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USER'S GUIDE to the Monthly Performance Report of the National Solar Data Program

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IBM Corporation
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United States Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

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USER'S GUIDE

To The

MONTHLY PERFORMANCE REPORT

1. INTRODUCTION

For each solar energy system demonstration site participating in the National Solar Data Program, administered by the Department of Energy, a Monthly Performance Report is prepared. The purpose of the report is to assemble in convenient form pertinent information on the operation and status of the system for the reporting period.

The report contains both an analysis of the system's performance for the month and computer printouts of associated data and performance factors. The Monthly Performance Report becomes the historical record of the performance of the system over the duration of the demonstration program.

Although the data content of each report varies from site to site, all have the same general format. As an aid to understanding this format, its nomenclature, parameters, and various elements, Section 2 of this User's Guide contains background information about the National Solar Data Network collection and processing functions, including how the measurements are gathered, transmitted and eventually presented in a usable form for each report. An overview of the report is given in Section 3. A detailed description of the various report forms is given in Section 4.

2. BACKGROUND INFORMATION

The following components of the National Solar Data Network must function together to provide the necessary data in the required form for the Monthly Performance Reports (see Figure 1).

1. Site Instrumentation, e.g., sensors, gages, etc.

2. Site Data Acquisition Subsystem (SDAS)

3. Communications Link

4. Central Data Processing System (CDPS), consisting of a communications processor with suitable software to control the data collection from the instrumented sites, and a Host (or main) computer with appropriate software and sufficient data storage to process the collected data

2.1 Site Instrumentation

The solar energy system at each site is instrumented to provide sufficient measurements to support the thermal performance analysis of the solar energy system and individual subsystems. This instrumentation generally includes sensor devices to monitor the following:

- Total Insolation (in the plane of the collector array)
- Outdoor ambient temperature
- Building temperature
- Collector loop flow rate and temperatures
- Storage inlet flow rate and temperatures
- Storage outlet flow rate and temperatures
- Storage temperature
- Load subsystem flow rates and temperatures
- Auxiliary fuel flows and values

Instruments are selected for each system to provide the data required for calculation of the performance factors to the extent that each is applicable and practicable. (See NBSIR 76-1137, August 1976, National Bureau of Standards.) Some sites have additional instrumentation as a result of site-unique requirements.

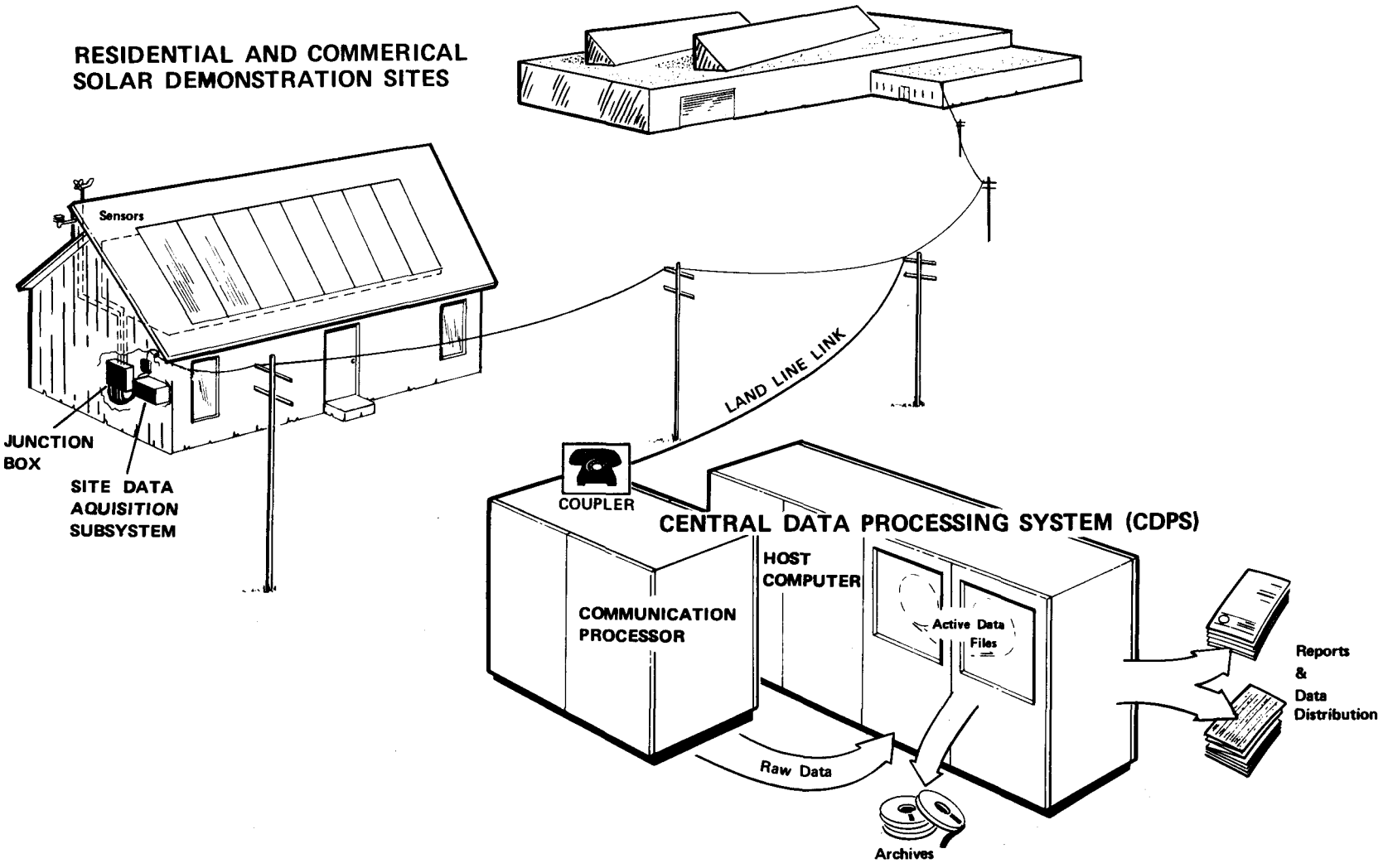

Figure 1. National Solar Data Network

2.2 Site Data Acquisition Subsystem

The data at each site are recorded automatically at prescribed intervals by the Site Data Acquisition Subsystem (SDAS). Periodically, these recorded data are transferred to the Central Data Processing System (CDPS) at the IBM facility in Huntsville, Alabama.

2.3 Communications Link

The communications link between each SDAS and the CDPS consists of voice-grade telephone lines and telephone data couplers. The recorded data at each remote site are collected periodically (usually daily) by the Communications Processor in the CDPS. The Communications Processor directs the calling of all sites, communicates with the SDAS, and temporarily stores the data until called for by the Host Computer for processing. For each site call, the Communications Processor establishes and verifies correct contact with the site by checking an address code transmitted from the SDAS. Also, the SDAS transmits the reading from its internal timer to insure that the data to be transmitted will be time-tagged correctly.

2.4 Central Data Processing System

After the Communications Processor scans the data as they are received to determine if there are any apparent errors in the transmission process, the measurement data are transferred to the Host Computer where they are converted from the binary transmission format to appropriate values in engineering units. This conversion uses factors which are unique to each site installation. The measurements are then checked to insure that they are reasonable, that is, they are not beyond the known limits of the instrumentation, or that they are not erratic. Data which appear questionable are discarded and are not used further in the site evaluation.

For each site, appropriate equations have been formulated and programmed. These equations define the desired performance factors for the system configuration at that site. All of the valid measurement data are processed using the performance equations to generate hourly performance factors. As sufficient data are accumulated, the hourly performance factors are combined to provide daily performance factors and, finally, monthly performance factors.

All of the performance factors are stored in the CDPS data files along with the measurements (in engineering units), site identification information (both numerical and textual), and certain site data which are used in processing and generating the performance factors.

3. REPORT OVERVIEW

The Monthly Performance Report consists of four main sections: (1) System Description, (2) Performance Evaluation, (3) Problem Status, and, (4) Report Forms. Of general concern to the overall report content are data integrity and energy savings. Brief discussions of all of the above are given in the following subsections.

3.1 System Description

The System Description section of each report includes sufficient basic system information to provide the user with an overall appreciation of the solar energy system and its intended application for the particular site.

3.2 Performance Evaluation

The Performance Evaluation section describes the overall assessment of the system and each subsystem, and includes the results of any special analysis performed on the site data during the reporting period. The system evaluation is directly derived from the measurement results contained on the computer-generated report forms.

3.3 Problem Status

This section identifies solar energy system and data system problems for the site which are outstanding at the end of the month. Recommended solutions and alternate solutions, along with schedules for implementing them are given for each specific problem.

3.4 Report Forms

For each site, all measurement data gathered during the month are processed by the Host Computer, and the resultant printouts are incorporated in the Monthly Performance Report for the site. These report printouts list the daily measurements of the individual subsystems and of the environmental and insolation sensors. In addition, site summary report printouts present a summation of the daily measurements, performance factors, and the subsystem energy totals for the month.

A detailed description of each report form, including definitions of the various terms, is presented in Section 4.

3.5 Data Integrity

As previously mentioned, all measurement data received from the remote site are checked to insure that the transmission quality is acceptable. All data from the remote site are examined, and data with apparent errors are tagged by the data processing software and recognized thereafter as invalid.

Similarly, there are data which may be transmitted properly but may appear questionable because of the values obtained after conversion to engineering units. These apparent anomalies may be caused by a sensor failure at the site, incorrect sensor installation, a transmission problem (otherwise undetected), a software problem not previously detected, or a malfunction of the solar energy system. Data of this character are also tagged as invalid.

No data which have been identified as invalid are used by the CDPS for the computation of performance factors. The existence of such invalid data, however, implies that suitable procedures must be incorporated into the software to assure viable data in the Monthly Performance Report, and to identify the existence of any unacceptable data. Such procedures are implemented in the software by enforcing a requirement for a minimum amount of data necessary to provide reasonable validity. These minimum limits are selected (from the results of data analysis studies) to insure that the performance factors computed from the data fall within 10 percent of the true value even in the case of missing data.

There may be a maximum of twelve measurement scans recorded within any particular clock hour. When there is a missing measurement, the next good measurement is assumed to replace the missing measurement for the purpose of computing the hourly performance factors. (The missing measurement is assumed only for the purpose of computing the appropriate performance factors; it is not actually replaced in the data.) Therefore, all performance factors which are computed are supported by a reasonable amount of good data. All other performance factors are tagged as invalid.

Similarly, there must be a representative number of good, hourly samples within any one calendar day to initiate the calculation of daily performance factors. When there are sufficient data, any invalid data are replaced (for computational purposes) by the average of the good samples.

The monthly performance factors are computed only if there is a minimum number of good daily samples. As before, the invalid data are replaced (for computation) by the average of all of the good daily samples. These techniques provide performance factors which are supported by sufficient data, thereby producing a high confidence level in the information.

3.6 Energy Savings

The electrical energy savings and the fossil energy savings for each subsystem of a given site are computed and reported in the Monthly Performance Report. Since the nature of these calculations is quite different from the other reported data, it is necessary to understand the characteristics of this information to appreciate its relative merit in the evaluation of system performance.

Most of the performance factors are generated from pre-defined data processing applied to instrumented data; consequently, most performance factors reflect measured data. The calculation of energy savings is not linked so clearly with measured data. To determine how much energy is saved by a system, it is first necessary to know how much energy would have been required without the energy savings feature. Obviously, this cannot be instrumented.

The approach used to compute energy savings consists of assuming the most reasonable alternative conventional system based on the existing auxiliary equipment, local utility rate structure, and local building practice. The energy requirements (of each kind) to support the measured load are then estimated from the characteristics of the assumed alternative system. Finally, the actual measured energy requirements (of each kind) of the solar-supported system are subtracted from the estimated requirements of the assumed system to determine the savings.

The energy savings figures, therefore, are subjective to the extent that engineering judgement must be applied to determine the most reasonable alternative system and its overall efficiency in supporting the measured load. As more data are collected during the program, additional insight into this problem will be achieved and applied to future calculations of the data, especially specific site data.

4. DETAILED DESCRIPTION OF REPORT FORMS

The numbers that appear in the completed report forms are presented in pre-defined positions and lengths. In general, energy values are given in the format-dddd.ddd, with each character representing a digit, and the value is in millions of BTU. This particular selection provides sufficient range to display very small energy values (1000 BTU) as well as the largest values that can be reasonably anticipated from the systems in the program (up to 10 billion BTU). This standard format should not be interpreted to imply that the numbers are accurate to the full number of digits presented; the data which appear are simply the result that is automatically generated (via the data processing program) from the measured data. The accuracy of the data must be inferred from the specifications of the instruments, the data collection and processing system, and the site-particular considerations such as faulty sensors or peculiar installation (which are items identified in the narrative summary).

A detailed description of each report form is given in the following subsections. In an actual report, the forms as shown would, of course, be filled in with data values.

4.1 Site Summary

The Site Summary includes the monthly values of all significant system performance parameters. See Figure 2A for an example in English Units. The Site Summary is also provided in S. I. Units as shown in Figure 2B.

In addition to the features and definitions provided here for the site summary form, the CDPS has the capability of maintaining notes and comments, in textual format, which will be needed to understand the significance of the data presented. These notes will be updated periodically so that recipients will be aware of any major system anomalies, off-line analysis results, or other items which may be important in assessing the system.

The main parts of this report form, identified on Figure 2A, are as follows:

(A) Site location, date of report, and site identification number. Each of the performance data report printouts will contain this information.

(B) A brief description of equipment used and intended thermal energy loads, or any pertinent system information.

(C) General parameters for the energy collection and storage subsystem.

(D) Performance parameters for each load subsystem.

(E) System performance factor value.

(F) Symbols which appear on the Site Summary form.

(G) Space available for listing applicable references which may be useful if further investigation is desired.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

(A) SITE: SOLAR/
REPORT PERIOD:

(B) SITE/SYSTEM DESCRIPTION:

(C) GENERAL SITE DATA:

INCIDENT SOLAR ENERGY ← (1)		MILLION BTU
		BTU/SQ.FT.
COLLECTED SOLAR ENERGY ← (2)		MILLION BTU
		BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE ← (3)		DEGREES F
AVERAGE BUILDING TEMPERATURE ← (4)		DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY ← (5)		
ECSS OPERATING ENERGY ← (6)		MILLION BTU
TOTAL SYSTEM OPERATING ENERGY ← (7)		MILLION BTU
TOTAL ENERGY CONSUMED ← (8)		MILLION BTU

(D) LOAD SUBSYSTEM SUMMARY:

(10)	HOT WATER	HEATING	COOLING	TOTAL	
LOAD					MILLION BTU
SOLAR FRACTION					PERCENT
SOLAR ENERGY USED					MILLION BTU
OPERATING ENERGY					MILLION BTU
AUX. THERMAL ENERGY					MILLION BTU
AUX. ELECTRIC FUEL					MILLION BTU
AUX. FOSSIL FUEL					MILLION BTU
ELECTRICAL SAVINGS					MILLION BTU
FOSSIL SAVINGS					MILLION BTU

(E) SYSTEM PERFORMANCE FACTOR: ← (9)

(F) * DENOTES UNAVAILABLE DATA
N.A. DENOTES NOT APPLICABLE DATA

(G) REFERENCE DOCUMENTS

Figure 2A. Monthly Site Report Summary Report Form (for English Units)

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: SOLAR/
REPORT PERIOD:

SITE/SYSTEM DESCRIPTION:

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	GIGA JOULES
	KJ/SQ.M.
COLLECTED SOLAR ENERGY	GIGA JOULES
	KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	DEGREES C
AVERAGE BUILDING TEMPERATURE	DEGREES C
ECSS SOLAR CONVERSION EFFICIENCY	
ECSS OPERATING ENERGY	GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	GIGA JOULES
TOTAL ENERGY CONSUMED	GIGA JOULES

LOAD SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	TOTAL	
LOAD					GIGA JOULES
SOLAR FRACTION					PERCENT
SOLAR ENERGY USED					GIGA JOULES
OPERATING ENERGY					GIGA JOULES
AUX. THERMAL ENG					GIGA JOULES
AUX. ELECTRIC FUEL					GIGA JOULES
AUX. FOSSIL FUEL					GIGA JOULES
ELECTRICAL SAVINGS					GIGA JOULES
FOSSIL SAVINGS					GIGA JOULES

SYSTEM PERFORMANCE FACTOR:

* DENOTES UNAVAILABLE DATA
N.A. DENOTES NOT APPLICABLE DATA

Figure 2B. Monthly Site Report Summary Report Form (for S. I. Units)

The data entries for the system's primary performance factors, summarized for the month, are identified on this report, as shown on Figure 2A, and are defined as follows:

(1) Incident Solar Energy is the total insolation available on the gross collector array area. This is the area of the collector energy-receiving aperture, including the framework which is an integral part of the collector structure. (This energy, expressed in BTU/Sq. Ft., will be about 60,000 for most average months and collector tilt angles. Pyranometers in the program are mounted tilted in the plane of the collector array.)

(2) Collected Solar Energy is the thermal energy removed from the collector array by the heat transfer medium.

(3) Average Ambient Temperature is the average temperature of the outdoor environment at the site.

(4) Average Building Temperature is the average temperature in the controlled space of the building which the system serves.

(5) ECSS* Solar Conversion Efficiency is the ratio of the solar energy delivered to the load subsystems to the total energy incident on the collector array. In general, this will be a small number since it includes effects of the overall collection efficiency, losses by the collectors, the transport mechanism, and the storage device, and losses imposed by the control system.

(6) ECSS Operating Energy is the electrical operating energy required to support the ECSS heat transfer loops.

(7) Total System Operating Energy is the total operating energy of all load subsystems and ECSS operating energy.

(8) Total Energy Consumed is the sum of the collected solar energy, the total system operating energy, the total fossil fuel energy, and the total electrical fuel energy. This performance factor represents the total energy demands of the system from all outside sources.

(9) System Performance Factor is the ratio of the total system load to the equivalent fossil energy required to support the system for the month. The equivalent energy, as used in this context, is the sum of the actual fossil fuel and (1/.3) times the electrical requirements (For operating energy and fuel). This multiplication factor results from the estimation that, on the average, the efficiency of extracting fossil fuels from the ground, converting to electricity, and transmitting the electrical energy to the site is about 0.3.

*Energy Collection and Storage Subsystem

⑩ Subsystem Load Summaries: All factors for the load subsystem summary are totaled here for the month. The energy savings figures are computed in accordance with the comments presented in paragraph 3.6. The following are the definitions for each subsystem load summary:

- Load is the amount of energy required for the month for each of the respective subsystems.

- Solar Fraction is the percentage of the load demand during the month for each subsystem which was supported by solar energy.

- Solar Energy Used is the total amount of solar energy supplied each subsystem for the month.

- Operating Energy is the energy-equivalent of the amount of electrical energy required to operate each subsystem for the month.

- Auxiliary Thermal Used is the amount of energy supplied, during the month, to the major components of each subsystem in the form of thermal energy in a heat transfer medium. This term also includes the converted electrical and fossil fuel energy supplied to the subsystem.

- Auxiliary Electrical Fuel is the total amount of electrical energy supplied directly to each subsystem during the month.

- Auxiliary Fossil Fuel is the total amount of fossil fuel energy supplied directly to each subsystem during the month.

- Electrical Energy Savings is the estimated difference between the electrical energy requirements of an alternative conventional system (carrying the full load) and the actual electrical energy required by each subsystem.

- Fossil Energy Savings is the estimated difference between the fossil energy requirements of the alternative conventional system (carrying the full load) and the actual fossil energy requirements of each subsystem.

4.2 Collector Array Performance

The collector array performance is characterized by the amount of solar energy collected with respect to the energy available to be collected. The specific items on this report form are listed on Figure 3 and defined by the following:

Incident Solar Energy is the total insolation available on the gross collector array area. This is the area of the collector energy-receiving aperture, including the framework which is an integral part of the collector structure. (This energy, expressed in BTU/Sq. Ft., will be about 60,000 for most average months and collector tilt angles. Pyranometers in the program are mounted tilted in the plane of the collector array.)

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: SOLAR/
REPORT PERIOD:

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
SUM					
AVG					
NBSID	Q001		Q100		N100

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

Figure 3. Collector Array Performance Report Form

- Operational Incident Energy is the amount of energy incident on the collector array during the time that the collector loop is active (attempting to collect energy).

- Collected Solar Energy is the thermal energy removed from the collector array by the heat transfer medium.

- Daytime Ambient Temperature is the average temperature of the environment at the site during the period from three hours prior to local solar noon to three hours past local solar noon. (This time frame is selected independently of the operation of the collectors at the site, and it is intended to serve as a historical record of the ambient temperature during normal collector operation.)

- Collector Array Efficiency is the ratio of the energy collected to the total energy incident on the collector array. It should be emphasized that this efficiency factor is for the collector array, and available energy includes the energy incident on the array when the collector loop is inactive. This efficiency must not be confused with the more common collector efficiency figures which are determined from instantaneous data during steady state operation of a single collector unit. These efficiency figures are often provided by collector manufacturers or presented in technical journals to characterize the functional capability of a particular collector design. In general, the collector panel maximum efficiency factor will be significantly higher than the collector array efficiency reported here. (NOTE: Collector performances for the National Solar Heating and Cooling Demonstration Program will be evaluated through analysis programs independent of these regular monthly reports.)

4.3 Storage Performance

The storage performance is characterized by the relationships among the energy delivered to storage, removed from storage, and the subsequent change in the amount of stored energy. The particular performance factors provided in this form are listed on Figure 4 and defined as follows:

- Energy To Storage is the amount of energy, both solar and auxiliary, delivered to the primary storage medium.

- Energy From Storage is the amount of energy extracted by the load subsystems from the primary storage medium.

- Change in Stored Energy is the difference in the estimated stored energy during the specified reporting period, as indicated by the relative temperature of the storage medium (either positive or negative value).

- Storage Average Temperature is the mass-weighted average temperature of the primary storage medium.

- Storage Efficiency is the ratio of the sum of the energy removed from storage and the change in stored energy to the energy delivered to storage.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: SOLAR/
REPORT PERIOD:

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
SUM					
AVG					
NBS ID	Q200	Q201	Q202		N108

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

Figure 4. Storage Performance Report Form

4.4 Energy Collection And Storage Subsystem

The Energy Collection and Storage Subsystem (ECSS) is composed of the collector array, the primary storage medium, the transport loops between these, and other components in the system design which are necessary to mechanize the collector and storage equipment.

The report form for the ECSS contains the following performance factors as listed on Figure 5:

- Incident Solar Energy is the total insolation available on the gross collector array area. This is the area of the collector energy-receiving aperture, including the framework which is an integral part of the collector structure. (This energy, expressed in BTU/Sq. Ft., will be about 60,000 for most average months and collector tilt angles. Pyranometers in the program are mounted tilted in the plane of the collector array.)

- Ambient Temperature is the average temperature of the outdoor environment at the site.

- Energy to Loads is the total thermal energy transported from the ECSS to all load subsystems.

- Auxiliary Thermal Energy to ECSS is the total auxiliary energy supplied to the ECSS, including auxiliary energy added to the storage tank, heating devices on the collectors for freeze-protection, etc.

- ECSS Operating Energy is the electrical operating energy required to support the ECSS heat transfer loops.

- ECSS Rejected Energy is the amount of energy rejected from the ECSS, including energy emitted through nocturnal radiation through the collectors for freeze-protection, excess energy released from storage for temperature control, etc.

- ECSS Solar Conversion Efficiency is the ratio of the solar energy delivered to the load subsystems to the total energy incident on the collector array. In general, this will be a rather small number, since it includes effects of the overall collection efficiency, losses by the collectors, transport mechanism, storage device, and losses imposed by the control system.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE:
REPORT PERIOD:

SOLAR/

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
SUM							
AVG							
NBS ID	Q001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

Figure 5. Energy Collection and Storage Subsystem Report Form

4.5 Hot Water Subsystem

The hot water subsystem is characterized by a complete accounting of the energy flow into and from the subsystem, as well as an accounting of internal energy. The energy into the subsystem is composed of auxiliary fossil fuel, and electrical auxiliary thermal energy, and the operating energy for the subsystem. In addition, the solar energy supplied to the subsystem, along with solar fraction, is tabulated. The load of the subsystem is tabulated and used to compute the estimated electrical and fossil savings of the subsystem. The load of the subsystem is further identified by tabulating the supply-water temperature, the outlet hot-water temperature, and the total hot-water consumption. The specific factors which are presented on this report form are shown in Figure 6 and defined as follows:

- Hot Water Load is the amount of energy required to heat the amount of hot water demanded at the site from the incoming temperature to the desired outlet temperature.

- Solar Fraction of Load is the percentage of the load demand which is supported by solar energy.

- Solar Energy Used is the amount of solar energy supplied to the hot water subsystem.

- Operating Energy is the amount of electrical energy required to support the subsystem, (e.g., fans, pumps, etc.) and which is not intended to affect directly the thermal state of the subsystem.

- Auxiliary Thermal Used is the amount of energy supplied to the major components of the subsystem in the form of thermal energy in a heat transfer fluid, or its equivalent. This term also includes the converted electrical and fossil fuel energy supplied to the subsystem.

- Auxiliary Electrical Fuel is the amount of electrical energy supplied directly to the subsystem.

- Auxiliary Fossil Fuel is the amount of fossil fuel energy supplied directly to the subsystem.

- Electrical Energy Savings is the estimated difference between the electrical energy requirements of an alternative conventional system (carrying the full load) and the actual electrical energy required by the subsystem.

- Fossil Energy Savings is the estimated difference between the fossil energy requirements of the alternative conventional system (carrying the full load) and the actual fossil energy requirements of the subsystem.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
HOT WATER SUBSYSTEM

SITE:
REPORT PERIOD:

SOLAR/

DAY OF MONTH	HOT WATER LOAD MILLION BTU	SOLAR FRACTION OF LOAD PERCENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	SUPPLY WATER TEMP. DEG F	H WATER AVG TEMP. DEG F	H WATER USED GAL
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
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19												
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21												
22												
23												
24												
25												
26												
27												
28												
29												
30												
31												
SUM												
AVG												
NBS ID	Q302	N300	Q300	Q303	Q301	Q305	Q306	Q311	Q313	N305	N307	N308

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

Figure 6. Hot Water Subsystem Report Form

- Supply Water Temperature is the average inlet temperature of the water supplied to the subsystem.

- Average Hot Water Temperature is the average temperature of the outlet water as it is supplied from the subsystem to the load.

- Hot Water Used is the volume of water used.

4.6 Space Heating Subsystem

The space heating subsystem is characterized by performance factors similar to those of the hot water subsystem, described in Section 4.5. The average building temperature and the average ambient temperature are tabulated again on this form to indicate the relative performance of the subsystem in satisfying the space heating load and in controlling the temperature of the conditioned space. The performance factors provided on this report form (Figure 7) are defined as follows:

- Space Heating Load is the sensible energy added to the air in the building.

- Solar Fraction of Load is the percentage of the load demand which is supported by solar energy.

- Solar Energy Used is the amount of solar energy supplied to the space heating subsystem.

- Operating Energy is the amount of electrical energy required to support the subsystem, (e.g., fans, pumps, etc.) and which is not intended to affect directly the thermal state of the subsystem.

- Auxiliary Thermal Used is the amount of energy supplied to the major components of the subsystem in the form of thermal energy in a heat transfer fluid or its equivalent. This term also includes the converted electrical and fossil fuel energy supplied to the subsystem.

- Auxiliary Electrical Fuel is the amount of electrical energy supplied directly to the subsystem.

- Auxiliary Fossil Fuel is the amount of fossil fuel energy supplied directly to the subsystem.

- Electrical Energy Savings is the estimated difference between the electrical energy requirements of an alternative conventional system (carrying the full load) and the actual electrical energy required by the subsystem.

- Fossil Energy Savings is the estimated difference between the fossil energy requirements of the alternative conventional system (carrying the full load) and the actual fossil energy requirements of the subsystem.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE HEATING SUBSYSTEM

SITE: SOLAR/
REPORT PERIOD:

DAY OF MONTH	SPACE HEATING LOAD MILLION BTU	SOLAR FRACTION OF LOAD PERCENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG TEMP DEG F	AMB TEMP DEG F
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28											
29											
30											
31											
SUM											
AVG											
NBS ID	Q402	N400	Q400	Q403	Q401		Q410	Q415	Q417	N406	N113

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

Figure 7. Space Heating Subsystem Report Form

- Building Temperature is the average space heated area dry bulb temperature.

- Ambient Temperature is the average ambient dry bulb temperature at the site.

4.7 Space Cooling Subsystem

The space cooling subsystem is characterized by performance factors similar to those of the hot water subsystem and space heating subsystem, described previously. The performance factors in this form (Figure 8) are defined as follows:

- Space Cooling Load is the total energy, including sensible and latent, removed from the air in the spaced-cooled area of the building.

- Solar Fraction of Load is the percentage of the load demand which is supported by solar energy.

- Solar Energy Used is the amount of solar energy supplied to the space-cooling subsystem.

- Operating Energy is the amount of electrical energy required to support the subsystem, (e.g., fans, pumps, etc.) and which is not intended to affect directly the thermal state of the subsystem.

- Auxiliary Thermal Used is the amount of energy supplied to the major components of the subsystem in the form of thermal energy in a heat transfer fluid, or its equivalent. This term also includes the converted electrical and fossil fuel energy supplied to the subsystem.

- Auxiliary Electrical Fuel is the amount of electrical energy supplied directly to the subsystem.

- Auxiliary Fossil Fuel is the amount of fossil fuel energy supplied directly to the subsystem.

- Electrical Energy Savings is the estimated difference between the electrical energy requirements of an alternative conventional system (carrying the full load) and the actual electrical energy required by the subsystem.

- Fossil Energy Savings is the estimated difference between the fossil energy requirements of the alternative conventional system (carrying the full load) and the actual fossil energy requirements of the subsystem.

- Building Dry Bulb Temperature is the average temperature of the spaced-cooled area.

- Ambient Temperature is the average ambient dry bulb temperature at the site.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE COOLING SUBSYSTEM

SITE:
REPORT PERIOD:

SOLAR/

DAY OF MONTH	SPACE COOLING LOAD MILLION BTU	SOLAR FRACTION OF LOAD PERCENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG DRY BULB TEMP DEG F	AMB TEMP DEG F
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2											
3											
4											
5											
6											
7											
8											
9											
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31											
SUM											
AVG											
NBS ID	Q502	N500	Q500	Q503	Q501		Q508	Q512	Q514	N406	N113

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

Figure 8. Space Cooling Subsystem Report Form

4.8 Environmental Summary

The environmental summary is a collection of the weather data which is generally instrumented at each site in the program. It is tabulated in this data report for two purposes--as a measure of the conditions prevalent during the operation of the system at the site, and as an historical record of weather data for the vicinity of the site.

The performance factors on the report form (Figure 9) are defined as follows:

- Total Insolation is accumulated total solar energy measured at the site.
- Diffuse Insolation is the accumulated diffuse solar energy measured at the site.
- Ambient Temperature is the average temperature of the environment at the site.
- Daytime Ambient Temperature is the average ambient temperature of the environment at the site during the period from three hours prior to local solar noon to three hours past local solar noon. (This time frame is selected independently of the operation of the collectors at the site, and it is intended to serve as historical data for the ambient temperatures during the normal collector operating period.)
- Relative Humidity is the average relative humidity of the environment at the site.
- Wind Direction is the averaged direction of the prevailing wind.
- Wind Speed is the average wind speed measured at the site.

4.9 Thermodynamic Conversion Equipment

The performance of all thermodynamic cycle equipment (e.g., heat pumps) used to transform energy at one temperature to energy at another temperature will be reported on this form. The performance is characterized by the energies flowing to and from the equipment and the coefficient of performance of the equipment. Due to the many methods that are used to calculate coefficient of performance, the method used will be noted on the same page that the coefficient of performance is presented.

The performance factors on this report form(Figure 10) are defined as follows:

- Equipment Load is the controlled energy output of thermodynamic conversion equipment.
- Thermal Energy Input is the equivalent thermal energy which is supplied as a fuel source to thermodynamic conversion equipment.
- Operating Energy is the amount of energy required to support the operation of thermodynamic conversion equipment which is not intended to appear directly in the load.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE:
REPORT PERIOD:

SOLAR/

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIPECTION DEGREES	WIND SPEED M.P.H.
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
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31							
SUM							
AVG							
NBS ID	Q001		N113			N115	N114

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

Figure 9. Environmental Summary Report Form

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
THERMODYNAMIC CONVERSION EQUIPMENT

SITE: SOLAR/
REPORT PERIOD: REPORT DATE:

DAY OF MONTH	EQUIPMENT LOAD MILLION BTU	THERMAL ENERGY INPUT MILLION BTU	OPERATING ENERGY MILLION BTU	ENERGY REJECTED MILLION BTU	COEFFICIENT OF PERFORMANCE (SEE NOTE)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
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23					
24					
25					
26					
27					
28					
29					
30					
31					
SUM					
AVG					

* DENOTES UNAVAILABLE DATA.
NOTE:

Figure 10. Thermodynamic Conversion Equipment Report Form

- Energy Rejected is the amount of energy intentionally rejected or dumped from thermodynamic conversion equipment as a by-product or consequence of its principal operation.

- Coefficient of Performance is the coefficient of performance of the thermodynamic conversion equipment.

4.10 Additional Forms

Certain solar energy systems in the Demonstration Program may have features which cannot be accurately described and evaluated by the data report forms described herein. The terms and definitions for these special forms will, for the most part, be obvious when compared to those already defined. Should any special form be used frequently, it will become a standard form accommodated by the CDPS and described in subsequent releases of this User's Guide.