:*,F6.0,* MILS/KWH*,T53,*FUEL-HI:*,F9.0,T81,
155  * *FR-ELECT:*,F6.2)
      WRITE (6,170) RFSC,DS1,PSP
      FORMAT (1/* FUEL RATE:*,F7.0,* CENTS/1000 CU. FT.*,T53,*ELECT: *,
      * F9.0,T81,*FR-SPACE:*,F6.2)
      WRITE (6,180) Y,DS2,P

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```

```

160 180 FORMAT(* PLANT LIFE :*,F4.0,* YEARS*,T53,*FUEL-LO:*,F9.0,T81 ,
    * *FR-TOTAL:*,F6.2)
    WRITE (6,190) DS,P1
190 190 FORMAT (T53,*TOTAL: *,F9.0,T81,*FUEL DSP:*,F6.2)
    WRITE (6,200)
165 200 190 FORMAT (/ ,45X,*ANNUAL OFF-SITE ENERGY COSTS*,5X,
    * *BREAK EVEN SCENARIOS*)
    WRITE (6,210) WDE,WDSP,DC1,CC,TERAT,DC2,FCR,DC,CEC
210 210 FORMAT (* ELECT DEMAND: *,E7.2,* MWH*/ * THERMAL DEMAND:*,E9.2,
    * * E9 BTU*,T53,*ELECT:*,F10.0,T81,*COLL COST :*,F5.1/
170 * * T/E RATIO: *,F7.4
    * * ,T53,*FUEL:*,F11.0,T81,*FCR :*,F5.1/
    * * ,T53,*TOTAL:*,F10.0,T81,*COMP ENERGY:*,F5.0)
    WRITE (6,220)
175 220 190 FORMAT(/ , * PERFORMANCE ANALYSIS*,31X,*ANNUALIZED COST ANALYSIS*
    * ,/)
    WRITE (6,230) ECR
230 230 190 FORMAT (* EQUIVALENT COST RATIO: *,F11.6,T53,*ON-SITE*,T81,
    * *OFF-SITE*)
    WRITE (6,240) CBR,CW
180 240 190 FORMAT (* COST BENEFIT RATIO: *,F11.6,T53,*FIXED: *,F9.0)
    WRITE (6,250) RATIO
250 250 190 FORMAT (* T/E ENERGY DSP RATIO: *,F11.6,T55,*EXPENSES*,
    * *EXPENSES*)
    WRITE (6,260) RN,DSFW,DCFW
185 260 190 FORMAT (* T/E ENERGY DSP NET RATIO:*,F11.6,T53,*FUEL: *,F9.0,
    * *T81,*FUEL: *,F9.0)
    WRITE (6,270) DSEW,DCEW
270 270 190 FORMAT (T53,*ELECT: *,F9.0,T81,*ELECT:*,F9.0)
    WRITE (6,280) DSW,DCW, DTOT
190 280 190 FORMAT(52X,*SUB: *,F9.0,T81,*TOTAL:*,F9.0/T53,*TOTAL: *,F9.0,
    2 //)
    WRITE (6,300) REQ,ONEPE,RU,ONEPSP2,PF
300 300 190 FORMAT ( * REQ:*,E12.4,* MILLS/KWH*,4X,
    * *FR-ELECT ENERGY DSP: *,F5.3,
195 * * / * RU: *,F12.4,* MILLS/KWH*,4X,*FR-THERMAL ENERGY DSP:*,
    * * ,F5.3,/T32,
    * *FR-THERMAL ENERGY USED FOR ELECT GEN:*,F5.3)
    WRITE (6,310) ( (K-1),K=1,25)
200 310 190 FORMAT (/ * TURBINE HISTOGRAM */ ,1X,25I4)
    WRITE (6,320) (PERIOD(K),K=1,25)
320 320 190 FORMAT (1X,25I4)
    DO 330 K=1,25
    PERIOD(K)=PERIOD(K)/365.
330 330 190 CONTINUE
    WRITE (6,340) (PERIOD(K),K=1,25)
205 340 190 FORMAT (1X,25F4.2)
    WRITE (6,350) ( (K-1),K=2,15)
350 350 190 FORMAT(/ * INSOLATION HISTOGRAM (TIMES 250.) */14I5)
    WRITE (6,360) (HSUN(K),K=1,14)
210 360 190 DO 370 K=1,14
    HSUN(K)=HSUN(K)/365.
    360 190 FORMAT (14F5.0)

```

VARIABLES	SN	TYPE	RELOCATION	REFS	40	74	83	83
1005	ACOP	REAL	BTUPAR	9				
0	A1	REAL	ARRAY	24	40	74	83	
1277	A1SC	REAL	OPTPAR	97	135	217	DEFINED	83
144	A2	REAL	ARRAY	24	40	75	89	
1305	A2SC	REAL	OPTPAR	143	DEFINED	89		
1236	C	REAL		44	95	98	149	DEFINED
3	CA	REAL	DEMBLK	16				
1264	CBR	REAL		104	179	217	DEFINED	72
2272	CBREF	REAL	TEST	27	122	DEFINED	123	
1311	CC	REAL		167	217	DEFINED	97	
1314	CEC	REAL		167	217	DEFINED	115	
774	CONLTD	REAL	BTUPAR	9				
1237	CW	REAL		48	53	71	72	102
			AVERAGE	44	53			
6	DC	REAL		6	167			
1245	DCEW	REAL		58	187	DEFINED	57	
1242	DCFW	REAL		58	184	DEFINED	54	
1246	DCW	REAL		71	72	97	98	104
			AVERAGE	58				
0	DC1	REAL		6	49	57	167	
1	DC2	REAL		6	48	54	167	
5	DS	REAL		6	162			
1244	DSEW	REAL		59	187	DEFINED	56	
1243	DSFW	REAL		59	184	DEFINED	55	
1247	DSW	REAL		71	72	97	98	102
			AVERAGE	107	189	DEFINED	59	
2	DS1	REAL		6	56	156		
3	DS2	REAL		6	48	55	159	
4	DS3	REAL		6	48	55	153	
1313	DTOT	REAL		189	DEFINED	102		
1263	ECR	REAL		115	122	123	176	217
			FIXED	71	107	110	113	
2	EF1	REAL		19				

```
1      SUBROUTINE SUN (IDAY)                                00001076
C      THIS SUBROUTINE ACCESSES EITHER THE SOLAR INSOLATION DATA 00001077
C      FROM TAPE 2 OR THE TEST DATA READ IN VIA NAMELIST.      00001078
5      00001079
C      00001080
C      00001081
C      COMMON /BTUPAR/                                         00001082
C      * QDOTSUN1(25),QDOTSUN2(25),QDOTE(25),RE(25),QDOTSP(25), 00001083
C      * RF(25),QDOTS(25),KP,                                  00001084
10     * QDOTB(25,2),QDOTA(25,2),QDOTH(25,2),QDOTW(25,2),QBAWH(4,5,4), 00001085
C      * ICHAR(12,4),STATION(3),ICOOL,CONLTD,IDFILE,NDF,TATLE(3) 00001086
C      * ,DSTEIC1,IDELOPT,ISOLOPT,ACOP,VCOP,PERIOD(25),HSUN(14) 00001087
C      00001088
C      COMMON /LC4BLK/                                         00001089
15     * SUNLCM(3,24,365),DEMLCM(3,24,365)                     00001090
C      LEVEL 2,SUNLCM,DEMLCM                                   00001091
C      00001092
C      COMMON /TEST/                                           00001093
20     * ITSOLI,ITDEMI,ITSOLD(12),ITDEND(12),TSTDEME(25,12)      00001094
C      * ,TSTDENT(25,12),TSTESOL(24,12),TSITSOL(24,12),IDINYR 00001095
C      * ,IDMBIAS,KL,IFLG,NF,NFILE,KHEADF,IDAYPR,CBREF          00001096
C      00001097
C      IS SOLAR INSOLATION DATA ON TAPE 2 OR IN NAMELIST ARRAYS. 00001098
C      IF ISOLOPT=0, INSOLATION DATA IS ON TAPE 2.             00001099
25     IF ISOLOPT=1, INSOLATION DATA IS IN NAMELIST ARRAYS.    00001100
C      00001101
C      IF (ISOLOPT .EQ. 1) GO TO 90                             00001102
C      00001103
C      INSOLATION DATA IS ON TAPE 2. IF THIS IS FIRST CALL TO 00001104
30     SUBROUTINE SUN THIS CASE THEN IFLG=0 AND MUST READ SOLAR 00001105
C      INSOLATION DATA FROM TAPE 2 AND STORE IT IN LCM IN ARRAY 00001106
C      SUNLCM. IF THIS IS NOT FIRST CALL TO SUBROUTINE SUN THIS 00001107
C      CASE THEN IFLAG=1 AND INSOLATION DATA HAS ALREADY BEEN READ 00001108
35     INTO LCM SO GO TO 90 AND BYPASS SECTION OF CODE WHERE TAPE 2 00001109
C      IS READ.                                                 00001110
C      00001111
C      IF (IFLG .NE. 0) GO TO 90                                00001112
C      00001113
C      INCREMENT IFLG TO INDICATE SOLAR INSOLATION DATA FROM TAPE 2 00001114
40     HAS ALREADY BEEN READ IN FOR THIS CASE.                 00001115
C      00001116
C      IFLG=IFLG+1                                              00001117
C      00001118
C      NFILE INDICATES FILE WE WANT TO READ IN.                00001119
45     NF INDICATES FILE WE ARE POSITIONED TO READ.             00001120
C      IF NFILE EQ NF, THEN WE ARE POSITIONED TO READ IN FILE WE WANT 00001121
C      IF NFILE LT NF, THEN WE ARE BEYOND FILE WE WANT AND MUST GO TO 00001122
C      20 WHERE WE REWIND TAPE 2.                                00001123
50     IF NFILE GT NF, THEN WE ARE NOT YET TO FILE WE WANT SO MUST 00001124
C      GO TO 30 WHERE WE READ OVER THIS FILE.                  00001125
C      00001126
10     CONTINUE                                                00001127
C      IF (NFILE-NF) 20,60,30                                   00001128
```

55	20	CONTINUE	00001129
		REWIND 2	00001130
		NF=1	00001131
		GO TO 10	00001132
	30	CONTINUE	00001133
		DO 50 I=1,366	00001134
60	40	CONTINUE	00001135
		READ (2)	00001136
		IF (EOF(2)) 40,50	00001137
	50	CONTINUE	00001138
		NF=NF+1	00001139
65		GO TO 10	00001140
			00001141
		WE ARE POSITIONED AT RIGHT FILE.	00001142
		READ HEADER RECORD INTO STATION.	00001143
			00001144
70	60	CONTINUE	00001145
		READ (2) STATION	00001146
		IF (EOF(2)) 60,70	00001147
			00001148
		READ HOURLY INSOLATION DATA FOR 365 DAYS INTO SUNLCM.	00001149
75			00001150
	70	CONTINUE	00001151
		DO 80 IDAYL=1,365	00001152
		READ (2) ((SUNLCM(I, I HOUR, IDAYL)), I=1,3), I HOUR=1,24)	00001153
	80	CONTINUE	00001154
80			00001155
		INCREMENT FILE COUNTER.	00001156
		NF=NF+1	00001157
			00001158
85		LOAD DATA INTO APPROPRIATE VECTORS AND DO CALCULATIONS	00001159
			00001160
	90	CONTINUE	00001161
			00001162
		IF ISOLOPT EQ 1, THEN USE TEST INSOLATION DATA READ IN VIA	00001163
90		NAMelist.	00001164
			00001165
		IF (ISOLOPT .EQ. 0) GO TO 130	00001166
			00001167
			00001168
95		DETERMINE INTERVAL TO WHICH DAY IDAY BELONGS.	00001169
		WHEN LEAVE LOOP 100 J WILL INDICATE APPROPRIATE INTERVAL.	00001170
		(WHEN DAY LIES WITHIN INTERVAL J IT WILL BE LESS THAN OR	00001171
		EQUAL TO THE LAST DAY OF THE INTERVAL AND EXECUTION WILL	00001172
		LEAVE THE LOOP)	00001173
			00001174
100		DO 100 J=1, ITSOLI	00001175
		IF (IDAY .LE. ITSOLD(J)) GO TO 110	00001176
	100	CONTINUE	00001177
			00001178
105		STORE HOURLY INSOLATION TEST DATA FROM INTERVAL J IN QDTSUN1	00001179
		(TOTAL HEMISPHERIC INSOLATION) AND QDTSUN2 (DIRECT INSOLATION)	00001180
			00001181

SUBROUTINE SUN

76/76 OPT=1

FTN 4.6+4288

08/22/78 19.12.113

```

110 CONTINUE
DO 120 I HOUR=1,24
QDTSUN1(IHOUR)=TSTESOL(IHOUR,J)
110 QDTSUN2(IHOUR)=TSTTSOL(IHOUR,J)
120 CONTINUE
RETURN
C
C
C
115 STORE HOURLY INSOLATION DATA FOR DAY IDAY IN QDTSUN1
(TOTAL HEMISPHERIC INSOLATION) AND QDTSUN2 (DIRECT INSOLATION)
C
130 CONTINUE
DO 140 I HOUR=1,24
QDTSUN2(IHOUR)=SUNLCM(1,IHOUR,IDAY)
120 QDTSUN1(IHOUR)=SUNLCM(2,IHOUR,IDAY)
140 CONTINUE
RETURN
END

```

SYMBOLIC REFERENCE MAP (R=3)

ENTRY	POINTS	DEF LINE	REFERENCES
3	SUN	1	112 122

VARIABLES	SN	TYPE	RELOCATION	REFS	7	16	59	78	119	120	DEFINED	1
1005	ACOP	REAL	BTUPAR	REFS	7							
2272	CBREF	REAL	TEST	REFS	18							
774	CONLTD	REAL	BTUPAR	REFS	7							
63250	DEMLCM	REAL	LCMBLK	REFS	14							
1040	HSUN	REAL	BTUPAR	REFS	7							
153	I	INTEGER		REFS	78		DEFINED					
710	ICHAR	INTEGER	BTUPAR	REFS	7							
773	ICCOL	INTEGER	BTUPAR	REFS	7							
0	IDAY	INTEGER	F.P.	REFS	101		DEFINED		119	120	DEFINED	1
154	IDAYL	INTEGER		REFS	78				DEFINED	77		
2271	IDAYPR	INTEGER	TEST	REFS	18							
1003	IDEMOPT	INTEGER	BTUPAR	REFS	7							
775	IDFILE	INTEGER	BTUPAR	REFS	7							
2262	IDINYR	INTEGER	TEST	REFS	18							
2263	IDMBIAS	INTEGER	TEST	REFS	18							
2265	IFLG	INTEGER	TEST	REFS	18							
155	I HOUR	INTEGER		REFS	78							
1004	ISOLOPT	INTEGER	BTUPAR	REFS	78							
16	ITDEMO	INTEGER	TEST	REFS	7							
1	ITDEMI	INTEGER	TEST	REFS	18							
2	ITSOLD	INTEGER	TEST	REFS	18							
0	ITSOLI	INTEGER	TEST	REFS	18							
156	J	INTEGER		REFS	101							
2270	KHEADF	INTEGER	TEST	REFS	18							

```

1      SUBROUTINE YEAR (I,J,K,L,M,IPRNT,ITRBOPT)
C
C
C
5      SUBROUTINE YEAR MODELS THE OPERATION OF A STES FACILITY
C      FOR ONE YEAR. FOR EACH DAY OF THE YEAR, SUBROUTINE SUN IS
C      CALLED TO GET THE DAYS INSOLATION, SUBROUTINE DEMAND IS
C      CALLED TO GET THE DAYS T/E ENERGY DEMAND, AND SUBROUTINE
C      DAY IS CALLED TO PERFORM THE DAYS ENERGY BALANCE. AT THE
C      END OF THE YEAR, SUBROUTINE REPORT IS CALLED TO GENERATE
10     THE OUTPUT REPORTS FOR THIS CASE.
C
C
C      COMMON /AVERAGE/
C      *      DC1,DC2,DS1,DS2,DS3,DS,DC,WSUN,WDE,WOSP,WE,WF1,WF2
C
15     COMMON /BTUPAR/
C      *      QDTSUN1(25),QDTSUN2(25),QDOTE(25),RE(25),QDOTSP(25),
C      *      RF(25),QDOTS(25),KP,
C      *      QDOTB(25,2),QDOTA(25,2),QDOTH(25,2),QDOTW(25,2),QBAWH(4,5,4),
C      *      ICHAR(12,4),STATION(3),ICOOL,CONLTD,IDFILE,NDF,TATLE(3)
C      *      ,OSTEIC1,IDEMOPT,ISOLOPT,ACOP,VCOP,PERIOD(25),HSUN(14)
C
C      COMMON /TEST/
C      *      ITSOLI,ITDEMI,ITSOLD(12),ITDEMD(12),TSTDEME(25,12)
C      *      ,TSTDENT(25,12),TSTESOL(24,12),TSTTSOL(24,12),IDINYR
C      *      ,IDMBIAS,KL,IFLG,NF,NFILE,KHEADF,IDAYPR,CBREF
C
C      DIMENSION
C      *      ARR(13),ARRT(13)
C
30     EQUIVALENCE
C      *      (DC1,ARR(1))
C
C      INITIALIZE CASE SUMMARY VARIABLES FOR THIS CASE.
C
35     DO 10 II=1,KL
C      ARRT(II)=0.0
10    CONTINUE
C
C      FOR EACH DAY OF THE YEAR:
C      CALL SUBROUTINE SUN TO GET DAYS INSOLATION.
C      CALL SUBROUTINE DEMAND TO GET DAYS T/E DEMAND.
C      CALL SUBROUTINE DAY TO PERFORM DAYS ENERGY BALANCE.
C
C
45     DO 30 IDAY=1,IDINYR
C      CALL SUN (IDAY)
C      CALL DEMAND (IDAY)
C
C
C      IF SPECIAL SUMMARY PRINTOUT REQUESTED, CALL HEADER TO
C      WRITE OUT SPECIAL SUMMARY PRINTOUT HEADER ON FILE 1.
C
50     IF (KHEADF .EQ. 1) CALL HEADER(1)
C      CALL DAY (I,J,K,L,M,IPRNT,IDAY,ITRBOPT)
C
C
C

```

SUBROUTINE YEAR

76/76

OPT=1

FTN 4.6+428B

08/22/78 19.12.11\$

```

55      C      FORM CUMULATIVE SUMS OF CASE SUMMARY VARIABLES.
      C
      DO 20 II=1,KL
      ARR(II)=ARR(II)+ARRT(II)
20      CONTINUE
30      CONTINUE
60      C      STORE CASE SUMMARY VARIABLES IN COMMON BLOCK AVERAGE
      C      SO THEY CAN BE ACCESSED IN SUBROUTINE REPORT.
      C
      DO 40 II=1,KL
      ARR(II)=ARRT(II)
65      40      CONTINUE
      C
      CALL SUBROUTINE REPORT TO GENERATE OUTPUT REPORTS FOR THIS
      CASE.
70      CALL REPORT (I,J,K,L,M,IPRNT)
      RETURN
      END

```

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00001252
00001253
00001254
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00001262
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00001268
00001269
00001270
00001271

```

SYMBOLIC REFERENCE MAP (R=3)

ENTRY	POINTS	DEF	LINE	REFERENCES					
3	YEAR	1	72						
VARIABLES	SN	TYPE	RELOCATION						
1005	ACOP	REAL	BTUPAR	ARRAY	15				
0	ARR	REAL	AVERAGE	ARRAY	27	30	57	DEFINED	65
127	ARRT	REAL			27	57	65	DEFINED	36
2272	CBREF	REAL	TEST		22				
774	CONLTD	REAL	BTUPAR		15				
6	DC	REAL	AVERAGE		12				
0	DC1	REAL	AVERAGE		12	30			
1	DC2	REAL	AVERAGE		12				
5	DS	REAL	AVERAGE		12				
2	DS1	REAL	AVERAGE		12				
3	DS2	REAL	AVERAGE		12				
4	DS3	REAL	AVERAGE		12				
1040	HSUN	REAL	BTUPAR	ARRAY	15				
0	I	INTEGER	F. P.		52	71	DEFINED	1	
710	ICHAR	INTEGER	BTUPAR	ARRAY	15				
773	ICQOL	INTEGER	BTUPAR		15				
126	IDAY	INTEGER			45	46	52	DEFINED	44
2271	IDAYPR	INTEGER	TEST		22				
1003	IDEMOPT	INTEGER	BTUPAR		15				
775	IDFILE	INTEGER	BTUPAR		15				
2262	IDINYR	INTEGER	TEST		22	44			
2263	IDMBIA	INTEGER	TEST		22				

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(NOTE: FOR OFF-SITE PERSONNEL, SHOW LOCATION SYMBOL, e.g. JOHN Q. PUBLIC/VAFB)

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SHEET 76 OF 76