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ALO/2744-13(Vol.3)(Pt.2)

CONCEPTUAL DESIGN AND SYSTEMS ANALYSIS OF PHOTOVOLTAIC
POWER SYSTEMS. FINAL REPORT

Volume 3(2). Technology

By
P. F. Pittman

May 1977

Work Performed Under Contract No. EY-76-C-04-2744

Westinghouse Electric Corporation
Research and Development Center
Pittsburgh, Pennsylvania

MASTER

U.S. Department of Energy

Solar Energy

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FINAL REPORT
CONCEPTUAL DESIGN AND SYSTEMS ANALYSIS OF
PHOTOVOLTAIC POWER SYSTEMS
VOLUME III(2) - TECHNOLOGY

by

P. F. Pittman

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Prepared for
Energy Research and Development Administration

May 1977

ERDA-ALBUQUERQUE OPERATIONS OFFICE

Contract E(11-1)2744
Dr. Donald G. Schueler
Sandia Laboratories

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FOREWORD

The work described in this report was done by Westinghouse and its subcontractors under ERDA Contract E(11-1)2744. This program is part of the National Photovoltaic Program managed by ERDA through the Division of Solar Energy, Dr. Morton B. Prince, Acting Assistant Director, Photovoltaic, and The Silicon Technology Branch, Dr. Leonard M. Magid, Acting Chief.

Responsibility for the management of the Systems Definition Project of the National Photovoltaic Program, under which this contract fell, was delegated by ERDA to the Sandia Laboratories. The Program Manager at Sandia with responsibility for this contract was Dr. Donald Schueler, who was assisted by Dr. Billy W. Marshall who was the Task Leader for the Systems Definition and Analysis Task.

PREFACE

This volume contains the second part of a description of the in-depth studies of the technologies which underlie the system designs performed on the contract entitled, "Conceptual Design and System Analysis of Solar Photovoltaic Power Systems", sponsored by the Energy Research and Development Administration.

This is the second part of Volume III of the final report which contains five volumes in all. The other volumes are as follows:

Volume I - Executive Summary

Volume II - Systems

Volume IV - Nontechnical Issues

Volume V - Additional Studies

ACKNOWLEDGEMENTS

The work described in this report was performed under ERDA Contract E(11-1)2744 by a number of contributors from Westinghouse and its subcontractors. A listing of contributors together with their areas of specialization is contained in the following paragraphs.

The program was organized with a coordinator responsible for the design and analysis of each of the three types of systems included in the study. The coordinator for the Residential Power System was Edward F. Federmann, and the coordinator for both the Intermediate and Central Power Systems was Dr. Robert R. Ferber. During the program, Dr. Ferber became ill and the responsibility for coordination of the later two systems was assumed by Carl R. Chowaniec. Mr. Federmann is a staff member of the Research and Development Center, while Dr. Ferber and Mr. Chowaniec are members of the Advanced Systems Technology Division.

A number of specialists in different areas of technology were called upon to contribute to the design and analysis of each of the systems. Members of the staff of the Research and Development Center who contributed in this way are as follows:

<u>Technical Area</u>	<u>Contributor</u>
System Analysis	William J. McAllister
Thermal Systems	Joseph M. Cardito Dr. Herbert S. Kirschbaum

In addition to the contributions of Westinghouse Research and Development Center staff members, the following people from the Advanced Systems Technology Division of Westinghouse contributed to the task of utility analysis:

Dr. David A. McCutchan
George C. Ruschak, Jr.

Three subcontractors contributed to the program. A listing of the firms and principal contributors in each area is as follows:

<u>Firm</u>	<u>Contributor</u>
Burt, Hill & Assoc.	P. Richard Rittelmann Steven Nearhoof
Philadelphia Electric	Joseph R. Pasternak
Univ. of Pennsylvania	Martin Wolf Thomas Wolf

In addition to the contributors listed, many other people within the Westinghouse Research and Development Center contributed to the design and analysis tasks as well as report preparation. Included were typing, drafting and duplicating services. In particular, Denise Horvath spent many hours preparing the drafts and final copy of this report.

TABLE OF CONTENTS

	<u>Page</u>
SUMMARY	1
INTRODUCTION	3
2. ANALYSIS AND SIMULATION.	7
2.1 Residential Power System Computer Simulations	7
2.1.1 Data Base.	7
2.1.1.1 Insolation Data	7
2.1.1.2 Absorbed Energy Computations.	46
2.1.1.3 Load Data	46
2.1.2 Computer Simulations	59
2.1.2.1 Electrical Energy Flow Model.	59
2.1.2.2 Total Energy Flow Model	308
2.1.3 Sizing	310
2.2 IPS Computer Simulation	369
2.3 CPS Computer Simulation	371
2.4 Array Comparative Performance	373
2.4.1 The Univ. of Penna. Solar Photovoltaic System Simulation Program	373
2.4.2 The Solar Energy Input Subprograms	375
2.4.3 Silicon Solar Cell Modeling.	381
2.4.4 Cu ₂ S/CdS Solar Cell Modeling	385
2.4.5 The Tracking and Shading Subroutines	388
2.4.6 Computations Carried Out	394
2.5 Utility Economic and Margin Analyses.	401
2.5.1 Summary.	401
2.5.2 Purpose and Scope.	401
2.5.3 Results of Utility Analysis.	403
2.5.3.1 Cost of the PVEPS to a Utility.	404
2.5.3.2 Benefit to the Utility of PVEPS Ownership	408
2.5.3.2.1 Fuel Savings	411
2.5.3.2.2 O&M Savings.	411
2.5.3.2.3 Capital Cost Credit.	411
2.5.3.2.4 Total Economic Benefit	412
2.5.3.3 Cost-Benefit Analysis of the Central Station PVEPS	413
2.5.3.4 Breakeven PVEPS Capital Cost.	416
2.5.3.5 Fuel Resource Conservation.	419
2.5.3.6 Key Assumptions	422

TABLE OF CONTENTS (CON'T)

	<u>Page</u>
2.5.4 Calculation Method	425
2.5.4.1 General Approach.	425
2.5.4.2 Photovoltaic Plant Performance Data.	427
2.5.4.3 Utility Data.	431
2.5.5 Production Cost Credit for the Central Station PVEPS.	433
2.5.5.1 Fuel Cost Credit.	435
2.5.5.2 Operating and Maintenance Cost Credit.	440
2.5.6 Capital Displacement Credit for the PVEPS.	443
2.5.7 Suggestions for Further Utility Analysis of the PVEPS	454
Appendix A	458
2.6 Financial Analysis Methodology.	471
2.6.1 RPS.	471
2.6.1.1 Optimum Sizing Methodology.	471
2.6.1.2 System Figure-of-Merit.	478
2.6.2 IPS and CPS.	483
2.6.2.1 Description of Algorithm.	485
2.6.2.2 Summarization of Equations.	488

ABSTRACT

Conceptual designs were made and analyses were performed on three types of solar photovoltaic power systems. Included were Residential (1 - 10 kW), Intermediate (0.1 - 10 MW), and Central (50 - 1000 MW) Power Systems to be installed in the 1985 to 2000 time period. In the residence, a total energy system where the waste heat from the array is used to heat the dwelling appears optimum. If a suitable government incentive is forthcoming, Residential Systems begin to become economically viable in selected areas in the 1985 to 1990 period, while Intermediate and Central Power Systems begin to become viable in the 1990 to 2000 period.

SUMMARY

This volume contains a number of independent discussions of separate areas of technology all of which were needed for the conceptual design and systems analysis of the solar photovoltaic power systems considered in this program. Each major section is separate and self-contained, and describes an in-depth investigation of the technological area as it relates to solar photovoltaic power system design and analysis.

Included are discussions of subsystem technologies needed for solar photovoltaic power system construction as well as techniques used for system simulation. The results of these investigations show that all of the basic technology needed to construct the types of subsystems required exists, but much design and development is yet to be done. No technology voids were uncovered which would preclude the successful construction of the solar photovoltaic power systems studied. Available system simulation techniques appear to be adequate, but the results obtained must be verified by the construction of structures with solar energy systems on which measurements can be made.

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INTRODUCTION

During the 1960's solar photovoltaic electric power systems were of interest primarily for use in space vehicles where the variability of weather need not be considered. Spacecraft systems started at power levels less than 100W in the yearly 1960's and increased in size to levels of several kilowatts in the early 1970's.

Until the advent of the oil embargo several years ago, terrestrial applications were limited to small, special purpose installations where the advantages of a totally isolated power supply made it possible to justify the high cost of the solar photovoltaic power system. Since the embargo, however, a great deal of thought and effort has been devoted to the use of solar power in general and solar photovoltaic power in particular as an alternative source of energy for terrestrial applications.

The National Photovoltaic Conversion Program, managed by ERDA, is oriented toward developing photovoltaic conversion of solar energy as an economically viable energy source. The effort of this contract is oriented toward the conceptual design and system analysis subtask of the Systems Definition Project which is one of the many facets of the National Photovoltaic Conversion Program. The principal objective of this contract is to provide conceptual designs and system analyses of three types of solar photovoltaic electric power systems. Included are:

- Residential Power System (1 - 10 kW).
- Intermediate Power System (0.1 - 10 MW).
- Central Station Power System (50 - 1000 MW).

The Residential Power System (RPS) considered provides a substantial fraction of the electrical and thermal needs of a residence. Two options were considered as means to obtain the supplemental energy needed. One assumed that the energy required would be supplied by a utility. For this case, the billing rate used by the utility for the small amount of energy used becomes a critical parameter. The other option assumes that the residence can be autonomous and require no utility connection at all. In this case, the supplemental electrical energy is furnished by a small engine/generator, and the thermal energy either from the same engine/generator or from a fossil fueled heater. For the systems utilizing utility energy to supplement the RPS output, the return of excess solar generated electrical energy to the utility grid was not considered.

In the Intermediate Power System (IPS), power may flow either from the solar array or from the battery into the utility system. The battery may be charged from the solar array or from the utility line, depending upon the strategy used, and would be used primarily for load leveling. The IPS would most likely be located at an industrial or commercial substation.

The Central Power System (CPS) is assumed to be tied into a large utility grid which would contain pumped hydro or other storage. Energy storage within the CPS itself was not included. Energy from the CPS would be dispatched directly into the utility grid whenever available. The operation of storage would be a separate utility system consideration.

The analysis of the performance of the RPS was accomplished with the aid of a mathematical model of the system analyzed by means of a computer program. Inputs to the computer model included weather and load data for the location selected. An additional input was operating strategy relating to power flow and timing within the system. The output was a description of system performance over a one year period to be used to verify the suitability of the parametric values chosen.

The performances of the Intermediate and Central Power Systems were determined using a computer program which contained an analytical model of the solar cell. The annual energy and peak power output of the cell were then determined on a per unit area basis for arrays operated in various tracking and non-tracking modes using hourly weather data.

After the performance of each system was determined, an appropriate economic analysis was made to determine the economic viability of each system installed during the 1985 to 2000 time period.

The final report on this program is divided into five volumes. This is the second part of Volume III entitled, "Technology", which contains in-depth descriptions of the investigations into the required subsystem technologies. Volume I entitled, "Executive Summary", contains a brief description of the entire program. Volume II entitled, "Systems", contains a detailed description of the conceptual designs and analyses of all three systems as well as a summary of the nontechnical issues task. The in-depth studies of the nontechnical issues are reported in Volume IV entitled, "Nontechnical Issues." The results of the follow-on efforts are not included in Volumes II, III, or IV but are reported in Volume V entitled, "Additional Studies."

During discussions regarding subsystem analysis, a continuing problem was encountered with varying definitions of the terms "array", "model", and "field" used in relation to the solar-cell arrays. The following definitions are used throughout this report.

Module - A module consists of solar cells and backplates, as well as concentrators, cover plate, and heat transfer means if used.

Array - An array consists of one or more modules mounted in a rigid supporting structure which may move as a unit if tracking is provided. The modules comprising the array are replaceable.

Field - A field comprises one or more arrays providing power for a solar photovoltaic power system.

Throughout this report, values of electrical power quoted are always peak and not average or rated. In addition, all economic analyses performed used constant dollars with the year 1975 as the base.

2. ANALYSIS AND SIMULATION

2.1 Residential Power System Computer Simulations

2.1.1 Data Base

The data base for the residential power system computer simulations contains the insolation and load data needed to simulate the performance of a given residential photovoltaic power system in each of the seven study regions. This data is described in the following sections. Examples are provided.

2.1.1.1 Insolation Data

The insolation data base consists of the direct and diffuse solar radiation incident on a normal collector, solar altitude and azimuth, and associated weather data for each of the seven site cities.

Data for Cleveland, Ohio (1962), Madison, Wisconsin (1962), and Phoenix, Arizona (1962) were supplied by the Civil Programs Division of the Aerospace Corporation of El Segundo, California. For examples, see Table 2.1.1 (Cleveland), 2.1.2 (Madison) and 2.1.3 (Phoenix).

The second column in these tables, labeled Total Solar Radiation, is the total solar radiation (diffuse and beam) incident on a horizontal surface in kW/m^2 . Columns three and four contain the extra terrestrial and terrestrial beam radiation incident on a surface normal to the beam also in kW/m^2 . The next column, labeled Percent Possible Radiation, relates the normal beam terrestrial radiation

Table 2.1.1(a)

AREOSPACE WEATHER DATA FOR CLEVELAND, OHIO - 1962

- MAR 21, 1962

HOUR	TOTAL SOLAR RADIATION (KW/SQ-M)	EXTRA TERRESTRIAL RADIATION (KW/SQ-M)	NORMAL INCIDENCE RADIATION (KW/SQ-M)	PERCENT POSSIBLE RADIATION	SOLAR ELEVATION (DEGREES)	SOLAR AZIMUTH (DEGREES)	TEMPERATURE DRY BULB (CENT)	TEMPERATURE DEWPOINT (CENT)	STATION PRESSURE (MB)
0	.000	.00	.00	0.	-1	0.	2.	-1.	978.
1	.000	.00	.00	0.	-1	0.	2.	-1.	977.
2	.000	.00	.00	0.	-1	0.	2.	-1.	975.
3	.000	.00	.00	0.	-1	0.	2.	0.	974.
4	.000	.00	.00	0.	-1	0.	2.	0.	972.
5	.000	.00	.00	0.	-1	0.	2.	0.	972.
6	.000	.00	.00	0.	-1	0.	1.	0.	969.
7	.002 -	.13	.00 -	1.	6	-85.	1.	0.	971.
8	.038 -	.39	.00 -	10.	17	-75.	0.	0.	970.
9	.073 -	.62	.00 -	12.	27	-63.	0.	-1.	969.
10	.101 -	.81	.00 -	12.	37	-49.	0.	0.	969.
11	.119 -	.94	.00 -	13.	44	-32.	1.	0.	969.
12	.130 -	1.01	.00 -	13.	48	-11.	1.	0.	969.
13	.130 -	1.01	.00 -	13.	48	11.	1.	0.	969.
14	.119 -	.94	.00 -	13.	44	32.	1.	0.	969.
15	.101 -	.81	.00 -	12.	37	49.	0.	-1.	970.
16	.073 -	.62	.00 -	12.	27	63.	0.	-1.	971.
17	.038 -	.39	.00 -	10.	17	75.	0.	-1.	972.
18	.002 -	.13	.00 -	1.	6	85.	1.	-1.	973.
19	.000	.00	.00	0.	-1	0.	1.	-1.	974.
20	.000	.00	.00	0.	-1	0.	1.	-1.	975.
21	.000	.00	.00	0.	-1	0.	1.	0.	976.
22	.000	.00	.00	0.	-1	0.	1.	0.	977.
23	.000	.00	.00	0.	-1	0.	1.	0.	978.

>

Table 2.1.1(b)

AREOSPACE WEATHER DATA FOR CLEVELAND, OHIO - 1962

- JUNE 21, 1962

HOUR	TOTAL SOLAR RADIATION (KW/SQ-M)	EXTRA TERRESTRIAL RADIATION (KW/SQ-M)	NORMAL INCIDENCE RADIATION (KW/SQ-M)	PERCENT POSSIBLE RADIATION	SOLAR ELEVATION (DEGREES)	SOLAR AZIMUTH (DEGREES)	TEMPERATURE DRY BULB (CENT)	DEWPOINT (CENT)	STATION PRESSURE (MB)
0	.000	.00	.00	0.	-1	0.	12.	10.	986.
1	.000	.00	.00	0.	-1	0.	11.	9.	986.
2	.000	.00	.00	0.	-1	0.	10.	9.	986.
3	.000	.00	.00	0.	-1	0.	9.	8.	986.
4	.000	.00	.00	0.	-1	0.	9.	8.	986.
5	.000	.02	.00	0.	-1	0.	9.	7.	986.
6	.118 -	.23	.50 -	51.	10	-113.	9.	8.	987.
7	.278 -	.46	.62 -	60.	21	-104.	13.	11.	987.
8	.432 -	.68	.65 -	63.	32	-94.	17.	13.	987.
9	.576 -	.89	.66 -	64.	43	-84.	18.	12.	988.
10	.626 -	1.05	.60 -	59.	54	-72.	21.	12.	987.
11	.707 -	1.17	.62 -	60.	64	-53.	22.	12.	987.
12	.755 -	1.23	.63 -	61.	71	-22.	22.	13.	987.
13	.737 -	1.23	.62 -	60.	71	22.	23.	13.	987.
14	.699 -	1.17	.62 -	60.	64	53.	23.	14.	986.
15	.614 -	1.05	.59 -	58.	54	72.	23.	13.	986.
16	.513 -	.89	.58 -	57.	43	84.	24.	14.	986.
17	.391 -	.68	.58 -	57.	32	94.	23.	14.	985.
18	.166 -	.46	.00 -	23.	21	104.	22.	14.	985.
19	.089 -	.23	.00 -	38.	10	113.	22.	14.	985.
20	.000	.02	.00	0.	-1	0.	21.	13.	985.
21	.000	.00	.00	0.	-1	0.	20.	13.	985.
22	.000	.00	.00	0.	-1	0.	18.	13.	986.
23	.000	.00	.00	0.	-1	0.	18.	13.	985.

Table 2.1.1(c)

AREOSPACE WEATHER DATA FOR CLEVELAND, OHIO - 1962

- SEPT 23, 1962

HOUR	TOTAL SOLAR RADIATION (KW/SQ-M)	EXTRA TERRESTRIAL RADIATION (KW/SQ-M)	NORMAL INCIDENCE RADIATION (KW/SQ-M)	PERCENT POSSIBLE RADIATION	SOLAR ELEVATION (DEGREES)	SOLAR AZIMUTH (DEGREES)	TEMPERATURE DEW BULB (CENT)	DEWPOINT (CENT)	STATION PRESSURE (MB)
0	.000	.00	.00	0.	-1	0.	11.	9.	995.
1	.000	.00	.00	0.	-1	0.	11.	9.	995.
2	.000	.00	.00	0.	-1	0.	11.	9.	995.
3	.000	.00	.00	0.	-1	0.	9.	8.	995.
4	.000	.00	.00	0.	-1	0.	10.	9.	995.
5	.000	.00	.00	0.	-1	0.	9.	8.	996.
6	.000	.00	.00	0.	-1	0.	10.	8.	996.
7	.041 -	.12	.27 -	32.	6	-85.	9.	7.	997.
8	.203 -	.38	.53 -	53.	17	-75.	12.	9.	997.
9	.341 -	.60	.58 -	57.	27	-63.	14.	10.	998.
10	.459 -	.79	.59 -	58.	36	-49.	16.	10.	998.
11	.546 -	.92	.60 -	59.	44	-32.	17.	9.	998.
12	.563 -	.93	.60 -	59.	43	-11.	18.	9.	998.
13	.520 -	.98	.53 -	53.	48	11.	18.	8.	997.
14	.488 -	.92	.52 -	52.	44	32.	19.	7.	997.
15	.408 -	.79	.52 -	52.	36	49.	18.	11.	996.
16	.303 -	.60	.49 -	50.	27	63.	17.	11.	996.
17	.179 -	.38	.46 -	47.	17	75.	17.	11.	995.
18	.038 -	.12	.25 -	30.	6	85.	16.	11.	995.
19	.000	.00	.00	0.	-1	0.	14.	12.	995.
20	.000	.00	.00	0.	-1	0.	13.	11.	995.
21	.000	.00	.00	0.	-1	0.	13.	11.	995.
22	.000	.00	.00	0.	-1	0.	12.	10.	994.
23	.000	.00	.00	0.	-1	0.	12.	9.	994.

Table 2.1.1(d)

AREOSPACE WEATHER DATA FOR CLEVELAND, OHIO - 1962

- DEC 21, 1962

HOUR	TOTAL SOLAR RADIATION (KW/SQ-M)	EXTRA TERRESTRIAL RADIATION (KW/SQ-M)	NORMAL INCIDENCE RADIATION (KW/SQ-M)	PERCENT POSSIBLE RADIATION	SOLAR ELEVATION (DEGREES)	SOLAR AZIMUTH (DEGREES)	TEMPERATURE DRY BULB (CENT)	DEWPOINT (CENT)	STATION PRESSURE (MB)
0	.000	.00	.00	0.	-1	0.	-7.	-14.	1000.
1	.000	.00	.00	0.	-1	0.	-6.	-15.	998.
2	.000	.00	.00	0.	-1	0.	-6.	-15.	998.
3	.000	.00	.00	0.	-1	0.	-6.	-15.	997.
4	.000	.00	.00	0.	-1	0.	-6.	-14.	996.
5	.000	.00	.00	0.	-1	0.	-6.	-14.	994.
6	.000	.00	.00	0.	-1	0.	-5.	-14.	994.
7	.000	.00	.00	0.	-1	0.	-4.	-12.	993.
8	.000 -	.02	.00 -	0.	0	-52.	-4.	-11.	992.
9	.011 -	.22	.00 -	5.	9	-47.	-3.	-9.	992.
10	.036 -	.39	.00 -	9.	16	-36.	-2.	-7.	992.
11	.055 -	.52	.00 -	11.	22	-22.	-2.	-6.	991.
12	.063 -	.58	.00 -	11.	25	-8.	-2.	-6.	990.
13	.063 -	.58	.00 -	11.	25	8.	-2.	-6.	988.
14	.055 -	.52	.00 -	11.	22	22.	-1.	-5.	987.
15	.036 -	.39	.00 -	9.	16	36.	-1.	-5.	986.
16	.011 -	.22	.00 -	5.	9	47.	-1.	-4.	986.
17	.000 -	.02	.00 -	0.	0	53.	-2.	-4.	985.
18	.000	.00	.00	0.	-1	0.	-2.	-4.	985.
19	.000	.00	.00	0.	-1	0.	-1.	-3.	984.
20	.000	.00	.00	0.	-1	0.	-1.	-3.	983.
21	.000	.00	.00	0.	-1	0.	-1.	-3.	982.
22	.000	.00	.00	0.	-1	0.	-1.	-3.	981.
23	.000	.00	.00	0.	-1	0.	-1.	-2.	980.

Table 2.1.2(a)

AREOSPACE WEATHER DATA FOR MADISON, WISCONSIN - 1962 - MAR 21, 1962

HOUR	TOTAL SOLAR RADIATION (KW/SQ-M)	EXTRA TERRESTRIAL RADIATION (KW/SQ-M)	NORMAL INCIDENCE RADIATION (KW/SQ-M)	PERCENT POSSIBLE RADIATION	SOLAR ELEVATION (DEGREES)	SOLAR AZIMUTH (DEGREES)	TEMPERATURE DRY BULB (CENT)	DEWPOINT (CENT)	STATION PRESSURE (MB)
0	.000	.00	.00	0.	-1	0.	1.	-2.	974.
1	.000	.00	.00	0.	-1	0.	1.	-2.	974.
2	.000	.00	.00	0.	-1	0.	1.	-2.	974.
3	.000	.00	.00	0.	-1	0.	0.	-2.	974.
4	.000	.00	.00	0.	-1	0.	0.	-2.	974.
5	.000	.00	.00	0.	-1	0.	0.	-2.	975.
6	.004 -	.12	.00 -	4.	6	-85.	0.	-2.	976.
7	.092 -	.38	.00 -	24.	16	-74.	0.	-2.	977.
8	.179 -	.60	.25 -	30.	27	-63.	0.	-2.	977.
9	.249 -	.79	.27 -	32.	36	-48.	0.	-2.	978.
10	.645 -	.91	.73 -	70.	43	-31.	0.	-2.	979.
11	.325 -	.98	.28 -	33.	47	-11.	1.	-1.	979.
12	.325 -	.98	.28 -	33.	47	11.	1.	-1.	980.
13	.573 -	.91	.64 -	62.	43	31.	2.	-1.	980.
14	.554 -	.79	.73 -	70.	36	48.	2.	-2.	981.
15	.408 -	.60	.70 -	67.	27	63.	2.	-2.	981.
16	.237 -	.38	.64 -	62.	16	74.	2.	-2.	982.
17	.052 -	.12	.38 -	41.	6	85.	2.	-3.	982.
18	.000	.00	.00	0.	-1	0.	1.	-3.	983.
19	.000	.00	.00	0.	-1	0.	0.	-4.	983.
20	.000	.00	.00	0.	-1	0.	0.	-4.	983.
21	.000	.00	.00	0.	-1	0.	-1.	-4.	984.
22	.000	.00	.00	0.	-1	0.	-1.	-4.	984.
23	.000	.00	.00	0.	-1	0.	-2.	-5.	984.

Table 2.1.2(b)

AREOSPACE WEATHER DATA FOR MADISON, WISCONSIN - 1962 - JUNE 21, 1962

HOUR	TOTAL SOLAR RADIATION (KW/SQ-M)	EXTRA TERRESTRIAL RADIATION (KW/SQ-M)	NORMAL INCIDENCE RADIATION (KW/SQ-M)	PERCENT POSSIBLE RADIATION	SOLAR ELEVATION (DEGREES)	SOLAR AZIMUTH (DEGREES)	TEMPERATURE DRY BULB (CENT)	DEWPOINT (CENT)	STATION PRESSURE (MB)
0	.000	.00	.00	0.	-1	0.	13.	11.	983.
1	.000	.00	.00	0.	-1	0.	12.	10.	983.
2	.000	.00	.00	0.	-1	0.	11.	9.	983.
3	.000	.00	.00	0.	-1	0.	11.	9.	983.
4	.000 -	.03	.00 -	0.	1	-122.	10.	8.	983.
5	.126 -	.24	.52 -	52.	11	-112.	11.	9.	983.
6	.311 -	.46	.70 -	67.	21	-103.	12.	10.	983.
7	.483 -	.68	.75 -	71.	32	-93.	14.	11.	983.
8	.609 -	.88	.73 -	69.	43	-83.	17.	11.	983.
9	.731 -	1.04	.73 -	70.	53	-70.	19.	13.	983.
10	.741 -	1.16	.66 -	64.	63	-51.	21.	13.	982.
11	.416 -	1.22	.29 -	34.	69	-20.	22.	15.	981.
12	.416 -	1.22	.29 -	34.	69	20.	22.	14.	981.
13	.394 -	1.16	.29 -	34.	63	51.	23.	15.	981.
14	.348 -	1.04	.28 -	33.	53	70.	23.	16.	980.
15	.287 -	.88	.28 -	33.	43	83.	23.	15.	980.
16	.304 -	.68	.42 -	44.	32	93.	24.	16.	980.
17	.266 -	.46	.58 -	57.	21	103.	23.	15.	979.
18	.132 -	.24	.54 -	54.	11	112.	23.	13.	979.
19	.000 -	.03	.00 -	0.	1	122.	21.	12.	979.
20	.000 -	.00	.00	0.	-1	0.	18.	12.	979.
21	.000	.00	.00	0.	-1	0.	17.	12.	979.
22	.000	.00	.00	0.	-1	0.	18.	13.	979.
23	.000	.00	.00	0.	-1	0.	18.	13.	979.

Table 2.1.2(c)

AREOSPACE WEATHER DATA FOR MADISON, WISCONSIN - 1962 - - SEPT 23, 1962

HOUR	TOTAL SOLAR RADIATION (KW/SQ-M)	EXTRA TERRESTRIAL RADIATION (KW/SQ-M)	NORMAL INCIDENCE RADIATION (KW/SQ-M)	PERCENT POSSIBLE RADIATION	SOLAR ELEVATION (DEGREES)	SOLAR AZIMUTH (DEGREES)	TEMPERATURE DRY BULB (CENT)	TEMPERATURE DEWPOINT (CENT)	STATION PRESSURE (MB)
0	.000	.00	.00	0.	-1	0.	4.	4.	995.
1	.000	.00	.00	0.	-1	0.	2.	2.	995.
2	.000	.00	.00	0.	-1	0.	1.	1.	995.
3	.000	.00	.00	0.	-1	0.	2.	1.	995.
4	.000	.00	.00	0.	-1	0.	1.	1.	995.
5	.000	.00	.00	0.	-1	0.	2.	1.	996.
6	.000 -	.12	.00 -	0.	5	-85.	3.	2.	996.
7	.089 -	.37	.00 -	24.	16	-74.	4.	3.	996.
8	.174 -	.59	.23 -	29.	26	-62.	6.	4.	996.
9	.245 -	.77	.26 -	31.	35	-48.	7.	6.	996.
10	.411 -	.89	.44 -	46.	42	-31.	11.	9.	996.
11	.688 -	.96	.75 -	71.	46	-11.	13.	9.	996.
12	.688 -	.96	.75 -	71.	46	11.	16.	11.	994.
13	.557 -	.89	.64 -	62.	42	31.	17.	9.	993.
14	.426 -	.77	.55 -	55.	35	48.	18.	9.	992.
15	.312 -	.59	.53 -	53.	26	62.	18.	9.	992.
16	.201 -	.37	.54 -	54.	16	74.	17.	8.	991.
17	.046 -	.12	.32 -	36.	5	85.	16.	8.	991.
18	.000	.00	.00	0.	-1	0.	14.	9.	990.
19	.000	.00	.00	0.	-1	0.	13.	8.	990.
20	.000	.00	.00	0.	-1	0.	11.	8.	990.
21	.000	.00	.00	0.	-1	0.	11.	8.	990.
22	.000	.00	.00	0.	-1	0.	11.	8.	989.
23	.000	.00	.00	0.	-1	0.	11.	8.	989.

Table 2.1.2(d)

AREOSPACE WEATHER DATA FOR MADISON, WISCONSIN - 1962 - DEC 21, 1962

HOUR	TOTAL SOLAR RADIATION (KW/SQ-M)	EXTRA TERRESTRIAL RADIATION (KW/SQ-M)	NORMAL INCIDENCE RADIATION (KW/SQ-M)	PERCENT POSSIBLE RADIATION	SOLAR ELEVATION (DEGREES)	SOLAR AZIMUTH (DEGREES)	TEMPERATURE DRY BULB (CENT)	DEWPOINT (CENT)	STATION PRESSURE (MB)
0	.000	.00	.00	0.	-1	0.	-4.	-8.	996.
1	.000	.00	.00	0.	-1	0.	-4.	-9.	995.
2	.000	.00	.00	0.	-1	0.	-5.	-8.	995.
3	.000	.00	.00	0.	-1	0.	-5.	-8.	994.
4	.000	.00	.00	0.	-1	0.	-5.	-9.	993.
5	.000	.00	.00	0.	-1	0.	-6.	-9.	992.
6	.000	.00	.00	0.	-1	0.	-7.	-9.	992.
7	.000	.02	.00	0.	-1	0.	-8.	-11.	991.
8	.089 -	.18	.47 -	48.	8	-47.	-8.	-11.	991.
9	.215 -	.36	.62 -	60.	15	-35.	-6.	-9.	990.
10	.308 -	.47	.68 -	65.	20	-22.	-4.	-7.	990.
11	.318 -	.54	.59 -	58.	23	-7.	-3.	-7.	988.
12	.282 -	.54	.52 -	52.	23	7.	-2.	-7.	987.
13	.270 -	.47	.58 -	57.	20	22.	-2.	-7.	985.
14	.132 -	.36	.33 -	37.	15	35.	-2.	-7.	985.
15	.019 -	.18	.00 -	11.	8	47.	-2.	-7.	984.
16	.000	.02	.00	0.	-1	0.	-2.	-7.	984.
17	.000	.00	.00	0.	-1	0.	-2.	-7.	983.
18	.000	.00	.00	0.	-1	0.	-2.	-7.	982.
19	.000	.00	.00	0.	-1	0.	-3.	-6.	982.
20	.000	.00	.00	0.	-1	0.	-3.	-6.	982.
21	.000	.00	.00	0.	-1	0.	-3.	-6.	981.
22	.000	.00	.00	0.	-1	0.	-3.	-7.	980.
23	.000	.00	.00	0.	-1	0.	-3.	-6.	979.

Table 2.1.3(a)

AREOSPACE WEATHER DATA FOR PHOENIX, ARIZONA - 1962 - MAR 21, 1962

HOUR	TOTAL SOLAR RADIATION (KW/SQ-M)	EXTRA TERRESTRIAL RADIATION (KW/SQ-M)	NORMAL INCIDENCE RADIATION (KW/SQ-M)	PERCENT POSSIBLE RADIATION	SOLAR ELEVATION (DEGREES)	SOLAR AZIMUTH (DEGREES)	TEMPERATURE DRY BULB (CENT)	DEWPOINT (CENT)	STATION PRESSURE (MB)
0	.000	.00	.00	0.	-1	0.	11.	8.	974.
1	.000	.00	.00	0.	-1	0.	11.	8.	973.
2	.000	.00	.00	0.	-1	0.	11.	8.	973.
3	.000	.00	.00	0.	-1	0.	11.	8.	973.
4	.000	.00	.00	0.	-1	0.	11.	7.	973.
5	.000	.00	.00	0.	-1	0.	11.	8.	973.
6	.000	.00	.00	0.	-1	0.	9.	6.	973.
7	.013 -	.15	.00 -	9.	6	-86.	10.	6.	974.
8	.097 -	.44	.00 -	22.	19	-77.	9.	6.	974.
9	.172 -	.69	.18 -	25.	31	-67.	11.	6.	975.
10	.451 -	.90	.49 -	50.	42	-55.	13.	7.	975.
11	.525 -	1.04	.49 -	50.	51	-37.	13.	6.	975.
12	.654 -	1.12	.59 -	58.	56	-14.	14.	6.	975.
13	.568 -	1.12	.49 -	50.	56	14.	16.	5.	974.
14	.661 -	1.04	.65 -	63.	51	37.	17.	6.	974.
15	.451 -	.90	.49 -	50.	42	55.	17.	5.	974.
16	.430 -	.69	.64 -	62.	31	67.	16.	4.	974.
17	.261 -	.44	.60 -	59.	19	77.	16.	2.	974.
18	.081 -	.15	.54 -	54.	6	86.	14.	6.	974.
19	.000	.00	.00	0.	-1	0.	13.	6.	975.
20	.000	.00	.00	0.	-1	0.	12.	7.	975.
21	.000	.00	.30	0.	-1	0.	11.	7.	976.
22	.000	.00	.00	0.	-1	0.	10.	7.	977.
23	.000	.00	.00	0.	-1	0.	9.	6.	978.

Table 2.1.3(b)

AREOSPACE WEATHER DATA FOR PHOENIX, ARIZONA - 1962

- JUNE 21, 1962

HOJR	TOTAL SOLAR RADIATION (KW/SQ-M)	EXTRA TERRESTRIAL RADIATION (KW/SQ-M)	NORMAL INCIDENCE RADIATION (KW/SQ-M)	PERCENT POSSIBLE RADIATION	SOLAR ELEVATION (DEGREES)	SOLAR AZIMUTH (DEGREES)	TEMPERATURE DRY BULB (CENT)	DEWPOINT (CENT)	STATION PRESSURE (MB)
0	.000	.00	.00	0.	-1	0.	24.	-1.	970.
1	.000	.00	.00	0.	-1	0.	26.	-3.	970.
2	.000	.00	.00	0.	-1	0.	24.	-4.	970.
3	.000	.00	.00	0.	-1	0.	21.	-4.	970.
4	.000	.00	.00	0.	-1	0.	20.	-2.	969.
5	.000	.00	.00	0.	-1	0.	18.	1.	970.
6	.076	.15	.50 -	51.	7	-114.	18.	-3.	971.
7	.287	.41	.73 -	69.	19	-106.	22.	0.	971.
8	.524	.67	.83 -	78.	31	-99.	28.	0.	971.
9	.730	.89	.89 -	82.	43	-92.	32.	0.	971.
10	.869	1.08	.86 -	80.	56	-83.	34.	3.	971.
11	.957	1.20	.85 -	79.	68	-69.	36.	5.	971.
12	.993	1.27	.83 -	73.	78	-35.	38.	4.	971.
13	.979 -	1.27	.83 -	77.	78	35.	39.	3.	970.
14	.925 -	1.20	.83 -	77.	68	69.	39.	2.	969.
15	.824 -	1.08	.81 -	76.	56	83.	41.	3.	968.
16	.677 -	.89	.81 -	76.	43	92.	42.	2.	967.
17	.503 -	.67	.80 -	75.	31	99.	41.	3.	966.
18	.302 -	.41	.76 -	72.	19	106.	41.	3.	966.
19	.091 -	.15	.63 -	61.	7	114.	39.	3.	966.
20	.000	.00	.00	0.	-1	0.	36.	3.	966.
21	.000	.00	.00	0.	-1	0.	33.	3.	966.
22	.000	.00	.00	0.	-1	0.	30.	2.	967.
23	.000	.00	.00	0.	-1	0.	28.	3.	967.

Table 2.1.3(c)

AREOSPACE WEATHER DATA FOR PHOENIX, ARIZONA - 1962 - SEPT 23, 1962

HOUR	TOTAL SOLAR RADIATION (KW/SQ-M)	EXTRA TERRESTRIAL RADIATION (KW/SQ-M)	NORMAL INCIDENCE RADIATION (KW/SQ-M)	PERCENT POSSIBLE RADIATION	SOLAR ELEVATION (DEGREES)	SOLAR AZIMUTH (DEGREES)	TEMPERATURE DRY BULB (CENT)	TEMPERATURE DEWPOINT (CENT)	STATION PRESSURE (MB)
0	.000	.00	.00	0.	-1	0.	26.	16.	973.
1	.000	.00	.00	0.	-1	0.	24.	18.	973.
2	.000	.00	.00	0.	-1	0.	24.	18.	973.
3	.000	.00	.00	0.	-1	0.	23.	18.	974.
4	.000	.00	.00	0.	-1	0.	23.	18.	974.
5	.000	.00	.00	0.	-1	0.	22.	19.	973.
6	.000	.00	.00	0.	-1	0.	21.	18.	973.
7	.004	.13	.00 -	3.	6	-86.	22.	18.	974.
8	.049	.43	.00 -	12.	19	-77.	22.	18.	974.
9	.092	.67	.00 -	14.	30	-67.	22.	19.	975.
10	.211	.88	.00 -	24.	41	-54.	23.	19.	975.
11	.277	1.03	.21 -	27.	50	-37.	24.	19.	975.
12	.123	1.10	.00 -	11.	56	-13.	24.	18.	975.
13	.126	1.10	.00 -	11.	56	13.	24.	18.	974.
14	.125	1.03	.00 -	12.	50	37.	24.	19.	974.
15	.194	.88	.00 -	22.	41	54.	24.	17.	973.
16	.123	.67	.00 -	18.	30	67.	25.	17.	973.
17	.044	.43	.00 -	10.	19	77.	24.	18.	972.
18	.009	.13	.00 -	7.	6	86.	24.	17.	971.
19	.000	.00	.00	0.	-1	0.	24.	18.	971.
20	.000	.00	.00	0.	-1	0.	23.	19.	971.
21	.000	.00	.00	0.	-1	0.	23.	18.	972.
22	.000	.00	.00	0.	-1	0.	24.	18.	972.
23	.000	.00	.00	0.	-1	0.	23.	19.	972.

Table 2.1.3(d)

AREOSPACE WEATHER DATA FOR PHOENIX, ARIZONA - 1962 - DEC 21, 1962

HOUR	TOTAL SOLAR RADIATION (KW/SQ-M)	EXTRA TERRESTRIAL RADIATION (KW/SQ-M)	NORMAL INCIDENCE RADIATION (KW/SQ-M)	PERCENT POSSIBLE RADIATION	SOLAR ELEVATION (DEGREES)	SOLAR AZIMUTH (DEGREES)	TEMPERATURE DRY BULB (CENT)	DEWPOINT (CENT)	STATION PRESSURE (MB)
0	.000	.00	.00	0.	-1	0.	10.	6.	982.
1	.000	.00	.00	0.	-1	0.	10.	6.	982.
2	.000	.00	.00	0.	-1	0.	8.	4.	982.
3	.000	.00	.00	0.	-1	0.	8.	4.	982.
4	.000	.00	.00	0.	-1	0.	7.	4.	982.
5	.000	.00	.00	0.	-1	0.	7.	3.	982.
6	.000	.00	.00	0.	-1	0.	6.	3.	982.
7	.000	.00	.00	0.	-1	0.	6.	2.	983.
8	.049	.10	.47 -	48.	4	-58.	4.	-1.	983.
9	.223	.33	.69 -	66.	14	-49.	8.	2.	983.
10	.398	.53	.80 -	75.	23	-37.	12.	2.	983.
11	.525	.67	.83 -	78.	29	-24.	14.	0.	983.
12	.576	.75	.81 -	76.	33	-8.	16.	0.	982.
13	.559	.75	.78 -	74.	33	8.	17.	0.	981.
14	.503	.67	.80 -	75.	29	24.	19.	-2.	980.
15	.387	.53	.76 -	72.	23	37.	19.	-2.	980.
16	.223	.33	.69 -	66.	14	49.	19.	-2.	979.
17	.055	.10	.53 -	53.	4	58.	18.	-3.	979.
18	.000	.00	.00	0.	-1	0.	17.	-1.	979.
19	.000	.00	.00	0.	-1	0.	14.	2.	980.
20	.000	.00	.00	0.	-1	0.	14.	1.	980.
21	.000	.00	.00	0.	-1	0.	12.	2.	980.
22	.000	.00	.00	0.	-1	0.	10.	2.	980.
23	.000	.00	.00	0.	-1	0.	8.	3.	980.

to the extraterrestrial radiation. The solar elevation zero reference is the horizon, while that for azimuth is due East.

Data for Atlanta, Georgia (1960), Madison Wisconsin (1956), Mobile, Alabama (1963), Santa Maria, California (1957), and Wilmington, Delaware (1958) were supplied by the Westinghouse Electric Corporation. These were computed from U.S. Weather Bureau data for Phase 0 of the NSF study of solar heating and cooling of buildings (see report NSF-RA-N-74-03B, Vol. 1, Chap. 2, Sec. 5.1 and Vol. 2, Appendix D, Sec. 3.1). For examples, see Tables 2.1.4 (Atlanta), 2.1.5 (Madison), 2.1.6 (Mobile), 2.1.7 (Santa Maria) and 2.1.8 (Wilmington). The radiation data is in BTU/hour/ft² and the temperature in °F instead of kW/m² and °C as was the case in tables shown previously.

The data presented in columns seven and eight of these tables are the direct and diffuse radiation incident on a surface normal to the beam. The zero reference for solar elevation is the horizon, and for solar azimuth it is due North. Wind velocity, given in column four, is in miles/hr., and barometric pressure, given in the last column, is in inches of mercury.

After examining this data, it was evident that an arithmetic error had been made in determining the effects of cloud cover. The data was then modified to correct for this. Figures 2.1.1 thru 2.1.5 show the daily distribution of direct insolation of the modified data for each of these five cities. Comparisons were made for the entire year between the data for Madison (1962) supplied by the Aerospace Corp. and the data for Madison (1958) supplied by the Westinghouse Electric Corp.

Table 2.1.4(a)

WEATHER DATA FOR ATLANTA, GEORGIA - 1960

- MAR 21 - TYPEDAY = 1

HOUR	DB TEMP	WB TEMP	WIND VELOCITY	RELATIVE HUMIDITY	SKY TEMP	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUM	AZIMUTH OF SUM	STATION PRESSURE
1	35.00	30.00	11.50	.550000	-13.162	.000	.000	.000	.000	29.130
2	34.00	30.00	10.35	.580000	-13.012	.000	.000	.000	.000	29.140
3	33.00	29.00	9.20	.580000	-15.282	.000	.000	.000	.000	29.140
4	32.00	28.00	10.35	.610000	-16.069	.000	.000	.000	.000	29.130
5	34.00	29.00	16.10	.550000	-14.529	.000	.000	.000	.000	29.130
6	34.00	30.00	13.80	.630000	-12.917	.000	.000	.000	.000	29.140
7	32.00	29.00	16.10	.670000	-14.959	121.439	6.617	9.513	96.038	29.170
8	31.00	28.00	11.50	.710000	-15.651	132.989	20.764	21.817	104.971	29.200
9	32.00	29.00	20.70	.700000	-14.424	156.191	27.649	33.563	115.544	29.220
10	33.00	30.00	23.00	.690000	-13.197	170.211	35.510	44.151	129.259	29.260
11	36.00	32.00	23.00	.680000	-9.129	187.763	37.850	52.461	148.160	29.280
12	39.00	33.00	18.40	.510000	-8.552	291.764	37.602	56.663	173.165	29.280
13	40.00	33.00	14.95	.460000	-8.425	291.952	37.061	55.205	199.991	29.280
14	42.00	32.00	13.80	.300000	-10.468	300.393	30.151	48.690	222.066	29.260
15	44.00	34.00	17.25	.320000	-7.201	294.824	27.447	39.055	238.111	29.240
16	45.00	34.00	25.30	.280000	-7.312	284.186	21.805	27.789	250.027	29.230
17	46.00	35.00	19.55	.280000	-6.013	244.526	11.916	15.709	259.629	29.220
18	46.00	35.00	17.25	.250000	-7.175	52.473	.047	3.268	268.143	29.210
19	44.00	34.00	20.70	.280000	-8.597	.000	.000	.000	.000	29.210
20	43.00	33.00	13.80	.290000	-9.526	.000	.000	.000	.000	29.210
21	41.00	33.00	11.50	.360000	-9.375	.000	.000	.000	.000	29.210
22	39.00	32.00	11.50	.410000	-11.104	.000	.000	.000	.000	29.210
23	37.00	30.00	10.35	.440000	-12.994	.000	.000	.000	.000	29.200
24	36.00	30.00	11.50	.480000	-13.367	.000	.000	.000	.000	29.190

Table 2.1.4(b)

WEATHER DATA FOR ATLANTA, GEORGIA - 1960

- JUNE 21 - TYPEDAY = 1

HOUR	DB TEMP	WB TEMP	WIND VELOCITY	RELATIVE HUMIDITY	SKY TEMP	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUM	AZIMUTH OF SUM	STATION PRESSURE
1	74.00	71.00	11.50	.830000	46.000	.000	.000	.000	.000	29.030
2	72.00	70.00	9.20	.910000	43.912	.000	.000	.000	.000	29.020
3	72.00	70.00	5.75	.920000	59.342	.000	.000	.000	.000	29.030
4	73.00	71.00	5.75	.920000	74.454	.000	.000	.000	.000	29.030
5	72.00	71.00	8.05	.920000	43.977	.000	.000	.000	.000	29.030
6	72.00	71.00	5.75	.950000	44.159	3.878	53.749	10.885	69.005	29.040
7	71.00	70.00	5.75	.960000	43.031	1.337	54.457	22.828	75.156	29.040
8	73.00	72.00	4.60	.960000	45.337	1.505	54.450	35.140	83.200	29.060
9	73.00	71.00	5.75	.910000	45.054	10.470	49.833	47.635	90.922	29.070
10	75.00	72.00	4.60	.850000	76.460	31.093	51.133	60.082	100.998	29.070
11	78.00	73.00	.00	.770000	76.715	80.506	53.087	71.889	118.926	29.070
12	81.00	73.00	3.45	.670000	76.854	172.256	46.907	79.840	168.217	29.070
13	84.00	75.00	.00	.650000	82.712	172.567	76.920	75.021	231.578	29.070
14	88.00	75.00	10.35	.550000	80.928	197.489	46.140	63.742	254.936	29.050
15	87.00	73.00	12.65	.520000	79.792	191.662	48.055	51.389	266.427	29.030
16	89.30	74.00	13.80	.500000	59.724	169.186	48.930	38.873	274.604	29.010
17	90.00	71.00	9.20	.370000	53.404	155.516	37.173	26.491	281.748	29.010
18	90.00	72.00	11.50	.400000	59.152	102.025	35.096	14.418	288.804	29.000
19	89.00	72.00	10.35	.440000	65.583	.562	12.839	2.858	296.361	28.990
20	87.00	72.00	6.90	.420000	67.202	.000	.000	.000	.000	29.010
21	86.00	72.00	4.60	.500000	78.668	.000	.000	.000	.000	29.020
22	76.00	69.00	26.45	.690000	77.467	.000	.000	.000	.000	29.060
23	72.00	68.00	11.50	.830000	43.313	.000	.000	.000	.000	29.060
24	70.00	68.00	9.20	.890000	51.005	.000	.000	.000	.000	29.080

Table 2.1.4(c)

WEATHER DATA FOR ATLANTA, GEORGIA - 1960

- SEP 23 - TYPEDAY = 3

HOUR	DB TEMP	WB TEMP	WIND VELOCITY	RELATIVE HUMIDITY	SKY TEMP	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUM	AZIMUTH OF SUM	STATION PRESSURE
1	67.00	65.00	13.80	.900000	65.623	.000	.000	.000	.000	29.140
2	66.00	65.00	12.65	.930000	64.625	.000	.000	.000	.000	29.130
3	66.00	65.00	11.50	.930000	36.961	.000	.000	.000	.000	29.140
4	66.00	63.00	12.65	.870000	36.395	.000	.000	.000	.000	29.130
5	65.00	63.00	9.20	.870000	35.141	.000	.000	.000	.000	29.110
6	65.00	62.00	10.35	.870000	35.141	.000	.000	.000	.000	29.110
7	64.00	61.00	11.50	.840000	33.528	44.283	48.841	12.225	98.317	29.120
8	63.00	61.00	11.50	.870000	32.592	23.854	38.941	24.423	107.538	29.130
9	65.00	62.00	12.65	.840000	34.810	42.968	42.102	35.940	118.697	29.140
10	68.00	63.00	13.80	.780000	37.910	90.142	49.884	46.085	133.421	29.140
11	71.00	64.00	13.80	.710000	40.810	168.379	50.121	53.576	153.705	29.150
12	73.00	64.00	16.10	.590000	41.510	265.396	41.782	56.516	179.547	29.140
13	76.00	65.00	14.95	.560000	44.334	260.755	41.926	53.759	205.510	29.120
14	78.00	66.00	11.50	.520000	46.633	251.365	40.802	46.387	226.003	29.100
15	78.00	64.00	10.35	.470000	45.528	241.042	36.213	36.306	240.881	29.060
16	80.00	66.00	13.80	.490000	48.579	192.867	34.711	24.820	252.129	29.050
17	79.00	66.00	12.65	.490000	47.294	111.751	23.347	12.638	261.394	29.040
18	73.00	65.00	12.65	.500000	46.218	.000	.000	.000	.000	29.040
19	77.00	65.00	9.20	.540000	45.741	.000	.000	.000	.000	29.040
20	74.00	65.00	6.90	.620000	43.303	.000	.000	.000	.000	29.050
21	71.00	64.00	11.50	.660000	40.097	.000	.000	.000	.000	29.050
22	69.00	63.00	11.50	.710000	38.268	.000	.000	.000	.000	29.070
23	68.00	62.00	11.50	.730000	37.264	.000	.000	.000	.000	29.070
24	67.00	62.00	11.50	.760000	36.384	.000	.000	.000	.000	29.080

Table 2.1.4(d)

WEATHER DATA FOR ATLANTA, GEORGIA - 1960

- DEC 21 - TYPEDAY = 1

HOUR	DB TEMP	WB TEMP	WIND VELOCITY	RELATIVE HUMIDITY	SKY TEMP	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUM	AZIMUTH OF SUM	STATION PRESSURE
1	50.00	47.00	27.60	.830000	14.057	.000	.000	.000	.000	28.780
2	50.00	47.00	23.00	.830000	14.057	.000	.000	.000	.000	28.780
3	51.00	49.00	13.80	.860000	52.428	.000	.000	.000	.000	28.780
4	45.00	42.00	23.00	.800000	46.429	.000	.000	.000	.000	28.810
5	41.00	39.00	28.75	.860000	1.367	.000	.000	.000	.000	28.830
6	36.00	34.00	27.60	.850000	-6.129	.000	.000	.000	.000	28.830
7	33.00	31.00	23.00	.790000	-11.467	.000	.000	.000	.000	28.850
8	31.00	29.00	28.75	.780000	-14.488	39.545	9.326	8.259	125.243	28.880
9	29.00	26.00	23.00	.690000	-13.765	136.735	29.357	17.814	135.416	28.910
10	28.00	25.00	24.15	.690000	-20.133	145.833	40.375	25.623	147.624	28.930
11	28.00	25.00	23.00	.690000	-20.133	148.185	45.704	30.969	162.038	28.970
12	28.00	25.00	26.45	.690000	-20.133	148.692	47.491	33.142	178.082	28.980
13	30.00	25.00	21.85	.560000	-19.719	255.995	27.405	31.782	194.323	28.970
14	32.00	26.00	25.30	.490000	-18.471	248.317	24.317	27.119	209.204	28.960
15	33.00	26.00	28.75	.400000	-19.176	264.777	19.845	19.817	221.932	28.970
16	33.00	26.00	23.00	.400000	-19.176	210.605	7.016	10.612	232.542	28.980
17	32.00	25.00	23.00	.400000	-20.444	.000	.000	.000	.000	29.000
18	30.00	23.00	27.60	.390000	-23.166	.000	.000	.000	.000	29.030
19	28.00	22.00	20.70	.450000	-24.423	.000	.000	.000	.000	29.050
20	25.00	20.00	25.30	.430000	-27.612	.000	.000	.000	.000	29.070
21	23.00	19.00	18.40	.500000	-29.749	.000	.000	.000	.000	29.090
22	22.00	18.00	16.10	.550000	-30.202	.000	.000	.000	.000	29.120
23	21.00	17.00	21.85	.550000	-31.445	.000	.000	.000	.000	29.140
24	19.00	16.00	23.00	.590000	-33.349	.000	.000	.000	.000	29.170

Table 2.1.5(a)

WEATHER DATA FOR MADISON, WISCONSIN - 1956

- MAR 21 - TYPEDAY = 1

HOUR	DB TEMP	WB TEMP	WIND VELOCITY	ABSOLUTE HUMIDITY	RELATIVE HUMIDITY	SKY RADIATION	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUN	AZIMUTH OF SUN	STATION PRESSURE
1	29.00	27.00	8.05	.002581	.760	65.602	.000	.000	.000	.000	29.330
2	29.00	26.00	6.90	.002308	.680	64.831	.000	.000	.000	.000	29.330
3	28.00	26.00	9.20	.002316	.710	64.316	.000	.000	.000	.000	29.300
4	29.00	27.00	9.20	.002585	.760	65.602	.000	.000	.000	.000	29.290
5	29.00	26.00	9.20	.002381	.700	71.090	.000	.000	.000	.000	29.280
6	30.00	27.00	12.65	.002480	.700	90.289	.000	.000	.000	.000	29.290
7	31.00	28.00	10.35	.002473	.670	82.270	70.831	.875	4.738	94.089	29.280
8	31.00	28.00	11.50	.002547	.690	75.194	194.205	14.866	15.548	104.670	29.280
9	34.00	30.00	16.10	.002627	.630	88.776	202.002	39.224	25.813	116.336	29.260
10	36.00	31.00	13.80	.002801	.620	95.280	215.845	47.155	34.984	130.186	29.260
11	37.00	32.00	17.25	.002774	.590	95.871	223.028	51.249	42.251	147.037	29.250
12	38.00	33.00	14.95	.002937	.600	99.605	225.560	53.301	46.536	167.224	29.240
13	40.00	34.00	17.25	.002860	.540	102.167	226.032	53.093	46.884	189.165	29.220
14	40.00	34.00	17.25	.002809	.530	104.536	224.160	51.173	43.204	209.816	29.200
15	36.00	35.00	14.95	.003946	.870	102.899	209.311	51.515	36.354	227.239	29.200
16	34.00	33.00	12.65	.003894	.930	101.911	195.795	44.577	27.435	241.486	29.200
17	34.00	33.00	14.95	.003811	.910	101.617	164.659	31.282	17.309	253.480	29.190
18	34.00	33.00	11.50	.003853	.920	101.907	75.144	6.289	6.559	264.191	29.190
19	34.00	33.00	11.50	.003936	.940	102.200	.000	.000	.000	.000	29.200
20	34.00	34.00	10.35	.003936	.940	102.200	.000	.000	.000	.000	29.200
21	34.00	33.00	8.05	.003894	.930	102.393	.000	.000	.000	.000	29.200
22	35.00	34.00	12.65	.004142	.950	103.333	.000	.000	.000	.000	29.200
23	35.00	34.00	11.50	.004009	.920	101.524	.000	.000	.000	.000	29.210
24	35.00	34.00	9.20	.003965	.910	101.152	.000	.000	.000	.000	29.210

Table 2.1.5(b)

WEATHER DATA FOR MADISON, WISCONSIN - 1956

- JUNE 21 - TYPEDAY = 1

HOUR	DB TEMP	WB TEMP	WIND VELOCITY	ABSOLUTE HUMIDITY	RELATIVE HUMIDITY	SKY RADIATION	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUN	AZIMUTH OF SUN	STATION PRESSURE
1	70.00	68.00	3.45	.015027	.920	118.116	.000	.000	.000	.000	28.850
2	70.00	69.00	2.30	.015529	.950	118.233	.000	.000	.000	.000	28.850
3	70.00	68.00	6.90	.015027	.920	110.900	.000	.000	.000	.000	28.850
4	69.00	68.00	2.30	.015485	.980	107.840	.000	.000	.000	.000	28.850
5	67.00	66.00	.00	.013985	.950	105.644	.000	.000	.000	.000	28.860
6	67.00	66.00	2.30	.014135	.960	105.709	57.309	48.683	10.751	67.888	28.860
7	72.00	69.00	3.45	.015010	.860	110.141	134.574	49.165	21.205	77.205	28.880
8	76.00	69.00	3.45	.014343	.720	113.215	187.338	46.743	32.054	86.695	28.880
9	80.00	71.00	4.60	.014778	.650	116.822	212.461	47.939	43.003	97.247	28.880
10	84.00	74.00	4.60	.015318	.610	120.729	223.251	44.096	53.645	110.464	28.870
11	86.00	72.00	3.45	.014338	.520	126.719	233.114	52.389	63.162	129.688	28.880
12	90.00	73.00	9.20	.014403	.460	141.560	208.879	45.919	69.535	160.660	28.870
13	90.00	74.00	3.45	.015050	.480	141.709	203.725	49.078	69.410	200.599	28.860
14	92.00	75.00	3.45	.015031	.450	143.775	199.970	48.779	62.879	231.108	28.840
15	92.00	76.00	8.05	.016070	.480	141.047	185.569	52.080	53.302	250.047	28.820
16	90.00	77.00	9.20	.017673	.560	144.007	163.347	45.387	42.640	263.136	28.790
17	83.00	76.00	6.90	.013450	.730	141.430	112.856	79.727	31.689	273.632	28.800
18	76.00	70.00	12.65	.015192	.760	135.918	97.957	81.891	20.849	283.104	28.820
19	78.00	71.00	9.20	.015378	.720	132.156	35.879	23.099	10.412	292.427	28.820
20	74.00	69.00	6.90	.014389	.770	135.839	.000	.000	.000	.000	28.810
21	73.00	69.00	13.80	.014836	.820	126.061	.000	.000	.000	.000	28.800
22	72.00	68.00	4.60	.014673	.840	124.664	.000	.000	.000	.000	28.840
23	70.00	67.00	5.75	.014020	.860	115.236	.000	.000	.000	.000	28.860
24	71.00	67.00	5.75	.014172	.840	114.536	.000	.000	.000	.000	28.850

Table 2.1.5(c)

WEATHER DATA FOR MADISON, WISCONSIN - 1956

- SEPT 23 - TYPEDAY = 3

HOURL	DB TEMP	WB TEMP	WIND VELOCITY	ABSOLUTE HUMIDITY	RELATIVE HUMIDITY	SKY RADIATION	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUN	AZIMUTH OF SUN	STATION PRESSURE
1	60.00	58.00	5.75	.010146	.890	119.672	.000	.000	.000	.000	29.070
2	60.00	58.00	5.75	.010146	.890	119.404	.000	.000	.000	.000	29.070
3	59.00	57.00	3.45	.010027	.910	118.377	.000	.000	.000	.000	29.030
4	59.00	57.00	3.45	.010139	.920	116.288	.000	.000	.000	.000	29.030
5	59.00	57.00	8.05	.010143	.920	116.288	.000	.000	.000	.000	29.020
6	59.00	57.00	3.45	.009807	.890	117.868	.000	.000	.000	.000	29.020
7	59.00	57.00	3.45	.009695	.880	118.295	34.834	25.428	7.057	96.745	29.020
8	60.00	58.00	5.75	.010041	.880	124.620	117.861	51.759	17.770	107.514	29.040
9	61.00	59.00	2.30	.010532	.890	114.926	151.497	64.867	27.818	119.622	29.020
10	68.00	62.00	3.45	.011156	.740	123.765	169.853	68.527	36.603	134.034	29.030
11	69.00	62.00	8.05	.010279	.660	116.908	211.330	40.752	43.248	151.629	29.030
12	71.00	63.00	8.05	.011015	.660	134.922	184.625	70.487	46.660	172.338	29.020
13	68.00	61.00	13.80	.010240	.680	130.337	187.771	68.213	46.038	194.120	29.020
14	70.00	62.00	17.25	.010479	.650	132.848	180.248	67.945	41.543	214.012	29.020
15	66.00	62.00	17.25	.010979	.780	131.657	164.886	68.211	34.146	230.591	29.030
16	65.00	59.00	13.80	.009635	.710	130.074	150.967	55.809	24.904	244.206	29.030
17	65.00	58.00	13.80	.009078	.670	109.366	137.893	26.942	14.604	255.816	29.050
18	65.00	57.00	5.75	.008392	.620	99.880	12.819	2.002	3.780	266.353	29.050
19	61.00	56.00	5.75	.008362	.710	96.839	.000	.000	.000	.000	29.060
20	58.00	54.00	8.05	.008259	.780	94.515	.000	.000	.000	.000	29.080
21	57.00	51.00	10.35	.007035	.690	92.183	.000	.000	.000	.000	29.090
22	53.00	49.00	5.75	.006616	.750	88.748	.000	.000	.000	.000	29.110
23	54.00	48.00	11.50	.006026	.660	88.480	.000	.000	.000	.000	29.130
24	52.00	47.00	10.35	.005637	.670	86.422	.000	.000	.000	.000	29.140

Table 2.1.5(d)

WEATHER DATA FOR MADISON, WISCONSIN - 1956

- DEC 21 - TYPEDAY = 1

HOOR	DB TEMP	WE TEMP	WIND VELOCITY	ABSOLUTE HUMIDITY	RELATIVE HUMIDITY	SKY RADIATION	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUN	AZIMUTH OF SUN	STATION PRESSURE
1	10.00	10.00	6.90	.001211	.810	82.595	.000	.000	.000	.000	29.460
2	10.00	10.00	4.60	.001197	.800	81.651	.000	.000	.000	.000	29.440
3	11.00	10.00	6.90	.001159	.740	80.541	.000	.000	.000	.000	29.410
4	11.00	10.00	3.45	.001112	.710	80.520	.000	.000	.000	.000	29.410
5	11.00	10.00	4.60	.001112	.710	80.771	.000	.000	.000	.000	29.410
6	11.00	11.00	3.45	.001221	.780	82.078	.000	.000	.000	.000	29.420
7	12.00	11.00	2.30	.001261	.770	79.233	.000	.000	.000	.000	29.410
8	12.00	12.00	4.60	.001245	.760	80.012	.000	.000	.000	.000	29.400
9	14.00	13.00	3.45	.001396	.780	81.871	129.835	8.915	8.292	133.268	29.400
10	15.00	14.00	2.30	.001440	.770	83.437	183.381	25.422	15.453	145.280	29.410
11	17.00	16.00	2.30	.001510	.740	85.325	202.555	34.101	20.612	158.700	29.410
12	19.00	18.00	2.30	.001715	.770	86.845	208.037	38.007	23.276	173.258	29.370
13	21.00	19.00	2.30	.001748	.720	70.021	238.307	22.646	23.133	188.231	29.340
14	23.00	21.00	4.60	.001799	.680	68.186	228.708	19.999	20.201	202.701	29.310
15	22.00	20.00	4.60	.001726	.680	63.474	232.885	15.723	14.818	215.985	29.280
16	22.00	20.00	4.60	.001727	.680	63.474	152.600	4.403	7.486	227.858	29.260
17	19.00	17.00	3.45	.001587	.710	70.003	.000	.000	.000	.000	29.250
18	16.00	15.00	4.60	.001455	.740	70.050	.000	.000	.000	.000	29.210
19	16.00	15.00	5.75	.001575	.800	69.902	.000	.000	.000	.000	29.180
20	18.00	17.00	10.35	.001634	.760	76.647	.000	.000	.000	.000	29.140
21	17.00	16.00	11.50	.001630	.790	72.149	.000	.000	.000	.000	29.080
22	18.00	17.00	11.50	.001684	.780	63.176	.000	.000	.000	.000	29.030
23	19.00	18.00	13.80	.001690	.750	78.487	.000	.000	.000	.000	29.020
24	19.00	18.00	17.25	.001696	.750	79.621	.000	.000	.000	.000	28.930

Table 2.1.6(a)

WEATHER DATA FOR MOBILE, ALABAMA - 1957

- MAR 21 - TYPEDAY = 1

HOUR	DB TEMP	WB TEMP	WIND VELOCITY	ABSOLUTE HUMIDITY	RELATIVE HUMIDITY	SKY RADIATION	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUM	AZIMUTH OF SUM	STATION PRESSURE
1	53.00	45.00	6.90	.004107	.480	84.065	.000	.000	.000	.000	29.890
2	53.00	44.00	5.75	.004107	.480	84.065	.000	.000	.000	.000	29.890
3	50.00	46.00	4.60	.005636	.740	85.341	.000	.000	.000	.000	29.890
4	47.00	43.00	4.60	.004826	.710	81.799	.000	.000	.000	.000	29.890
5	48.00	43.00	5.90	.004442	.630	81.618	.000	.000	.000	.000	29.900
6	46.00	41.00	4.60	.004116	.630	79.597	.000	.000	.000	.000	29.910
7	46.00	42.00	6.90	.004572	.700	80.636	93.494	3.788	6.597	94.078	29.940
8	49.00	44.00	6.90	.004753	.650	82.963	226.082	20.528	19.370	102.168	29.950
9	53.00	46.00	12.65	.004782	.560	85.677	270.618	28.090	31.720	111.637	29.980
10	55.00	45.00	16.10	.003756	.410	84.496	286.453	34.349	43.154	123.930	29.990
11	59.00	44.00	13.80	.002424	.230	82.881	317.037	30.490	52.699	141.330	29.990
12	61.00	45.00	19.55	.002487	.220	84.400	320.345	31.360	58.504	166.022	29.990
13	62.00	45.00	16.10	.001989	.170	83.119	310.488	34.744	58.396	194.912	29.980
14	69.00	47.00	17.25	.001787	.120	86.777	309.415	32.662	52.428	219.361	29.950
15	69.00	46.00	14.95	.001340	.090	84.690	307.762	28.944	42.796	236.547	29.930
16	66.00	45.00	16.10	.001749	.130	84.652	290.980	24.449	31.320	248.714	29.930
17	65.00	45.00	13.80	.001690	.130	83.751	260.098	14.794	18.949	258.117	29.930
18	64.00	44.00	18.40	.001758	.140	83.412	140.283	1.008	6.168	266.180	29.940
19	60.00	43.00	13.80	.001856	.170	81.306	.000	.000	.000	.000	29.960
20	56.00	41.00	8.05	.001893	.200	78.989	.000	.000	.000	.000	30.000
21	53.00	39.00	8.05	.001952	.230	77.404	.000	.000	.000	.000	30.030
22	51.00	38.00	8.05	.001797	.230	75.618	.000	.000	.000	.000	30.060
23	48.00	36.00	8.05	.001815	.260	73.930	.000	.000	.000	.000	30.080
24	47.00	35.00	9.20	.001747	.260	73.096	.000	.000	.000	.000	30.090

Table 2.1.6(b)

WEATHER DATA FOR MOBILE, ALABAMA - 1957

- JUNE 21 - TYPEDAY = 1

HOUR	DB TEMP	WB TEMP	WIND VELOCITY	ABSOLUTE HUMIDITY	RELATIVE HUMIDITY	SKY RADIATION	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUM	AZIMUTH OF SUM	STATION PRESSURE
1	70.00	70.00	.00	.015893	1.000	108.937	.000	.000	.000	.000	29.690
2	70.00	69.00	3.45	.015236	.960	108.729	.000	.000	.000	.000	29.700
3	70.00	69.00	3.45	.015236	.960	108.729	.000	.000	.000	.000	29.700
4	70.00	69.00	3.45	.015242	.960	108.729	.000	.000	.000	.000	29.690
5	70.00	69.00	3.45	.015242	.960	108.729	.000	.000	.000	.000	29.690
6	69.00	69.00	3.45	.015351	1.000	107.947	16.366	36.383	7.083	66.916	29.690
7	72.00	71.00	4.60	.016332	.960	113.519	100.866	45.494	19.231	73.560	29.690
8	75.00	73.00	4.60	.016928	.900	119.097	154.909	37.844	31.790	79.803	29.710
9	80.00	77.00	10.35	.019366	.870	141.444	132.769	45.429	44.597	93.768	29.710
10	82.00	73.00	17.25	.019980	.840	120.084	145.716	47.269	57.499	93.922	29.700
11	72.00	71.00	8.05	.015797	.930	138.720	172.259	45.952	70.213	106.203	29.710
12	75.00	72.00	5.75	.016344	.870	136.149	173.526	46.834	81.195	143.094	29.720
13	80.00	72.00	.00	.014582	.660	138.155	206.501	48.160	79.088	231.176	29.710
14	84.00	76.00	8.05	.017431	.690	139.542	188.010	53.940	67.295	257.500	29.710
15	82.00	77.00	14.95	.018767	.790	146.487	148.644	53.780	54.490	268.088	29.680
16	85.00	77.00	14.95	.018047	.690	146.704	134.420	53.276	41.594	275.326	29.660
17	84.00	76.00	16.10	.017461	.690	139.542	123.871	52.843	28.832	281.645	29.660
18	82.00	77.00	11.50	.018781	.790	143.530	51.893	52.121	16.353	287.937	29.660
19	80.00	73.00	11.50	.015736	.710	144.263	1.652	30.109	4.329	294.744	29.670
20	75.00	73.00	8.05	.016952	.900	139.027	.000	.000	.000	.000	29.670
21	73.00	72.00	5.75	.016361	.930	134.124	.000	.000	.000	.000	29.690
22	73.00	71.00	6.90	.015820	.900	111.402	.000	.000	.000	.000	29.690
23	72.00	71.00	6.90	.015803	.930	130.273	.000	.000	.000	.000	29.700
24	72.00	71.00	.00	.015803	.930	130.273	.000	.000	.000	.000	29.700

Table 2.1.6(c)

WEATHER DATA FOR MOBILE, ALABAMA - 1957

- SEPT 23 - TYPEDAY = 2

HOOR	DB TEMP	WB TEMP	WIND VELOCITY	ABSOLUTE HUMIDITY	RELATIVE HUMIDITY	SKY RADIATION	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUM	AZIMUTH OF SUM	STATION PRESSURE
1	70.00	67.00	5.75	.013724	.870	108.159	.000	.000	.000	.000	29.810
2	70.00	66.00	5.75	.012276	.780	107.412	.000	.000	.000	.000	29.810
3	68.00	64.00	4.60	.012359	.840	105.845	.000	.000	.000	.000	29.800
4	67.00	65.00	5.75	.012372	.870	105.052	.000	.000	.000	.000	29.800
5	67.00	65.00	5.75	.012367	.870	105.052	.000	.000	.000	.000	29.810
6	65.00	63.00	6.90	.011934	.900	103.217	.000	.000	.000	.000	29.820
7	64.00	62.00	5.75	.011518	.900	102.175	63.655	34.587	9.813	95.536	29.830
8	66.00	64.00	6.90	.011931	.870	104.009	159.945	47.028	22.533	103.836	29.840
9	69.00	65.00	8.05	.012308	.810	115.330	203.352	50.958	34.753	113.786	29.850
10	67.00	65.00	11.50	.012776	.900	105.289	171.767	80.149	45.905	127.023	29.870
11	69.00	65.00	11.50	.012296	.810	106.632	183.668	78.429	54.842	146.068	29.880
12	72.00	66.00	12.65	.012780	.760	109.344	185.293	79.756	59.475	172.602	29.870
13	73.00	66.00	9.20	.011456	.660	109.342	218.277	45.240	57.856	201.510	29.860
14	77.00	67.00	9.20	.011717	.590	112.835	238.292	50.009	50.758	224.360	29.820
15	80.00	70.00	11.50	.012738	.580	116.029	215.325	51.005	40.515	240.144	29.800
16	83.00	70.00	8.05	.012590	.520	118.537	160.231	43.664	28.732	251.479	29.790
17	81.00	69.00	11.50	.012251	.540	116.586	103.832	37.037	16.212	260.447	29.780
18	82.00	70.00	6.90	.012659	.540	117.708	1.536	14.341	3.372	268.333	29.790
19	79.00	69.00	4.60	.012759	.600	115.181	.000	.000	.000	.000	29.790
20	77.00	69.00	4.60	.013150	.660	113.695	.000	.000	.000	.000	29.790
21	75.00	69.00	6.90	.013623	.730	112.246	.000	.000	.000	.000	29.790
22	73.00	67.00	4.60	.013256	.760	110.402	.000	.000	.000	.000	29.800
23	72.00	68.00	5.75	.013146	.780	109.524	.000	.000	.000	.000	29.820
24	71.00	67.00	5.75	.012711	.780	108.470	.000	.000	.000	.000	29.800

Table 2.1.6(d)

WEATHER DATA FOR MOBILE, ALABAMA - 1957

- DEC 21 - TYPEDAY = 1

HOUR	DB TEMP	WB TEMP	WIND VELOCITY	ABSOLUTE HUMIDITY	RELATIVE HUMIDITY	SKY RADIATION	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUM	AZIMUTH OF SUM	STATION PRESSURE
1	58.00	56.00	4.60	.008871	.360	95.449	.000	.000	.000	.000	29.830
2	58.00	56.00	.00	.008874	.360	95.449	.000	.000	.000	.000	29.870
3	58.00	56.00	.00	.008874	.360	95.449	.000	.000	.000	.000	29.870
4	58.00	55.00	4.60	.008553	.830	95.116	.000	.000	.000	.000	29.860
5	58.00	56.00	4.60	.008883	.860	95.449	.000	.000	.000	.000	29.840
6	58.00	55.00	5.75	.008569	.830	95.116	.000	.000	.000	.000	29.840
7	58.00	55.00	4.60	.008566	.830	95.116	.000	.000	.000	.000	29.850
8	58.00	56.00	.00	.008877	.860	95.449	45.790	23.784	7.546	122.984	29.860
9	59.00	57.00	5.75	.009201	.360	96.514	124.999	51.781	17.771	132.432	29.860
10	62.00	59.00	6.90	.009874	.830	99.395	155.567	63.902	26.391	144.020	29.860
11	65.00	61.00	8.05	.010705	.810	102.389	167.555	70.426	32.662	158.114	29.860
12	68.00	63.00	9.20	.010993	.750	134.606	171.942	72.661	35.754	174.345	29.850
13	70.00	65.00	11.50	.012272	.780	107.412	162.826	78.476	35.122	191.233	29.320
14	72.00	66.00	13.80	.012299	.730	138.727	152.929	76.700	30.885	205.861	29.790
15	73.00	66.00	11.50	.011846	.680	133.737	133.122	70.320	23.738	220.112	29.770
16	71.00	66.00	11.50	.012229	.750	128.836	93.690	40.741	14.510	230.928	29.760
17	68.00	65.00	11.50	.012376	.840	128.850	2.972	36.346	3.880	239.788	29.760
18	67.00	64.00	4.60	.011949	.840	130.707	.000	.000	.000	.000	29.770
19	66.00	64.00	6.90	.012380	.900	132.574	.000	.000	.000	.000	29.770
20	66.00	64.00	6.90	.011960	.870	132.575	.000	.000	.000	.000	29.770
21	65.00	63.00	16.10	.011950	.900	103.217	.000	.000	.000	.000	29.780
22	64.00	62.00	.00	.011537	.900	130.572	.000	.000	.000	.000	29.780
23	64.00	62.00	4.60	.011012	.860	130.573	.000	.000	.000	.000	29.790
24	64.00	62.00	4.60	.011019	.860	130.573	.000	.000	.000	.000	29.770

Table 2.1.7(a)

WEATHER DATA FOR SANTA MARIA, CALIFORNIA - 1957 - MAR 21 - TYPEDAY = 1

HOJR	DB TEMP	WB TEMP	WIND VELOCITY	ABSOLUTE HUMIDITY	RELATIVE HUMIDITY	SKY RADIATION	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUN	AZIMUTH OF SUN	STATION PRESSURE
1	49.00	48.00	.00	.006860	.930	93.467	.000	.000	.000	.000	29.790
2	48.00	47.00	.00	.006600	.930	91.513	.000	.000	.000	.000	29.810
3	47.00	47.00	8.05	.006559	.960	114.458	.000	.000	.000	.000	29.820
4	46.00	47.00	4.60	.006600	.930	112.382	.000	.000	.000	.000	29.810
5	48.00	46.00	9.20	.006027	.850	84.654	.000	.000	.000	.000	29.810
6	48.00	46.00	4.60	.005880	.830	84.414	.000	.000	.000	.000	29.830
7	49.00	45.00	10.35	.005437	.740	84.291	27.273	2.062	4.272	93.058	29.840
8	49.00	43.00	6.90	.004248	.580	85.255	207.968	18.818	16.581	101.793	29.880
9	49.00	42.00	12.65	.003803	.520	87.836	261.236	28.380	28.471	111.721	29.900
10	52.00	43.00	11.50	.003678	.450	89.659	282.818	33.151	39.457	124.089	29.900
11	55.00	45.00	16.10	.003952	.430	92.367	290.485	36.196	48.666	140.662	29.900
12	58.00	49.00	14.95	.005022	.490	93.083	288.003	38.904	54.586	163.008	29.890
13	57.00	47.00	20.70	.004150	.420	90.521	294.499	37.715	55.434	189.281	29.880
14	57.00	47.00	23.00	.004351	.440	90.969	290.205	37.038	50.874	213.264	29.870
15	57.00	47.00	23.00	.004353	.440	87.323	294.243	30.659	42.461	231.473	29.850
16	55.00	47.00	20.70	.004701	.510	86.792	273.251	27.573	31.822	244.895	29.850
17	54.00	47.00	20.70	.004982	.560	86.732	229.309	20.957	20.209	255.402	29.850
18	53.00	46.00	13.80	.005059	.590	86.228	114.633	5.782	7.938	264.389	29.870
19	50.00	46.00	11.50	.005406	.710	84.914	.000	.000	.000	.000	29.890
20	48.00	45.00	8.05	.005435	.770	83.654	.000	.000	.000	.000	29.920
21	47.00	44.00	6.90	.005434	.800	83.002	.000	.000	.000	.000	29.940
22	46.00	44.00	6.90	.005424	.830	82.339	.000	.000	.000	.000	29.960
23	44.00	42.00	.00	.004960	.820	80.174	.000	.000	.000	.000	29.970
24	46.00	42.00	.00	.004434	.680	80.349	.000	.000	.000	.000	29.930

Table 2.1.7(b)

WEATHER DATA FOR SANTA MARIA, CALIFORNIA - 1957 - JUNE 21 - TYPEDAY = 1

HOUR	DB TEMP	WB TEMP	WIND VELOCITY	ABSOLUTE HUMIDITY	RELATIVE HUMIDITY	SKY RADIATION	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUN	AZIMUTH OF SUN	STATION PRESSURE
1	54.00	52.00	5.75	.007851	.870	91.304	.000	.000	.000	.000	29.560
2	53.00	52.00	4.60	.007838	.900	90.574	.000	.000	.000	.000	29.540
3	52.00	51.00	5.75	.007496	.900	89.437	.000	.000	.000	.000	29.520
4	52.00	51.00	5.75	.007752	.930	89.755	.000	.000	.000	.000	29.510
5	52.00	51.00	8.05	.008005	.960	90.059	.000	.000	.000	.000	29.510
6	52.00	52.00	5.75	.008003	.960	90.059	35.691	16.706	6.534	66.059	29.520
7	51.00	51.00	5.75	.008031	1.000	89.394	128.222	44.655	18.190	73.555	29.530
8	52.00	52.00	8.05	.008335	1.000	90.442	165.783	57.333	30.294	80.745	29.540
9	55.00	54.00	4.60	.008430	.900	92.689	186.185	62.179	42.651	91.696	29.550
10	62.00	57.00	11.50	.008642	.720	98.071	266.689	38.455	55.049	97.460	29.540
11	63.00	56.00	13.80	.008199	.660	98.300	278.929	38.387	67.083	111.545	29.530
12	70.00	60.00	8.05	.008692	.550	104.275	279.695	39.149	77.141	143.731	29.520
13	74.00	62.00	11.50	.008679	.480	107.439	280.325	38.789	77.828	210.761	29.510
14	74.00	60.00	12.65	.007766	.430	106.221	282.604	36.948	68.231	246.455	29.500
15	75.00	59.00	19.55	.006901	.370	105.643	281.114	34.402	56.279	261.446	29.490
16	77.00	60.00	19.55	.006978	.350	107.361	269.038	31.876	43.893	269.119	29.480
17	74.00	58.00	16.10	.006860	.380	104.776	248.239	27.653	31.522	278.529	29.470
18	71.00	60.00	13.80	.008015	.490	104.187	186.069	23.757	19.383	285.722	29.470
19	66.00	53.00	11.50	.007998	.580	100.304	71.008	8.950	7.673	293.162	29.490
20	63.00	55.00	9.20	.008081	.650	98.144	.000	.000	.000	.000	29.500
21	60.00	55.00	4.60	.008062	.720	95.887	.000	.000	.000	.000	29.500
22	59.00	55.00	.00	.008102	.750	95.208	.000	.000	.000	.000	29.520
23	56.00	53.00	.00	.007864	.810	92.737	.000	.000	.000	.000	29.520
24	58.00	54.00	.00	.007820	.750	94.124	.000	.000	.000	.000	29.510

Table 2.1.7(c)

WEATHER DATA FOR SANTA MARIA, CALIFORNIA - 1957 - SEPT 23 - TYPEDAY = 2

HOURL	DB TEMP	WB TEMP	WIND VELOCITY	ABSOLUTE HUMIDITY	RELATIVE HUMIDITY	SKY RADIATION	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUN	AZIMUTH OF SUN	STATION PRESSURE
1	52.00	52.00	.00	.008320	1.000	90.442	.000	.000	.000	.000	29.590
2	54.00	53.00	5.75	.008388	.930	91.941	.000	.000	.000	.000	29.600
3	54.00	54.00	4.60	.008663	.960	92.236	.000	.000	.000	.000	29.600
4	54.00	53.00	.00	.008391	.930	91.941	.000	.000	.000	.000	29.590
5	53.00	53.00	.00	.008704	1.000	91.563	.000	.000	.000	.000	29.600
6	54.00	53.00	.00	.008111	.900	91.631	.000	.000	.000	.000	29.610
7	54.00	53.00	6.90	.008111	.900	91.631	48.913	18.275	7.398	94.694	29.610
8	54.00	53.00	.00	.008385	.930	91.941	136.934	48.673	19.654	103.609	29.610
9	55.00	54.00	4.60	.008694	.930	92.995	171.564	60.298	31.412	113.964	29.620
10	60.00	57.00	3.45	.009387	.840	97.366	242.462	44.528	42.122	127.136	29.620
11	64.00	58.00	8.05	.008598	.670	99.556	270.697	38.847	50.778	145.028	29.610
12	67.00	60.00	10.35	.009401	.660	102.727	271.526	40.334	55.700	168.861	29.610
13	67.00	60.00	10.35	.009405	.660	102.727	271.074	40.284	55.223	195.468	29.600
14	66.00	59.00	11.50	.008947	.650	101.470	267.163	39.050	49.541	218.364	29.590
15	66.00	59.00	10.35	.008947	.650	101.470	253.369	37.394	40.444	235.331	29.590
16	62.00	57.00	11.50	.008627	.720	98.071	228.432	33.880	29.506	247.913	29.590
17	61.00	57.00	8.05	.009031	.780	97.754	160.144	31.502	17.635	257.948	29.590
18	58.00	55.00	6.90	.008428	.810	94.883	24.185	10.314	5.333	266.723	29.600
19	56.00	54.00	5.75	.008723	.900	93.747	.000	.000	.000	.000	29.610
20	56.00	54.00	.00	.008723	.900	93.747	.000	.000	.000	.000	29.610
21	56.00	54.00	5.75	.008720	.900	93.747	.000	.000	.000	.000	29.620
22	56.00	54.00	.00	.008723	.900	93.747	.000	.000	.000	.000	29.610
23	55.00	55.00	.00	.009171	.980	93.470	.000	.000	.000	.000	29.610
24	56.00	54.00	.00	.008726	.900	93.747	.000	.000	.000	.000	29.600

Table 2.1.7(d)

WEATHER DATA FOR SANTA MARIA, CALIFORNIA - 1957 - DEC 21 - TYPEDAY = 1

HOJR	DB TEMP	WE TEMP	WIND VELOCITY	ABSOLUTE HUMIDITY	RELATIVE HUMIDITY	SKY RADIATION	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SJM	AZIMUTH OF SJM	STATION PRESSURE
1	38.00	38.00	.00	.004621	.960	75.716	.000	.000	.000	.000	29.810
2	37.00	36.00	4.60	.004303	.930	74.453	.000	.000	.000	.000	29.800
3	38.00	37.00	3.45	.004476	.930	75.420	.000	.000	.000	.000	29.810
4	38.00	37.00	.00	.004476	.930	75.420	.000	.000	.000	.000	29.810
5	35.00	35.00	.00	.004099	.960	72.833	.000	.000	.000	.000	29.810
6	34.00	33.00	5.75	.003435	.850	70.840	.000	.000	.000	.000	29.800
7	34.00	32.00	4.60	.003351	.820	70.537	.000	.000	.000	.000	29.800
8	34.00	32.00	4.60	.003197	.780	70.121	49.645	.559	3.898	121.827	29.800
9	39.00	37.00	3.45	.003950	.790	74.879	204.543	14.641	13.874	131.427	29.820
10	51.00	45.00	4.60	.004666	.590	84.042	250.838	23.059	22.338	142.853	29.830
11	56.00	47.00	8.05	.005073	.530	88.270	269.872	27.361	28.637	156.418	29.810
12	57.00	51.00	13.80	.006468	.650	91.553	263.348	32.191	32.046	171.877	29.780
13	59.00	47.00	14.95	.004154	.390	88.140	288.504	27.085	32.046	188.123	29.750
14	61.00	48.00	17.25	.004115	.360	89.399	280.852	25.002	28.637	203.582	29.740
15	60.00	47.00	16.10	.003639	.330	87.404	265.924	19.924	22.338	217.147	29.740
16	59.00	46.00	10.35	.003726	.350	86.983	216.580	11.475	13.874	228.573	29.750
17	56.00	43.00	14.95	.002961	.310	82.728	65.190	.189	3.898	238.173	29.770
18	52.00	42.00	6.90	.003197	.390	80.912	.000	.000	.000	.000	29.790
19	49.00	40.00	14.95	.003225	.440	79.118	.000	.000	.000	.000	29.810
20	47.00	39.00	4.60	.003192	.470	77.797	.000	.000	.000	.000	29.840
21	46.00	38.00	6.90	.003071	.470	76.845	.000	.000	.000	.000	29.850
22	45.00	38.00	8.05	.003203	.510	76.629	.000	.000	.000	.000	29.860
23	43.00	37.00	6.90	.003145	.540	75.250	.000	.000	.000	.000	29.870
24	42.00	36.00	6.90	.003194	.570	74.789	.000	.000	.000	.000	29.870

Table 2.1.8(a)

WEATHER DATA FOR WILMINGTON, DELAWARE - 1958

- MAR 21 - TYPEDAY = 1

HOOR	DB TEMP	WB TEMP	WIND VELOCITY	ABSOLUTE HUMIDITY	RELATIVE HUMIDITY	SKY RADIATION	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUM	AZIMUTH OF SUM	STATION PRESSURE
1	48.00	45.00	5.75	.005508	.780	83.785	.000	.000	.000	.000	29.910
2	47.00	45.00	.00	.005718	.840	83.493	.000	.000	.000	.000	29.890
3	46.00	45.00	.00	.005840	.890	83.035	.000	.000	.000	.000	29.860
4	47.00	45.00	.00	.006140	.900	84.183	.000	.000	.000	.000	29.840
5	45.00	44.00	4.60	.005817	.920	82.332	.000	.000	.000	.000	29.830
6	45.00	44.00	3.45	.006013	.950	103.661	.000	.000	.000	.000	29.810
7	44.00	44.00	4.60	.005789	.950	102.732	21.072	1.277	3.869	93.404	29.790
8	44.00	44.00	3.45	.005912	.970	102.792	154.695	19.976	15.258	103.321	29.790
9	48.00	47.00	.00	.006679	.940	85.656	198.357	30.365	26.157	114.366	29.780
10	56.00	51.00	6.90	.006824	.710	91.399	220.711	34.096	36.039	127.586	29.770
11	63.00	54.00	16.10	.006893	.560	109.776	233.245	35.475	44.080	144.198	29.740
12	65.00	55.00	21.85	.006865	.520	104.710	271.565	40.227	49.066	164.865	29.710
13	68.00	56.00	19.55	.006442	.440	113.558	241.298	35.668	49.791	187.992	29.670
14	70.00	56.00	20.70	.006432	.410	122.408	239.638	34.216	46.035	209.750	29.630
15	68.00	55.00	19.55	.006163	.420	116.801	232.357	32.001	38.807	227.629	29.590
16	68.00	55.00	14.95	.006169	.420	131.070	187.753	46.267	29.394	241.782	29.560
17	66.00	57.00	12.65	.007985	.580	132.594	140.684	40.681	18.746	253.384	29.540
18	62.00	55.00	13.80	.007430	.620	128.610	56.007	13.630	7.466	263.555	29.530
19	57.00	54.00	11.50	.008252	.820	93.928	.000	.000	.000	.000	29.530
20	54.00	52.00	6.90	.007768	.860	91.192	.000	.000	.000	.000	29.530
21	53.00	50.00	20.70	.007041	.810	89.533	.000	.000	.000	.000	29.560
22	47.00	43.00	18.40	.004735	.690	81.511	.000	.000	.000	.000	29.600
23	43.00	39.00	25.30	.003938	.670	77.221	.000	.000	.000	.000	29.630
24	38.00	33.00	17.25	.002505	.520	95.741	.000	.000	.000	.000	29.690

Table 2.1.8(b)

WEATHER DATA FOR WILMINGTON, DELAWARE - 1958 - JUNE 21 - TYPEDAY = 1

HOUR	DB TEMP	WB TEMP	WIND VELOCITY	ABSOLUTE HUMIDITY	RELATIVE HUMIDITY	SKY RADIATION	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUM	AZIMUTH OF SUM	STATION PRESSURE
1	66.00	61.00	8.05	.010569	.770	103.033	.000	.000	.000	.000	29.750
2	63.00	60.00	6.90	.010142	.820	100.358	.000	.000	.000	.000	29.750
3	63.00	59.00	8.05	.010016	.810	100.250	.000	.000	.000	.000	29.750
4	62.00	59.00	5.75	.009730	.820	108.081	.000	.000	.000	.000	29.750
5	61.00	58.00	5.75	.009683	.840	104.270	.000	.000	.000	.000	29.750
6	62.00	59.00	6.90	.009908	.830	99.395	57.750	17.976	8.754	66.707	29.760
7	63.00	60.00	5.75	.010135	.820	100.358	135.282	33.899	19.645	75.392	29.770
8	69.00	62.00	6.90	.010325	.680	105.210	178.504	37.658	30.973	84.052	29.780
9	71.00	63.00	6.90	.010395	.640	106.873	176.165	65.923	42.481	93.502	29.790
10	73.00	63.00	8.05	.009689	.570	120.735	217.221	40.443	53.841	105.236	29.800
11	75.00	62.00	9.20	.008888	.480	125.250	230.169	39.329	64.389	122.724	29.800
12	78.00	62.00	11.50	.008169	.400	124.126	238.397	38.076	72.177	154.194	29.800
13	80.00	64.00	11.50	.008733	.400	112.523	268.071	43.037	72.695	200.929	29.790
14	83.00	63.00	11.50	.007590	.320	113.562	282.426	35.874	65.471	234.624	29.780
15	84.00	64.00	13.80	.007594	.310	114.407	264.539	39.179	55.096	253.170	29.780
16	84.00	65.00	9.20	.008199	.330	126.122	248.397	37.978	43.784	265.322	29.770
17	82.00	64.00	5.75	.008391	.360	128.033	196.612	31.668	32.273	274.936	29.760
18	83.00	66.00	8.05	.009649	.400	123.002	172.092	31.014	20.912	283.637	29.760
19	82.00	66.00	8.05	.010287	.440	119.254	76.571	20.078	9.958	292.288	29.760
20	79.00	67.00	5.75	.011035	.520	113.999	.000	.000	.000	.000	29.770
21	72.00	65.00	10.35	.011274	.670	108.372	.000	.000	.000	.000	29.780
22	70.00	65.00	9.20	.012128	.770	107.316	.000	.000	.000	.000	29.780
23	70.00	67.00	9.20	.013089	.830	107.851	.000	.000	.000	.000	29.790
24	69.00	67.00	6.90	.013739	.900	107.345	.000	.000	.000	.000	29.780

Table 2.1.8(c)

WEATHER DATA FOR WILMINGTON, DELAWARE - 1958

- SEPT 23 - TYPEDAY = 2

HOOR	DB TEMP	WB TEMP	WIND VELOCITY	ABSOLUTE HUMIDITY	RELATIVE HUMIDITY	SKY RADIATION	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUM	AZIMUTH OF SUM	STATION PRESSURE
1	55.00	52.00	5.75	.007351	.800	91.542	.000	.000	.000	.000	30.070
2	55.00	52.00	4.60	.007537	.820	91.738	.000	.000	.000	.000	30.070
3	53.00	52.00	3.45	.007869	.920	90.785	.000	.000	.000	.000	30.080
4	52.00	51.00	4.60	.007601	.930	89.755	.000	.000	.000	.000	30.090
5	51.00	50.00	3.45	.007319	.930	88.700	.000	.000	.000	.000	30.100
6	51.00	49.00	4.60	.006758	.860	87.928	.000	.000	.000	.000	30.120
7	50.00	48.00	5.75	.005579	.870	86.987	68.652	7.297	6.818	95.344	30.150
8	53.00	50.00	5.75	.007153	.840	89.898	139.863	24.248	18.141	105.439	30.180
9	60.00	55.00	8.05	.007986	.730	96.025	232.001	32.364	28.882	116.837	30.190
10	65.00	58.00	6.90	.008857	.680	100.806	249.317	37.066	38.458	130.807	30.210
11	70.00	58.00	5.75	.007395	.480	102.805	274.638	35.082	45.949	148.426	30.220
12	73.00	58.00	6.90	.006638	.390	103.906	285.788	34.221	50.061	170.080	30.220
13	75.00	60.00	6.90	.007472	.410	106.854	277.726	35.742	49.703	193.447	30.210
14	74.00	59.00	5.75	.007049	.400	105.384	276.129	33.917	44.984	214.552	30.200
15	76.00	60.00	6.90	.007353	.390	107.458	261.382	31.986	37.097	231.539	30.180
16	76.00	60.00	.00	.007165	.380	107.152	238.510	27.149	27.293	244.998	30.170
17	76.00	61.00	3.45	.008122	.430	108.577	169.118	21.569	16.431	256.172	30.160
18	74.00	61.00	.00	.007952	.450	106.734	30.997	3.527	5.056	266.143	30.160
19	72.00	60.00	.00	.008435	.510	105.772	.000	.000	.000	.000	30.160
20	67.00	59.00	.00	.008377	.600	101.782	.000	.000	.000	.000	30.160
21	63.00	58.00	3.45	.008762	.720	99.164	.000	.000	.000	.000	30.170
22	61.00	58.00	3.45	.009428	.830	98.327	.000	.000	.000	.000	30.180
23	62.00	59.00	4.60	.009765	.830	99.395	.000	.000	.000	.000	30.190
24	59.00	55.00	3.45	.008560	.810	95.957	.000	.000	.000	.000	30.200

Table 2.1.8(d)

WEATHER DATA FOR WILMINGTON, DELAWARE - 1958

- DEC 21 - TYPEDAY = 1

HOOR	DB TEMP	WB TEMP	WIND VELOCITY	ABSOLUTE HUMIDITY	RELATIVE HUMIDITY	SKY RADIATION	DIRECT RADIATION	DIFFUSED RADIATION	ALTITUDE OF SUM	AZIMUTH OF SUM	STATION PRESSURE
1	18.00	15.00	9.20	.000935	.450	55.110	.000	.000	.000	.000	30.120
2	19.00	16.00	6.90	.001215	.560	56.543	.000	.000	.000	.000	30.130
3	16.00	13.00	5.75	.001104	.580	54.775	.000	.000	.000	.000	30.150
4	14.00	12.00	4.60	.001151	.660	54.016	.000	.000	.000	.000	30.160
5	14.00	12.00	4.60	.001099	.630	53.843	.000	.000	.000	.000	30.150
6	13.00	12.00	5.75	.001152	.690	53.563	.000	.000	.000	.000	30.160
7	14.00	12.00	6.90	.001133	.650	53.959	.000	.000	.000	.000	30.180
8	16.00	14.00	5.75	.001312	.690	55.466	.000	.000	.000	.000	30.210
9	17.00	15.00	5.75	.001329	.670	72.863	171.264	7.549	9.997	132.257	30.230
10	23.00	20.00	10.35	.001408	.550	59.138	254.091	18.673	17.694	144.012	30.260
11	27.00	23.00	13.80	.001603	.530	61.789	236.076	21.389	23.343	157.416	30.230
12	28.00	23.00	13.80	.001323	.420	61.327	251.291	23.475	26.370	172.216	30.280
13	30.00	25.00	11.50	.001712	.500	63.691	216.903	39.302	26.391	187.581	30.260
14	29.00	24.00	14.95	.001347	.410	61.913	244.634	21.180	23.401	202.394	30.250
15	29.00	24.00	11.50	.001513	.460	62.492	224.601	16.282	17.784	215.821	30.240
16	29.00	24.00	12.65	.001381	.420	62.030	199.156	7.420	10.110	227.596	30.240
17	29.00	24.00	14.95	.001413	.430	62.147	.000	.000	.000	.000	30.250
18	23.00	20.00	6.90	.001356	.530	58.964	.000	.000	.000	.000	30.230
19	20.00	18.00	3.45	.001216	.540	57.043	.000	.000	.000	.000	30.300
20	23.00	19.00	4.60	.001227	.480	58.523	.000	.000	.000	.000	30.310
21	22.00	19.00	3.45	.001298	.530	58.287	.000	.000	.000	.000	30.330
22	21.00	18.00	3.45	.001197	.510	57.459	.000	.000	.000	.000	30.340
23	18.00	16.00	4.60	.001176	.570	55.971	.000	.000	.000	.000	30.340
24	19.00	17.00	4.60	.001400	.650	57.190	.000	.000	.000	.000	30.350

17 MAY 76 - 03:38:51 PM
4154269 PLOT

PVEPS - DAILY INSOLATION PLOT

ATLANTA, GEORGIA - 1960 - CSU INSOLATION DATA - QDIR (M1)

Figure 2.1.1

24 JUN 76 - 09:03:39 AM
4154269 PLOT

PVEPS - DAILY INSOLATION PLOT

MADISON, WISCONSIN - 1956 - ~~H~~ INSOLATION DATA - QDIR (S3)

Figure 2.1.2

24 MAR 76 - 02:16:10 PM
4154269 MAS2

PVEPS - DAILY INSOLATION PLOT

MOBILE, ALABAMA - 1963 - W INSOLATION DATA - QDIR (S1)

Figure 2.1.3

15 MAR 76 - 03:55:51 PM
4154269 SMS2

FVEPS - DAILY INSOLATION PLOT

SANTA MARIA, CALIFORNIA - 1957 - N INSOLATION DATA - Q-DIR (S1)

Figure 2.1.4

13 MAY 76 - 04:57:51 PM
4154269 PLOT

PVEPS - DAILY INSOLATION PLOT

WILMINGTON, DELAWARE - 1958 - W INSOLATION DATA - QDIR (S1)

Figure 2.1.5

after the latter had been modified. These two sets of data appeared essentially the same and gave similar results when used as input for the RPS simulation programs.

2.1.1.2 Absorbed Energy Computations

The energy absorbed by a given collector was computed with formulas developed for the NSF Phase 0 study based on the work of Austin Whillier. Figures 2.1.6-2.1.13 show the daily distribution of absorbed insolation.

2.1.1.3 Load Data

The load data base consists of the CASE I and CASE II loads, which do not vary from region to region, and the heating-cooling loads which are region dependent.

The electrical demand for a representative single family house is needed to properly determine the type and size of the system. It is expected that houses constructed in the future will be equipped with most of the functional apparatus now in use, but with more energy-conscious designs. Equipment with high energy requirements, such as electric space heating and water heating, electric clothes dryers and central air-conditioning, will become more expensive to operate as electric rates rise. However, projections show electricity use per household increasing to the year 2000⁽¹⁾.

¹An Engineering/Economic Model of Residential Energy Use, Eric Hirst, et al., Oak Ridge National Laboratory (to be published).

2 FEB 76 - 11:17:39 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.

CLEVELAND, OHIO - 1962 - A INSOLATION DATA - ENERGY ABSORBED

Figure 2.1.6

2 FEB 76 - 11:47:10 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.

MADISON, WISCONSIN - 1962 - A INSOLATION DATA - ENERGY ABSORBED

Figure 2.1.7

2 FEB 76 - 11:06:01 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.

PHOENIX, ARIZONA - 1962 - A INSOLATION DATA - ENERGY ABSORBED

Figure 2.1.8

14 MAY 76 - 01:35:44 PM
4154269 PLOT

PVEPS - DAILY INSOLATION PLOT

ATLANTA, GEORGIA - CSU INSOLATION DATA - ENERGY ABSORBED (ORIGINAL)

Figure 2.1.9

2 FEB 76 - 11:25:53 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.

MADISON, WISCONSIN - W INSOLATION DATA (S3) - ENERGY ABSORBED

Time (Months)
Figure 2.1.10

24 MAR 76 - 03:27:36 PM
4154269 MAS2

PVEPS - DAILY INSOLATION PLOT

MOBILE, ALABAMA - 1963 - V INSOLATION DATA - ENERGY ABSORBED (S1)

Figure 2.1.11

15 MAR 76 - 04:59:22 PM
4154269 SAS2

PYEPS - DAILY INSOLATION PLOTS

SANTA MARIA - 1957 - Y INSOLATION DATA - ENERGY ABSORBED (S1)

Figure 2.1.12

14 MAY 76 - 01:24:00 PM
4154269 PLOT

PVEPS - DAILY INSOLATION PLOT

WILMINGTON, DELAWARE - 1958 - W INSOLATION DATA - ENERGY ABSORBED (S1)

Figure 2.1.13

Many references give the average residential usage of various electrical appliances and projected future usage. However, there is large variance in actual home to home usage. In a field test of a group of similar homes in Biddeford, Maine, the usage varied by more than a factor of two. This is attributed to differences in number of persons in the household, number of children, number of persons working, and differences in lifestyle. Recognizing this, convenient numbers close to the projected average were selected as parameters for sizing and analyzing the solar design. These are shown in Table 2.1.9 including a sample composition of the load. The CASE I or basic load is 5027 kWh/year, and the CASE II load, which adds loads normally supplied at 220 volts, is 7217 kWh/year. The sensitivity to changes in load can be obtained by examining the different results obtained in treating these two cases, keeping in mind that CASE II has a heavier peak demand pattern. The miscellaneous load could be made up of elements from Table 2.1.10 showing other residential loads, both occasional and continuous.

The assumed pattern of residential use during the year is listed in Table 2.1.11. Loads are assumed to be the same from day to day during a particular month, with two exceptions. A vacation period for the last 16 days of July decreases the daily load level below normal, and the holiday season for the final 17 days of the year is assigned a slightly increased demand.

²Assessing the Potential for Optimal Utilization of Off-Peak Power, Volume II - Biddeford Demonstration, for FEA Contract Number 14-01-0001-1892, December, 1975.

TABLE 2.1.9

SAMPLE RESIDENTIAL LOAD COMPOSITION

<u>Use</u>	<u>kWh/Yr</u>
<u>CASE I</u>	
Lights	1200
Refrigerator	1200
Freezer	800
Coffee Maker	100
Washer	100
Iron	140
Color TV	470
Radio	90
Misc. (1)	<u>927</u>
TOTAL	5027

CASE II

CASE I Load (from above)	5027
Electric Range	
Clothes Dryer (2)	<u>2190</u>
TOTAL	7217

- (1) Considerable variation to be expected. Exact number selected to yield total equal to that in Table 2.1.11 Residential Electrical Load During Year.
- (2) Considerable variation to be expected, although this figure is considered representative. Exact number selected as result of $6 \text{ kWh/day} \times 365 \text{ days/year} = 2190 \text{ kWh/year}$, for convenience in calculation.

TABLE 2.1.10.

OTHER RESIDENTIAL ELECTRICAL LOADS

<u>Unit</u>	<u>kWh/Yr.</u>	<u>Unit</u>	<u>kWh/Yr.</u>
Dishwasher	350	Waffle Iron	20
Waste Disposer	30	Air Cleaner	215
Furnace Fan	400	Circulating Fan	45
Radiant Heater	170-1100	Heating Pad	10
Electric Blanket	140	Hair Dryer	15
Mixer	15	Sewing Machine	10
Toaster	40	Vacuum Cleaner	45

Continuous Small Loads

Door bell transformer exciting current and button light

Electric clocks

Phone light and night lights

Garage door opener detector circuit

Furnace transformer exciting current

Instant-on TV

TABLE 2.1.11

RESIDENTIAL ELECTRICAL LOAD DURING THE YEAR

<u>Time Period</u>		<u>CASE I</u>		<u>CASE II</u>	
<u>Month</u>	<u>Day</u>	<u>kWh/Day</u>	<u>kWh/Period</u>	<u>kWh/Day</u>	<u>kWh/Period</u>
January	31	16	496	22	682
February	28	16	448	22	616
March	31	15	465	21	651
April	30	14	420	20	600
May	31	13	403	19	589
June	30	12	360	18	540
July	15	12	180	18	270
July	16 (1)	6	96	12	192
August	31	12	372	18	558
September	30	13	390	19	570
October	31	14	434	20	620
November	30	15	450	21	630
December	14	16	224	22	308
December	17 (2)	17	289	23	391
Year Total	365		5027		7217

(1) Two-week vacation assumed at reduced consumption.

(2) Heavier consumption assumed near holiday season.

Heating and cooling loads for Cleveland (1962) and Phoenix (1962) were computed from U. S. Weather Bureau data and structure requirements supplied by Burt, Hill & Associates. The hourly loads were computed for a modern design heat pump system. Figures 2.1.14 and 2.1.15 show the daily heating and cooling load distribution for Cleveland and Phoenix.

Hourly heating and cooling loads for Atlanta (1960), Madison (1956), Mobile (1963), Santa Maria (1957) and Wilmington (1958) were supplied by the Westinghouse Electric Corporation. This data was computed from U. S. Weather Bureau data for Phase 0 of the NSF study of solar heating and cooling of buildings (see Report NSF-RA-N-74-03B, Vol. 2, Appendix D). For examples, See Tables 2.1.12-2.1.16.

2.1.2 Computer Simulations

Various simulation programs were written to evaluate the performance of different residential photovoltaic power systems. Two of these models are described in the following sections.

2.1.2.1 Electrical Energy Flow Model

The electrical energy flow model examines the basic concepts of a residential photovoltaic power system. It is simple, robust and adaptable enabling it to be used to analyze many systems beside the specific system it models.

The system modeled is specified by the collector array size and the electrical storage capacity. For a given set of insolation data, i.e., a specified city and year, the photovoltaic energy input is calculated over the time period selected. The input energy is directly stored. Any energy input received in excess of the available storage capacity is wasted.

2 FEB 76 - 10:34:30 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.

CLEVELAND, OHIO - 1962 - HEATING AND COOLING LOADS (CL2) - COMPUTED FROM A DATA

Figure 2.1.14

2 FEB 76 - 10:42:59 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.

PHOENIX, ARIZONA - 1962 - HEATING AND COOLING LOADS - COMPUTED FROM A DATA

Figure 2.1.15

Table 2.1.12(a)

AIR CONDITIONING DATA FOR ATLANTA, GEORGIA - 1960 - 21 MAR

HOUE	ZONE SENSIBLE LOAD		ZONE LATENT LOAD		VENTILATION LOAD		TEMPERATURE		HUMIDITY	TOTAL KW USED
	(BTU)	(KW-HR)	(BTU)	(KW-HR)	(BTU)	(KW-HR)	SPACE	OUTSIDE		
1	-15094.5	-4.421	720.0	.211	.0	.000	68.400	35.000	.002	8.007
2	-17584.8	-5.150	720.0	.211	.0	.000	68.400	34.000	.002	8.007
3	-18135.2	-5.311	720.0	.211	.0	.000	68.400	33.000	.002	8.007
4	-19494.5	-5.709	720.0	.211	.0	.000	68.400	32.000	.002	8.007
5	-21902.0	-6.415	720.0	.211	.0	.000	68.400	34.000	.002	8.007
6	-20115.0	-5.891	720.0	.211	.0	.000	68.400	34.000	.003	11.870
7	-14551.9	-4.262	720.0	.211	.0	.000	70.200	32.000	.003	25.389
8	-13587.5	-3.979	480.0	.141	.0	.000	72.000	31.000	.003	28.700
9	-22097.3	-6.472	240.0	.070	.0	.000	72.000	32.000	.003	18.491
10	-23333.9	-6.834	240.0	.070	.0	.000	72.000	33.000	.003	13.249
11	-23161.5	-6.783	240.0	.070	.0	.000	72.000	36.000	.003	13.249
12	-18726.9	-5.485	240.0	.070	.0	.000	72.000	39.000	.003	16.284
13	-16343.9	-4.787	480.0	.141	.0	.000	72.000	40.000	.002	13.249
14	-13739.3	-4.024	240.0	.070	.0	.000	72.000	42.000	.002	11.870
15	-11457.2	-3.356	240.0	.070	.0	.000	72.000	44.000	.002	12.146
16	-11053.8	-3.237	480.0	.141	.0	.000	72.000	45.000	.002	14.629
17	-7782.9	-2.279	720.0	.211	.0	.000	72.000	46.000	.002	18.491
18	-10733.3	-3.144	720.0	.211	.0	.000	72.000	46.000	.002	20.699
19	-13552.6	-3.969	960.0	.281	.0	.000	72.000	44.000	.002	23.182
20	-10194.5	-2.986	1200.0	.351	.0	.000	72.000	43.000	.002	29.251
21	-11355.2	-3.326	1200.0	.351	.0	.000	72.000	41.000	.002	25.389
22	-12249.0	-3.587	1200.0	.351	.0	.000	72.000	39.000	.002	25.941
23	-13583.7	-3.978	720.0	.211	.0	.000	70.200	37.000	.002	24.561
24	-12490.2	-3.658	720.0	.211	.0	.000	68.400	36.000	.002	20.423

Table 2.1.12(b)

AIR CONDITIONING DATA FOR ATLANTA, GEORGIA - 1960 - 21 JUNE

HOUR	ZONE SENSIBLE LOAD		ZONE LATENT LOAD		VENTILATION LOAD		TEMPERATURE		HUMIDITY	TOTAL KW USED
	(BTU)	(KW-HR)	(BTU)	(KW-HR)	(BTU)	(KW-HR)	SPACE	OUTSIDE		
1	12632.4	3.700	5232.4	1.532	.0	.000	73.112	74.000	.016	8.007
2	.0	.000	.0	.000	.0	.000	72.265	72.000	.016	8.007
3	3403.8	.997	3127.8	.916	.0	.000	73.112	72.000	.016	8.007
4	1192.6	.349	3329.0	.975	.0	.000	73.112	73.000	.017	8.007
5	2712.7	.794	3874.5	1.135	.0	.000	73.112	72.000	.016	11.370
6	8801.4	2.578	3318.2	.972	.0	.000	74.480	72.000	.017	25.339
7	8439.2	2.472	2938.7	.861	.0	.000	76.000	71.000	.016	28.700
8	5033.3	1.474	2563.6	.780	.0	.000	76.000	73.000	.017	18.491
9	5247.9	1.537	2774.3	.813	.0	.000	76.000	73.000	.015	13.249
10	4792.6	1.404	2373.4	.695	.0	.000	76.000	75.000	.016	13.249
11	5769.6	1.690	807.8	.237	.0	.000	76.000	78.000	.016	16.284
12	6249.8	1.830	2056.0	.602	.0	.000	76.000	81.000	.016	13.249
13	6409.1	1.877	842.9	.247	.0	.000	76.000	84.000	.017	11.870
14	10748.4	3.148	4206.6	1.232	.0	.000	76.000	88.000	.016	12.146
15	14263.3	4.177	4250.9	1.245	.0	.000	76.000	87.000	.015	14.629
16	18333.7	5.369	5077.9	1.487	.0	.000	76.000	89.000	.015	18.491
17	19854.1	5.815	1366.0	.547	.0	.000	74.480	90.000	.011	20.699
18	24647.3	7.219	2957.0	.866	.0	.000	73.112	90.000	.012	23.182
19	22858.5	6.695	3512.5	1.029	.0	.000	73.112	89.000	.013	29.251
20	17834.3	5.223	3099.6	.908	.0	.000	73.112	87.000	.014	25.389
21	16297.9	4.773	2538.3	.743	.0	.000	73.112	86.000	.014	25.941
22	13164.8	3.856	6641.6	1.945	.0	.000	73.112	76.000	.014	24.561
23	8935.1	2.617	3963.0	1.161	.0	.000	73.112	72.000	.014	20.423
24	3910.8	1.145	3410.0	.999	.0	.000	73.112	70.000	.014	8.007

Table 2.1.2(c)

AIR CONDITIONING DATA FOR ATLANTA, GEORGIA - 1960 - 23 SEPT

HOOR	ZONE SENSIBLE LOAD (BTU) (KW-HR)		ZONE LATENT LOAD (BTU) (KW-HR)		VENTILATION LOAD (BTU) (KW-HR)		TEMPERATURE SPACE OUTSIDE		HUMIDITY	TOTAL KW USED
1	.0	.000	.0	.000	.0	.000	72.020	67.000	.013	2.607
2	.0	.000	.0	.000	.0	.000	70.057	66.000	.013	2.607
3	.0	.000	.0	.000	.0	.000	71.057	66.000	.013	2.607
4	.0	.000	.0	.000	.0	.000	70.301	66.000	.012	2.607
5	.0	.000	.0	.000	.0	.000	70.881	65.000	.012	6.470
6	.0	.000	.0	.000	.0	.000	72.066	65.000	.012	19.989
7	.0	.000	.0	.000	.0	.000	74.503	64.000	.011	23.300
8	.0	.000	.0	.000	.0	.000	74.445	63.000	.011	13.091
9	.0	.000	.0	.000	.0	.000	75.541	65.000	.011	7.849
10	1094.8	.321	2057.5	.603	.0	.000	76.000	63.000	.012	7.849
11	2954.5	.368	2122.5	.622	.0	.000	76.000	71.000	.012	10.834
12	3997.1	1.171	1494.4	.438	.0	.000	76.000	73.000	.010	7.849
13	4928.2	1.443	1613.8	.473	.0	.000	76.000	75.000	.011	6.470
14	7653.6	2.302	1275.4	.374	.0	.000	76.000	73.000	.011	6.746
15	11234.2	3.290	811.7	.238	.0	.000	76.000	78.000	.010	9.229
16	14397.2	4.217	2001.4	.536	.0	.000	76.000	80.000	.011	13.091
17	13503.6	3.955	1658.9	.486	.0	.000	74.480	79.000	.011	15.299
18	13016.0	3.812	1804.8	.529	.0	.000	73.112	78.000	.011	17.782
19	14472.3	4.239	2095.0	.614	.0	.000	73.112	77.000	.011	23.351
20	10259.8	3.005	2087.4	.611	.0	.000	73.112	74.000	.011	19.989
21	8762.4	2.566	2286.9	.670	.0	.000	73.112	71.000	.011	20.541
22	6515.0	1.908	1840.8	.539	.0	.000	73.112	69.000	.011	19.161
23	4521.7	1.324	1796.3	.526	.0	.000	73.112	68.000	.011	15.023
24	243.0	.071	1838.0	.538	.0	.000	73.112	67.000	.011	2.607

Table 2.1.12(d)

AIR CONDITIONING DATA FOR ATLANTA, GEORGIA - 1960 - 21 DEC

HOUR	ZONE SENSIBLE LOAD (BTU) (KW-HR)	ZONE LATENT LOAD (BTU) (KW-HR)	VENTILATION LOAD (BTU) (KW-HR)	TEMPERATURE SPACE OUTSIDE	HUMIDITY	TOTAL KW USED
1	-10815.0	-3.167	720.0 .211	.0 .000	68.400 50.000	.007 8.007
2	-12151.1	-3.568	720.0 .211	.0 .000	68.400 50.000	.007 8.007
3	-10176.7	-2.930	720.0 .211	.0 .000	68.400 51.000	.007 8.007
4	-14953.3	-4.330	720.0 .211	.0 .000	68.400 45.000	.005 8.007
5	-19443.8	-5.695	720.0 .211	.0 .000	68.400 41.000	.005 8.007
6	-21763.2	-6.374	720.0 .211	.0 .000	68.400 36.000	.004 11.370
7	-19543.2	-5.724	720.0 .211	.0 .000	70.200 33.000	.003 25.389
8	-24773.3	-7.255	480.0 .141	.0 .000	72.000 31.000	.003 28.700
9	-26054.4	-7.631	240.0 .070	.0 .000	72.000 29.000	.002 18.491
10	-26594.4	-7.739	240.0 .070	.0 .000	72.000 28.000	.002 13.249
11	-26550.1	-7.776	240.0 .070	.0 .000	72.000 28.000	.002 13.249
12	-27522.5	-8.061	240.0 .070	.0 .000	72.000 28.000	.002 16.234
13	-25133.8	-7.361	480.0 .141	.0 .000	72.000 30.000	.002 13.249
14	-25125.2	-7.359	240.0 .070	.0 .000	72.000 32.000	.002 11.870
15	-24424.2	-7.153	240.0 .070	.0 .000	72.000 33.000	.002 12.146
16	-21206.0	-6.211	480.0 .141	.0 .000	72.000 33.000	.002 14.629
17	-24319.0	-7.269	720.0 .211	.0 .000	72.000 32.000	.002 18.491
18	-23423.3	-6.324	720.0 .211	.0 .000	72.000 30.000	.001 20.699
19	-25064.8	-7.575	960.0 .281	.0 .000	72.000 28.000	.001 23.132
20	-20579.0	-5.370	1200.0 .351	.0 .000	72.000 25.000	.001 29.251
21	-27345.7	-8.009	1200.0 .351	.0 .000	72.000 23.000	.001 25.389
22	-20800.6	-7.051	1200.0 .351	.0 .000	72.000 22.000	.001 25.941
23	-31766.2	-9.304	720.0 .211	.0 .000	70.200 21.000	.001 24.561
24	-31187.0	-9.134	720.0 .211	.0 .000	68.400 19.000	.001 20.423

Table 2.1.13(a)

AIR CONDITIONING DATA FOR MADISON, WISCONSIN - 1960 - 21 MAR

HOOR	ZONE SENSIBLE LOAD		ZONE LATENT LOAD		VENTILATION LOAD		TEMPERATURE		HUMIDITY	TOTAL
	(BTU)	(KW-HR)	(BTU)	(KW-HR)	(BTU)	(KW-HR)	SPACE	OUTSIDE		KW USED
1	-7437.2	-2.178	720.0	.211	.0	.000	68.400	29.000	.003	8.607
2	-9301.5	-2.724	720.0	.211	.0	.000	68.400	29.000	.002	8.607
3	-10706.5	-3.136	720.0	.211	.0	.000	68.400	28.000	.002	8.607
4	-10776.0	-3.156	720.0	.211	.0	.000	68.400	29.000	.003	8.607
5	-10896.0	-3.192	720.0	.211	.0	.000	68.400	29.000	.002	8.607
6	-10843.3	-3.176	720.0	.211	.0	.000	68.400	30.000	.002	12.470
7	-4441.3	-1.301	720.0	.211	.0	.000	70.200	31.000	.002	25.989
8	-2776.4	-.813	480.0	.141	.0	.000	72.000	31.000	.003	29.300
9	-6785.2	-1.937	240.0	.070	.0	.000	72.000	34.000	.003	19.091
10	-6119.6	-1.792	240.0	.070	.0	.000	72.000	36.000	.003	13.649
11	-8436.1	-2.471	240.0	.070	.0	.000	72.000	37.000	.003	13.649
12	-7687.2	-2.251	240.0	.070	.0	.000	72.000	38.000	.003	16.884
13	-8393.6	-2.458	480.0	.141	.0	.000	72.000	40.000	.003	13.849
14	-8443.5	-2.473	240.0	.070	.0	.000	72.000	40.000	.003	12.470
15	-7564.6	-2.215	240.0	.070	.0	.000	72.000	36.000	.004	12.746
16	-5732.4	-1.679	480.0	.141	.0	.000	72.000	34.000	.004	15.229
17	-5175.6	-1.516	720.0	.211	.0	.000	72.000	34.000	.004	19.091
18	-5123.1	-1.500	720.0	.211	.0	.000	72.000	34.000	.004	21.299
19	-5466.1	-1.601	360.0	.101	.0	.000	72.000	34.000	.004	23.782
20	-3659.0	-1.072	1200.0	.351	.0	.000	72.000	34.000	.004	29.651
21	-4149.7	-1.215	1200.0	.351	.0	.000	72.000	34.000	.004	25.989
22	-3304.0	-1.553	1200.0	.351	.0	.000	72.000	35.000	.004	26.541
23	-5783.5	-1.694	720.0	.211	.0	.000	70.200	35.000	.004	25.161
24	-3534.2	-1.035	720.0	.211	.0	.000	68.400	35.000	.004	21.023

Table 2.1.13(b)

AIR CONDITIONING DATA FOR MADISON, WISCONSIN - 1960 - 21 JUNE

HOUR	ZONE SENSIBLE LOAD (BTU) (KW-HR)		ZONE LATENT LOAD (BTU) (KW-HR)		VENTILATION LOAD (BTU) (KW-HR)		TEMPERATURE SPACE OUTSIDE		HUMIDITY	TOTAL KW USED
1	3927.3	2.615	2233.5	.569	.0	.000	73.112	70.000	.015	8.607
2	.0	.000	.0	.000	.0	.000	70.596	70.000	.015	8.607
3	4520.9	1.324	2021.8	.556	.0	.000	73.112	70.000	.015	8.607
4	.0	.000	.0	.000	.0	.000	72.114	69.000	.015	8.607
5	3100.4	.908	1476.3	.433	.0	.000	73.112	67.000	.014	12.470
6	7392.0	2.312	1360.5	.545	.0	.000	74.430	67.000	.014	25.939
7	11131.5	3.260	2038.8	.597	.0	.000	75.000	72.000	.015	29.300
8	9017.2	2.641	1616.9	.474	.0	.000	76.000	76.000	.014	19.091
9	9530.9	2.794	1939.1	.568	.0	.000	76.000	80.000	.015	13.349
10	8520.0	2.495	2261.7	.662	.0	.000	76.000	84.000	.016	13.349
11	7799.9	2.284	1615.5	.473	.0	.000	76.000	86.000	.014	16.884
12	8120.8	2.378	2821.2	.826	.0	.000	76.000	90.000	.014	13.349
13	6674.4	1.955	1809.8	.530	.0	.000	76.000	90.000	.015	12.470
14	7355.8	2.301	1804.5	.529	.0	.000	76.000	92.000	.015	12.746
15	10817.8	3.168	3334.5	.977	.0	.000	76.000	92.000	.016	15.229
16	12888.6	3.775	4561.6	1.336	.0	.000	76.000	90.000	.018	19.091
17	12684.8	3.715	4238.1	1.241	.0	.000	74.480	83.000	.018	21.299
18	14773.5	4.327	4320.0	1.265	.0	.000	73.112	76.000	.015	23.782
19	15683.8	4.593	3988.6	1.163	.0	.000	73.112	78.000	.015	29.851
20	10581.8	3.099	3156.8	.925	.0	.000	73.112	74.000	.014	25.939
21	9625.2	2.819	4562.8	1.336	.0	.000	73.112	73.000	.015	26.541
22	6025.9	2.351	2386.6	.699	.0	.000	73.112	72.000	.015	25.161
23	6346.7	1.859	2359.3	.691	.0	.000	73.112	70.000	.014	21.023
24	2714.0	.795	2412.1	.706	.0	.000	73.112	71.000	.014	8.607

Table 2.1.13(c)

AIR CONDITIONING DATA FOR MADISON, WISCONSIN - 1960 - 23 SEPT

HOUR	ZONE SENSIBLE LOAD (BTU)	(KW-HR)	ZONE LATENT LOAD (BTU)	(KW-HR)	VENTILATION LOAD (BTU)	(KW-HR)	TEMPERATURE SPACE	OUTSIDE	HUMIDITY	TOTAL KW USED
1	5599.3	1.640	1013.8	.297	.0	.000	73.112	60.000	.010	3.207
2	-6059.7	-1.775	1013.8	.297	.0	.000	68.400	60.000	.010	3.207
3	.0	.000	.0	.000	.0	.000	72.454	59.000	.010	3.207
4	-5520.0	-1.617	949.1	.278	.0	.000	68.400	59.000	.010	3.207
5	.0	.000	.0	.000	.0	.000	72.156	59.000	.010	7.070
6	.0	.000	.0	.000	.0	.000	71.358	59.000	.010	20.589
7	5419.5	1.587	587.3	.172	.0	.000	76.000	59.000	.010	23.900
8	.0	.000	.0	.000	.0	.000	74.562	60.000	.010	13.691
9	5096.4	1.493	530.6	.155	.0	.000	76.000	61.000	.011	8.449
10	2525.6	.740	746.6	.219	.0	.000	76.000	68.000	.011	8.449
11	3456.9	1.012	652.9	.191	.0	.000	76.000	59.000	.010	11.484
12	2745.5	.804	1203.1	.352	.0	.000	76.000	71.000	.011	8.449
13	1250.6	.366	810.8	.237	.0	.000	76.000	68.000	.010	7.070
14	2000.1	.586	1087.7	.319	.0	.000	76.000	70.000	.010	7.346
15	2831.3	.829	1686.8	.494	.0	.000	76.000	66.000	.011	9.829
16	4433.1	1.298	923.8	.271	.0	.000	76.000	65.000	.010	13.691
17	5023.9	1.471	720.0	.211	.0	.000	74.480	65.000	.009	15.899
18	6909.5	2.024	960.0	.281	.0	.000	73.112	65.000	.008	18.382
19	7793.8	2.283	1200.0	.351	.0	.000	73.112	61.000	.008	24.451
20	4050.9	1.186	1200.0	.351	.0	.000	73.112	58.000	.008	20.589
21	3158.4	.925	1200.0	.351	.0	.000	73.112	57.000	.007	21.141
22	1889.6	.553	720.0	.211	.0	.000	73.112	53.000	.007	19.761
23	.0	.000	.0	.000	.0	.000	73.075	54.000	.006	15.623
24	.0	.000	.0	.000	.0	.000	69.801	52.000	.006	3.207

Table 2.1.13(d)

AIR CONDITIONING DATA FOR MADISON, WISCONSIN - 1960 - 21 DEC

HOOR	ZONE SENSIBLE LOAD		ZONE LATENT LOAD		VENTILATION LOAD		TEMPERATURE		HUMIDITY	TOTAL KW USED
	(BTU)	(KW-HR)	(BTU)	(KW-HR)	(BTU)	(KW-HR)	SPACE	OUTSIDE		
1	-13119.2	-3.842	720.0	.211	.0	.000	68.400	10.000	.001	8.607
2	-14080.0	-4.124	720.0	.211	.0	.000	68.400	10.000	.001	8.607
3	-15409.2	-4.513	720.0	.211	.0	.000	68.400	11.000	.001	8.607
4	-13722.3	-4.019	720.0	.211	.0	.000	68.400	11.000	.001	8.607
5	-14357.7	-4.205	720.0	.211	.0	.000	68.400	11.000	.001	8.607
6	-12772.5	-3.741	720.0	.211	.0	.000	68.400	11.000	.001	12.470
7	-8545.4	-2.503	720.0	.211	.0	.000	70.200	12.000	.001	25.989
8	-11988.6	-3.482	480.0	.141	.0	.000	72.000	12.000	.001	29.300
9	-11539.3	-3.380	240.0	.070	.0	.000	72.000	14.000	.001	19.091
10	-10974.7	-3.214	240.0	.070	.0	.000	72.000	15.000	.001	13.349
11	-9182.3	-2.689	240.0	.070	.0	.000	72.000	17.000	.002	13.849
12	-7546.8	-2.240	240.0	.070	.0	.000	72.000	19.000	.002	16.884
13	-3340.7	-2.443	480.0	.141	.0	.000	72.000	21.000	.002	13.849
14	-9918.1	-2.905	240.0	.070	.0	.000	72.000	23.000	.002	12.470
15	-3784.2	-2.573	240.0	.070	.0	.000	72.000	22.000	.002	12.746
16	-7950.5	-2.329	480.0	.141	.0	.000	72.000	22.000	.002	15.229
17	-7959.8	-2.331	720.0	.211	.0	.000	72.000	19.000	.002	19.091
18	-9223.0	-2.701	720.0	.211	.0	.000	72.000	16.000	.001	21.299
19	-9351.8	-2.739	960.0	.281	.0	.000	72.000	16.000	.002	23.782
20	-9411.9	-2.757	1200.0	.351	.0	.000	72.000	18.000	.002	29.851
21	-11215.9	-3.285	1200.0	.351	.0	.000	72.000	17.000	.002	25.989
22	-10999.1	-3.221	1200.0	.351	.0	.000	72.000	18.000	.002	26.541
23	-12553.4	-3.677	720.0	.211	.0	.000	70.200	19.000	.002	25.161
24	-12177.7	-3.567	720.0	.211	.0	.000	68.400	19.000	.002	21.023

Table 2.1.14(a)

AIR CONDITIONING DATA FOR MOBILE, ALABAMA - 1963 - 21 MAR

HOOR	ZONE SENSIBLE LOAD (BTU) (KW-HR)		ZONE LATENT LOAD (BTU) (KW-HR)		VENTILATION LOAD (BTU) (KW-HR)		TEMPERATURE SPACE OUTSIDE		HUMIDITY	TOTAL KW USED
1	.0	.000	.0	.000	.0	.000	70.614	53.000	.004	8.007
2	-5394.1	-1.580	720.0	.211	.0	.000	68.400	53.000	.004	8.007
3	-1251.4	-.366	720.0	.211	.0	.000	68.400	50.000	.006	8.007
4	-4251.0	-1.245	720.0	.211	.0	.000	68.400	47.000	.005	8.007
5	-5387.5	-1.578	720.0	.211	.0	.000	68.400	48.000	.004	8.007
6	-4448.4	-1.303	720.0	.211	.0	.000	68.400	46.000	.004	11.870
7	.0	.000	.0	.000	.0	.000	70.210	46.000	.005	25.389
8	.0	.000	.0	.000	.0	.000	75.966	49.000	.005	28.700
9	.0	.000	.0	.000	.0	.000	72.851	53.000	.005	18.491
10	.0	.000	.0	.000	.0	.000	75.180	55.000	.004	13.249
11	-4988.0	-1.461	240.0	.079	.0	.000	72.000	59.000	.002	13.249
12	.0	.000	.0	.000	.0	.000	72.616	61.000	.002	16.284
13	-2274.9	-.666	480.0	.141	.0	.000	72.000	62.000	.002	13.249
14	.0	.000	.0	.000	.0	.000	73.751	69.000	.002	11.870
15	.0	.000	.0	.000	.0	.000	74.471	69.000	.001	12.146
16	2608.9	.764	480.0	.141	.0	.000	76.000	66.000	.002	14.629
17	2587.0	.758	720.0	.211	.0	.000	76.000	65.000	.002	18.491
18	2064.0	.605	720.0	.211	.0	.000	74.480	64.000	.002	20.699
19	2799.3	.820	960.0	.281	.0	.000	73.112	60.000	.002	23.182
20	5001.1	1.465	1200.0	.351	.0	.000	73.112	56.000	.002	29.251
21	1243.0	.364	1200.0	.351	.0	.000	73.112	53.000	.002	25.389
22	146.9	.043	1200.0	.351	.0	.000	73.112	51.000	.002	25.941
23	.0	.000	.0	.000	.0	.000	71.352	48.000	.002	24.561
24	.0	.000	.0	.000	.0	.000	70.069	47.000	.002	20.423

Table 2.1.14(b)

AIR CONDITIONING DATA FOR MOBILE, ALABAMA - 1963 - 21 JUNE

HOUR	ZONE SENSIBLE LOAD (BTU)	ZONE SENSIBLE LOAD (KW-HR)	ZONE LATENT LOAD (BTU)	ZONE LATENT LOAD (KW-HR)	VENTILATION LOAD (BTU)	VENTILATION LOAD (KW-HR)	TEMPERATURE SPACE	TEMPERATURE OUTSIDE	HUMIDITY	TOTAL KW USED
1	8944.9	2.620	1252.5	.367	.0	.000	73.112	70.000	.016	8.007
2	.0	.000	.0	.000	.0	.000	70.758	70.000	.015	8.007
3	4414.9	1.293	2302.2	.674	.0	.000	73.112	70.000	.015	8.007
4	.0	.000	.0	.000	.0	.000	72.125	70.000	.015	8.007
5	3154.9	.924	2303.6	.675	.0	.000	73.112	70.000	.015	11.870
6	8142.4	2.385	2332.7	.683	.0	.000	74.480	69.000	.015	25.389
7	11591.0	3.395	2789.6	.817	.0	.000	76.000	72.000	.016	28.700
8	8997.0	2.635	2745.6	.804	.0	.000	76.000	75.000	.017	18.491
9	8714.6	2.552	6662.5	1.951	.0	.000	76.000	80.000	.019	13.249
10	8615.5	2.523	11022.0	3.228	.0	.000	76.000	82.000	.020	13.249
11	4414.1	1.293	3581.1	1.049	.0	.000	76.000	72.000	.015	16.284
12	3326.2	.974	3229.7	.946	.0	.000	76.000	75.000	.016	13.249
13	3444.0	1.009	666.6	.195	.0	.000	76.000	80.000	.015	11.870
14	6406.4	1.876	4420.9	1.295	.0	.000	76.000	84.000	.017	12.146
15	9061.6	2.654	8865.8	2.597	.0	.000	76.000	82.000	.019	14.629
16	13062.1	3.826	8467.4	2.480	.0	.000	76.000	85.000	.018	18.491
17	15145.5	4.436	8453.7	2.476	.0	.000	74.480	84.000	.017	20.699
18	17292.2	5.064	7596.3	2.225	.0	.000	73.112	82.000	.019	23.182
19	17618.0	5.160	5705.0	1.671	.0	.000	73.112	80.000	.016	29.251
20	11285.0	3.305	5134.8	1.504	.0	.000	73.112	75.000	.017	25.389
21	10337.9	3.028	3956.5	1.159	.0	.000	73.112	73.000	.016	25.941
22	6812.0	2.581	3669.0	1.075	.0	.000	73.112	73.000	.016	24.561
23	7050.0	2.065	3661.2	1.072	.0	.000	73.112	72.000	.016	20.423
24	3313.1	.970	1245.3	.365	.0	.000	73.112	72.000	.016	8.007

Table 2.1.14(c)

AIR CONDITIONING DATA FOR MOBILE, ALABAMA - 1963 - 23 SEPT

HOUR	ZONE SENSIBLE LOAD (BTU)	(KW-HR)	ZONE LATENT LOAD (BTU)	(KW-HR)	VENTILATION LOAD (BTU)	(KW-HR)	TEMPERATURE SPACE OUTSIDE	HUMIDITY	TOTAL KW USED
1	9010.6	2.639	2447.1	.717	.0	.000	73.112 70.000	.014	8.007
2	.0	.000	.0	.000	.0	.000	70.702 70.000	.012	8.007
3	4122.0	1.207	1724.9	.505	.0	.000	73.112 68.000	.012	8.007
4	.0	.000	.0	.000	.0	.000	71.480 67.000	.012	8.007
5	3392.0	.993	1917.5	.562	.0	.000	73.112 67.000	.012	11.870
6	2245.3	.658	1911.2	.560	.0	.000	74.480 65.000	.012	25.389
7	5356.4	1.569	1345.7	.394	.0	.000	76.000 64.000	.012	28.700
8	6102.9	1.737	1430.0	.419	.0	.000	76.000 66.000	.012	18.491
9	7512.0	2.200	1786.9	.523	.0	.000	76.000 69.000	.012	13.249
10	3830.9	1.122	2673.5	.783	.0	.000	76.000 67.000	.013	13.249
11	2990.8	.876	2336.9	.684	.0	.000	76.000 69.000	.012	16.284
12	2691.2	.788	3131.3	.917	.0	.000	76.000 72.000	.013	13.249
13	2456.7	.720	1462.3	.434	.0	.000	76.000 73.000	.011	11.870
14	4682.3	1.371	1632.4	.478	.0	.000	76.000 77.000	.012	12.146
15	8224.7	2.409	2886.8	.845	.0	.000	76.000 80.000	.013	14.629
16	10771.3	3.155	2411.5	.706	.0	.000	76.000 83.000	.013	18.491
17	11476.0	3.361	2785.8	.816	.0	.000	74.480 81.000	.012	20.699
18	12468.2	3.652	2479.4	.726	.0	.000	73.112 82.000	.013	23.182
19	13402.0	3.925	2336.0	.684	.0	.000	73.112 79.000	.013	29.251
20	10328.4	3.025	2464.5	.722	.0	.000	73.112 77.000	.013	25.389
21	9678.1	2.834	3155.3	.924	.0	.000	73.112 75.000	.014	25.941
22	7865.9	2.304	2019.5	.591	.0	.000	73.112 73.000	.013	24.561
23	6248.0	1.830	2221.3	.651	.0	.000	73.112 72.000	.013	20.423
24	2441.1	.715	2051.5	.601	.0	.000	73.112 71.000	.013	8.007

Table 2.1.14(d)

AIR CONDITIONING DATA FOR MOBILE, ALABAMA - 1963 - 21 DEC

HOUR	ZONE SENSIBLE LOAD		ZONE LATENT LOAD		VENTILATION LOAD		TEMPERATURE		HUMIDITY	TOTAL
	(BTU)	(KW-HR)	(BTU)	(KW-HR)	(BTU)	(KW-HR)	SPACE	OUTSIDE		KW USED
1	.0	.000	.0	.000	.0	.000	71.972	58.000	.009	8.007
2	-4956.7	-1.452	720.0	.211	.0	.000	68.400	58.000	.009	8.007
3	.0	.000	.0	.000	.0	.000	70.904	58.000	.009	8.007
4	-5011.9	-1.468	720.0	.211	.0	.000	68.400	58.000	.009	8.007
5	.0	.000	.0	.000	.0	.000	68.883	58.000	.009	8.007
6	-1685.5	-.494	720.0	.211	.0	.000	68.400	58.000	.009	11.370
7	.0	.000	.0	.000	.0	.000	70.794	58.000	.009	25.389
8	.0	.000	.0	.000	.0	.000	73.560	58.000	.009	26.700
9	.0	.000	.0	.000	.0	.000	74.492	59.000	.009	13.491
10	1753.3	.514	499.8	.145	.0	.000	76.000	62.000	.010	13.249
11	.0	.000	.0	.000	.0	.000	75.791	65.000	.011	13.249
12	2497.4	.731	1215.3	.356	.0	.000	76.000	63.000	.011	16.284
13	2545.1	.745	2560.6	.750	.0	.000	76.000	70.000	.012	13.249
14	3724.4	1.091	2710.6	.794	.0	.000	76.000	72.000	.012	11.370
15	4819.1	1.411	2022.5	.592	.0	.000	76.000	73.000	.012	12.146
16	5051.5	1.479	2530.3	.741	.0	.000	76.000	71.000	.012	14.629
17	2746.5	.804	2873.3	.842	.0	.000	76.000	68.000	.012	18.491
18	3465.3	1.015	1590.1	.466	.0	.000	74.480	67.000	.012	20.699
19	6009.8	1.760	2353.2	.689	.0	.000	73.112	66.000	.012	23.132
20	8267.0	2.421	2403.0	.704	.0	.000	73.112	66.000	.012	29.251
21	4298.8	1.259	3711.3	1.087	.0	.000	73.112	65.000	.012	25.389
22	5675.0	1.662	1380.7	.404	.0	.000	73.112	64.000	.012	25.941
23	3838.2	1.124	1282.2	.376	.0	.000	73.112	64.000	.011	24.561
24	2644.2	.774	1284.7	.376	.0	.000	73.112	64.000	.011	20.423

Table 2.1.15(a)

AIR CONDITIONING DATA FOR SANTA MARIA, CALIF. - 1957 - 21 MAR

HOOR	ZONE SENSIBLE LOAD		ZONE LATENT LOAD		VENTILATION LOAD		TEMPERATURE		HUMIDITY	TOTAL
	(BTU)	(KW-HR)	(BTU)	(KW-HR)	(BTU)	(KW-HR)	SPACE	OUTSIDE		KW USED
1	-4573.7	-1.341	720.0	.211	.0	.000	68.400	49.000	.007	7.607
2	-6778.6	-1.985	720.0	.211	.0	.000	68.400	48.000	.007	7.607
3	-10536.2	-3.056	720.0	.211	.0	.000	68.400	47.000	.007	7.607
4	-9286.6	-2.720	720.0	.211	.0	.000	68.400	48.000	.007	7.607
5	-10803.9	-3.164	720.0	.211	.0	.000	68.400	48.000	.006	7.607
6	-8228.6	-2.410	720.0	.211	.0	.000	68.400	48.000	.006	11.470
7	-6000.3	-1.757	720.0	.211	.0	.000	70.200	49.000	.005	24.989
8	-2978.4	-.872	480.0	.141	.0	.000	72.000	49.000	.004	28.300
9	-7577.8	-2.219	240.0	.070	.0	.000	72.000	49.000	.004	18.091
10	-5697.1	-1.669	240.0	.070	.0	.000	72.000	52.000	.004	12.849
11	-5945.3	-1.741	240.0	.070	.0	.000	72.000	55.000	.004	12.849
12	-3407.0	-.998	240.0	.070	.0	.000	72.000	53.000	.005	15.884
13	-4991.0	-1.462	480.0	.141	.0	.000	72.000	57.000	.004	12.849
14	-5351.0	-1.567	240.0	.070	.0	.000	72.000	57.000	.004	11.470
15	-3590.3	-1.052	240.0	.070	.0	.000	72.000	57.000	.004	11.746
16	-1828.4	-.535	480.0	.141	.0	.000	72.000	55.000	.005	14.229
17	-978.6	-.287	720.0	.211	.0	.000	72.000	54.000	.005	18.091
18	-1743.4	-.512	720.0	.211	.0	.000	72.000	53.000	.005	20.299
19	-4557.2	-1.335	960.0	.281	.0	.000	72.000	50.000	.005	22.782
20	-3323.6	-.973	1200.0	.351	.0	.000	72.000	48.000	.005	28.851
21	-5144.9	-1.507	1200.0	.351	.0	.000	72.000	47.000	.005	24.989
22	-6059.7	-1.775	1200.0	.351	.0	.000	72.000	46.000	.005	25.541
23	-4539.0	-1.329	720.0	.211	.0	.000	70.200	44.000	.005	24.161
24	-3199.9	-.937	720.0	.211	.0	.000	68.400	46.000	.004	20.023

Table 2.1.15(b)

AIR CONDITIONING DATA FOR SANTA MARIA, CALIF. - 1957 - 21 JUNE

HOOR	ZONE SENSIBLE LOAD		ZONE LATENT LOAD		VENTILATION LOAD		TEMPERATURE		HUMIDITY	TOTAL
	(BTU)	(KW-HR)	(BTU)	(KW-HR)	(BTU)	(KW-HR)	SPACE	OUTSIDE		KJ USED
1	-1422.4	-.417	720.0	.211	.0	.000	68.400	54.000	.008	7.607
2	-5404.3	-1.533	720.0	.211	.0	.000	68.400	53.000	.008	7.607
3	-6534.7	-1.943	720.0	.211	.0	.000	68.400	52.000	.007	7.607
4	-7009.9	-2.053	720.0	.211	.0	.000	68.400	52.000	.008	7.607
5	-6855.4	-2.008	720.0	.211	.0	.000	68.400	52.000	.008	11.470
6	-2066.1	-.605	720.0	.211	.0	.000	70.200	52.000	.008	24.989
7	-1488.2	-.436	480.0	.141	.0	.000	72.000	51.000	.008	23.300
8	-5005.6	-1.466	240.0	.070	.0	.000	72.000	52.000	.008	18.091
9	-2511.7	-.736	240.0	.070	.0	.000	72.000	55.000	.008	12.849
10	-1217.2	-.356	240.0	.070	.0	.000	72.000	52.000	.009	12.849
11	-657.0	-.192	240.0	.070	.0	.000	72.000	53.000	.008	15.884
12	.0	.000	.0	.000	.0	.000	74.083	70.000	.009	12.849
13	.0	.000	.0	.000	.0	.000	75.100	74.000	.009	11.470
14	3556.9	1.042	240.0	.070	.0	.000	76.000	74.000	.008	11.746
15	7156.0	2.096	480.0	.141	.0	.000	76.000	75.000	.007	14.229
16	12142.7	3.556	720.0	.211	.0	.000	76.000	77.000	.007	18.091
17	13232.5	3.875	720.0	.211	.0	.000	74.480	74.000	.007	20.299
18	15164.4	4.441	960.0	.281	.0	.000	73.112	71.000	.008	22.732
19	12250.6	3.533	1200.0	.351	.0	.000	73.112	66.000	.008	23.351
20	5672.4	1.661	1200.0	.351	.0	.000	73.112	63.000	.008	24.989
21	4096.3	1.200	1200.0	.351	.0	.000	73.112	60.000	.008	25.541
22	2950.1	.864	720.0	.211	.0	.000	73.112	59.000	.008	24.161
23	414.9	.122	720.0	.211	.0	.000	73.112	56.000	.008	20.023
24	.0	.000	.0	.000	.0	.000	70.250	58.000	.008	7.607

Table 2.1.15(c)

AIR CONDITIONING DATA FOR SANTA MARIA, CALIF. - 1957 - 23 SEPT

HOUR	ZONE SENSIBLE LOAD		ZONE LATENT LOAD		VENTILATION LOAD		TEMPERATURE		HUMIDITY	TOTAL
	(BTU)	(KW-HR)	(BTU)	(KW-HR)	(BTU)	(KW-HR)	SPACE	OUTSIDE		KW USED
1	-447.6	-.131	720.0	.211	.0	.000	68.400	52.000	.008	7.607
2	-5665.9	-1.659	720.0	.211	.0	.000	68.400	54.000	.008	7.607
3	-5981.2	-1.752	720.0	.211	.0	.000	68.400	54.000	.009	7.607
4	-4924.1	-1.442	720.0	.211	.0	.000	68.400	54.000	.008	7.607
5	-4242.6	-1.243	720.0	.211	.0	.000	68.400	53.000	.009	11.470
6	-764.4	-.224	720.0	.211	.0	.000	70.200	54.000	.008	24.939
7	-3714.4	-1.088	480.0	.141	.0	.000	72.000	54.000	.008	28.300
8	-2689.9	-.788	240.0	.070	.0	.000	72.000	54.000	.008	18.091
9	-2327.7	-.682	240.0	.070	.0	.000	72.000	55.000	.009	12.849
10	.0	.000	.0	.000	.0	.000	72.241	60.000	.009	12.849
11	.0	.000	.0	.000	.0	.000	73.621	64.000	.009	15.884
12	.0	.000	.0	.000	.0	.000	74.467	67.000	.009	12.849
13	.0	.000	.0	.000	.0	.000	75.635	67.000	.009	11.470
14	1581.0	.463	240.0	.070	.0	.000	76.000	66.000	.009	11.746
15	5278.9	1.546	480.0	.141	.0	.000	76.000	66.000	.009	14.229
16	6764.5	1.931	720.0	.211	.0	.000	76.000	62.000	.009	18.091
17	7123.1	2.086	720.0	.211	.0	.000	74.430	61.000	.009	20.299
18	5275.6	1.545	960.0	.281	.0	.000	73.112	58.000	.008	22.782
19	4741.1	1.389	1200.0	.351	.0	.000	73.112	56.000	.009	23.851
20	2923.5	.856	1200.0	.351	.0	.000	73.112	56.000	.009	24.989
21	182.4	.053	1200.0	.351	.0	.000	73.112	56.000	.009	25.541
22	270.2	.079	720.0	.211	.0	.000	73.112	56.000	.009	24.161
23	.0	.000	.0	.000	.0	.000	71.319	55.000	.009	20.023
24	.0	.000	.0	.000	.0	.000	68.924	56.000	.009	7.607

Table 2.1.15(d)

AIR CONDITIONING DATA FOR SANTA MARIA, CALIF. - 1957 - 21 DEC

HOUR	ZONE SENSIBLE LOAD		ZONE LATENT LOAD		VENTILATION LOAD		TEMPERATURE		HUMIDITY	TOTAL
	(BTU)	(KW-HR)	(BTU)	(KW-HR)	(BTU)	(KW-HR)	SPACE	OUTSIDE		KW USED
1	-8220.7	-2.408	720.0	.211	.0	.000	68.400	38.000	.005	7.607
2	-13487.5	-3.950	720.0	.211	.0	.000	68.400	37.000	.004	7.607
3	-13211.0	-3.859	720.0	.211	.0	.000	68.400	38.000	.004	7.607
4	-11401.0	-3.339	720.0	.211	.0	.000	68.400	33.000	.004	7.607
5	-12231.4	-3.532	720.0	.211	.0	.000	68.400	35.000	.004	7.607
6	-15608.4	-4.571	720.0	.211	.0	.000	68.400	34.000	.003	11.470
7	-11955.5	-3.501	720.0	.211	.0	.000	70.200	34.000	.003	24.989
8	-14340.0	-4.200	480.0	.141	.0	.000	72.000	34.000	.003	28.300
9	-14614.4	-4.280	240.0	.070	.0	.000	72.000	39.000	.004	18.091
10	-4632.1	-1.357	240.0	.070	.0	.000	72.000	51.000	.005	12.849
11	-2497.5	-.731	240.0	.070	.0	.000	72.000	56.000	.005	12.849
12	-1702.2	-.499	240.0	.070	.0	.000	72.000	57.000	.006	15.884
13	-743.3	-.218	480.0	.141	.0	.000	72.000	59.000	.004	12.849
14	.0	.000	.0	.000	.0	.000	72.385	61.000	.004	11.470
15	.0	.000	.0	.000	.0	.000	73.372	60.000	.004	11.746
16	-3134.9	-.918	480.0	.141	.0	.000	72.000	59.000	.004	14.229
17	-2326.9	-.681	720.0	.211	.0	.000	72.000	56.000	.003	18.091
18	-3469.0	-1.016	720.0	.211	.0	.000	72.000	52.000	.003	20.299
19	-7432.6	-2.177	960.0	.281	.0	.000	72.000	49.000	.003	22.782
20	-3376.6	-.939	1200.0	.351	.0	.000	72.000	47.000	.003	28.851
21	-6399.3	-1.874	1200.0	.351	.0	.000	72.000	46.000	.003	24.939
22	-7701.1	-2.255	1200.0	.351	.0	.000	72.000	45.000	.003	25.541
23	-9105.6	-2.667	720.0	.211	.0	.000	70.200	43.000	.003	24.161
24	-8244.4	-2.415	720.0	.211	.0	.000	68.400	42.000	.003	20.023

Table 2.1.16(a)

AIR CONDITIONING DATA FOR WILMINGTON, DELAWARE - 1958 - 21 MAR

HOOR	ZONE SENSIBLE LOAD (BTU) (KW-HR)		ZONE LATENT LOAD (BTU) (KW-HR)		VENTILATION LOAD (BTU) (KW-HR)		TEMPERATURE SPACE OUTSIDE		HUMIDITY	TOTAL KW USED
1	-5342.9	-1.565	720.0	.211	.0	.000	68.400	48.000	.006	8.707
2	-6470.7	-1.895	720.0	.211	.0	.000	68.400	47.000	.006	8.707
3	-7481.6	-2.191	720.0	.211	.0	.000	68.400	46.000	.006	8.707
4	-7977.3	-2.336	720.0	.211	.0	.000	68.400	47.000	.006	8.707
5	-9012.4	-2.639	720.0	.211	.0	.000	68.400	45.000	.006	8.707
6	-7556.7	-2.213	720.0	.211	.0	.000	68.400	45.000	.006	12.570
7	-3031.6	-.888	720.0	.211	.0	.000	70.200	44.000	.006	26.089
8	1136.9	.348	480.0	.141	.0	.000	72.000	44.000	.006	29.400
9	.0	.000	.0	.000	.0	.000	75.830	48.000	.007	19.191
10	2364.7	.693	240.0	.070	.0	.000	76.000	56.000	.007	13.949
11	5152.4	1.500	240.0	.070	.0	.000	76.000	63.000	.007	13.949
12	5345.2	1.565	240.0	.070	.0	.000	76.000	65.000	.007	16.984
13	5385.6	1.577	480.0	.141	.0	.000	76.000	68.000	.006	13.949
14	7216.3	2.113	240.0	.070	.0	.000	76.000	70.000	.006	12.570
15	9320.3	2.730	240.0	.070	.0	.000	76.000	68.000	.006	12.846
16	11370.9	3.330	480.0	.141	.0	.000	76.000	68.000	.006	15.329
17	11770.3	3.447	720.0	.211	.0	.000	76.000	66.000	.008	19.191
18	6930.4	2.030	720.0	.211	.0	.000	74.480	62.000	.007	21.399
19	3639.6	1.066	960.0	.281	.0	.000	73.112	57.000	.008	23.882
20	3228.7	.946	1200.0	.351	.0	.000	73.112	54.000	.008	29.951
21	-2013.2	-.590	1200.0	.351	.0	.000	72.000	53.000	.007	26.089
22	-2453.0	-.716	1200.0	.351	.0	.000	72.000	47.000	.005	26.641
23	-6698.2	-2.020	720.0	.211	.0	.000	70.200	43.000	.004	25.261
24	-6688.9	-1.959	720.0	.211	.0	.000	68.400	38.000	.003	21.123

Table 2.1.16(b)

AIR CONDITIONING DATA FOR WILMINGTON, DELAWARE - 1958 - 21 JUNE

HOUR	ZONE SENSIBLE LOAD		ZONE LATENT LOAD		VENTILATION LOAD		TEMPERATURE		HUMIDITY	TOTAL
	(BTU)	(KW-HR)	(BTU)	(KW-HR)	(BTU)	(KW-HR)	SPACE	OUTSIDE		KW USED
1	.0	.000	.0	.000	.0	.000	72.709	66.000	.011	8.707
2	-5360.1	-1.570	899.5	.263	.0	.000	68.400	63.000	.010	8.707
3	.0	.000	.0	.000	.0	.000	70.303	63.000	.010	8.707
4	-3590.0	-1.051	812.4	.238	.0	.000	68.400	62.000	.010	8.707
5	.0	.000	.0	.000	.0	.000	68.846	61.000	.010	12.570
6	.0	.000	.0	.000	.0	.000	74.381	62.000	.010	26.089
7	3015.7	.883	637.4	.187	.0	.000	76.000	63.000	.010	29.400
8	6190.7	1.813	458.5	.134	.0	.000	76.000	69.000	.010	19.191
9	8925.6	2.614	473.4	.139	.0	.000	76.000	71.000	.010	13.949
10	11183.0	3.275	380.3	.111	.0	.000	76.000	73.000	.010	13.949
11	12891.1	3.775	240.0	.070	.0	.000	76.000	75.000	.009	16.984
12	12517.9	3.666	480.0	.141	.0	.000	76.000	78.000	.008	13.949
13	12738.4	3.731	240.0	.070	.0	.000	76.000	80.000	.009	12.570
14	16069.8	4.706	240.0	.070	.0	.000	76.000	83.000	.008	12.846
15	20107.2	5.889	480.0	.141	.0	.000	76.000	84.000	.008	15.329
16	22543.9	6.604	720.0	.211	.0	.000	76.000	84.000	.008	19.191
17	22798.1	6.677	720.0	.211	.0	.000	74.480	82.000	.008	21.399
18	24258.1	7.105	1043.1	.305	.0	.000	73.112	83.000	.010	23.882
19	21005.5	6.152	1434.3	.420	.0	.000	73.112	82.000	.010	29.951
20	12090.3	3.541	1526.9	.447	.0	.000	73.112	79.000	.011	26.089
21	8497.9	2.489	1767.4	.518	.0	.000	73.112	72.000	.011	26.641
22	5366.7	1.572	1463.1	.429	.0	.000	73.112	70.000	.012	25.261
23	3241.9	.949	1715.5	.502	.0	.000	73.112	70.000	.013	21.123
24	.0	.000	.0	.000	.0	.000	72.411	69.000	.014	8.707

Table 2.1.16(c)

> AIR CONDITIONING DATA FOR WILMINGTON, DELAWARE - 1958 - 23 SEPT.

HOUR	ZONE SENSIBLE LOAD		ZONE LATENT LOAD		VENTILATION LOAD		TEMPERATURE		HUMIDITY	TOTAL
	(BTU)	(KW-HR)	(BTU)	(KW-HR)	(BTU)	(KW-HR)	SPACE	OUTSIDE		KW USED
1	-1708.3	-.500	720.0	.211	.0	.000	68.400	55.000	.007	8.707
2	-4356.0	-1.276	720.0	.211	.0	.000	68.400	55.000	.008	8.707
3	-4989.6	-1.461	720.0	.211	.0	.000	68.400	53.000	.008	8.707
4	-5547.9	-1.654	720.0	.211	.0	.000	68.400	52.000	.008	8.707
5	-4917.9	-1.440	720.0	.211	.0	.000	68.400	51.000	.007	12.570
6	-1607.5	-.529	720.0	.211	.0	.000	70.200	51.000	.007	26.089
7	-1298.3	-.380	480.0	.141	.0	.000	72.000	50.000	.007	29.400
8	.0	.000	.0	.000	.0	.000	72.329	53.000	.007	19.191
9	4447.5	1.303	240.0	.070	.0	.000	76.000	60.000	.008	13.949
10	4191.2	1.228	240.0	.070	.0	.000	76.000	65.000	.009	13.949
11	10186.6	2.963	240.0	.070	.0	.000	76.000	70.000	.007	16.934
12	11571.3	3.389	480.0	.141	.0	.000	76.000	73.000	.007	13.949
13	12934.5	3.768	240.0	.070	.0	.000	76.000	75.000	.007	12.570
14	16293.4	4.772	240.0	.070	.0	.000	76.000	74.000	.007	12.846
15	19862.5	5.817	480.0	.141	.0	.000	76.000	76.000	.007	15.329
16	22441.7	6.573	720.0	.211	.0	.000	76.000	75.000	.007	19.191
17	21919.9	6.420	720.0	.211	.0	.000	74.480	75.000	.008	21.399
18	15293.8	4.479	960.0	.281	.0	.000	73.112	74.000	.008	23.882
19	11076.2	3.244	1200.0	.351	.0	.000	73.112	72.000	.008	29.951
20	5581.6	1.635	1200.0	.351	.0	.000	73.112	67.000	.008	26.089
21	3137.9	.919	1200.0	.351	.0	.000	73.112	63.000	.009	26.641
22	915.1	.268	737.8	.216	.0	.000	73.112	61.000	.009	25.261
23	.0	.000	.0	.000	.0	.000	72.330	62.000	.010	21.123
24	-3513.0	-1.029	720.0	.211	.0	.000	68.400	59.000	.009	8.707

Table 2.1.16(d)

AIR CONDITIONING DATA FOR WILMINGTON, DELAWARE - 1953 - 21 DEC

HOOR	ZONE SENSIBLE LOAD		ZONE LATENT LOAD		VENTILATION LOAD		TEMPERATURE		HUMIDITY	TOTAL KW USED
	(BTU)	(KW-HR)	(BTU)	(KW-HR)	(BTU)	(KW-HR)	SPACE	OUTSIDE		
1	-17980.7	-5.266	720.0	.211	.0	.000	68.400	18.000	.001	8.707
2	-18582.0	-5.442	720.0	.211	.0	.000	68.400	19.000	.001	8.707
3	-18798.5	-5.506	720.0	.211	.0	.000	68.400	16.000	.001	8.707
4	-19127.5	-5.602	720.0	.211	.0	.000	68.400	14.000	.001	8.707
5	-19599.7	-5.740	720.0	.211	.0	.000	68.400	14.000	.001	8.707
6	-19325.9	-5.660	720.0	.211	.0	.000	68.400	13.000	.001	12.570
7	-16200.1	-4.745	720.0	.211	.0	.000	70.200	14.000	.001	26.089
8	-16938.4	-4.961	480.0	.141	.0	.000	72.000	16.000	.001	29.400
9	-15547.4	-4.553	240.0	.070	.0	.000	72.000	17.000	.001	19.191
10	-12625.7	-3.698	240.0	.070	.0	.000	72.000	23.000	.001	13.949
11	-11669.5	-3.418	240.0	.070	.0	.000	72.000	27.000	.002	13.949
12	-10927.5	-3.200	240.0	.070	.0	.000	72.000	28.000	.001	16.984
13	-9478.9	-2.776	480.0	.141	.0	.000	72.000	30.000	.002	13.949
14	-9147.5	-2.679	240.0	.070	.0	.000	72.000	29.000	.001	12.570
15	-7179.7	-2.103	240.0	.070	.0	.000	72.000	29.000	.002	12.846
16	-6675.1	-1.955	480.0	.141	.0	.000	72.000	29.000	.001	15.329
17	-12451.7	-3.647	720.0	.211	.0	.000	72.000	29.000	.001	19.191
18	-12535.8	-3.671	720.0	.211	.0	.000	72.000	23.000	.001	21.399
19	-12512.0	-3.664	960.0	.281	.0	.000	72.000	20.000	.001	23.882
20	-11723.6	-3.434	1200.0	.351	.0	.000	72.000	23.000	.001	29.951
21	-12704.6	-3.721	1200.0	.351	.0	.000	72.000	22.000	.001	26.089
22	-12901.0	-3.778	1200.0	.351	.0	.000	72.000	21.000	.001	26.641
23	-14817.7	-4.340	720.0	.211	.0	.000	70.200	18.000	.001	25.261
24	-14070.2	-4.121	720.0	.211	.0	.000	68.400	19.000	.001	21.123

As much as possible of the given load is satisfied from storage. If the load is less than the amount stored, the surplus storage is carried over to the next time period. All energy flows into and out of the system are computed with a time step of one day. This process is detailed in Figure 2.1.16.

The model was run for each city with Case I, II, and III loads for a variety of array sizes and storage capacities. The results are displayed as follows: Cleveland (1962), Tables 2.1.17-2.1.20, Figures 2.1.17-2.1.20; Phoenix (1962), Tables 2.1.21-2.1.24, Figures 2.1.21-2.1.24; Atlanta (1960), Tables 2.1.25-2.1.28, Figures 2.1.25-2.1.28; Madison (1956), Tables 2.1.29-2.1.32, Figures 2.1.29-2.1.32; Mobile (1963), Tables 2.1.33-2.1.26, Figures 2.1.33-2.1.36; Santa Maria (1957), Tables 2.1.37-2.1.40, Figures 2.1.37-2.1.40; Wilmington (1958), Tables 2.1.41-2.1.44, Figures 2.1.41-2.1.44.

This model is conservative in two respects. Firstly, it requires that all input energy go through storage. In practice, naturally, all energy that can be used directly, will be, to avoid battery loss. Thus storage capacity could be somewhat smaller than optimized on this basis. Secondly, since the process was simulated with a time step of one day, the load demands on storage are somewhat larger than they would be with a smaller time step. For a few cases, this model was run with a time step of one hour and the results compared with the daily model. The improvement was judged insufficient to justify the much greater cost of the hourly model. Moreover, both of these conservative tendencies are largely offset by the anticipated variation in user loads.

ELECTRICAL ENERGY FLOW MODEL

for a given collector array area and a given storage capacity:

1. for each day, $i = 1, 2, \dots, 365$;

1. $QI_i = ES \times CA \times QA_i$

2. $QW_i = \max \quad 0 \quad \text{and} \quad (QI_i + QS_{i-1} - SC)$

3. $QS_i = \min \quad SC \quad \text{and} \quad (QI_i + QS_{i-1})$

4. $QO_i = \min \quad QS_i \quad \text{and} \quad QL_i$

5. $QS_i = QS_i - QO_i$

6. $PL_i = 100 \times QO_i / QL_i$

where:

ES = system efficiency

CA = collector array area (sq-m)

SC = storage capacity (kw-hr)

QA = energy absorbed (kw-hr / sq-m)

QI = energy input (kw-hr)

QS = energy stored (kw-hr)

QW = energy wasted (kw-hr)

QL = energy load (kw-hr)

QO = energy output (kw-hr)

PL = % load supplied by system

Figure 2.1.16

Table 2.1.17(a)

28 JAN 76 - 11:29:41 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO - CASE 1 - A INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 10 SQ-M							
5	937.66	937.66	5027.00	18.7	937.66	0.00	0.00
10	937.66	937.66	5027.00	18.7	937.66	0.00	0.00
15	937.66	937.66	5027.00	18.7	937.66	0.00	0.00
20	937.66	937.66	5027.00	18.7	937.66	0.00	0.00
25	937.66	937.66	5027.00	18.7	937.66	0.00	0.00
30	937.66	937.66	5027.00	18.7	937.66	0.00	0.00
35	937.66	937.66	5027.00	18.7	937.66	0.00	0.00
60	937.66	937.66	5027.00	18.7	937.66	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	937.66	1875.32	5027.00	27.8	1395.05	0.00	480.27
10	937.66	1875.32	5027.00	37.0	1360.88	57.78	14.44
15	937.66	1875.32	5027.00	37.1	1365.88	126.38	9.44
20	937.66	1875.32	5027.00	37.2	1370.88	169.21	4.44
25	937.66	1875.32	5027.00	37.3	1375.32	188.78	0.00
30	937.66	1875.32	5027.00	37.3	1375.32	188.78	0.00
35	937.66	1875.32	5027.00	37.3	1375.32	188.78	0.00
60	937.66	1875.32	5027.00	37.3	1375.32	188.78	0.00

Table 2.1.17(b)

28 JAN 76 - 11:31:16 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO - CASE 1 - A INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 30 SQ-M							
5	937.66	2812.98	5027.00	30.5	1535.57	0.00	1277.40
10	937.66	2812.98	5027.00	48.7	2446.69	64.00	366.29
15	937.66	2812.98	5027.00	54.4	2734.58	237.05	78.40
20	937.66	2812.98	5027.00	54.6	2745.96	354.24	67.02
25	937.66	2812.98	5027.00	54.7	2750.96	448.13	62.02
30	937.66	2812.98	5027.00	54.8	2755.96	554.36	57.02
35	937.66	2812.98	5027.00	54.9	2760.96	676.15	52.02
60	937.66	2812.98	5027.00	55.4	2785.96	1615.25	27.02
COLLECTOR AREA = 40 SQ-M							
5	937.66	3750.64	5027.00	31.8	1599.26	0.00	2151.38
10	937.66	3750.64	5027.00	54.2	2726.34	64.00	1024.30
15	937.66	3750.64	5027.00	64.8	3255.62	409.04	495.02
20	937.66	3750.64	5027.00	67.1	3372.54	1086.08	378.10
25	937.66	3750.64	5027.00	67.9	3414.47	1769.70	336.17
30	937.66	3750.64	5027.00	68.4	3437.72	2391.25	312.92
35	937.66	3750.64	5027.00	68.7	3453.89	2969.06	296.75
60	937.66	3750.64	5027.00	69.3	3485.52	6290.84	265.12

Table 2.1.17(c)

28 JAN 76 • 11:32:44 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO - CASE 1 - A INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 50 SQ-M							
5	937.66	4688.30	5027.00	32.6	1638.70	0.00	3049.59
10	937.66	4688.30	5027.00	57.7	2898.69	64.00	1789.61
15	937.66	4688.30	5027.00	70.7	3554.22	446.91	1134.08
20	937.66	4688.30	5027.00	73.6	3700.43	1334.04	987.87
25	937.66	4688.30	5027.00	74.9	3764.82	2220.94	923.48
30	937.66	4688.30	5027.00	75.6	3802.54	3123.99	885.75
35	937.66	4688.30	5027.00	76.1	3824.90	3974.83	863.40
60	937.66	4688.30	5027.00	77.1	3875.73	8452.91	812.51
•							
COLLECTOR AREA = 60 SQ-M							
5	937.66	5625.96	5027.00	33.1	1666.33	0.00	3959.63
10	937.66	5625.96	5027.00	59.8	3007.15	64.00	2618.81
15	937.66	5625.96	5027.00	75.2	3781.87	470.64	1844.08
20	937.66	5625.96	5027.00	78.4	3939.05	1496.45	1686.91
25	937.66	5625.96	5027.00	79.9	4016.48	2539.76	1609.48
30	937.66	5625.96	5027.00	80.9	4069.35	3574.57	1556.61
35	937.66	5625.96	5027.00	81.8	4114.48	4605.09	1511.48
60	937.66	5625.96	5027.00	83.1	4178.08	10086.27	1447.87

Table 2.1.17(d)

28 JAN 76 * 11:34:28 AM

PVEPS * ENERGY FLOW SIMULATIONS * V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO * CASE 1 * A INSOLATION DATA * NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 70 SQ-M							
5	937.66	6563.62	5027.00	33.6	1687.31	0.00	4876.31
10	937.66	6563.62	5027.00	61.2	3078.40	64.00	3485.22
15	937.66	6563.62	5027.00	78.2	3932.65	492.64	2630.97
20	937.66	6563.62	5027.00	81.9	4119.21	1623.96	2444.41
25	937.66	6563.62	5027.00	83.8	4212.58	2751.77	2351.03
30	937.66	6563.62	5027.00	85.0	4274.87	3891.50	2288.75
35	937.66	6563.62	5027.00	86.0	4322.68	5067.85	2240.94
60	937.66	6563.62	5027.00	88.0	4423.07	11010.02	2140.54
.							
COLLECTOR AREA = 80 SQ-M							
5	937.66	7501.28	5027.00	33.9	1704.55	0.00	5796.73
10	937.66	7501.28	5027.00	62.4	3134.52	64.00	4366.76
15	937.66	7501.28	5027.00	80.4	4043.71	507.78	3457.57
20	937.66	7501.28	5027.00	84.5	4249.50	1709.13	3251.78
25	937.66	7501.28	5027.00	87.0	4373.97	2931.51	3127.30
30	937.66	7501.28	5027.00	88.5	4450.52	4154.45	3050.76
35	937.66	7501.28	5027.00	89.4	4495.66	5397.84	3005.62
60	937.66	7501.28	5027.00	92.1	4631.32	12080.17	2869.96

Table 2.1.17(e)

28 JAN 76 * 11:35:59 AM

PVEPS * ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO * CASE 1 * A INSOLATION DATA * NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 90 SQ-M							
5	937.66	8438.94	5027.00	34.2	1718.87	0.00	6720.07
10	937.66	8438.94	5027.00	63.2	3179.10	64.00	5259.83
15	937.66	8438.94	5027.00	82.1	4126.71	519.22	4312.23
20	937.66	8438.94	5027.00	86.5	4349.12	1775.39	4088.45
25	937.66	8438.94	5027.00	89.1	4480.03	3050.31	3957.49
30	937.66	8438.94	5027.00	90.9	4567.72	4347.85	3869.80
35	937.66	8438.94	5027.00	91.8	4614.76	5727.11	3819.80
60	937.66	8438.94	5027.00	94.4	4747.69	13026.94	3686.41
COLLECTOR AREA = 100 SQ-M							
5	937.66	9376.60	5027.00	34.4	1729.12	0.00	7647.48
10	937.66	9376.60	5027.00	63.9	3213.41	64.00	6163.19
15	937.66	9376.60	5027.00	83.4	4190.11	523.81	5186.49
20	937.66	9376.60	5027.00	88.0	4424.73	1839.10	4948.87
25	937.66	9376.60	5027.00	90.7	4561.09	3188.36	4810.16
30	937.66	9376.60	5027.00	92.5	4648.85	4556.42	4722.40
35	937.66	9376.60	5027.00	93.4	4696.71	6004.44	4671.36
60	937.66	9376.60	5027.00	95.5	4801.16	13588.74	4557.45

28 JAN 76 - 12:22:17 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO - CASE 1 - A INSOLATION DATA - NOMINAL LOAD 2

Figure 2.1.17(a)

28 JAN 76 - 11:41:09 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO - CASE 1 - A INSOLATION DATA - NOMINAL LOAD 2

Figure 2.1.17(b)

28 JAN 76 - 12:27:29 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO - CASE 1 - A INSOLATION DATA - NOMINAL LOAD 2

Figure 2.1.17(c)

Table 2.1.18(a)

28 JAN 76 - 12:46:47 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME-STEP = 1 DAY)

CLEVELAND, OHIO - 1962 - CASE 2 - A INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 10 SQ-M							
5	937.66	937.66	7217.00	13.0	937.66	0.00	0.00
10	937.66	937.66	7217.00	13.0	937.66	0.00	0.00
15	937.66	937.66	7217.00	13.0	937.66	0.00	0.00
20	937.66	937.66	7217.00	13.0	937.66	0.00	0.00
25	937.66	937.66	7217.00	13.0	937.66	0.00	0.00
30	937.66	937.66	7217.00	13.0	937.66	0.00	0.00
35	937.66	937.66	7217.00	13.0	937.66	0.00	0.00
60	937.66	937.66	7217.00	13.0	937.66	0.00	0.00
.							
COLLECTOR AREA = 20 SQ-M							
5	937.66	1875.32	7217.00	19.3	1395.05	0.00	480.27
10	937.66	1875.32	7217.00	26.0	1875.32	0.00	0.00
15	937.66	1875.32	7217.00	26.0	1875.32	0.00	0.00
20	937.66	1875.32	7217.00	26.0	1875.32	0.00	0.00
25	937.66	1875.32	7217.00	26.0	1875.32	0.00	0.00
30	937.66	1875.32	7217.00	26.0	1875.32	0.00	0.00
35	937.66	1875.32	7217.00	26.0	1875.32	0.00	0.00
60	937.66	1875.32	7217.00	26.0	1875.32	0.00	0.00

Table 2.1.18(b)

28 JAN 75 - 12:48:14 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO - 1962 - CASE 2 - A INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 30 SQ-M							
5	937.66	2812.98	7217.00	21.3	1535.57	0.00	1277.40
10	937.66	2812.98	7217.00	34.7	2502.28	0.00	310.70
15	937.66	2812.98	7217.00	39.0	2812.98	5.84	0.00
20	937.66	2812.98	7217.00	39.0	2812.98	5.84	0.00
25	937.66	2812.98	7217.00	39.0	2812.98	5.84	0.00
30	937.66	2812.98	7217.00	39.0	2812.98	5.84	0.00
35	937.66	2812.98	7217.00	39.0	2812.98	5.84	0.00
60	937.66	2812.98	7217.00	39.0	2812.98	5.84	0.00
.							
COLLECTOR AREA = 40 SQ-M							
5	937.66	3750.64	7217.00	22.2	1599.26	0.00	2151.38
10	937.66	3750.64	7217.00	38.7	2790.11	0.00	960.53
15	937.66	3750.64	7217.00	48.7	3513.35	42.22	237.29
20	937.66	3750.64	7217.00	51.6	3721.61	126.18	29.03
25	937.66	3750.64	7217.00	51.6	3726.61	210.73	24.03
30	937.66	3750.64	7217.00	51.7	3731.61	292.93	19.03
35	937.66	3750.64	7217.00	51.8	3736.61	353.00	14.03
60	937.66	3750.64	7217.00	52.0	3750.64	464.48	0.00

Table 2.1.18(c)

28 JAN 76 * 12:49:41 PM

PVEPS - ENERGY FLOW SIMULATIONS * V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO * 1962 * CASE 2 * A INSOLATION DATA * NOMINAL LOAD 2-

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 50 SQ-M							
5	937.66	4688.30	7217.00	22.7	1638.70	0.00	3049.59
10	937.66	4688.30	7217.00	41.1	2962.69	0.00	1725.61
15	937.66	4688.30	7217.00	53.7	3678.45	48.00	809.84
20	937.66	4688.30	7217.00	60.8	4389.52	238.00	298.77
25	937.66	4688.30	7217.00	62.5	4510.63	709.36	177.66
30	937.66	4688.30	7217.00	63.1	4556.20	1052.06	132.09
35	937.66	4688.30	7217.00	63.4	4578.09	1277.16	110.21
60	937.66	4688.30	7217.00	63.9	4614.59	2405.42	73.71
.							
COLLECTOR AREA = 60 SQ-M							
5	937.66	5625.96	7217.00	23.1	1666.33	0.00	3959.63
10	937.66	5625.96	7217.00	42.6	3071.15	0.00	2554.81
15	937.66	5625.96	7217.00	57.3	4137.50	48.00	1488.46
20	937.66	5625.96	7217.00	66.3	4783.22	282.92	842.73
25	937.66	5625.96	7217.00	68.8	4966.62	994.56	659.34
30	937.66	5625.96	7217.00	70.2	5065.51	1690.81	560.45
35	937.66	5625.96	7217.00	70.9	5119.53	2407.17	506.43
60	937.66	5625.96	7217.00	72.3	5215.77	5885.96	410.19

Table 2.1.18(d)

28 JAN 76 - 12:51:13 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO - 1962 - CASE 2 - A INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 70 SQ-M							
5	937.66	6563.62	7217.00	23.4	1687.31	0.00	4876.31
10	937.66	6563.62	7217.00	43.5	3142.40	0.00	3421.22
15	937.66	6563.62	7217.00	59.9	4322.40	48.00	2241.22
20	937.66	6563.62	7217.00	70.3	5074.28	291.10	1489.33
25	937.66	6563.62	7217.00	73.1	5278.76	1120.32	1284.86
30	937.66	6563.62	7217.00	74.8	5396.43	1986.61	1167.19
35	937.66	6563.62	7217.00	75.7	5460.12	2841.46	1103.50
60	937.66	6563.62	7217.00	77.3	5580.10	7076.55	983.51
.							
COLLECTOR AREA = 80 SQ-M							
5	937.66	7501.28	7217.00	23.6	1704.55	0.00	5796.73
10	937.66	7501.28	7217.00	44.3	3198.52	0.00	4302.76
15	937.66	7501.28	7217.00	61.8	4458.17	48.00	3043.10
20	937.66	7501.28	7217.00	73.6	5311.42	299.27	2189.86
25	937.66	7501.28	7217.00	76.7	5537.71	1214.22	1963.57
30	937.66	7501.28	7217.00	78.4	5657.82	2203.86	1843.46
35	937.66	7501.28	7217.00	79.4	5728.18	3186.08	1773.10
60	937.66	7501.28	7217.00	82.0	5915.89	8054.37	1585.38

Table 2.1.18(e)

28 JAN 76 - 12:52:47 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO - 1962 - CASE 2 - A INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR PER YEAR
=====						
COLLECTOR AREA = 90 SQ-M						
5	937.66	8438.94	7217.00	23.8	1718.87	6720.07
10	937.66	8438.94	7217.00	44.9	3243.10	5195.83
15	937.66	8438.94	7217.00	63.2	4558.72	3880.21
20	937.66	8438.94	7217.00	76.1	5491.29	2947.65
25	937.66	8438.94	7217.00	79.5	5738.85	2700.09
30	937.66	8438.94	7217.00	81.2	5862.49	2576.45
35	937.66	8438.94	7217.00	82.4	5946.51	2492.42
60	937.66	8438.94	7217.00	85.5	6168.00	2270.94
.						
COLLECTOR AREA = 100 SQ-M						
5	937.66	9376.60	7217.00	24.0	1729.12	7647.48
10	937.66	9376.60	7217.00	45.4	3277.41	6099.19
15	937.66	9376.60	7217.00	64.2	4632.64	4743.96
20	937.66	9376.60	7217.00	78.1	5635.46	3741.14
25	937.66	9376.60	7217.00	81.7	5893.03	3483.57
30	937.66	9376.60	7217.00	83.7	6039.11	3337.49
35	937.66	9376.60	7217.00	85.0	6134.98	3241.62
60	937.66	9376.60	7217.00	88.3	6375.36	3001.24

28 JAN 76 - 01:02:40 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO - 1962 - CASE 2 - A INSOLATION DATA - NOMINAL LOAD 2

Figure 2.1.18(a)

28 JAN 76 - 12:58:16 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO - 1962 - CASE 2 - A INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

Figure 2.1.18(b)

28 JAN 76 * 01:08:14 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO * 1962 * CASE 2 * A INSOLATION DATA * NOMINAL LOAD 2

Figure 2.1.18(c)

Table 2.1.19(a)

2 FEB 76 - 09:22:46 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO 1962 - CASE 3A - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
<hr/>							
COLLECTOR AREA = 10 SQ-M							
5	937.66	937.66	6371.51	14.7	937.66	0.00	0.00
10	937.66	937.66	6371.51	14.7	937.66	0.00	0.00
15	937.66	937.66	6371.51	14.7	937.66	0.00	0.00
20	937.66	937.66	6371.51	14.7	937.66	0.00	0.00
25	937.66	937.66	6371.51	14.7	937.66	0.00	0.00
30	937.66	937.66	6371.51	14.7	937.66	0.00	0.00
35	937.66	937.66	6371.51	14.7	937.66	0.00	0.00
60	937.66	937.66	6371.51	14.7	937.66	0.00	0.00
•							
COLLECTOR AREA = 20 SQ-M							
5	937.66	1875.32	6371.51	21.9	1395.05	0.00	480.27
10	937.66	1875.32	6371.51	29.4	1875.32	0.37	0.00
15	937.66	1875.32	6371.51	29.4	1875.32	0.37	0.00
20	937.66	1875.32	6371.51	29.4	1875.32	0.37	0.00
25	937.66	1875.32	6371.51	29.4	1875.32	0.37	0.00
30	937.66	1875.32	6371.51	29.4	1875.32	0.37	0.00
35	937.66	1875.32	6371.51	29.4	1875.32	0.37	0.00
60	937.66	1875.32	6371.51	29.4	1875.32	0.37	0.00

Table 2.1.19(b)

2 FEB 76 - 09:24:45 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO 1962 - CASE 3A -- A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 30 SQ-M							
5	937.66	2812.98	6371.51	24.1	1535.57	0.00	1277.40
10	937.66	2812.98	6371.51	39.2	2499.83	2.45	313.15
15	937.66	2812.98	6371.51	44.1	2810.07	22.94	2.91
20	937.66	2812.98	6371.51	44.1	2812.98	26.22	0.00
25	937.66	2812.98	6371.51	44.1	2812.98	26.22	0.00
30	937.66	2812.98	6371.51	44.1	2812.98	26.22	0.00
35	937.66	2812.98	6371.51	44.1	2812.98	26.22	0.00
60	937.66	2812.98	6371.51	44.1	2812.98	26.22	0.00
COLLECTOR AREA = 40 SQ-M							
5	937.66	3750.64	6371.51	25.1	1599.26	0.00	2151.38
10	937.66	3750.64	6371.51	43.7	2785.19	4.92	965.45
15	937.66	3750.64	6371.51	54.8	3489.32	89.37	261.32
20	937.66	3750.64	6371.51	57.5	3663.26	376.59	87.38
25	937.66	3750.64	6371.51	58.1	3700.16	605.88	50.48
30	937.66	3750.64	6371.51	58.4	3717.91	772.28	32.73
35	937.66	3750.64	6371.51	58.5	3729.08	917.94	21.56
60	937.66	3750.64	6371.51	58.9	3750.64	1526.42	0.00

Table 2.1.19(c)

2 FEB 76 - 09:26:22 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO 1962 - CASE 3A - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	937.66	4688.30	6371.51	25.7	1638.70	0.00	3049.59
10	937.66	4688.30	6371.51	46.4	2957.63	5.06	1730.67
15	937.66	4688.30	6371.51	60.2	3836.71	120.47	851.58
20	937.66	4688.30	6371.51	66.0	4207.09	598.28	481.21
25	937.66	4688.30	6371.51	68.2	4346.81	1056.38	341.49
30	937.66	4688.30	6371.51	69.3	4413.10	1488.61	275.20
35	937.66	4688.30	6371.51	69.8	4450.25	1859.66	238.05
60	937.66	4688.30	6371.51	70.9	4520.20	3517.86	168.10
COLLECTOR AREA = 60 SQ-M							
5	937.66	5625.96	6371.51	26.2	1666.33	0.00	3959.63
10	937.66	5625.96	6371.51	48.1	3066.09	5.06	2559.87
15	937.66	5625.96	6371.51	64.0	4077.64	143.07	1548.32
20	937.66	5625.96	6371.51	71.1	4527.44	765.73	1098.52
25	937.66	5625.96	6371.51	74.8	4768.44	1446.45	857.52
30	937.66	5625.96	6371.51	76.8	4891.75	2124.52	734.21
35	937.66	5625.96	6371.51	78.0	4972.39	2774.78	653.57
60	937.66	5625.96	6371.51	80.5	5128.11	6098.51	497.85

Table 2.1.19(d)

2 FEB 76 - 09:27:53 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO 1962 - CASE 3A - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 70 SQ-M							
5	937.66	6563.62	6371.51	26.5	1687.31	0.00	4876.31
10	937.66	6563.62	6371.51	49.2	3137.34	5.06	3426.27
15	937.66	6563.62	6371.51	66.5	4238.55	157.30	2325.07
20	937.66	6563.62	6371.51	74.4	4737.99	892.96	1825.63
25	937.66	6563.62	6371.51	79.1	5041.43	1691.72	1522.19
30	937.66	6563.62	6371.51	81.9	5221.31	2527.16	1342.31
35	937.66	6563.62	6371.51	83.7	5330.15	3404.14	1233.47
60	937.66	6563.62	6371.51	87.6	5584.16	7755.22	979.46
COLLECTOR AREA = 80 SQ-M							
5	937.66	7501.28	6371.51	26.8	1704.55	0.00	5796.73
10	937.66	7501.28	6371.51	50.1	3193.46	5.06	4307.82
15	937.66	7501.28	6371.51	68.4	4357.39	168.58	3143.89
20	937.66	7501.28	6371.51	76.8	4890.90	974.54	2610.38
25	937.66	7501.28	6371.51	82.3	5246.69	1883.68	2254.59
30	937.66	7501.28	6371.51	85.8	5468.31	2831.23	2032.97
35	937.66	7501.28	6371.51	87.8	5594.98	3827.14	1906.30
60	937.66	7501.28	6371.51	92.9	5918.43	9531.41	1582.85

Table 2.1.19(e)

2 FEB 76 - 09:29:30 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO 1962 - CASE 3A - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 90 SQ-M							
5	937.66	8438.94	6371.51	27.0	1718.87	0.00	5720.07
10	937.66	8438.94	6371.51	50.8	3238.05	5.06	5200.89
15	937.66	8438.94	6371.51	69.8	4447.83	177.18	3991.11
20	937.66	8438.94	6371.51	78.6	5005.73	1038.72	3431.84
25	937.66	8438.94	6371.51	84.3	5370.25	2021.43	3067.27
30	937.66	8438.94	6371.51	88.3	5623.63	3053.18	2813.89
35	937.66	8438.94	6371.51	90.5	5766.81	4218.30	2667.75
60	937.66	8438.94	6371.51	95.2	6065.17	10971.04	2368.93
COLLECTOR AREA = 100 SQ-M							
5	937.66	9376.60	6371.51	27.1	1729.12	0.00	7647.48
10	937.66	9376.60	6371.51	51.4	3272.35	5.06	6104.25
15	937.66	9376.60	6371.51	70.9	4514.57	180.90	4862.03
20	937.66	9376.60	6371.51	79.9	5089.05	1103.61	4284.54
25	937.66	9376.60	6371.51	85.7	5461.15	2157.45	3910.10
30	937.66	9376.60	6371.51	89.9	5724.88	3286.08	3646.36
35	937.66	9376.60	6371.51	92.3	5881.68	4536.20	3486.39
60	937.66	9376.60	6371.51	96.1	6121.12	11792.43	3237.49

2 FEB 76 - 09:56:57 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO 1962 - CASE 3A - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

Figure 2.1.19 (a)

2 FEB 76 - 09:53:50 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO 1962 - CASE 3A - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

Figure 2.1.19 (b)

2 FEB 76 - 09:38:18 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO 1962 - CASE 3A - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

Figure 2.1.19(c)

Table 2.1.20(a)

2 FEB 76 - 10:06:21 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIC 1962 - CASE 3B - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
FW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 10 SQ-M							
5	937.66	937.66	8561.51	11.0	937.66	0.00	0.00
10	937.66	937.66	8561.51	11.0	937.66	0.00	0.00
15	937.66	937.66	8561.51	11.0	937.66	0.00	0.00
20	937.66	937.66	8561.51	11.0	937.66	0.00	0.00
25	937.66	937.66	8561.51	11.0	937.66	0.00	0.00
30	937.66	937.66	8561.51	11.0	937.66	0.00	0.00
35	937.66	937.66	8561.51	11.0	937.66	0.00	0.00
60	937.66	937.66	8561.51	11.0	937.66	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	937.66	1875.32	8561.51	16.3	1395.05	0.00	480.27
10	937.66	1875.32	8561.51	21.9	1875.32	0.00	0.00
15	937.66	1875.32	8561.51	21.9	1875.32	0.00	0.00
20	937.66	1875.32	8561.51	21.9	1875.32	0.00	0.00
25	937.66	1875.32	8561.51	21.9	1875.32	0.00	0.00
30	937.66	1875.32	8561.51	21.9	1875.32	0.00	0.00
35	937.66	1875.32	8561.51	21.9	1875.32	0.00	0.00
60	937.66	1875.32	8561.51	21.9	1875.32	0.00	0.00

Table 2.1.20(b)

2 FEB 76 - 10:07:52 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO 1962 - CASE 3B - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR PER YEAR
COLLECTOR AREA = 30 SQ-M						
5	937.66	2812.98	8561.51	17.9	1535.57	1277.40
10	937.66	2812.98	8561.51	29.2	2502.28	310.70
15	937.66	2812.98	8561.51	32.9	2812.98	0.00
20	937.66	2812.98	8561.51	32.9	2812.98	0.00
25	937.66	2812.98	8561.51	32.9	2812.98	0.00
30	937.66	2812.98	8561.51	32.9	2812.98	0.00
35	937.66	2812.98	8561.51	32.9	2812.98	0.00
60	937.66	2812.98	8561.51	32.9	2812.98	0.00
COLLECTOR AREA = 40 SQ-M						
5	937.66	3750.64	8561.51	18.7	1599.26	2151.38
10	937.66	3750.64	8561.51	32.6	2790.11	960.53
15	937.66	3750.64	8561.51	41.3	3534.45	216.19
20	937.66	3750.64	8561.51	43.8	3750.64	0.00
25	937.66	3750.64	8561.51	43.8	3750.64	0.00
30	937.66	3750.64	8561.51	43.8	3750.64	0.00
35	937.66	3750.64	8561.51	43.8	3750.64	0.00
60	937.66	3750.64	8561.51	43.8	3750.64	0.00

Table 2.1.20(c)

2 FEB 76 - 10:09:40 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO 1962 - CASE 3B - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR PER YEAR
COLLECTOR AREA = 50 SQ-M						
5	937.66	4688.30	8561.51	19.1	1638.70	3049.59
10	937.66	4688.30	8561.51	34.6	2962.69	1725.61
15	937.66	4688.30	8561.51	45.8	3919.92	768.38
20	937.66	4688.30	8561.51	52.8	4517.40	170.90
25	937.66	4688.30	8561.51	54.4	4660.98	27.32
30	937.66	4688.30	8561.51	54.7	4683.43	4.86
35	937.66	4688.30	8561.51	54.8	4686.30	0.00
60	937.66	4688.30	8561.51	54.8	4688.30	0.00
COLLECTOR AREA = 60 SQ-M						
5	937.66	5625.96	8561.51	19.5	1666.33	3959.63
10	937.66	5625.96	8561.51	35.9	3071.15	2554.81
15	937.66	5625.96	8561.51	48.9	4182.31	1443.65
20	937.66	5625.96	8561.51	58.2	4979.46	646.49
25	937.66	5625.96	8561.51	62.3	5335.89	290.07
30	937.66	5625.96	8561.51	63.7	5455.37	170.59
35	937.66	5625.96	8561.51	64.3	5504.77	121.19
60	937.66	5625.96	8561.51	65.1	5573.83	52.13

Table 2.1.20(d)

2 FEB 76 - 10:12:03 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO 1962 - CASE 3B - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 70 SQ-M							
5	937.66	6563.62	8561.51	19.7	1687.31	0.00	4876.31
10	937.66	6563.62	8561.51	36.7	3142.40	0.00	3421.22
15	937.66	6563.62	8561.51	51.0	4367.34	3.06	2196.28
20	937.66	6563.62	8561.51	61.8	5287.43	51.05	1276.19
25	937.66	6563.62	8561.51	67.2	5755.30	492.29	808.32
30	937.66	6563.62	8561.51	70.1	5998.89	993.90	564.72
35	937.66	6563.62	8561.51	71.4	6113.64	1452.36	449.98
60	937.66	6563.62	8561.51	73.6	6297.15	3330.12	266.46
COLLECTOR AREA = 80 SQ-M							
5	937.66	7501.28	8561.51	19.9	1704.55	0.00	5796.73
10	937.66	7501.28	8561.51	37.4	3198.52	0.00	4302.76
15	937.66	7501.28	8561.51	52.6	4503.12	3.06	2998.16
20	937.66	7501.28	8561.51	64.6	5533.28	57.84	1967.99
25	937.66	7501.28	8561.51	70.8	6060.00	578.47	1441.28
30	937.66	7501.28	8561.51	74.4	6365.62	1234.37	1135.66
35	937.66	7501.28	8561.51	76.4	6542.90	1891.18	958.38
60	937.66	7501.28	8561.51	80.4	6887.08	4944.12	614.20

Table 2.1.20(e)

2 FEB 76 - 10:13:56 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO 1962 - CASE 3B - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 90 SQ-M							
5	937.66	8438.94	8561.51	20.1	1718.37	0.00	6720.07
10	937.66	8438.94	8561.51	37.9	3243.10	0.00	5195.83
15	937.66	8438.94	8561.51	53.8	4603.57	3.06	3835.27
20	937.66	8438.94	8561.51	65.8	5717.61	64.77	2721.33
25	937.66	8438.94	8561.51	73.4	6282.15	674.64	2156.79
30	937.66	8438.94	8561.51	77.4	6625.12	1421.34	1813.82
35	937.66	8438.94	8561.51	80.0	6852.77	2207.50	1586.17
50	937.66	8438.94	8561.51	85.5	7316.45	6353.44	1122.49
COLLECTOR AREA = 100 SQ-M							
5	937.66	9376.60	8561.51	20.2	1729.12	0.00	7647.48
10	937.66	9376.60	8561.51	38.3	3277.41	0.00	6099.19
15	937.66	9376.60	8561.51	54.6	4677.58	3.06	4699.02
20	937.66	9376.60	8561.51	68.5	5862.69	67.63	3513.91
25	937.66	9376.60	8561.51	75.4	6455.22	736.28	2921.37
30	937.66	9376.60	8561.51	79.8	6835.44	1574.63	2541.16
35	937.66	9376.60	8561.51	82.9	7097.73	2428.01	2278.87
60	937.66	9376.60	8561.51	88.9	7615.39	7463.34	1761.21

2 FEB 76 - 10:25:36 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO 1962 - CASE 3B - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

Figure 2.1.20(a)

2 FEB 76 - 10:20:41 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO 1962 - CASE 3B - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

Figure 2.1.20(b)

2 FEB 76 - 10:17:11 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CLEVELAND, OHIO 1962 - CASE 3B - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

Figure 2.1.20(c)

Table 2.1.21(a)

28 JAN 76 * 08:58:38 PM

PVEPS * ENERGY FLOW SIMULATIONS * V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA * 1962 * CASE 1 * A INSOLATION DATA * NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 10 SQ-M							
5	1611.99	1611.99	5027.00	31.6	1590.31	0.00	21.68
10	1611.99	1611.99	5027.00	32.1	1611.99	0.00	0.00
15	1611.99	1611.99	5027.00	32.1	1611.99	0.00	0.00
20	1611.99	1611.99	5027.00	32.1	1611.99	0.00	0.00
25	1611.99	1611.99	5027.00	32.1	1611.99	0.00	0.00
30	1611.99	1611.99	5027.00	32.1	1611.99	0.00	0.00
35	1611.99	1611.99	5027.00	32.1	1611.99	0.00	0.00
60	1611.99	1611.99	5027.00	32.1	1511.99	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1611.99	3223.97	5027.00	35.3	1773.26	0.00	1450.71
10	1611.99	3223.97	5027.00	62.2	3128.74	63.93	95.24
15	1611.99	3223.97	5027.00	63.2	3177.09	140.59	46.88
20	1611.99	3223.97	5027.00	63.3	3182.09	218.01	41.88
25	1611.99	3223.97	5027.00	63.4	3187.09	299.26	36.88
30	1611.99	3223.97	5027.00	63.5	3192.09	381.10	31.88
35	1611.99	3223.97	5027.00	63.6	3197.09	464.35	26.88
60	1611.99	3223.97	5027.00	64.1	3222.09	919.49	1.88

Table 2.1.21(b)

28 JAN 76 * 09:00:20 PM

PVEPS * ENERGY FLOW SIMULATIONS * V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA * 1962 * CASE 1 * A INSOLATION DATA * NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 30 SQ-M							
5	1611.99	4835.96	5027.00	35.7	1793.34	0.00	3042.62
10	1611.99	4835.96	5027.00	68.4	3439.39	64.00	1396.57
15	1611.99	4835.96	5027.00	87.6	4401.24	479.86	434.72
20	1611.99	4835.96	5027.00	88.2	4432.58	1464.47	403.38
25	1611.99	4835.96	5027.00	88.5	4447.58	2435.12	388.38
30	1611.99	4835.96	5027.00	88.8	4462.58	3420.69	373.38
35	1611.99	4835.96	5027.00	89.0	4476.09	4388.98	359.87
60	1611.99	4835.96	5027.00	89.6	4504.12	8880.24	331.84
COLLECTOR AREA = 40 SQ-M							
5	1611.99	6447.95	5027.00	35.9	1803.35	0.00	4644.60
10	1611.99	6447.95	5027.00	69.3	3482.53	64.00	2965.42
15	1611.99	6447.95	5027.00	93.0	4675.68	547.08	1772.27
20	1611.99	6447.95	5027.00	95.6	4806.00	1995.92	1641.36
25	1611.99	6447.95	5027.00	96.4	4846.88	3420.97	1600.47
30	1611.99	6447.95	5027.00	96.9	4872.57	4850.94	1574.78
35	1611.99	6447.95	5027.00	97.2	4887.57	6304.67	1559.78
60	1611.99	6447.95	5027.00	98.1	4931.81	13626.48	1515.54

Table 2.1.21(c)

28 JAN 76 * 09:02:02 PM

PVEPS * ENERGY FLOW SIMULATIONS * V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA * 1962 * CASE 1 * A INSOLATION DATA * NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 50 SQ-M							
5	1611.99	8059.93	5027.00	36.0	1809.13	0.00	6250.80
10	1611.99	8059.93	5027.00	69.8	3508.25	64.00	4551.68
15	1611.99	8059.93	5027.00	94.3	4738.47	549.00	3321.46
20	1611.99	8059.93	5027.00	97.2	4888.26	2144.77	3168.67
25	1611.99	8059.93	5027.00	98.4	4947.55	3794.77	3104.38
30	1611.99	8059.93	5027.00	99.1	4982.12	5463.00	3064.81
35	1611.99	8059.93	5027.00	99.5	4999.44	7160.57	3043.00
60	1611.99	8059.93	5027.00	99.8	5017.55	15989.01	3006.50
COLLECTOR AREA = 60 SQ-M							
5	1611.99	9671.92	5027.00	36.1	1812.89	0.00	7859.04
10	1611.99	9671.92	5027.00	70.1	3522.67	64.00	6149.25
15	1611.99	9671.92	5027.00	95.0	4774.79	549.14	4897.13
20	1611.99	9671.92	5027.00	98.0	4928.63	2176.69	4740.29
25	1611.99	9671.92	5027.00	99.0	4977.18	3921.07	4686.74
30	1611.99	9671.92	5027.00	99.5	5001.58	5676.07	4657.34
35	1611.99	9671.92	5027.00	99.7	5010.26	7464.84	4643.66
60	1611.99	9671.92	5027.00	99.8	5018.86	16468.97	4610.06

Table 2.1.21(d)

28 JAN 76 - 09:03:29 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 1 - A INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 70 SQ-M							
5	1611.99	11283.91	5027.00	36.1	1815.78	0.00	9468.12
10	1611.99	11283.91	5027.00	70.3	3534.13	64.00	7749.77
15	1611.99	11283.91	5027.00	95.6	4804.37	550.99	6479.53
20	1611.99	11283.91	5027.00	98.5	4950.27	2199.58	6330.64
25	1611.99	11283.91	5027.00	99.3	4992.60	3961.01	6283.31
30	1611.99	11283.91	5027.00	99.6	5007.30	5755.80	6263.61
35	1611.99	11283.91	5027.00	99.7	5012.30	7560.65	6253.61
60	1611.99	11283.91	5027.00	99.9	5020.17	16596.04	6220.74
.							
COLLECTOR AREA = 80 SQ-M							
5	1611.99	12895.90	5027.00	36.2	1818.04	0.00	11077.86
10	1611.99	12895.90	5027.00	70.5	3542.70	64.00	9353.19
15	1611.99	12895.90	5027.00	95.9	4819.75	551.00	8076.14
20	1611.99	12895.90	5027.00	98.7	4963.54	2211.03	7929.36
25	1611.99	12895.90	5027.00	99.5	4999.52	3985.56	7888.38
30	1611.99	12895.90	5027.00	99.6	5009.34	5789.71	7873.55
35	1611.99	12895.90	5027.00	99.7	5014.34	7602.00	7863.55
60	1611.99	12895.90	5027.00	99.9	5021.48	16654.86	7831.42

Table 2.1.21(e)

28 JAN 76 - 09:05:02 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 1 - A INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 90 SQ-M							
5	1611.99	14507.88	5027.00	36.2	1820.00	0.00	12687.88
10	1611.99	14507.88	5027.00	70.6	3548.54	64.00	10959.34
15	1611.99	14507.88	5027.00	96.1	4833.01	551.00	9674.87
20	1611.99	14507.88	5027.00	98.9	4972.85	2218.16	9532.03
25	1611.99	14507.88	5027.00	99.5	5003.08	4001.14	9496.80
30	1611.99	14507.88	5027.00	99.7	5011.39	5808.21	9483.50
35	1611.99	14507.88	5027.00	99.8	5016.39	7623.21	9473.50
60	1611.99	14507.88	5027.00	99.9	5022.79	16691.10	9442.09
.							
COLLECTOR AREA = 100 SQ-M							
5	1611.99	16119.87	5027.00	36.2	1821.67	0.00	14298.20
10	1611.99	16119.87	5027.00	70.7	3554.26	64.00	12565.61
15	1611.99	16119.87	5027.00	96.4	4844.62	551.00	11275.25
20	1611.99	16119.87	5027.00	99.1	4980.88	2221.74	11135.99
25	1611.99	16119.87	5027.00	99.6	5006.65	4010.97	11105.22
30	1611.99	16119.87	5027.00	99.7	5013.43	5819.83	11093.44
35	1611.99	16119.87	5027.00	99.8	5018.43	7634.83	11083.44
60	1611.99	16119.87	5027.00	99.9	5024.10	16711.29	11052.77

28 JAN 76 09:15:49 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 1 - A INSOLATION DATA - NOMINAL LOAD 2

Figure 2.1.21(a)

28 JAN 76 - 09:12:10 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 1 - A INSOLATION DATA - NOMINAL LOAD 2

Figure 2.1.21(b)

28 JAN 76 - 09:08:29 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 1 - A INSOLATION DATA - NOMINAL LOAD 2

Figure 2.1.21(c)

Table 2.1.22(a)

28 JAN 76 - 09:24:29 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 2 - A INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 10 SQ-M							
5	1611.99	1611.99	7217.00	22.0	1590.31	0.00	21.68
10	1611.99	1611.99	7217.00	22.3	1611.99	0.00	0.00
15	1611.99	1611.99	7217.00	22.3	1611.99	0.00	0.00
20	1611.99	1611.99	7217.00	22.3	1611.99	0.00	0.00
25	1611.99	1611.99	7217.00	22.3	1611.99	0.00	0.00
30	1611.99	1611.99	7217.00	22.3	1611.99	0.00	0.00
35	1611.99	1611.99	7217.00	22.3	1611.99	0.00	0.00
60	1611.99	1611.99	7217.00	22.3	1611.99	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1611.99	3223.97	7217.00	24.6	1773.26	0.00	1450.71
10	1611.99	3223.97	7217.00	44.1	3180.62	0.00	43.36
15	1611.99	3223.97	7217.00	44.7	3223.97	0.00	0.00
20	1611.99	3223.97	7217.00	44.7	3223.97	0.00	0.00
25	1611.99	3223.97	7217.00	44.7	3223.97	0.00	0.00
30	1611.99	3223.97	7217.00	44.7	3223.97	0.00	0.00
35	1611.99	3223.97	7217.00	44.7	3223.97	0.00	0.00
60	1611.99	3223.97	7217.00	44.7	3223.97	0.00	0.00

Table 2.1.22(b)

28 JAN 76 - 09:26:08 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 2 - A INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 30 SQ-M							
5	1611.99	4835.96	7217.00	24.8	1793.34	0.00	3042.62
10	1611.99	4835.96	7217.00	48.5	3502.67	0.00	1333.29
15	1611.99	4835.96	7217.00	65.7	4741.10	44.47	94.86
20	1611.99	4835.96	7217.00	66.7	4811.14	118.62	24.82
25	1611.99	4835.96	7217.00	66.7	4816.14	182.35	19.82
30	1611.99	4835.96	7217.00	66.8	4821.14	232.79	14.82
35	1611.99	4835.96	7217.00	66.9	4826.14	279.23	9.82
60	1611.99	4835.96	7217.00	67.0	4835.96	359.80	0.00
COLLECTOR AREA = 40 SQ-M							
5	1611.99	6447.95	7217.00	25.0	1803.35	0.00	4644.60
10	1611.99	6447.95	7217.00	49.1	3546.53	0.00	2901.42
15	1611.99	6447.95	7217.00	71.5	5160.54	48.00	1287.41
20	1611.99	6447.95	7217.00	85.4	6166.39	272.05	281.56
25	1611.99	6447.95	7217.00	86.3	6229.08	947.36	218.86
30	1611.99	6447.95	7217.00	86.7	6254.64	1655.08	193.31
35	1611.99	6447.95	7217.00	86.9	6270.03	2321.03	177.92
60	1611.99	6447.95	7217.00	87.5	6313.74	4414.69	134.21

Table 2.1.22(c)

28 JAN 76 - 09:27:52 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 2 - A INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1611.99	8059.93	7217.00	25.1	1809.13	0.00	6250.80
10	1611.99	8059.93	7217.00	49.5	3572.25	0.00	4487.68
15	1611.99	8059.93	7217.00	72.5	5235.47	48.00	2824.46
20	1611.99	8059.93	7217.00	91.2	6581.17	328.82	1478.76
25	1611.99	8059.93	7217.00	93.8	6770.36	1596.39	1289.57
30	1611.99	8059.93	7217.00	94.3	6807.01	2901.01	1252.92
35	1611.99	8059.93	7217.00	94.7	6836.71	4176.09	1223.22
60	1611.99	8059.93	7217.00	95.7	6904.64	10588.54	1155.29
COLLECTOR AREA = 60 SQ-M							
5	1611.99	9671.92	7217.00	25.1	1812.89	0.00	7859.04
10	1611.99	9671.92	7217.00	49.7	3586.67	0.00	6085.25
15	1611.99	9671.92	7217.00	73.0	5271.79	48.00	4400.13
20	1611.99	9671.92	7217.00	92.5	6674.44	337.90	2997.49
25	1611.99	9671.92	7217.00	96.0	6928.72	1778.28	2741.20
30	1611.99	9671.92	7217.00	96.9	6996.35	3341.30	2668.58
35	1611.99	9671.92	7217.00	97.6	7045.82	4863.18	2616.81
60	1611.99	9671.92	7217.00	99.1	7155.02	12772.14	2507.61

Table 2.1.22(d)

28 JAN 76 - 09:29:30 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 2 - A INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 70 SQ-M							
5	1611.99	11283.91	7217.00	25.2	1815.78	0.00	9468.12
10	1611.99	11283.91	7217.00	49.9	3598.13	0.00	7685.77
15	1611.99	11283.91	7217.00	73.5	5301.37	48.00	5982.53
20	1611.99	11283.91	7217.00	93.1	6721.70	338.00	4562.20
25	1611.99	11283.91	7217.00	96.8	6987.90	1808.04	4294.01
30	1611.99	11283.91	7217.00	97.8	7061.77	3484.56	4215.13
35	1611.99	11283.91	7217.00	98.6	7115.63	5136.02	4156.27
60	1611.99	11283.91	7217.00	99.8	7203.30	13744.06	4043.61
COLLECTOR AREA = 80 SQ-M							
5	1611.99	12895.90	7217.00	25.2	1818.04	0.00	11077.86
10	1611.99	12895.90	7217.00	50.0	3606.70	0.00	9289.19
15	1611.99	12895.90	7217.00	73.7	5318.60	48.00	7577.30
20	1611.99	12895.90	7217.00	93.6	6757.06	338.00	6138.84
25	1611.99	12895.90	7217.00	97.4	7029.76	1826.77	5864.14
30	1611.99	12895.90	7217.00	98.3	7097.60	3543.82	5791.30
35	1611.99	12895.90	7217.00	99.0	7145.98	5267.02	5737.91
60	1611.99	12895.90	7217.00	99.8	7205.34	14159.58	5653.55

Table 2.1.22(e)

28 JAN 76 - 09:31:22 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 2 - A INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 90 SQ-M							
5	1611.99	14507.88	7217.00	25.2	1820.00	0.00	12687.88
10	1611.99	14507.88	7217.00	50.1	3612.54	0.00	10895.34
15	1611.99	14507.88	7217.00	73.9	5332.01	48.00	9175.87
20	1611.99	14507.88	7217.00	94.1	6789.55	338.00	7718.33
25	1611.99	14507.88	7217.00	97.8	7060.74	1838.70	7445.14
30	1611.99	14507.88	7217.00	98.7	7121.10	3579.92	7379.78
35	1611.99	14507.88	7217.00	99.3	7164.77	5335.14	7331.11
60	1611.99	14507.88	7217.00	99.9	7206.79	14312.90	7264.09
COLLECTOR AREA = 100 SQ-M							
5	1611.99	16119.87	7217.00	25.2	1821.67	0.00	14298.20
10	1611.99	16119.87	7217.00	50.1	3618.26	0.00	12501.61
15	1611.99	16119.87	7217.00	74.0	5343.62	48.00	10776.25
20	1611.99	16119.87	7217.00	94.3	6808.50	338.56	9311.37
25	1611.99	16119.87	7217.00	98.2	7085.19	1849.11	9032.68
30	1611.99	16119.87	7217.00	98.9	7139.86	3603.66	8973.01
35	1611.99	16119.87	7217.00	99.4	7176.65	5372.10	8931.22
60	1611.99	16119.87	7217.00	99.9	7208.10	14393.77	8874.77

28 JAN 76 - 09:45:56 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 2 - A INSOLATION DATA - NOMINAL LOAD 2

Figure 2.1.22(a)

28 JAN 76 - 09:40:37 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 2 - A INSOLATION DATA - NOMINAL LOAD 2

Figure 2.1.22(b)

28 JAN 76 - 09:35:36 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 2 - A INSOLATION DATA - NOMINAL LOAD 2.

Figure 2.1.22(c)

Table 2.1.23(a)

28 JAN 76 - 10:29:02 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 3A - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTEDLOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 10 SQ-M							
5	1611.99	1611.99	12160.83	13.1	1590.31	0.00	21.68
10	1611.99	1611.99	12160.83	13.3	1611.99	0.00	0.00
15	1611.99	1611.99	12160.83	13.3	1611.99	0.00	0.00
20	1611.99	1611.99	12160.83	13.3	1611.99	0.00	0.00
25	1611.99	1611.99	12160.83	13.3	1611.99	0.00	0.00
30	1611.99	1611.99	12160.83	13.3	1611.99	0.00	0.00
35	1611.99	1611.99	12160.83	13.3	1611.99	0.00	0.00
60	1611.99	1611.99	12160.83	13.3	1611.99	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1611.99	3223.97	12160.83	14.6	1773.26	0.00	1450.71
10	1611.99	3223.97	12160.83	26.2	3180.62	0.00	43.36
15	1611.99	3223.97	12160.83	26.5	3223.97	0.00	0.00
20	1611.99	3223.97	12160.83	26.5	3223.97	0.00	0.00
25	1611.99	3223.97	12160.83	26.5	3223.97	0.00	0.00
30	1611.99	3223.97	12160.83	26.5	3223.97	0.00	0.00
35	1611.99	3223.97	12160.83	26.5	3223.97	0.00	0.00
60	1611.99	3223.97	12160.83	26.5	3223.97	0.00	0.00

Table 2.1.23(b)

28 JAN 76 - 10:30:42 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 3A - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTEDLOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 30 SQ-M							
5	1611.99	4835.96	12160.83	14.7	1793.34	0.00	3042.62
10	1611.99	4835.96	12160.83	28.8	3502.67	0.00	1333.29
15	1611.99	4835.96	12160.83	39.2	4770.93	0.00	65.03
20	1611.99	4835.96	12160.83	39.7	4822.45	47.85	13.51
25	1611.99	4835.96	12160.83	39.7	4827.45	79.38	8.51
30	1611.99	4835.96	12160.83	39.7	4832.45	104.16	3.51
35	1611.99	4835.96	12160.83	39.8	4835.96	119.35	0.00
60	1611.99	4835.96	12160.83	39.8	4835.96	119.35	0.00
.							
COLLECTOR AREA = 40 SQ-M							
5	1611.99	6447.95	12160.83	14.8	1803.35	0.00	4644.60
10	1611.99	6447.95	12160.83	29.2	3546.53	0.00	2901.42
15	1611.99	6447.95	12160.83	42.8	5205.91	0.00	1242.04
20	1611.99	6447.95	12160.83	50.4	6128.34	411.69	319.01
25	1611.99	6447.95	12160.83	51.2	6222.66	795.10	224.69
30	1611.99	6447.95	12160.83	51.4	6250.58	1170.41	196.77
35	1611.99	6447.95	12160.83	51.5	6265.58	1567.84	181.77
60	1611.99	6447.95	12160.83	52.0	6328.41	3238.76	118.94

Table 2.1.23(c)

28 JAN 76 - 10:32:46 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 3A - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1611.99	8059.93	12160.83	14.9	1809.13	0.00	6250.80
10	1611.99	8059.93	12160.83	29.4	3572.25	0.00	4487.68
15	1611.99	8059.93	12160.83	43.4	5283.09	0.38	2776.84
20	1611.99	8059.93	12160.83	52.8	6426.94	561.98	1629.99
25	1611.99	8059.93	12160.83	59.2	7197.08	1212.09	854.86
30	1611.99	8059.93	12160.83	60.1	7309.50	1880.72	737.44
35	1611.99	8059.93	12160.83	60.4	7349.17	2576.71	693.27
60	1611.99	8059.93	12160.83	60.9	7409.33	6262.68	614.72
COLLECTOR AREA = 60 SQ-M							
5	1611.99	9671.92	12160.83	14.9	1812.89	0.00	7859.04
10	1611.99	9671.92	12160.83	29.5	3586.67	0.00	6085.25
15	1611.99	9671.92	12160.83	43.7	5319.42	0.38	4352.51
20	1611.99	9671.92	12160.83	53.3	6484.56	596.53	3184.37
25	1611.99	9671.92	12160.83	61.4	7462.69	1351.36	2201.23
30	1611.99	9671.92	12160.83	66.6	8097.91	2193.76	1561.02
35	1611.99	9671.92	12160.83	67.3	8183.90	3127.45	1470.02
60	1611.99	9671.92	12160.83	68.1	8280.39	8091.64	1348.53

Table 2.1.23(d)

28 JAN 76 - 10:34:37 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 3A - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 70 SQ-M							
5	1611.99	11283.91	12160.83	14.9	1815.78	0.00	9468.12
10	1611.99	11283.91	12160.83	29.6	3598.13	0.00	7685.77
15	1611.99	11283.91	12160.83	44.0	5349.00	0.38	5934.91
20	1611.99	11283.91	12160.83	53.5	6511.92	616.94	4768.98
25	1611.99	11283.91	12160.83	61.8	7516.14	1386.24	3759.77
30	1611.99	11283.91	12160.83	68.5	8334.04	2293.49	2936.87
35	1611.99	11283.91	12160.83	72.6	8824.10	3323.93	2441.81
60	1611.99	11283.91	12160.83	73.7	8961.81	8708.48	2279.10
COLLECTOR AREA = 80 SQ-M							
5	1611.99	12895.90	12160.83	14.9	1818.04	0.00	11077.86
10	1611.99	12895.90	12160.83	29.7	3606.70	0.00	9289.19
15	1611.99	12895.90	12160.83	44.1	5366.22	0.38	7529.67
20	1611.99	12895.90	12160.83	53.7	6528.85	626.57	6364.05
25	1611.99	12895.90	12160.83	62.0	7539.15	1410.97	5348.74
30	1611.99	12895.90	12160.83	69.0	8390.68	2335.29	4492.22
35	1611.99	12395.90	12160.83	74.4	9052.20	3389.88	3825.69
60	1611.99	12395.90	12160.83	78.9	9590.00	9040.39	3262.90

Table 2.1.23(e)

28 JAN 76 - 10:36:57 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 3A - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTEDLOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 90 SQ-M							
5	1611.99	14507.88	12160.83	15.0	1820.00	0.00	12687.88
10	1611.99	14507.88	12160.83	29.7	3612.54	0.00	10895.34
15	1611.99	14507.88	12160.83	44.2	5379.63	0.38	9128.25
20	1611.99	14507.88	12160.83	53.8	6541.87	631.85	7963.02
25	1611.99	14507.88	12160.83	62.1	7547.23	1424.70	6952.65
30	1611.99	14507.88	12160.83	69.2	8411.49	2353.65	6083.39
35	1611.99	14507.88	12160.83	75.0	9124.98	3418.12	5364.91
60	1611.99	14507.88	12160.83	83.4	10144.55	9291.65	4320.33
.							
COLLECTOR AREA = 100 SQ-M							
5	1611.99	16119.87	12160.83	15.0	1821.67	0.00	14298.20
10	1611.99	16119.87	12160.83	29.8	3618.26	0.00	12501.61
15	1611.99	16119.87	12160.83	44.3	5391.24	0.38	10728.63
20	1611.99	16119.87	12160.83	53.9	6553.59	633.59	9563.28
25	1611.99	16119.87	12160.83	62.1	7554.49	1432.69	8557.38
30	1611.99	16119.87	12160.83	69.3	8424.40	2363.42	7682.47
35	1611.99	16119.87	12160.83	75.2	9148.12	3429.43	6953.75
60	1611.99	16119.87	12160.83	87.6	10658.35	9492.21	5418.52

28 JAN 76 - 10:49:02 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 3A - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

Figure 2.1.23(a)

28 JAN 76 - 10:45:26 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 3A - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

Figure 2.1.23(b)

28 JAN 76 - 10:41:07 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 3A - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

Figure 2.1.23(c)

Table 2.1.24(a)

28 JAN 76 - 09:56:48 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 3B - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 10 SQ-M							
5	1611.99	1611.99	14350.83	11.1	1590.31	0.00	21.68
10	1611.99	1611.99	14350.83	11.2	1611.99	0.00	0.00
15	1611.99	1611.99	14350.83	11.2	1611.99	0.00	0.00
20	1611.99	1611.99	14350.83	11.2	1611.99	0.00	0.00
25	1611.99	1611.99	14350.83	11.2	1611.99	0.00	0.00
30	1611.99	1611.99	14350.83	11.2	1611.99	0.00	0.00
35	1611.99	1611.99	14350.83	11.2	1611.99	0.00	0.00
60	1611.99	1611.99	14350.83	11.2	1611.99	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1611.99	3223.97	14350.83	12.4	1773.26	0.00	1450.71
10	1611.99	3223.97	14350.83	22.2	3180.62	0.00	43.36
15	1611.99	3223.97	14350.83	22.5	3223.97	0.00	0.00
20	1611.99	3223.97	14350.83	22.5	3223.97	0.00	0.00
25	1611.99	3223.97	14350.83	22.5	3223.97	0.00	0.00
30	1611.99	3223.97	14350.83	22.5	3223.97	0.00	0.00
35	1611.99	3223.97	14350.83	22.5	3223.97	0.00	0.00
60	1611.99	3223.97	14350.83	22.5	3223.97	0.00	0.00

Table 2.1.24(b)

28 JAN 76 - 09:58:24 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 3B - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 30 SQ-M							
5	1611.99	4835.96	14350.83	12.5	1793.34	0.00	3042.62
10	1611.99	4835.96	14350.83	24.4	3502.67	0.00	1333.29
15	1611.99	4835.96	14350.83	33.2	4770.93	0.00	65.03
20	1611.99	4835.96	14350.83	33.7	4835.96	0.00	0.00
25	1611.99	4835.96	14350.83	33.7	4835.96	0.00	0.00
30	1611.99	4835.96	14350.83	33.7	4835.96	0.00	0.00
35	1611.99	4835.96	14350.83	33.7	4835.96	0.00	0.00
60	1611.99	4835.96	14350.83	33.7	4835.96	0.00	0.00
COLLECTOR AREA = 40 SQ-M							
5	1611.99	6447.95	14350.83	12.6	1803.35	0.00	4644.60
10	1611.99	6447.95	14350.83	24.7	3546.53	0.00	2901.42
15	1611.99	6447.95	14350.83	36.3	5205.91	0.00	1242.04
20	1611.99	6447.95	14350.83	44.3	6361.24	0.00	86.71
25	1611.99	6447.95	14350.83	44.8	6436.04	30.71	11.91
30	1611.99	6447.95	14350.83	44.9	6441.04	60.98	6.91
35	1611.99	6447.95	14350.83	44.9	6446.04	78.99	1.91
60	1611.99	6447.95	14350.83	44.9	6447.95	82.80	0.00

Table 2.1.24(c)

28 JAN 76 - 09:59:57 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 3B - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1611.99	8059.93	14350.83	12.6	1803.13	0.00	6250.80
10	1611.99	8059.93	14350.83	24.9	3572.25	0.00	4487.68
15	1611.99	8059.93	14350.83	36.8	5283.47	0.00	2776.46
20	1611.99	8059.93	14350.83	48.0	6894.16	0.00	1165.77
25	1611.99	8059.93	14350.83	54.5	7822.50	243.82	237.43
30	1611.99	8059.93	14350.83	55.2	7921.62	495.55	138.31
35	1611.99	8059.93	14350.83	55.4	7951.32	707.87	108.61
60	1611.99	8059.93	14350.83	55.7	7998.55	1595.91	61.28
COLLECTOR AREA = 60 SQ-M							
5	1611.99	9671.92	14350.83	12.6	1812.89	0.00	7859.04
10	1611.99	9671.92	14350.83	25.0	3586.67	0.00	6085.25
15	1611.99	9671.92	14350.83	37.1	5319.79	0.00	4352.13
20	1611.99	9671.92	14350.83	48.8	7005.34	0.00	2666.58
25	1611.99	9671.92	14350.83	57.4	8242.59	400.54	1427.33
30	1611.99	9671.92	14350.83	62.7	8993.25	952.90	671.67
35	1611.99	9671.92	14350.83	63.6	9129.33	1474.26	533.30
60	1611.99	9671.92	14350.83	64.6	9266.18	4262.41	396.45

Table 2.1.24(d)

28 JAN 76 - 10:02:02 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 3B - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 70 SQ-M							
5	1611.99	11283.91	14350.83	12.7	1815.78	0.00	9468.12
10	1611.99	11283.91	14350.83	25.1	3598.13	0.00	7685.77
15	1611.99	11283.91	14350.83	37.3	5349.37	0.00	5934.53
20	1611.99	11283.91	14350.83	49.2	7057.70	0.00	4226.20
25	1611.99	11283.91	14350.83	58.1	8336.46	433.22	2945.45
30	1611.99	11283.91	14350.83	65.0	9327.07	1115.26	1949.84
35	1611.99	11283.91	14350.83	69.6	9983.79	1831.05	1288.11
60	1611.99	11283.91	14350.83	71.3	10237.96	6199.36	1008.95
COLLECTOR AREA = 80 SQ-M							
5	1611.99	12895.90	14350.83	12.7	1818.04	0.00	11077.86
10	1611.99	12895.90	14350.83	25.1	3606.70	0.00	9289.19
15	1611.99	12895.90	14350.83	37.4	5366.60	0.00	7529.30
20	1611.99	12895.90	14350.83	49.4	7093.06	0.00	5802.84
25	1611.99	12895.90	14350.83	58.5	8389.76	452.12	4504.14
30	1611.99	12895.90	14350.83	65.6	9415.62	1176.02	3473.27
35	1611.99	12895.90	14350.83	71.5	10267.88	1998.38	2616.02
60	1611.99	12895.90	14350.83	76.2	10930.51	7120.39	1928.39

Table 2.1.24(e)

28 JAN 76 - 10:03:46 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1982 - CASE 3B - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 90 SQ-M							
5	1611.99	14507.88	14350.83	12.7	1820.00	0.00	12687.88
10	1611.99	14507.88	14350.83	25.2	3612.54	0.00	10895.34
15	1611.99	14507.88	14350.83	37.5	5380.01	0.00	9127.87
20	1611.99	14507.88	14350.83	49.7	7125.55	0.00	7382.33
25	1611.99	14507.88	14350.83	58.7	8421.55	462.20	6084.34
30	1611.99	14507.88	14350.83	65.9	9452.60	1210.08	5048.29
35	1611.99	14507.88	14350.83	72.2	10360.11	2058.91	4135.77
60	1611.99	14507.88	14350.83	80.6	11568.65	7455.72	2902.24

COLLECTOR AREA = 100 SQ-M

5	1611.99	16119.87	14350.83	12.7	1821.67	0.00	14298.20
10	1611.99	16119.87	14350.83	25.2	3618.26	0.00	12501.61
15	1611.99	16119.87	14350.83	37.6	5391.62	0.00	10728.25
20	1611.99	16119.87	14350.83	49.8	7144.50	0.00	8975.37
25	1611.99	16119.87	14350.83	58.9	8445.99	470.75	7671.88
30	1611.99	16119.87	14350.83	66.1	9479.60	1231.36	6633.27
35	1611.99	16119.87	14350.83	72.4	10393.77	2090.99	5714.10
60	1611.99	16119.87	14350.83	84.6	12142.34	7689.79	3940.53

28 JAN 76 - 10:22:50 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 3B - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

Figure 2.1.24(a)

28 JAN 76 - 10:18:34 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 3B - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

LOAD PROVIDED BY STORAGE

Figure 2.1.24(b)

28 JAN 76 - 10:11:49 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 3B - A INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA COMPUTED

Figure 2.1.24(c)

Table 2.1.25(a)

17 MAY 76 - 05:00:32 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 1 - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 10 SQ-M							
5	1246.16	1246.16	5027.00	24.7	1242.63	0.00	3.52
10	1246.16	1246.16	5027.00	24.8	1246.16	0.00	0.00
15	1246.16	1246.16	5027.00	24.8	1246.16	0.00	0.00
20	1246.16	1246.16	5027.00	24.8	1246.16	0.00	0.00
25	1246.16	1246.16	5027.00	24.8	1246.16	0.00	0.00
30	1246.16	1246.16	5027.00	24.8	1246.16	0.00	0.00
35	1246.16	1246.16	5027.00	24.8	1246.16	0.00	0.00
60	1246.16	1246.16	5027.00	24.8	1246.16	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1246.16	2492.31	5027.00	33.6	1691.09	0.00	801.24
10	1246.16	2492.31	5027.00	49.2	2472.07	47.45	20.25
15	1246.16	2492.31	5027.00	49.4	2484.12	109.70	8.20
20	1246.16	2492.31	5027.00	49.5	2489.12	164.56	3.20
25	1246.16	2492.31	5027.00	49.6	2492.31	192.66	0.00
30	1246.16	2492.31	5027.00	49.6	2492.31	192.66	0.00
35	1246.16	2492.31	5027.00	49.6	2492.31	192.66	0.00
60	1246.16	2492.31	5027.00	49.6	2492.31	192.66	0.00

Table 2.1.25(b)

17 MAY 76 - 05:02:17 PM

PVEFS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 1 - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 30 SQ-M							
5	1246.16	3738.47	5027.00	35.2	1768.24	0.00	1970.23
10	1246.16	3738.47	5027.00	62.2	3127.30	63.58	611.17
15	1246.16	3738.47	5027.00	72.6	3647.89	219.41	90.58
20	1246.16	3738.47	5027.00	73.0	3670.80	404.45	67.67
25	1246.16	3738.47	5027.00	73.2	3680.80	543.78	57.67
30	1246.16	3738.47	5027.00	73.3	3686.20	648.57	52.27
35	1246.16	3738.47	5027.00	73.4	3691.20	753.31	47.27
60	1246.16	3738.47	5027.00	73.9	3716.20	1314.03	22.27
COLLECTOR AREA = 40 SQ-M							
5	1246.16	4984.63	5027.00	35.8	1800.87	0.00	3183.76
10	1246.16	4984.63	5027.00	65.1	3322.43	64.00	1662.20
15	1246.16	4984.63	5027.00	84.4	4244.93	448.38	739.70
20	1246.16	4984.63	5027.00	87.4	4395.12	1441.76	589.51
25	1246.16	4984.63	5027.00	88.5	4449.97	2417.36	534.66
30	1246.16	4984.63	5027.00	89.0	4472.96	3341.84	511.67
35	1246.16	4984.63	5027.00	89.2	4484.17	4249.74	500.45
60	1246.16	4984.63	5027.00	89.9	4516.95	9015.18	467.68

Table 2.1.25(c)

17 MAY 76 - 05:05:28 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 1 - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1246.16	6230.78	5027.00	36.1	1816.75	0.00	4414.03
10	1246.16	6230.78	5027.00	67.9	3411.74	64.00	2819.04
15	1246.16	6230.78	5027.00	88.9	4468.02	507.89	1762.76
20	1246.16	6230.78	5027.00	92.9	4670.42	1833.33	1560.36
25	1246.16	6230.78	5027.00	94.5	4752.08	3230.68	1478.70
30	1246.16	6230.78	5027.00	95.4	4798.16	4650.26	1432.62
35	1246.16	6230.78	5027.00	96.1	4830.35	6107.89	1400.73
60	1246.16	6230.78	5027.00	97.0	4874.98	13898.21	1334.85
COLLECTOR AREA = 60 SQ-M							
5	1246.16	7476.94	5027.00	36.3	1823.08	0.00	5653.87
10	1246.16	7476.94	5027.00	69.1	3472.49	64.00	4004.46
15	1246.16	7476.94	5027.00	91.2	4582.62	524.42	2894.32
20	1246.16	7476.94	5027.00	95.0	4776.85	1975.75	2700.09
25	1246.16	7476.94	5027.00	95.8	4866.61	3537.55	2610.33
30	1246.16	7476.94	5027.00	97.5	4900.03	5162.25	2572.52
35	1246.16	7476.94	5027.00	97.8	4915.59	6802.85	2551.97
60	1246.16	7476.94	5027.00	98.4	4945.46	15042.09	2497.09

Table 2.1.25(d)

17 MAY 76 - 05:07:18 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 1 - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 70 SQ-M							
5	1246.16	8723.10	5027.00	36.3	1824.42	0.00	6898.68
10	1246.16	8723.10	5027.00	69.8	3511.04	64.00	5212.06
15	1246.16	8723.10	5027.00	92.8	4662.88	534.06	4060.21
20	1246.16	8723.10	5027.00	96.4	4845.90	2049.38	3877.20
25	1246.16	8723.10	5027.00	97.8	4918.47	3692.94	3803.85
30	1246.16	8723.10	5027.00	98.3	4941.66	5387.14	3775.65
35	1246.16	8723.10	5027.00	98.4	4948.12	7115.24	3764.19
60	1246.16	8723.10	5027.00	98.9	4973.12	15592.45	3714.19
COLLECTOR AREA = 80 SQ-M							
5	1246.16	9969.26	5027.00	36.3	1825.00	0.00	8144.26
10	1246.16	9969.26	5027.00	70.4	3537.74	64.00	6431.52
15	1246.16	9969.26	5027.00	93.9	4721.22	541.78	5248.04
20	1246.16	9969.26	5027.00	97.2	4886.18	2110.22	5083.07
25	1246.16	9969.26	5027.00	98.3	4942.76	3795.21	5024.31
30	1246.16	9969.26	5027.00	98.7	4961.66	5539.98	5000.41
35	1246.16	9969.26	5027.00	98.9	4972.26	7287.95	4934.82
60	1246.16	9969.26	5027.00	99.4	4997.80	15957.92	4934.27

Table 2.1.25(e)

17 MAY 76 - 05:08:58 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 1 - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 90 SQ-M							
5	1246.16	11215.41	5027.00	36.3	1825.00	0.00	9390.41
10	1246.16	11215.41	5027.00	70.8	3556.71	64.00	7658.71
15	1246.16	11215.41	5027.00	94.8	4766.33	551.17	6449.09
20	1246.16	11215.41	5027.00	97.9	4919.80	2145.04	5295.61
25	1246.16	11215.41	5027.00	98.7	4960.36	3872.47	6251.47
30	1246.16	11215.41	5027.00	99.0	4976.13	5631.27	6230.70
35	1246.16	11215.41	5027.00	99.2	4985.20	7405.36	6216.63
60	1246.16	11215.41	5027.00	99.5	5001.62	16235.81	6175.21
COLLECTOR AREA = 100 SQ-M							
5	1246.16	12461.57	5027.00	36.3	1825.00	0.00	10636.57
10	1246.16	12461.57	5027.00	71.0	3569.50	64.00	8892.07
15	1246.16	12461.57	5027.00	95.4	4797.05	554.00	7664.52
20	1246.16	12461.57	5027.00	98.4	4946.95	2161.05	7514.62
25	1246.16	12461.57	5027.00	99.0	4974.71	3911.90	7481.88
30	1246.16	12461.57	5027.00	99.2	4987.58	5683.81	7464.01
35	1246.16	12461.57	5027.00	99.3	4992.67	7468.63	7453.92
60	1246.16	12461.57	5027.00	99.5	5004.13	16390.26	7417.46

17 MAY 76 - 05:11:21 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 1 - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2

Figure 2.1.25(a)

17 MAY 76 - 05:14:55 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 1 - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2

Figure 2.1.25(b)

17 MAY 76 - 05:19:01 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 1 - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2

Figure 2.1.25(c)

Table 2.1.26(a)

18 MAY 76 - 11:04:43 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 2 - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STOAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 10 SQ-M							
5	1246.16	1246.16	7217.00	17.2	1242.63	0.00	3.52
10	1246.16	1246.16	7217.00	17.3	1246.16	0.00	0.00
15	1246.16	1246.16	7217.00	17.3	1246.16	0.00	0.00
20	1246.16	1246.16	7217.00	17.3	1246.16	0.00	0.00
25	1246.16	1246.16	7217.00	17.3	1246.16	0.00	0.00
30	1246.16	1246.16	7217.00	17.3	1246.16	0.00	0.00
35	1246.16	1246.16	7217.00	17.3	1246.16	0.00	0.00
60	1246.16	1246.16	7217.00	17.3	1246.16	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1246.16	2492.31	7217.00	23.4	1691.08	0.00	801.24
10	1246.16	2492.31	7217.00	34.4	2485.26	0.00	7.05
15	1246.16	2492.31	7217.00	34.5	2492.31	0.00	0.00
20	1246.16	2492.31	7217.00	34.5	2492.31	0.00	0.00
25	1246.16	2492.31	7217.00	34.5	2492.31	0.00	0.00
30	1246.16	2492.31	7217.00	34.5	2492.31	0.00	0.00
35	1246.16	2492.31	7217.00	34.5	2492.31	0.00	0.00
60	1246.16	2492.31	7217.00	34.5	2492.31	0.00	0.00

Table 2.1.26(b)

18 MAY 76 - 11:05:29 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 2 - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 30 SQ-M							
5	1246.16	3738.47	7217.00	24.5	1768.24	0.00	1970.23
10	1246.16	3738.47	7217.00	44.1	3179.39	0.00	559.08
15	1246.16	3738.47	7217.00	51.7	3727.90	5.92	10.57
20	1246.16	3738.47	7217.00	51.8	3738.47	5.92	0.00
25	1246.16	3738.47	7217.00	51.8	3738.47	5.92	0.00
30	1246.16	3738.47	7217.00	51.8	3738.47	5.92	0.00
35	1246.16	3738.47	7217.00	51.8	3738.47	5.92	0.00
60	1246.16	3738.47	7217.00	51.8	3738.47	5.92	0.00
COLLECTOR AREA = 40 SQ-M							
5	1246.16	4984.63	7217.00	25.0	1800.87	0.00	3183.76
10	1246.16	4984.63	7217.00	46.9	3392.16	0.00	1602.47
15	1246.16	4984.63	7217.00	63.1	4551.73	38.24	432.90
20	1246.16	4984.63	7217.00	69.5	4943.10	99.98	41.53
25	1246.16	4984.63	7217.00	68.8	4962.75	198.82	21.88
30	1246.16	4984.63	7217.00	68.8	4968.01	267.56	16.62
35	1246.16	4984.63	7217.00	68.9	4973.01	338.68	11.62
60	1246.16	4984.63	7217.00	69.1	4984.63	482.00	0.00

Table 2.1.26(c)

18 MAY 76 - 11:08:32 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 2 - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1246.16	6230.78	7217.00	25.2	1816.75	0.00	4414.03
10	1246.16	6230.78	7217.00	48.2	3475.40	0.00	2755.38
15	1246.16	6230.78	7217.00	67.4	4864.44	42.90	1366.34
20	1246.16	6230.78	7217.00	79.9	5769.59	240.35	461.19
25	1246.16	6230.78	7217.00	82.3	5942.26	884.71	288.52
30	1246.16	6230.78	7217.00	82.9	5982.84	1458.38	247.94
35	1246.16	6230.78	7217.00	83.2	6001.49	2016.55	229.29
60	1246.16	6230.78	7217.00	84.0	6062.59	5037.59	168.19
COLLECTOR AREA = 60 SQ-M							
5	1246.16	7476.94	7217.00	25.3	1823.08	0.00	5653.87
10	1246.16	7476.94	7217.00	49.0	3535.49	0.00	3940.46
15	1246.16	7476.94	7217.00	69.7	5031.64	47.47	2445.30
20	1246.16	7476.94	7217.00	84.9	6124.38	293.34	1352.57
25	1246.16	7476.94	7217.00	88.9	6414.47	1308.75	1062.48
30	1246.16	7476.94	7217.00	90.4	6527.52	2380.29	949.42
35	1246.16	7476.94	7217.00	91.3	6586.52	3443.10	890.42
60	1246.16	7476.94	7217.00	93.0	6714.85	8864.06	762.09

Table 2.1.26(d)

18 MAY 76 - 11:10:12 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 2 - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M.	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 70 SQ-M.							
5	1246.16	8723.10	7217.00	25.3	1824.42	0.00	6898.68
10	1246.16	8723.10	7217.00	49.5	3575.04	0.00	5148.06
15	1246.16	8723.10	7217.00	71.0	5126.60	48.00	3596.50
20	1246.16	8723.10	7217.00	87.8	6337.61	312.89	2385.48
25	1246.16	8723.10	7217.00	92.1	6646.43	1529.33	2076.67
30	1246.16	8723.10	7217.00	93.8	6767.07	2925.05	1956.02
35	1246.16	8723.10	7217.00	94.8	6844.30	4308.38	1878.80
60	1246.16	8723.10	7217.00	96.8	6989.16	11636.44	1722.20
COLLECTOR AREA = 80 SQ-M.							
5	1246.16	9969.26	7217.00	25.3	1825.00	0.00	8144.26
10	1246.16	9969.26	7217.00	49.9	3601.74	0.00	6367.52
15	1246.16	9969.26	7217.00	72.0	5199.10	48.00	4770.15
20	1246.16	9969.26	7217.00	89.5	6462.59	325.86	3506.66
25	1246.16	9969.26	7217.00	93.8	6766.47	1627.30	3202.78
30	1246.16	9969.26	7217.00	95.5	6889.36	3127.31	3079.90
35	1246.16	9969.26	7217.00	96.6	6969.98	4665.63	2999.09
60	1246.16	9969.26	7217.00	97.9	7066.90	12715.68	2877.18

Table 2.1.26(e)

18 MAY 76 - 11:11:54 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 2 - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 90 SQ-M							
5	1246.16	11215.41	7217.00	25.3	1825.00	0.00	9390.41
10	1246.16	11215.41	7217.00	50.2	3620.71	0.00	7594.71
15	1246.16	11215.41	7217.00	72.8	5256.73	48.00	5958.68
20	1246.16	11215.41	7217.00	90.8	6550.79	330.00	4664.62
25	1246.16	11215.41	7217.00	94.9	6950.91	1672.19	4364.50
30	1246.16	11215.41	7217.00	96.5	6963.12	3239.33	4252.29
35	1246.16	11215.41	7217.00	97.6	7040.94	4840.83	4172.89
60	1246.16	11215.41	7217.00	98.4	7103.44	13273.84	4085.39
.							
COLLECTOR AREA = 100 SQ-M							
5	1246.16	12461.57	7217.00	25.3	1825.00	0.00	10636.57
10	1246.16	12461.57	7217.00	50.3	3633.50	0.00	8828.07
15	1246.16	12461.57	7217.00	73.4	5298.49	48.00	7163.08
20	1246.16	12461.57	7217.00	91.8	6626.45	333.01	5835.12
25	1246.16	12461.57	7217.00	95.9	6917.55	1724.51	5544.02
30	1246.16	12461.57	7217.00	97.3	7020.17	3336.50	5441.40
35	1246.16	12461.57	7217.00	98.1	7079.48	4998.35	5379.11
60	1246.16	12461.57	7217.00	98.8	7130.60	13604.23	5302.99

18 MAY 76 - 11:14:13 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 2 - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

Figure 2.1.26(a)

18 MAY 76 - 11:17:52 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 2 - CSU INSOLATION DATA (M1) - NOMINAL LOAD.2

Figure 2.1.26(b)

18 MAY 76 - 03:31:06 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 2 - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2

Figure 2.1.26(c)

Table 2.1.27(a)

18 MAY 76 - 04:21:21 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 3A - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2 - CSU A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 10 SQ-M							
5	1246.16	1246.16	10344.38	12.0	1242.63	0.00	3.52
10	1246.16	1246.16	10344.38	12.0	1246.16	0.00	0.00
15	1246.16	1246.16	10344.38	12.0	1245.16	0.00	0.00
20	1246.16	1246.16	10344.38	12.0	1245.16	0.00	0.00
25	1246.16	1246.16	10344.38	12.0	1245.16	0.00	0.00
30	1246.16	1246.16	10344.38	12.0	1246.16	0.00	0.00
35	1246.16	1246.16	10344.38	12.0	1246.16	0.00	0.00
60	1246.16	1246.16	10344.38	12.0	1246.16	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1246.16	2492.31	10344.38	16.3	1691.08	0.00	801.24
10	1246.16	2492.31	10344.38	24.0	2485.26	0.00	7.05
15	1246.16	2492.31	10344.38	24.1	2492.31	0.00	0.00
20	1246.16	2492.31	10344.38	24.1	2492.31	0.00	0.00
25	1246.16	2492.31	10344.38	24.1	2492.31	0.00	0.00
30	1246.16	2492.31	10344.38	24.1	2492.31	0.00	0.00
35	1246.16	2492.31	10344.38	24.1	2492.31	0.00	0.00
60	1246.16	2492.31	10344.38	24.1	2492.31	0.00	0.00

Table 2.1.27(b)

18 MAY 76 - 04:23:06 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 3A - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2 - CSU A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 30 SQ-M							
5	1246.16	3738.47	10344.38	17.1	1768.24	0.00	1970.23
10	1246.16	3738.47	10344.38	30.7	3179.39	0.00	559.08
15	1246.16	3738.47	10344.38	36.0	3726.53	2.03	11.95
20	1246.16	3738.47	10344.38	36.1	3738.47	9.82	0.00
25	1246.16	3738.47	10344.38	36.1	3738.47	9.82	0.00
30	1246.16	3738.47	10344.38	36.1	3738.47	9.82	0.00
35	1246.16	3738.47	10344.38	36.1	3738.47	9.82	0.00
60	1246.16	3738.47	10344.38	36.1	3738.47	9.82	0.00
° COLLECTOR AREA = 40 SQ-M							
5	1246.16	4984.63	10344.38	17.4	1800.87	0.00	3183.76
10	1246.16	4984.63	10344.38	32.7	3382.16	0.00	1602.47
15	1246.16	4984.63	10344.38	44.2	4568.57	8.19	416.06
20	1246.16	4984.63	10344.38	47.3	4890.24	207.18	94.39
25	1246.16	4984.63	10344.38	47.7	4932.95	330.97	51.68
30	1246.16	4984.63	10344.38	47.9	4949.82	388.67	34.80
35	1246.16	4984.63	10344.38	47.9	4959.82	431.89	24.80
60	1246.16	4984.63	10344.38	48.2	4984.63	544.91	0.00

Table 2.1.27(c)

18 MAY 76 - 04:24:52 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 3A - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2 - CSU A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 50 SQ-M							
5	1246.16	6230.78	10344.38	17.6	1816.75	0.00	4414.03
10	1246.16	6230.78	10344.38	33.6	3475.40	0.00	2755.38
15	1246.16	6230.78	10344.38	47.3	4892.67	8.19	1338.11
20	1246.16	6230.78	10344.38	54.8	5667.73	361.72	563.00
25	1246.16	6230.78	10344.38	56.9	5881.56	822.34	349.22
30	1246.16	6230.78	10344.38	57.5	5945.81	1299.27	284.98
35	1246.16	6230.78	10344.38	57.9	5986.26	1783.72	244.53
60	1246.16	6230.78	10344.38	59.0	6107.71	4123.35	102.12
COLLECTOR AREA = 60 SQ-M							
5	1246.16	7476.94	10344.38	17.6	1823.08	0.00	5653.87
10	1246.16	7476.94	10344.38	34.2	3536.49	0.00	3940.46
15	1246.16	7476.94	10344.38	49.0	5065.05	8.19	2411.89
20	1246.16	7476.94	10344.38	58.3	6033.71	431.85	1443.23
25	1246.16	7476.94	10344.38	63.3	6545.59	1053.09	931.36
30	1246.16	7476.94	10344.38	64.6	6690.79	1752.27	791.77
35	1246.16	7476.94	10344.38	65.0	6721.12	2472.53	746.44
60	1246.16	7476.94	10344.38	66.1	6840.03	6073.86	602.52

Table 2.1.27(d)

18 MAY 76 - 04:26:42 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 3A - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2 - CSU A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 70 SQ-M							
5	1246.16	3723.10	10344.38	17.6	1824.42	0.00	6898.68
10	1246.16	3723.10	10344.38	34.6	3575.04	0.00	5148.06
15	1246.16	3723.10	10344.38	49.9	5163.93	8.19	3559.16
20	1246.16	3723.10	10344.38	60.3	6232.99	458.39	2490.11
25	1246.16	3723.10	10344.38	67.0	6929.03	1147.74	1793.29
30	1246.16	3723.10	10344.38	70.3	7272.81	1935.86	1444.50
35	1246.16	3723.10	10344.38	71.1	7354.24	2762.58	1358.08
60	1246.16	3723.10	10344.38	72.1	7457.99	6899.59	1229.33
° COLLECTOR AREA = 80 SQ-M							
5	1246.16	9969.26	10344.38	17.6	1825.00	0.00	8144.26
10	1246.16	9969.26	10344.38	34.8	3601.74	0.00	6367.52
15	1246.16	9969.26	10344.38	50.6	5238.38	8.73	4730.88
20	1246.16	9969.26	10344.38	61.5	6360.31	482.80	3608.95
25	1246.16	9969.26	10344.38	69.0	7132.93	1212.80	2834.15
30	1246.16	9969.26	10344.38	74.1	7669.83	2074.30	2292.25
35	1246.16	9969.26	10344.38	76.4	7901.82	2997.90	2055.25
60	1246.16	9969.26	10344.38	77.8	8042.94	7593.80	1889.13

Table 2.1.27(e)

18 MAY 76 - 04:28:27 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 3A - CSU INSOLATION DATA (M1) - NOMINAL LOAD 2 - CSU A/C DATA

LCAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 90 SQ-M							
5	1246.16	11215.41	10344.38	17.6	1825.00	0.00	9390.41
10	1246.16	11215.41	10344.38	35.0	3620.71	0.00	7594.71
15	1246.16	11215.41	10344.38	51.2	5296.00	8.73	5919.41
20	1246.16	11215.41	10344.38	62.3	6448.94	495.87	4766.47
25	1246.16	11215.41	10344.38	70.4	7283.05	1267.73	3928.79
30	1246.16	11215.41	10344.38	76.3	7897.53	2161.73	3309.30
35	1246.16	11215.41	10344.38	80.2	8294.32	3172.49	2907.51
60	1246.16	11215.41	10344.38	82.9	8577.15	8301.74	2599.68
° COLLECTOR AREA = 100 SQ-M							
5	1246.16	12461.57	10344.38	17.6	1825.00	0.00	10636.57
10	1246.16	12461.57	10344.38	35.1	3633.50	0.00	8828.07
15	1246.16	12461.57	10344.38	51.6	5337.51	8.98	7124.06
20	1246.16	12461.57	10344.38	63.0	6519.08	505.77	5942.49
25	1246.16	12461.57	10344.38	71.3	7375.44	1311.63	5081.15
30	1246.16	12461.57	10344.38	77.7	8039.44	2262.68	4412.15
35	1246.16	12461.57	10344.38	82.5	8533.33	3314.06	3913.26
60	1246.16	12461.57	10344.38	87.5	9048.60	9030.84	3372.99

18 MAY 76 - 04:34:47 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 3A

CSU INSOLATION DATA (M1) - NOMINAL LOAD 2 - CSU A/C DATA

Figure 2.1.27(a)

18 MAY 76 - 04:37:34 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 3A

CSU INSOLATION DATA (M1) - NOMINAL LOAD 2 - CSU A/C DATA

LOAD PROVIDED BY STORAGE

Figure 2.1.27(b)

18 MAY 76 - 04:42:02 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 3A

CSU INSOLATION DATA (M1) - NOMINAL LOAD 2 - CSU A/C DATA

Figure 2.1.27(c)

Table 2.1.28(a)

18 MAY 76 - 04:58:26 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 3B - CSU INSOLATION DATA - NOMINAL LOAD 2 - CSU A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 10 SQ-M							
5	1246.16	1246.16	12534.38	9.9	1242.63	0.00	3.52
10	1246.16	1246.16	12534.38	9.9	1246.16	0.00	0.00
15	1246.16	1246.16	12534.38	9.9	1246.16	0.00	0.00
20	1246.16	1246.16	12534.38	9.9	1246.16	0.00	0.00
25	1246.16	1246.16	12534.38	9.9	1246.16	0.00	0.00
30	1246.16	1246.16	12534.38	9.9	1246.16	0.00	0.00
35	1246.16	1246.16	12534.38	9.9	1246.16	0.00	0.00
60	1246.16	1246.16	12534.38	9.9	1246.16	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1246.16	2492.31	12534.38	13.5	1651.08	0.00	801.24
10	1246.16	2492.31	12534.38	19.8	2455.26	0.00	7.05
15	1246.16	2492.31	12534.38	19.9	2492.31	0.00	0.00
20	1246.16	2492.31	12534.38	19.9	2492.31	0.00	0.00
25	1246.16	2492.31	12534.38	19.9	2492.31	0.00	0.00
30	1246.16	2492.31	12534.38	19.9	2492.31	0.00	0.00
35	1246.16	2492.31	12534.38	19.9	2492.31	0.00	0.00
60	1246.16	2492.31	12534.38	19.9	2492.31	0.00	0.00

Table 2.1.28(b)

18 MAY 76 - 05:03:01 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1950 - CASE 3B - CSU INSOLATION DATA - NOMINAL LOAD 2 - CSU A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KV-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KW-HR	KV-HR PER YEAR

COLLECTOR AREA = 30 SQ-M							
5	1246.16	3738.47	12534.38	14.1	1768.24	0.00	1970.23
10	1246.16	3738.47	12534.38	25.4	3179.39	0.00	559.08
15	1246.16	3738.47	12534.38	29.7	3727.90	0.00	10.57
20	1246.16	3738.47	12534.38	29.8	3738.47	0.00	0.00
25	1246.16	3738.47	12534.38	29.8	3738.47	0.00	0.00
30	1246.16	3738.47	12534.38	29.8	3738.47	0.00	0.00
35	1246.16	3738.47	12534.38	29.8	3738.47	0.00	0.00
60	1246.16	3738.47	12534.38	29.8	3738.47	0.00	0.00
COLLECTOR AREA = 40 SQ-M							
5	1246.16	4984.63	12534.38	14.4	1800.87	0.00	3183.76
10	1246.16	4984.63	12534.38	27.0	3382.16	0.00	1602.47
15	1246.16	4984.63	12534.38	35.5	4576.46	0.00	408.16
20	1246.16	4984.63	12534.38	39.7	4970.53	0.00	14.10
25	1246.16	4984.63	12534.38	39.8	4984.63	4.47	0.00
30	1246.16	4984.63	12534.38	39.8	4984.63	4.47	0.00
35	1246.16	4984.63	12534.38	39.8	4984.63	4.47	0.00
60	1246.16	4984.63	12534.38	39.8	4984.63	4.47	0.00

Table 2.1.28(c)

18 MAY 76 - 05:04:42 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 3B - CSU INSOLATION DATA - NOMINAL LOAD 2 - CSU A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	•/• LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 50 SQ-M							
5	1246.16	6230.78	12534.38	14.5	1816.75	0.00	4414.03
10	1246.16	6230.78	12534.38	27.7	3475.40	0.00	2755.38
15	1246.16	6230.78	12534.38	39.1	4900.86	0.00	1329.92
20	1246.16	6230.78	12534.38	47.1	5909.73	2.03	321.06
25	1246.16	6230.78	12534.38	49.3	6177.23	88.97	53.55
30	1246.16	6230.78	12534.38	49.4	6197.64	136.78	33.14
35	1246.16	6230.78	12534.38	49.5	6207.64	174.87	23.14
60	1246.16	6230.78	12534.38	49.7	6230.73	257.55	0.00
COLLECTOR AREA = 60 SQ-M							
5	1246.16	7476.94	12534.38	14.5	1823.08	0.00	5653.87
10	1246.16	7476.94	12534.38	28.2	3535.49	0.00	3940.46
15	1246.16	7476.94	12534.38	40.5	5073.23	0.00	2403.71
20	1246.16	7476.94	12534.38	50.7	6356.10	2.68	1120.84
25	1246.16	7476.94	12534.38	56.4	7068.07	225.82	408.87
30	1246.16	7476.94	12534.38	57.8	7250.07	516.72	226.87
35	1246.16	7476.94	12534.38	58.2	7296.43	752.11	180.51
60	1246.16	7476.94	12534.38	59.2	7419.10	1480.98	57.84

Table 2.1.28(d)

18 MAY 76 - 05:06:28 PM

EVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 38 - CSU INSOLATION DATA - NOMINAL LOAD 2 - CSU A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 70 SQ-M							
5	1246.16	8723.10	12534.38	14.6	1824.42	0.00	5898.68
10	1246.16	8723.10	12534.38	28.5	3575.04	0.00	5148.05
15	1246.16	8723.10	12534.38	41.3	5172.12	0.00	3550.98
20	1246.16	8723.10	12534.38	52.7	6504.70	2.68	2118.40
25	1246.16	8723.10	12534.38	60.4	7573.96	282.69	1149.14
30	1246.16	8723.10	12534.38	64.1	8029.77	791.31	693.33
35	1246.16	8723.10	12534.38	65.3	8178.76	1297.85	544.34
60	1246.16	8723.10	12534.38	56.9	8382.94	4191.85	328.42
COLLECTOR AREA = 80 SQ-M							
5	1246.16	9969.26	12534.38	14.6	1825.00	0.00	8144.26
10	1246.16	9969.26	12534.38	28.7	3501.74	0.00	6367.52
15	1246.16	9969.26	12534.38	41.9	5247.10	0.00	4722.15
20	1246.15	9969.26	12534.38	53.9	6761.63	2.68	3207.63
25	1246.16	9969.26	12534.38	62.6	7845.66	315.53	2123.59
30	1246.16	9969.26	12534.38	68.0	8518.33	910.00	1450.87
35	1246.16	9969.26	12534.38	70.7	8859.40	1577.19	1109.68
60	1246.15	9969.26	12534.38	72.3	9068.52	5282.74	875.55

Table 2.1.28(e)

18 MAY 76 - 05:08:14 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 3B - CSJ INSOLATION DATA - NOMINAL LOAD 2 - CSJ A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 90 SQ-M							
5	1246.16	11215.41	12534.38	14.6	1825.00	0.00	9390.41
10	1246.16	11215.41	12534.38	28.9	3620.71	0.00	7594.71
15	1246.16	11215.41	12534.38	42.3	5304.73	0.00	5910.68
20	1246.16	11215.41	12534.38	54.8	6864.11	2.68	4351.30
25	1246.16	11215.41	12534.38	64.1	8033.95	333.36	3181.46
30	1246.16	11215.41	12534.38	70.2	8802.90	970.26	2412.51
35	1246.16	11215.41	12534.38	74.4	9327.15	1705.99	1886.68
60	1246.16	11215.41	12534.38	77.4	9702.65	5791.16	1486.18
° COLLECTOR AREA = 100 SQ-M							
5	1246.16	12461.57	12534.38	14.6	1825.00	0.00	10636.57
10	1246.16	12461.57	12534.38	29.0	3633.50	0.00	8828.07
15	1246.16	12461.57	12534.38	42.7	5346.49	0.00	7115.08
20	1246.16	12461.57	12534.38	55.4	6948.13	2.68	5513.44
25	1246.16	12461.57	12534.38	65.1	8164.20	346.65	4297.37
30	1246.16	12461.57	12534.38	71.8	8995.06	1016.39	3466.51
35	1246.16	12461.57	12534.38	76.9	9636.14	1796.03	2822.45
60	1246.16	12461.57	12534.38	82.1	10294.55	6370.71	2138.93

18 MAY 76 - 05:13:31 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 35

CSU INSOLATION DATA - NOMINAL LOAD 2 - CSU A/C DATA

LOAD PROVIDED BY STORAGE

Figure 2.1.28(a)

18 MAY 76 - 05:16:30 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 3B

CSU INSOLATION DATA - NOMINAL LOAD 2 - CSU A/C DATA

LOAD PROVIDED BY STORAGE

Figure 2.1:28(b)

18 MAY 76 - 05:20:55 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 3B

CSU INSOLATION DATA - NOMINAL LOAD 2 - CSU A/C DATA

Figure 2.1.28(c)

Table 2.1.29(a)

26 JAN 76 - 06:19:37 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 1 - W INSOLATION DATA (S3) - NOMINAL LOAD 2LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 10 SQ-M							
5	1143.97	1143.97	5027.00	22.6	1138.42	0.00	5.55
10	1143.97	1143.97	5027.00	22.8	1143.97	0.00	0.00
15	1143.97	1143.97	5027.00	22.8	1143.97	0.00	0.00
20	1143.97	1143.97	5027.00	22.8	1143.97	0.00	0.00
25	1143.97	1143.97	5027.00	22.8	1143.97	0.00	0.00
30	1143.97	1143.97	5027.00	22.8	1143.97	0.00	0.00
35	1143.97	1143.97	5027.00	22.8	1143.97	0.00	0.00
60	1143.97	1143.97	5027.00	22.8	1143.97	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1143.97	2287.94	5027.00	33.8	1700.06	0.00	587.87
10	1143.97	2287.94	5027.00	45.3	2276.34	14.18	11.09
15	1143.97	2287.94	5027.00	45.5	2287.94	14.18	0.00
20	1143.97	2287.94	5027.00	45.5	2287.94	14.18	0.00
25	1143.97	2287.94	5027.00	45.5	2287.94	14.18	0.00
30	1143.97	2287.94	5027.00	45.5	2287.94	14.18	0.00
35	1143.97	2287.94	5027.00	45.5	2287.94	14.18	0.00
60	1143.97	2287.94	5027.00	45.5	2287.94	14.18	0.00

Table 2.1.29(b)

26 JAN 76. - 06:21:14 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 1 - Y INSOLATION DATA (S3) - NOMINAL LOAD 2LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 30 SQ-M							
5	1143.97	3431.90	5027.00	35.8	1801.93	0.00	1629.98
10	1143.97	3431.90	5027.00	60.2	3026.03	59.61	405.88
15	1143.97	3431.90	5027.00	67.0	3369.33	197.63	62.57
20	1143.97	3431.90	5027.00	67.7	3405.01	366.52	26.89
25	1143.97	3431.90	5027.00	67.9	3414.40	464.73	17.50
30	1143.97	3431.90	5027.00	68.0	3419.40	528.94	12.50
35	1143.97	3431.90	5027.00	68.1	3424.40	585.92	7.50
60	1143.97	3431.90	5027.00	68.3	3431.90	664.69	0.00
COLLECTOR AREA = 40 SQ-M							
5	1143.97	4575.87	5027.00	36.2	1821.44	0.00	2754.44
10	1143.97	4575.87	5027.00	66.6	3348.88	64.00	1226.99
15	1143.97	4575.87	5027.00	81.0	4072.69	383.42	503.18
20	1143.97	4575.87	5027.00	83.5	4199.43	1191.86	376.44
25	1143.97	4575.87	5027.00	84.2	4232.64	2070.17	343.23
30	1143.97	4575.87	5027.00	84.5	4246.80	3071.56	329.07
35	1143.97	4575.87	5027.00	84.7	4256.80	4094.72	319.07
60	1143.97	4575.87	5027.00	85.2	4282.65	9104.57	293.22

Table 2.1.29(c)

26 JAN 76 - 06:22:49 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 1 - INSOLATION DATA (S3) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1143.97	5719.84	5027.00	36.3	1824.63	0.00	3895.21
10	1143.97	5719.84	5027.00	69.3	3481.66	64.00	2238.18
15	1143.97	5719.84	5027.00	88.4	4445.37	494.57	1274.47
20	1143.97	5719.84	5027.00	90.4	4545.60	1717.21	1174.24
25	1143.97	5719.84	5027.00	91.0	4575.71	2971.62	1144.13
30	1143.97	5719.84	5027.00	91.2	4586.27	4220.84	1133.57
35	1143.97	5719.84	5027.00	91.3	4591.27	5484.39	1128.57
60	1143.97	5719.84	5027.00	91.8	4616.27	11829.46	1103.57
COLLECTOR AREA = 60 SQ-M							
5	1143.97	6863.81	5027.00	36.3	1825.00	0.00	5038.81
10	1143.97	6863.81	5027.00	70.4	3539.85	64.00	3323.96
15	1143.97	6863.81	5027.00	92.1	4630.79	537.69	2233.01
20	1143.97	6863.81	5027.00	94.5	4750.10	1907.66	2110.71
25	1143.97	6863.81	5027.00	95.2	4786.68	3329.56	2073.56
30	1143.97	6863.81	5027.00	95.5	4801.20	4755.44	2059.04
35	1143.97	6863.81	5027.00	95.6	4806.20	6201.84	2054.04
60	1143.97	6863.81	5027.00	96.1	4831.20	13341.92	2029.04

Table 2.1.29(d)

26 JAN 76 - 06:24:23 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 1 - INSOLATION DATA (S3) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 70 SQ-M							
5	1143.97	8007.78	5027.00	36.3	1825.00	0.00	6182.78
10	1143.97	8007.78	5027.00	71.0	3568.72	64.00	4439.05
15	1143.97	8007.78	5027.00	94.3	4739.59	546.32	3268.19
20	1143.97	8007.78	5027.00	97.0	4878.64	2049.51	3126.14
25	1143.97	8007.78	5027.00	97.6	4908.72	3644.76	3091.06
30	1143.97	8007.78	5027.00	98.1	4931.30	5283.09	3066.54
35	1143.97	8007.78	5027.00	98.4	4946.50	6946.03	3051.44
60	1143.97	8007.78	5027.00	99.1	4981.90	15181.34	3016.04
COLLECTOR AREA = 80 SQ-M							
5	1143.97	9151.74	5027.00	36.3	1825.00	0.00	7326.74
10	1143.97	9151.74	5027.00	71.2	3578.87	64.00	5572.87
15	1143.97	9151.74	5027.00	95.7	4810.48	551.23	4341.26
20	1143.97	9151.74	5027.00	98.2	4935.12	2143.97	4213.62
25	1143.97	9151.74	5027.00	98.7	4963.73	3853.37	4180.01
30	1143.97	9151.74	5027.00	99.0	4978.73	5565.29	4160.01
35	1143.97	9151.74	5027.00	99.3	4993.73	7276.29	4141.92
60	1143.97	9151.74	5027.00	100.0	5025.17	16043.27	4110.48

Table 2.1.29(e)

26 JAN 76 - 06:25:57 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 1 - W INSOLATION DATA (S3) - NOMINAL LOAD 2LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 90 SQ-M							
5	1143.97	10295.71	5027.00	36.3	1825.00	0.00	8470.71
10	1143.97	10295.71	5027.00	71.3	3532.49	64.00	6713.22
15	1143.97	10295.71	5027.00	96.6	4856.87	553.91	5438.84
20	1143.97	10295.71	5027.00	99.0	4974.60	2174.21	5318.11
25	1143.97	10295.71	5027.00	99.4	4995.84	3921.49	5291.87
30	1143.97	10295.71	5027.00	99.7	5009.63	5676.17	5273.02
35	1143.97	10295.71	5027.00	99.8	5016.12	7447.82	5261.59
60	1143.97	10295.71	5027.00	100.0	5027.00	16396.26	5232.24
COLLECTOR AREA = 100 SQ-M							
5	1143.97	11439.68	5027.00	36.3	1825.00	0.00	9614.68
10	1143.97	11439.68	5027.00	71.3	3585.26	64.00	7854.42
15	1143.97	11439.68	5027.00	97.2	4885.75	555.00	6553.93
20	1143.97	11439.68	5027.00	99.5	5004.06	2210.03	6432.62
25	1143.97	11439.68	5027.00	99.8	5018.19	3995.59	6413.49
30	1143.97	11439.68	5027.00	99.9	5024.23	5794.90	6402.45
35	1143.97	11439.68	5027.00	100.0	5027.00	7600.17	6394.68
60	1143.97	11439.68	5027.00	100.0	5027.00	16618.49	6369.68

26 JAN 76 - 06:36:54 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 1 - $\frac{1}{2}$ INSOLATION DATA (S3) - NOMINAL LOAD 2

Figure 2.1.29(a)

26 JAN 76 - 06:31:49 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 1 - INSOLATION DATA (S3) - NOMINAL LOAD 2

Figure 2.1.29(b)

26 JAN 76 - 06:46:20 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 1 - W INSOLATION DATA (S3) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

Figure 2.1.29(c)

Table 2.1.30(a)

26 JAN 76 - 07:03:08 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 2 - INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KV-HR	KV-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KV-HR	KW-HR PER YEAR
COLLECTOR AREA = 10 SQ-M							
5	1143.97	1143.97	7217.00	15.8	1138.42	0.00	5.55
10	1143.97	1143.97	7217.00	15.9	1143.97	0.00	0.00
15	1143.97	1143.97	7217.00	15.9	1143.97	0.00	0.00
20	1143.97	1143.97	7217.00	15.9	1143.97	0.00	0.00
25	1143.97	1143.97	7217.00	15.9	1143.97	0.00	0.00
30	1143.97	1143.97	7217.00	15.9	1143.97	0.00	0.00
35	1143.97	1143.97	7217.00	15.9	1143.97	0.00	0.00
60	1143.97	1143.97	7217.00	15.9	1143.97	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1143.97	2287.94	7217.00	23.6	1700.06	0.00	537.87
10	1143.97	2287.94	7217.00	31.5	2276.84	0.00	11.09
15	1143.97	2287.94	7217.00	31.7	2287.94	0.00	0.00
20	1143.97	2287.94	7217.00	31.7	2287.94	0.00	0.00
25	1143.97	2287.94	7217.00	31.7	2287.94	0.00	0.00
30	1143.97	2287.94	7217.00	31.7	2287.94	0.00	0.00
35	1143.97	2287.94	7217.00	31.7	2287.94	0.00	0.00
60	1143.97	2287.94	7217.00	31.7	2287.94	0.00	0.00

Table 2.1.30(b)

26 JAN 76 - 07:04:44 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 2 - W INSOLATION DATA - NOMINAL LOAD 2LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 30 SQ-M							
5	1143.97	3431.90	7217.00	25.0	1801.93	0.00	1629.98
10	1143.97	3431.90	7217.00	42.3	3055.45	0.00	376.45
15	1143.97	3431.90	7217.00	47.3	3415.27	0.00	16.64
20	1143.97	3431.90	7217.00	47.6	3431.90	0.00	0.00
25	1143.97	3431.90	7217.00	47.6	3431.90	0.00	0.00
30	1143.97	3431.90	7217.00	47.6	3431.90	0.00	0.00
35	1143.97	3431.90	7217.00	47.6	3431.90	0.00	0.00
60	1143.97	3431.90	7217.00	47.6	3431.90	0.00	0.00
COLLECTOR AREA = 40 SQ-M							
5	1143.97	4575.87	7217.00	25.2	1821.44	0.00	2754.44
10	1143.97	4575.87	7217.00	47.1	3400.13	0.00	1175.75
15	1143.97	4575.87	7217.00	59.2	4271.51	16.45	304.36
20	1143.97	4575.87	7217.00	63.1	4550.89	44.81	24.98
25	1143.97	4575.87	7217.00	63.4	4575.64	76.23	0.23
30	1143.97	4575.87	7217.00	63.4	4575.87	76.55	0.00
35	1143.97	4575.87	7217.00	63.4	4575.87	76.55	0.00
60	1143.97	4575.87	7217.00	63.4	4575.87	76.55	0.00

Table 2.1.39(c)

26 JAN 76 - 07:06:24 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 2 - W INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1143.97	5719.84	7217.00	25.3	1824.63	0.00	3895.21
10	1143.97	5719.84	7217.00	49.1	3541.76	0.00	2178.08
15	1143.97	5719.84	7217.00	66.5	4798.27	34.56	921.57
20	1143.97	5719.84	7217.00	74.7	5391.77	171.09	328.07
25	1143.97	5719.84	7217.00	76.8	5542.00	632.47	177.84
30	1143.97	5719.84	7217.00	77.6	5603.22	1044.26	116.62
35	1143.97	5719.84	7217.00	78.1	5638.03	1407.65	81.80
60	1143.97	5719.84	7217.00	79.1	5708.72	2386.37	11.12
COLLECTOR AREA = 60 SQ-M							
5	1143.97	6863.81	7217.00	25.3	1825.00	0.00	5038.81
10	1143.97	6863.81	7217.00	49.9	3603.85	0.00	3259.96
15	1143.97	6863.81	7217.00	70.2	5068.99	43.53	1794.81
20	1143.97	6863.81	7217.00	82.7	5969.27	247.21	894.54
25	1143.97	6863.81	7217.00	85.6	6180.80	1071.07	683.01
30	1143.97	6863.81	7217.00	86.6	6250.42	1993.95	613.39
35	1143.97	6863.81	7217.00	87.0	6279.03	2982.71	584.78
60	1143.97	6863.81	7217.00	87.7	6329.25	8279.98	534.56

Table 2.1.30(d)

26 JAN 76 - 07:07:56 PM

EVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 2 - 4 INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 70 SQ-M							
5	1143.97	8007.78	7217.00	25.3	1825.00	0.00	6182.78
10	1143.97	8007.78	7217.00	50.3	3632.72	0.00	4375.05
15	1143.97	8007.78	7217.00	72.4	5223.14	47.89	2784.63
20	1143.97	8007.78	7217.00	87.7	6326.87	301.46	1680.91
25	1143.97	8007.78	7217.00	90.5	6528.16	1413.24	1479.61
30	1143.97	8007.78	7217.00	91.2	6579.75	2650.96	1428.03
35	1143.97	8007.78	7217.00	91.6	6609.75	3896.49	1398.03
60	1143.97	8007.78	7217.00	92.2	6654.77	10153.63	1353.00
COLLECTOR AREA = 80 SQ-M							
5	1143.97	9151.74	7217.00	25.3	1825.00	0.00	7326.74
10	1143.97	9151.74	7217.00	50.5	3642.87	0.00	5508.87
15	1143.97	9151.74	7217.00	73.5	5307.60	48.00	3844.14
20	1143.97	9151.74	7217.00	90.6	6536.36	317.98	2615.38
25	1143.97	9151.74	7217.00	93.5	6745.28	1562.58	2404.46
30	1143.97	9151.74	7217.00	94.3	6804.44	2928.56	2343.21
35	1143.97	9151.74	7217.00	94.7	6836.35	4312.86	2311.30
60	1143.97	9151.74	7217.00	95.2	6872.94	11296.89	2274.71

Table 2.1.30(e)

26 JAN 76 - 07:09:35 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 2 - INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 90 SQ-M							
5	1143.97	10295.71	7217.00	25.3	1825.00	0.00	8470.71
10	1143.97	10295.71	7217.00	50.5	3646.49	0.00	6649.22
15	1143.97	10295.71	7217.00	74.2	5357.78	48.00	4937.93
20	1143.97	10295.71	7217.00	92.4	6669.79	335.42	3625.92
25	1143.97	10295.71	7217.00	95.7	6905.18	1668.04	3387.53
30	1143.97	10295.71	7217.00	96.4	6963.49	3142.55	3328.22
35	1143.97	10295.71	7217.00	96.9	6994.06	4651.42	3291.30
60	1143.97	10295.71	7217.00	97.7	7047.80	12214.81	3237.55
COLLECTOR AREA = 100 SQ-M							
5	1143.97	11439.68	7217.00	25.3	1825.00	0.00	9614.68
10	1143.97	11439.68	7217.00	50.6	3649.26	0.00	7790.42
15	1143.97	11439.68	7217.00	74.7	5390.93	48.00	6048.75
20	1143.97	11439.68	7217.00	93.6	6757.00	339.00	4682.68
25	1143.97	11439.68	7217.00	97.1	7006.90	1736.61	4430.78
30	1143.97	11439.68	7217.00	97.9	7063.04	3360.42	4369.64
35	1143.97	11439.68	7217.00	98.2	7090.28	4989.82	4337.40
60	1143.97	11439.68	7217.00	99.3	7165.24	13404.68	4257.83

26 JAN 76 - 07:22:25 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 2 - W INSOLATION DATA - NOMINAL LOAD 2

Figure 2.1.30(a)

26 JAN 76 - 07:12:49 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 2 - INSOLATION DATA - NOMINAL LOAD 2

Figure 2.1.30(b)

Figure 2.1.30(c)

Table 2.1.31(a)

26 JAN 76 - 07:32:16 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 3A - W INSOLATION DATA (S3) - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KV-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 10 SQ-M							
5	1143.97	1143.97	8081.55	14.1	1138.42	0.00	5.55
10	1143.97	1143.97	8081.55	14.2	1143.97	0.00	0.00
15	1143.97	1143.97	8081.55	14.2	1143.97	0.00	0.00
20	1143.97	1143.97	8081.55	14.2	1143.97	0.00	0.00
25	1143.97	1143.97	8081.55	14.2	1143.97	0.00	0.00
30	1143.97	1143.97	8081.55	14.2	1143.97	0.00	0.00
35	1143.97	1143.97	8081.55	14.2	1143.97	0.00	0.00
60	1143.97	1143.97	8081.55	14.2	1143.97	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1143.97	2287.94	8081.55	21.0	1730.06	0.00	587.87
10	1143.97	2287.94	8081.55	28.2	2276.84	0.00	11.09
15	1143.97	2287.94	8081.55	28.3	2287.94	0.00	0.00
20	1143.97	2287.94	8081.55	28.3	2287.94	0.00	0.00
25	1143.97	2287.94	8081.55	28.3	2287.94	0.00	0.00
30	1143.97	2287.94	8081.55	28.3	2287.94	0.00	0.00
35	1143.97	2287.94	8081.55	28.3	2287.94	0.00	0.00
60	1143.97	2287.94	8081.55	28.3	2287.94	0.00	0.00

Table 2.1.31(b)

26 JAN 76 - 07:34:04 PM

PEEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 3A - $\bar{Q}$ INSOLATION DATA (S3) - NOMINAL LOAD 2 - $\bar{Q}$ A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KJ-HR PER SQ-M	KJ-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 30 SQ-M							
5	1143.97	3431.90	8081.55	22.3	1801.93	0.00	1629.98
10	1143.97	3431.90	8081.55	37.8	3055.45	0.00	376.45
15	1143.97	3431.90	8081.55	42.2	3413.66	1.71	18.24
20	1143.97	3431.90	8081.55	42.5	3431.52	20.78	0.38
25	1143.97	3431.90	8081.55	42.5	3431.90	21.55	0.00
30	1143.97	3431.90	8081.55	42.5	3431.90	21.55	0.00
35	1143.97	3431.90	8081.55	42.5	3431.90	21.55	0.00
60	1143.97	3431.90	8081.55	42.5	3431.90	21.55	0.00
COLLECTOR AREA = 40 SQ-M							
5	1143.97	4575.87	8081.55	22.5	1821.44	0.00	2754.44
10	1143.97	4575.87	8081.55	42.1	3400.13	0.00	1175.75
15	1143.97	4575.87	8081.55	52.9	4271.78	9.03	304.09
20	1143.97	4575.87	8081.55	55.4	4474.79	224.94	101.09
25	1143.97	4575.87	8081.55	55.7	4502.06	450.11	73.81
30	1143.97	4575.87	8081.55	55.9	4514.49	705.37	61.39
35	1143.97	4575.87	8081.55	56.0	4524.49	962.83	51.39
60	1143.97	4575.87	8081.55	56.5	4566.12	2001.70	9.76

Table 2.1.31(c)

26 JAN 76 - 07:35:42 PM

PVTPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 3A - W INSOLATION DATA (S3) - NOMINAL LOAD 2 - W A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1143.97	5719.84	8081.55	22.6	1824.63	0.00	3895.21
10	1143.97	5719.84	8081.55	43.8	3541.76	0.00	2178.08
15	1143.97	5719.84	8081.55	59.3	4794.72	25.39	925.12
20	1143.97	5719.84	8081.55	64.6	5222.75	473.33	497.05
25	1143.97	5719.84	8081.55	66.0	5332.22	995.85	387.62
30	1143.97	5719.84	8081.55	66.4	5366.72	1433.04	353.12
35	1143.97	5719.84	8081.55	66.6	5381.86	1840.18	337.98
60	1143.97	5719.84	8081.55	66.9	5406.86	3771.55	312.98
COLLECTOR AREA = 60 SQ-M							
5	1143.97	6863.81	8081.55	22.6	1825.00	0.00	5038.81
10	1143.97	6863.81	8081.55	44.6	3603.85	0.00	3259.96
15	1143.97	6863.81	8081.55	62.8	5075.33	26.56	1788.48
20	1143.97	6863.81	8081.55	70.3	5677.79	624.30	1183.02
25	1143.97	6863.81	8081.55	73.3	5924.75	1371.51	935.49
30	1143.97	6863.81	8081.55	74.2	6000.19	2169.45	860.05
35	1143.97	6863.81	8081.55	74.7	6039.62	2956.31	820.62
60	1143.97	6863.81	8081.55	76.2	6157.46	6440.75	702.78

Table 2.1.31(d)

26 JAN 76 - 07:37:17 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 3A - W INSOLATION DATA (S3) - NOMINAL LOAD 2 - W A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KJ-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 70 SQ-M							
5	1143.97	8007.78	8081.55	22.6	1825.00	0.00	6182.78
10	1143.97	8007.78	8081.55	45.0	3632.72	0.00	4375.05
15	1143.97	8007.78	8081.55	64.7	5230.41	31.50	2777.37
20	1143.97	8007.78	8081.55	73.8	5967.16	765.17	2037.62
25	1143.97	8007.78	8081.55	78.1	6312.68	1685.96	1687.10
30	1143.97	8007.78	8081.55	79.9	6454.21	2761.50	1543.74
35	1143.97	8007.78	8081.55	80.6	6510.57	3872.08	1487.37
60	1143.97	8007.78	8081.55	82.6	6678.19	9318.91	1319.75
COLLECTOR AREA = 80 SQ-M							
5	1143.97	9151.74	8081.55	22.6	1825.00	0.00	7326.74
10	1143.97	9151.74	8081.55	45.1	3642.87	0.00	5508.87
15	1143.97	9151.74	8081.55	65.8	5320.14	33.08	3831.60
20	1143.97	9151.74	8081.55	75.7	6114.23	847.47	3034.52
25	1143.97	9151.74	8081.55	80.9	6539.11	1923.32	2604.63
30	1143.97	9151.74	8081.55	83.7	6763.88	3103.11	2374.86
35	1143.97	9151.74	8081.55	84.8	6849.92	4351.58	2285.73
60	1143.97	9151.74	8081.55	86.6	7001.14	10707.34	2134.51

Table 2.1.31(e)

25 JAN 76 - 07:38:47 PM

PVFES - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 3A - Y INSOLATION DATA (S3) - NOMINAL LOAD 2 - Y A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KV-HR PER SQ-M	KW-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 90 SQ-M							
5	1143.97	10295.71	8081.55	22.6	1825.00	0.00	8470.71
10	1143.97	10295.71	8081.55	45.1	3646.49	0.00	6649.22
15	1143.97	10295.71	8081.55	66.5	5372.85	33.50	4922.86
20	1143.97	10295.71	8081.55	76.8	6205.12	884.45	4087.59
25	1143.97	10295.71	8081.55	82.8	6693.96	2017.94	3593.76
30	1143.97	10295.71	8081.55	86.2	6965.71	3260.71	3317.00
35	1143.97	10295.71	8081.55	87.8	7097.05	4599.60	3180.66
60	1143.97	10295.71	8081.55	89.9	7261.42	11444.60	2997.81
COLLECTOR AREA = 100 SQ-M							
5	1143.97	11439.68	8081.55	22.6	1825.00	0.00	9614.68
10	1143.97	11439.68	8081.55	45.2	3649.26	0.00	7790.42
15	1143.97	11439.68	8081.55	66.9	5404.91	34.01	6034.77
20	1143.97	11439.68	8081.55	77.5	6264.90	924.98	5171.78
25	1143.97	11439.68	8081.55	83.9	6784.15	2105.67	4647.53
30	1143.97	11439.68	8081.55	87.9	7106.02	3409.43	4320.66
35	1143.97	11439.68	8081.55	90.0	7276.87	4791.27	4144.81
60	1143.97	11439.68	8081.55	92.4	7465.75	12035.97	3930.89

26 JAN 76 - 07:50:01 PM

EVERPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 3A - $\bar{H}$ INSOLATION DATA (S3) - NOMINAL LOAD 2 - $\bar{H}$ A/C DATA

Figure 2.1.31(a)

26 JAN 76 - 07:41:29 PM

EVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 3A - W INSOLATION DATA (S3) - NOMINAL LOAD 2 - W A/C DATA

Figure 2.1.31(b)

26 JAN 76 - 07:45:20 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 3A - W INSOLATION DATA (S3) - NOMINAL LOAD 2 - W A/C DATA

Figure 2.1.31(c)

Table 2.1.32(a)

26 JAN 76 - 07:56:15 PM

PEEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 3B - INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KJ-HR PER SQ-M	KJ-HR PER YEAR	KJ-HR PER YEAR	% LOAD SUPPLIED	KJ-HR PER YEAR	KW-HR	KJ-HR PER YEAR

COLLECTOR AREA = 10 SQ-M							
5	1143.97	1143.97	10271.55	11.1	1138.42	0.00	5.55
10	1143.97	1143.97	10271.55	11.1	1143.97	0.00	0.00
15	1143.97	1143.97	10271.55	11.1	1143.97	0.00	0.00
20	1143.97	1143.97	10271.55	11.1	1143.97	0.00	0.00
25	1143.97	1143.97	10271.55	11.1	1143.97	0.00	0.00
30	1143.97	1143.97	10271.55	11.1	1143.97	0.00	0.00
35	1143.97	1143.97	10271.55	11.1	1143.97	0.00	0.00
60	1143.97	1143.97	10271.55	11.1	1143.97	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1143.97	2287.94	10271.55	16.6	1700.06	0.00	587.87
10	1143.97	2287.94	10271.55	22.2	2276.84	0.00	11.09
15	1143.97	2287.94	10271.55	22.3	2287.94	0.00	0.00
20	1143.97	2287.94	10271.55	22.3	2287.94	0.00	0.00
25	1143.97	2287.94	10271.55	22.3	2287.94	0.00	0.00
30	1143.97	2287.94	10271.55	22.3	2287.94	0.00	0.00
35	1143.97	2287.94	10271.55	22.3	2287.94	0.00	0.00
60	1143.97	2287.94	10271.55	22.3	2287.94	0.00	0.00

Table 2.1.32(b)

26 JAN 76 - 07:57:49 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 3B - 4 INSOLATION DATA - NOMINAL LOAD 2 - 4 A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 30 SQ-M							
5	1143.97	3431.90	10271.55	17.5	1801.93	0.00	1629.98
10	1143.97	3431.90	10271.55	29.7	3055.45	0.00	376.45
15	1143.97	3431.90	10271.55	33.2	3415.27	0.00	16.64
20	1143.97	3431.90	10271.55	33.4	3431.90	0.00	0.00
25	1143.97	3431.90	10271.55	33.4	3431.90	0.00	0.00
30	1143.97	3431.90	10271.55	33.4	3431.90	0.00	0.00
35	1143.97	3431.90	10271.55	33.4	3431.90	0.00	0.00
60	1143.97	3431.90	10271.55	33.4	3431.90	0.00	0.00
.							
COLLECTOR AREA = 40 SQ-M							
5	1143.97	4575.87	10271.55	17.7	1821.44	0.00	2754.44
10	1143.97	4575.87	10271.55	33.1	3400.13	0.00	1175.75
15	1143.97	4575.87	10271.55	41.6	4275.11	0.00	299.76
20	1143.97	4575.87	10271.55	44.3	4553.69	0.00	22.18
25	1143.97	4575.87	10271.55	44.5	4575.87	9.40	0.00
30	1143.97	4575.87	10271.55	44.5	4575.87	9.40	0.00
35	1143.97	4575.87	10271.55	44.5	4575.87	9.40	0.00
60	1143.97	4575.87	10271.55	44.5	4575.87	9.40	0.00

Table 2.1.32(c)

26 JAN 76 - 07:59:49 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 3B - 1 INSOLATION DATA - NOMINAL LOAD 2 - 1 A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1143.97	5719.84	10271.55	17.8	1824.63	0.00	3895.21
10	1143.97	5719.84	10271.55	34.5	3541.76	0.00	2178.08
15	1143.97	5719.84	10271.55	46.9	4817.36	0.00	902.48
20	1143.97	5719.84	10271.55	53.1	5457.75	0.14	262.09
25	1143.97	5719.84	10271.55	55.0	5648.00	117.54	71.84
30	1143.97	5719.84	10271.55	55.4	5689.10	235.92	30.74
35	1143.97	5719.84	10271.55	55.6	5707.19	371.92	12.65
60	1143.97	5719.84	10271.55	55.7	5719.84	489.15	0.00
COLLECTOR AREA = 60 SQ-M							
5	1143.97	6863.81	10271.55	17.8	1825.00	0.00	5038.81
10	1143.97	6863.81	10271.55	35.1	3603.85	0.00	3259.96
15	1143.97	6863.81	10271.55	49.7	5100.19	0.00	1763.62
20	1143.97	6863.81	10271.55	59.5	6110.75	0.14	753.05
25	1143.97	6863.81	10271.55	63.5	6526.57	231.13	337.14
30	1143.97	6863.81	10271.55	64.6	6639.30	562.68	224.50
35	1143.97	6863.81	10271.55	64.9	6669.68	886.72	194.12
60	1143.97	6863.81	10271.55	65.3	6711.23	2662.05	152.58

Table 2.1.32(d)

26 JAN 76 - 08:01:21 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 3B - V INSOLATION DATA - NOMINAL LOAD 2 - V A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KV-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 70 SQ-M							
5	1143.97	8007.78	10271.55	17.8	1825.00	0.00	6182.78
10	1143.97	8007.78	10271.55	35.4	3632.72	0.00	4375.05
15	1143.97	8007.78	10271.55	51.2	5261.33	0.00	2746.45
20	1143.97	8007.78	10271.55	63.7	6542.72	2.24	1465.05
25	1143.97	8007.78	10271.55	69.4	7131.82	378.88	875.95
30	1143.97	8007.78	10271.55	71.6	7358.33	941.43	649.44
35	1143.97	8007.78	10271.55	72.4	7437.72	1514.43	570.05
60	1143.97	8007.78	10271.55	73.4	7534.37	3752.88	473.40
COLLECTOR AREA = 80 SQ-M							
5	1143.97	9151.74	10271.55	17.8	1825.00	0.00	7326.74
10	1143.97	9151.74	10271.55	35.5	3642.87	0.00	5508.87
15	1143.97	9151.74	10271.55	52.1	5352.65	0.00	3799.10
20	1143.97	9151.74	10271.55	66.2	6798.01	2.24	2353.74
25	1143.97	9151.74	10271.55	73.4	7534.88	460.27	1514.86
30	1143.97	9151.74	10271.55	76.7	7873.81	1156.75	1273.84
35	1143.97	9151.74	10271.55	78.1	8022.86	1923.00	1124.79
60	1143.97	9151.74	10271.55	79.8	8199.56	5738.66	948.09

Table 2.1.32(e)

26 JAN 76 - 08:02:43 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 38 - W INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KV-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 90 SQ-M							
5	1143.97	10295.71	10271.55	17.8	1825.00	0.00	8470.71
10	1143.97	10295.71	10271.55	35.5	3646.49	0.00	6649.22
15	1143.97	10295.71	10271.55	52.5	5405.78	0.00	4889.93
20	1143.97	10295.71	10271.55	67.9	6970.46	2.24	3325.25
25	1143.97	10295.71	10271.55	76.3	7838.12	543.82	2455.59
30	1143.97	10295.71	10271.55	80.3	8243.81	1355.01	2044.90
35	1143.97	10295.71	10271.55	82.4	8457.33	2278.47	1818.03
60	1143.97	10295.71	10271.55	84.8	8705.17	7075.11	1580.18
COLLECTOR AREA = 100 SQ-M							
5	1143.97	11439.68	10271.55	17.8	1825.00	0.00	9614.68
10	1143.97	11439.68	10271.55	35.5	3649.26	0.00	7790.42
15	1143.97	11439.68	10271.55	53.0	5438.93	0.00	6000.75
20	1143.97	11439.68	10271.55	68.9	7081.28	2.24	4358.40
25	1143.97	11439.68	10271.55	78.1	8017.78	602.28	3419.90
30	1143.97	11439.68	10271.55	82.8	8509.01	1553.65	2923.67
35	1143.97	11439.68	10271.55	85.6	8791.59	2609.23	2636.09
60	1143.97	11439.68	10271.55	88.8	9121.67	9687.01	2301.39

27 JAN 76 - 10:09:08 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 3B - Y INSOLATION DATA - NOMINAL LOAD 2 - N A/C DATA

Figure 2.1.32(a)

27 JAN 76 - 10:04:41 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 3B - INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA

LOAD PROVIDED BY STORAGE

Figure 2.1.32(b)

27 JAN 76 - 10:22:52 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MADISON, WISCONSIN - CASE 36 - H INSOLATION DATA - NOMINAL LOAD 2 - H A/C DATA

Figure 2.1.32(c)

Table 2.1.33(a)

24 MAR 76 - 04:03:48 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 1 - INSOLATION DATA (S1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 10 SQ-M							
5	1053.63	1053.63	5027.00	20.9	1049.90	0.00	3.73
10	1053.63	1053.63	5027.00	21.0	1053.63	0.00	0.00
15	1053.63	1053.63	5027.00	21.0	1053.63	0.00	0.00
20	1053.63	1053.63	5027.00	21.0	1053.63	0.00	0.00
25	1053.63	1053.63	5027.00	21.0	1053.63	0.00	0.00
30	1053.63	1053.63	5027.00	21.0	1053.63	0.00	0.00
35	1053.63	1053.63	5027.00	21.0	1053.63	0.00	0.00
60	1053.63	1053.63	5027.00	21.0	1053.63	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1053.63	2107.25	5027.00	33.0	1659.99	0.00	447.26
10	1053.63	2107.25	5027.00	41.8	2099.79	3.60	7.46
15	1053.63	2107.25	5027.00	41.9	2107.25	3.60	0.00
20	1053.63	2107.25	5027.00	41.9	2107.25	3.60	0.00
25	1053.63	2107.25	5027.00	41.9	2107.25	3.60	0.00
30	1053.63	2107.25	5027.00	41.9	2107.25	3.60	0.00
35	1053.63	2107.25	5027.00	41.9	2107.25	3.60	0.00
60	1053.63	2107.25	5027.00	41.9	2107.25	3.60	0.00

Table 2.1.33(b)

24 MAR 76 - 04:05:30 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 1 - W INSOLATION DATA (S1) - NOMINAL LOAD 2LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KV-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 30 SQ-M							
5	1053.63	3150.88	5027.00	35.9	1805.57	0.00	1354.31
10	1053.63	3160.88	5027.00	57.1	2868.06	51.18	292.82
15	1053.63	3160.88	5027.00	62.4	3135.68	124.43	24.20
20	1053.63	3160.88	5027.00	62.8	3153.01	211.55	4.37
25	1053.63	3160.88	5027.00	62.9	3150.88	249.10	0.00
30	1053.63	3160.88	5027.00	62.9	3160.88	249.10	0.00
35	1053.63	3160.88	5027.00	62.9	3160.88	249.10	0.00
60	1053.63	3160.88	5027.00	62.9	3160.88	249.10	0.00
COLLECTOR AREA = 40 SQ-M							
5	1053.63	4214.51	5027.00	36.2	1821.70	0.00	2392.81
10	1053.63	4214.51	5027.00	55.2	3275.92	60.56	938.59
15	1053.63	4214.51	5027.00	77.8	3909.43	247.45	305.08
20	1053.63	4214.51	5027.00	80.6	4052.03	745.11	162.48
25	1053.63	4214.51	5027.00	81.6	4100.92	1129.54	113.59
30	1053.63	4214.51	5027.00	82.3	4136.76	1479.40	77.75
35	1053.63	4214.51	5027.00	82.7	4156.59	1808.27	57.91
60	1053.63	4214.51	5027.00	83.7	4210.06	3231.05	4.45

Table 2.1.33(c)

24 MAR 76 - 04:07:12 PM

PIEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 1 - 4 INSOLATION DATA (S1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KV-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1053.63	5268.13	5027.00	36.3	1824.79	0.00	3443.35
10	1053.63	5268.13	5027.00	69.2	3472.07	62.20	1790.06
15	1053.63	5268.13	5027.00	87.1	4380.53	336.41	887.61
20	1053.63	5268.13	5027.00	90.5	4551.91	1318.28	713.22
25	1053.63	5268.13	5027.00	92.0	4625.59	2409.44	638.94
30	1053.63	5268.13	5027.00	92.9	4667.91	3487.47	595.62
35	1053.63	5268.13	5027.00	93.5	4697.91	4604.86	565.62
60	1053.63	5268.13	5027.00	95.6	4806.09	11078.59	458.44
COLLECTOR AREA = 60 SQ-M							
5	1053.63	6321.76	5027.00	36.3	1825.00	0.00	4496.76
10	1053.63	6321.76	5027.00	70.6	3549.51	63.84	2772.25
15	1053.63	6321.76	5027.00	92.6	4654.88	441.09	1655.83
20	1053.63	6321.76	5027.00	95.8	4814.44	1768.39	1504.32
25	1053.63	6321.76	5027.00	96.9	4872.87	3273.18	1440.89
30	1053.63	6321.76	5027.00	97.5	4901.13	4339.97	1409.90
35	1053.63	6321.76	5027.00	97.8	4914.85	6413.01	1396.16
60	1053.63	6321.76	5027.00	98.7	4953.12	14354.97	1347.90

Table 2.1.33(d)

24 MAR 76 - 04:08:53 PM

PVPS - ENERGY FLOW SIMULATIONS - 73.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 1 - 1 INSOLATION DATA (S1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 70 SQ-M							
5	1053.63	7375.39	5027.00	36.3	1825.00	0.00	5550.39
10	1053.63	7375.39	5027.00	71.0	3569.52	64.00	3805.87
15	1053.63	7375.39	5027.00	95.4	4793.44	511.92	2581.95
20	1053.63	7375.39	5027.00	97.9	4921.65	2028.29	2450.72
25	1053.63	7375.39	5027.00	98.7	4960.97	3675.20	2406.41
30	1053.63	7375.39	5027.00	99.1	4980.46	5364.09	2381.93
35	1053.63	7375.39	5027.00	99.2	4983.67	7112.51	2368.72
60	1053.63	7375.39	5027.00	99.7	5013.67	15662.72	2343.53
.							
COLLECTOR AREA = 80 SQ-M							
5	1053.63	8429.01	5027.00	36.3	1825.00	0.00	6604.01
10	1053.63	8429.01	5027.00	71.2	3579.40	64.00	4849.62
15	1053.63	8429.01	5027.00	96.8	4863.16	534.34	3560.85
20	1053.63	8429.01	5027.00	99.1	4980.40	2144.96	3445.62
25	1053.63	8429.01	5027.00	99.5	5003.28	3893.64	3417.73
30	1053.63	8429.01	5027.00	99.7	5009.62	5656.77	3406.39
35	1053.63	8429.01	5027.00	99.8	5014.62	7418.51	3396.39
60	1053.63	8429.01	5027.00	100.0	5027.00	16361.86	3363.75

Table 2.1.33(e)

24 MAR 76 - 04:10:33 PM

EVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 1 - 2 INSOLATION DATA (S1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KJ-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 90 SQ-M							
5	1053.63	9482.64	5027.00	36.3	1825.00	0.00	7657.64
10	1053.63	9482.64	5027.00	71.3	3583.62	64.00	5899.03
15	1053.63	9482.64	5027.00	97.4	4896.23	542.67	4586.41
20	1053.63	9482.64	5027.00	99.7	5012.28	2203.64	4467.36
25	1053.63	9482.64	5027.00	99.9	5021.67	4006.38	4452.97
30	1053.63	9482.64	5027.00	100.0	5026.67	5806.40	4442.97
35	1053.63	9482.64	5027.00	100.0	5027.00	7624.75	4437.64
60	1053.63	9482.64	5027.00	100.0	5027.00	16698.65	4412.64

COLLECTOR AREA = 100 SQ-M

5	1053.63	10536.27	5027.00	36.3	1825.00	0.00	8711.27
10	1053.63	10536.27	5027.00	71.3	3535.57	64.00	6950.69
15	1053.63	10536.27	5027.00	97.7	4909.60	546.05	5626.67
20	1053.63	10536.27	5027.00	99.9	5021.50	2242.60	5511.77
25	1053.63	10536.27	5027.00	100.0	5027.00	4058.31	5501.27
30	1053.63	10536.27	5027.00	100.0	5027.00	5893.31	5496.27
35	1053.63	10536.27	5027.00	100.0	5027.00	7707.77	5491.27
60	1053.63	10536.27	5027.00	100.0	5027.00	16790.85	5466.27

24 MAR 76 - 04:13:11 PM

EVAPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 1 - INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.33(a)

24 MAR 76 - 04:17:20 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 1 - 4 INSOLATION DATA (S1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

Figure 2.1.33(b)

24 MAR 76 - 04:21:44 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 1 - (4 INSOLATION DATA (S1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

Figure 2.1.33(c)

Table 2.1.34(a)

25 MAR 76 - 11:13:28 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 2 - INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KV-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 10 SQ-M							
5	1053.63	1053.63	7217.00	14.5	1049.90	0.00	3.73
10	1053.63	1053.63	7217.00	14.6	1053.63	0.00	0.00
15	1053.63	1053.63	7217.00	14.6	1053.63	0.00	0.00
20	1053.63	1053.63	7217.00	14.6	1053.63	0.00	0.00
25	1053.63	1053.63	7217.00	14.6	1053.63	0.00	0.00
30	1053.63	1053.63	7217.00	14.6	1053.63	0.00	0.00
35	1053.63	1053.63	7217.00	14.6	1053.63	0.00	0.00
60	1053.63	1053.63	7217.00	14.6	1053.63	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1053.63	2107.25	7217.00	23.0	1659.99	0.00	447.26
10	1053.63	2107.25	7217.00	29.1	2099.79	0.00	7.46
15	1053.63	2107.25	7217.00	29.2	2107.25	0.00	0.00
20	1053.63	2107.25	7217.00	29.2	2107.25	0.00	0.00
25	1053.63	2107.25	7217.00	29.2	2107.25	0.00	0.00
30	1053.63	2107.25	7217.00	29.2	2107.25	0.00	0.00
35	1053.63	2107.25	7217.00	29.2	2107.25	0.00	0.00
60	1053.63	2107.25	7217.00	29.2	2107.25	0.00	0.00

Table 2.1.34(b)

25 MAR 76 - 11:15:19 AM

EVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 2 - W INSOLATION DATA - NOMINAL LOAD 2LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 30 SQ-M							
5	1053.63	3160.88	7217.00	25.0	1806.57	0.00	1354.31
10	1053.63	3160.88	7217.00	39.9	2831.74	0.00	279.14
15	1053.63	3160.88	7217.00	43.6	3149.69	0.00	11.19
20	1053.63	3160.88	7217.00	43.8	3160.88	0.00	0.00
25	1053.63	3160.88	7217.00	43.8	3160.88	0.00	0.00
30	1053.63	3160.88	7217.00	43.8	3160.88	0.00	0.00
35	1053.63	3160.88	7217.00	43.8	3160.88	0.00	0.00
60	1053.63	3160.88	7217.00	43.8	3160.88	0.00	0.00
COLLECTOR AREA = 40 SQ-M							
5	1053.63	4214.51	7217.00	25.2	1821.70	0.00	2392.81
10	1053.63	4214.51	7217.00	46.0	3319.99	0.00	894.52
15	1053.63	4214.51	7217.00	55.4	3994.84	6.57	219.67
20	1053.63	4214.51	7217.00	58.2	4199.59	7.21	14.92
25	1053.63	4214.51	7217.00	58.4	4214.51	13.59	0.00
30	1053.63	4214.51	7217.00	58.4	4214.51	13.69	0.00
35	1053.63	4214.51	7217.00	58.4	4214.51	13.69	0.00
60	1053.63	4214.51	7217.00	58.4	4214.51	13.69	0.00

Table 2.1.34(c)

25 MAR 76 - 11:17:22 AM

PVSPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 2 - 2 INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KV-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1053.63	5268.13	7217.00	25.3	1824.79	0.00	3443.35
10	1053.63	5268.13	7217.00	49.0	3535.71	0.00	1732.43
15	1053.63	5268.13	7217.00	63.6	4586.64	17.55	681.50
20	1053.63	5268.13	7217.00	70.3	5071.40	56.37	195.74
25	1053.63	5268.13	7217.00	72.0	5196.50	249.24	71.63
30	1053.63	5268.13	7217.00	72.5	5229.72	377.58	38.42
35	1053.63	5268.13	7217.00	72.8	5251.81	487.25	16.33
60	1053.63	5268.13	7217.00	73.0	5268.13	617.19	0.00
COLLECTOR AREA = 60 SQ-M							
5	1053.63	6321.76	7217.00	25.3	1825.00	0.00	4496.76
10	1053.63	6321.76	7217.00	50.1	3613.13	0.00	2708.63
15	1053.63	6321.76	7217.00	68.7	4959.05	36.59	1362.70
20	1053.63	6321.76	7217.00	79.1	5703.58	157.79	613.18
25	1053.63	6321.76	7217.00	82.3	5940.88	730.74	379.14
30	1053.63	6321.76	7217.00	83.8	6046.97	1319.19	273.05
35	1053.63	6321.76	7217.00	84.7	6112.90	1890.72	207.13
60	1053.63	6321.76	7217.00	86.5	6239.62	4189.67	80.41

Table 2.1.34(d)

25 MAR 76 - 11:19:22 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 2 - INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 70 SQ-M							
5	1053.63	7375.39	7217.00	25.3	1825.00	0.00	5550.39
10	1053.63	7375.39	7217.00	50.3	3633.52	0.00	3741.87
15	1053.63	7375.39	7217.00	71.9	5189.47	44.24	2185.91
20	1053.63	7375.39	7217.00	85.2	6152.09	198.53	1223.29
25	1053.63	7375.39	7217.00	89.0	6421.81	1008.50	951.58
30	1053.63	7375.39	7217.00	90.5	6531.13	2051.06	838.07
35	1053.63	7375.39	7217.00	91.4	6594.97	3102.66	774.23
60	1053.63	7375.39	7217.00	93.8	6766.27	8324.50	602.93
COLLECTOR AREA = 80 SQ-M							
5	1053.63	8429.01	7217.00	25.3	1825.00	0.00	6604.01
10	1053.63	8429.01	7217.00	50.5	3643.40	0.00	4785.62
15	1053.63	8429.01	7217.00	73.7	5317.93	46.12	3111.09
20	1053.63	8429.01	7217.00	89.6	6468.63	234.19	1960.38
25	1053.63	8429.01	7217.00	93.4	6738.86	1253.47	1688.16
30	1053.63	8429.01	7217.00	94.7	6834.51	2470.47	1587.51
35	1053.63	8429.01	7217.00	95.6	6898.79	3739.38	1518.22
60	1053.63	8429.01	7217.00	97.4	7030.66	10995.55	1384.71

Table 2.1.34(e)

25 MAR 76 - 11:22:55 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 2 - H INSOLATION DATA - NOMINAL LOAD 2LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 90 SQ-M							
5	1053.63	9482.64	7217.00	25.3	1825.00	0.00	7657.64
10	1053.63	9482.64	7217.00	50.5	3647.62	0.00	5835.03
15	1053.63	9482.64	7217.00	74.4	5372.27	47.75	4110.37
20	1053.63	9482.64	7217.00	92.5	6678.26	280.59	2804.39
25	1053.63	9482.64	7217.00	95.2	6945.37	1485.83	2535.27
30	1053.63	9482.64	7217.00	97.2	7017.88	3004.04	2457.76
35	1053.63	9482.64	7217.00	97.9	7065.27	4607.92	2405.37
60	1053.63	9482.64	7217.00	99.0	7147.13	12739.34	2314.36
COLLECTOR AREA = 100 SQ-M							
5	1053.63	10536.27	7217.00	25.3	1825.00	0.00	8711.27
10	1053.63	10536.27	7217.00	50.5	3649.57	0.00	6886.69
15	1053.63	10536.27	7217.00	74.8	5385.92	48.00	5140.35
20	1053.63	10536.27	7217.00	94.2	6860.68	310.32	3735.59
25	1053.63	10536.27	7217.00	97.8	7057.88	1670.55	3476.38
30	1053.63	10536.27	7217.00	98.5	7106.75	3309.78	3422.52
35	1053.63	10536.27	7217.00	98.9	7139.17	4972.72	3385.10
60	1053.63	10536.27	7217.00	99.6	7131.53	13622.24	3315.18

25 MAR 76 - 11:25:19 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 2 - INSOLATION DATA - NOMINAL LOAD 2

Figure 2.1.34(a)

25 MAR 76 - 11:31:58 AM

FVEPS - ENERGY FLOW SIMULATIONS - 73.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 2 - 1 INSOLATION DATA - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

Figure 2.1.34(b)

25 MAR 76 - 11:37:46 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 2 - W INSOLATION DATA - NOMINAL LOAD 2

Figure 2.1.34(c)

Table 2.1.35(a)

25 MAR 76 - 11:54:32 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 3A - Y INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KJ-HR PER SQ-M	KW-HR PER YEAR	KJ-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KJ-HR PER YEAR
COLLECTOR AREA = 10 SQ-M							
5	1053.63	1053.63	13161.31	8.0	1049.90	0.00	3.73
10	1053.63	1053.63	13161.31	8.0	1053.63	0.00	0.00
15	1053.63	1053.63	13161.31	8.0	1053.63	0.00	0.00
20	1053.63	1053.63	13161.31	8.0	1053.63	0.00	0.00
25	1053.63	1053.63	13161.31	9.0	1053.63	0.00	0.00
30	1053.63	1053.63	13161.31	8.0	1053.63	0.00	0.00
35	1053.63	1053.63	13161.31	8.0	1053.63	0.00	0.00
60	1053.63	1053.63	13161.31	8.0	1053.63	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1053.63	2107.25	13161.31	12.6	1559.99	0.00	447.26
10	1053.63	2107.25	13161.31	16.0	2099.79	0.00	7.45
15	1053.63	2107.25	13161.31	16.0	2107.25	0.00	0.00
20	1053.63	2107.25	13161.31	16.0	2107.25	0.00	0.00
25	1053.63	2107.25	13161.31	16.0	2107.25	0.00	0.00
30	1053.63	2107.25	13161.31	16.0	2107.25	0.00	0.00
35	1053.63	2107.25	13161.31	16.0	2107.25	0.00	0.00
60	1053.63	2107.25	13161.31	16.0	2107.25	0.00	0.00

Table 2.1.35(b)

25 MAR 76 - 11:56:20 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 34 - N INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 30 SQ-M							
5	1053.63	3160.88	13161.31	13.7	1806.57	0.00	1354.31
10	1053.63	3160.88	13161.31	21.9	2881.74	0.00	279.14
15	1053.63	3160.88	13161.31	23.9	3149.69	0.00	11.19
20	1053.63	3160.88	13161.31	24.0	3160.88	0.50	0.00
25	1053.63	3160.88	13161.31	24.0	3160.88	0.50	0.00
30	1053.63	3160.88	13161.31	24.0	3160.88	0.50	0.00
35	1053.63	3160.88	13161.31	24.0	3160.88	0.50	0.00
60	1053.63	3160.98	13161.31	24.0	3160.88	0.50	0.00
COLLECTOR AREA = 40 SQ-M							
5	1053.63	4214.51	13161.31	13.3	1821.70	0.00	2392.81
10	1053.63	4214.51	13161.31	25.2	3319.99	0.00	894.52
15	1053.63	4214.51	13161.31	30.4	3995.15	0.00	219.36
20	1053.63	4214.51	13161.31	31.8	4180.21	70.79	34.29
25	1053.63	4214.51	13161.31	32.0	4207.13	112.53	7.33
30	1053.63	4214.51	13161.31	32.0	4212.18	133.07	2.33
35	1053.63	4214.51	13161.31	32.0	4214.51	151.55	0.00
60	1053.63	4214.51	13161.31	32.0	4214.51	151.55	0.00

Table 2.1.35(c)

25 MAR 76 - 11:53:16 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 34 - INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1053.63	5268.13	13161.31	13.9	1824.79	0.00	3443.35
10	1053.63	5268.13	13161.31	26.9	3535.71	0.00	1732.43
15	1053.63	5268.13	13161.31	34.9	4593.20	0.00	674.93
20	1053.63	5268.13	13161.31	38.0	5000.37	153.42	266.06
25	1053.63	5268.13	13161.31	38.9	5118.14	396.43	147.68
30	1053.63	5268.13	13161.31	39.2	5158.17	597.97	107.65
35	1053.63	5268.13	13161.31	39.4	5183.45	803.73	82.37
60	1053.63	5268.13	13161.31	39.8	5234.20	1370.86	31.61
COLLECTOR AREA = 60 SQ-M							
5	1053.63	6321.76	13161.31	13.9	1825.00	0.00	4496.76
10	1053.63	6321.76	13161.31	27.5	3613.13	0.00	2708.63
15	1053.63	6321.76	13161.31	37.8	4979.98	0.00	1341.78
20	1053.63	6321.76	13161.31	42.9	5644.17	182.96	675.88
25	1053.63	6321.76	13161.31	44.7	5878.88	526.49	436.17
30	1053.63	6321.76	13161.31	45.4	5969.72	891.05	342.60
35	1053.63	6321.76	13161.31	45.7	6017.44	1253.06	294.88
60	1053.63	6321.76	13161.31	46.8	6153.13	2576.85	159.19

Table 2.1.35(d)

25 MAR 76 * 12:00:03 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 3A - 1/2 INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KV-HR	KV-HR PER SQ-M	KW-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR

COLLECTOR AREA = 70 SQ-M							
5	1053.63	7375.39	13161.31	13.9	1825.00	0.00	5550.39
10	1053.63	7375.39	13161.31	27.6	3633.52	0.00	3741.87
15	1053.63	7375.39	13161.31	39.7	5223.42	0.00	2151.97
20	1053.63	7375.39	13161.31	46.4	6111.48	218.50	1262.20
25	1053.63	7375.39	13161.31	49.4	6506.57	642.89	862.11
30	1053.63	7375.39	13161.31	50.7	6670.45	1141.79	693.23
35	1053.63	7375.39	13161.31	51.2	6741.65	1656.58	617.03
60	1053.63	7375.39	13161.31	52.6	6927.49	3876.87	431.00

COLLECTOR AREA = 80 SQ-M

5	1053.63	8429.01	13161.31	13.9	1825.00	0.00	5604.01
10	1053.63	8429.01	13161.31	27.7	3643.40	0.00	4785.62
15	1053.63	8429.01	13161.31	40.7	5359.75	0.00	3069.27
20	1053.63	8429.01	13161.31	48.9	6439.66	236.51	1987.65
25	1053.63	8429.01	13161.31	53.1	6987.93	723.48	1434.38
30	1053.63	8429.01	13161.31	55.1	7247.65	1290.90	1169.66
35	1053.63	8429.01	13151.31	56.0	7364.28	1896.09	1048.03
60	1053.63	8429.01	13161.31	57.4	7553.83	4988.79	850.83

Table 2.1.35(e)

25 MAR 78 - 12:01:53 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 3A - 1/2 INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 30 SQ-M							
5	1053.63	9482.64	13161.31	13.9	1825.00	0.00	7657.64
10	1053.63	9482.64	13161.31	27.7	3647.62	0.00	5835.03
15	1053.63	9482.64	13161.31	41.2	5419.70	0.00	4062.94
20	1053.63	9482.64	13161.31	50.7	5671.23	254.61	2909.71
25	1053.63	9482.64	13161.31	55.8	7349.73	805.28	2126.20
30	1053.63	9482.64	13161.31	59.7	7729.23	1414.45	1741.70
35	1053.63	9482.64	13161.31	60.1	7909.61	2057.21	1556.33
60	1053.63	9482.64	13161.31	61.7	8121.46	5544.17	1325.06
COLLECTOR AREA = 100 SQ-M							
5	1053.63	10536.27	13161.31	13.9	1825.00	0.00	8711.27
10	1053.63	10536.27	13161.31	27.7	3649.57	0.00	6886.69
15	1053.63	10536.27	13161.31	41.4	5443.92	0.00	5092.35
20	1053.63	10536.27	13161.31	51.8	6817.23	274.69	3717.33
25	1053.63	10536.27	13161.31	57.9	7624.08	832.79	2905.48
30	1053.63	10536.27	13161.31	61.7	8116.93	1492.69	2407.63
35	1053.63	10536.27	13161.31	63.8	8390.42	2196.08	2129.14
60	1053.63	10536.27	13161.31	65.9	8669.23	6076.20	1825.34

25 MAR 76 - 01:49:25 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 3A

INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATA

Figure 2.1.35(a)

25 MAR 76 - 01:52:23 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 34

INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATA

Figure 2.1.35(b)

W INSULATION DATA - NOMINAL LOAD 2 - W A/C DATA

Table 2.1.36(a)

25 MAR 76 - 04:36:37 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 38 - 1 INSOLATION DATA(S1) - NOMINAL LOAD 2 - 1 A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KV-HR	KJ-HR PER SQ-M	KJ-HR PER YEAR	KJ-HR PER YEAR	% LOAD SUPPLIED	KJ-HR PER YEAR	KV-HR	KJ-HR PER YEAR
COLLECTOR AREA = 10 SQ-M							
5	1053.63	1053.63	15351.31	6.8	1049.90	0.00	3.73
10	1053.63	1053.63	15351.31	6.9	1053.63	0.00	0.00
15	1053.63	1053.63	15351.31	6.9	1053.63	0.00	0.00
20	1053.63	1053.63	15351.31	6.9	1053.63	0.00	0.00
25	1053.63	1053.63	15351.31	6.9	1053.63	0.00	0.00
30	1053.63	1053.63	15351.31	6.9	1053.63	0.00	0.00
35	1053.63	1053.63	15351.31	6.9	1053.63	0.00	0.00
60	1053.63	1053.63	15351.31	6.9	1053.63	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1053.63	2107.25	15351.31	10.8	1559.99	0.00	447.25
10	1053.63	2107.25	15351.31	13.7	2099.79	0.00	7.46
15	1053.63	2107.25	15351.31	13.7	2107.25	0.00	0.00
20	1053.63	2107.25	15351.31	13.7	2107.25	0.00	0.00
25	1053.63	2107.25	15351.31	13.7	2107.25	0.00	0.00
30	1053.63	2107.25	15351.31	13.7	2107.25	0.00	0.00
35	1053.63	2107.25	15351.31	13.7	2107.25	0.00	0.00
60	1053.63	2107.25	15351.31	13.7	2107.25	0.00	0.00

Table 2.1.36(b)

25 MAR 76 - 04:40:20 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 3B - $\frac{1}{2}$ INSOLATION DATA(S1) - NOMINAL LOAD 2 - $\frac{1}{2}$ A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KV-HR	KV-HR PER SQ-M	KJ-HR PER YEAR	KJ-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 30 SQ-M							
5	1053.63	3160.88	15351.31	11.8	1805.57	0.00	1354.31
10	1053.63	3160.88	15351.31	18.8	2381.74	0.00	279.14
15	1053.63	3160.88	15351.31	20.5	3149.59	0.00	11.19
20	1053.63	3160.88	15351.31	20.6	3160.88	0.00	0.00
25	1053.63	3160.88	15351.31	20.6	3160.88	0.00	0.00
30	1053.63	3160.88	15351.31	20.6	3160.88	0.00	0.00
35	1053.63	3160.88	15351.31	20.6	3160.88	0.00	0.00
60	1053.63	3160.88	15351.31	20.6	3160.88	0.00	0.00
COLLECTOR AREA = 40 SQ-M							
5	1053.63	4214.51	15351.31	11.9	1821.70	0.00	2392.91
10	1053.63	4214.51	15351.31	21.6	3319.99	0.00	994.52
15	1053.63	4214.51	15351.31	26.0	3995.15	0.00	219.36
20	1053.63	4214.51	15351.31	27.4	4199.59	0.00	14.92
25	1053.63	4214.51	15351.31	27.5	4214.51	0.00	0.00
30	1053.63	4214.51	15351.31	27.5	4214.51	0.00	0.00
35	1053.63	4214.51	15351.31	27.5	4214.51	0.00	0.00
60	1053.63	4214.51	15351.31	27.5	4214.51	0.00	0.00

Table 2.1.36(c)

25 MAR 76 - 04:42:00 PM

PVSPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 36 - H INSOLATION DATA(S1) - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KV-HR	KW-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1053.63	5268.13	15351.31	11.9	1824.79	0.00	3443.35
10	1053.63	5268.13	15351.31	23.0	3535.71	0.00	1732.43
15	1053.63	5268.13	15351.31	29.9	4593.20	0.00	674.93
20	1053.63	5268.13	15351.31	33.1	5079.72	0.00	188.41
25	1053.63	5268.13	15351.31	34.1	5241.01	29.44	27.12
30	1053.63	5268.13	15351.31	34.3	5265.52	55.10	2.62
35	1053.63	5268.13	15351.31	34.3	5268.13	60.33	0.00
60	1053.63	5268.13	15351.31	34.3	5268.13	60.33	0.00
COLLECTOR AREA = 60 SQ-M							
5	1053.63	6321.76	15351.31	11.9	1825.00	0.00	4496.75
10	1053.63	6321.76	15351.31	23.5	3613.13	0.00	2708.63
15	1053.63	6321.76	15351.31	32.4	4979.98	0.00	1341.78
20	1053.63	6321.76	15351.31	37.5	5763.47	0.00	558.29
25	1053.63	6321.76	15351.31	39.8	6112.41	83.26	208.92
30	1053.63	6321.76	15351.31	40.6	6225.10	232.78	96.22
35	1053.63	6321.76	15351.31	40.8	6269.52	363.53	51.80
60	1053.63	6321.76	15351.31	41.2	6321.32	790.54	0.00

Table 2.1.36(d)

25 MAR 76 - 04:43:42 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 38 - 1 INSOLATION DATA(S1) - NOMINAL LOAD 2 - 1 A/C DATA

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT	STORAGE	WASTE
KV-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR PER YEAR
COLLECTOR AREA = 70 SQ-M						
5	1053.63	7375.39	15351.31	11.9	1825.00	5550.39
10	1053.63	7375.39	15351.31	23.7	3633.52	3741.87
15	1053.63	7375.39	15351.31	34.0	5223.42	2151.97
20	1053.63	7375.39	15351.31	40.9	6274.15	1101.24
25	1053.63	7375.39	15351.31	44.5	6823.69	550.99
30	1053.63	7375.39	15351.31	45.8	7037.69	332.80
35	1053.63	7375.39	15351.31	46.4	7130.49	240.00
60	1053.63	7375.39	15351.31	47.3	7266.29	104.22
COLLECTOR AREA = 80 SQ-M						
5	1053.63	8429.01	15351.31	11.9	1825.00	6504.01
10	1053.63	8429.01	15351.31	23.7	3643.40	4785.62
15	1053.63	8429.01	15351.31	34.9	5359.75	3069.27
20	1053.63	8429.01	15351.31	43.3	6639.98	1789.04
25	1053.63	8429.01	15351.31	48.2	7398.58	1029.73
30	1053.63	8429.01	15351.31	50.4	7738.89	684.42
35	1053.63	8429.01	15351.31	51.4	7890.30	528.01
60	1053.63	8429.01	15351.31	52.9	8123.41	293.25

Table 2.1.36(e)

25 MAR 76 - 04:45:33 PM

PVFPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 38 - INSOLATION DATA(S1) - NOMINAL LOAD 2 - A/C DATA

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KW-HR	KV-HR PER YEAR
COLLECTOR AREA = 90 SQ-M							
5	1053.63	9482.64	15351.31	11.9	1825.00	0.00	7657.64
10	1053.63	9482.64	15351.31	23.8	3647.62	0.00	5835.03
15	1053.63	9482.64	15351.31	35.3	5419.70	0.00	4062.94
20	1053.63	9482.64	15351.31	44.9	6897.00	0.00	2585.64
25	1053.63	9482.64	15351.31	51.1	7838.64	141.66	1643.30
30	1053.63	9482.64	15351.31	54.2	8316.13	528.72	1160.81
35	1053.63	9482.64	15351.31	55.8	8558.43	992.80	913.51
60	1053.63	9482.64	15351.31	57.7	9851.01	3372.98	611.82
COLLECTOR AREA = 100 SQ-M							
5	1053.63	10536.27	15351.31	11.9	1825.00	0.00	8711.27
10	1053.63	10536.27	15351.31	23.8	3649.57	0.00	6886.69
15	1053.63	10536.27	15351.31	35.5	5443.92	0.00	5092.35
20	1053.63	10536.27	15351.31	46.1	7071.41	0.00	3464.85
25	1053.63	10536.27	15351.31	53.2	8174.33	151.51	2361.23
30	1053.63	10536.27	15351.31	57.2	9775.90	585.08	1754.66
35	1053.63	10536.27	15351.31	59.3	9106.26	1118.84	1419.30
60	1053.63	10536.27	15351.31	61.8	9493.74	4109.97	1015.26

25 MAR 76 - 04:52:33 PM

PVEPS - ENERGY FLOW SIMULATIONS - 13.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1983 - CASE 3B

INSOLATION DATA(S1) - NOMINAL LOAD 2 - 1 A/C DATA

Figure 2.1.36(a)

25 MAR 76 - 04:56:00 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 38

INSOLATION DATA(S1) - NOMINAL LOAD 2 - A/C DATA

Figure 2.1.36(b)

25 MAR 76 - 05:00:38 PM

PVAPS - ENERGY FLOW SIMULATIONS - 73.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 3E

INSOLATION DATA(S1) - NOMINAL LOAD, 2 - H A/C DATA

Figure 2.1.36(c)

Table 2.1.37(a)

15 MAR 76 - 05:14:25 PM

PIEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 1 - 4 INSOLATION DATA (S1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KV-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 10 SQ-M							
5	1312.30	1312.30	5027.00	26.1	1311.45	0.00	0.84
10	1312.30	1312.30	5027.00	26.1	1312.30	0.00	0.00
15	1312.30	1312.30	5027.00	26.1	1312.30	0.00	0.00
20	1312.30	1312.30	5027.00	26.1	1312.30	0.00	0.00
25	1312.30	1312.30	5027.00	26.1	1312.30	0.00	0.00
30	1312.30	1312.30	5027.00	26.1	1312.30	0.00	0.00
35	1312.30	1312.30	5027.00	26.1	1312.30	0.00	0.00
60	1312.30	1312.30	5027.00	26.1	1312.30	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1312.30	2624.59	5027.00	35.2	1769.91	0.00	854.69
10	1312.30	2624.59	5027.00	51.7	2597.80	61.38	26.80
15	1312.30	2624.59	5027.00	51.8	2604.47	127.13	20.12
20	1312.30	2624.59	5027.00	51.9	2609.47	189.02	15.12
25	1312.30	2624.59	5027.00	52.0	2614.47	242.83	10.12
30	1312.30	2624.59	5027.00	52.1	2619.47	291.13	5.12
35	1312.30	2624.59	5027.00	52.2	2624.47	332.76	0.12

Table 2.1.37(b)

15 MAR 76 - 05:16:18 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 1 - 2 INSOLATION DATA (S1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT	STORAGE	WASTE
KV-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR PER YEAR
COLLECTOR AREA = 30 SQ-M						
5	1312.30	3936.89	5027.00	36.2	1818.77	2118.12
10	1312.30	3936.89	5027.00	65.2	3279.67	657.22
15	1312.30	3936.89	5027.00	76.0	3822.78	114.11
20	1312.30	3936.89	5027.00	76.4	3840.44	95.45
25	1312.30	3936.89	5027.00	76.5	3847.79	89.10
30	1312.30	3936.89	5027.00	76.6	3852.79	84.10
35	1312.30	3936.89	5027.00	76.7	3857.79	79.10
60	1312.30	3936.89	5027.00	77.2	3882.79	54.10
COLLECTOR AREA = 40 SQ-M						
5	1312.30	5249.19	5027.00	36.3	1824.59	3424.60
10	1312.30	5249.19	5027.00	69.1	3475.81	1773.38
15	1312.30	5249.19	5027.00	87.5	4399.66	849.53
20	1312.30	5249.19	5027.00	89.4	4491.99	757.20
25	1312.30	5249.19	5027.00	89.8	4514.60	734.59
30	1312.30	5249.19	5027.00	90.0	4524.60	724.59
35	1312.30	5249.19	5027.00	90.2	4534.60	714.59
60	1312.30	5249.19	5027.00	90.9	4571.10	678.09

Table 2.1.37(c)

15 MAR 76 - 05:18:07 PM.

PIEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 1 - W INSOLATION DATA (S1) - NOMINAL LOAD 2LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1312.30	6561.49	5027.00	36.3	1825.00	0.00	4736.49
10	1312.30	6561.49	5027.00	70.6	3547.67	64.00	3013.82
15	1312.30	6561.49	5027.00	92.1	4628.34	545.19	1933.15
20	1312.30	6561.49	5027.00	94.2	4733.79	1939.81	1827.69
25	1312.30	6561.49	5027.00	94.8	4766.08	3372.36	1795.40
30	1312.30	6561.49	5027.00	95.2	4784.40	4804.62	1775.69
35	1312.30	6561.49	5027.00	95.4	4794.40	6201.50	1760.69
60	1312.30	6561.49	5027.00	95.8	4814.79	13204.21	1715.90
COLLECTOR AREA = 60 SQ-M							
5	1312.30	7873.78	5027.00	35.3	1825.00	0.00	6048.78
10	1312.30	7873.78	5027.00	71.1	3573.54	64.00	4300.25
15	1312.30	7873.78	5027.00	94.7	4752.96	550.22	3110.83
20	1312.30	7873.78	5027.00	96.8	4864.49	2053.77	3009.29
25	1312.30	7873.78	5027.00	97.3	4891.10	3611.07	2981.81
30	1312.30	7873.78	5027.00	97.6	4905.29	5184.57	2962.62
35	1312.30	7873.78	5027.00	97.8	4915.29	6775.43	2947.62
60	1312.30	7873.78	5027.00	98.3	4942.96	14614.59	2894.95

Table 2.1.37(d)

15 MAR 76 - 05:19:53 PM

PEEPS - ENERGY FLOW SIMULATIONS - /3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 1 - W INSOLATION DATA (S1) - NOMINAL LOAD 2LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR PER YEAR
COLLECTOR AREA = 70 SQ-M						
5	1312.30	9186.08	5027.00	36.3	1825.00	7361.08
10	1312.30	9186.08	5027.00	71.2	3581.50	5604.58
15	1312.30	9186.08	5027.00	96.2	4837.44	4348.64
20	1312.30	9186.08	5027.00	98.3	4942.41	4243.18
25	1312.30	9186.08	5027.00	98.6	4958.98	4221.75
30	1312.30	9186.08	5027.00	98.9	4973.98	4201.75
35	1312.30	9186.08	5027.00	99.1	4981.22	4189.51
60	1312.30	9186.08	5027.00	99.5	5001.64	4144.08
COLLECTOR AREA = 80 SQ-M						
5	1312.30	10498.38	5027.00	36.3	1825.00	8673.38
10	1312.30	10498.38	5027.00	71.3	3585.18	6913.20
15	1312.30	10498.38	5027.00	97.1	4879.86	5618.52
20	1312.30	10498.38	5027.00	99.2	4989.19	5506.18
25	1312.30	10498.38	5027.00	99.5	5004.19	5486.18
30	1312.30	10498.38	5027.00	99.7	5013.47	5471.90
35	1312.30	10498.38	5027.00	99.8	5015.46	5464.92
60	1312.30	10498.38	5027.00	99.8	5015.46	5439.92

Table 2.1.37(e)

15 MAR 76 - 05:21:44 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 1 - W INSOLATION DATA (S1) - NOMINAL LOAD 2LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 90 SQ-M							
5	1312.30	11810.67	5027.00	36.3	1825.00	0.00	9985.67
10	1312.30	11810.67	5027.00	71.3	3586.00	64.00	8224.67
15	1312.30	11810.67	5027.00	97.5	4901.31	555.00	6909.37
20	1312.30	11810.67	5027.00	99.8	5017.10	2223.78	6790.57
25	1312.30	11810.67	5027.00	100.0	5026.72	4011.66	6775.95
30	1312.30	11810.67	5027.00	100.0	5026.72	5798.10	6770.95
35	1312.30	11810.67	5027.00	100.0	5026.72	7583.10	6765.95
50	1312.30	11810.67	5027.00	100.0	5026.72	16445.15	6740.95
COLLECTOR AREA = 100 SQ-M							
5	1312.30	13122.97	5027.00	36.3	1825.00	0.00	11297.97
10	1312.30	13122.97	5027.00	71.3	3586.00	64.00	9536.97
15	1312.30	13122.97	5027.00	97.7	4910.00	555.00	8212.98
20	1312.30	13122.97	5027.00	100.0	5025.00	2253.56	8094.97
25	1312.30	13122.97	5027.00	100.0	5027.00	4070.44	8087.97
30	1312.30	13122.97	5027.00	100.0	5027.00	5884.41	8082.97
35	1312.30	13122.97	5027.00	100.0	5027.00	7677.76	8077.97
50	1312.30	13122.97	5027.00	100.0	5027.00	15609.27	8052.97

15 MAR 76 - 05:32:15 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 1 - 1 INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.37(a)

13 MAR 76 - 05:25:01 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 1 - W-INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.37(b)

16 MAR 76 - 06:04:54 PM

PIEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 1 - 4 INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.37(c)

Table 2.1.38(a)

16 MAR 76 - 06:21:05 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 2 - 1/2 INSOLATION DATA (S1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT	STORAGE	WASTE
KV-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR PER YEAR
COLLECTOR AREA = 10 SQ-M						
5	1312.30	1312.30	7217.00	18.2	1311.46	0.84
10	1312.30	1312.30	7217.00	18.2	1312.30	0.00
15	1312.30	1312.30	7217.00	18.2	1312.30	0.00
20	1312.30	1312.30	7217.00	18.2	1312.30	0.00
25	1312.30	1312.30	7217.00	18.2	1312.30	0.00
30	1312.30	1312.30	7217.00	18.2	1312.30	0.00
35	1312.30	1312.30	7217.00	18.2	1312.30	0.00
60	1312.30	1312.30	7217.00	18.2	1312.30	0.00
COLLECTOR AREA = 20 SQ-M						
5	1312.30	2624.59	7217.00	24.5	1769.91	854.59
10	1312.30	2624.59	7217.00	36.3	2622.92	1.68
15	1312.30	2624.59	7217.00	36.4	2624.59	0.00
20	1312.30	2624.59	7217.00	36.4	2624.59	0.00
25	1312.30	2624.59	7217.00	36.4	2624.59	0.00
30	1312.30	2624.59	7217.00	36.4	2624.59	0.00
35	1312.30	2624.59	7217.00	36.4	2624.59	0.00
60	1312.30	2624.59	7217.00	36.4	2624.59	0.00

Table 2.1.38(b)

16 MAR 76 - 05:22:55 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 2 - Y INSOLATION DATA (S1) - NOMINAL LOAD 2LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 30 SQ-M							
5	1312.30	3936.89	7217.00	25.2	1818.77	0.00	2118.12
10	1312.30	3936.89	7217.00	46.3	3341.73	0.00	595.16
15	1312.30	3936.89	7217.00	54.5	3934.38	7.13	2.51
20	1312.30	3936.89	7217.00	54.6	3936.89	7.13	0.00
25	1312.30	3936.89	7217.00	54.6	3936.89	7.13	0.00
30	1312.30	3936.89	7217.00	54.6	3936.89	7.13	0.00
35	1312.30	3936.89	7217.00	54.6	3936.89	7.13	0.00
60	1312.30	3936.89	7217.00	54.6	3936.89	7.13	0.00
COLLECTOR AREA = 40 SQ-M							
5	1312.30	5249.19	7217.00	25.3	1824.59	0.00	3424.60
10	1312.30	5249.19	7217.00	49.0	3539.81	0.00	1709.38
15	1312.30	5249.19	7217.00	66.3	4788.38	46.75	460.81
20	1312.30	5249.19	7217.00	72.0	5195.12	131.82	54.07
25	1312.30	5249.19	7217.00	72.1	5203.47	230.68	45.72
30	1312.30	5249.19	7217.00	72.2	5208.47	334.77	40.72
35	1312.30	5249.19	7217.00	72.2	5213.47	442.19	35.72
60	1312.30	5249.19	7217.00	72.6	5238.47	1141.35	10.72

Table 2.1.38(c)

16 MAR 76 - 06:24:39 PM

PVRES - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 2 - W INSOLATION DATA (S1) - NOMINAL LOAD 2LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KV-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1312.30	6561.49	7217.00	25.3	1825.00	0.00	4736.49
10	1312.30	6561.49	7217.00	50.0	3611.67	0.00	2949.82
15	1312.30	6561.49	7217.00	70.7	5099.25	48.00	1462.24
20	1312.30	6561.49	7217.00	83.5	6028.86	288.83	532.63
25	1312.30	6561.49	7217.00	85.3	6154.00	1109.28	407.48
30	1312.30	6561.49	7217.00	85.9	6196.81	1916.11	364.68
35	1312.30	6561.49	7217.00	86.3	6226.39	2661.43	335.10
40	1312.30	6561.49	7217.00	87.1	6287.21	5125.26	274.28
COLLECTOR AREA = 50 SQ-M							
5	1312.30	7873.78	7217.00	25.3	1825.00	0.00	6048.78
10	1312.30	7873.78	7217.00	50.4	3637.54	0.00	4236.25
15	1312.30	7873.78	7217.00	72.9	5261.72	48.00	2612.06
20	1312.30	7873.78	7217.00	88.5	6389.69	317.99	1484.10
25	1312.30	7873.78	7217.00	91.4	6598.62	1459.56	1275.16
30	1312.30	7873.78	7217.00	92.1	6547.09	2740.47	1226.69
35	1312.30	7873.78	7217.00	92.4	6565.63	4017.54	1208.15
40	1312.30	7873.78	7217.00	93.0	6714.39	10165.85	1159.39

Table 2.1.38(d)

16 MAR 76 - 06:26:28 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 2 - 1/2 INSOLATION DATA (S1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 70 SQ-M							
5	1312.30	9186.08	7217.00	25.3	1825.00	0.00	7361.08
10	1312.30	9186.08	7217.00	50.5	3645.50	0.00	5540.58
15	1312.30	9186.08	7217.00	74.1	5344.44	48.00	3841.64
20	1312.30	9186.08	7217.00	91.5	6505.30	339.96	2580.78
25	1312.30	9186.08	7217.00	94.2	6801.55	1647.40	2384.53
30	1312.30	9186.08	7217.00	94.8	6844.51	3088.32	2341.57
35	1312.30	9186.08	7217.00	95.3	6874.51	4526.35	2311.57
60	1312.30	9186.08	7217.00	96.2	6939.76	11580.36	2223.97
COLLECTOR AREA = 30 SQ-M							
5	1312.30	10498.38	7217.00	25.3	1825.00	0.00	8673.38
10	1312.30	10498.38	7217.00	50.6	3649.18	0.00	6849.20
15	1312.30	10498.38	7217.00	74.6	5386.26	48.00	5111.52
20	1312.30	10498.38	7217.00	93.4	6738.63	341.00	3759.75
25	1312.30	10498.38	7217.00	96.2	6942.39	1715.06	3555.98
30	1312.30	10498.38	7217.00	96.8	6983.80	3240.12	3514.58
35	1312.30	10498.38	7217.00	97.1	7004.74	4785.65	3491.81
60	1312.30	10498.38	7217.00	97.8	7058.95	12645.62	3412.59

Table 2.1.38(e)

16 MAR 76 - 06:28:12 PM

PIEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 2 - W INSOLATION DATA (S1) - NOMINAL LOAD 2LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 93 SQ-M							
5	1312.30	11810.67	7217.00	25.3	1825.00	0.00	9985.67
10	1312.30	11810.67	7217.00	50.6	3650.00	0.00	8160.67
15	1312.30	11810.67	7217.00	74.9	5408.31	48.00	6402.37
20	1312.30	11810.67	7217.00	94.6	6828.07	341.00	4982.60
25	1312.30	11810.67	7217.00	97.5	7039.46	1776.15	4771.21
30	1312.30	11810.67	7217.00	98.0	7075.25	3380.36	4734.12
35	1312.30	11810.67	7217.00	98.3	7094.97	5017.98	4709.40
60	1312.30	11810.67	7217.00	98.8	7133.14	13111.57	4646.23
COLLECTOR AREA = 100 SQ-M							
5	1312.30	13122.97	7217.00	25.3	1825.00	0.00	11297.97
10	1312.30	13122.97	7217.00	50.6	3650.00	0.00	9472.97
15	1312.30	13122.97	7217.00	75.1	5417.00	48.00	7705.98
20	1312.30	13122.97	7217.00	95.4	6882.33	341.00	6240.64
25	1312.30	13122.97	7217.00	98.5	7106.93	1804.46	6014.07
30	1312.30	13122.97	7217.00	98.9	7128.40	3485.71	5983.78
35	1312.30	13122.97	7217.00	99.0	7143.40	5184.25	5968.78
60	1312.30	13122.97	7217.00	99.5	7182.25	13555.97	5904.93

15 MAR 76 - 06:30:12 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 2 - 1 INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.38(a)

16 MAR 76 - 06:35:04 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 2 - INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.38(b)

16 MAR 76 - 06:41:38 PM

PVSPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 2 - 4 INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.38(c)

Table 2.1.39(a)

17 MAR 76 - 11:17:58 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3A - W INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 10 SQ-M							
5	1312.30	1312.30	6706.25	19.6	1311.46	0.00	0.84
10	1312.30	1312.30	6706.25	19.6	1312.30	0.00	0.00
15	1312.30	1312.30	6706.25	19.6	1312.30	0.00	0.00
20	1312.30	1312.30	6706.25	19.6	1312.30	0.00	0.00
25	1312.30	1312.30	6706.25	19.6	1312.30	0.00	0.00
30	1312.30	1312.30	6706.25	19.6	1312.30	0.00	0.00
35	1312.30	1312.30	6706.25	19.6	1312.30	0.00	0.00
60	1312.30	1312.30	6706.25	19.6	1312.30	0.00	0.00
•							
COLLECTOR AREA = 20 SQ-M							
5	1312.30	2624.59	6706.25	26.4	1769.91	0.00	854.69
10	1312.30	2624.59	6706.25	39.1	2622.92	0.00	1.68
15	1312.30	2624.59	6706.25	39.1	2624.59	0.00	0.00
20	1312.30	2624.59	6706.25	39.1	2624.59	0.00	0.00
25	1312.30	2624.59	6706.25	39.1	2624.59	0.00	0.00
30	1312.30	2624.59	6706.25	39.1	2624.59	0.00	0.00
35	1312.30	2624.59	6706.25	39.1	2624.59	0.00	0.00
60	1312.30	2624.59	6706.25	39.1	2624.59	0.00	0.00

Table 2.1.39(b)

17 MAR 76 - 11:20:13 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3A - W INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 30 SQ-M							
5	1312.30	3936.89	6706.25	27.1	1818.77	0.00	2118.12
10	1312.30	3936.89	6706.25	49.8	3340.73	1.00	596.15
15	1312.30	3936.89	6706.25	58.7	3933.29	17.05	3.60
20	1312.30	3936.89	6706.25	58.7	3936.89	17.51	0.00
25	1312.30	3936.89	6706.25	58.7	3936.89	17.51	0.00
30	1312.30	3936.89	6706.25	58.7	3936.89	17.51	0.00
35	1312.30	3936.89	6706.25	58.7	3936.89	17.51	0.00
60	1312.30	3936.89	6706.25	58.7	3936.89	17.51	0.00
.							
COLLECTOR AREA = 40 SQ-M							
5	1312.30	5249.19	6706.25	27.2	1824.59	0.00	3424.60
10	1312.30	5249.19	6706.25	52.8	3538.82	1.00	1710.37
15	1312.30	5249.19	6706.25	71.3	4782.16	54.16	467.03
20	1312.30	5249.19	6706.25	76.6	5134.11	335.42	115.08
25	1312.30	5249.19	6706.25	77.2	5176.58	570.17	72.61
30	1312.30	5249.19	6706.25	77.5	5197.89	870.85	51.30
35	1312.30	5249.19	6706.25	77.7	5211.85	1139.80	37.34
60	1312.30	5249.19	6706.25	78.2	5243.06	1936.80	6.13

Table 2.1.39(c)

17 MAR 76 - 11:22:22 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3A - $\frac{1}{2}$ INSOLATION DATA - NOMINAL LOAD 2 - $\frac{1}{2}$ A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1312.30	6561.49	6706.25	27.2	1825.00	0.00	4736.49
10	1312.30	6561.49	6706.25	53.8	3610.67	1.00	2950.82
15	1312.30	6561.49	6706.25	75.9	5088.10	59.46	1473.39
20	1312.30	6561.49	6706.25	86.2	5783.53	621.66	777.96
25	1312.30	6561.49	6706.25	88.5	5933.14	1469.02	628.35
30	1312.30	6561.49	6706.25	89.3	5990.45	2350.63	571.04
35	1312.30	6561.49	6706.25	89.8	6020.45	3196.13	541.04
60	1312.30	6561.49	6706.25	91.3	6119.93	7414.18	441.55
COLLECTOR AREA = 60 SQ-M							
5	1312.30	7873.78	6706.25	27.2	1825.00	0.00	6048.78
10	1312.30	7873.78	6706.25	54.2	3636.54	1.00	4237.24
15	1312.30	7873.78	6706.25	78.3	5249.16	60.56	2624.63
20	1312.30	7873.78	6706.25	90.1	6044.50	743.06	1829.28
25	1312.30	7873.78	6706.25	93.7	6285.38	1865.08	1588.41
30	1312.30	7873.78	6706.25	94.8	6357.58	3148.66	1516.21
35	1312.30	7873.78	6706.25	95.5	6407.59	4440.94	1466.09
60	1312.30	7873.78	6706.25	97.2	6515.48	11242.16	1334.40

Table 2.1.39(d)

17 MAR 76 - 11:24:20 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3A - W INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 70 SQ-M							
5	1312.30	9186.08	6706.25	27.2	1825.00	0.00	7361.08
10	1312.30	9186.08	6706.25	54.3	3644.50	1.00	5541.58
15	1312.30	9186.08	6706.25	79.5	5330.88	61.56	3855.20
20	1312.30	9186.08	6706.25	92.1	6173.80	820.96	3012.28
25	1312.30	9186.08	6706.25	96.0	6435.51	2117.90	2750.57
30	1312.30	9186.08	6706.25	97.2	6520.00	3588.40	2666.08
35	1312.30	9186.08	6706.25	97.8	6558.59	5078.35	2622.50
60	1312.30	9186.08	6706.25	98.6	6611.51	12968.37	2544.59
.							
COLLECTOR AREA = 80 SQ-M							
5	1312.30	10498.38	6706.25	27.2	1825.00	0.00	8673.38
10	1312.30	10498.38	6706.25	54.4	3648.18	1.00	6850.20
15	1312.30	10498.38	6706.25	80.1	5373.30	61.56	5125.08
20	1312.30	10498.38	6706.25	93.3	6259.24	862.64	4236.85
25	1312.30	10498.38	6706.25	97.2	6520.80	2260.32	3975.29
30	1312.30	10498.38	6706.25	98.4	6598.71	3865.28	3895.20
35	1312.30	10498.38	6706.25	98.8	6627.76	5516.11	3861.15
60	1312.30	10498.38	6706.25	99.3	6658.72	13752.92	3805.20

Table 2.1.39(e)

17 MAR 76 - 11:28:11 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3A - W INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR PER YEAR
COLLECTOR AREA = 90 SQ-M						
5	1312.30	11810.67	6706.25	27.2	1825.00	9985.67
10	1312.30	11810.67	6706.25	54.4	3649.00	8161.67
15	1312.30	11810.67	6706.25	80.4	5394.74	6415.93
20	1312.30	11810.67	6706.25	94.1	6310.59	5497.77
25	1312.30	11810.67	6706.25	98.0	6572.53	5233.36
30	1312.30	11810.67	6706.25	99.0	6642.17	5159.56
35	1312.30	11810.67	6706.25	99.3	6661.02	5135.72
60	1312.30	11810.67	6706.25	99.8	6690.31	5081.42
COLLECTOR AREA = 100 SQ-M						
5	1312.30	13122.97	6706.25	27.2	1825.00	11297.97
10	1312.30	13122.97	6706.25	54.4	3649.00	9473.97
15	1312.30	13122.97	6706.25	80.6	5403.43	7719.54
20	1312.30	13122.97	6706.25	94.5	6335.40	6785.27
25	1312.30	13122.97	6706.25	98.3	6588.91	6526.75
30	1312.30	13122.97	6706.25	99.3	6657.33	6453.34
35	1312.30	13122.97	6706.25	99.5	6674.90	6430.76
60	1312.30	13122.97	6706.25	100.0	6704.20	6376.46

17 MAR 76 - 11:31:04 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3A

W INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATA

Figure 2.1.39(a)

17 MAR 76 - 11:38:43 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3A

INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATA

Figure 2.1.39(b)

17 MAR 76 - 12:22:32 PM

P/EPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3A

INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATA

Figure 2.1.39(c)

Table 2.1.40(a)

17 MAR 76 - 12:31:03 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3B - W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 10 SQ-M							
5	1312.30	1312.30	8896.25	14.7	1311.46	0.00	0.84
10	1312.30	1312.30	8896.25	14.8	1312.30	0.00	0.00
15	1312.30	1312.30	8896.25	14.8	1312.30	0.00	0.00
20	1312.30	1312.30	8896.25	14.8	1312.30	0.00	0.00
25	1312.30	1312.30	8896.25	14.8	1312.30	0.00	0.00
30	1312.30	1312.30	8896.25	14.8	1312.30	0.00	0.00
35	1312.30	1312.30	8896.25	14.8	1312.30	0.00	0.00
60	1312.30	1312.30	8896.25	14.8	1312.30	0.00	0.00
.							
COLLECTOR AREA = 20 SQ-M							
5	1312.30	2624.59	8896.25	19.9	1769.91	0.00	854.69
10	1312.30	2624.59	8896.25	29.5	2622.92	0.00	1.68
15	1312.30	2624.59	8896.25	29.5	2624.59	0.00	0.00
20	1312.30	2624.59	8896.25	29.5	2624.59	0.00	0.00
25	1312.30	2624.59	8896.25	29.5	2624.59	0.00	0.00
30	1312.30	2624.59	8896.25	29.5	2624.59	0.00	0.00
35	1312.30	2624.59	8896.25	29.5	2624.59	0.00	0.00
60	1312.30	2624.59	8896.25	29.5	2624.59	0.00	0.00

Table 2.1.40(b)

17 MAR 76 - 12:32:54 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3B - W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
=====							
COLLECTOR AREA = 30 SQ-M							
5	1312.30	3936.89	8896.25	20.4	1818.77	0.00	2118.12
10	1312.30	3936.89	8896.25	37.6	3341.73	0.00	595.16
15	1312.30	3936.89	8896.25	44.2	3934.38	0.00	2.51
20	1312.30	3936.89	8896.25	44.3	3936.89	0.00	0.00
25	1312.30	3936.89	8896.25	44.3	3936.89	0.00	0.00
30	1312.30	3936.89	8896.25	44.3	3936.89	0.00	0.00
35	1312.30	3936.89	8896.25	44.3	3936.89	0.00	0.00
60	1312.30	3936.89	8896.25	44.3	3936.89	0.00	0.00

COLLECTOR AREA = 40 SQ-M

5	1312.30	5249.19	8896.25	20.5	1824.59	0.00	3424.60
10	1312.30	5249.19	8896.25	39.8	3539.81	0.00	1709.38
15	1312.30	5249.19	8896.25	54.3	4827.75	0.00	421.43
20	1312.30	5249.19	8896.25	59.0	5245.84	0.25	3.35
25	1312.30	5249.19	8896.25	59.0	5249.19	0.38	0.00
30	1312.30	5249.19	8896.25	59.0	5249.19	0.38	0.00
35	1312.30	5249.19	8896.25	59.0	5249.19	0.38	0.00
60	1312.30	5249.19	8896.25	59.0	5249.19	0.38	0.00

Table 2.1.40(c)

17 MAR 76 - 12:34:40 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3B - W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 50 SQ-M							
5	1312.30	6561.49	8896.25	20.5	1825.00	0.00	4736.49
10	1312.30	6561.49	8896.25	40.6	3611.67	0.00	2949.82
15	1312.30	6561.49	8896.25	57.8	5145.68	0.00	1415.81
20	1312.30	6561.49	8896.25	70.2	6243.01	24.70	318.47
25	1312.30	6561.49	8896.25	73.3	6524.23	156.29	37.26
30	1312.30	6561.49	8896.25	73.6	6546.59	234.89	14.89
35	1312.30	6561.49	8896.25	73.7	6560.27	293.13	1.21
60	1312.30	6561.49	8896.25	73.8	6561.49	295.56	0.00
COLLECTOR AREA = 60 SQ-M							
5	1312.30	7873.78	8896.25	20.5	1825.00	0.00	6048.78
10	1312.30	7873.78	8896.25	40.9	3637.54	0.00	4236.25
15	1312.30	7873.78	8896.25	59.7	5309.72	0.00	2564.06
20	1312.30	7873.78	8896.25	74.8	6658.55	27.32	1215.24
25	1312.30	7873.78	8896.25	82.9	7375.75	378.99	498.03
30	1312.30	7873.78	8896.25	84.8	7547.24	930.66	326.54
35	1312.30	7873.78	8896.25	85.5	7602.74	1504.55	271.05
60	1312.30	7873.78	8896.25	86.6	7704.29	4166.13	169.49

Table 2.1.40(d)

17 MAR 76 - 12:37:32 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3B - W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 70 SQ-M							
5	1312.30	9186.08	8896.25	20.5	1825.00	0.00	7361.08
10	1312.30	9186.08	8896.25	41.0	3645.50	0.00	5540.58
15	1312.30	9186.08	8896.25	60.6	5392.44	0.00	3793.64
20	1312.30	9186.08	8896.25	77.7	6909.11	27.42	2276.97
25	1312.30	9186.08	8896.25	87.5	7788.18	478.80	1397.91
30	1312.30	9186.08	8896.25	90.8	8077.62	1409.41	1108.46
35	1312.30	9186.08	8896.25	91.8	8165.17	2460.18	1020.91
60	1312.30	9186.08	8896.25	93.5	8320.70	7689.00	865.38

COLLECTOR AREA = 80 SQ-M

5	1312.30	10498.38	8896.25	20.5	1825.00	0.00	8673.38
10	1312.30	10498.38	8896.25	41.0	3649.18	0.00	6849.20
15	1312.30	10498.38	8896.25	61.1	5434.86	0.00	5063.52
20	1312.30	10498.38	8896.25	79.3	7052.21	27.42	3446.17
25	1312.30	10498.38	8896.25	90.2	8020.68	533.57	2477.69
30	1312.30	10498.38	8896.25	93.8	8348.05	1628.25	2150.33
35	1312.30	10498.38	8896.25	95.0	8455.64	2903.06	2042.74
60	1312.30	10498.38	8896.25	97.0	8625.76	9781.86	1856.15

Table 2.1.40(e)

17 MAR 76 * 12:39:21 PM

PVEPS * ENERGY FLOW SIMULATIONS * V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. * 1957 * CASE 3B * W INSOLATION DATA (S1) * NOMINAL LOAD 2 * W A/C DATALOAD PROVIDED BY STORAGE

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD		ENERGY OUTPUT	STORAGE	WASTE
KW-HR	KV-HR PER SQ-M	KV-HR PER YEAR	KV-HR PER YEAR	% LOAD SUPPLIED	KV-HR PER YEAR	KV-HR	KV-HR PER YEAR

COLLECTOR AREA = 90 SQ-M							
5	1312.30	11810.67	8896.25	20.5	1825.00	0.00	9985.67
10	1312.30	11810.67	8896.25	41.0	3650.00	0.00	8160.67
15	1312.30	11810.67	8896.25	61.3	5456.31	0.00	6354.37
20	1312.30	11810.67	8896.25	80.3	7141.66	27.42	4669.02
25	1312.30	11810.67	8896.25	91.8	8162.74	592.43	3647.93
30	1312.30	11810.67	8896.25	95.5	8498.89	1790.83	3311.78
35	1312.30	11810.67	8896.25	96.8	8609.60	3218.98	3201.08
60	1312.30	11810.67	8896.25	98.1	8729.03	10889.71	3060.65
COLLECTOR AREA = 100 SQ-M							
5	1312.30	13122.97	8896.25	20.5	1825.00	0.00	11297.97
10	1312.30	13122.97	8896.25	41.0	3650.00	0.00	9472.97
15	1312.30	13122.97	8896.25	61.4	5465.00	0.00	7657.98
20	1312.30	13122.97	8896.25	80.9	7195.92	27.42	5927.06
25	1312.30	13122.97	8896.25	92.3	8255.71	619.98	4865.98
30	1312.30	13122.97	8896.25	96.7	8599.11	1884.03	4522.58
35	1312.30	13122.97	8896.25	97.9	8707.39	3421.20	4413.70
60	1312.30	13122.97	8896.25	98.9	8794.57	11529.41	4302.98

17 MAR 76 - 12:42:45 PM

FVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3B

W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

Figure 2.1.40(a)

17 MAR 76 - 12:45:50 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3B

W INSOLATION DATA (S1) - NOMINAL LOAD 2 - 4 A/C DATA

Figure 2.1.40(b)

17 MAR 76 - 12:52:00 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3B

INSOLATION DATA (S1), - NOMINAL LOAD 2 - W A/C DATA

Figure 2.1.40(c)

Table 2.1.41(a)

18 MAY 76 - 05:38:20 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 1 - W INSOLATION DATA (S1) - NOMINAL LOAD 2

STORAGE CAPACITY	INSOLATION KW-HR PER SQ-M	ENERGY INPUT KW-HR PER YEAR	LOAD PROVIDED BY STORAGE				STORAGE KW-HR	WASTE KW-HR PER YEAR
			LOAD KW-HR PER YEAR	% LOAD SUPPLIED	ENERGY OUTPUT KW-HR PER YEAR			

COLLECTOR AREA = 10 SQ-M								
5	1191.84	1191.84	5027.00	23.6	1187.01	0.00	4.83	
10	1191.84	1191.84	5027.00	23.7	1191.84	0.00	0.00	
15	1191.84	1191.84	5027.00	23.7	1191.84	0.00	0.00	
20	1191.84	1191.84	5027.00	23.7	1191.84	0.00	0.00	
25	1191.84	1191.84	5027.00	23.7	1191.84	0.00	0.00	
30	1191.84	1191.84	5027.00	23.7	1191.84	0.00	0.00	
35	1191.84	1191.84	5027.00	23.7	1191.84	0.00	0.00	
60	1191.84	1191.84	5027.00	23.7	1191.84	0.00	0.00	
° COLLECTOR AREA = 20 SQ-M								
5	1191.84	2383.68	5027.00	34.9	1752.10	0.00	631.58	
10	1191.84	2383.68	5027.00	47.2	2374.01	21.94	9.67	
15	1191.84	2383.68	5027.00	47.4	2383.68	21.94	0.00	
20	1191.84	2383.68	5027.00	47.4	2383.68	21.94	0.00	
25	1191.84	2383.68	5027.00	47.4	2383.68	21.94	0.00	
30	1191.84	2383.58	5027.00	47.4	2383.68	21.94	0.00	
35	1191.84	2383.68	5027.00	47.4	2383.68	21.94	0.00	
60	1191.84	2383.68	5027.00	47.4	2383.68	21.94	0.00	

Table 2.1.41(b)

18 MAY 76 - 05:40:44 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 1 - W INSOLATION DATA (S1) - NOMINAL LOAD 2

STORAGE CAPACITY	INSOLATION KW-HR PER SQ-M	ENERGY INPUT KW-HR PER YEAR	LOAD PROVIDED BY STORAGE				STORAGE KW-HR	WASTE KW-HR PER YEAR
			LOAD KW-HR PER YEAR	°/° LOAD SUPPLIED	ENERGY OUTPUT KW-HR PER YEAR			

COLLECTOR AREA = 30 SQ-M								
5	1191.84	3575.52	5027.00	36.1	1815.35	0.00	1760.17	
10	1191.84	3575.52	5027.00	63.0	3167.15	61.48	408.37	
15	1191.84	3575.52	5027.00	70.0	3517.29	171.55	58.23	
20	1191.84	3575.52	5027.00	70.4	3538.95	304.65	36.57	
25	1191.84	3575.52	5027.00	70.5	3545.75	400.36	29.77	
30	1191.84	3575.52	5027.00	70.6	3550.75	491.57	24.77	
35	1191.84	3575.52	5027.00	70.7	3555.75	581.36	19.77	
60	1191.84	3575.52	5027.00	71.1	3575.52	882.61	0.00	
COLLECTOR AREA = 40 SQ-M								
5	1191.84	4767.36	5027.00	36.3	1824.83	0.00	2942.53	
10	1191.84	4767.36	5027.00	68.5	3443.95	64.00	1323.40	
15	1191.84	4767.36	5027.00	85.2	4283.89	375.23	483.46	
20	1191.84	4767.36	5027.00	87.5	4400.90	1218.32	366.46	
25	1191.84	4767.36	5027.00	88.2	4435.50	2069.30	331.85	
30	1191.84	4767.36	5027.00	88.5	4450.50	2889.09	316.85	
35	1191.84	4767.36	5027.00	88.8	4465.07	3814.94	302.29	
60	1191.84	4767.36	5027.00	89.3	4490.07	9238.81	277.29	

Table 2.1.41(c)

18 MAY 76 - 05:42:25 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 1 - W INSOLATION DATA (S1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	°/° LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 50 SQ-M							
5	1191.84	5959.20	5027.00	36.3	1825.00	0.00	4134.20
10	1191.84	5959.20	5027.00	70.2	3529.57	64.00	2429.63
15	1191.84	5959.20	5027.00	92.0	4523.55	502.00	1335.65
20	1191.84	5959.20	5027.00	94.7	4761.30	1813.27	1197.90
25	1191.84	5959.20	5027.00	95.3	4792.15	3133.08	1167.05
30	1191.84	5959.20	5027.00	95.7	4808.75	4435.68	1150.45
35	1191.84	5959.20	5027.00	95.9	4820.43	5795.58	1138.77
60	1191.84	5959.20	5027.00	96.4	4848.15	12453.05	1111.05
COLLECTOR AREA = 60 SQ-M							
5	1191.84	7151.04	5027.00	36.3	1825.00	0.00	5326.04
10	1191.84	7151.04	5027.00	71.0	3566.70	64.00	3584.33
15	1191.84	7151.04	5027.00	94.6	4757.79	536.81	2393.25
20	1191.84	7151.04	5027.00	97.9	4919.96	2063.50	2230.52
25	1191.84	7151.04	5027.00	98.8	4964.86	3732.94	2185.62
30	1191.84	7151.04	5027.00	99.3	4991.39	5399.20	2159.10
35	1191.84	7151.04	5027.00	99.5	5004.30	7060.03	2142.79
60	1191.84	7151.04	5027.00	99.8	5019.44	15087.72	2105.89

Table 2.1.41(d)

18 MAY 76 - 05:44:05 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 1 - W INSOLATION DATA (S1) - NOMINAL LOAD 2

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	<u>LOAD PROVIDED BY STORAGE</u>		ENERGY OUTPUT	STORAGE	WASTE
			LOAD	% LOAD SUPPLIED			
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR		KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 70 SQ-M							
5	1191.84	8342.88	5027.00	36.3	1825.00	0.00	6517.88
10	1191.84	8342.88	5027.00	71.2	3580.72	64.00	4762.15
15	1191.84	8342.88	5027.00	96.1	4831.32	547.95	3511.56
20	1191.84	8342.88	5027.00	98.8	4968.68	2161.22	3371.20
25	1191.84	8342.88	5027.00	99.4	4998.74	3906.07	3339.11
30	1191.84	8342.88	5027.00	99.7	5012.25	5670.34	3320.60
35	1191.84	8342.88	5027.00	99.9	5019.53	7443.35	3308.31
60	1191.84	8342.88	5027.00	99.9	5022.93	16359.20	3279.91
COLLECTOR AREA = 80 SQ-M							
5	1191.84	9534.71	5027.00	36.3	1825.00	0.00	7709.71
10	1191.84	9534.71	5027.00	71.3	3585.66	64.00	5949.05
15	1191.84	9534.71	5027.00	96.9	4870.45	553.52	4664.26
20	1191.84	9534.71	5027.00	99.4	4994.77	2200.06	4536.95
25	1191.84	9534.71	5027.00	99.8	5014.86	3977.53	4511.85
30	1191.84	9534.71	5027.00	99.9	5022.62	5773.97	4499.10
35	1191.84	9534.71	5027.00	100.0	5024.64	7572.91	4492.09
60	1191.84	9534.71	5027.00	100.0	5024.64	16569.15	4467.08

Table 2.1.41(e)

18 MAY 76 - 05:45:44 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 1 - W INSOLATION DATA (S1) - NOMINAL LOAD 2

STORAGE CAPACITY	INSOLATION	ENERGY INPUT	<u>LOAD PROVIDED BY STORAGE</u>		ENERGY OUTPUT	STORAGE	WASTE
			LOAD	°/° LOAD SUPPLIED			
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR		KW-HR PER YEAR	KW-HR	KW-HR PER YEAR
COLLECTOR AREA = 90 SQ-M							
5	1191.84	10726.55	5027.00	36.3	1825.00	0.00	8901.55
10	1191.84	10726.55	5027.00	71.3	3586.00	64.00	7140.55
15	1191.84	10726.55	5027.00	97.3	4893.44	555.00	5833.12
20	1191.84	10726.55	5027.00	99.8	5015.29	2223.67	5708.27
25	1191.84	10726.55	5027.00	100.0	5024.70	4022.36	5693.86
30	1191.84	10726.55	5027.00	100.0	5026.34	5834.07	5687.21
35	1191.84	10726.55	5027.00	100.0	5026.34	7647.86	5682.21
60	1191.84	10726.55	5027.00	100.0	5026.34	16665.09	5657.21
° COLLECTOR AREA = 100 SQ-M							
5	1191.84	11918.39	5027.00	36.3	1825.00	0.00	10093.39
10	1191.84	11918.39	5027.00	71.3	3586.00	64.00	8332.39
15	1191.84	11918.39	5027.00	97.6	4907.12	555.00	7011.28
20	1191.84	11918.39	5027.00	100.0	5025.03	2244.57	6890.37
25	1191.84	11918.39	5027.00	100.0	5027.00	4061.07	6883.39
30	1191.84	11918.39	5027.00	100.0	5027.00	5876.07	6878.39
35	1191.84	11918.39	5027.00	100.0	5027.00	7691.07	6873.39
60	1191.84	11918.39	5027.00	100.0	5027.00	16732.89	6848.39

18 MAY 76 - 05:48:05 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 1 - W INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.41(a)

18 MAY 76 - 05:50:50 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 1 - W INSOLATION DATA (S1) - NOMINAL LOAD, 2

Figure 2.1.41(b)

18 MAY 76 - 05:54:19 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 1 - W INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.41(c)

Table 2.1.42(a)

18 MAY 76 - 06:08:07 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 2 - W INSOLATION DATA (S1) - NOMINAL LOAD 2

STORAGE CAPACITY	INSOLATION KW-HR PER SQ-M	ENERGY INPUT KW-HR PER YEAR	LOAD PROVIDED BY STORAGE				STORAGE KW-HR	WASTE KW-HR PER YEAR
			LOAD KW-HR PER YEAR	% LOAD SUPPLIED	ENERGY OUTPUT			
					KW-HR PER YEAR			

COLLECTOR AREA = 10 SQ-M								
5	1191.84	1191.84	7217.00	16.4	1187.01	0.00	4.83	
10	1191.84	1191.84	7217.00	16.5	1191.84	0.00	0.00	
15	1191.84	1191.84	7217.00	16.5	1191.84	0.00	0.00	
20	1191.84	1191.84	7217.00	16.5	1191.84	0.00	0.00	
25	1191.84	1191.84	7217.00	16.5	1191.84	0.00	0.00	
30	1191.84	1191.84	7217.00	16.5	1191.84	0.00	0.00	
35	1191.84	1191.84	7217.00	16.5	1191.84	0.00	0.00	
60	1191.84	1191.84	7217.00	16.5	1191.84	0.00	0.00	
COLLECTOR AREA = 20 SQ-M								
5	1191.84	2383.68	7217.00	24.3	1752.10	0.00	631.58	
10	1191.84	2383.68	7217.00	32.9	2374.01	0.00	9.67	
15	1191.84	2383.68	7217.00	33.0	2383.68	0.00	0.00	
20	1191.84	2383.68	7217.00	33.0	2383.68	0.00	0.00	
25	1191.84	2383.68	7217.00	33.0	2383.68	0.00	0.00	
30	1191.84	2383.68	7217.00	33.0	2383.68	0.00	0.00	
35	1191.84	2383.68	7217.00	33.0	2383.68	0.00	0.00	
60	1191.84	2383.68	7217.00	33.0	2383.68	0.00	0.00	

Table 2.1.42(b)

18 MAY 76 - 06:10:10 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 2 - W INSOLATION DATA (S1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	°/° LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 30 SQ-M							
5	1191.84	3575.52	7217.00	25.2	1815.35	0.00	1760.17
10	1191.84	3575.52	7217.00	44.5	3209.41	0.00	356.11
15	1191.84	3575.52	7217.00	49.3	3561.02	0.00	14.50
20	1191.84	3575.52	7217.00	49.5	3575.52	0.00	0.00
25	1191.84	3575.52	7217.00	49.5	3575.52	0.00	0.00
30	1191.84	3575.52	7217.00	49.5	3575.52	0.00	0.00
35	1191.84	3575.52	7217.00	49.5	3575.52	0.00	0.00
60	1191.84	3575.52	7217.00	49.5	3575.52	0.00	0.00
COLLECTOR AREA = 40 SQ-M							
5	1191.84	4767.36	7217.00	25.3	1824.83	0.00	2942.53
10	1191.84	4767.36	7217.00	48.6	3504.19	0.00	1263.17
15	1191.84	4767.36	7217.00	62.3	4496.41	21.77	270.94
20	1191.84	4767.36	7217.00	65.8	4748.03	45.24	19.33
25	1191.84	4767.36	7217.00	66.1	4767.36	70.90	0.00
30	1191.84	4767.36	7217.00	66.1	4767.36	70.90	0.00
35	1191.84	4767.36	7217.00	66.1	4767.36	70.90	0.00
60	1191.84	4767.36	7217.00	66.1	4767.36	70.90	0.00

Table 2.1.42(c)

18 MAY 76 - 06:12:57 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 2 - W INSOLATION DATA (S1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 50 SQ-M							
5	1191.84	5959.20	7217.00	25.3	1825.00	0.00	4134.20
10	1191.84	5959.20	7217.00	49.8	3593.39	0.00	2365.81
15	1191.84	5959.20	7217.00	69.3	4999.21	40.47	959.99
20	1191.84	5959.20	7217.00	78.6	5669.39	179.45	289.80
25	1191.84	5959.20	7217.00	80.6	5814.76	583.70	144.43
30	1191.84	5959.20	7217.00	81.2	5860.93	915.96	98.27
35	1191.84	5959.20	7217.00	81.5	5880.21	1168.99	78.98
60	1191.84	5959.20	7217.00	82.3	5936.70	3093.38	22.49
COLLECTOR AREA = 60 SQ-M							
5	1191.84	7151.04	7217.00	25.3	1825.00	0.00	5326.04
10	1191.84	7151.04	7217.00	50.3	3630.70	0.00	3520.33
15	1191.84	7151.04	7217.00	72.2	5213.93	47.78	1937.11
20	1191.84	7151.04	7217.00	86.7	6259.72	245.28	891.32
25	1191.84	7151.04	7217.00	89.7	6475.83	1104.39	675.21
30	1191.84	7151.04	7217.00	90.8	6549.93	2064.50	601.11
35	1191.84	7151.04	7217.00	91.2	6585.11	3065.81	565.93
60	1191.84	7151.04	7217.00	92.1	6647.16	8423.75	503.88

Table 2.1.42(d)

18 MAY 76 - 06:14:36 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 2 - W INSOLATION DATA (S1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KJ-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 70 SQ-M							
5	1191.84	8342.88	7217.00	25.3	1825.00	0.00	6517.88
10	1191.84	8342.88	7217.00	50.5	3644.72	0.00	4698.15
15	1191.84	8342.88	7217.00	73.6	5312.17	48.00	3030.71
20	1191.84	8342.88	7217.00	90.9	6558.73	300.99	1784.14
25	1191.84	8342.88	7217.00	94.6	6823.99	1495.87	1518.88
30	1191.84	8342.88	7217.00	95.5	6890.27	2788.17	1452.61
35	1191.84	8342.88	7217.00	95.8	6915.01	4100.08	1427.87
60	1191.84	8342.88	7217.00	96.7	6977.80	10790.58	1355.07
COLLECTOR AREA = 80 SQ-M							
5	1191.84	9534.71	7217.00	25.3	1825.00	0.00	7709.71
10	1191.84	9534.71	7217.00	50.6	3649.66	0.00	5885.05
15	1191.84	9534.71	7217.00	74.4	5366.07	48.00	4168.65
20	1191.84	9534.71	7217.00	93.0	6714.78	318.93	2819.94
25	1191.84	9534.71	7217.00	96.8	6982.94	1676.63	2551.38
30	1191.84	9534.71	7217.00	98.0	7073.54	3234.08	2460.78
35	1191.84	9534.71	7217.00	98.7	7121.52	4852.76	2412.80
60	1191.84	9534.71	7217.00	99.5	7181.51	12315.77	2352.80

Table 2.1.42(e)

18 MAY 76 - 06:16:45 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 2 - N INSOLATION DATA (S1) - NOMINAL LOAD 2

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 90 SQ-M							
5	1191.84	10726.55	7217.00	25.3	1825.00	0.00	8901.55
10	1191.84	10726.55	7217.00	50.6	3650.00	0.00	7076.55
15	1191.84	10726.55	7217.00	74.8	5398.06	48.00	5328.50
20	1191.84	10726.55	7217.00	94.3	6802.51	330.49	3924.04
25	1191.84	10726.55	7217.00	98.0	7073.46	1758.88	3651.10
30	1191.84	10726.55	7217.00	98.8	7133.96	3454.10	3589.27
35	1191.84	10726.55	7217.00	99.3	7164.01	5178.58	3558.94
60	1191.84	10726.55	7217.00	99.9	7209.17	13905.80	3488.77
•							
COLLECTOR AREA = 100 SQ-M							
5	1191.84	11918.39	7217.00	25.3	1825.00	0.00	10093.39
10	1191.84	11918.39	7217.00	50.6	3650.00	0.00	8268.39
15	1191.84	11918.39	7217.00	75.0	5414.12	48.00	6504.28
20	1191.84	11918.39	7217.00	95.1	6860.04	334.44	5058.35
25	1191.84	11918.39	7217.00	98.7	7124.97	1812.56	4791.42
30	1191.84	11918.39	7217.00	99.3	7153.70	3552.80	4747.69
35	1191.84	11918.39	7217.00	99.6	7136.73	5315.30	4719.67
60	1191.84	11918.39	7217.00	99.9	7212.05	14240.71	4669.35

18 MAY 76 - 05:19:19 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 2 - W INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.42(a)

18 MAY 76 - 06:22:46 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 2 - W INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.42(b)

18 MAY 76 - 06:27:45 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 2 - W INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.42(c)

Table 2.1.43(a)

18 MAY 76 - 06:36:25 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DELAWARE - 1958 - CASE 3A - W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 10 SQ-M							
5	1191.84	1191.84	9949.71	11.9	1187.01	0.00	4.83
10	1191.84	1191.84	9949.71	12.0	1191.84	0.00	0.00
15	1191.84	1191.84	9949.71	12.0	1191.84	0.00	0.00
20	1191.84	1191.84	9949.71	12.0	1191.84	0.00	0.00
25	1191.84	1191.84	9949.71	12.0	1191.84	0.00	0.00
30	1191.84	1191.84	9949.71	12.0	1191.84	0.00	0.00
35	1191.84	1191.84	9949.71	12.0	1191.84	0.00	0.00
60	1191.84	1191.84	9949.71	12.0	1191.84	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1191.84	2383.68	9949.71	17.6	1752.10	0.00	631.58
10	1191.84	2383.68	9949.71	23.9	2374.01	0.00	9.67
15	1191.84	2383.68	9949.71	24.0	2383.68	0.00	0.00
20	1191.84	2383.68	9949.71	24.0	2383.68	0.00	0.00
25	1191.84	2383.68	9949.71	24.0	2383.68	0.00	0.00
30	1191.84	2383.68	9949.71	24.0	2383.68	0.00	0.00
35	1191.84	2383.68	9949.71	24.0	2383.68	0.00	0.00
60	1191.84	2383.68	9949.71	24.0	2383.68	0.00	0.00

Table 2.1.43(b)

18 MAY 76 - 06:38:15 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DELAWARE - 1958 - CASE 3A - W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 30 SQ-M							
5	1191.84	3575.52	9949.71	18.2	1815.35	0.00	1750.17
10	1191.84	3575.52	9949.71	32.3	3209.41	0.00	366.11
15	1191.84	3575.52	9949.71	35.8	3561.02	0.00	14.50
20	1191.84	3575.52	9949.71	35.9	3575.52	3.53	0.00
25	1191.84	3575.52	9949.71	35.9	3575.52	3.53	0.00
30	1191.84	3575.52	9949.71	35.9	3575.52	3.53	0.00
35	1191.84	3575.52	9949.71	35.9	3575.52	3.53	0.00
60	1191.84	3575.52	9949.71	35.9	3575.52	3.53	0.00
COLLECTOR AREA = 40 SQ-M							
5	1191.84	4767.36	9949.71	18.3	1824.83	0.00	2942.53
10	1191.84	4767.36	9949.71	35.2	3504.19	0.00	1263.17
15	1191.84	4767.36	9949.71	45.2	4499.58	0.00	267.78
20	1191.84	4767.36	9949.71	47.5	4721.31	58.65	46.05
25	1191.84	4767.36	9949.71	47.7	4750.29	100.60	17.08
30	1191.84	4767.36	9949.71	47.9	4762.71	122.43	4.65
35	1191.84	4767.36	9949.71	47.9	4767.36	128.53	0.00
60	1191.84	4767.36	9949.71	47.9	4767.36	128.53	0.00

Table 2.1.43(c)

18 MAY 76 - 06:39:59 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DELAWARE - 1958 - CASE 3A - W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 50 SQ-M							
5	1191.84	5959.20	9949.71	18.3	1825.00	0.00	4134.20
10	1191.84	5959.20	9949.71	36.1	3593.39	0.00	2365.81
15	1191.84	5959.20	9949.71	50.5	5028.01	1.65	931.19
20	1191.84	5959.20	9949.71	56.7	5644.20	191.68	315.00
25	1191.84	5959.20	9949.71	58.2	5788.94	438.57	170.25
30	1191.84	5959.20	9949.71	58.6	5831.87	654.24	127.32
35	1191.84	5959.20	9949.71	58.8	5855.03	902.23	104.17
60	1191.84	5959.20	9949.71	59.2	5887.68	1941.35	71.51
° COLLECTOR AREA = 60 SQ-M							
5	1191.84	7151.04	9949.71	18.3	1825.00	0.00	5326.04
10	1191.84	7151.04	9949.71	36.5	3630.70	0.00	3520.33
15	1191.84	7151.04	9949.71	52.8	5254.64	1.65	1896.40
20	1191.84	7151.04	9949.71	62.3	6202.49	372.93	948.00
25	1191.84	7151.04	9949.71	66.0	6568.26	962.60	582.23
30	1191.84	7151.04	9949.71	67.2	6690.16	1624.24	460.33
35	1191.84	7151.04	9949.71	67.7	6736.85	2230.39	410.71
60	1191.84	7151.04	9949.71	68.4	6802.22	4207.20	341.10

Table 2.1.43(d)

18 MAY 76 - 06:41:40 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DELAWARE - 1958 - CASE 3A - W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 70 SQ-M							
5	1191.84	8342.88	9949.71	18.3	1825.00	0.00	6517.88
10	1191.84	8342.88	9949.71	36.6	3644.72	0.00	4698.15
15	1191.84	8342.88	9949.71	53.8	5356.77	1.81	2986.10
20	1191.84	8342.88	9949.71	65.1	6481.30	452.72	1858.57
25	1191.84	8342.88	9949.71	70.6	7023.60	1202.63	1314.60
30	1191.84	8342.88	9949.71	72.8	7243.76	2037.73	1089.43
35	1191.84	8342.88	9949.71	73.6	7319.57	2903.86	1008.63
60	1191.84	8342.88	9949.71	74.8	7442.01	7194.25	861.19
COLLECTOR AREA = 80 SQ-M							
5	1191.84	9534.71	9949.71	18.3	1825.00	0.00	7709.71
10	1191.84	9534.71	9949.71	36.7	3649.66	0.00	5885.05
15	1191.84	9534.71	9949.71	54.4	5412.25	1.81	4122.46
20	1191.84	9534.71	9949.71	66.4	6603.95	496.39	2927.76
25	1191.84	9534.71	9949.71	73.5	7311.57	1316.12	2215.14
30	1191.84	9534.71	9949.71	76.9	7655.99	2264.51	1865.73
35	1191.84	9534.71	9949.71	78.3	7792.38	3288.75	1724.33
60	1191.84	9534.71	9949.71	79.8	7937.27	8516.55	1554.45

Table 2.1.43(e)

18 MAY 76 - 06:43:29 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DELAWARE - 1958 - CASE 3A - W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

STORAGE CAPACITY	INSOLATION KW-HR PER SQ-M	ENERGY INPUT KW-HR PER YEAR	LOAD PROVIDED BY STORAGE				
			LOAD	ENERGY OUTPUT		STORAGE	WASTE
			KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 90 SQ-M							
5	1191.84	10726.55	9949.71	18.3	1825.00	0.00	8901.55
10	1191.84	10726.55	9949.71	36.7	3650.00	0.00	7076.55
15	1191.84	10726.55	9949.71	54.7	5444.24	1.81	5282.31
20	1191.84	10726.55	9949.71	67.0	6569.39	514.57	4054.17
25	1191.84	10726.55	9949.71	75.2	7479.83	1365.21	3238.72
30	1191.84	10726.55	9949.71	79.8	7936.17	2354.96	2777.39
35	1191.84	10726.55	9949.71	82.0	8154.12	3448.27	2554.43
60	1191.84	10726.55	9949.71	84.1	8365.44	9258.33	2318.12
° COLLECTOR AREA = 100 SQ-M							
5	1191.84	11918.39	9949.71	18.3	1825.00	0.00	10093.39
10	1191.84	11918.39	9949.71	36.7	3650.00	0.00	8268.39
15	1191.84	11918.39	9949.71	54.9	5460.30	1.81	6458.09
20	1191.84	11918.39	9949.71	67.4	6701.71	531.51	5213.68
25	1191.84	11918.39	9949.71	76.0	7557.09	1397.50	4353.30
30	1191.84	11918.39	9949.71	81.8	8142.71	2403.47	3762.69
35	1191.84	11918.39	9949.71	84.8	8437.54	3529.86	3462.86
60	1191.84	11918.39	9949.71	87.7	8729.40	9739.50	3145.99

18 MAY 76 - 06:47:23 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DELAWARE - 1958 - CASE 3A

INSOLATION DATA (S1) - NOMINAL LOAD 2 - A/C DATA

LOAD PROVIDED BY STORAGE

Figure 2.1.43(a)

18 MAY 76 - 06:52:02 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DELAWARE - 1958 - CASE 3A

W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

Figure 2.1.43(b)

18 MAY 76 - 06:56:34 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DELAWARE - 1958 - CASE 3A

W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

Figure 2.1.43(c)

Table 2.1.44(a)

18 MAY 76 - 07:03:23 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DELAWARE - 1958 - CASE 3B - W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 10 SQ-M							
5	1191.84	1191.84	12139.71	9.8	1187.01	0.00	4.83
10	1191.84	1191.84	12139.71	9.8	1191.84	0.00	0.00
15	1191.84	1191.84	12139.71	9.8	1191.84	0.00	0.00
20	1191.84	1191.84	12139.71	9.8	1191.84	0.00	0.00
25	1191.84	1191.84	12139.71	9.8	1191.84	0.00	0.00
30	1191.84	1191.84	12139.71	9.8	1191.84	0.00	0.00
35	1191.84	1191.84	12139.71	9.8	1191.84	0.00	0.00
60	1191.84	1191.84	12139.71	9.8	1191.84	0.00	0.00
COLLECTOR AREA = 20 SQ-M							
5	1191.84	2383.68	12139.71	14.4	1752.10	0.00	631.59
10	1191.84	2383.68	12139.71	19.6	2374.01	0.00	9.67
15	1191.84	2383.68	12139.71	19.6	2383.68	0.00	0.00
20	1191.84	2383.68	12139.71	19.6	2383.68	0.00	0.00
25	1191.84	2383.68	12139.71	19.6	2383.68	0.00	0.00
30	1191.84	2383.68	12139.71	19.6	2383.68	0.00	0.00
35	1191.84	2383.68	12139.71	19.6	2383.68	0.00	0.00
60	1191.84	2383.68	12139.71	19.6	2383.68	0.00	0.00

Table 2.1.44(b)

18 MAY 76 - 07:07:48 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DELAWARE - 1958 - CASE 3B - $\bar{H}$ INSOLATION DATA (S1) - NOMINAL LOAD 2 - $\bar{H}$ A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 30 SQ-M							
5	1191.84	3575.52	12139.71	15.0	1815.35	0.00	1760.17
10	1191.84	3575.52	12139.71	26.4	3209.41	0.00	366.11
15	1191.84	3575.52	12139.71	29.3	3561.02	0.00	14.50
20	1191.84	3575.52	12139.71	29.5	3575.52	0.00	0.00
25	1191.84	3575.52	12139.71	29.5	3575.52	0.00	0.00
30	1191.84	3575.52	12139.71	29.5	3575.52	0.00	0.00
35	1191.84	3575.52	12139.71	29.5	3575.52	0.00	0.00
60	1191.84	3575.52	12139.71	29.5	3575.52	0.00	0.00
COLLECTOR AREA = 40 SQ-M							
5	1191.84	4767.36	12139.71	15.0	1824.83	0.00	2942.53
10	1191.84	4767.36	12139.71	28.9	3504.19	0.00	1263.17
15	1191.84	4767.36	12139.71	37.1	4499.58	0.00	267.78
20	1191.84	4767.36	12139.71	39.1	4748.03	0.00	19.33
25	1191.84	4767.36	12139.71	39.3	4767.36	2.25	0.00
30	1191.84	4767.36	12139.71	39.3	4767.36	2.25	0.00
35	1191.84	4767.36	12139.71	39.3	4767.36	2.25	0.00
60	1191.84	4767.36	12139.71	39.3	4767.36	2.25	0.00

Table 2.1.44(c)

18 MAY 76 - 07:09:35 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DELAWARE - 1958 - CASE 3B - W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 50 SQ-M							
5	1191.84	5959.20	12139.71	15.0	1825.00	0.00	4134.20
10	1191.84	5959.20	12139.71	29.6	3593.39	0.00	2365.81
15	1191.84	5959.20	12139.71	41.4	5029.66	0.00	929.54
20	1191.84	5959.20	12139.71	47.2	5730.52	0.00	228.68
25	1191.84	5959.20	12139.71	48.8	5919.11	25.73	40.08
30	1191.84	5959.20	12139.71	49.0	5946.76	53.89	12.43
35	1191.84	5959.20	12139.71	49.1	5958.81	71.67	0.39
60	1191.84	5959.20	12139.71	49.1	5959.20	72.06	0.00
COLLECTOR AREA = 50 SQ-M							
5	1191.84	7151.04	12139.71	15.0	1825.00	0.00	5326.04
10	1191.84	7151.04	12139.71	29.9	3630.70	0.00	3520.33
15	1191.84	7151.04	12139.71	43.3	5256.29	0.00	1894.75
20	1191.84	7151.04	12139.71	52.9	6418.82	0.00	732.21
25	1191.84	7151.04	12139.71	56.9	6905.67	77.59	245.37
30	1191.84	7151.04	12139.71	58.0	7044.04	204.82	106.99
35	1191.84	7151.04	12139.71	58.4	7084.56	316.27	66.47
60	1191.84	7151.04	12139.71	58.8	7136.63	791.89	14.41

Table 2.1.44(d)

18 MAY 76 - 07:11:17 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DELAWARE - 1958 - CASE 3B - W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 70 SQ-M							
5	1191.84	8342.88	12139.71	15.0	1825.00	0.00	6517.88
10	1191.84	8342.88	12139.71	30.0	3644.72	0.00	4698.15
15	1191.84	8342.88	12139.71	44.1	5358.58	0.00	2984.29
20	1191.84	8342.88	12139.71	56.1	6808.55	0.00	1534.32
25	1191.84	8342.88	12139.71	62.9	7640.87	167.13	702.01
30	1191.84	8342.88	12139.71	65.6	7959.00	469.75	383.88
35	1191.84	8342.88	12139.71	66.4	8060.49	763.35	282.39
60	1191.84	8342.88	12139.71	67.2	8152.71	2192.37	190.17
COLLECTOR AREA = 80 SQ-M							
5	1191.84	9534.71	12139.71	15.0	1825.00	0.00	7709.71
10	1191.84	9534.71	12139.71	30.1	3649.66	0.00	5985.05
15	1191.84	9534.71	12139.71	44.6	5414.07	0.00	4120.65
20	1191.84	9534.71	12139.71	57.7	7008.38	0.00	2526.33
25	1191.84	9534.71	12139.71	66.7	8098.56	258.43	1435.75
30	1191.84	9534.71	12139.71	71.0	8622.24	794.27	912.07
35	1191.84	9534.71	12139.71	72.9	8846.19	1437.09	688.13
60	1191.84	9534.71	12139.71	74.6	9051.58	3809.84	482.73

Table 2.1.44(e)

18 MAY 76 - 07:12:57 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DELAWARE - 1958 - CASE 3B - W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE							
STORAGE CAPACITY	INSOLATION	ENERGY INPUT	LOAD	ENERGY OUTPUT		STORAGE	WASTE
KW-HR	KW-HR PER SQ-M	KW-HR PER YEAR	KW-HR PER YEAR	% LOAD SUPPLIED	KW-HR PER YEAR	KW-HR	KW-HR PER YEAR

COLLECTOR AREA = 90 SQ-M							
5	1191.84	10726.55	12139.71	15.0	1825.00	0.00	8901.55
10	1191.84	10726.55	12139.71	30.1	3650.00	0.00	7076.55
15	1191.84	10726.55	12139.71	44.9	5446.06	0.00	5280.50
20	1191.84	10726.55	12139.71	58.6	7118.59	0.00	3607.96
25	1191.84	10726.55	12139.71	68.9	8364.54	293.08	2359.92
30	1191.84	10726.55	12139.71	74.3	9017.44	978.09	1705.79
35	1191.84	10726.55	12139.71	77.1	9360.51	1764.38	1362.72
60	1191.84	10726.55	12139.71	79.6	9668.00	6322.36	1030.29
COLLECTOR AREA = 100 SQ-M							
5	1191.84	11918.39	12139.71	15.0	1825.00	0.00	10093.39
10	1191.84	11918.39	12139.71	30.1	3650.00	0.00	8268.39
15	1191.84	11918.39	12139.71	45.0	5462.12	0.00	6456.28
20	1191.84	11918.39	12139.71	59.2	7186.78	0.00	4731.62
25	1191.84	11918.39	12139.71	70.0	8495.53	335.32	3420.86
30	1191.84	11918.39	12139.71	76.5	9282.19	1080.86	2629.20
35	1191.84	11918.39	12139.71	80.0	9713.48	1977.61	2192.91
60	1191.84	11918.39	12139.71	83.4	10129.00	7285.74	1752.40

18 MAY 76 - 07:16:55 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DELAWARE - 1958 - CASE 3B

INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE

Figure 2.1.44(a)

18 MAY 76 - 07:20:16 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DELAWARE - 1958 - CASE 3B

INSOLATION DATA (S1) - NOMINAL LOAD 2 - A/C DATA

Figure 2.1.44(b)

18 MAY 76 - 07:24:08 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DELAWARE - 1958 - CASE 3B

INSOLATION DATA (S1) - NOMINAL LOAD 2 - A/C DATA

Figure 2.1.44(c)

The capability of using reject heat was taken from area-storage determinations made for the NSF Phase 0 study. For Phoenix and Cleveland (not available from Phase 0), it was calculated on a simplified basis.

2.1.2.2 Total Energy Flow Model

The total energy flow model simulates the operation of a specific thermal/photovoltaic residential power system. A sample simulation is presented for a system composed of 40 square meters of water cooled silicon collector, 110 square meters of air cooled cadmium sulfide collector (or equivalently, 70 square meters of air cooled silicon collector), 25 kWh of electrical storage and 105 kWh of thermal storage. The energy flow paths are shown in Figure 2.1.45. All energy flows into and out of the system are computed with a time step of one hour. Air conditioning loads are treated as electrical loads. The domestic hot water-load is treated as a heating load.

Photovoltaic energy input is used as follows: (1) to satisfy the electrical load directly; (2) via a heat pump to satisfy the heating load directly; (3) to recharge the electrical storage; (4) to heat the thermal storage. Any remaining photovoltaic energy is wasted.

Solar thermal energy input is used as follows: (1) to satisfy the heating load directly; (2) to heat the thermal storage. Any remaining solar heat energy is wasted.

The electrical load is satisfied: (1) by photovoltaic energy input; (2) from electrical storage.

Fig. 2. 1. 45 — Thermal electric energy flow model

The heating load is satisfied: (1) by solar thermal energy input; (2) via a heat pump by photovoltaic energy input; (3) from thermal storage.

This process is detailed in Figure 2.1.46. The results for a CASE 3B load in Atlanta are shown in Tables 2.1.45-2.1.48

2.1.3 Sizing

As a result of the Electrical Energy Flow Model simulations, it was possible to select array sizes on the basis of an incremental analysis of energy value versus array cost. The storage capacity chosen for this analysis is rather sharply defined by the storage matrix. Figures 2.1.47-2.1.53 show the curves used for area optimizations for the various load cases. Each point represents the total yearly output a system with the given array size and the optimal storage. The optimization procedure used is described in Section 2.6.

THERMAL - ELECTRIC ENERGY FLOW MODEL

given: QIE , QIT , SCE , SCT , COP

1. for each day, $i = 1, 2, \dots, 365$;
 1. for each hour, $j = 1, 2, \dots, 24$;
 1. $QOE_{i,j} \leftarrow \min\{QIE_{i,j} \text{ and } QLE_{i,j}\}$
 2. $QIE_{i,j} \leftarrow QIE_{i,j} - QOE_{i,j}$
 3. $QOT_{i,j} \leftarrow \min\{QIT_{i,j} \text{ and } QLT_{i,j}\}$
 4. $QIT_{i,j} \leftarrow QIT_{i,j} - QOT_{i,j}$
 5. if $QOT_{i,j} < QLT_{i,j}$

then,

 1. $Q \leftarrow \min\{QST_{i,j} \text{ and } (QLT_{i,j} - QOT_{i,j})\}$
 2. $QOT_{i,j} \leftarrow QOT_{i,j} + Q$
 3. $QST_{i,j} \leftarrow QST_{i,j} - Q$
 4. if $QOT_{i,j} < QLT_{i,j}$

then,

 1. $Q \leftarrow \min\{QIE_{i,j} \text{ and } (\frac{QLT_{i,j} - QOT_{i,j}}{COP})\}$
 2. $QOT_{i,j} \leftarrow QOT_{i,j} + (COP \times Q)$
 3. $QIE_{i,j} \leftarrow QIE_{i,j} - Q$
 5. $QWT_{i,j} \leftarrow 0$
 - else,
 1. $Q \leftarrow \min\{QIT_{i,j} \text{ and } (SCT - QST_{i,j})\}$
 2. $QST_{i,j} \leftarrow QST_{i,j} + Q$
 3. $QWT_{i,j} \leftarrow QIT_{i,j} - Q$

Figure 2.1.46(a)

Figure 2.1.46(b)

where:

SCE = storage capacity, electrical

SCT = storage capacity, thermal

COP = coefficient of performance for heat pump

QIE = energy input, photovoltaic

QLE = energy load, electrical

QOE = energy output, electrical

QSE = energy stored, electrical

QWE = energy wasted, electrical

QIT = energy input, thermal solar

QLT = energy load, heating

QOT = energy output, thermal

QST = energy stored, thermal

QWT = energy wasted, thermal

all units = kw-hr

Figure 2.1.46(c)

Table 2.1.45
(All units are kWh)

15 JUN 76 - 04:34:11 PM
4154269 TEEPS

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP = 1 HR

ATLANTA, GEORGIA - 1960 - CASE 3B - ELECTRICAL STORAGE CAPACITY 20 KW-HR

	ELECTRICAL					THERMAL				
	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE
JAN	880.2	682.0	609.2	89.3	118.7	2062.7	2606.4	1911.6	73.3	453.9
FEB	1062.1	616.0	601.8	97.7	232.9	2292.5	2814.1	2432.3	86.4	399.8
MAR	1477.8	651.0	643.1	98.8	611.9	3108.4	2493.9	2294.6	92.0	1306.4
APR	1702.0	898.6	881.5	98.1	811.2	3547.9	782.5	782.5	100.0	2797.0
MAY	2004.7	1143.8	1075.3	94.0	934.7	3873.6	542.5	542.5	100.0	3331.1
JUN	1813.5	1437.5	1336.0	92.9	479.6	3398.5	525.0	525.0	100.0	2872.5
JUL	1735.9	1637.5	1403.9	85.7	328.1	3338.4	542.5	542.5	100.0	2796.9
AUG	1469.2	1648.8	1307.0	79.3	166.0	3010.9	542.5	542.5	100.0	2468.4
SEP	1258.1	1317.4	1080.9	82.0	174.6	2741.6	525.0	525.0	100.0	2217.6
OCT	1182.3	1039.1	944.8	90.9	231.8	2829.0	687.9	687.9	100.0	2146.0
NOV	1094.7	630.0	630.0	100.0	411.4	2849.1	1487.0	1487.0	100.0	1510.7
DEC	1108.3	699.0	697.1	99.7	178.8	2796.8	3141.0	2850.4	90.7	531.4
	16789	12401	11211	90	4680	35850	16690	15124	91	22832

Table 2.1.46
(All units are kWh)

31 JAN 77 - 02:19:00 PM
4154269 TEEFS

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR
ATLANTA, GEORGIA - 1960 - CASE 3B - ELECTRICAL STORAGE CAPACITY 25 KW-HR

NOV	ELECTRICAL					THERMAL				
	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE
JAN	880.2	682.0	606.2	88.9	59.3	1384.2	2606.4	1484.0	56.9	149.2
FEB	1062.1	616.0	599.2	97.3	30.3	1601.4	2814.1	2073.6	73.7	28.9
MAR	1477.8	651.0	650.0	99.9	368.8	2218.2	2493.9	2107.2	84.5	583.4
APR	1702.0	898.6	898.3	100.0	771.9	2545.4	782.5	782.5	100.0	1798.4
MAY	2004.7	1143.8	1126.7	98.5	883.3	2837.0	542.5	542.5	100.0	2295.1
JUN	1813.5	1437.5	1405.6	97.8	412.8	2483.8	525.0	525.0	100.0	1957.9
JUL	1735.9	1637.5	1512.4	92.4	216.8	2471.3	542.5	542.5	100.0	1929.2
AUG	1469.2	1648.8	1397.1	84.7	76.3	2208.4	542.5	542.5	100.0	1666.1
SEP	1258.1	1317.4	1119.4	85.0	135.6	1953.1	525.0	525.0	100.0	1429.1
OCT	1182.3	1039.1	976.4	94.0	196.0	1977.0	687.9	687.9	100.0	1302.5
NOV	1094.7	630.0	630.0	100.0	326.9	2002.6	1487.0	1487.0	100.0	704.3
DEC	1108.3	699.0	696.6	99.7	83.2	2000.9	3141.0	2270.0	72.3	164.7
	16789	12401	11618	94	3561	25684	16690	13570	81	14009

Table 2.1.47(a)
(All units are kWh)

31 JAN 77 - 02:21:21 PM
4154269 TEEFS

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR

ATLANTA, GEORGIA - 1960 - CASE 3B - ELECTRICAL STORAGE CAPACITY 25 KW-HR

JAN	ELECTRICAL					THERMAL				
	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE
1	13.2	22.0	20.9	95.1	0.0	6.9	120.4	70.5	58.5	0.0
2	13.2	22.0	7.7	34.9	0.0	6.9	120.4	19.7	16.3	0.0
3	10.5	22.0	7.5	33.9	0.0	1.7	125.7	8.6	6.9	0.0
4	27.4	22.0	17.7	80.5	0.0	48.2	97.4	51.3	52.7	0.0
5	33.0	22.0	22.0	100.0	0.0	57.9	105.7	57.3	54.2	0.0
6	11.6	22.0	22.0	100.0	0.0	3.8	65.1	17.1	26.3	0.0
7	17.0	22.0	14.9	67.7	0.0	15.7	91.7	24.0	26.1	0.0
8	29.7	22.0	17.7	80.6	0.0	52.1	103.0	51.3	49.8	0.0
9	36.7	22.0	22.0	100.0	0.0	72.5	53.9	30.2	56.0	0.0
10	37.5	22.0	22.0	100.0	8.5	74.8	32.5	32.5	100.0	10.2
11	35.5	22.0	22.0	100.0	13.5	71.8	31.4	31.4	100.0	40.4
12	26.4	22.0	22.0	100.0	4.0	37.5	29.2	29.2	100.0	8.3
13	21.4	22.0	22.0	100.0	0.0	21.5	17.8	17.8	100.0	3.6
14	38.2	22.0	22.0	100.0	15.9	78.1	26.9	26.9	100.0	58.3
15	14.9	22.0	22.0	100.0	0.0	10.4	78.0	78.0	100.0	0.0
16	26.4	22.0	22.0	100.0	0.0	42.4	78.9	68.9	87.2	0.0
17	28.0	22.0	22.0	100.0	0.0	38.3	150.5	47.4	31.5	0.0
18	40.9	22.0	22.0	100.0	0.0	73.3	160.9	93.8	58.3	0.0
19	48.0	22.0	22.0	100.0	0.0	89.1	169.0	111.8	66.1	0.0
20	45.4	22.0	22.0	100.0	0.0	80.8	181.1	111.1	61.3	0.0
21	41.3	22.0	22.0	100.0	0.0	71.6	130.0	57.7	44.4	0.0
22	42.5	22.0	22.0	100.0	0.0	70.9	107.0	81.4	76.1	0.0
23	46.8	22.0	22.0	100.0	0.0	88.8	76.6	76.6	100.0	0.0
24	44.2	22.0	22.0	100.0	17.3	86.8	52.2	52.2	100.0	28.4
25	13.8	22.0	22.0	100.0	0.0	6.2	59.4	59.4	100.0	0.0
26	16.4	22.0	22.0	100.0	0.0	10.5	31.5	31.5	100.0	0.0
27	15.0	22.0	15.2	69.3	0.0	8.1	61.6	32.6	52.8	0.0
28	13.9	22.0	8.6	39.2	0.0	6.5	77.0	18.7	24.2	0.0
29	18.2	22.0	16.2	73.5	0.0	15.9	67.0	20.5	30.7	0.0
30	31.2	22.0	17.7	80.6	0.0	54.1	50.6	20.8	41.0	0.0
31	42.1	22.0	22.0	100.0	0.0	81.2	54.1	54.1	100.0	0.0
	880.2	682.0	606.2	88.9	59.3	1384.2	2606.4	1484.0	56.9	149.2

Table 2.1.47(b)
(All units are kWh)

31 JAN 77 - 02:24:42 PM
4154269 TEEFS

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR

ATLANTA, GEORGIA - 1960 - CASE 3E - ELECTRICAL STORAGE CAPACITY 25 KW-HR

FEB	ELECTRICAL					THERMAL				
	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE
1	21.4	22.0	22.0	100.0	0.0	22.1	81.0	81.0	100.0	0.0
2	13.9	22.0	22.0	100.0	0.0	5.0	129.1	37.6	29.1	0.0
3	14.1	22.0	12.4	56.5	0.0	6.4	80.4	14.9	18.5	0.0
4	22.0	22.0	18.1	82.2	0.0	23.0	83.7	30.0	35.8	0.0
5	38.5	22.0	18.7	84.9	0.0	68.6	100.8	54.7	54.3	0.0
6	45.5	22.0	22.0	100.0	0.0	85.7	81.1	55.5	68.4	0.0
7	23.4	22.0	22.0	100.0	0.0	28.7	55.2	55.2	100.0	0.0
8	20.0	22.0	22.0	100.0	0.0	16.6	34.1	34.1	100.0	0.0
9	50.5	22.0	22.0	100.0	0.0	92.5	75.9	75.9	100.0	0.0
10	49.2	22.0	22.0	100.0	13.0	90.4	77.9	77.9	100.0	12.8
11	46.8	22.0	22.0	100.0	9.0	85.2	96.3	96.3	100.0	11.2
12	22.6	22.0	22.0	100.0	0.0	20.2	116.8	103.4	88.5	0.0
13	53.4	22.0	22.0	100.0	0.0	91.1	119.8	80.4	67.1	0.0
14	55.8	22.0	22.0	100.0	0.0	97.0	119.7	119.7	100.0	0.0
15	14.2	22.0	22.0	100.0	0.0	4.5	119.7	66.9	55.9	0.0
16	56.7	22.0	22.0	100.0	0.0	97.5	119.6	82.2	68.7	0.0
17	54.0	22.0	22.0	100.0	0.0	90.6	119.4	119.4	100.0	0.0
18	46.9	22.0	22.0	100.0	0.0	74.7	119.4	119.4	100.0	0.0
19	34.3	22.0	22.0	100.0	0.0	43.0	119.4	87.0	72.9	0.0
20	23.7	22.0	22.0	100.0	0.0	21.3	119.3	39.0	32.7	0.0
21	52.4	22.0	22.0	100.0	0.0	83.7	119.3	84.1	70.5	0.0
22	24.4	22.0	22.0	100.0	0.0	23.1	119.2	59.7	50.1	0.0
23	46.7	22.0	22.0	100.0	0.0	70.8	119.1	79.0	66.3	0.0
24	53.6	22.0	22.0	100.0	0.0	84.7	119.0	103.6	87.0	0.0
25	48.7	22.0	22.0	100.0	0.0	78.7	131.4	118.8	90.4	0.0
26	33.7	22.0	22.0	100.0	0.0	41.9	99.7	76.4	76.6	0.0
27	51.5	22.0	22.0	100.0	0.0	83.5	50.4	34.2	67.9	0.0
28	44.1	22.0	22.0	100.0	3.3	70.6	87.4	87.4	100.0	4.9
	1062.1	616.0	599.2	97.3	30.3	1601.4	2814.1	2073.6	73.7	28.9

Table: 2.1.47(c)
(All units are kWh)

31 JAN 77 - 02:27:59 PM
4154269 TEEFS

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR

ATLANTA, GEORGIA - 1960 - CASE 3B - ELECTRICAL STORAGE CAPACITY 25 KW-HR

MAR	ELECTRICAL					THERMAL				
	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE
1	31.3	21.0	21.0	100.0	0.0	42.7	96.5	96.5	100.0	0.0
2	31.5	21.0	21.0	100.0	0.0	42.8	95.6	74.1	77.5	0.0
3	43.2	21.0	21.0	100.0	0.0	66.3	95.5	67.4	70.5	0.0
4	31.6	21.0	21.0	100.0	0.0	38.7	95.4	93.0	97.5	0.0
5	59.1	21.0	21.0	100.0	0.0	95.3	95.4	59.2	62.1	0.0
6	10.5	21.0	21.0	100.0	0.0	1.0	95.4	76.9	80.7	0.0
7	53.9	21.0	21.0	100.0	0.0	88.7	95.3	51.6	54.1	0.0
8	11.8	21.0	21.0	100.0	0.0	3.0	95.2	68.2	71.6	0.0
9	51.6	21.0	21.0	100.0	0.0	80.2	95.2	56.3	59.1	0.0
10	50.8	21.0	21.0	100.0	0.0	76.9	95.2	95.2	100.0	0.0
11	52.1	21.0	21.0	100.0	0.0	80.5	95.2	95.2	100.0	0.0
12	55.5	21.0	21.0	100.0	9.1	89.8	95.1	95.1	100.0	13.0
13	55.8	21.0	21.0	100.0	16.0	89.8	95.1	95.1	100.0	13.5
14	61.9	21.0	21.0	100.0	26.1	100.1	69.5	69.5	100.0	36.8
15	17.6	21.0	21.0	100.0	0.0	8.4	125.5	99.2	79.0	0.0
16	16.3	21.0	21.0	100.0	0.0	5.6	114.1	21.0	18.4	0.0
17	36.4	21.0	20.0	95.5	0.0	48.7	75.7	39.5	52.2	0.0
18	62.8	21.0	21.0	100.0	0.0	97.8	110.6	96.0	86.7	0.0
19	56.6	21.0	21.0	100.0	7.9	88.7	95.2	95.2	100.0	6.9
20	52.2	21.0	21.0	100.0	0.0	77.1	121.8	121.8	100.0	0.0
21	59.9	21.0	21.0	100.0	0.0	91.8	122.0	122.0	100.0	0.0
22	69.0	21.0	21.0	100.0	24.8	115.6	89.5	89.5	100.0	29.3
23	70.1	21.0	21.0	100.0	35.9	113.9	69.5	69.5	100.0	50.1
24	69.0	21.0	21.0	100.0	43.2	119.1	40.7	40.7	100.0	83.1
25	62.1	21.0	21.0	100.0	30.5	92.1	69.5	69.5	100.0	38.5
26	67.8	21.0	21.0	100.0	43.3	113.7	32.1	32.1	100.0	80.0
27	61.1	21.0	21.0	100.0	40.1	100.2	26.3	26.3	100.0	74.0
28	43.6	21.0	21.0	100.0	22.3	58.8	17.9	17.9	100.0	41.0
29	25.3	21.0	21.0	100.0	3.8	21.7	19.5	19.5	100.0	2.1
30	44.9	21.0	21.0	100.0	24.5	67.7	19.2	19.2	100.0	48.6
31	62.6	21.0	21.0	100.0	41.4	101.2	34.9	34.9	100.0	66.5
	477.8	651.0	650.0	99.9	368.8	2218.2	2493.9	2107.2	84.5	583.4

Table 2.1.47(d)
(All units are kWh)

31 JAN 77 - 02:31:39 PM
4154269 TEEFS

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR
ATLANTA, GEORGIA - 1960 - CASE 3B - ELECTRICAL STORAGE CAPACITY 25 KW-HR

APR	ELECTRICAL					THERMAL				
	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE
1	60.6	31.5	31.5	100.0	36.8	103.5	23.0	23.0	100.0	80.5
2	28.5	24.1	24.1	100.0	0.0	28.4	17.5	17.5	100.0	10.8
3	24.7	25.3	25.3	100.0	0.0	20.2	20.9	20.9	100.0	0.0
4	24.3	20.7	20.7	100.0	0.0	20.3	17.6	17.6	100.0	2.0
5	60.0	20.0	20.0	100.0	38.0	92.0	60.7	60.7	100.0	44.3
6	70.5	24.1	24.1	100.0	39.3	114.7	48.7	48.7	100.0	64.8
7	62.4	30.0	30.0	100.0	35.3	103.5	21.7	21.7	100.0	81.7
8	65.8	25.5	25.5	100.0	36.2	105.8	23.4	23.4	100.0	82.4
9	67.7	20.5	20.5	100.0	45.0	105.5	36.5	36.5	100.0	72.7
10	75.1	20.0	20.0	100.0	38.6	111.6	81.3	81.3	100.0	52.4
11	74.3	23.4	23.4	100.0	45.4	115.7	38.2	38.2	100.0	76.1
12	73.3	30.2	30.2	100.0	47.5	118.4	29.8	29.8	100.0	88.6
13	71.7	34.3	34.3	100.0	39.3	117.1	18.1	18.1	100.0	99.0
14	66.8	34.0	34.0	100.0	32.7	108.2	17.5	17.5	100.0	90.7
15	56.2	30.5	30.5	100.0	23.6	84.5	17.6	17.6	100.0	66.9
16	59.7	36.3	36.3	100.0	26.4	98.7	17.5	17.5	100.0	81.2
17	60.7	33.4	33.4	100.0	24.9	94.8	17.5	17.5	100.0	77.1
18	59.0	22.9	22.9	100.0	31.1	82.8	29.4	29.4	100.0	53.6
19	74.9	28.1	28.1	100.0	50.2	117.2	28.0	28.0	100.0	89.1
20	30.2	26.5	26.5	100.0	2.9	28.3	23.8	23.8	100.0	4.5
21	46.2	27.1	27.1	100.0	17.6	62.3	19.1	19.1	100.0	42.4
22	43.0	35.7	35.7	100.0	14.2	60.4	17.5	17.5	100.0	43.7
23	57.4	43.7	43.7	100.0	15.5	90.8	17.5	17.5	100.0	73.3
24	65.8	47.0	47.0	100.0	19.6	106.1	17.5	17.5	100.0	88.6
25	63.9	48.2	48.2	100.0	15.6	101.8	17.5	17.5	100.0	84.3
26	63.4	47.3	47.0	99.4	15.6	101.4	17.5	17.5	100.0	83.9
27	43.9	31.3	31.3	100.0	6.7	53.9	17.5	17.5	100.0	36.3
28	66.8	23.7	23.7	100.0	39.5	94.0	20.6	20.6	100.0	73.4
29	56.3	25.3	25.3	100.0	32.3	79.3	27.2	27.2	100.0	52.1
30	29.1	28.2	28.2	100.0	2.1	24.4	22.0	22.0	100.0	1.8
	1702.0	898.6	898.3	100.0	771.9	2545.4	782.5	782.5	100.0	1798.4

Table 2.1.47(e)
(All units are kWh)

31 JAN 77 - 02:34:54 PM
4154269 TEEFS

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR

ATLANTA, GEORGIA - 1960 - CASE 3B - ELECTRICAL STORAGE CAPACITY 25 KW-HR

MAY	ELECTRICAL					THERMAL				
	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE
1	57.1	24.4	24.4	100.0	30.3	80.4	17.5	17.5	100.0	63.9
2	67.5	22.7	22.7	100.0	44.3	93.3	17.5	17.5	100.0	75.8
3	67.2	27.3	27.3	100.0	42.8	100.1	17.5	17.5	100.0	82.6
4	53.6	28.4	28.4	100.0	25.4	74.6	17.5	17.5	100.0	57.1
5	63.2	27.7	27.7	100.0	35.3	89.0	17.5	17.5	100.0	71.4
6	60.8	27.6	27.6	100.0	32.7	84.4	17.5	17.5	100.0	66.6
7	41.0	25.5	25.5	100.0	12.5	45.3	17.5	17.5	100.0	27.1
8	68.6	19.3	19.3	100.0	46.9	96.6	17.5	17.5	100.0	80.1
9	65.6	25.5	25.5	100.0	44.1	92.3	17.5	17.5	100.0	74.8
10	65.8	19.0	19.0	100.0	42.4	85.6	17.5	17.5	100.0	68.1
11	56.1	19.0	19.0	100.0	37.2	69.6	17.5	17.5	100.0	52.1
12	62.6	21.8	21.8	100.0	43.2	85.0	17.5	17.5	100.0	67.5
13	72.1	28.9	28.9	100.0	47.5	104.3	17.5	17.5	100.0	86.8
14	73.7	33.6	33.6	100.0	42.7	107.6	17.5	17.5	100.0	90.1
15	69.3	37.5	37.5	100.0	33.8	100.0	17.5	17.5	100.0	82.3
16	72.0	44.1	44.1	100.0	30.9	106.1	17.5	17.5	100.0	88.7
17	62.7	47.9	47.9	100.0	14.8	93.5	17.5	17.5	100.0	76.0
18	65.5	50.1	49.6	99.0	16.5	99.4	17.5	17.5	100.0	81.7
19	71.8	52.3	50.4	96.3	21.1	106.9	17.5	17.5	100.0	89.3
20	41.4	48.8	45.5	93.4	0.0	47.6	17.5	17.5	100.0	29.6
21	61.0	48.4	43.1	88.9	11.1	85.9	17.5	17.5	100.0	68.4
22	74.7	46.4	46.4	100.0	29.6	111.5	17.5	17.5	100.0	94.9
23	75.9	48.7	48.7	100.0	27.7	111.7	17.5	17.5	100.0	94.0
24	68.8	53.3	52.4	98.3	17.0	100.0	17.5	17.5	100.0	82.4
25	69.9	55.7	54.0	97.0	17.0	103.2	17.5	17.5	100.0	85.8
26	63.7	46.1	42.6	92.5	12.4	93.2	17.5	17.5	100.0	75.0
27	57.9	34.2	34.2	100.0	25.2	78.4	17.5	17.5	100.0	61.9
28	69.1	36.3	36.3	100.0	33.9	97.2	17.5	17.5	100.0	79.4
29	67.9	45.0	45.0	100.0	26.0	99.2	17.5	17.5	100.0	81.6
30	70.4	49.9	49.9	100.0	20.8	99.8	17.5	17.5	100.0	82.1
31	68.0	48.3	48.3	100.0	18.3	95.3	17.5	17.5	100.0	77.9
	2004.7	1143.8	1126.7	98.5	883.3	2837.0	542.5	542.5	100.0	2295.1

Table 2.1.47(f)
(All units are kWh)

31 JAN 77 - 02:38:26 PM
4154269 TEEFS

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR

ATLANTA, GEORGIA - 1960 - CASE 3E - ELECTRICAL STORAGE CAPACITY 25 KW-HR

JUN	ELECTRICAL					THERMAL				
	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE
1	73.8	45.1	45.1	100.0	28.6	103.7	17.5	17.5	100.0	86.3
2	61.6	43.8	43.8	100.0	17.2	83.9	17.5	17.5	100.0	66.5
3	54.1	42.7	42.7	100.0	11.1	69.4	17.5	17.5	100.0	51.5
4	59.1	44.8	44.8	100.0	15.2	83.9	17.5	17.5	100.0	66.4
5	55.9	42.1	42.1	100.0	12.8	76.7	17.5	17.5	100.0	58.8
6	68.1	52.2	52.2	100.0	20.8	100.5	17.5	17.5	100.0	83.5
7	68.4	49.7	47.3	95.1	14.9	97.9	17.5	17.5	100.0	79.9
8	38.9	39.8	39.8	100.0	0.0	44.8	17.5	17.5	100.0	27.3
9	69.1	33.9	33.9	100.0	34.6	97.4	17.5	17.5	100.0	80.5
10	71.8	37.6	37.6	100.0	33.9	97.1	17.5	17.5	100.0	79.8
11	69.0	40.0	40.0	100.0	29.3	92.6	17.5	17.5	100.0	74.8
12	71.1	50.8	50.8	100.0	25.4	102.2	17.5	17.5	100.0	84.7
13	67.2	49.3	47.3	95.9	17.4	93.1	17.5	17.5	100.0	75.5
14	54.8	48.3	48.3	100.0	5.7	72.9	17.5	17.5	100.0	54.5
15	68.4	44.4	44.4	100.0	24.3	95.8	17.5	17.5	100.0	79.4
16	54.4	45.0	45.0	100.0	6.3	70.2	17.5	17.5	100.0	52.1
17	59.2	42.0	42.0	100.0	19.2	80.2	17.5	17.5	100.0	62.6
18	63.1	49.9	49.9	100.0	16.1	88.2	17.5	17.5	100.0	70.9
19	62.0	51.5	51.5	100.0	11.0	87.4	17.5	17.5	100.0	69.9
20	62.5	54.1	53.4	98.7	10.1	88.8	17.5	17.5	100.0	71.3
21	49.3	55.1	52.3	94.9	0.0	65.3	17.5	17.5	100.0	47.7
22	55.0	54.0	50.1	92.6	2.9	76.5	17.5	17.5	100.0	59.1
23	65.6	60.9	56.3	92.4	7.7	94.4	17.5	17.5	100.0	75.9
24	57.9	61.9	56.7	91.5	0.0	81.9	17.5	17.5	100.0	64.4
25	47.9	49.5	49.5	100.0	0.0	59.8	17.5	17.5	100.0	42.3
26	33.0	40.9	37.4	91.5	0.0	34.2	17.5	17.5	100.0	16.8
27	54.6	39.7	37.9	95.5	6.4	69.5	17.5	17.5	100.0	51.8
28	61.7	48.5	48.5	100.0	17.1	82.0	17.5	17.5	100.0	65.6
29	64.8	58.5	58.5	100.0	10.4	90.6	17.5	17.5	100.0	73.1
30	71.2	61.6	56.7	92.1	14.4	102.8	17.5	17.5	100.0	84.9
	1813.5	1437.5	1405.6	97.8	412.8	2483.8	525.0	525.0	100.0	1957.9

Table 2.1.47(g)
(All units are kWh)

31 JAN 77 - 02:41:54 PM
4154269 TEEFS

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR

ATLANTA, GEORGIA - 1960 - CASE 3B - ELECTRICAL STORAGE CAPACITY 25 KW-HR

JUL	ELECTRICAL					THERMAL				
	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE
1	58.4	70.7	60.5	85.5	0.2	86.2	17.5	17.5	100.0	68.1
2	59.9	68.3	55.7	81.5	3.2	88.7	17.5	17.5	100.0	72.2
3	63.2	64.3	56.7	88.1	7.4	92.1	17.5	17.5	100.0	74.6
4	58.5	56.5	49.0	86.8	7.1	80.3	17.5	17.5	100.0	62.9
5	64.4	57.9	54.0	93.2	9.2	93.1	17.5	17.5	100.0	74.9
6	56.1	55.3	51.7	93.6	3.9	79.5	17.5	17.5	100.0	62.2
7	41.1	48.0	45.4	94.7	0.0	46.7	17.5	17.5	100.0	29.2
8	62.4	47.9	43.9	91.6	12.0	88.3	17.5	17.5	100.0	70.9
9	60.5	51.8	51.8	100.0	9.9	86.0	17.5	17.5	100.0	68.8
10	42.5	54.3	47.8	88.1	0.0	52.0	17.5	17.5	100.0	34.5
11	51.0	56.3	49.5	87.9	0.0	69.6	17.5	17.5	100.0	51.9
12	62.8	54.6	50.1	91.8	9.4	91.2	17.5	17.5	100.0	73.7
13	62.5	60.5	57.7	95.4	8.5	92.2	17.5	17.5	100.0	75.0
14	55.1	59.0	50.1	84.9	1.8	76.2	17.5	17.5	100.0	58.7
15	72.3	51.7	50.4	97.5	21.8	104.7	17.5	17.5	100.0	87.4
16	50.9	44.8	43.3	96.8	3.4	71.7	17.5	17.5	100.0	54.0
17	66.4	45.6	45.6	100.0	21.7	95.7	17.5	17.5	100.0	78.3
18	66.9	49.2	49.2	100.0	19.5	98.8	17.5	17.5	100.0	81.8
19	42.7	49.8	48.7	97.8	0.0	57.0	17.5	17.5	100.0	39.6
20	60.9	52.2	46.2	88.6	9.1	90.5	17.5	17.5	100.0	72.7
21	73.2	52.7	51.7	98.0	20.8	111.4	17.5	17.5	100.0	93.7
22	57.4	52.5	52.2	99.5	4.5	84.4	17.5	17.5	100.0	66.8
23	53.7	50.3	50.3	100.0	5.2	78.3	17.5	17.5	100.0	60.8
24	55.6	49.5	48.9	98.9	6.4	81.4	17.5	17.5	100.0	63.9
25	62.4	56.8	55.2	97.2	9.0	95.0	17.5	17.5	100.0	77.6
26	52.3	55.0	52.0	94.5	0.0	77.3	17.5	17.5	100.0	59.9
27	30.3	45.6	34.1	74.6	0.0	36.6	17.5	17.5	100.0	19.7
28	30.4	43.3	30.4	70.2	0.0	35.3	17.5	17.5	100.0	17.7
29	54.0	42.6	39.9	93.7	6.1	76.8	17.5	17.5	100.0	58.8
30	54.0	45.6	45.6	100.0	8.4	76.9	17.5	17.5	100.0	59.4
31	53.9	44.6	44.6	100.0	8.4	77.0	17.5	17.5	100.0	59.5
	1735.9	1637.5	1512.4	92.4	216.8	2471.3	542.5	542.5	100.0	1929.2

Table 2.1.47(h)
(All units are kWh)

31 JAN 77 - 02:45:23 PM
4154269 TEEFS

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR

ATLANTA, GEORGIA - 1960 - CASE 3B - ELECTRICAL STORAGE CAPACITY 25 KW-HR

AUG	ELECTRICAL					THERMAL				
	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE
1	41.7	54.6	50.6	92.7	0.0	58.2	17.5	17.5	100.0	40.6
2	53.5	57.8	48.1	83.3	4.3	82.3	17.5	17.5	100.0	64.8
3	53.4	57.8	49.2	85.3	4.2	82.5	17.5	17.5	100.0	65.0
4	53.4	57.8	49.2	85.3	4.1	82.6	17.5	17.5	100.0	65.1
5	33.2	50.6	34.2	67.6	0.0	46.4	17.5	17.5	100.0	29.1
6	53.2	53.7	46.0	85.6	3.4	81.4	17.5	17.5	100.0	63.6
7	56.9	58.9	52.7	89.5	5.1	89.4	17.5	17.5	100.0	71.9
8	45.1	54.4	47.5	87.2	0.0	64.7	17.5	17.5	100.0	47.4
9	40.6	50.9	41.2	80.9	0.0	60.0	17.5	17.5	100.0	42.7
10	38.7	48.0	38.7	80.8	0.0	54.7	17.5	17.5	100.0	37.1
11	20.6	45.3	20.6	45.4	0.0	17.4	17.5	17.5	100.0	0.0
12	40.0	49.2	40.0	81.4	0.0	56.1	17.5	17.5	100.0	38.6
13	45.1	49.6	43.7	88.2	0.0	66.3	17.5	17.5	100.0	48.7
14	51.1	50.8	44.2	87.0	2.6	79.6	17.5	17.5	100.0	62.2
15	44.8	50.6	48.1	95.1	0.0	66.2	17.5	17.5	100.0	48.5
16	52.1	52.8	48.1	91.0	3.8	81.0	17.5	17.5	100.0	63.5
17	49.1	52.6	46.5	88.4	0.0	73.9	17.5	17.5	100.0	56.3
18	59.1	50.6	47.8	94.5	12.1	95.9	17.5	17.5	100.0	78.7
19	55.7	52.0	49.0	94.1	5.7	89.3	17.5	17.5	100.0	71.5
20	47.6	55.3	52.4	94.7	0.0	71.8	17.5	17.5	100.0	54.3
21	50.9	59.2	49.7	83.9	0.0	81.0	17.5	17.5	100.0	63.5
22	25.6	55.9	27.6	49.4	0.0	30.7	17.5	17.5	100.0	13.2
23	42.8	56.6	42.8	75.6	0.0	62.7	17.5	17.5	100.0	45.2
24	51.7	53.7	44.1	82.1	1.8	82.7	17.5	17.5	100.0	65.2
25	34.6	47.8	40.5	84.8	0.0	44.1	17.5	17.5	100.0	26.7
26	48.6	43.1	41.4	96.2	0.3	66.8	17.5	17.5	100.0	49.3
27	34.7	47.2	41.5	88.0	0.0	39.3	17.5	17.5	100.0	21.8
28	55.4	54.2	49.2	90.7	3.5	87.0	17.5	17.5	100.0	69.7
29	68.6	61.9	57.5	92.9	12.9	114.1	17.5	17.5	100.0	96.6
30	68.0	61.8	55.2	89.3	12.6	115.0	17.5	17.5	100.0	97.3
31	53.3	54.3	49.8	91.7	0.0	85.2	17.5	17.5	100.0	67.9
	1469.2	1648.8	1397.1	84.7	76.3	2208.4	542.5	542.5	100.0	1666.1

Table 2.1.47(i)
(All units are kWh)

31 JAN 77 - 02:49:00 PM
4154269 TEEPS

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR

ATLANTA, GEORGIA - 1960 - CASE 3B - ELECTRICAL STORAGE CAPACITY 25 KW-HR

SEP	ELECTRICAL					THERMAL				
	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE
1	38.9	51.2	43.6	85.1	0.0	62.5	17.5	17.5	100.0	45.9
2	36.4	48.0	36.4	75.9	0.0	54.9	17.5	17.5	100.0	36.2
3	50.9	52.9	47.1	89.2	0.5	85.5	17.5	17.5	100.0	68.6
4	42.5	53.7	45.8	85.4	0.0	67.5	17.5	17.5	100.0	49.4
5	50.3	57.3	49.6	86.5	0.0	85.0	17.5	17.5	100.0	67.9
6	51.8	61.1	52.1	85.2	0.0	90.2	17.5	17.5	100.0	72.2
7	38.5	59.9	39.0	65.1	0.0	59.5	17.5	17.5	100.0	42.0
8	37.7	56.6	37.7	66.6	0.0	58.1	17.5	17.5	100.0	41.3
9	45.8	54.8	45.8	83.6	0.0	76.7	17.5	17.5	100.0	58.5
10	39.4	58.3	39.4	67.5	0.0	62.1	17.5	17.5	100.0	45.1
11	36.8	54.3	36.8	67.7	0.0	54.8	17.5	17.5	100.0	37.3
12	58.5	41.2	36.9	89.5	13.6	100.7	17.5	17.5	100.0	83.6
13	60.3	33.9	33.9	100.0	25.3	104.9	17.5	17.5	100.0	87.4
14	57.9	29.4	29.4	100.0	26.8	97.6	17.5	17.5	100.0	80.1
15	30.6	29.4	29.4	100.0	0.0	30.7	17.5	17.5	100.0	12.2
16	28.1	42.7	40.3	94.3	0.0	28.1	17.5	17.5	100.0	10.6
17	31.7	48.6	31.7	65.3	0.0	37.9	17.5	17.5	100.0	21.4
18	36.3	42.5	36.3	85.3	0.0	48.6	17.5	17.5	100.0	31.1
19	50.0	46.0	43.5	94.6	2.8	86.1	17.5	17.5	100.0	68.6
20	55.8	52.7	50.7	96.3	6.2	100.9	17.5	17.5	100.0	83.4
21	57.9	52.9	48.8	92.3	9.2	106.2	17.5	17.5	100.0	88.7
22	23.6	48.3	26.0	53.9	0.0	27.9	17.5	17.5	100.0	10.5
23	51.0	35.9	33.5	93.1	9.6	89.0	17.5	17.5	100.0	71.5
24	54.0	35.3	35.3	100.0	19.2	97.0	17.5	17.5	100.0	79.4
25	48.6	31.6	31.6	100.0	13.9	80.8	17.5	17.5	100.0	63.3
26	37.1	24.3	24.3	100.0	8.5	49.9	17.5	17.5	100.0	32.4
27	24.1	25.2	25.2	100.0	0.0	20.5	17.5	17.5	100.0	3.0
28	24.2	24.6	24.6	100.0	0.0	20.8	17.5	17.5	100.0	3.3
29	25.4	30.9	30.9	100.0	0.0	23.2	17.5	17.5	100.0	5.7
30	33.7	33.7	33.7	100.0	0.0	45.6	17.5	17.5	100.0	28.4
	1258.1	1317.4	1119.4	85.0	135.6	1953.1	525.0	525.0	100.0	1429.1

Table 2.1.47(j)
(All units are kWh)

31 JAN 77 - 02:52:34 PM
4154269 TEEFS

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR

ATLANTA, GEORGIA - 1960 - CASE 3B - ELECTRICAL STORAGE CAPACITY 25 KW-HR

OCT	ELECTRICAL					THERMAL				
	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE
1	50.9	40.3	40.3	100.0	13.1	93.1	17.5	17.5	100.0	75.6
2	35.8	39.4	39.4	100.0	0.0	53.4	17.5	17.5	100.0	35.3
3	48.5	49.3	46.0	93.3	0.9	87.3	17.5	17.5	100.0	69.6
4	46.1	45.8	43.7	95.5	0.0	79.3	17.5	17.5	100.0	61.8
5	27.1	40.7	32.7	80.3	0.0	31.0	17.5	17.5	100.0	13.5
6	32.8	40.3	32.8	81.4	0.0	42.8	17.5	17.5	100.0	25.3
7	24.9	43.4	24.9	57.4	0.0	25.3	17.5	17.5	100.0	7.8
8	24.6	42.5	24.6	57.8	0.0	24.7	17.5	17.5	100.0	7.2
9	39.2	35.8	33.1	92.6	0.0	61.8	17.5	17.5	100.0	44.3
10	33.5	35.0	35.0	100.0	0.0	48.9	17.5	17.5	100.0	31.9
11	35.8	38.9	38.9	100.0	0.0	57.4	17.5	17.5	100.0	40.0
12	42.0	37.3	36.1	96.8	1.0	75.9	17.5	17.5	100.0	58.5
13	45.6	39.8	39.8	100.0	6.7	84.7	17.5	17.5	100.0	67.3
14	35.8	39.8	39.8	100.0	0.0	59.3	17.5	17.5	100.0	41.6
15	38.3	38.6	37.4	96.9	0.0	58.4	17.5	17.5	100.0	41.0
16	41.7	38.2	37.8	99.1	0.0	75.4	17.5	17.5	100.0	58.0
17	31.3	33.8	33.8	100.0	0.0	49.2	17.5	17.5	100.0	31.8
18	44.9	34.7	34.7	100.0	6.1	85.0	17.6	17.6	100.0	67.5
19	36.5	36.5	36.5	100.0	2.8	59.3	17.5	17.5	100.0	41.8
20	27.5	20.5	20.5	100.0	0.0	33.4	35.4	35.4	100.0	9.9
21	49.1	21.3	21.3	100.0	18.4	92.3	51.0	51.0	100.0	35.3
22	41.2	24.9	24.9	100.0	18.6	75.5	30.9	30.9	100.0	44.6
23	42.7	25.3	25.3	100.0	17.9	80.9	27.8	27.8	100.0	53.2
24	49.6	25.9	25.9	100.0	23.4	99.5	24.5	24.5	100.0	75.0
25	51.2	26.9	26.9	100.0	25.3	100.3	33.2	33.2	100.0	67.1
26	43.0	23.0	23.0	100.0	16.9	75.6	25.7	25.7	100.0	49.9
27	40.0	27.5	27.5	100.0	16.3	69.9	27.7	27.7	100.0	42.3
28	29.0	22.1	22.1	100.0	3.1	46.7	25.3	25.3	100.0	21.4
29	35.3	24.8	24.8	100.0	12.6	64.5	29.6	29.6	100.0	34.9
30	38.7	25.2	25.2	100.0	12.8	70.8	22.3	22.3	100.0	48.5
31	19.7	21.3	21.3	100.0	0.0	15.4	22.0	22.0	100.0	0.0
	1182.3	1039.1	976.4	94.0	196.0	1977.0	687.9	687.9	100.0	1302.5

Table 2.1.47(k)
(All units are kWh)

31 JAN 77 - 02:55:56 PM
4154269 TEEFS

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR

ATLANTA, GEORGIA - 1960 - CASE 3B - ELECTRICAL STORAGE CAPACITY 25 KW-HR

NOV	ELECTRICAL					THERMAL				
	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE
1	39.6	21.0	21.0	100.0	10.3	74.5	53.2	53.2	100.0	22.4
2	46.5	21.0	21.0	100.0	23.5	93.8	43.0	43.0	100.0	49.3
3	44.0	21.0	21.0	100.0	23.0	85.3	41.1	41.1	100.0	49.0
4	48.1	21.0	21.0	100.0	24.2	95.6	52.1	52.1	100.0	41.6
5	48.4	21.0	21.0	100.0	27.4	98.6	43.2	43.2	100.0	60.4
6	41.2	21.0	21.0	100.0	13.4	78.7	72.4	72.4	100.0	20.5
7	47.0	21.0	21.0	100.0	15.5	89.9	84.4	84.4	100.0	19.0
8	49.0	21.0	21.0	100.0	9.9	93.9	91.2	91.2	100.0	17.9
9	42.7	21.0	21.0	100.0	12.7	76.8	54.7	54.7	100.0	18.7
10	24.9	21.0	21.0	100.0	1.2	32.5	64.2	64.2	100.0	0.0
11	38.2	21.0	21.0	100.0	0.0	64.1	91.2	91.2	100.0	0.0
12	32.7	21.0	21.0	100.0	0.0	57.3	65.1	65.1	100.0	0.0
13	36.3	21.0	21.0	100.0	0.3	66.4	46.3	46.3	100.0	0.0
14	43.5	21.0	21.0	100.0	22.5	89.1	34.6	34.6	100.0	54.5
15	44.9	21.0	21.0	100.0	23.9	92.8	33.7	33.7	100.0	59.1
16	28.0	21.0	21.0	100.0	7.0	45.2	29.0	29.0	100.0	16.2
17	38.0	21.0	21.0	100.0	17.0	73.4	26.2	26.2	100.0	47.2
18	30.2	21.0	21.0	100.0	9.2	47.3	33.9	33.9	100.0	20.7
19	42.7	21.0	21.0	100.0	14.8	86.6	60.3	60.3	100.0	28.5
20	44.4	21.0	21.0	100.0	23.4	92.9	31.3	31.3	100.0	59.0
21	40.6	21.0	21.0	100.0	19.6	80.2	30.7	30.7	100.0	49.6
22	19.1	21.0	21.0	100.0	0.0	18.9	23.2	23.2	100.0	0.0
23	17.2	21.0	21.0	100.0	0.0	14.9	33.8	33.8	100.0	0.0
24	22.3	21.0	21.0	100.0	0.0	28.3	34.3	34.3	100.0	0.0
25	26.3	21.0	21.0	100.0	0.0	39.8	28.2	28.2	100.0	0.0
26	27.2	21.0	21.0	100.0	5.8	44.6	21.8	21.8	100.0	6.8
27	23.3	21.0	21.0	100.0	2.3	38.9	23.3	23.3	100.0	15.6
28	29.7	21.0	21.0	100.0	8.6	53.5	46.7	46.7	100.0	28.8
29	33.3	21.0	21.0	100.0	11.4	59.9	55.4	55.4	100.0	19.5
30	45.4	21.0	21.0	100.0	0.0	88.9	138.8	138.8	100.0	0.0
	1094.7	630.0	630.0	100.0	326.9	2002.6	1487.0	1487.0	100.0	704.3

Table 2.1.47(1)
(All units are kWh)

31 JAN 77 - 02:59:15 PM
4154269 TEEFS

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR

ATLANTA, GEORGIA - 1960 - CASE 3B - ELECTRICAL STORAGE CAPACITY 25 KW-HR

DEC	ELECTRICAL					THERMAL				
	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	WASTE
1	43.4	22.0	22.0	100.0	0.0	81.4	152.3	137.5	90.3	0.0
2	45.0	22.0	22.0	100.0	0.0	87.7	102.4	56.7	55.4	0.0
3	44.5	22.0	22.0	100.0	8.2	89.7	58.6	58.6	100.0	12.4
4	42.7	22.0	22.0	100.0	19.4	87.8	50.9	50.9	100.0	34.1
5	38.7	22.0	22.0	100.0	16.7	77.9	41.5	41.5	100.0	36.4
6	39.5	22.0	22.0	100.0	17.6	82.8	33.8	33.8	100.0	49.1
7	29.0	22.0	22.0	100.0	6.0	49.5	37.8	37.8	100.0	12.7
8	37.1	22.0	22.0	100.0	14.4	69.2	71.4	71.4	100.0	20.0
9	42.5	22.0	22.0	100.0	0.8	84.0	107.5	107.5	100.0	0.0
10	37.0	22.0	22.0	100.0	0.0	66.2	79.7	79.7	100.0	0.0
11	16.1	22.0	22.0	100.0	0.0	14.8	67.2	67.2	100.0	0.0
12	35.9	22.0	22.0	100.0	0.0	62.5	168.3	94.3	56.0	0.0
13	44.3	22.0	22.0	100.0	0.0	83.3	183.2	108.6	59.3	0.0
14	41.5	22.0	22.0	100.0	0.0	78.2	129.7	73.3	56.5	0.0
15	14.6	23.0	23.0	100.0	0.0	9.2	100.5	47.8	47.6	0.0
16	40.4	23.0	20.6	89.6	0.0	78.1	143.2	86.2	60.2	0.0
17	42.0	23.0	23.0	100.0	0.0	82.8	123.5	69.8	56.6	0.0
18	37.2	23.0	23.0	100.0	0.0	71.1	104.0	86.4	83.1	0.0
19	40.7	23.0	23.0	100.0	0.0	82.5	87.8	77.6	88.4	0.0
20	34.3	23.0	23.0	100.0	0.0	61.2	83.7	83.7	100.0	0.0
21	33.0	23.0	23.0	100.0	0.0	53.8	177.3	113.7	64.1	0.0
22	38.9	23.0	23.0	100.0	0.0	68.3	198.3	87.6	44.2	0.0
23	39.8	23.0	23.0	100.0	0.0	73.5	157.0	92.0	58.6	0.0
24	36.3	23.0	23.0	100.0	0.0	63.5	103.1	65.1	63.1	0.0
25	31.5	23.0	23.0	100.0	0.0	55.3	74.0	57.9	78.3	0.0
26	31.4	23.0	23.0	100.0	0.0	53.8	67.8	59.2	87.3	0.0
27	23.2	23.0	23.0	100.0	0.0	33.5	68.0	62.5	91.9	0.0
28	36.4	23.0	23.0	100.0	0.0	64.8	98.3	71.0	72.2	0.0
29	36.7	23.0	23.0	100.0	0.0	65.5	91.8	60.1	65.4	0.0
30	31.1	23.0	23.0	100.0	0.0	57.0	77.1	76.0	98.6	0.0
31	23.7	23.0	23.0	100.0	0.0	12.1	101.5	54.7	53.9	0.0
	1108.3	699.0	696.6	99.7	83.2	2000.9	3141.0	2270.0	72.3	164.7

Table 2.1.48(a)
(all units are kWh)

PVEFS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR - 31 JAN 77, 03:14:06 PM, 4154269 TEEFS

MAR 20	ELECTRICAL						THERMAL					
	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE
1:00	0.0	0.4	0.4	100.0	16.7	0.0	0.0	3.9	3.9	100.0	71.7	0.0
2:00	0.0	0.4	0.4	100.0	16.3	0.0	0.0	5.0	5.0	100.0	66.7	0.0
3:00	0.0	0.4	0.4	100.0	15.9	0.0	0.0	5.8	5.8	100.0	60.9	0.0
4:00	0.0	0.4	0.4	100.0	15.5	0.0	0.0	5.6	5.6	100.0	55.4	0.0
5:00	0.0	0.4	0.4	100.0	15.1	0.0	0.0	5.4	5.4	100.0	50.0	0.0
6:00	0.0	0.8	0.8	100.0	14.3	0.0	0.0	5.1	5.1	100.0	44.9	0.0
7:00	0.0	0.8	0.8	100.0	13.9	0.0	0.0	4.0	4.0	100.0	40.9	0.0
8:00	1.2	0.8	0.8	100.0	14.3	0.0	0.0	4.8	4.8	100.0	36.1	0.0
9:00	2.1	0.8	0.8	100.0	15.5	0.0	1.2	6.6	6.6	100.0	30.7	0.0
10:00	4.9	0.9	0.9	100.0	19.5	0.0	6.5	6.8	6.8	100.0	30.5	0.0
11:00	7.2	0.9	0.9	100.0	25.0	0.0	11.8	6.8	6.8	100.0	36.4	0.0
12:00	8.5	0.9	0.9	100.0	25.0	0.0	15.2	6.0	6.0	100.0	53.1	0.0
13:00	8.3	0.9	0.9	100.0	25.0	0.0	14.7	5.6	5.6	100.0	69.7	0.0
14:00	7.6	0.9	0.9	100.0	25.0	0.0	13.2	6.0	6.0	100.0	83.5	0.0
15:00	6.1	0.9	0.9	100.0	25.0	0.0	9.0	5.5	5.5	100.0	92.2	0.0
16:00	4.2	1.2	1.2	100.0	25.0	0.0	4.8	4.9	4.9	100.0	95.1	0.0
17:00	1.9	1.2	1.2	100.0	25.0	0.0	0.7	4.3	4.3	100.0	92.2	0.0
18:00	0.0	1.2	1.2	100.0	23.8	0.0	0.0	4.9	4.9	100.0	87.3	0.0
19:00	0.0	1.2	1.2	100.0	22.5	0.0	0.0	4.9	4.9	100.0	82.4	0.0
20:00	0.0	1.2	1.2	100.0	21.3	0.0	0.0	3.9	3.9	100.0	78.5	0.0
21:00	0.0	1.2	1.2	100.0	20.0	0.0	0.0	4.2	4.2	100.0	74.3	0.0
22:00	0.0	1.2	1.2	100.0	18.8	0.0	0.0	4.4	4.4	100.0	69.9	0.0
23:00	0.0	1.2	1.2	100.0	17.5	0.0	0.0	4.2	4.2	100.0	65.7	0.0
24:00	0.0	0.4	0.4	100.0	17.2	0.0	0.0	3.7	3.7	100.0	62.1	0.0
	52.2	21.0	21.0	100.0		0.0	77.1	121.8	121.8	100.0		0.0

Table 2.1.48(b)
(All units are kWh)

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR - 31 JAN 77, 03:26:56 PM, 4154269 TEEPS

MAR 21	ELECTRICAL						THERMAL					
	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE
1:00	0.0	0.4	0.4	100.0	16.8	0.0	0.0	4.2	4.2	100.0	57.9	0.0
2:00	0.0	0.4	0.4	100.0	16.4	0.0	0.0	4.9	4.9	100.0	52.9	0.0
3:00	0.0	0.4	0.4	100.0	16.0	0.0	0.0	5.1	5.1	100.0	47.8	0.0
4:00	0.0	0.4	0.4	100.0	15.6	0.0	0.0	5.5	5.5	100.0	42.3	0.0
5:00	0.0	0.4	0.4	100.0	15.2	0.0	0.0	6.2	6.2	100.0	35.1	0.0
6:00	0.0	0.8	0.8	100.0	14.4	0.0	0.0	5.7	5.7	100.0	30.4	0.0
7:00	0.7	0.8	0.8	100.0	14.3	0.0	0.0	5.0	5.0	100.0	25.4	0.0
8:00	2.1	0.8	0.8	100.0	15.6	0.0	0.9	4.8	4.8	100.0	21.5	0.0
9:00	3.6	0.8	0.8	100.0	18.4	0.0	3.8	7.4	7.4	100.0	18.0	0.0
10:00	5.1	0.9	0.9	100.0	22.6	0.0	7.0	7.7	7.7	100.0	17.3	0.0
11:00	6.3	0.9	0.9	100.0	25.0	0.0	10.1	7.7	7.7	100.0	22.7	0.0
12:00	9.7	0.9	0.9	100.0	25.0	0.0	18.4	6.4	6.4	100.0	43.5	0.0
13:00	9.5	0.9	0.9	100.0	25.0	0.0	17.8	5.6	5.6	100.0	64.3	0.0
14:00	8.7	0.9	0.9	100.0	25.0	0.0	15.6	4.9	4.9	100.0	82.7	0.0
15:00	7.0	0.9	0.9	100.0	25.0	0.0	11.2	4.3	4.3	100.0	95.8	0.0
16:00	4.8	1.2	1.2	100.0	25.0	0.0	5.9	4.1	4.1	100.0	101.2	0.0
17:00	2.2	1.2	1.2	100.0	25.0	0.0	1.0	3.0	3.0	100.0	100.1	0.0
18:00	0.1	1.2	1.2	100.0	23.8	0.0	0.0	3.9	3.9	100.0	96.2	0.0
19:00	0.0	1.2	1.2	100.0	22.6	0.0	0.0	4.7	4.7	100.0	91.6	0.0
20:00	0.0	1.2	1.2	100.0	21.3	0.0	0.0	3.6	3.6	100.0	88.0	0.0
21:00	0.0	1.2	1.2	100.0	20.1	0.0	0.0	3.9	3.9	100.0	84.0	0.0
22:00	0.0	1.2	1.2	100.0	18.8	0.0	0.0	4.2	4.2	100.0	79.8	0.0
23:00	0.0	1.2	1.2	100.0	17.6	0.0	0.0	4.7	4.7	100.0	75.1	0.0
24:00	0.0	0.4	0.4	100.0	17.2	0.0	0.0	4.4	4.4	100.0	70.6	0.0
	59.9	21.0	21.0	100.0		0.0	91.8	122.0	122.0	100.0		0.0

Table 2.1.48(c)
(All units are kWh)

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR - 31 JAN 77, 03:30:08 PM, 4154269 TEEFS

MAR 22	ELECTRICAL						THERMAL					
	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE
1:00	0.0	0.4	0.4	100.0	16.8	0.0	0.0	4.5	4.5	100.0	66.1	0.0
2:00	0.0	0.4	0.4	100.0	16.4	0.0	0.0	5.1	5.1	100.0	61.0	0.0
3:00	0.0	0.4	0.4	100.0	16.0	0.0	0.0	5.0	5.0	100.0	55.9	0.0
4:00	0.0	0.4	0.4	100.0	15.6	0.0	0.0	5.6	5.6	100.0	50.3	0.0
5:00	0.0	0.4	0.4	100.0	15.2	0.0	0.0	5.9	5.9	100.0	44.3	0.0
6:00	0.0	0.8	0.8	100.0	14.4	0.0	0.0	6.0	6.0	100.0	38.4	0.0
7:00	1.0	0.8	0.8	100.0	14.6	0.0	0.0	4.6	4.6	100.0	33.8	0.0
8:00	3.6	0.8	0.8	100.0	17.5	0.0	2.9	5.1	5.1	100.0	31.6	0.0
9:00	6.1	0.8	0.8	100.0	22.7	0.0	8.2	6.5	6.5	100.0	33.3	0.0
10:00	7.9	0.9	0.9	100.0	25.0	0.0	13.4	6.7	6.7	100.0	44.8	0.0
11:00	9.2	0.9	0.9	100.0	25.0	0.0	17.4	5.5	5.5	100.0	64.9	0.0
12:00	9.8	0.9	0.9	100.0	25.0	0.0	19.6	4.6	4.6	100.0	88.8	0.0
13:00	9.4	0.9	0.9	100.0	25.0	7.2	18.7	3.9	3.9	100.0	105.0	0.0
14:00	8.4	0.9	0.9	100.0	25.0	7.5	16.1	2.8	2.8	100.0	105.0	13.2
15:00	6.8	0.9	0.9	100.0	25.0	5.9	11.8	1.3	1.3	100.0	105.0	10.5
16:00	4.6	1.2	1.2	100.0	25.0	3.4	6.3	1.0	1.0	100.0	105.0	5.3
17:00	2.1	1.2	1.2	100.0	25.0	0.8	1.3	1.0	1.0	100.0	105.0	0.3
18:00	0.2	1.2	1.2	100.0	23.8	0.0	0.0	1.7	1.7	100.0	103.3	0.0
19:00	0.0	1.2	1.2	100.0	22.5	0.0	0.0	1.0	1.0	100.0	102.3	0.0
20:00	0.0	1.2	1.2	100.0	21.3	0.0	0.0	1.0	1.0	100.0	101.3	0.0
21:00	0.0	1.2	1.2	100.0	20.0	0.0	0.0	1.6	1.6	100.0	99.7	0.0
22:00	0.0	1.2	1.2	100.0	18.8	0.0	0.0	2.2	2.2	100.0	97.5	0.0
23:00	0.0	1.2	1.2	100.0	17.5	0.0	0.0	3.5	3.5	100.0	94.0	0.0
24:00	0.0	0.4	0.4	100.0	17.1	0.0	0.0	3.4	3.4	100.0	90.6	0.0
	69.0	21.0	21.0	100.0		24.8	115.6	89.5	89.5	100.0		29.3

Table 2.1.48(d)
(All units are kWh)

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR - 31 JAN 77, 03:33:39 PM, 4154269 TEEPS

JUN 20	ELECTRICAL						THERMAL					
	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE
1:00	0.0	2.2	2.2	100.0	2.7	0.0	0.0	0.0	0.0	100.0	99.1	0.0
2:00	0.0	0.3	0.3	100.0	2.4	0.0	0.0	0.0	0.0	100.0	99.1	0.0
3:00	0.0	1.0	1.0	100.0	1.4	0.0	0.0	0.0	0.0	100.0	99.1	0.0
4:00	0.0	0.9	0.9	100.0	0.5	0.0	0.0	0.0	0.0	100.0	99.1	0.0
5:00	0.0	0.8	0.5	57.9	0.0	0.0	0.0	0.0	0.0	100.0	99.1	0.0
6:00	1.7	1.9	1.7	88.8	0.0	0.0	1.3	0.0	0.0	100.0	100.3	0.0
7:00	1.8	1.9	1.8	92.2	0.0	0.0	1.3	1.0	1.0	100.0	100.7	0.0
8:00	1.9	1.6	1.6	100.0	0.4	0.0	1.6	1.0	1.0	100.0	101.4	0.0
9:00	2.2	1.7	1.7	100.0	0.9	0.0	2.1	1.0	1.0	100.0	102.4	0.0
10:00	7.8	1.9	1.9	100.0	6.8	0.0	12.0	1.0	1.0	100.0	105.0	8.5
11:00	8.7	2.0	2.0	100.0	13.5	0.0	14.9	1.0	1.0	100.0	105.0	13.9
12:00	8.1	1.9	1.9	100.0	19.7	0.0	14.1	1.0	1.0	100.0	105.0	13.1
13:00	8.0	1.8	1.8	100.0	25.0	0.9	13.5	1.0	1.0	100.0	105.0	12.5
14:00	7.2	2.2	2.2	100.0	25.0	5.0	11.7	1.0	1.0	100.0	105.0	10.7
15:00	6.0	2.9	2.9	100.0	25.0	3.1	8.5	1.0	1.0	100.0	105.0	7.5
16:00	4.4	3.2	3.2	100.0	25.0	1.2	4.9	1.0	1.0	100.0	105.0	4.0
17:00	2.8	3.7	3.7	100.0	24.1	0.0	2.1	1.0	1.0	100.0	105.0	1.1
18:00	1.5	4.0	4.0	100.0	21.6	0.0	0.9	1.0	1.0	100.0	104.9	0.0
19:00	0.4	4.2	4.2	100.0	17.8	0.0	0.0	1.0	1.0	100.0	103.9	0.0
20:00	0.0	3.5	3.5	100.0	14.3	0.0	0.0	1.0	1.0	100.0	103.0	0.0
21:00	0.0	3.3	3.3	100.0	11.0	0.0	0.0	1.0	1.0	100.0	102.0	0.0
22:00	0.0	3.4	3.4	100.0	7.6	0.0	0.0	1.0	1.0	100.0	101.0	0.0
23:00	0.0	2.6	2.6	100.0	5.0	0.0	0.0	1.0	1.0	100.0	100.0	0.0
24:00	0.0	1.2	1.2	100.0	3.9	0.0	0.0	1.0	1.0	100.0	99.1	0.0
	62.5	54.1	53.4	98.7		10.1	88.8	17.5	17.5	100.0		71.3

Table 2.1.48(e)
(All units are kWh)

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR - 31 JAN 77, 03:36:47 PM, 4154269 TEEFS

JUN 21	ELECTRICAL						THERMAL					
	INPUT	LOAD	OUTPUT	%LOAD	STCRD	WASTE	INPUT	LOAD	OUTPUT	%LOAD	STCRD	WASTE
1:00	0.0	2.4	2.4	100.0	1.4	0.0	0.0	0.0	0.0	100.0	99.1	0.0
2:00	0.0	0.3	0.3	100.0	1.1	0.0	0.0	0.0	0.0	100.0	99.1	0.0
3:00	0.0	1.1	1.1	100.0	0.0	0.0	0.0	0.0	0.0	100.0	99.1	0.0
4:00	0.0	0.9	0.0	1.8	0.0	0.0	0.0	0.0	0.0	100.0	99.1	0.0
5:00	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	99.1	0.0
6:00	1.6	2.1	1.6	76.8	0.0	0.0	1.3	0.0	0.0	100.0	100.4	0.0
7:00	1.6	2.0	1.6	81.3	0.0	0.0	1.3	1.0	1.0	100.0	100.8	0.0
8:00	1.6	1.6	1.6	100.0	0.1	0.0	1.4	1.0	1.0	100.0	101.2	0.0
9:00	1.7	1.6	1.6	100.0	0.2	0.0	1.5	1.0	1.0	100.0	101.7	0.0
10:00	2.4	1.6	1.6	100.0	0.9	0.0	2.6	1.0	1.0	100.0	103.3	0.0
11:00	4.0	1.6	1.6	100.0	3.3	0.0	5.7	1.0	1.0	100.0	105.0	3.0
12:00	6.8	1.8	1.8	100.0	8.3	0.0	11.4	1.0	1.0	100.0	105.0	10.4
13:00	7.6	1.6	1.6	100.0	14.3	0.0	12.6	1.0	1.0	100.0	105.0	11.7
14:00	6.9	2.5	2.5	100.0	18.6	0.0	11.2	1.0	1.0	100.0	105.0	10.2
15:00	5.9	3.0	3.0	100.0	21.5	0.0	8.4	1.0	1.0	100.0	105.0	7.4
16:00	4.4	3.8	3.8	100.0	22.1	0.0	5.0	1.0	1.0	100.0	105.0	4.0
17:00	2.8	3.6	3.6	100.0	21.3	0.0	2.0	1.0	1.0	100.0	105.0	1.0
18:00	1.6	4.3	4.3	100.0	18.6	0.0	0.9	1.0	1.0	100.0	105.0	0.0
19:00	0.4	4.2	4.2	100.0	14.9	0.0	0.1	1.0	1.0	100.0	104.1	0.0
20:00	0.0	3.5	3.5	100.0	11.3	0.0	0.0	1.0	1.0	100.0	103.1	0.0
21:00	0.0	3.3	3.3	100.0	8.1	0.0	0.0	1.0	1.0	100.0	102.2	0.0
22:00	0.0	3.4	3.4	100.0	4.7	0.0	0.0	1.0	1.0	100.0	101.2	0.0
23:00	0.0	2.6	2.6	100.0	2.1	0.0	0.0	1.0	1.0	100.0	100.2	0.0
24:00	0.0	1.2	1.2	100.0	0.9	0.0	0.0	1.0	1.0	100.0	99.2	0.0
	49.3	55.1	52.3	94.9		0.0	65.3	17.5	17.5	100.0		47.7

Table 2.1.48(f)
(All units are kWh)

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR - 31 JAN 77, 03:40:00 PM, 4154269 TEEFS

JUN 22	ELECTRICAL						THERMAL					
	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE
1:00	0.0	2.0	0.9	45.2	0.0	0.0	0.0	0.0	0.0	100.0	99.2	0.0
2:00	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	99.2	0.0
3:00	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	99.2	0.0
4:00	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	99.2	0.0
5:00	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	99.2	0.0
6:00	1.6	1.8	1.6	92.2	0.0	0.0	1.3	0.0	0.0	100.0	100.5	0.0
7:00	1.5	1.8	1.5	85.9	0.0	0.0	1.1	1.0	1.0	100.0	100.6	0.0
8:00	1.8	1.3	1.3	100.0	0.5	0.0	1.5	1.0	1.0	100.0	101.1	0.0
9:00	2.4	1.5	1.5	100.0	1.4	0.0	2.5	1.0	1.0	100.0	102.6	0.0
10:00	3.9	2.2	2.2	100.0	3.1	0.0	5.2	1.0	1.0	100.0	105.0	1.8
11:00	6.4	2.0	2.0	100.0	7.5	0.0	10.3	1.0	1.0	100.0	105.0	9.4
12:00	7.7	1.7	1.7	100.0	13.6	0.0	13.3	1.0	1.0	100.0	105.0	12.4
13:00	8.4	2.1	2.1	100.0	19.9	0.0	14.4	1.0	1.0	100.0	105.0	13.4
14:00	6.7	2.3	2.3	100.0	24.4	0.0	11.0	1.0	1.0	100.0	105.0	10.0
15:00	5.7	3.0	3.0	100.0	25.0	2.1	8.2	1.0	1.0	100.0	105.0	7.3
16:00	4.4	3.6	3.6	100.0	25.0	0.8	5.0	1.0	1.0	100.0	105.0	4.0
17:00	2.5	4.0	4.0	100.0	23.5	0.0	1.9	1.0	1.0	100.0	105.0	0.9
18:00	1.4	4.5	4.5	100.0	20.4	0.0	0.9	1.0	1.0	100.0	104.9	0.0
19:00	0.4	4.2	4.2	100.0	16.6	0.0	0.1	1.0	1.0	100.0	104.0	0.0
20:00	0.0	3.9	3.9	100.0	12.6	0.0	0.0	1.0	1.0	100.0	103.0	0.0
21:00	0.0	3.1	3.1	100.0	9.5	0.0	0.0	1.0	1.0	100.0	102.1	0.0
22:00	0.0	2.8	2.8	100.0	6.7	0.0	0.0	1.0	1.0	100.0	101.1	0.0
23:00	0.0	2.6	2.6	100.0	4.1	0.0	0.0	1.0	1.0	100.0	100.1	0.0
24:00	0.0	1.1	1.1	100.0	3.0	0.0	0.0	1.0	1.0	100.0	99.2	0.0
	55.0	54.0	50.1	92.6		2.9	76.5	17.5	17.5	100.0		59.1

Table 2.1.48(g)
(All units are kWh)

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR - 31 JAN 77, 03:43:23 PM, 4154269 TEEFS

SEP 22	ELECTRICAL						THERMAL					
	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE
1:00	0.0	2.1	2.1	100.0	0.3	0.0	0.0	0.0	0.0	100.0	98.2	0.0
2:00	0.0	0.4	0.3	94.6	0.0	0.0	0.0	0.0	0.0	100.0	98.2	0.0
3:00	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	98.2	0.0
4:00	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	98.2	0.0
5:00	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	98.2	0.0
6:00	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	98.2	0.0
7:00	1.7	2.0	1.7	81.1	0.0	0.0	1.3	1.0	1.0	100.0	98.5	0.0
8:00	1.5	1.7	1.5	88.8	0.0	0.0	1.1	1.0	1.0	100.0	98.7	0.0
9:00	1.4	1.8	1.4	78.0	0.0	0.0	1.0	1.0	1.0	100.0	98.7	0.0
10:00	1.3	1.8	1.3	72.8	0.0	0.0	1.0	1.0	1.0	100.0	98.7	0.0
11:00	1.7	2.0	1.7	85.5	0.0	0.0	1.7	1.0	1.0	100.0	99.5	0.0
12:00	2.3	2.2	2.2	100.0	0.1	0.0	3.0	1.0	1.0	100.0	101.5	0.0
13:00	2.9	2.0	2.0	100.0	1.0	0.0	4.1	1.0	1.0	100.0	104.6	0.0
14:00	3.9	2.4	2.4	100.0	2.5	0.0	6.4	1.0	1.0	100.0	105.0	5.0
15:00	3.1	2.7	2.7	100.0	3.0	0.0	4.4	1.0	1.0	100.0	105.0	3.4
16:00	2.5	3.3	3.3	100.0	2.2	0.0	3.0	1.0	1.0	100.0	105.0	2.0
17:00	1.3	3.2	3.2	100.0	0.3	0.0	0.9	1.0	1.0	100.0	104.9	0.0
18:00	0.0	3.1	0.3	9.7	0.0	0.0	0.0	1.0	1.0	100.0	104.0	0.0
19:00	0.0	3.2	0.0	0.0	0.0	0.0	0.0	1.0	1.0	100.0	103.0	0.0
20:00	0.0	2.7	0.0	0.0	0.0	0.0	0.0	1.0	1.0	100.0	102.0	0.0
21:00	0.0	2.5	0.0	0.0	0.0	0.0	0.0	1.0	1.0	100.0	101.1	0.0
22:00	0.0	2.3	0.0	0.0	0.0	0.0	0.0	1.0	1.0	100.0	100.1	0.0
23:00	0.0	2.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	100.0	99.1	0.0
24:00	0.0	0.4	0.0	0.0	0.0	0.0	0.0	1.0	1.0	100.0	98.1	0.0
	23.6	48.3	26.0	53.9		0.0	27.9	17.5	17.5	100.0		10.5

Table 2.1.48(h)
(All units are kWh)

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR - 31 JAN 77, 03:46:27 PM, 4154269 TEEPS

335

SEP 23	ELECTRICAL						THERMAL					
	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE
1:00	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	98.1	0.0
2:00	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	98.1	0.0
3:00	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	98.1	0.0
4:00	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	98.1	0.0
5:00	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	98.1	0.0
6:00	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	98.1	0.0
7:00	1.7	0.7	0.7	100.0	1.0	0.0	1.2	1.0	1.0	100.0	98.3	0.0
8:00	1.5	0.7	0.7	100.0	1.7	0.0	1.0	1.0	1.0	100.0	98.3	0.0
9:00	2.1	0.7	0.7	100.0	3.1	0.0	2.1	1.0	1.0	100.0	99.5	0.0
10:00	3.7	1.2	1.2	100.0	5.6	0.0	5.6	1.0	1.0	100.0	104.1	0.0
11:00	6.2	1.4	1.4	100.0	10.4	0.0	11.7	1.0	1.0	100.0	105.0	9.8
12:00	9.1	1.5	1.5	100.0	18.0	0.0	19.1	1.0	1.0	100.0	105.0	18.2
13:00	8.6	1.6	1.6	100.0	25.0	0.0	17.9	1.0	1.0	100.0	105.0	16.9
14:00	7.5	1.9	1.9	100.0	25.0	5.6	14.7	1.0	1.0	100.0	105.0	13.7
15:00	5.8	2.2	2.2	100.0	25.0	3.5	10.1	1.0	1.0	100.0	105.0	9.1
16:00	3.5	3.0	3.0	100.0	25.0	0.5	4.7	1.0	1.0	100.0	105.0	3.8
17:00	1.4	2.9	2.9	100.0	23.5	0.0	0.9	1.0	1.0	100.0	104.9	0.0
18:00	0.0	2.9	2.9	100.0	20.6	0.0	0.0	1.0	1.0	100.0	103.9	0.0
19:00	0.0	3.1	3.1	100.0	17.5	0.0	0.0	1.0	1.0	100.0	103.0	0.0
20:00	0.0	2.6	2.6	100.0	14.9	0.0	0.0	1.0	1.0	100.0	102.0	0.0
21:00	0.0	2.4	2.4	100.0	12.5	0.0	0.0	1.0	1.0	100.0	101.0	0.0
22:00	0.0	2.1	2.1	100.0	10.4	0.0	0.0	1.0	1.0	100.0	100.1	0.0
23:00	0.0	1.9	1.9	100.0	8.6	0.0	0.0	1.0	1.0	100.0	99.1	0.0
24:00	0.0	0.6	0.6	100.0	8.0	0.0	0.0	1.0	1.0	100.0	98.1	0.0
	51.0	35.9	33.5	93.1		9.6	89.0	17.5	17.5	100.0		71.5

Table 2.1.48(i)
(All units are kwh)

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR -- 31 JAN 77, 03:49:32 PM, 4154269 TEEES

SEP 24	ELECTRICAL						THERMAL					
	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE
1:00	0.0	0.4	0.4	100.0	7.6	0.0	0.0	0.0	0.0	100.0	98.1	0.0
2:00	0.0	0.4	0.4	100.0	7.3	0.0	0.0	0.0	0.0	100.0	98.1	0.0
3:00	0.0	0.4	0.4	100.0	6.9	0.0	0.0	0.0	0.0	100.0	98.1	0.0
4:00	0.0	0.4	0.4	100.0	6.5	0.0	0.0	0.0	0.0	100.0	98.1	0.0
5:00	0.0	0.4	0.4	100.0	6.2	0.0	0.0	0.0	0.0	100.0	98.1	0.0
6:00	0.0	0.7	0.7	100.0	5.5	0.0	0.0	0.0	0.0	100.0	98.1	0.0
7:00	0.9	0.7	0.7	100.0	5.7	0.0	0.2	1.0	1.0	100.0	97.4	0.0
8:00	1.3	0.7	0.7	100.0	6.2	0.0	0.7	1.0	1.0	100.0	97.1	0.0
9:00	2.4	0.7	0.7	100.0	7.9	0.0	2.7	1.0	1.0	100.0	98.9	0.0
10:00	5.4	0.8	0.8	100.0	12.5	0.0	9.4	1.0	1.0	100.0	105.0	2.3
11:00	8.7	0.8	0.8	100.0	20.3	0.0	17.7	1.0	1.0	100.0	105.0	16.7
12:00	8.8	1.4	1.4	100.0	25.0	2.8	18.5	1.0	1.0	100.0	105.0	17.6
13:00	8.5	1.5	1.5	100.0	25.0	7.0	17.4	1.0	1.0	100.0	105.0	16.5
14:00	7.4	1.8	1.8	100.0	25.0	5.5	14.4	1.0	1.0	100.0	105.0	13.5
15:00	5.7	2.3	2.3	100.0	25.0	3.4	10.0	1.0	1.0	100.0	105.0	9.0
16:00	3.5	3.0	3.0	100.0	25.0	0.5	4.8	1.0	1.0	100.0	105.0	3.8
17:00	1.4	2.9	2.9	100.0	23.5	0.0	1.0	1.0	1.0	100.0	105.0	0.0
18:00	0.0	3.0	3.0	100.0	20.5	0.0	0.0	1.0	1.0	100.0	104.0	0.0
19:00	0.0	3.1	3.1	100.0	17.4	0.0	0.0	1.0	1.0	100.0	103.1	0.0
20:00	0.0	2.7	2.7	100.0	14.7	0.0	0.0	1.0	1.0	100.0	102.1	0.0
21:00	0.0	2.5	2.5	100.0	12.3	0.0	0.0	1.0	1.0	100.0	101.1	0.0
22:00	0.0	2.2	2.2	100.0	10.1	0.0	0.0	1.0	1.0	100.0	100.1	0.0
23:00	0.0	2.0	2.0	100.0	8.1	0.0	0.0	1.0	1.0	100.0	99.2	0.0
24:00	0.0	0.7	0.7	100.0	7.3	0.0	0.0	1.0	1.0	100.0	98.2	0.0
	54.0	35.3	35.3	100.0		19.2	97.0	17.5	17.5	100.0		79.4

Table 2.1.48(j)
(All units are kWh)

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR - 31 JAN 77, 03:53:00 PM, 4154269 TEEPS

DEC 20	ELECTRICAL						THERMAL					
	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE
1:00	0.0	0.4	0.4	100.0	14.5	0.0	0.0	2.3	2.3	100.0	56.4	0.0
2:00	0.0	0.4	0.4	100.0	14.1	0.0	0.0	2.7	2.7	100.0	53.7	0.0
3:00	0.0	0.4	0.4	100.0	13.6	0.0	0.0	3.4	3.4	100.0	50.3	0.0
4:00	0.0	0.4	0.4	100.0	13.2	0.0	0.0	3.8	3.8	100.0	46.5	0.0
5:00	0.0	0.4	0.4	100.0	12.8	0.0	0.0	4.0	4.0	100.0	42.5	0.0
6:00	0.0	0.9	0.9	100.0	11.9	0.0	0.0	3.7	3.7	100.0	38.8	0.0
7:00	0.0	0.9	0.9	100.0	11.0	0.0	0.0	3.9	3.9	100.0	34.8	0.0
8:00	0.0	0.9	0.9	100.0	11.0	0.0	0.2	4.5	4.5	100.0	30.5	0.0
9:00	2.2	0.9	0.9	100.0	12.3	0.0	2.5	5.6	5.6	100.0	27.5	0.0
10:00	3.6	1.0	1.0	100.0	14.9	0.0	5.3	5.4	5.4	100.0	27.4	0.0
11:00	5.0	1.0	1.0	100.0	18.9	0.0	8.8	4.8	4.8	100.0	31.4	0.0
12:00	6.2	1.0	1.0	100.0	24.1	0.0	12.1	4.2	4.2	100.0	39.3	0.0
13:00	6.8	1.0	1.0	100.0	25.0	0.0	15.1	3.9	3.9	100.0	55.5	0.0
14:00	4.9	1.0	1.0	100.0	25.0	0.0	9.6	3.2	3.2	100.0	65.8	0.0
15:00	3.4	1.0	1.0	100.0	25.0	0.0	5.9	2.6	2.6	100.0	71.5	0.0
16:00	1.3	1.4	1.4	100.0	25.0	0.0	1.6	2.6	2.6	100.0	70.5	0.0
17:00	0.0	1.4	1.4	100.0	23.6	0.0	0.0	2.6	2.6	100.0	68.0	0.0
18:00	0.0	1.4	1.4	100.0	22.2	0.0	0.0	2.8	2.8	100.0	65.2	0.0
19:00	0.0	1.4	1.4	100.0	20.9	0.0	0.0	2.6	2.6	100.0	62.6	0.0
20:00	0.0	1.4	1.4	100.0	19.5	0.0	0.0	2.7	2.7	100.0	59.9	0.0
21:00	0.0	1.4	1.4	100.0	18.1	0.0	0.0	2.8	2.8	100.0	57.1	0.0
22:00	0.0	1.4	1.4	100.0	16.7	0.0	0.0	3.1	3.1	100.0	53.9	0.0
23:00	0.0	1.4	1.4	100.0	15.4	0.0	0.0	3.6	3.6	100.0	50.3	0.0
24:00	0.0	0.4	0.4	100.0	14.9	0.0	0.0	2.8	2.8	100.0	47.6	0.0
	34.3	23.0	23.0	100.0		0.0	61.2	83.7	83.7	100.0		0.0

Table 2.1.48(k)
(All units are kWh)

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR - 31 JAN 77; 03:56:44 PM, 4154269 TEEPS

DEC 21	ELECTRICAL						THERMAL					
	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE
1:00	0.0	0.4	0.4	100.0	14.5	0.0	0.0	3.0	3.0	100.0	44.6	0.0
2:00	0.0	0.4	0.4	100.0	14.1	0.0	0.0	3.4	3.4	100.0	41.3	0.0
3:00	0.0	0.4	0.4	100.0	13.6	0.0	0.0	2.8	2.8	100.0	38.5	0.0
4:00	0.0	0.4	0.4	100.0	13.2	0.0	0.0	4.2	4.2	100.0	34.3	0.0
5:00	0.0	0.4	0.4	100.0	12.7	0.0	0.0	5.5	5.5	100.0	28.8	0.0
6:00	0.0	0.9	0.9	100.0	11.9	0.0	0.0	6.2	6.2	100.0	22.7	0.0
7:00	0.0	0.9	0.9	100.0	11.0	0.0	0.0	6.5	6.5	100.0	16.2	0.0
8:00	0.5	0.9	0.9	100.0	10.6	0.0	0.0	8.1	8.1	100.0	8.1	0.0
9:00	2.5	0.9	0.9	100.0	12.3	0.0	2.9	8.5	8.5	100.0	2.5	0.0
10:00	3.7	1.0	1.0	100.0	14.6	0.0	5.3	8.7	8.7	100.0	0.0	0.0
11:00	4.4	1.0	1.0	100.0	17.1	0.0	6.8	8.7	8.7	100.0	0.0	0.0
12:00	4.6	1.0	1.0	100.0	20.2	0.0	7.5	9.0	9.0	100.0	0.0	0.0
13:00	6.1	1.0	1.0	100.0	25.0	0.0	12.2	8.2	8.2	100.0	4.3	0.0
14:00	5.2	1.0	1.0	100.0	25.0	0.0	9.8	8.3	8.3	100.0	10.1	0.0
15:00	4.1	1.0	1.0	100.0	25.0	0.0	7.2	8.1	8.1	100.0	12.4	0.0
16:00	1.8	1.4	1.4	100.0	25.0	0.0	2.1	7.0	7.0	100.0	7.8	0.0
17:00	0.0	1.4	1.4	100.0	23.6	0.0	0.0	8.0	7.8	97.7	0.0	0.0
18:00	0.0	1.4	1.4	100.0	22.3	0.0	0.0	9.1	0.0	0.0	0.0	0.0
19:00	0.0	1.4	1.4	100.0	20.9	0.0	0.0	8.3	0.0	0.0	0.0	0.0
20:00	0.0	1.4	1.4	100.0	19.5	0.0	0.0	9.0	0.0	0.0	0.0	0.0
21:00	0.0	1.4	1.4	100.0	18.2	0.0	0.0	8.6	0.0	0.0	0.0	0.0
22:00	0.0	1.4	1.4	100.0	16.8	0.0	0.0	8.5	0.0	0.0	0.0	0.0
23:00	0.0	1.4	1.4	100.0	15.4	0.0	0.0	10.1	0.0	0.0	0.0	0.0
24:00	0.0	0.4	0.4	100.0	15.0	0.0	0.0	9.9	0.0	0.0	0.0	0.0
	33.0	23.0	23.0	100.0		0.0	53.8	177.3	113.7	64.1		0.0

Table 2.1.48(1)
(All units are kWh)

PVEPS - THERMAL-ELECTRIC ENERGY FLOW SIMULATION - TIME STEP 1 HR - 31 JAN 77, 04:00:11 PM, 4154269 TEEFS

DEC 22	ELECTRICAL						THERMAL					
	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE	INPUT	LOAD	OUTPUT	•/•LOAD	STORED	WASTE
1:00	0.0	0.4	0.4	100.0	14.5	0.0	0.0	9.2	0.0	0.0	0.0	0.0
2:00	0.0	0.4	0.4	100.0	14.1	0.0	0.0	9.6	0.0	0.0	0.0	0.0
3:00	0.0	0.4	0.4	100.0	13.6	0.0	0.0	10.4	0.0	0.0	0.0	0.0
4:00	0.0	0.4	0.4	100.0	13.2	0.0	0.0	10.1	0.0	0.0	0.0	0.0
5:00	0.0	0.4	0.4	100.0	12.8	0.0	0.0	9.8	0.0	0.0	0.0	0.0
6:00	0.0	0.9	0.9	100.0	11.9	0.0	0.0	9.6	0.0	0.0	0.0	0.0
7:00	0.0	0.9	0.9	100.0	11.0	0.0	0.0	9.3	0.0	0.0	0.0	0.0
8:00	0.7	0.9	0.9	100.0	10.8	0.0	0.0	9.7	0.0	0.0	0.0	0.0
9:00	1.7	0.9	0.9	100.0	10.8	0.0	0.9	9.6	2.8	29.3	0.0	0.0
10:00	3.1	1.0	1.0	100.0	11.1	0.0	3.7	7.9	7.9	100.0	0.0	0.0
11:00	6.9	1.0	1.0	100.0	17.0	0.0	13.5	9.6	9.6	100.0	3.9	0.0
12:00	7.4	1.0	1.0	100.0	23.4	0.0	14.9	8.3	8.3	100.0	10.5	0.0
13:00	7.1	1.0	1.0	100.0	25.0	0.0	14.4	7.9	7.9	100.0	21.6	0.0
14:00	6.0	1.0	1.0	100.0	25.0	0.0	11.6	8.8	8.8	100.0	29.4	0.0
15:00	4.2	1.0	1.0	100.0	25.0	0.0	7.2	6.6	6.6	100.0	33.2	0.0
16:00	1.8	1.4	1.4	100.0	25.0	0.0	2.1	6.0	6.0	100.0	29.7	0.0
17:00	0.0	1.4	1.4	100.0	23.6	0.0	0.0	7.1	7.1	100.0	22.5	0.0
18:00	0.0	1.4	1.4	100.0	22.3	0.0	0.0	7.0	7.0	100.0	15.5	0.0
19:00	0.0	1.4	1.4	100.0	20.9	0.0	0.0	7.1	7.1	100.0	8.4	0.0
20:00	0.0	1.4	1.4	100.0	19.5	0.0	0.0	6.4	6.4	100.0	2.0	0.0
21:00	0.0	1.4	1.4	100.0	18.2	0.0	0.0	6.9	2.0	28.9	0.0	0.0
22:00	0.0	1.4	1.4	100.0	16.8	0.0	0.0	7.2	0.0	0.0	0.0	0.0
23:00	0.0	1.4	1.4	100.0	15.4	0.0	0.0	7.3	0.0	0.0	0.0	0.0
24:00	0.0	0.4	0.4	100.0	15.0	0.0	0.0	6.8	0.0	0.0	0.0	0.0
	38.9	23.0	23.0	100.0		0.0	68.3	198.3	87.6	44.2		0.0

3 FEB 76 - 01:29:40 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.

CLEVELAND, OHIO - 1962 - CASE 1

A INSOLATION DATA - NOMINAL LOAD 2 - A/C LOAD COMPUTED - TIME STEP = 1 DAY

LOAD PROVIDED BY STORAGE

Figure 2.1.47(a)

3 FEB 76 - 01:35:17 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1

CLEVELAND, OHIO - 1962 - CASE 2

A INSOLATION DATA - NOMINAL LOAD 2 - A/C LOAD COMPUTED - TIME STEP = 1 DAY

LOAD PROVIDED BY STORAGE

Figure 2.1.47(b)

3 FEB 76 - 01:43:07 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1

CLEVELAND, OHIO - 1962 - CASE 3A

A INSOLATION DATA - NOMINAL LOAD 2 - A/C LOAD COMPUTED - TIME STEP = 1 DAY
LOAD PROVIDED BY STORAGE

Figure 2.1.47(c)

3 FEB 76 - 01:51:54 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1

CLEVELAND, OHIO - 1962 - CASE 3B

A INSOLATION DATA - NOMINAL LOAD 2 - A/C LOAD COMPUTED - TIME STEP = 1 DAY

LOAD PROVIDED BY STORAGE

Figure 2.1.47(d)

2 FEB 76 - 02:47:24 PM

EVEPS - ENERGY FLOW SIMULATIONS - V3.1-

PHOENIX, ARIZONA - 1962 - CASE 1

A INSOLATION DATA - NOMINAL LOAD 2 - A/C LOAD COMPUTED - TIME STEP = 1 DAY

LOAD PROVIDED BY STORAGE

Figure 2.1.48(a)

2 FEB 76 - 03:10:40 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1

PHOENIX, ARIZONA - 1962 - CASE 2

A INSOLATION DATA - NOMINAL LOAD 2 - A/C LOAD COMPUTED - TIME STEP = 1 DAY

LOAD PROVIDED BY STORAGE

Figure 2.1.48(b)

2 FEB 76 - 03:25:59 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1

PHOENIX, ARIZONA - 1962 - CASE 3A

A INSOLATION DATA - NOMINAL LOAD 2 - A/C LOAD COMPUTED - TIME STEP = 1 DAY

LOAD PROVIDED BY STORAGE

Figure 2.1.48(c)

2 FEB 76 - 03:35:29 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1

PHOENIX, ARIZONA - 1962 - CASE 3B

A INSOLATION DATA - NOMINAL LOAD 2 - A/C LOAD COMPUTED - TIME STEP = 1 DAY

LOAD PROVIDED BY STORAGE

Figure 2.1.48(d)

20 MAY 76 ~ 12:27:29 PM

PVEPS ~ ENERGY FLOW SIMULATIONS ~ V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA ~ 1960 ~ CASE 1

CSU INSOLATION DATA (M1) ~ NOMINAL LOAD 2

Figure 2.1.49(a)

20 MAY 76 - 12:46:54 PM

PVEPS * ENERGY FLOW SIMULATIONS * V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 * CASE 2

CSU INSOLATION DATA (M1) - NOMINAL LOAD 2

Figure 2.1.49(b)

20 MAY 76 - 12:56:45 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA - 1960 - CASE 3A

CSU INSOLATION DATA (M1) - NOMINAL LOAD 2 - CSU A/C DATA

Figure 2.1.49(c)

20 MAY 76 * 01:02:17 PM

PVEPS * ENERGY FLOW SIMULATIONS * V3.1 (TIME STEP = 1 DAY)

ATLANTA, GEORGIA * 1960 * CASE 3B

CSU INSOLATION DATA (M1) * NOMINAL LOAD 2 * CSU A/C DATA

Figure 2.1.49(d)

2 FEB 76 - 07:48:18 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1

MADISON, WISCONSIN - CASE 1

W INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATA - TIME STEP = 1 DAY

LOAD PROVIDED BY STORAGE

Figure 2.1.50(a)

2 FEB 76 - 07:56:51 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1

MADISON, WISCONSIN - CASE 2

INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA - TIME STEP = 1 DAY

LOAD PROVIDED BY STORAGE

Figure 2.1.50(b)

2 FEB 76 - 08:01:24 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1

MADISON, WISCONSIN - CASE 3A

INSOLATION DATA - NOMINAL LOAD 2 - W A/C DATA - TIME STEP = 1 DAY

LOAD PROVIDED BY STORAGE

Figure 2.1.50(c)

2 FEB 76 - 08:07:16 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1

MADISON, WISCONSIN - CASE 3B

INSOLATION DATA - NOMINAL LOAD 2 - A/C DATA - TIME STEP = 1 DAY

LOAD PROVIDED BY STORAGE

Figure 2.1.50(d)

3 SEP 76 - 02:46:05 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 1

INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.51(a)

3 SEP 76 - 02:52:06 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 2

INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.51(b)

7 SEP 76 - 11:30:01 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 3A

W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

LOAD PROVIDED BY STORAGE

Figure 2.1.51(c)

7 SEP 76 ~ 11:37:02 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

MOBILE, ALABAMA - 1963 - CASE 3B

W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

Figure 2.1.51(d)

19 MAR 76 - 05:04:10 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 1

INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.52(a)

19 MAR 76 - 05:10:20 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 2

INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.52(b)

19 MAR 76 - 05:17:00 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3A

INSOLATION DATA (S1) - NOMINAL LOAD 2 - A/C DATA

LOAD PROVIDED BY STORAGE

Figure 2.1.52(c)

19 MAR 76 - 05:27:04 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

SANTA MARIA, CALIF. - 1957 - CASE 3B

INSOLATION DATA (S1) - NOMINAL LOAD 2 - A/C DATA

Figure 2.1.52(d)

20 MAY 76 - 11:49:06 AM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 1

INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.53(a)

20 MAY 76 - 12:04:05 PM

PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 2

INSOLATION DATA (S1) - NOMINAL LOAD 2

Figure 2.1.53(b)

20 MAY 76 - 12:12:11 PM

FVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 3A

INSOLATION DATA (S1) - NOMINAL LOAD 2 - A/C DATA

Figure 2.1.53(c)

20 MAY 76 - 12:21:18 PM

FVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

WILMINGTON, DEL. - 1958 - CASE 3B

W INSOLATION DATA (S1) - NOMINAL LOAD 2 - W A/C DATA

Figure 2.1.53(d)

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2.2 IPS Computer Simulation

The electrical output of the solar cell alone was simulated for a full year using hourly weather data. From these simulations, the peak power and annual energy per unit area were obtained for all array/module combinations considered. Using this data and data regarding the performance of the power conditioning and battery subsystems, overall system performance was obtained without the need for an hourly simulation of the entire system.

The solar cell array/module simulations are described in Section 2.4 of this volume.

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2.3 CPS Computer Simulation

The electrical output of the solar cell alone was simulated for a full year using hourly weather data. From these simulations, the peak power and annual energy per unit area were obtained for all array/module combinations considered. By combining this data with data regarding the performance of the power conditioning subsystem, overall system performance was obtained without the need for an hourly simulation of the entire system.

The overall cell array/module simulations are described in Section 2.4 of this volume.

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2.4 Array Comparative Performance

Martin Wolf and Thomas G. Wolf
University of Pennsylvania

The original plan foresaw utilization of the pre-existing photovoltaic system program in its entirety, including studies of the interaction between the independent statistics of solar radiation availability (diurnal variation and meteorology) and of electric power demand. However, the development of the project led to studies involving the program only to the solar cell output level, that is through subprogram SOCOUT. These studies were directed primarily towards parametric evaluation of the effectiveness of various tracking and optical concentrating methods in photovoltaic conversion systems. The following paragraphs will therefore concentrate on a description of those parts of the program which were utilized in this project.

2.4.1 The U of P Solar Photovoltaic System Simulation Program

A photovoltaic solar energy conversion system, either central or on-site, including electrical energy storage and an auxiliary energy system interface, is complex and difficult to analyze. Also, the relationships determining the performance of some of the individual subsystems and components are complicated, so that evaluations can be performed only in either a very rough approximation or by computer. The task has therefore been undertaken to construct a complete, detailed computer model of the entire photovoltaic system.

To make such a model most useful, it is best structured by individual subprograms, where each subprogram represents one of the subsystems of the entire system, or a functional portion of such a subsystem. The main program then merely controls the routing through the available subsystems. Such a program structure permits the relatively easy replacement of any one subsystem by one of a different design. A properly designed main program provides the flexibility to analyze any portion or

all of the system, and the interactions of the subsystems. Any quantity which may be varied in design or operation should be accessible as a program variable. Since any adequately large computer provides ready capability for exact solutions or high order approximations by numerical methods, rough approximations which could lead to early obsolescence of the program, can readily be avoided. These guidelines have been carefully observed in the evolution of the U of P photovoltaic solar energy system program.

The important aspects under which the algorithms for such a system analysis program for terrestrial solar energy utilization by photovoltaic conversion have been developed, are:

- a. The input intensity and the spectral distribution vary randomly.
- b. The input radiation contains both collimated and scattered components.
- c. Array temperature is, in most cases, determined by the ambient air temperature and the radiative energy flux to the array.
- d. Since the solar cell spectral response varies with temperature, and since the incident spectral distribution varies with time, a simple temperature correction on light generated current is generally not adequate.

Further key features of the simulation program are:

- a. As far as practical, the simulation is based on a full description of established underlying phenomena. This includes the atmospheric modification of the solar spectral distribution, the spectral response and the current-voltage characteristic of the solar cells, the characteristic of storage batteries, etc.

- b. Summary experience factors such as the "packing factor" for solar cells on the array, the "assembly loss" factor (array output relative to sum of individual cell outputs), etc., are included.
- c. Various operating modes are provided, such as resistive loads, constant voltage operation as incurred with battery buffer, or maximum power point tracking.
- d. The system can be operated as single runs or for simulated continuous operation over extended time periods at selectable intervals as short as 10 min, using the load and solar input data provided for each time interval.
- e. The system can operate off available Weather Bureau tapes with hourly insolation data.
- f. For a given array area, design voltage, and minimum acceptable cell voltage; the numbers of cells to be series connected and parallel connected in the array are determined.
- g. Outputs of energy used, of energy delivered by solar array and by auxiliary supply, change in battery storage and total charge stored are provided for each time interval and as period totals; most intermediate results are available on special command.
- h. Outputs can be tabulated and plotted.

Figure 1 shows a generalized block diagram of the main program controlling the information flow through the most important subprograms.

2.4.2 The Solar Energy Input Subprograms.

An important part of the program is the evaluation of the incident radiation (Fig. 2). The program operates in local standard time or solar time, with internal conversion to local solar time in the first case. From this, the incidence angle on the horizontal and on an arbitrarily oriented surface, the azimuth

Fig. 1 Simplified flow chart for main program logic with subroutine calls.

Fig. 2 Simplified flow chart for the computations of times, angles, direct and indirect insolation, atmospheric transmittance and sunlight spectral distribution in subprograms CALNDR, SOLANG, IWH, ABSATM, and INDRAD.

angles on both surfaces, and sunrise and sunset on both surfaces are determined in subprogram SOLANG, using latitude, surface tilt and rotation angles, together with the solar declination, which is either computed from the calendar date or inputted directly.

Since the spectral response of photovoltaic converters is far from constant over the major portion of the solar spectrum, and since the solar spectral irradiance is a function of meteorological conditions and air mass, use of summary data such as insolation, total absorptivity, or average spectral response is not adequate for analyzing these systems. It is thus necessary to determine the spectral irradiance for the time interval of each performance evaluation.

The direct irradiance on the horizontal or the arbitrary surface can be determined from the extraterrestrial radiation by use of the Bouguer relationship with the appropriate air mass value and atmospheric pressure.

The Bouguer relationship describes the combined spectral transmission factor τ_λ of the atmosphere in terms of the spectral transmissivities due to scattering by the air molecules (Rayleigh scattering) $\tau_{a\lambda}$, by water molecules $\tau_{w\lambda}$, and by dust particles or other aerosols $\tau_{d\lambda}$, and due to absorption by ozone $\tau_{o\lambda}$ and by water vapor $\tau_{wa\lambda}$ according to:

$$\tau_\lambda = [\tau_{a\lambda}^{\frac{p}{760}} \tau_{w\lambda}^{\frac{w}{20}} \tau_{d\lambda}^{\frac{d}{800}} \tau_{o\lambda}^{\frac{o}{3.8}} \tau_{wa\lambda}^{\frac{w}{20}}]^M \quad (1)$$

where p = average atmospheric pressure at altitude of array location, in Torr.

w = precipitable water content of a column (over unit area) through the entire atmosphere, expressed by the height of the precipitated water column in mm.

d = dust or aerosol content of atmosphere expressed in particles per cm^3 .

o = ozone content of atmosphere, expressed as average partial pressure in Torr in entire atmospheric column.

M = airmass.

The transmissivities are normalized to 760 Torr pressure, 20 mm precipitable water, 800 dust particles per cm^3 , and 3.8 Torr partial pressure for ozone.

The absolute extraterrestrial radiation is stored in the program as absolute spectral distribution in 10 μm wavelength intervals according to NASA data ¹⁾. The determination of the earth surface solar irradiance (subprogram ABSATM) involves computation of the modification of the direct solar radiation by atmospheric absorption and scattering ²⁾, if the atmospheric constants, including dust content and precipitable water vapor, are known. Entering in addition either the fractional cloud cover or the total insolation, an estimate of the indirect irradiance can be made. While the spectral distribution of the direct radiation is provided by this method, no reliable method for the determination of the spectral and/or spatial distribution of the indirect radiation seems yet to exist.

Since the atmospheric constants are mostly not known, available insolation data have to be used as an alternate. Data for the total horizontal insolation at hourly intervals are available on the U.S. Weather Bureau "Solar Radiation, Hourly" magnetic tapes No. 280. These hourly solar radiation data are read from the Weather Bureau tape by subprogram WTH RTP and are split into the direct and indirect components of the irradiance by use of the Liu-Jordan relationship ⁴⁾

represented by:

$$H_{ind} = \frac{H_{tot, norm}}{M} \cdot \cos^2\left(\frac{\pi}{2} \frac{H_{tot, norm}}{HO_{norm}}\right) ; \text{ for } \frac{H_{tot, norm}}{HO_{norm}} \leq 0.75 \quad (2a)$$

$$H_{ind} = \frac{H_{tot, norm}}{M} \cdot 0.16; \quad \text{for } \frac{H_{tot, norm}}{HO_{norm}} > 0.75 \quad (2b)$$

where: H_{ind} is the total indirect (scatter) irradiance on the horizontal surface

$H_{tot, norm}$ the total irradiance, direct plus indirect, falling on a surface of zero incidence angle for the direct radiation

HO_{norm} the irradiance outside the earth's atmosphere on a surface normal to the incident light

M The airmass value.

The Liu-Jordan relationship has been derived for daily totals only, but is here applied to hourly data in the absence of a better method. Problems with this approach have been encountered only at high airmass values, where the total normal radiation flux (direct plus indirect) has occasionally reached excessively large values. In these cases, the total normal flux has been limited essentially to 85% of the extraterrestrial radiation, including 16% indirect radiation. Since the contribution at the high-airmass times to the total available solar energy is small, significant errors are not incurred by this approach.

The direct horizontal insolation is converted into an irradiance value normal to the beam by use of the angle of incidence on the horizontal surface, as determined in subprogram SOLANG. The total solar irradiance is then synthesized by simple superposition of the total indirect and the converted direct irradiance. The total insolation on the arbitrarily oriented collector is similarly obtained by use of the angle of incidence on this surface, which is also computed for each hour in subprogram SOLANG.

When more accurate evaluations are desired, including the variations of spectral response and spectral distribution, then the spectral distribution has to be synthesized from the basically insufficient total horizontal insolation data. In this case, the magnitude of the direct normal component of radiation is used to obtain the total precipitable water content of the atmosphere for a fixed ozone and dust content of 2.5 Torr and 300 cm^{-3} , respectively. The procedure used involves repeated determination and integration of the spectral distribution of the direct radiation with iteration of the precipitable water content, until a match of the calculated with the actual normal direct irradiance, the latter obtained from the horizontal insolation, is reached. Tentatively, the same spectral distribution is applied to the indirect radiation.

In a simplified approach, as used for the evaluation of the CdS cell performance, the spectral absorption in the atmosphere is not computed, bypassing the subprogram ABSATM.

2.4.3 Silicon Solar Cell Modeling

The silicon solar cell is represented in the program by its commonly used model for the pn-junction device:

$$j = j_0 \left[\exp\left(\frac{q(V - jR_s)}{AkT}\right) - 1 \right] - j_L \frac{A_L}{A_j} \quad [\text{A cm}^{-2}] \quad (3)$$

where j = terminal current density
 V = terminal voltage
 j_o = diode saturation current density
 j_L = light generated current density
 A = empirical adjustment factor ($A=1$ for 1985 and 2000 silicon solar cells).
 R_s = effective lumped series resistance based on unit junction area
 A_L = light exposed area
 A_j = junction area
 T = cell temperature
 q, k = physical constants (electronic charge, Boltzman constant)

Terminal voltage, maximum power point, open circuit voltage, power under given load conditions, etc. are all derived from this relationship. The quantities j_L and j_o are the determining quantities in this relationship, and they are computed in the program from first principles, using the detailed charge balance and the small signal approximations. The latter can be easily shown to be applicable up to optical concentration ratios near 1000. Both quantities are computed in subroutine COLEFF through similar algorithms. These algorithms are based on charge carrier transport by both diffusion and drift. They permit modeling of both the base and the diffused regions of the cell by up to 3 sublayers of differing material properties. This sublayer approach has been taken to obtain closed form solutions for the collection efficiency and the saturation current. These closed form solutions require constant coefficients. That means that the material parameters have to be constant within each layer of the device, and that the collection efficiency results are valid for a particular value of absorption coefficient, that is, a particular wavelength interval. Thus, the spectral collection efficiency is obtained, a form of spectral response, which is multiplied,

by wavelength intervals, with the spectral photon distribution of the incident light to obtain the light generated current. Where the assumptions of the small signal theory hold, that is, the parameters are light intensity independent, the approach has full validity.

A detailed description of the algorithm used for the collection efficiency is contained in the published literature⁴⁾, while the algorithm for the saturation current is fully analogous, omitting only the generation term, which means solving the homogeneous differential equation rather than the inhomogeneous one. All relevant material and dimensional parameters, including the thickness of each layer and the recombination velocities at all surfaces, are used as variables to permit highly accurate simulation.

One of the tasks of the project was to model a silicon solar cell which would be in low-cost mass production in the year 1985, and another which could be available from such production lines in the year 2000. The performance/characteristic and design/material parameters of the silicon solar cell to be in production in 1985 were assumed to be equal to those of the Comsat Non-Reflective Cell, that is a cell which has been fabricated on a laboratory pilot line in significant quantities and with verified performance of over 15% airmass zero conversion efficiency, or near 17% idealized airmass 1 efficiency. Since the collection efficiency related parameters of this cell are, for practical purposes, fully optimized, the predicted improvements for the "year 2000" cell consist of an increase of the voltages of the cell, such as an open circuit voltage increase from 0.60 V to 0.68 V. The design/material parameters for the two cells are listed in Table I. The current-voltage

TABLE I

INPUT DATA USED IN PHOTOVOLTAIC SYSTEMS ANALYSIS

<u>Subsystem</u>	<u>Quantity</u>	<u>System</u>	<u>Unit</u>	
Atmosph. Absorp.	Date	1962	-	
	Number of Days	365	-	
	Atm. Pressure	760	Torr	
	Ozone	2.5	mm ⁻³	
	Dust	300	cm ⁻³	
	Precip. Water	compute	mm	
	Wavelength			
	Min	250	nm	
	Max	1100	nm	
	Interval	50	nm	
Location	Latitude	33.5	degree N	
	Longitude	112.5	degree W	
Time	Start	Jan. 1, 0.0	h	
	Interval	60	min	
		"1985"-Cell	"2000"-Cell	
Solar Cell	Thickness	300	300	μm
	Junction Depth	0.2	0.2	μm
	Mobility			
	Base (el/hole)	1180/420	760/260	cm ² V ⁻¹ s ⁻¹
	Diff. Region	40	40	cm ² V ⁻¹ s ⁻¹
	Carrier Conc.			
	Base(p-type)	4·10 ¹⁵	7·10 ¹⁶	cm ⁻³
	Diff. Region	10 ¹⁹	10 ¹⁹	cm ⁻³
	Surface Recomb.			
	Base (Back Surface Field)	1	1	cm s ⁻¹
	Diff. Region	100	100	cm s ⁻¹
	Minority Carrier Lifetime			
	Base	25	30	μs
	Diff. Region	3	3	ns
	Light Exposed Area			
	Area	0.92	0.92	cm ²
	Junction Area	1.0	1.0	cm ²
	Series Resistance	0.34	0.34	Ω cm ²
Reflectance	0.03	0.03	-	

characteristic is of the single exponential type, corresponding to equ. (3). While most of the current production solar cells exhibit the "double exponential type" of characteristic, which causes a 5 to 10% loss of output power, the Comsat "violet" and "nonreflective" cells have the saturation current of the second exponential term sufficiently reduced to have a current-voltage characteristic of essentially the single exponential type.

The temperature dependence of the performance parameters is partially contained in the algebraic relationships, partially introduced through the temperature dependence of the material parameters. Accordingly, the absorption coefficients, in dependence on wavelength, are determined by interpolation and extrapolation from empirically determined, published data for a few fixed temperatures.⁽⁵⁾ The energy gap E_g which dominantly determines the saturation current j_0 based on carrier diffusion, is used as:

$$E_g = 1.12 - (T - 300) \cdot 2.8 \cdot 10^{-4} \text{ [eV]} \quad (4)$$

Since the temperature dependences of the mobilities and minority carrier lifetimes are of lesser importance in the temperature range of interest, these quantities have been kept constant.

2.4.4 Cu₂S/CdS Solar Cell Modeling

Similar to the predictive modeling of the silicon solar cells, a Cu₂S/CdS thin film solar cell was modeled, which is expected to be available from mass production lines in the year 1985. While the modeling of the silicon solar cells was done entirely by the University of Pennsylvania team, the predicted

performance data for the $\text{Cu}_2\text{S}/\text{CdS}$ cell were supplied by Fred Shirland of the Westinghouse Research Laboratory.

The applicability of the mathematical model represented by Equation (3) of the $\text{Cu}_2\text{S}/\text{CdS}$ thin film solar cell has not been determined for the complete ranges of light intensity and temperature covered in the present simulated output runs. For the purposes of this program, the $\text{Cu}_2\text{S}/\text{CdS}$ cell has been modelled in conformance with Equation (3), with an empirical light generated current value of 25 mA/cm^2 for idealized air mass 1 conditions. This light generated current is scaled linearly with available light intensity disregarding any effects of changing spectral distribution due to varying atmospheric attenuation.

To closely approximate the current-voltage characteristic at 298 K, a saturation current value $j_0 = 3 \times 10^{-11} \text{ A cm}^{-2}$ was chosen, together with an A-value (adjustment factor in exponent) of 1.0. These values provide an open circuit voltage of 0.528 V, and a maximum power point of 23.2 mA cm^{-2} at 0.43 V, for an output of 10 mW cm^{-2} at an irradiance of 100 mW cm^{-2} .

The temperature dependence has been represented by a decrease of the open circuit voltage by 1.6 mV per degree Celsius. This temperature dependence is simulated through a temperature dependence of the saturation current

$$j_0(T) = j_{00} T^a e^{-\frac{E_{\text{act}}}{kT}} \quad (5)$$

with $a = 0$ for the $\text{Cu}_2\text{S}/\text{CdS}$ cell.

Using this form together with equ. (3) yields:

$$\frac{dv_{oc}}{dT} = \frac{Ak}{q} \{ \ln j_L - \ln j_{oo} T^a - a \} ; \quad (6)$$

Equation (6) provides the j_{oo} value ($2.899 \times 10^6 \text{ A cm}^{-2}$), with which the appropriate value for the activation energy E_{act} of 1.004 eV is obtained from equ. (5) by use of the given value for the saturation current j_o at 298K.

While the modeling for the $\text{Cu}_2\text{S}/\text{CdS}$ cell for all runs except run K was done on a "predicted performance" basis, using light generated current, open circuit voltage, and "fill factor" (for maximum power point), run K contained a model which was more based on "predicted cell characteristics". Thus, the A-factor was set equal to 1, and the saturation was to be $1 \cdot 10^{-10} \text{ A cm}^{-2}$. Since this would have resulted in an open circuit voltage under standard conditions below 0.5 V, the saturation current was decreased to $3 \cdot 10^{-11} \text{ A cm}^{-2}$. To compensate for the significantly higher fill factor, even with the series resistance value of $1 \Omega \text{ cm}^2$ ($0.35 \Omega \text{ cm}^2$ in the other runs), the light generated current was reduced to 25 mA cm^{-2} , to maintain an efficiency of approximately 10% under standard conditions. To maintain the temperature dependence of the open circuit voltage at $1.6 \text{ mV}/^\circ\text{C}$ at the changed saturation current and A-factor values, a j_{oo} of $2.899 \cdot 10^6 \text{ A cm}^{-2}$ and an activation energy of 1.004 eV were used.

The result of run K carried out under conditions identical to run V, except for the cell model, that is for a truss collector with a heat transfer coefficient of $0.0455 \text{ kW}/(\text{m}^2^\circ\text{C})$, is an annual energy availability of 24.11 Wh/cm^2 (241.1 kWh/m^2), with a peak power output of 13.82 mW cm^{-2} (0.138 kW m^{-2}). The maximum temperature reached by the array is 337.8K (64.6°C). It

may be noted that the energy available from the cells during the year from run K is 5.5% higher than from run V. It is even 1% higher than the energy availability from run W, which has a higher heat transfer coefficient. The difference between runs K and V can thus not solely be attributed to thermal effects. In fact, the differences in the modeling itself resulted in a 3.5% higher power output under standard conditions for the model used in run K compared to the model used in the other $\text{Cu}_2\text{S}/\text{CdS}$ cell computations. Thus, a 2% increase in annual energy availability may be attributable to a more favorable modeling of the temperature dependence in run K.

2.4.5 The Tracking and Shading Subroutines

As explained previously, the routine SOLANG provides the azimuth and incidence angle on both the horizontal plane and a plane with an arbitrary tilt and rotation, as a function of latitude, declination, and time (see Fig. 3). The routine TRACK then uses these results to locate the sun and compute new tilt and rotation angles for the collector, depending on the mode of tracking, and from these new incidence and azimuth angles on the arbitrary plane (collector). The possible modes of tracking thus far implemented are: fixed rotation angle and tracking tilt; tracking tilt and tracking rotation (2 axis tracking); tracking rotation and fixed tilt; and fixed rotation and fixed tilt (non-tracking). Note that a fixed rotation of zero and a tracking tilt corresponds to a tracking axis running east-west, whereas a fixed rotation of ninety degrees corresponds to a tracking axis running north-south. A fixed tilt, variable rotation corresponds to a tracking axis running toward the zenith.

Fig. 3 — Collector orientation. Q is the rotation angle and is negative toward the east (as shown). P is the tilt angle and is positive upward (as shown)

Fig. 4 — Network arrangement. The arrangement of elements in a 4×3 network, with an offset between rows of $1/3$ the element spacing. Thus, after three rows, the pattern repeats. Note also the equal tilt and rotation angles of all the elements

Once the new orientation of the tracked collector (tilt and rotation after tracking adjustment) and the location of the sun relative to this new collector position (azimuth and incidence angles) are known, from TRACK, the mutual shading of collectors can be computed using routine SHADE. To do this, some definitions and assumptions must be clarified. First, the field of collectors will be called the "network", and each collector will be called an "element". All elements are assumed to be tilted and rotated the same amount at any one time, and the network is assumed to be essentially rectangular in structure and facing south, as in Fig. 4. Finally, the inter-element spacings must be established as in Fig. 5, with the required inputs listed in Table II.

From these inputs, the routine proceeds as follow: First, those four of the ten nearest neighbors of a particular collector (see Fig. 5) are determined which could possibly shade that collector. This determination is based on the azimuth angle of the sun in the horizontal system. Then, the actual area shaded by each of these neighbors is computed, by calculating the projection of the neighbor by the sun onto the center element. Since all collectors are parallel to each other, this projection is straightforward, in particular, because the images are rectangular. Next, any coincident shading from more than one neighbor is computed to avoid double counting. Finally, a careful accounting is made of how many elements lie on each boundary, so that the shading on those elements that lack some of their neighbors, can be included correctly. After these computations, the routine simply adds up the area shaded by each neighbor times the number of elements having such neighbors, eliminating coincident shadowing, to obtain the total area shaded. Dividing by the total collector area in the field, the fraction of the total collector area that is shaded is obtained as the subroutine output.

Fig. 5 — Network dimensions and neighbors. One element (shown with zero tilt and rotation) with its ten nearest neighbors, showing the inter-element distances required as inputs

TABLE II

Inputs for SHADE

A	Spacing between elements in a row.
B	Spacing between rows.
C	Offset of elements between rows
E	Height of Element
F	Width of Element
M	Number of rows
N	Number of elements in a row.

2.4.6 Computations Carried Out

Applying the program and the solar cell models described in the preceding subsection, with the inclusion, where appropriate, of subprograms for V-trough, truss, compound parabolic, or linear Fresnel lens concentrators supplied by Westinghouse, several parametric studies were carried out. These computations were executed to the solar cell output level only, omitting such array assembly parameters as packing factors or mismatch losses, but including a cover glass reflectance of 7% besides the cell reflectance of 3%. Also omitted were the inverter/regulator, battery, and load interactions, as well as the effects resulting from the interactions of the independent statistics of solar availability and power demand.

The output of the program is given on the unit cell area (cm^2) basis, as hourly quantities, for direct and indirect irradiance separately, for cell temperature and its difference against the ambient temperature, for the light generated current, open circuit voltage, maximum power point voltage, current, and power, and for the logarithm of the dark diode saturation current. These data are provided on magnetic tape in the format shown in Fig. 6. In addition, the sum of the hourly maximum power output values for the entire year is obtained, as well as the highest power output value during the year (Table III).

The computations were carried out for the year 1962 using the US Weather Bureau data for Phoenix, Arizona, as corrected and augmented by Aerospace Corp. These data contain a division into direct and indirect irradiance on the horizontal plane which differs in its results from that obtained by our own program. In particular, at high insolation conditions with low airmass values, our program yields more direct radiation, while at low insolation and high airmass values, it gives more indirect radiation than the Aerospace program, which is based on a linear interpolation rather than the $\cos^2$ relationship given in equ. (2a). Nevertheless, the Aerospace data were used in order to maintain uniformity among similar studies.

Format Statement : (A1, 4I2, 2(2I3, I4), 2(I3, I2), I1)

	Indicator (1 Implies Power > 100, Power Contains Power - 100)
	Negative of Characteristic of Saturation Current
	Mantissa of Log of Saturation Current (Amps cm ⁻²)
	Temperature of Collector Above Ambient (0-99°K)
	Max Power Pt. Power (Units of 0.1 mW cm ⁻² 0-99.9 mW)
	Max Power Pt. Current (Units of 0.1 mA cm ⁻² 0-999.9 mA)
	Max Power Pt. Voltage (0-999 mV)
	Open Circuit Voltage (0-999 mV)
	Light Generated Current (Units of 0.1 mA, cm ⁻² 0-999.9 mA)
	Temperature (000-999°K)
	Direct Radiation (001-999 mW/cm ²)
	Indirect Radiation (01-99 mW/cm ²)
	Hour (1 - 24)
	Date (1 - 31)
	Month (1 - 12)
	Run Identifier

Fig. 6 - Format of solar cell output tape

A portion of the parametric studies was directed towards evaluation of the effects of various array cooling or mounting methods. For this purpose, a thermal conductance (or resistance) value between solar cell and ambient was used, which resulted in temperature differences between the cells and the ambient. The modeling was carried out by determining this temperature difference as the product of thermal resistance R_{th} and energy flux across the cell-substrate interface, substrate, and substrate-ambient interface. This thermal energy flux is actually the irradiance minus the electrical power delivered to the load. This electrical power delivered is equal to the irradiance H times the conversion efficiency η . Although the latter is a function of irradiance and temperature, it is considered constant, neglecting second order effects. This constant efficiency has been chosen as 15% for the silicon cells, and 9% for the Cu_2S/CdS cell. However, for programming simplicity, an equivalent thermal resistance value R_{th}' has been used which incorporates the effect of the efficiency:

$$\Delta T = H(1-\eta) R_{th} = H R_{th} \left(1 - \frac{\Delta R}{R_{th}}\right) = H R_{th}'; \quad (6)$$

Thus:

$$R_{th} = \frac{R_{th}'}{1-\eta}; \quad (7)$$

where R_{th}' is the equivalent value used and appearing in the 11th column of Table III, while the true thermal resistance value is larger according to equ. (7). The thermal conductance value U in column 10 of Table III is the inverse of R_{th}' , that is, the true thermal conductance.

One run (#E) was made simulating forced liquid cooling, by using a fixed temperature difference of $10^{\circ}C$ against ambient.

Table III Parameters and Results of Output Runs.

Run #	DS #	Conver-	Concentrator Type	Tracking Mode	Orientation				Cooling		Total Energy Delivered	Max. Power Output
					Tilt	Rot'n	Conc.	Y-axis Rot'n	U kW m ² /°C	Mode R _h cm ² /°C mW	Wh/cm ²	mW/cm ²
1	01	Si	Flat	Fixed	33.5	0	-	-	0.212	0.04	37.79	19.50
2	02			2-axis	var.	var.	-	-			52.36	19.70
3	03			NS-axis	var.	90	-	-			47.70	17.80
4	04			EW-axis	var.	0	-	-			40.92	19.50
5	05			vert.-axis	33.5	var.	-	-			47.96	19.60
I	10			vert.-axis	50.0	var.	-	-			50.00	19.40
H	12			2-axis	var.	var.	-	-	0.085	0.1	51.16	19.10
G	11			2-axis	var.	var.	-	-	0.34	0.025	52.76	19.80
X	24			2-axis	var.	var.	-	-	0.0255	0.33	46.48	16.98
Y	25		Flat, w. shading field of 100x100', 30% ground cover	2-axis	var.	var.	-	-	0.212	0.04	48.16	19.64
Z	26		dto, 50% gr. cover	2-axis	var.	var.	-	-			44.64	19.62
D	9		Truss	Fixed	0	0	0	EW			48.72	27.35
Ø	27			Fixed	0	0	0	EW	0.0425	0.2	43.31	24.45
6	1		V-trough, 2x	Fixed	33.5	0	0	EW	0.212	0.04	48.90	29.56
7	2		CPC, 3x	Fixed	33.5	0	0	EW			47.44	*
8	3		, 3x	NS-axis	var.	90	0	NS			106.9	39.5
F	19		, 10x	NS-axis	var.	90	-90	EW			54.15	96.5
9	4		, 10x	vert.-axis	50.0	var.	90	NS			283.2	104.8
E	8		, 10x	2-axis	var.	var.	-	-	T _{amb} + 10°C		311.9	111.0
T	20		, 10x	NS-axis	var.	90	0	NS	0.212	0.04	266.7	95.02
B	6		Fresnel, 10x	vert.-axis	50.0	var.	90	NS	0.212	0.04	233.2	105.2
J	17		(linear), 10x	vert.-axis	33.5	var.	90	NS			191.4	102.8
A	5		10x movg. coll'r.	Fixed	33.5	0	90	NS			79.11	69.40
L	18		10x movg. coll'r.	Fixed	33.5	0	0	EW			80.60	99.65
C	7	CdS	Flat	Fixed	33.5	0	-	-	0.228		21.70	10.99
M	13			2-axis	var.	var.	-	-			30.50	11.80
N	14			NS-axis	var.	90	-	-			27.31	11.60
O	15			EW-axis	var.	0	-	-			23.53	11.58
Q	16			vert.-axis	33.5	var.	-	-			29.00	11.16
U	21		Truss	Fixed	0	0	0	EW	0.0091	0.9777	15.10	7.24
V	22								0.5455	0.2	22.21	13.78
W	23								0.091	0.1	23.84	14.72

After a sequence of trial - and debugging runs, 32 final computer runs were carried out, all for the full year 1962 in Phoenix, Arizona (Table III). 24 of the computer runs were for silicon cells, 11 of these for flat arrays, the rest with 4 different types of concentrating systems. 9 of the flat array runs and the concentrator runs, except for the truss concentrator, were carried out for single arrays or concentrators which is equivalent to very large spacing for a field of concentrators, so that no mutual shading occurs. Two of the flat array runs, however, were carried out for a field of 100×100 arrays of $10\text{m} \times 10\text{m}$ each. Each array in the field was tracked in 2 axes so that normal incidence was always obtained. Center-to-center spacing of the arrays was equal both within rows and from row to row, with the arrays arranged with a 50% stagger in alternating rows. In one of the runs (#Y), 30% of the ground would have been covered by arrays if they would have been swung into the horizontal position, which means a center-to-center spacing 1.8257 times the edge length of each array, or 18.26 m. In the other run (#Z), 50% of the ground was covered, for a center-to-center spacing 1.4142 times the array edge length, or 14.14 m. These two runs provided, due to shading, 8% and 15% less energy output throughout the year, respectively, than the run for very large array spacing (#2) with otherwise identical conditions.

The concentrators evaluated are all of the linear concentrating type. Their orientation is uniformly described by a right-handed coordinate system with the X-axis normal to the plane of the solar cell array, the Y-axis parallel to the longitudinal or non-focusing axis of concentrator, and the Z-axis parallel to the transverse or maximum focusing direction of the concentrator. Since the opening angles of the concentrators are limited, and differ in the Y and Z directions, the con-

centrator orientation relative to the apparent sun movement and to the tracking axis is important, particularly at higher concentration ratios. This is exemplified by runs #F and #T for the 10 x compound parabolic concentrator with East-West and North-South orientation of the Y-axis, respectively, which showed a 1:5 difference in energy delivered during the year. All other parameters were identical in the two runs.

It is important to note that, because of the limited opening angles, single axis tracked concentrating systems, particularly those of higher concentration ratio, may not deliver power during certain hours or seasons. These output availability limitations are not discernable from the annual energy delivery totals shown in Table III, but are included in the information stored on the magnetic tape.

All further discussions of the results will be contained in the sections of the report which deal with the system studies.

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2.5 Utility Economic and Margin Analyses

2.5.1 Summary

The economics of a 100 MWe central station photovoltaic electric power system (PVEPS) built in the Phoenix area in 1990 appear to be competitive with conventional power, assuming single-crystal silicon cells at 100 \$/kW cell cost or thin-film CdS cells at 20 \$/kW, and employing financing costs characteristic of a publicly owned utility.* This conclusion is based on 1990 fuel costs judged likely; at higher fuel costs the PVEPS plant will be competitive in an investor-owned utility also.

Over 90% of the credit attributed to the photovoltaic plant derives from savings in production cost elsewhere in the generating system. The capacity credits derived in this work were very small under the conditions examined (no battery storage, low PVEPS penetration in the generation mix, conventional loss-of-load probability formulation).

2.5.2 Purpose and Scope

The utility calculations presented here were conducted to provide perspective in the selection of the PVEPS central power station designs developed in another part of this contract, and to estimate the plant cost goals necessary to achieve significant use of this energy option. Independent projections of the capital investment in various PVEPS plants and the corresponding annual O and M costs were made in the accompanying investigations. The bulk of the actual computational effort described here concerned the value of the plant to the utility

* Values of power quoted are always peak, and costs are in constant 1975 dollars.

owner, rather than the cost of owning it. The benefits quantified here are economic; for example, in terms of the fossil and nuclear fuel costs saved as a result of the operation of the PVEPS plant. A principal result of this study is the allowable or "breakeven" capital investment in a PVEPS system entering service in the 1990 time frame.

All of the present utility impacts were computed by simulating the operation of a utility in the Phoenix area in the year 1990, using a generating system of 6271 MW installed capacity loosely conforming to the Salt River Project's planned future expansion.* Aggregate PVEPS capacities of 200 MW and 400 MW were added to this system and the resulting production cost savings were computed by simulating the operation of the system with and without the solar plants present.

The maximum solar penetration level of 400 MW considered here represents about 6% of the installed capacity and was selected to conform to the 1990 time frame in which economic PVEPS plants might first see service.

In this study the PVEPS central power station did not include a local battery storage facility: the value to the system of the PVEPS plant was therefore limited to displacing conventional generation during sunlight hours. Thus, the electric energy from the PVEPS could not be preferentially dispatched to the grid at times of peak load (and high

* For convenience however, future power purchases and sales to other utilities were not included in the analysis. Thus, while the reference system projected here is representative of the Southwest generally, it cannot be compared in detail with projections made by Salt River Project.

system generating cost). In comparison with studies where storage is assumed, the credits derived here should be smaller in consequence. On the other hand, we have not burdened the PVEPS plant with the cost of owning and operating a storage device: we reason that a bulk storage facility - if economically justified - would better be located elsewhere on the grid to maximize its usefulness or to minimize siting difficulty and operating cost. (The objective of the PVEPS design must be to reduce overall utility costs, primarily in generation, and not to maximize the credit attributed to the PVEPS energy).

The benefits (credits) derived here are not specific to the PVEPS technology: they should be equally valid for a solar thermal-electric plant with the same hourly output power profile and annual energy, in the given utility generating system.

2.5.3 Results of Utility Analysis

This section presents a summary of the principal results of the utility analysis task whose major goals were to calculate:

- (1) The cost to a utility of owning the PVEPS
- (2) The benefits of PVEPS ownership, principally its economic benefits in fuel saving.

Sections 2.5.3.1 and 2.5.3.2 present summaries of these economic factors for the central station PVEPS designs selected for detailed study. In Section 2.5.3.3 the costs and benefits are ratioed to provide an indication of the relative economic viability of the plant designs developed in this contract. The "worth" of the PVEPS to a utility is also presented as a breakeven capital cost in Section 2.5.3.4.

Section 2.5.3.5 gives the resource impact of the PVEPS in terms of fuel savings. Finally, Section 2.5.3.6 recapitulates the key assumptions made in the analysis.

2.5.3.1 Cost of the PVEPS to a Utility

Tables 2.5.1 and 2.5.2 develop the cost of owning a central station PVEPS to public and privately owned utilities, based on the plant designs and costs developed under this project. That is, they are "actual", rather than "breakeven" costs. The costs are in 1975 dollars and except where noted otherwise are per peak kilowatt PVEPS output. The derivation of these numbers is described in detail in Appendix A; only the energy cost results will be discussed here. Key assumptions are also noted in Section 2.5.3.6.

Three designs for the central station PVEPS are evaluated here. Two employ tilted flat cell arrays with flat reflector surfaces to increase the radiant energy reaching the cells. These are termed the "lean-to" and "windrow" design concepts in this discussion. The third utilizes a tilted, vertical-axis tracking array with two array design variations. With relatively expensive silicon cells the design concept employs parallel, small-scale Winston compound parabolic concentrators to achieve a ten-fold increase in the incident energy on the cells. With the inexpensive thin-film CdS cell no concentration is provided.

The bottom lines of the tables present the final result in terms of a busbar energy cost. With an assumed cell cost of 100 \$/kW (peak), favorable energy costs are obtained under silicon cells.

Table 2.5.1

Cost of Owning and Operating a CPS in a Publicly Owned Utility

Utility Costs	Orientation CPS Concept	Fixed-Tilt "Lean-To" Design				Fixed-Tilt "Windrow" Design				Vertical-Axis Tracking 10X Winston Flat Plate			
	Cell Type Annual Energy, $\frac{\text{kWh}}{\text{kW}_p}$ Cell Cost \$/kW _p	Si 1780	Si 1780	CdS 1725	CdS 1725	Si 1770	Si 1770	CdS 1650	CdS 1650	Si 2770	Si 2770	CdS 2590	CdS 2950
A. Capital Costs, \$/kW _p													
405	Plant Investment, Less IDC	716	353	433	357	749	342	424	334	966	872	735	624
	IDC (7% Interest, 24 mo.)	49	24	29	24	51	23	29	23	66	59	50	42
	Total Investment I	765	377	462	381	800	365	453	355	1032	931	784	665
	Annual Charge = 0.12I	92	45	55	46	96	44	54	43	124	112	94	80
PW of Revenue Reqts. for capital (7% Discount)		1139	561	688	567	1191	544	675	530	1537	1386	1168	990
B. O&M Expenses, \$/kW													
Levelized Annual O&M		13	7	8	7	14	6	8	6	18	16	13	12
PW of Revenue Reqts. for O&M		171	84	103	85	179	82	101	82	231	208	175	149
C. Total Revenue Reqts.													
Annual Revenue Reqts., \$/kW *		102	51	62	51	107	48	61	48	138	124	104	89
PW of all Revenue Reqts., \$/kW		1310	646	791	653	1370	625	776	610	1767	1594	1338	1139
Levelized Energy Cost, m/kWh		57	28	36	29	60	28	37	29	51	46	40	34
Levelized Energy Cost Without O&M Calculation, m/kWh		54	27	34	28	57	26	35	27	48	43	38	32

* This is the sum of the annual O&M, assumed to be paid at mid-year (middle of service year), and the mid-year equivalent of the annual capital charge, which is reduced from the annual charge, a year-end value by the factor 1.07^{0.5}.

Table 2.5.2

Cost of Owning and Operating a PCS in a Privately Owned Utility

Utility Costs	Orientation CPS Concept	Fixed-Tilt "Lean-To" Design				Fixed-Tilt "Windrow" Design				Vertical-Axis Tracking 10X Winston Flat Plate				
	Cell Type	Si	Si	Cds	Cds	Si	Si	Cds	Cds	Si	Si	Cds	Cds	
	Annual Energy, $\frac{\text{kWh}}{\text{kw}_p}$	1780	1780	1725	1725	1770	1770	1650	1650	2700	2700	2590	2590	
	Cell Cost \$/kw _p	500	100	100	20	500	100	100	20	500	100	100	20	
A. Capital Costs, \$/kw _p														
	Plant Investment, Less IDC	716	353	433	357	749	342	424	334	966	872	735	624	
	IDC	59	29	36	30	62	28	35	27	80	72	61	51	
	Total Investment I	775	382	469	387	811	370	459	361	1046	944	795	675	
	Annual Charge = 0.18I	140	69	84	70	146	67	83	65	188	170	143	121	
	PW of Revenue Reqts. for capital (10% Discount)	1315	648	796	657	1376	628	779	613	1775	1602	1349	1145	
B. O&M Expenses, \$/kw _p														
	Levelized Annual O&M	12	6	7	6	13	6	7	6	17	15	13	11	
	PW of Revenue Reqts. for O&M	122	60	74	61	128	58	72	57	165	149	125	107	
C. Total Revenue Reqts.														
	Annual Revenue Req., \$/kW*	145	72	87	73	152	70	86	68	197	177	149	127	
	PW of all Revenue Reqts., \$/kW	1437	708	870	718	1504	686	851	670	1940	1751	1474	1252	
	Levelized Energy Cost, m/kWh	82	40	50	42	86	39	52	41	73	66	58	49	
	Levelized Energy Cost Without O&M Escalation, m/kWh	79	39	53	43	83	38	51	40	70	63	56	47	

* This is the sum of the annual O&M, assumed to be paid at mid-year (middle of service year), and the mid-year equivalent of the annual capital charge, which is reduced from the annual charge, a year-end value, by the factor $1:10.5$.

The low (10%)-efficiency polycrystalline CdS cell produced higher equipment costs and overall plant costs than the silicon cell at the same \$/kW cell cost because of its greater area requirement. In the vertical-axis tracking concept, however the CdS cell produced lower plant costs than the Si cell at the same 100 \$/kW cell cost: note that cell area is much reduced in the Winston collector concept.

The greater electric energy output of the vertical-axis tracking plant design did not compensate for its greater cost. Since the annual O&M cost for this design was probably overoptimistic relative to the fixed array alternatives, our conclusion is that for low cost cells, tracking is not beneficial. Moreover, if a shorter period has been adopted as the basis of the present worth calculation, the advantage would shift further toward the less capital-intensive fixed-array concepts. The use of a period shorter than the plant life in a sense recognizes the utility budget constraint. Where a utility's ability to secure capital financing at reasonable rates is limited, this constraint would strongly inhibit consideration of the tracking system, even if its energy cost were equal to that of the fixed array concepts.

The reader will note that the present worth (PW) of all capital costs (revenue requirements) is somewhat higher in the case of the privately-owned utility (Table 2.5.2) and that the energy cost in mills/kWh and the annual expense are much higher. The latter two costs are strongly influenced by the fixed charge rate, which is 50% higher in the private-financing case. (The adverse effect on the PW of all revenue requirements is not so great under private

financing because of the higher discount rate: 10% for the privately-owned utility vs. 7% for the publicly-owned utility.)

The energy cost calculated here is not the best indication of the attractiveness of the plant since it ignores the interactions of the PVEPS with the remaining generation system, both in operation and in the selection of an optimum generating mix. A better overall measure is the present worth of all future revenue requirements for the expanding generation system including both capital and operating costs. An estimate of the impact of the PVEPS on this quantity is given in Section 2.5.3.3.

The reader is warned that the selection of a "best" candidate for implementation in 1990 must presuppose the cost reduction each cell will experience by the 1990 time frame. Conceivably, the thin-film cost goal of 20 \$/kW must be as easily achievable as the 100 \$/kW goal for the silicon cell. In this connection it is worthwhile to note that although the plant cost is expressed in dollars per peak kilowatt, the array manufacturing cost is fundamentally area-dependent. All costs presented here in \$/kW thus imply the Phoenix insolation and weather data compiled and/or estimated by The Aerospace Corporation for 1962 and the assumed conversion factors of about 16% for the silicon cell and 10% for the CdS polycrystalline cell.

2.5.3.2 Benefit to the Utility of PVEPS Ownership

The calculated benefits accruing to the owner of a PVEPS plant under the assumed conditions are given in Tables 2.5.3 and 2.5.4 for public and private financing conditions respectively. (The major

Table 2.5.3

Credits Evaluated for a Central-Station PVEPS in Phoenix with Moderate 1990 Fuel Costs
 (High Fuel Cost Values in Parentheses)
 Units: mid-1975 \$/kW

A. Public Financing

Credit	Orientation CPS Design Concept Photovoltaic Cell Annual Energy, kWh/kW	Fixed-Tilt Lean-To-Design		Fixed-Tilt Windrow Design		Vertical-Axis Tracking	
		Si 1780	CdS 1725	Si 1770	CdS 1650	Si 2700	CdS 2590
Displaced thermal plant fuel use*		631(895)	611(867)	627(890)	585(829)	956(1374)	917(1318)
409 Displaced thermal plant O&M cost		58	56	58	54	88	85
Displaced Capacity		11	10	11	10	106	93
Total Credit		700(964)	677(933)	696(959)	649(893)	1150(1568)	1095(1496)

*Based on "moderate" fuel cost scenario. Numbers in parentheses are based on "high" fuel cost.
 (See Section 2.5.3.6)

Table 2.5.4

Credits Evaluated for a Central-Station PVEPS in Phoenix, with Moderate 1990 Fuel Costs
 Fuel Costs (High Fuel Cost Values in Parentheses)
 Units: mid-1975 \$/kW

B. Private Financing

Credit or Benefits (PW of Revenue Requirements Saved)	Orientation CPS Design Concept PV Cell Annual Energy, kWh/kW	Fixed-Tilt Lean-To Design		Fixed-Tilt Windrow Design		Vertical Axis Tracking	
		Si 1780	CdS 1725	Si 1770	CdS 1-50	Si(10X CPC) 2700	CdS 2590
Displaced thermal plant fuel use*		430(605)	416(587)	427(602)	398(561)	653(933)	627(895)
Displaced thermal plant O&M Cost		40	39	40	37	62	58
Displaced Capacity		11	11	11	11	106	106
Total Credit		481(656)	466(637)	478(653)	446(609)	821(1101)	791(1059)

* Based on "moderate" fuel cost scenario. Numbers in parentheses are based on "high" fuel cost scenario.
 (See Section 2.5.3.6)

difference here is in the present worth factors by which the annual fuel savings are multiplied to obtain a total credit.)

2.5.3.2.1 Fuel Savings

Credits in conventional unit fuel saving were calculated for two different fuel price levels: "moderate" and "high". These are defined in Section 2.5.3.6. About 60% of the fuel cost saving in the "moderate" case derives from the displacement of oil at a cost of 5 \$/million BTU, and another 33-35% from reduced coal consumption at 1.20 \$/MMBTU.* Displacement of nuclear fuel was relatively unimportant. The total fuel cost credit is obviously sensitive to the relative amounts of the various fuels displaced, which is in turn dependent on the specific generating plant mix and load shape examined. Thus while the fuel cost credits are relatively firm, provided the present fuel costs are accepted, they are not necessarily valid for Southwestern utilities in general because of their differing generation and load characteristics. The calculation of fuel savings is described in Section 2.5.5.1.

2.5.3.2.2 O&M Savings

The reduced generation by conventional generating units yields a saving in the variable (energy-dependent) component of the O&M costs for these plants. The magnitude of this saving is small relative to the fuel saving, but must logically be counted as a further credit to the PVEPS.

2.5.3.2.3 Capital Cost Credit

A relatively small credit was derived here for the reduction in installed capacity of conventional generating units. Although the displaced units were admittedly relatively inexpensive (gas turbine

*These fuel costs are in current 1990 dollars.

plants at 400 \$/kW (in 1990 \$), the magnitude of this credit would obviously still be small, even if the same calculated capacity displacement in kW units had been assessed at a value representative of a 1990 base load coal plant, say 990 \$/kW (in 1990 \$).

The credit derived for capacity displacement is much smaller than that obtained by The Aerospace Corporation in their mission analyses of solar-thermal and photovoltaic power plants, typically using some energy storage device; whether this is entirely due to the fact that storage was not assumed here or is indicative of a fundamental difference in method remains to be determined. A battery is a high-reliability power source, and accordingly, a PVEPS with battery storage would earn a substantial capacity credit.

Somewhat surprisingly, the capacity credit calculated here was relatively insensitive to the system reliability criterion.

2.5.3.2.4 Total Economic Benefit

The individual credits for production (fuel and variable O&M) cost savings and displaced capacity are summed in Tables 2.5.3 and 2.5.4 to obtain a present worth value which may be compared to the present worth of the owner's cost (revenue requirements) associated with the PVEPS plant. The total \$/kW credit shown is not equal to the allowable plant investment in the PVEPS, as explained in Section 2.5.3.4.

A further point of clarification may be in order as to the dollar base used in these tables. The credits are expressed in mid-1975 dollars and are directly comparable to the PW costs given in Tables 2.5.1 and 2.5.2. Each credit was first derived as the PW in 1990 of a saving

attributed to a PVEPS plant starting operation on January 1, 1990 and expressed in 1990 dollars. The credits are directly comparable to the PW of capital expenses in 1990 if the latter are similarly expressed in 1990 dollars. The derived 1990 credits were then reduced by the factor 2.03 to obtain the numbers shown here. This factor is the estimated escalation of the PVEPS investment cost over the interval June 1, 1975 to January 1, 1990 at a rate of 5%/year:

$$(1.05)^{14.5} = 2.03^*$$

2.5.3.3 Cost-Benefit Analysis of the Central Station PVEPS

Table 2.5.5 summarizes the result of the utility analysis of the central power station PVEPS in terms of a cost-benefit ratio.

"Cost" is defined as the present worth of all revenue requirements incurred by the utility as a result of owning a PVEPS, as presented in Section 2.5.3.1.

The "benefit" (or credit against the PVEPS capital costs) is the present worth of all savings in revenue requirement elsewhere in the generating system. As presented in Section 2.5.3.2, these benefits are primarily reduced future fuel costs.

A cost-benefit ratio less than 1 suggests that the PVEPS plant would be a justifiable investment on the basis of internal utility

*The validity of the equivalent inverse procedure may be more readily apparent: that is, the credits could have been left in terms of a PW in 1990 in 1990 \$. In this case the PVEPS owning costs must be increased by the factor 2.03 to obtain a comparable cost in 1990 \$. The present approach was taken so that all results could be expressed in mid-1975 dollars.

Table 2.5.5

Cost-Benefit Evaluation of Selected CPS Designs Entering Service in Phoenix, 1990

Cost and Benefits	Orientation CPS Concept	Fixed-Tilt "Lean-To" Design				Fixed-Tilt "Windrow" Design				Vertical-Axis Tracking 10X-Winston Flat Plate			
	Cell Type	Si		CdS		Si		CdS		Si		CdS	
	Annual Energy, $\frac{\text{kWh}}{\text{kw p}}$ Cell Cost, \$/kW p	1780	1780	1725	1725	1770	1770	1650	1620	2700	2700	2590	2590
		500	100	100	20	500	100	100	20	500	100	100	20
PUBLIC FINANCING													
	Cost (Table 2.5.1), \$/kW	1310	646	791	653	1370	625	776	610	1767	1594	1340	1139
	Benefit (Table 2.5.3), \$/kW												
	• moderate fuel costs	700	700	677	677	696	696	649	649	1150	1150	1095	1095
	• high fuel costs	964	964	933	933	959	959	893	893	1568	1568	1496	1496
	Cost/Benefit Ratio												
	• moderate fuel costs	1.9	0.9	1.2	1.0	2.0	0.9	1.2	0.9	1.5	1.4	1.2	1.0
	• high fuel costs	1.4	0.7	0.9	0.7	1.4	0.7	0.9	0.7	1.1	1.0	0.9	0.8
PRIVATE FINANCING													
	Cost (Table 2.5.2), \$/kW	1437	708	870	718	1504	686	85	670	1940	1751	1474	1252
	Benefit (Table 2.5.4), \$/kW												
	• moderate fuel costs	481	481	466	466	478	478	446	446	821	821	791	791
	• high fuel costs	656	656	637	637	653	653	609	609	1101	1101	1059	1059
	Cost/Benefit Ratio												
	• moderate fuel costs	3.0	1.5	1.9	1.5	3.2	1.4	1.9	1.5	2.4	2.1	1.9	1.6
	• high fuel costs	2.2	1.1	1.4	1.1	2.3	1.1	1.4	1.1	1.8	1.6	1.4	1.2

economics alone. The scope of this study did not permit quantifying and including external benefits to society, although very tangible benefits are known to exist (e.g. a reduction in atmospheric pollution or dependence on foreign oil).

The reader will note that the economic position of the PVEPS is much better (lower cost/benefit ratios) in the case of a publicly-owned utility than the private (investor)-owned utility. (The financing assumptions used in the former case approximate costs provided by The Salt River Project.) This is true for two reasons. First, the present worth of the annual revenue requirement per dollar of invested capital (fixed charge rate) is less, and second, the present worth, or "weighting" of the future benefit in terms of reduced conventional unit operating costs is higher, as a result of the lower discount rate appropriate to the public utility.*

Under the "moderate" fuel cost assumption, either of the fixed-tilt design concepts appear to be economically feasible under the public financing condition on the basis of present worth revenue requirements with silicon cells at 100\$/kW (peak) or CdS cells at 20 \$/kW.

If fuel prices reach the "high" values by 1990 but the PVEPS plant escalation over the same time is no more than a factor of about 2 (corresponding to 5%/year from 1975 to 1990), more favorable cost-benefit ratios are obtained. The thin film polycrystalline CdS cell

* It is general utility practice to take the discount rate equal to the average cost of money.

at 100 \$/kW now becomes a contender in both the fixed and tracking designs, at least from the present worth of revenue requirements standpoint, given the public-financing environment. A capital-short utility might still prefer the reduced investment in the fixed-array designs, however.

Under "high" fuel costs, the selected fixed-tilt designs also look promising under the more stringent financing conditions of the investor-owned utility.

2.5.3.4 Breakeven PVEPS Capital Cost

An alternative way of summarizing the analysis is the "breakeven" cost of the central station PVEPS; that is, the maximum capital investment which a utility can make in the expectation of recovering its investment in future production and other cost savings throughout the conventional generating system. It is in effect the "worth" of the PVEPS energy production.

The savings occurring elsewhere in the utility system were summarized in Table 2.5.5. The result, labeled benefit, represents a credit toward the cost of owning the PVEPS, which entails capital charges and annual O&M expenses. If we assume that the annual O&M represents about 1% of the investment in the PVEPS plant, and subtract the present worth of PVEPS O&M expenses from the benefits, the balance is the amount available to offset the capital costs of the PVEPS plant, that is the revenue required to meet the return on borrowed money, depreciation, income and property taxes and insurance. With the prescription developed in Appendix A, the allowed capital investment

in the PVEPS plant at the start of operation is obtained by dividing the benefit by a factor of 1.713 to obtain the allowed investment in the PVEPS plant under public financing. This number is the sum of the PW of capital requirements per dollar investment (1.4891) and the PW of the annual O&M expense (0.2236), as derived in Table A-2. The corresponding factor for private financing is $(1.6968 + 0.1578 = 1.8546)$.

As an example, the total credit of 700 \$/kW obtained in Table 2.5.3 for the "lean-to" plant design with silicon cells corresponds to an allowed plant investment of 409 \$/kW including contingencies, indirect costs and IDC. Dividing by the factors 1.0678 and 1.30 to obtain the associated installed cost of equipment yields 294 \$/kW. Finally, we subtract the total cost of PVEPS equipment other than the cells as well as the cost of array structure to obtain 103 \$/kW allowable for the cells themselves. (Because of the many assumptions implicit in the calculations of both PVEPS costs and credits, the indicated three-digit precision is misleading.)

Table 2.5.6 shows the calculated breakeven costs associated with the two reference power profiles and annual energies used in the utility computer calculations. The breakeven costs for specific plant designs producing different annual energies may be approximated by scaling these in proportion to energy. (A small error results because we have elsewhere taken the capital cost credit of the PVEPS to be proportional to its peak output rather than its annual energy).

TABLE 2.5.6

Breakeven Capital Cost for a 1990 PVEPS Plant in Phoenix
Units: Mid-1975 Dollars/kW Peak

<u>Utility Financing</u>	<u>PVEPS Annual O&M Per \$ Invested</u>	<u>Fixed Tilt Power Profile (1938 kWh/Year)</u>		<u>Two-Axis Tracking Power Profile (2658 kWh/Year)</u>	
		<u>Moderate Fuel Costs</u>	<u>High Fuel Costs</u>	<u>Moderate Fuel Costs</u>	<u>High Fuel Costs</u>
Public	0.01	442	610	653	894
Private	0.01	281	384	436	584

A few observations may be made regarding the tabulated costs.

- (1) The breakeven costs are rather low (i.e. difficult to meet) with private utility financing, which penalizes any capital-intensive plant.
- (2) The economic position of the PVEPS is sensitive to fuel costs.
- (3) The extra energy output of the tracking system would appear to justify a substantial investment in tracking. However, when the credits were compared to the estimated cost of a tracking system, it appeared that the tracking system was still too expensive.

It is worth reiterating that the table expresses only the breakeven cost of hypothetical PVEPS systems with a specific hourly output profile and in a specific utility environment. Of the many implicit assumptions affecting these breakeven costs, the use of the high Phoenix 1962 insolation, the 30 year life over which discounted benefits were accrued, a predominantly coal-based generating system, and fairly conservative (high) fixed charge ratios may be mentioned: the first two factors are optimistic while the final two are pessimistic.

We should also point out that the capacity credit developed herein is quite small, despite the favorable nature of the load (daylight peaking); this is apparently at variance with some prior work.

2.5.3.5 Fuel Resource Conservation

When the hypothetical PVEPS plant was added to the reference utility, the reduction in conventional fuel use occurred roughly in

proportion to the fuel consumption in the original generation system, in which 53% of the energy consumed was in the form of coal. The results showed that the presence of the PVEPS tended to preferentially reduce the consumption of peaking fuel (oil), but the shift was not enough to substantially change the overall fuel use pattern. Of the thermal energy saved, about 2/3 was coal energy.

Over the limited range of PVEPS capacities examined, the saving in each fuel was nearly linear with PVEPS energy. For example, Figure 2.5.1 shows a saving of 2630 BTU of oil energy per kWh of electricity provided by the solar plant in the generating system examined. For a typical CPS plant like the silicon cell/"windrow" configuration which produces 1770 kWh annually per kW of installed capacity, the oil saving would be 80,000 bbl for each 100 MW plant, assuming Phoenix 1962 insolation and 100% mechanical reliability. In a predominantly oil-fueled system, the saving could be much higher.*

The greater energy collection of the tracked array results in an even larger fuel saving for the same peak PVEPS installed capacity. For example, in the case of the hypothetical two-axis tracking system, about 28% more oil is saved in comparison to the corresponding fixed-tilt array.

* In the extreme case of an all oil-fueled generating system, the saving would be intermediate between the heat rates of the gas turbine and a baseload, oil-fired steam plant, say 10,000 and 12,000 Btu/kWh respectively. Using the lower number, a 100 MW PVEPS plant would displace 302,000 bbl of oil annually at 100% availability.

Fig.2.5.1-Fuel oil conservation produced by the photovoltaic electric power plant

2.5.3.6 Key Assumptions

The results presented in the previous sections are contingent upon a variety of assumptions. To keep these in the foreground the following list should be noted:

Technical Assumptions

- (1) Phoenix 1962 insolation and temperature conditions (Aerospace Corporation tapes).
- (2) Electric load and generating mix roughly approximating that of the future Salt River Project configuration, a predominately coal-fired generating system.
- (3) No energy storage on-site.
- (4) Capacity displaced is peaking gas turbine generation.
- (5) PVEPS maintenance outages and forced outages other than those of solar origin were neglected.

Economic Assumptions

- (6) A long (30-year) useful life.
- (7) Discounting at average cost of money: 7%/yr (public), 10%/yr (private).
- (8) Conservative (high) fixed charges on capital for both private and public ownership: 18%/yr and 12%/yr, respectively. The latter rate approximates the Salt River Project financing.*

* Note: Salt River Project makes voluntary contributions to local governments in lieu of income taxes: it is not strictly tax-free.

- (9) A relatively low annual O&M cost (1% of installed PVEPS cost).
- (10) Contingency and indirect expenses associated with PVEPS construction were calculated as 20% and 10% of the installed equipment cost, respectively.
- (11) PVEPS construction was assumed to take 24 months with equal expenditures in each month. IDC was estimated with this construction period and with annually compounded interest rates of 7% (public financing) and 8.5% (private financing). Escalation during construction was neglected.
- (12) PVEPS capital cost escalation rate of 5% over the period 1975-1990. The present-worth in January, 1990 of all system annual fuel and O&M savings was first obtained in 1990 \$ as a credit against the installed cost of the PVEPS at that time. This amount was then deescalated to the equivalent mid-1975 plant cost level by the factor 2.03.
- (13) 1990 fuel costs are as follows in 1990 \$:

	<u>Moderate Fuel Cost Scenario</u>	<u>High Fuel Cost Scenario</u>
<u>Oil Cost, \$/MMBTU*</u>		
1990 Cost	5.00	6.00
Levelized Costs (private)	11.23	13.47
Levelized Costs (public)	12.97	15.56
<u>Coal Cost, \$/MMBTU</u>		
1990 Cost	1.20	1.80
Levelized Costs (private)	1.92	3.20
Levelized Costs (public)	2.09	3.56
<u>Nuclear Cost, \$/MMBTU</u>		
1990 Cost	1.00	1.40
Levelized Costs (private)	1.60	3.14
Levelized Costs (public)	1.74	3.63

* MMBTU signifies million BTU. $1.00 \text{ \$/MMBTU} = 0.94782 \text{ \$/GJ}$.

The levelized costs reflect a 30-year interval, the applicable public and private discount rates and the following escalation rates for the "moderate" cost scenario: oil, 8%/yr; coal, 5%/yr; nuclear, 5%/yr. In the "high" cost scenario the escalation rates are 8, 6, and 8%/yr, respectively.

These assumptions affect both the absolute and relative magnitudes of the cost-benefit ratios presented above. For example, the assumption of a shorter period, say 15 years, as the interval over which production cost benefits are summed would tend to have an adverse effect on the economics of all PVEPS plants, but particularly on the more capital-intensive tracking system. The negative impact of assumption No. 8 is considerable in comparison to some solar energy assessments in which only a capital recovery factor is employed to represent annual capital charges (i.e., taxes and insurance are ignored).

2.5.4 Calculation Method

2.5.4.1 General Approach

The approach taken in this work was to utilize conventional utility planning methods without modification. The effects of a given amount of solar plant capacity were established by difference. This may be illustrated for the system production cost calculation. First, a calculation was made for the reference generating system without solar plants. Then the output of the solar plant was subtracted from the load and the operation of the conventional generating units to meet the net remaining load was simulated. For a central power station without storage, this represents the way in which the solar plant would actually operate; it is the way non-storage or "run-of-river" hydroelectric plants are dispatched. This being the case, it follows that the difference method should produce a realistic amount of the value of the PVEPS plant to the utility since all calculations are for conventional plants and employ methods which have been thoroughly verified in such applications.* At many points in the calculation, however, assumptions were made which influence the results and deserve further scrutiny; these are indicated in the detailed discussion throughout this report.

Two kinds of calculations were made for this study:

- (1) A calculation of the generating system dispatch and production (fuel plus O&M) cost for the year 1990

* It is not unreasonable to expect that some modification of the standard utility planning methods may be desirable to more accurately treat the distinctive properties of the PVEPS. An extension of the reliability analysis is suggested in Section 2.5.7.

using the Westinghouse Daily System Production Cost and Economy Interchange Program. Separate calculations were made for five cases:

- a) base system with no PVEPS capacity.
- b) base system plus 200 MW PVEPS capacity with fixed-tilt output profile.
- c) base system plus 400 MW PVEPS capacity with fixed-tilt output profile.
- d) base system plus 200 MW PVEPS capacity, 2-axis tracking power profile.
- e) base system plus 400 MW PVEPS capacity, 2-axis tracking power profile.

As noted above, the generating mix in all the above was really the same, but the hourly loads "seen" by the conventional plants were distinct.

- (2) A calculation of the total installed capacity required to meet the forecast 1990 loads. Separate calculations were made for each of the five generating system/load combinations indicated above and for two levels of required system reliability, 1 and 10 years operation per day of outage.

The two kinds of calculations established respectively the production cost benefit and the capacity displacement credit attributable to the hypothetical PVEPS plant and are described in Sections 2.5.5 and 2.5.6, respectively.

In the computer calculations, two PVEPS power profiles were employed to simulate the performance of actual PVEPS plants. These were hourly output profiles calculated for unconcentrated, convectively cooled silicon cells by Prof. Martin Wolf for Phoenix from 1962 insolation under fixed-tilt and two-axis tracking (normal orientation) conditions. Typical daily profiles are shown in Figure 2.5.2. The application of these results to the actual central power station designs developed under this contract is discussed in Sections 2.5.4.3 and 2.5.4.4.

All calculations utilized a data base composed of (1) the output of fixed and tracking silicon cells computed for the 1962 Phoenix insolation characteristics developed by the Aerospace Corporation; (2) the hourly loads experienced by the Salt River Project in 1974, which were simply scaled to represent the 1990 load variation; and (3) a hypothetical generating unit mix loosely approximating the future Salt River project Systems.

The photovoltaic cell output information is discussed in the following section, while the utility load and generation mix are described in Section 2.5.4.3.

2.5.4.2 Photovoltaic Plant Performance Data

The bulk of the utility calculations were carried out in parallel with the plant design studies, using two power profiles to represent the extremes of the expected CPS plant output shapes. For this purpose, the output of a single-crystal silicon cell was utilized under two orientations: (1) fixed tilt, at latitude angle (33.5

Curve 686618-A

Fig. 2.5.2 - PVEPS power output profiles on a clear day in Phoenix

degrees for Phoenix) and (2) two-axis tracking such that the cell is always maintained normal to the sun's rays. The profiles for these cases were shown in Figure 2.5.2. The cell output profiles in watts per square centimeter were calculated by Prof. Martin Wolf of the University of Pennsylvania using 1962 Phoenix insolation conditions and assuming operation at a load impedance varied continuously to maximize cell output power. The cell temperature difference above ambient dry bulb temperature for the assumed natural convection cooling mode was calculated by employing a heat transfer coefficient of 0.21 kW per square meter per degk. The normal and diffuse insolation and temperature were taken from data provided by Aerospace Corporation.

Table 2.5.7

Characteristics of Base Silicon Cell Output, Phoenix 1962

<u>Cell Orientation</u>	<u>Peak Output</u>	<u>Annual Integrated Energy</u>	<u>Annual Energy Divided by Peak Output*</u>	<u>Capacity Factor</u>
	$\frac{W}{m^2} = \frac{MW}{km^2}$	$\frac{kWh}{m^2}$	$\frac{kWh}{kW}$	
Fixed Tilt	195.0	377.9	1938	0.221
2-Axis	197.0	523.6	2658	0.303

The peak output occurred at noon, March 14, for both the fixed tilt and 2-axis tracking cells. Conditions at this time were optimum for a

* Note that this quantity in hour units represents the equivalent annual operating time at full power, about 5.3 hours/day for the fixed-tilt cell and 7.3 hours/day for the tracking cell. Actual operating times ranged from 10 hours (winter) to 12 hours (summer).

cell cooled by natural convection, with air temperature at 18C (32F) and high normal insolation ($.195 \text{ kW/m}^2$). The magnitude of the peak cell output per unit area was not used directly in the utility analysis. The hourly power outputs from the University of Pennsylvania were scaled to simulate the output of a fixed-tilt or two-axis tracking PVEPS with either 200 or 400 MW peak output at noon, March 14.

The two sizes were chosen to represent two levels of total PVEPS capacity in the reference utility generation system and may be thought of as representing two or four 100 MW PVEPS plants. The total PVEPS capacity was aggregated in the utility analysis. This is not expected to affect the production cost calculations. While unit size is generally important in reliability calculations, under the optimistic assumption made here (no mechanical or "non-solar" PVEPS outages), the PVEPS plant capacity was immaterial.

Many additional PVEPS output calculations were made by the University of Pennsylvania for various array design cell cooling options and for Si and CdS cells. These were utilized in the design and performance work done elsewhere under this contract but only one result of each of these calculations directly enters the present economic analysis: the annual integrated energy generation for each PVEPS Plant with specified peak output. (It was originally intended to repeat some of the utility simulations using additional output profiles but this was not possible in the available time). The results obtained here indicate the economics of the PVEPS plant are relatively insensitive to the hourly output profile within the range

studied. Thus, the error involved here is small relative to other uncertainties in the assessment.

2.5.4.3 Utility Data

Load and existing generation plants for several Southwest utilities were obtained from the Form 12 reports submitted to the U.S. Federal Power Commission. The FPC reports are an accessible data source for all utilities but are incomplete, consisting of only three weeks' hourly load data per year. To derive good average load shapes and other statistical parameters, a great deal more information is normally utilized in utility planning studies. In particular, the Westinghouse margin analysis methodology requires enough historical load information to derive the mean peak load and the variance in peak load over various seasons or months. Accordingly, the effort to utilize the FPC data base was discontinued when the Salt River Project made available to this study an extensive load history covering the years 1968-1974, and a variety of other planning data.

The cooperation of the Salt River Project greatly facilitated the present work and prompted us to focus the utility simulation effort on the configuration projected for the Salt River Project generation system.* It was expedient, however, to exclude the relatively large energy purchases made by the Salt River Project from federal hydroelectric projects. Because of the omission of these purchases and likewise of sales to

*The Arizona Public Service Company also supplied valuable data to this project. Although we would have liked to study the PVEPS plant in this system also, time did not permit.

other utilities in the present work, we would not expect that our detailed results would agree closely with those of the Salt River Project. As our purpose required only a representative Phoenix generation system we have not attempted to reconcile our results with those of the SRP.

Table 2.5.8 shows the generation mix derived for the base 1990 utility system. Unit sizes and outage rates are given in Appendix B.

Table 2.5.8

Reference Generating Unit Mix For a 1990
Phoenix-Area Utility

<u>Generation Unit Type</u>	<u>Total Installed Capacity</u>	
	<u>MW</u>	<u>% of Total</u>
Pondage Hydro	92	1
Pumped Hydro	872	14
Gas Turbines *	434	7
Combined-Cycle	292	5
Oil-Steam	539	9
Coal-Steam	2271	36
Nuclear	<u>1771</u>	<u>28</u>
TOTAL	6271	100

* Ten additional 50-MW units were added in the production cost calculation.

Hourly loads for the year 1990 were developed by scaling the actual loads experienced by the Salt River Projects in 1974 to the peak forecast developed by SRP under a medium growth scenario. Future sales and purchases were excluded in this projection. The ratio of the 1990 peak to the 1974 peak was 2.90, which is equivalent to a constant growth rate of 6.87%/year.

2.5.5 Production Cost Credit for the Central Station PVEPS

In order to calculate the saving in conventional fuel and O&M resulting from the addition of a central station PVEPS to the reference utility generating system, the sequence of calculations diagrammed in Figure 2.5.3 was employed.

As the first step (Block A in the diagram), the 8760 hourly load values were scaled by a factor of 2.90. Next, hourly load values for the output of a single crystal cell under either fixed or tracking orientation were read from the tapes provided by Prof. Wolf. These values, in milliwatts per square centimeter, were scaled to obtain the power produced by a square kilometer of cell surface, bringing the annual peak outputs to 195 MW and 197 MW, as shown in column one of Table 2.5.7. The scaled PVEPS outputs were then subtracted from the hourly loads. The preceding steps were also repeated with twice the cell area to simulate the electrical output of a nominal 400 MW capacity PVEPS, or four 100 MW PVEPS units. The preceding steps were performed with a simple Fortran program.

The reduced hourly loads were then passed to Westinghouse production costs programs in Steps B and C. The major computer program

Figure 2.5.3

Calculation Sequence Used to Determine PVEPS Fuel and O&M Credits

utilized (The Westinghouse Daily Production Cost Program) simulates the hourly economic dispatch of a generation system over one year. The kWh generation is accumulated by unit category and fuel use is evaluated by fuel type.

2.5.5.1 Fuel Cost Credit

Tables 2.5.9 and 2.5.10 indicate the reduction in thermal fuel use in the reference system per unit PVEPS electric energy output. These were calculated from the simulations for 400 MW PVEPS penetration. The calculated effects were nearly proportional to PVEPS energy up to this penetration level, as was illustrated in Figure 2.5.1 in the case of oil.

Under the assumed conditions, the oil-fired intermediate and peaking units saw relatively little service, so that the bulk of the fuel saving consisted of the abundant, inexpensive baseload fuels coal and nuclear heat. This result is perhaps unduly pessimistic relative to two important features of photovoltaic power, its impact on oil resource depletion and the saving in fuel cost to the utility. The choice of a utility generating mix with a higher penetration of oil-fuel capacity, a more favorable seasonal load variation, or a smaller capacity margin would improve the picture. Although the conditions described here are pessimistic, they are counteracted to some extent by the fact that PVEPS mechanical outages were neglected (leading to an annual energy output which may be 5 to 10% too high.*

*To a limited extent, a more detailed representation of unit maintenance would have increased the generation by peaking units. A simplifying assumption made here was that unit forced and planned outages were uniformly distributed throughout the year.

Table 2.5.9

Calculation of System Fuel Cost Saving for a
Hypothetical PVEPS Fixed-Tilt Plant

PVEPS Annual Energy: 1938 kWh per kW peak capacity

Fuel Type	1990	Fuel Saving		Fuel	PW in 1990	
	Fuel	Per Unit		Escalation	of 30 years'	
	Price	PVEPS Peak		Rate	Private	Public
	<u>\$</u>	<u>MMBTU</u>	<u>\$</u>	<u>%</u>	<u>1990\$</u>	<u>1990\$</u>
	<u>MMBTU</u>	<u>kW</u>	<u>kW</u>	<u>Year</u>		
A. Moderate Fuel Cost Scenario						
1. • oil	5.00	5.10	25.50	8	566	849
2. • coal	1.20	17.31	20.77	5	328	464
3. • nuclear	1.00	3.57	3.57	5	<u>56</u>	<u>80</u>
4. • total PW credit toward PVEPS capital cost, 1990 (1990\$)					950	1393
5. • equivalent reduction in capital cost in 1975 (1975\$) (line 4 divided by 2.03)					468	687
B. High Fuel Cost Scenario						
1. • oil	6.00	5.10	30.60	8	679	1019
2. • coal	1.80	17.31	31.16	6	548	791
3. • nuclear	1.20	3.57	5.00	8	<u>111</u>	<u>166</u>
4. • total PW credit toward PVEPS capital cost, 1990 (1990\$)					1338	1976
5. • equivalent reduction in capital cost in 1975 (1975\$) (line 4 divided by 2.03)					659	974

Table 2.5.10

Calculation of System Fuel Cost Saving for a Hypothetical PVEPS
Two-Axis Tracking Plant

PVEPS Annual Energy: 2658 kWh per kW peak capacity

Fuel Type	1990	Fuel Saving		Fuel Escalation Rate	PW in 1990 of 30 years' Fuel Savings	
	Fuel Price	PVEPS Peak	Per Unit		Private	Public
	<u>\$</u> MMBTU	<u>MMBTU</u> kW	<u>\$</u> kW	<u>%</u> Year	1990\$	1990\$
A. Moderate Fuel Cost Scenario						
1. • oil	5.00	6.54	32.70	8	726	1098
2. • coal	1.20	26.58	31.90	5	503	713
3. • nuclear	1.00	4.81	4.81	5	<u>76</u>	<u>108</u>
4. • total PW credit toward PVEPS capital cost, 1990 (1990\$)					1305	1910
5. • equivalent reduction in capital cost in 1975 (1975\$) (line 4 divided by 2.03)					643	941
B. High Fuel Cost Scenario						
1. • oil	6.00	6.54	39.24	8	871	1307
2. • coal	1.80	26.58	47.84	6	842	1215
3. • nuclear	1.20	4.81	6.73	8	<u>149</u>	<u>224</u>
4. • total PW credit toward PVEPS capital cost, 1990 (1990\$)					1862	2746
5. • equivalent reduction in capital cost in 1975 (1975\$) (line 4 divided by 2.03)					918	1353

The same dispatch of generation plants was used for both sets of fuel prices; some error is incurred thereby, but it should be acceptably small relative to other sources of uncertainty.

In the computer calculation, only one year (1990) was simulated. To obtain the total capitalized credit for all of the fuel saved during the service life of the photovoltaic plant it was assumed that the annual savings in energy units would be constant but that the value of the displaced fuels would escalate. The calculation may be illustrated for the first line of Table 2.5.9. For each kilowatt of installed capacity a PVEPS plant with the fixed-tilt cell profile will displace 5.1 MMBTU of oil energy, worth \$25.50 in 1990 (in 1990 dollars). Assuming equal fuel savings in each of 30 years' plant operation, multiply the annual saving by a present worth factor of 22.20 to obtain the present worth of all fuel savings in a privately-owned utility. This factor is derived in Appendix A, Table A-1 for a 30 year interval, 10%/yr discounting and escalation. The last column of Table 2.5.9 gives the corresponding result of the 7% discount rate employed to represent a publicly financed utility.

The present worth credits obtained by this procedure are referred to the plant startup year of 1990 and are in 1990 dollars. Since the PVEPS plant costs were evaluated in this study on the basis of present-day prices, it is necessary to escalate the plant cost in order to make them comparable. An escalation rate consistent with our assumption of a long-term inflation rate is 5.0%/yr. Rather than escalate the plant cost to 1990 we have chosen to de-escalate the credits

attributed to the PVEPS plant to a mid-1975 cost basis. Accordingly the present worth fuel savings have been divided by a factor of $1.05^{14.5} = 2.03$ to translate them into current costs.

The final step in the calculation of the fuel savings for the selected PVEPS designs was to scale the savings according to the annual energy production calculated for each concept per unit of installed capacity. The resulting credits are tabulated in Tables 2.5.3 and 2.5.4. For example, the windrow design using CdS cells was estimated to produce 165,000 MWh annually and to reach a peak output of 100 MW. The output energy per unit of installed capacity is the 1650 MWh/MW. Using public financing and the moderate fuel costs, the hypothetical PVEPS using a fixed-tilt Si array generated 1938 kWh/kW and was attributed a fuel saving credit of 687 \$/kW in Table 2.5.9. The CdS windrow plant design is therefore estimated to have a fuel credit of

$$\frac{687 \text{ $/kW} (1650)}{1938} = 585 \text{ $/kW}$$

These energy scalings were performed for each of the candidate plants, using the credit calculations for the fixed-tilt Si cell profile as the basis for evaluating lean-to and windrow CPS designs with either Si or CdS cells. The credit calculated for the two-axis tracking profile was taken as the basis for evaluating the vertical axis-tracking plants. The error in applying the reference profile credits to plants of slightly different output profiles is believed to be negligible in light of the close agreement in fuel displacement per kWh of PVEPS generation for the very different fixed-tilt and two-axis tracking power output profiles.

2.5.5.2 Operating and Maintenance Cost Credit

The reduced operating hours for conventional units on the generating system produce an additional cost saving, namely, a reduction in the variable or energy-dependent component of the plant O&M costs.*

To calculate this saving we need to know the amount of generation displaced by unit type. This is provided by the production cost program and is shown in Table 2.5.11. Representative values for the variable O&M cost in 1990 are then multiplied by these energies to give the O&M credit for the single year 1990. Summing a central power station PVEPS with the fixed-tilt Si cell profile produces a net saving of 5.7\$ or 2.9\$ for each MWh of electricity generated by the PVEPS. A somewhat higher credit is obtained (in absolute terms) for the two-axis tracking profile because of its greater annual energy production. On a kWh basis however, the displacements were sufficiently similar to produce essentially the same credit. This result permits the extension of these results to the selected concept designs without concern for the different output profiles of each concept.

The development of a present worth credit for all displaced O&M costs, shown in Table 2.5.12 is similar to the procedure used for summing displaced fuel credits. Again the present worth credits are translated to an equivalent mid-1975 basis by de-escalating at 5%/year.

*The operation of the PVEPS naturally entails O&M expense also; here we do not subtract this from the conventional plant O&M credit but simply calculate the credit external to the PVEPS. The O&M cost for the PVEPS is separately treated and is summarized in Tables 2.5.1 and 2.5.2.

Table 2.5.11

Calculation of Savings in Conventional Plant
O&M Expense in 1990 Due to the PVEPS

Unit Type	Annual Generation Displaced Per		Unit Variable O&M Cost In 1990 \$ MWh	O&M Savings In Mid-1990	
	kW Peak PVEPS Fixed-Tilt Profile MWh	Capacity Two-Axis Profile MWh		Per kW Peak PVEPS Fixed-Tilt Profile 1990\$	Two-Axis Profile 1990\$
Gas Turbine	0.16	0.24	5	0.80	1.20
Combined Cycle	0.10	0.16	3	0.30	0.48
Oil-Steam	0.19	0.11	2	0.38	0.22
Coal	1.16	1.70	3	3.48	5.10
Nuclear	0.37	0.45	2	0.74	0.90
Pumped Hydro	<u>-0.04</u>	<u>0.00</u>	0	<u>0.00</u>	<u>0.00</u>
TOTALS	1.94	2.66		5.70	7.90
Savings per MWh PVEPS Output				2.9	3.0

Table 2.5.12

Present Worth of Lifetime Savings in
Conventional Unit O&M Cost Due to PVEPS Operation

PVEPS Power Profile	Annual PVEPS Energy kWh	Total O&M Savings in Mid-1990 1990\$	P.W. on 1/1/1990 of all O&M Savings (5%/yr O&M Escalation)*		Equivalent 1975 PVEPS Capital Cost Credit**	
			Public 1990%	Private 1990\$	Public 1975\$	Private 1975\$
Fixed-Tilt Si Cell Profile	1938	5.7	127	90	63	44
2-Axis Tracking Si Cell Profile	2658	7.9	177	125	87	61

*See Table A-1 for present worth factors at 7%/yr (public) and 10%/yr (private).

**De-Escalated from 1/1/1990 to 6/1/1975 at 5%/year, or a factor of
1.05^{14.5} = 2.03.

As the final step the resulting credits for the two hypothetical profiles were scaled on the basis of PVEPS annual energy output to obtain the results shown in Tables 2.5.3 and 2.5.4.

2.5.6 Capital Displacement Credit for the PVEPS

To the extent that the central station PVEPS can reliably replace conventional generating units, it may be credited with the capital and fixed costs associated with those plants. The operative word here is "reliably", since the amount of generation capacity installed by utilities reflects a calculation of the risk of having insufficient capacity to meet the load.

To evaluate the allowable reduction in installed conventional generating capacity the sequence of calculations indicated in Figure 2.5.4 was performed. As in the production cost analysis, the output of PVEPS was subtracted from the actual load. The operation of the conventional generation system to meet the reduced hourly loads was then analyzed by the standard probabilistic technique developed by Westinghouse to assess generation system reliability. This procedure begins with an analysis of historical daily peak loads to extract the parameters of a normal distribution fitting the observed peak load data for 1974. (The normality of the daily peak loads was confirmed by plotting the ranked loads on probability paper.) The density function for the available capacity was developed by the Westinghouse Capacity Model from the list of unit sizes, planned outage rates and forced outage rates. The distribution of margin (capacity minus load) was then developed and the combined probability of all negative

Figure 2.5.4

Calculation Sequence Used to
Determine PVEPS Capacity Credit

margin events computed. Planned maintenance was scheduled throughout the year to tend to equalize the risk of loss-of-load; during the time of the annual peak no units were placed on schedule maintenance.

To summarize, conventional loss-of-load probability estimates were made for the same reference generating system at two load levels. The Capacity Model also computes the capacity additions required to meet the specified system reliability criterion. The capacity additions were specified to be 50 MW gas turbine units.

The calculations were done at two levels of PVEPS penetration, with aggregate PVEPS capacities of 200 and 400 MW. Table 2.5.13 shows the results at the latter penetration level.

The table indicates that virtually no reduction in margin (i.e., peaking capacity) could be credited to a fixed-tilt array without storage. Basically, the PVEPS in this case produced so little power during the time of the summer peak load (about 6 p.m.) that the net load seen by the conventional units was unchanged. Figure 2.5.5 shows this for the day of load peak. This figure does not convey the adverse effect of insolation statistical variation. If the solar plant output is substantially reduced during the afternoon peak period, the risk of insufficient generation capacity (loss-of-load probability) rises to the level with no PVEPS capacity. Because of the exponential dependence of LOLP on capacity margin, insolation outages can negate much of the capacity credit which might otherwise accrue to the PVEPS.

For a tracking array, the situation improves, but the capacity displaced is still only about one-third of the PVEPS peak rating. The

Table 2.5.13

Peaking Capacity Displacement By a Central
Station PVEPS, Phoenix 1962 Insolation

Basis: 400 MW PVEPS Maximum Penetration

Item	Fixed-Tilt Si Cell Profile		Two-Axis Tracking Si Cell Profile	
	<u>1 year</u> day	<u>10 year</u> day	<u>1 year</u> day	<u>10 year</u> day
<u>Installed Capacity Margins</u>				
Reference system (zero MW, PVEPS)	1417	1975	1417	1975
Reference system plus 400 MW PVEPS	1404	1968	1290	1833
Reduction	13	7	127	142
Reduction in installed capacity margins per MW PVEPS capacity	0.033	0.018	0.318	0.355

Fig. 2.5.5 – Hourly load carried by conventional generating units before and after addition of a CPS on the day of the system load peak

preceding results are indicative only of the magnitude of the capacity credit in that the calculations considered only one year's insolation (1962) in relation to one year's load trend (1974, scaled by a factor of 2.90 to simulate the expected 1990 load). A multi-year comparison would be distinctly preferable. It may also be noted that the conventional utility technique is governed only by the load peak occurring each day: it should be determined whether a calculation of loss-of-load probability on an hourly basis would develop a significantly greater credit. Presumably, the credit would increase since the system reliability in off-peak hours will improve.

From the standpoint of the seasonal variation in load shape, the reference system chosen tends to accentuate the benefit of the PVEPS. That is, the system annual load peak occurs in the late daylight hours in the summer when the PVEPS is active. During the winter the load peak occurs after sundown, but this is relatively unimportant because the absolute load peaks are then low, as shown in Figure 2.5.6.

The present calculation is in one sense optimistic in that PVEPS forced outages of non-solar origin are ignored. Also, no storage is assumed here for the PVEPS: if this were added, the forced outage rate might well be below that for a conventional generating plant. Conceivably a PVEPS with storage might earn a higher credit, but it is not obvious that the added cost of the storage facility could be justified.

- Basis— 1. Phoenix 1962 Insolation and Temperature
2. Salt River Project 1974 Loads, Scaled to 1990

Legend

- Original Peak Loads in Each 4-Week Period
- Maximum Period Net Demand With 400 MWp Fixed Tilt CPS
- △ Max. period Net Demand With 400 MWp 2-Axis Tracking CPS

Fig. 2.5.6. —Effect of the CPS in reducing the peak demand seen by conventional generation.

To convert the capacity displacement in units of gas turbine capacity to economic terms, one must identify the total saving to the utility per MW of displaced capacity. This amounts to the present worth of all capital charges, which substantially exceeds the gas turbine plant investment. The two quantities are in the ratio 1.70 under the private financing assumption and 1.49 under public financing. These numbers result from multiplying the respective annual fixed charge rates of 0.18 and 0.12, respectively by the present worth factors given in Appendix A for 10 and 7% discounting, assuming a 30 year life. No gas turbine fuel credits are introduced here as these were included in the production cost credit.

Table 2.5.14 summarizes the conversion of the capacity credit to the PVEPS to economic terms. The results proved to be small in comparison to the production cost credit. These credits were taken to be proportional to PVEPS rated capacity rather than energy and therefore were applied directly to the corresponding CPS designs in the final summation of benefits.

To complete the discussion Table 2.5.15 shows the capacity displacements obtained at the 200 MW penetration level and at a more stringent reliability criterion. In contrast to the production cost analysis, the effect of penetration appears to be pronounced, i.e. the second 200 MW of PVEPS capacity produced little further benefit. It was surprising to see such a strong saturation effect at a PVEPS penetration amounting to only 6% of the total generation. The relatively late afternoon load peaking in the SRP system tended to occur at a time

Table 2.5.14

Calculation of Capacity Credit for a
Central Station PVEPS, 1990 Phoenix Startup

Basis: 1 Year/Day Reliability Criterion
400 MW Penetration

Item	Fixed Tilt Si Cell Profile	Two-Axis Tracking Si Cell Profile
1. Peaking capacity displaced per kW PVEPS capacity	0.033	0.318
2. Peaking plant investment (displaced per kW PVEPS (line 1 x 400\$/kW)	13\$	127\$
3. P.W. of all peaking plant capital charges displaced (credit toward 1990 PVEPS cost)		
a. Private financing (1.6968 times Line 2)	22\$	215\$
b. Public financing (1.4891 times Line 2)	19\$	189\$
4. Capacity credit referred to mid-1975 construction costs. (Line 3a or 3b divided by 1.05 exp 14.5 = 2.03)		
a. Private financing	11\$	106\$
b. Public financing	10\$	93\$

Table 2.5.15
Results of Capacity Analysis

Nominal CPS Capacity	Annual Risk Reliability Criterion (years/day)	Required Installed Capacity Margin (MW)	Incremental Decrease in Margin Assoc. with Each 200 MW CPS (MW)	Incremental Margin Derived per MW of CPS Capacity (MW)
<u>Base Case</u>				
Zero	1.0	1417	--	--
	10.0	1975	--	--
<u>Two-Axis CPS</u>				
200 MW	1.0	1330	87	0.44
	10.0	1876	99	0.50
400 MW	1.0	1290	40	0.20
	10.0	1833	43	0.22
<u>Fixed-Tilt CPS</u>				
200 MW	1.0	1425	-8	-0.04
	10.0	1972	3	0.02
400 MW	1.0	1404	21	0.11
	10.0	1968	4	0.02

the PVEPS plant output was failing in magnitude and reliability; this may have aggravated the effect of PVEPS outages.

Another surprising result was that the application of a high reliability goal did not adversely affect the capacity credit calculated for the PVEPS.

The preceding results were expressed on a per-kilowatt peak basis reflecting the generally linear relationship of utility capacity cost benefits over the range examined; up to 6% of the system generating capacity. Table 2.5.15 shows the results obtained for 200 MW and 400 MW PVEPS capacity increments added to a base conventional generating system of 6271 MW capacity. The limited penetration levels studied here relate to the study emphasis on the 1990 startup period for the PVEPS plant.

A different approach was pursued briefly, that of allowing the CPS to displace conventional intermediate and baseload capacity, as implied in the results obtained by The Aerospace Corporation for residential PVEPS units with storage. In this calculation the PVEPS was combined with a backup gas turbine plant of equal rating to synthesize a hypothetical station with an availability comparable to the displaced thermal plants.

The results of this effort were negative although they are not conclusive. The basic difficulty is that even if one attempts to replace a costly generating unit at low annual use, say 1000 hours, the fuel for backup gas turbine is too expensive.

The results obtained in this exploratory work suggest that a capacity credit cannot be estimated definitively without performing duplicate expansion plans with and without the installation of PVEPS under a specified reliability criterion to unambiguously determine how much credit is possible. The apparent difference between the preliminary results found here and the prior estimates of The Aerospace Corporation would tend to indicate the importance of further work in this area.

2.5.7 Suggestions for Further Utility Analysis of the PVEPS

Although substantial fuel saving credits were found for the PVEPS, the capacity credits derived in this work were relatively small. In other words, the utility investment in conventional capacity would not be appreciably reduced by adding the PVEPS, which itself is a high capital-cost plant. Since the economic position of the PVEPS is marginal in the absence of a capacity credit, the viability of the PVEPS may depend upon this factor. Five related efforts are indicated:

- (1) Comparison with published work: a careful comparison should be made between the methods, assumptions and conclusion reached here and the prior work of The Aerospace Corporation, Southern California Edison and others. Although the SCE study, currently in progress, specifically deals with solar thermal plants it resembles the present work in several respects.

- (2) Extension of the solar model: a refinement of the standard utility model to treat loss-of-load on an hourly basis is indicated.
- (3) Extension of the data base in time: a multi-year analysis of both insolation and utility hourly loads should be made to better define the hourly margin (installed capacity minus load) for the conventional system. Use of a shorter time interval for the insolation record might be useful also.
- (4) Expansion planning: when a capacity credit is established solely on the basis of a margin analysis, as in this work and in most previous studies, a subjective factor enters in the identification of the type of generating unit displaced by the PVEPS plant. Here it was assumed that the PVEPS plant would influence the amount of peaking capacity. That is, the total capacity required in the form of 50 MW gas turbine units was computed with and without the presence of the PVEPS plant in the generating system. This capacity difference was then multiplied by the capital cost of the gas turbine plant to obtain a dollar capacity credit to the PVEPS. A more refined procedure would entail developing a multi-year expansion plan with and without the PVEPS capacity on the basis of some objective criterion, e.g., minimizing the present worth of all capital and

production costs, as is done in the Westinghouse GENOP computer program. The difference in the present worth of the two plans would then be taken as the PVEPS capacity credit. (The GENOP formulation will also allow the expansion to be made under an imposed capital constraint while still minimizing the present worth of all revenue requirements.)

- (5) Analysis of a CPS-with-storage: to settle the relative economics of on-site versus system bulk electric storage, comparable utility simulations are required of each.
- (6) Further PVEPS utility simulations: utility simulations using the plant output characteristics for selected PVEPS design concepts may deserve a modest effort to verify the approach used here.

In addition to further work on CPS reliability and capacity credit, generalizations of this work are needed to assess the PVEPS option. Some of these are as follows:

- (1) Extension of the utility data and fuel cost data: the production cost and resource benefits of the PVEPS depend largely on the displacement of premium fuels. Variations in the generation mix may strongly influence the economic position of the PVEPS in a given utility.
- (2) Geographical and penetration analysis: analyses treating regional insolation characteristics and a parametric investigation of higher CPS penetration levels

are obvious prerequisites to assessing the PVEPS option as a national resource for electricity production.

- (3) Dispersion effects: CPS plants dispersed over a utility's service area may experience time-correlated but non-simultaneous insolation outages, affecting plant reliability.
- (4) Sensitivity study: Within the framework of the present study, all costs and credits are expressed as explicit functions. A study of the sensitivity of the results to the input parameters: cell life, insolation intensity, fuel cost can therefore be made with relatively small effort.

APPENDIX A

Miscellaneous Financing Equations

In this appendix we collect a few formulas used in the analysis, to make the economic calculations completely explicit. The end result of the calculations described here was presented as the cost of owning an isolated PVEPS plant in Tables 2.5.1 and 2.5.2. Table A-2 of this appendix derives the entries of these tables line by line. (We have noted elsewhere that the presence of the PVEPS favorably impacts the owner's expense external to the PVEPS; these impacts are calculated as the benefit to the owner in Section 2.5.3.1 and are compared to the costs in Section 2.5.3.3).

A.1 Present Worth Factor for Capital

The present worth (PW) of a series of n annual year-end payments of A is given by the expression

$$PW = A \frac{(1+d)^n - 1}{d(1+d)^n}$$

A = annual payment

d = discount rate, normally equal to the average cost of money

(A-1)

This formula was utilized to find the PW of the revenue requirements for plant capital investments, or PW_C . Further, the annual capital

requirement was taken to be a constant fixed charge rate f times the initial plant investment (including IDC), I :

$$A_C = fI \quad (A-2)$$

Assuming (or more precisely, defining) the result to be a year-end value, we can substitute it in (A-1) to obtain

$$PW_C = fI \frac{(1+d)^n - 1}{d(1+d)^n} \quad (A-3)$$

for the PW of all capital requirements at the start of the first year of plant operation.

We have used the following numerical values in this analysis:

$$\begin{aligned} d &= 7\%/yr \text{ (public financing)} \\ &= 10\%/year \text{ (private financing)} \end{aligned}$$

$$n = 30 \text{ years}$$

$$\begin{aligned} f &= 12\%/yr \text{ (public financing)} \\ &= 18\%/yr \text{ (private financing)}. \end{aligned}$$

giving

$$\begin{aligned} PW_C &= 1.48908 I \text{ (public financing)} \\ &= 1.69684 I \text{ (private financing)} \end{aligned}$$

As a consequence of the stated assumptions, the PW of capital costs are about 14% higher under private financing, a difference which is unfavorable to the capital-intensive PVEPS plant.

A.2 Present Worth of O&M and Fuel Expenses

The annual expenses for O&M and fuel are in general not constant annual amounts because of escalation. In addition these amounts are distributed throughout the year. Although they could be handled as uniform monthly amounts we will approximate them by a single lumped annual payment at mid-year. If the escalating O&M or fuel cost is evaluated at that time, the PW is extremely close to that obtained by a monthly calculation.

Let A_1 be the first mid-year* annual payment, which already includes 6 months' escalation from the time of plant startup. The ensuing payments are assumed to escalate annually by a factor $(1+e)$:

$$\begin{aligned} A_2 &= (1+e) A_1 \\ &\vdots \\ A_n &= (1+e) A_{n-1} = (1+e)^{n-1} A_1 \end{aligned} \quad (A-4)$$

Here e is the annual escalation (per unit), not the base of natural logarithms. The PW of the escalating series over n years at discount rate d and escalation rate e is:

$$\begin{aligned} PW_{n,d,e} &= \frac{A_1}{(1+d)^{0.5}} + \frac{(1+e)A_1}{(1+d)^{1.5}} + \dots + \frac{(1+e)^{n-1}A_1}{(1+d)^{n-0.5}} \\ &= \frac{A_1}{(1+d)^{0.5}} \left[1 + \left(\frac{1+e}{1+d} \right) + \dots + \left(\frac{1+e}{1+d} \right)^{n-1} \right] \end{aligned}$$

* "Mid-year" here designates the mid-point of the operating year, not necessarily June 1.

$$= A_1 \frac{(1+d)^{0.5}}{d-e} \left[1 - \left(\frac{1+e}{1+d} \right)^n \right] \quad d \neq e \quad (A-5)$$

$$= \frac{n A_1}{(1+d)^{0.5}} \quad , \quad d = e \quad (A-6)$$

With zero escalation, (A-5) becomes

$$PW_{n,d,0} = A_1 \frac{(1+d)^{0.5}}{d} \left[1 - \left(\frac{1}{1+d} \right)^n \right] \quad (A-7)$$

Levelizing formulas may easily be derived to obtain the constant annual payment mid-year which gives the same PW as an escalating mid-year payment. (A-5) or (A-6) must first be applied to find the PW. Then we rewrite (A-7) with the unknown constant payment designated A_L

$$PW_{n,d,e} = A_L \frac{(1+d)^{0.5}}{d} \left[1 - \left(\frac{1}{1+d} \right)^n \right] \quad (A-8)$$

$$= A_L \frac{PW_{n,d,0}}{A_1} \quad (A-9)$$

From (A-9) the ratio of the levelized annual cost to the actual first year cost is

$$\frac{A_L}{A_1} = \frac{PW_{n,d,e}}{PW_{n,d,0}} \quad (A-10)$$

Table A-1 gives a few values for the present worth factor computed from (A-5) or (A-6) and for the levelizing factor from (A-10).

Table A-1

Numerical Values for Present Worth and
Cost-Levelizing Factors Assuming
30 Mid-Year Payments

Escalation Rate e	Public Financing ($d = 7\%/yr$)		Private Financing ($d = 10\%/yr$)	
	$\frac{PW}{A_1}$	$\frac{A_L}{A_1}$	$\frac{PW}{A_1}$	$\frac{A_L}{A_1}$
0	12.8360	1.0000	9.8879	1.0000
3	17.6144	1.3723	12.8988	1.3046
4	19.7891	1.5417	14.2310	1.4394
5	22.3556	1.7416	15.7807	1.5961
6	25.3941	1.9784	17.5898	1.7791
8	33.2978	2.5941	22.1993	2.2453
10	44.5681	3.4713	28.6039	2.8931

A.3 IDC Formula

The plant investment placed on the utility books includes the accrued interest on the payments during the construction period. For the special case of equal monthly construction costs and zero escalation during construction, assumed here for simplicity, the total (or "future") value of the progress payments at the time of plant startup is

$$I = \frac{I'}{n} \left[(1+i_m)^{n-1} + (1+i_m)^{n-2} + \dots + (1+i) + 1 \right]$$

$$= \frac{I'}{n} \frac{(1+i_m)^n - 1}{i_m} \quad (A-11)$$

where I = total capital investment including IDC

I' = the plant investment excluding IDC

n = construction period, months

i_m = monthly interest rate

If the yearly interest rate is i , we compute an equivalent monthly rate from

$$(1+i_m)^{12} = 1+i \quad (A-12)$$

Substituting in (A-11),

$$I = \frac{I'}{n} \frac{(1+i)^{\frac{n}{12}} - 1}{(1+i)^{\frac{1}{12}} - 1} \quad (A-13)$$

If N is the construction period in years, so that $n = 12N$, (A-13)

may be written

$$I = \frac{I'}{12N} \frac{(1+i)^N - 1}{(1+i)^{12} - 1} \quad (A-14)$$

The IDC alone is obtained if needed as the different $I - I'$.

The quantity I' is the installed cost of equipment including equipment cost, construction labor and materials, engineering and overhead and contingency allowance. In this project the installed equipment cost was first estimated, then increased 20% for indirect costs and 10% for contingencies - a total of 30% over installed cost.

Example 1:

$$n = 24, N = 2$$

$$i = 8.5\% \text{ (Private Financing)}$$

$$\frac{I}{I'} = \frac{1.085^2 - 1}{24(1.085^{1/12} - 1)} = 1.08252 \quad (A-15)$$

$$\frac{IDC}{I'} = \frac{I - I'}{I'} = 0.08252$$

Example 2:

$$n = 24, N = 2$$

$$i = 7.0\% \text{ (Public Financing)}$$

$$\frac{I}{I'} = \frac{1.07^2 - 1}{24(1.07^{1/12} - 1)} = 1.0678 \quad (A-16)$$

Comparing the two examples the plant investment with IDC under private financing is greater by 1.4% for the same installed cost I'.

A.4 Calculation of Levelized Energy Cost

The sequence of calculations used to derive the annual revenue requirement, or "cost of ownership" for the PVEPS plant is detailed in Table A-2. This table corresponds to the format of Tables 2.5.1 and 2.5.2 which present annual cost and cost per unit PVEPS electric energy generated.

The procedure is basically the standard revenue requirement approach used throughout the utility industry, although the mid-year present worth formulas add some additional complication.

Table A-2

Numerical Basis for Ownership Cost Estimates
Developed in Tables 2.5.1 and 2.5.2

Basis: Plant Investment for 1 kW Peak PVEPS Capacity (1975\$)

Item	Eqn. Used	Public Financing	Private Financing
A. CAPITAL COSTS			
1. Plant investment less IDC (installed equipment cost times 1.30)		I'	I'
2. IDC: 24 months, equal monthly payments, interest = 7% (public), 8.5% (private)	A-15 A-16	0.0678 I'	0.0825 I'
3. Total capital investment at start of service, I	A-11	1.0678 I'	1.0825 I'
4. Annual capital charge, end-of-year basis = (FCR) (I)	A-2	0.12 I	0.18 I
5. PW factor for 30 years, end-of-year payments	A-1	12.409	9.4269
6. PW of 30 years' capital charges = (Item 4) (Item 5)	A-3	1.48908 I	1.69684 I
7. Annual capital charge referred to mid-year basis $FCR_M \cdot I = \frac{FCR \cdot I}{(1+d)^{0.5}}$		0.11601 I	0.17162 I
B. O&M EXPENSES			
8. First year's O&M expense (assumed at mid-year, A)		0.01 I	0.01 I
9. PW of 30 years' O&M, mid-year payments, 5%/year escalation (see Table A-1)	A-5	0.22356 I	0.15781 I
10. Same without escalation	A-7	0.12836 I	0.09887 I
11. Levelizing Factor Item 10 ÷ Item 9	A-10	1.7416	1.5961
12. Levelized annual O&M expense mid-year. Item 11 x Item 8		0.01746 I	0.015961 I
C. TOTAL REVENUE REQUIREMENTS			
13. Annual revenue requirement mid-year, O&M escalation assumed Item 7 + 12. Note 1kW capacity basis		0.13343 I	0.18758 I
14. Levelized energy cost, mill/kWh 1000 x Item 13 (rev. reqt/yr-kW _p + (annual energy/kW _p))		See Tables 2.5.1, 2.5.2	
15. Annual revenue requirement mid-year, no escalation Item 7 + Item 8		0.12601 I	0.18162 I
16. Levelized energy cost, mill/kWh 1000 x Item 15 + (annual energy/kW _p)		See Tables 2.5.1, 2.5.2	

APPENDIX B

Reference Generating System

Table B-1 shows the manner in which the existing and planned generating plants of the Salt River Project were aggregated in the computer calculations. The total capacity of each type was previously given in Table 2.5.8.

Table B-2 gives the planned and expected forced outage rate data used in the reliability analysis.

Table B-1

Base Generating System

Generation Type	Rating ⁽¹⁾ MW	Number of Units	Station Name
Pondage Hydro	92	1	Aggregate of existing units
Pumped Hydro	872	1	Aggregate of existing and planned units
Gas Turbines	62 50	7 10	Simulates existing units. Added units to meet reli- ability criteria
Combined Cycle	73	4	Santan 1,2,3,4
Oil Steam	179 90	1 4	Agua Fria 3, Kyrene cross- cut units
Coal-Steam	350 200 163 110 78	3 1 3 2 4	Coronado 1,2,3 Hayden 2 Navajo 1,2,3 Craig 1,2 Four Corners 4,5 Mohave 1,2
Nuclear	357 350	3 2	Palo Verde 1,2,3 Future nuclear addition, speculated

⁽¹⁾ SRP share only

Table B-2
Typical Reliability Inputs

	<u>Forced Outage Rate</u>	<u>Maintenance Outage Rate</u>	<u>Availability</u>
Gas Turbines	0.10	0.04	0.86
Combined Cycle	0.11	0.04	0.85
Oil-Steam			
179 MW units	0.04	0.08	0.88
90 MW units	0.02	0.08	0.90
Coal Steam	0.13-0.16	0.10	0.74-.77
Nuclear			
Mature units	0.12-0.14	0.13	0.73-0.75
Immature units	0.18-0.26	0.13	0.61-0.69
Pondage Hydro	0.01	0.00	0.99
Pumped Hydro	0.02	0.00	0.90

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2.6 Financial Analysis Methodology

2.6.1 RPS

The background material relating to the costs of the various subsystems which comprise the RPS is presented in Volume III(1). For each of the seven sites considered and each of the four load cases considered for each site, optimum array and battery sizes were chosen using a cost/performance criterion utilizing incremental financial analyses techniques.

After appropriate array and battery sizes were chosen, the entire system cost was found and a Figure-of-Merit (F_M) devised which characterized the capital cost of the system divided by the annual amount of energy saved. The Figure-of-Merit for each system was then related to the cost of energy to establish economic viability of a given type of system installed in a given year at a given location. Descriptions of the methodologies used are presented in the following sections.

2.6.1.1 Optimum Sizing Methodology

Using computersimulations of the residential systems, curves relating the percentage of the electrical energy supplied by solar energy to either array area or battery capacity were derived for all types of loads in all seven locations. These curves all have characteristic forms which include two straight line segments connected by a knee as shown in Figures 2.6.1, 2.6.2, and 2.6.3. The techniques used to obtain these curves and complete results for all loads and all sites are presented in Section 2.1 of this volume.

Incremental financial analysis techniques can be used to determine optimum array area or battery capacity when used in the

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PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 1 - A INSOLATION DATA - NOMINAL LOAD 2

Figure 2.6.1

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PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 1 - A INSOLATION DATA - NOMINAL LOAD 2

Figure 2.6.2

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PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

CASE 1 - A INSOLATION DATA - NOMINAL LOAD 2

Figure 2.6.3

following way. Consider Figure 2.6.1 which relates percent solar energy to battery storage capacity. Each kilowatt-hour of energy storage capacity added to the system costs a certain amount. When the system storage capacity is near zero, the addition of another kilowatt-hour of capacity increases the amount of energy supplied by solar energy by a large amount because the slopes of the curves are high.

However, when another kilowatt-hour of energy storage capacity is added to a system already containing a significant amount, say 20 kilowatt-hours, the incremental increase in percentage of energy supplied by solar is quite small because the slopes of the curves are much smaller than they were near to the origin.

As kilowatt-hours of battery storage capacity are added incrementally, a point is reached at the knee of the curve where the cost of the utility electrical energy displaced by the added battery capacity over the life of the system just equals the battery cost. This is a condition of optimum battery size because incremental battery additions beyond this do not pay for themselves in utility energy saved. Referring to Figure 2.6.2, a similar argument can be made for choosing optimum array area in the same way.

It can be seen that for curves with sharp knees and large slope changes, choosing the size of array area or storage capacity is quite simple. Consider the curve of energy supplied by solar versus storage capacity after 15 kWh. The incremental gain of energy derived from insolation per kWh of added storage capacity beyond the knee is trivial, therefore, almost regardless of cost of storage per kilowatt-hour,

there is no incentive to increase storage. When the storage capacity has been chosen, the same type of incremental analysis can be used to obtain optimum array area. Specific values of efficiency were chosen to determine numerical values for the array area curve. Variations in efficiency change the numerical values of the x axis, but not the shape of the curve; therefore, the net result of efficiency variation is a change in array area with a minor perturbation of the energy supplied by insolation. Of course, there is the economic effect of the change in area, thus efficiency is important in the economic evaluation.

When the knee is not sharp enough to make the selection of size obvious, it is necessary to determine numerical criteria for optimum size selection. To do this, it is necessary to relate the value of the energy saved by adding cell area or battery capacity to the cost of purchasing and installing it. Note that these are incremental values. The equation relating these variables is

$$C = rEM \quad (2.4.1)$$

where C = total system cost

r = cost per unit of energy displaced

E = energy displaced per year

M = multiplier relating energy cost and system cost

The numerical value of M is influenced by the cost of money, the anticipated savings in reduced energy costs which is dependent on the anticipated energy cost and escalation, and the life of the system.

This equation relates the total cost of the system, C , to the annual energy saving, rE , over the life of the system by the multiplier, M . The value of M is derived in the following way. The amount of money (P) accrued in a time period (n) by payment of an amount A which continually increases at a rate (e) can be calculated approximately using the expression,

$$dP = mPdn + A_0 e^{en} dn \quad (2.4.2)$$

where m = the mortgage interest rate in this case.

The first term on the right side of equation (2.4.2) is the interest accruing on P in interval dn , while the second is the addition to P of the escalated value of payment (A_0) made in the n th time interval.

The solution of this equation is:

$$P = \frac{A_0 (e^{mn} - e^{en})}{m - e} \quad (2.4.3)$$

The approximate present value, obtained by multiplying by e^{-mn} , is

$$P.V. = \frac{A_0 (1 - e^{-(m-e)n})}{m - e} = AM \quad (2.4.4)$$

and

$$M = \frac{1 - e^{-(m-e)n}}{m - e} \quad (2.4.5)$$

The value of M for the 30 year period used in this study and the range of projected mortgage and electric cost escalation rates is from about 12 to 18.

As a numerical example, assume that the total cost per unit area of silicon photovoltaic array is \$40/m² and anticipated energy rates are in the order of 5 to 6 ¢/kWh. Therefore, the breakeven annual energy saving (E) when the present worth of the total energy saved over the life of the system equals the system installed capital cost is:

$$E = \frac{C}{rM} \approx \frac{\$40/\text{m}^2}{\$0.055 \text{ kWh} \times 15} \approx 50 \text{ kWh/m}^2$$

The scales on the curves relating energy supplied to collector area in Figure 2.6.4 are such as to make a 45° slope equivalent to 50 kilowatt-hours per meter squared. Then, the point of tangency of the curve with a line of 45° slope is the optimum choice for maximum array sizing.

2.6.1.2 System Figure-Of-Merit

In order to relate system cost to the value of energy supplied, a Figure-of-Merit was defined relating system cost to energy supplied per year. The Figure-of-Merit is thus related to the energy cost by a concept of presentation called the ACCEPT Curve. The mathematical derivation of this concept is presented in the following paragraphs.

Let the Figure-of-Merit F_M , be defined as follows:

$$F_M = \frac{\text{Total System Cost}}{\text{Annual Energy Supplied}} \quad (2.4.6)$$

Then, from equation (2.4.1),

$$F_M = \frac{C}{E} \quad (2.4.7)$$

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PVEPS - ENERGY FLOW SIMULATIONS - V3.1 (TIME STEP = 1 DAY)

PHOENIX, ARIZONA - 1962 - CASE 1 - A INSOLATION DATA - NOMINAL LOAD 2

Figure 2.6.4

Also, from equation (2.4.1)

$$r = \frac{C}{E} \cdot \frac{1}{M} \quad (2.4.8)$$

where all variables included in equation (2.4.8) are defined following equation (2.4.1). Then, by substituting equation (2.4.7) into equation (2.4.8)

$$r = \frac{F_M}{M} \quad (2.4.9)$$

The multiplier, M, is defined in equation (2.4.5) as follows:

$$M = \frac{1 - \epsilon^{-(m-e)n}}{m - e} \quad (2.4.10)$$

where all variables included in equation (2.4.10) are defined prior to equation (2.4.2). By substituting equation (2.4.10) into equation (2.4.9), the result is:

$$r = \frac{1}{\frac{1 - \epsilon^{-(m-e)n}}{m - e}} \cdot F_M \quad (2.4.11)$$

Let $i = m - e$. Then

$$r = \frac{1}{\frac{1 - \epsilon^{-in}}{i}} F_M \quad (2.4.12)$$

Equation (2.4.12) is shown plotted in Figure 2.6.5. The variable r is a linear function of F_M for a given value of i . As i is increased, the slope of the line relating r and F_M increases.

Figure 2.6.5

ACCEPT Curve

The x axis, labeled F_M , is the Figure-of-Merit for the photovoltaic system which relates system cost to the kilowatt-hours supplied by the system for an average year. The kilowatt-hours supplied include both electrical and thermal energy used to satisfy the annual energy requirements of the residence. The system cost includes the installed cost of all components plus present value of all future repair, maintenance, and necessary replacement for a thirty-year lifetime. The Figure-of-Merit (F_M) is the system cost divided by the yearly kilowatt-hours supplied. When using these curves, all dollar values are expressed in 1975 dollars regardless of the time of installation.

The y axis represents the composite average residential fuel rate (r) projected to the year of system installation and is expressed in 1975 dollars. It should be noted that if energy rates and costs are reduced by equivalent amounts, there is no effect on the analysis.

The straight lines relating F_M to r are for various composite mortgage interest and fuel escalation rates at the time of installation - the rate (i) equaling mortgage interest minus the fuel escalation rate. Thus, if the mortgage interest is 8% of the residential energy escalation rate is 4%, then $i = .08 - .04 = .04$.

An example of use of the curve is as follows: Assume that a system cost for a residence in a particular region is projected to be \$12,000 for the year 1985 and the composite residential fuel rate is \$0.05/kWh for the year 1985, both in 1975 dollars. Assume that the mortgage interest rate is 8% and residential fuel escalation rate

from 1985 on is estimated at 4%. Assume also that the system has been computed to save the user 15,000 kilowatt-hours per year, making $F_M = \frac{12000}{15000} = 0.8$ for this example. Obviously, a low cost, high energy saving system, represented by a low F_M is desired: therefore, the value indicated by the intersection of the $i = .04$ line and the $r = .05$ rate should be at least equal to or preferably higher than the calculated value of F_M for the system of 0.8. For the example given, this intersection occurs at a value of F_M of 0.87, so the system postulated slightly surpasses the breakeven point. However, not considered in this simplified evaluation of viability are the tax deductions of mortgage interest, which vary with the individual, etc.

It should be noted that the use of the curves requires estimates of system cost and fuel rates at the time of installation expressed in 1975 dollars, mortgage rates at the time of installation, and projections beyond the time of installation for energy rate escalation. Also, while system costs are expressed in 1975 dollars, the cost of the system can be less in 1975 than estimated in 1975 because of the quantity produced as expressed by the learning curve.

2.6.2 IPS and CPS

The background material relating to IPS and CPS subsystem costs which are used to obtain total system equipment cost is presented in Volume III(1). The techniques then used to derive total capital cost from system equipment costs are discussed in Section 2.5 of this volume. Discussed also in Section 2.5 are techniques used to obtain busbar energy cost and present worth, cost/benefit ratios.

In the analysis of the CPS subsystems and to a lesser extent in that of the IPS subsystems, a number of solar cell array/module concepts were designed and evaluated. The final comparative evaluation was made using a cost/performance index which provided a measure of the array/module cost relative to its annual electrical energy output.

Because of the large number of cases to be analyzed and because of the complexity of the required calculations, a computer program was written to perform this task. The program was purposely written to be flexible enough to analyze either array/module combinations or entire systems. The form of the program and a summary of some of the results obtained using it are presented in this section.

2.6.2.1. Description of Algorithm

The program is divided into several large segments. The major segments are: Input - system, array, power conditioning, battery, facility; Output - capital cost, O&M cost, capital write-off cost, power output. The following flow diagram shows all detailed inputs and outputs. Explanation of equations and variables are given on Attachments 1 and 2, respectively.

Line 80

INPUT POWER COND.
TECH. SPECS & COST FACTORS

Line 98

ARE BATTERIES USED?

No

Yes

Line 100

INPUT BATTERY
SPECS

Line 107

OUTPUT BATTERY
INSTALLED KWH

Line 110

INPUT BATTERY
CAPITAL COST FACTORS

Line 125

INPUT FACILITY
SPACE FACTORS

Line 132

OUTPUT FLOOR SPACE
AND LAND AREA

Line 135

INPUT FACILITY
CAPITAL COST
FACTORS

Line 270

INPUT CONSTRUCTION
COST FACTORS

Line 160
Line 320

OUTPUT CAPITAL
COSTS

The program models the photovoltaic system as four major components: the array, power conditioning, batteries (if included), and facility (land and buildings). The system block diagram follows:

2.6.2.2. Summarization of Equations

The computer program requires as initial input the general system technical requirements of peak capacity (MW), storage capacity (MWh) (both measured at the utility lines) and power conditioner efficiency. These factors are used to size the array area and battery capacity required as input to the power conditioner.

The array technical specs requested by the computer are the solar cell efficiency, concentration ratio, packing fraction-concentrator aperture area to module area, packing fraction-module area to array area, peak output of the specific array configuration (per unit of solar cell area) and annual output of the array configuration (again, per unit area of solar cell).

The equations used are presented in Attachment 1. Equation 1 sizes the total solar cell area directly from the peak array output, power conditioner efficiency and required system peak output. Equation 2 calculates the aperture area from the solar cell area and concentration ratio. Equation 3 calculates the module area from the aperture area and the aperture/module packing factor (this assumes that there is some "wasted" space in the module between collector apertures). Similarly, Equation 4 calculates the total array area from the module area and the module/array packing fraction. Equations 5 and 6 are the combinations of Equations 1-4 which are used by the program. Equation 7 calculates the array annual output from the total solar cell area and the annual output per unit solar cell area. Equation 8 generates the system annual output from the array output and the power conditioner efficiency.

The array capital cost factors requested as input are the solar cell cost (per kW), the module structure cost (per unit module area), the array structure cost (per unit array area), the tracking equipment cost (per unit array area), and the installation cost (per unit array area).

Equation 9 is used to calculate the solar cell cost per unit cell area assuming that the input cost per kW is based on 1.1 kW/m^2 insolation

and a cell efficiency as input to the program (typically .16 for Si, .10 for CdS). Equation 10 calculates the array capital cost from the solar cell cost (per unit cell area) and cell area, the module cost factor and module area, and the array structure cost factor, tracking cost factor, installation cost factor and array area. Equation 11 highlights the solar cell cost alone for user interest. Equations 12 and 13 calculate the specific capital cost, per peak array output and per annual array output.

The program asks the user if new array data is to be entered. This allows the user to run through comparative data on various array configurations without consideration for the rest of the system.

Once the array information is set, the program requests as input the floor space and capital cost factors of the power conditioner. If batteries are to be used (as identified by the system storage requirements), the program requests the battery and auxiliary floor space and capital cost factors as well as the allowable depth of discharge. Equation 14 is used to calculate the installed battery capacity from the system storage requirement, power conditioner efficiency and allowed depth of discharge.

The program requests facility space factors (array area to array land area, and building floor area to building land area), and facility cost factors--land cost, building cost, and site preparation cost. Equation 15 is used to calculate the total building area from the battery, auxiliary and power conditioner floor space factors and the installed battery capacity and power conditioner peak output. Equation 16 then calculates the total land area required from the array/land space factor and array area and the building/land space factor and floor area.

Equation 17 is used to calculate the subsystem capital cost (array, power conditioner and battery) from the respective cost factors and sizes. Equation 18 calculates the facility cost (land, site preparation and buildings) from the calculated areas required and the input cost factors.

Equation 19 calculates the installation costs of the array, power conditioner, batteries and auxiliaries from the respective cost factors and required sizes.

The net capital cost is calculated in Equation 20 from a summation of the prior three results. Equation 21 is used to generate the capital cost per peak output power.

Construction cost factors are requested by the program. These are allowance for contingency and spares, indirect costs, annual interest rate during construction, and the construction period. The fixed charge rate for capital write-off is also requested. Equation 22 calculates the cost of contingency and spares. Equation 23 similarly identifies the indirect costs. In order to determine the interest during construction, the program calculates the monthly interest rate from the yearly rate in Equation 24. Equation 25 is then used to calculate the total capital required, including IDC, for the construction period. The capital write-off portion of the busbar cost of energy is calculated in Equation 26, using the total capital, fixed charge rate and system annual output.

In calculating the system O&M costs, the program considers that each major component has an O&M factor as well as a replacement rate (the exception is the power conditioning system; the replacement rate is absorbed in the O&M factor).

O&M factors are requested for the array, array tracking, power conditioning system, battery cells and auxiliaries, building area, and land area. Replacement rates are requested for the arrays and battery cells and auxiliaries. In addition, since the battery O&M figures are based on kWh of stored energy, the annual number of discharge cycles is requested.

Equations 28 and 29 are used to calculate the building and land O&M. Equation 30 calculates the battery O&M costs from the O&M cost

factors, number of discharge cycles, delivered capacity per cycle, original capital cost and yearly replacement rate.

Equation 31 is used to calculate the Power Conditioner O&M cost from the cost factor and its rated output. Equations 32, 33, and 34 calculate the array O&M costs, including tracking O&M, array O&M, array replacement and module cleaning. For this study, the cleaning costs were assumed to be nil. Equation 35 totals the O&M costs. Equation 36 calculates the O&M bus bar energy cost from the total annual O&M and the annual system output (mills/kWh = \$/MWh).

A listing of all variables used is included in Attachment 2.

ATTACHMENT 1

Equations

I. ARRAY AREA, SOLAR CELL AREA REQUIRED

$$(\text{Total Solar Cell Area}) \times (\text{Pk. Solar Cell Output}) \times (\text{Power. Cond. Eff.})$$

m^2

kW_p/m^2

Decimal

$$= \text{System Pk. Output}$$

kW

$$1. \quad [X4][I1][N6] = [P1 * 1000]$$

$$\text{Aperture Area} = (\text{Solar Cell Area}) \times (\text{Concentration Ratio})$$

m^2

m^2

≥ 1

$$2. \quad [X3] = [X4][R1]$$

$$\text{Module Area} = (\text{Aperture Area}) \div (\text{Aperture/Module Packing Factor})$$

m^2

m^2

Decimal

$$3. \quad [X2] = [X3]/[N4]$$

$$\text{Array Area} = (\text{Module Area}) \div (\text{Module/Array Packing Factor})$$

m^2

m^2

Decimal

$$4. \quad [X1] = [X2]/[N5]$$

ATTACHMENT 1 (continued)

Thus, combining equations 1 through 4:

$$5. \quad \underline{X1 = 1000 * P1 * R1 / (N4 * N5 * N6 * I1)} \quad \text{Line 48}$$

And, combining equations 2 through 5:

$$6. \quad \underline{X4 = N4 * N5 * X1 / R1} \quad \text{Line 301}$$

II. ARRAY OUTPUTS

$$\text{Array Annual Output} = (\text{Array Output/m}^2 \text{ of Cell}) * (\text{Cell Area})$$

MWh MWh/m² m²

$$[Z2] = (Z1/1000) * X4, \text{ or}$$

$$7. \quad \underline{Z2 = Z1 * X4 / 1000} \quad \text{Line 304}$$

$$\text{System Generated Output} = (\text{Array Output}) * (\text{Power Conditioning Efficiency})$$

MWh MWh Decimal

$$8. \quad \underline{Z3 = Z2 * N6} \quad \text{Line 306}$$

III. ARRAY CAPITAL COSTS

$$\text{Solar Cell Cost} = (\text{Solar Cell Power Cost})(\text{Insolation})(\text{Solar Cell Efficiency})$$

\$/m² \$/kW kW Decimal

$$9. \quad \underline{A3 = S3 * 1.1 * N3} \quad \text{Line 60}$$

ATTACHMENT 1 (continued)

Array Capital Cost = (Module Cost) * (Module Area)

$\$/m^2 \quad m^2$

+ (Array Structure Cost + Tracking Cost) * (Array Area)

$\$/m^2 \quad \$/m^2 \quad m^2$

+ (Solar Cell Cost) * (Cell Area) + (Installation Cost)

$\$/m^2 \quad m^2 \quad \$/m^2$

* (Array Area)

m^2

10. $X5 = A5 * X2 + (A6 + A7) * X1 + A3 * X4 + A8 * X1$

Line 65

Solar Cell Cost = (Cost/Area) * (Solar Cell Area)

$\$ \quad \$/m^2 \quad m^2$

11. Print Out = $A3 * X4$

Line 67

Cost/Array Peak Power = (Eq 10: $X5$) $\div$ [$(Pk. Power/m^2)(Cell Area)$]

m^2

12. Print Out = $X5/(I1 * X4)$

Line 69

Cost Performance Index = Capital Cost $\div$ Annual Array Output kWh

13. Printout = $X5/(Z2 * 1000)$

Line 70

ATTACHMENT 1 (continued)

IV. BATTERY CALCULATIONS (CAPACITY)

$$\text{Battery Capacity Installed} = \frac{(\text{kWh Delivered})}{[(\text{P.C. Efficiency}) \times (\text{Depth of Discharge})]} \div \text{to utility grid}$$

kWh

$$* (\text{Depth of Discharge})]$$

$$14. \quad K2 = 1000 * K1 / (N6 * B6)$$

Line 106

V. AREAS REQUIRED

$$\text{Building (Floor) Area} = (\text{Cell Area/kWh} + \text{Aux. Area/kWh}) * (\text{Installed kWh})$$

$$+ (\text{P.C. Area/kW}_p) * (\text{Output Peak Power})$$

$$15. \quad Y1 = (B4 + B5) * K2 + C3 * P1 * 1000$$

Line 129

$$\text{Land Area} = (\text{Array Area}) \div (\text{Array Packing Factor}) + (\text{Building Area})$$

$$\div (\text{Building Packing Factor})$$

$$16. \quad Y2 = X1/F4 + Y1/F5$$

Line 130

VI. CAPITAL COSTS

$$\text{Subsystem Cost} = (\text{Array Capital Cost} - \text{Array Installation})$$

$$+ (\text{Cell Cost/kWh} + \text{Aux. Cost/kWh}) * (\text{Installed kWh})$$

$$+ (\text{P.C. Cost/kW} + \text{P.C. Cooling Cost/kW}) * (\text{Output kW Peak})$$

ATTACHMENT 1 (continued)

17. Y6 = (X5 - A8 * X1) + (B1 + B2) * K2' + (C1 + C4) : Line 150
* P1 * 1000

$$\text{Facility Cost} = (\text{Land Cost}/\text{m}^2 + \text{Site Prep}/\text{m}^2) * (\text{Land Area}) \\ + (\text{Building Cost}/\text{m}^2) * (\text{Building Area})$$

18. Y3 = (F1 + F2) * Y2 + F3 * Y1 Line 153

$$\begin{aligned} \text{Installation Cost} &= (\text{Array Inst. Cost}/\text{m}^2) * (\text{Array Area}) \\ &+ (\text{P.C. Install.}/\text{kW}_p) * (\text{Peak Output}) \\ &+ (\text{Battery Inst Cost}/\text{kWh}) * (\text{Installed kWh}) \end{aligned}$$

```
19.  Y4 = A3 * X1 + C2 * P1 * 1000 + B2 * K2
```

$$\text{Net Capital Cost} = \text{Subsystem Cost} + \text{Facility Cost} + \text{Installation Cost}$$

20. $Y5 = Y6 + Y3 + Y4$ Line 155

$$\text{Capital Cost/Peak Power} = \text{Cost}/(\text{Output Peak kW})$$

```
21. Printout = Y5/(1000 * P1)                                     Line 173
```

$$\text{Cost of Contingency \& Spares} = [\text{Capital Cost}] * [\text{Cont. \& Spares Factor}]$$

```
22. Printout = Y5 * Q1
```


ATTACHMENT 1 (continued)

$$\text{Indirect Costs} = [\text{Capital Cost}] * [\text{Indirect Cost Factor}]$$

\$

\$

Decimal

$$23. \text{ Printout} = Y5 * Q2$$

Line 322

$$[\text{Monthly Interest}] = [1 + \text{Yearly Interest}] \uparrow \left(\frac{1}{12}\right) - 1$$

Decimal

Decimal

$$24. Q6 = (1 + Q3) \uparrow (1/12.0) - 1$$

Line 286

$$[\text{Total Capital}] = \text{Summation of Monthly Loans} + \text{Interest}$$

Assuming a Linear
Borrowing Rate →

Amount
Borrowed

Time

$$Q7 = \frac{Q5 * (1 + Q1 + Q2)}{Q4} [(1 + Q6)^{Q4} - 1 + (1 + Q6)^{Q4} - 2$$

$$+ \dots + (1 + Q6) + 1]$$

$$25. Q7 = \frac{Q5 * (1 + Q1 + Q2)}{Q4} \frac{[(1 + Q6) \uparrow Q4 - 1]}{Q6}$$

Lines 283, 326

$$[\text{Capital Bus Bar Cost of Energy}] = [\text{Total Capital} + \text{Interest}]$$

$$* [\text{Fixed Charge Rate}]/[\text{Annual kWh}]$$

ATTACHMENT 1 (continued)

$$26. \quad Q8 = Q7 * Q5/Z3$$

Lines 290, 328

$$[Interest \text{ During Construction}] = [Total \text{ Capital} + Interest] \\ - [Total \text{ Principal Borrowed}]$$

$$27. \quad Printout = Q7 - Y5 * (1 + Q1 + Q2)$$

Line 324

$$[Building \text{ Maintenance Cost}] = [O\&M \text{ per } m^2][Floor \text{ Area}]$$

$$\$ \quad \quad \quad \$/m^2 \quad \quad m^2$$

$$28. \quad M1 = G8 * Y1$$

Line 230

$$[Land \text{ O\&M Cost}] = [Land \text{ O\&M per } m^2][Land \text{ Area}]$$

\$

$$29. \quad M2 = G7 * Y2$$

Line 231

$$[Battery \text{ O\&M Cost}] = [O\&M \text{ Factors}] * [Annual \text{ kWh Stored}] \\ (\text{cell} + \text{auxiliaries})$$

$$+ [Cell + Aux. \text{ Replacement}]$$

$$30. \quad M3 = (G5 + G6) * K3 * K1 * 1000$$

Line 232

$$+ (B1 + B2 + B3) * K2 * T2$$

$$[Power \text{ Conditioner O\&M Cost}] = [P.C. \text{ O\&M Cost Factor}]$$

$$* [P.C. \text{ Rating}]$$

ATTACHMENT 1 (continued)

$$31. \quad \underline{M4 = G4 * P1 * 1000}$$

Line 233

$$[Tracking \ O\&M \ Cost] = [Tracking \ Cost \ Factor] * [Array \ Area]$$

$$32. \quad \underline{M5 = G3 * X1}$$

Line 234

$$[Array \ O\&M \ Cost] = [Array \ Cost \ Factor] * [Array \ Area] + [Array \ Replacement]$$

$$33. \quad \underline{M6 = G2 * X1 + X5 * T1}$$

Line 235

$$[Array \ Cleaning \ Costs] = [Array \ Cleaning \ Cost \ Factor] * [Module \ Area]$$

$$34. \quad \underline{M7 = G1 * X2}$$

Line 236

$$[Total \ O\&M] = \text{Summation of Subpart O\&M Costs}$$

$$35. \quad \underline{M8 = M1 + M2 + M3 + M4 + M5 + M6 + M7}$$

Line 240

$$[O\&M \ Cost \ mills/kWh] = [Total \ O\&M] / [Annual \ Output \ MWh]$$

\$

$$36. \quad \underline{Printout = M8/Z3}$$

Line 259

ATTACHMENT 2
Variable Listing

<u>Variable</u>	<u>Description</u>	<u>Input</u>	<u>Output</u>	<u>Inter.</u>
A3	Solar Cell Cost $\$/m^2$		✓	✓
A5	Module Structure Cost $\$/m^2$	✓		
A6	Array Structure Cost $\$/m^2$	✓		
A7	Tracking Cost $\$/m^2$ of Array	✓		
A8	Array Inst. Cost $\$/m^2$	✓		
B1	Battery Cell Capital Cost $\$/kWh$			
B2	Battery Aux. Cap. Cost $\$/kWh$	✓		
B3	Battery Inst. Cost $\$/kWh$	✓		
B4	Battery Cell Floor Space m^2/kWh	✓		
B5	Batt. Aux. Floor Space m^2/kWh	✓		
B6	Battery Depth of Discharge (Decimal)	✓		
C1	Power Conditioner Cost $\$/kW_p$	✓		
C2	Power Conditioner Inst. Cost $\$/kW_p$	✓		
C3	P.C. Floor Size Required m^2/kW_p	✓		
C4	P.C. Cooling Cost $\$/kW_p$	✓		
C\$	New Array Data Branching Variable (Y,N)	✓		
E\$	O&M Cost Branching Variable	✓		
F1	Land Cost ($\$/m^2$)	✓		
F2	Site Preparation Cost ($\$/m^2$)	✓		
F3	Building Cost ($\$/m^2$)	✓		
F4	Array/Land Packing Factor (Decimal)	✓		
F5	Building/Land Packing Factor (Decimal)	✓		

ATTACHMENT 2 (continued)

<u>Variable</u>	<u>Description</u>	<u>Input</u>	<u>Output</u>	<u>Inter.</u>
G1	Array Cover Cleaning Cost (O&M) $\$/m^2$	Not used, Set=0		
G2	Array Maintenance Cost (O&M) $\$/m^2$	✓		
G3	Tracking Maintenance Cost $\$/m^2$	✓		
G4	Power Cond. O&M Cost $\$/m^2$	✓		
G5	Battery Cell O&M Cost $\$/kWh$ Stored	✓		
G6	Auxiliary (Batt.) O&M Cost $\$/kWh$ Stored	✓		
G7	Land Maintenance O&M Cost $\$/m^2$	✓		
G8	Building O&M Cost $\$/m^2$	✓		
I1	Array Output (Peak) kW/m^2 of Cell	✓		
K1	Battery Storage Capacity (Measured at the P.C. Output) MWh	✓		✓
K2	Battery Storage Capacity-Installed (kWh)			✓
K3	Annual Charge/Discharge Cycles	✓		
M1	Building O&M Cost \$		✓	✓
M2	Land O&M Cost \$		✓	✓
M3	Battery + Auxiliary O&M Cost \$		✓	
M4	Power Cond. O&M Cost \$		✓	
M5	Tracking O&M Cost \$		✓	✓
M6	Array O&M Cost \$		✓	✓
M7	Cover Cleaning Cost \$	Set=0		
M8	Total O&M Cost \$		✓	✓
N3	Solar Cell Efficiency (Decimal)	✓		
N4	Aperture/Module Packing Factor (Decimal)	✓		
N5	Module/Array Packing Factor (Decimal)	✓		
N6	Power Conditioner Efficiency (Decimal)	✓		

ATTACHMENT 2 (continued)

<u>Variable</u>	<u>Description</u>	<u>Input</u>	<u>Output</u>	<u>Inter.</u>
P1	System Peak Output Power (MW)	✓		
Q1	Contingency & Spares (Decimal)	✓		
Q2	Indirect Costs (Decimal)	✓		
Q3	Annual Interest Rate (Decimal)	✓		
Q4	Construction Period (Months-Integer)	✓		
Q5	Fixed Charge Rate (Decimal)	✓		
Q6	Monthly Interest Rate			✓
Q7	Total Capital Cost		✓	✓
Q8	Capital Bus Bar Cost (mills/kWh)		✓	
R1	Concentration Ratio (Module)(≥ 1)	✓		
S3	Solar Cell Cost \$/kW _p	✓		
X1	Array Area m ²		✓	
X2	Module Area m ²			✓
X3	Aperature Area m ²			✓
X4	Solar Cell Area m ²		✓	
X5	Array Capital Cost \$		✓	✓
Y1	Building (Floor) Area m ²		✓	✓
Y2	Land Area m ²		✓	✓
Y3	Facility Cost (Capital) \$		✓	✓
Y4	Installation Cost \$		✓	✓
Y5	Total Capital Cost \$		✓	✓
Y6	Subsystem Capital Cost \$		✓	✓

ATTACHMENT 2 (continued)

<u>Variable</u>	<u>Description</u>	<u>Input</u>	<u>Output</u>	<u>Inter.</u>
Z1	Array Annual Output - kWh/m ² of Cell	✓		
Z2	Array Annual Output - MWh		✓	✓
Z3	System Generated Output - MWh		✓	✓

The following pages include a complete listing of the system cost calculation program.

LIST

JUN 7 9:59 /PUCSTIRU/

```
0010 PRINT"
      PHOTOVOLTAIC SYSTEM CAPITAL, OCM COST CALCULATION"
15 PRINT
20 PRINT"
SYSTEM TECHNICAL SPECIFICATIONS:"
21 PRINT
30 PRINT"PEAK OUTPUT POWER(MW):": DEMAND P1
32 PRINT"USABLE STORAGE CAPACITY(MWH):": DEMAND K1
34 PRINT"POWER COND. EFFICIENCY:": DEMAND H6
36 PRINT
40 PRINT"
ARRAY SPECS:
"
41 PRINT"CELL EFFICIENCY (DECIMAL):": DEMAND H3
42 PRINT"CONCENTRATOR RATIO:": DEMAND R1
43 PRINT"PEAK OUTPUT (KW/SQM CELL):": DEMAND I1
44 PRINT"ANNUAL OUTPUT (KWH/SQM CELL):": DEMAND Z1
46 PRINT"APERTURE/MODULE PACKING FRACTION:": DEMAND H4
47 PRINT"MODULE/ARRAY PACKING FRACTION:": DEMAND H5
48 X1=1000*P1*R1/(H4*H5*H6*I1)
49 GOTO 300
50 PRINT"
ARRAY CAPITAL COST FACTORS"
51 PRINT
55 PRINT"MODULE STRUCTURE COST($/SQM):": DEMAND A5
56 PRINT"ARRAY STRUCTURE COST($/SQM):": DEMAND A6
57 PRINT"TRACKING EQUIPMENT COST($/SQM ARRAY) :": DEMAND A7
58 PRINT"SOLAR CELL COST($/KW) :": DEMAND S3
59 PRINT"ARRAY INSTALLATION COST($/SQM ARRAY):": DEMAND A8
60 A3=S3*1.1*H3
61 PRINT"BASED ON MAX. INSOLATION OF 1.1KW/SQM, AND THE ABOVE CELL
EFFICIENCY, THE CELL COST CONVERTS TO ($/SQM)...":
PRINT IN FORM"62.22":A3
62 X2=H5*X1
63 X3=H4*X2
64 X4=X3/R1
65 X5=A5*X2+(A6+A7)*X1+A3*X4+A8*X1
66 PRINT
67 PRINT"SOLAR CELL CAPITAL COST.....":PRINT IN FORM"152.22":X4*A3
,PRINT
68 PRINT"ARRAY CAPITAL COST.....":PRINT IN FORM"152.22":X5
69 PRINT"COST PER ARRAY KWP.....":PRINT IN FORM"152.22":
X5/(I1*X4),PRINT
70 PRINT"COST/PERF. INDEX.....":PRINT IN FORM"152.62":
X5/(Z1*1000),PRINT,PRINT
71 PRINT"NEW ARRAY DATA?(Y OR N)": DEMAND C#
72 GOTO 80 IF C#='N'
73 PRINT"NEW COSTS ONLY?(Y OR N)": DEMAND C#
74 GOTO 50 IF C#='Y'
75 GOTO 40
80 PRINT"
POWER CONDITIONER SPECS:"
81 PRINT
82 PRINT"EFFICIENCY:":H6
83 PRINT"FLOOR SIZE(SQM/KWP)": DEMAND C3
```

```

84 PRINT
90 PRINT"
POWER CONDITIONER CAPITAL COST FACTORS"
91 PRINT
92 PRINT"P.C. COST($/KWP):":DEMAND C1
93 PRINT"P.C. COOLING COST($/KWP):":DEMAND C4
94 PRINT"P.C. INSTALLATION COST($/KWP):":DEMAND C2
95 PRINT
98 GOTO 120 IF K1=0
100 PRINT"
BATTERY SPECS"
101 PRINT
102 PRINT"BATTERY CELL FLOOR SPACE(SQM/INSTALLED KWH):":DEMAND B4
103 PRINT"AUXILIARY FLOOR SPACE(SQM/INSTALLED KWH):":DEMAND B5
104 PRINT"DEPTH OF DISCHARGE(FRACTION):":DEMAND B6
105 PRINT
106 K2=1000*K1/(B6*NG)
107 PRINT"INSTALLED CAPACITY (KWH)....":PRINT IN FORM"152":K2
108 PRINT
110 PRINT"
BATTERY CAPITAL COST FACTORS"
111 PRINT
112 PRINT"BATTERY CELL COST($/INSTALLED KWH):":DEMAND B1
113 PRINT"AUXILIARY COST($/INSTALLED KWH):":DEMAND B2
114 PRINT"INSTALLATION COST($/INSTALLED KWH):":DEMAND B3
115 PRINT
116 GOTO 125
120 PRINT"
STORAGE BATTERIES NOT USED"
121 PRINT
125 PRINT"
FACILITY SPACE FACTORS"
126 PRINT
127 PRINT"APRAY/LAND FRACTION:":DEMAND F4
128 PRINT"BUILDING/BUILDING LAND FRACTION:":DEMAND F5
129 Y1=(B4+B5)*K2+C3*P1*1000
130 Y2=X1/F4+Y1/F5
131 PRINT
132 PRINT"FLOOR SPACE REQUIRED(SQM).....":PRINT IN FORM"152":Y1,
PRINT
133 PRINT"LAND AREA REQUIRED(SQM).....":PRINT IN FORM"152":Y2,
PRINT
135 PRINT"
FACILITY CAPITAL COST FACTORS"
136 PRINT
137 PRINT"LAND COST($/SQM):":DEMAND F1
138 PRINT"SITE PREPARATION($/SQM):":DEMAND F2
139 PRINT"BUILDING COST($/SQM):":DEMAND F3
140 PRINT
150 Y6=X5+(B1+B2)*K2+(C1+C4)*P1*1000-A8*X1
153 Y3=(F1+F2)*Y2+F3*Y1
154 Y4=A8*X1+C2*P1*1000+B3*K2
155 Y5=Y6+Y3+Y4
156 GOTO 270
160 PRINT"
SYSTEM CAPITAL COSTS"
161 PRINT
165 PRINT"SUBSYSTEM COST.....":PRINT IN FORM"152.32":Y6,
PRINT
167 PRINT"FACILITY COST.....":PRINT IN FORM"152.22":Y3,
PRINT
169 PRINT"INSTAL. COST.....":PRINT IN FORM"152.32":Y4,

```

```

PRINT
171 PRINT"CAPITAL COST.....":PRINT IN FORM"152.22":Y5/(1000*P
PRINT
173 PRINT"COST PER KWP.....":PRINT IN FORM"152.22":Y5/(1000*P
175
PRINT
174 GOTO 320
175 PRINT
180 PRINT"
ARE O&M COSTS TO BE CALCULATED? (Y OR N)":DEMAND E5
181 STOP IF E5#='N'
190 PRINT"
ARRAY O&M COST FACTORS"
191 PRINT
192 G1=0
193 PRINT"ARRAY MAINTENANCE COST($/SQM)":DEMAND G2
194 PRINT"TRACKING MAINT. COST($/SQM ARRAY)":DEMAND G3
195 PRINT"ANNUAL ARRAY REPLACEMENT (DECIMAL)":DEMAND G1
196 PRINT
200 PRINT"
P.C. O&M COST FACTOR($/KWP)":DEMAND G4
201 PRINT
205 PRINT"
BATTERIES NOT CONSIDERED" IF K1=0
206 GOTO 215 IF K1=0
208 PRINT"
BATTERY O&M COST FACTORS"
209 PRINT
210 PRINT"NO. OF FULL DISCHARGE CYCLES(ANNUAL)":DEMAND K3
212 PRINT"BATTERY CELL COST ($/ANNUAL STORED KWH)":DEMAND G5
213 PRINT"AUXILIARY COST($/ANNUAL STORED KWH)":DEMAND G6
214 PRINT"ANNUAL CELL REPLACEMENT (DECIMAL)":DEMAND L2
215 PRINT
220 PRINT"
FACILITY O&M COST FACTORS"
221 PRINT
222 PRINT"LAND MAINTENANCE & SECURITY($/SQM)":DEMAND G7
223 PRINT"BUILDING HVAC, MAINTENANCE & SECURITY($/SQM)":DEMAND G8
224 PRINT
230 M1=G8*Y1
231 M2=G7*Y2
232 M3=(G5+G6)*K3*K1*1000+(E1+E2+E3)*K2*T2
233 M4=G4*P1*1000
234 M5=G3*X1
235 M6=G2*X1+X5*T1
236 M7=G1*X2
240 M8=M1+M2+M3+M4+M5+M6+M7
245 PRINT"
SYSTEM O&M COSTS"
246 PRINT
248 PRINT"ARRAY .....":
PRINT IN FORM"152.22":M5+M6+M7,PRINT
250 PRINT"POWER COND.....":
PRINT IN FORM"152.22":M4,PRINT
252 PRINT"BATTERY.....":
PRINT IN FORM"152.22":M3,PRINT
254 PRINT"FACILITY.....":
PRINT IN FORM"152.22":M1+M2,PRINT
256 PRINT"TOTAL.....":
PRINT IN FORM"152.22":M8,PRINT
258 PRINT"TOTAL PER KWP.....":
PRINT IN FORM"152.22": M8/(1000*P1),PRINT

```

```

259 PRINT"BUS BAR
ENERGY COST (MILS/KWH).....":
PRINT IN FORM"152.22":N6/23,PRINT
260 PRINT"CAPITAL BUS BAR
ENERGY COST (MILS/KWH).....":
PRINT IN FORM"152.22":00
261 PRINT"TOTAL BUS BAR
ENERGY COST (MILS/KWH).....":
PRINT IN FORM"152.32":N6/23+08
262 PRINT
263 GOTO 180
270 PRINT"
CONSTRUCTION COST FACTORS"
272 PRINT
274 PRINT"CONTINGENCY & SPARES (DECIMAL):":DEMAND 01
276 PRINT"INDIRECT COSTS (DECIMAL):":DEMAND 02
278 PRINT"ANNUAL INTEREST RATE (DECIMAL):":DEMAND 03
280 PRINT"CONSTRUCTION PERIOD (MONTHS):":DEMAND 04
282 PRINT"FIXED CHARGE RATE (DECIMAL):":DEMAND 05
284 PRINT
286 Q6=(1+03)*(1/12.00)-1
288 Q7=Y5*(1+01+02)*((1+Q6)*04-1)/(04*Q6)
289 Q7=Y5*(1+01+02) IF Q6=0
290 Q8=Q7*05/23
292 GOTO 160
300 PRINT"ARRAY AREA REQUIRED(SQM)....":PRINT IN FORM"1020":X3
301 X4=N4*N5*X1/P1
303 PRINT
303 PRINT"SOLAR CELL AREA(SQM).....":PRINT IN FORM"1020":X4
304 Z2=Z1*X4/1000,PRINT
305 PRINT"ARRAY ANNUAL OUTPUT (KWH)..." :PRINT IN FORM"1020":
Z2,PRINT
306 Z3=Z2*N6
307 PRINT"TOTAL ANNUAL OUTPUT (KWH)..." :PRINT IN FORM"1020":Z3
308 PRINT
310 GOTO 50
320 PRINT"CONT.& SPARES.....":
PRINT IN FORM"152.22":Y5*01,PRINT
322 PRINT"INDIRECT COSTS.....":
PRINT IN FORM"152.22":Y5*02,PRINT
324 PRINT"IDC.....":
PRINT IN FORM"152.22":Q7-Y5*(01+02+1),PRINT
326 PRINT"TOTAL CAPITAL.....":
PRINT IN FORM"152.22":Q7,PRINT
328 PRINT"CAPITAL BUS BAR
ENERGY COST (MILS/KWH)....":PRINT IN FORM"152.32":Q8,PRINT
330 PRINT
332 GOTO 180

```

The program runs in a conversational mode to facilitate the entry of new data for each run. A sample run for a simple flat plate fixed at latitude tilt using cells costing \$500/kW is shown in the following pages. All input data is shown.

SYSTEM TECHNICAL SPECIFICATIONS:

PEAK OUTPUT POWER(MW):100
USABLE STORAGE CAPACITY(MWH):0
POWER COND. EFFICIENCY:.92

ARRAY SPECS:

CONCENTRATOR RATIO:1
PEAK OUTPUT (KW/SQM CELL):.195
ANNUAL OUTPUT (KWH/SQM CELL):378
APERTURE/MODULE PACKING FRACTION:1
MODULE/ARRAY PACKING FRACTION:1
ARRAY AREA REQUIRED(SQM).... 557414
SOLAR CELL AREA(SQM)..... 557414
ARRAY ANNUAL OUTPUT (MWH)... 210702
TOTAL ANNUAL OUTPUT (MWH)... 193846

ARRAY CAPITAL COST FACTORS

MODULE STRUCTURE COST(\$/SQM):1.16
ARRAY STRUCTURE COST(\$/SQM):16.79
TRACKING EQUIPMENT COST(\$/SQM ARRAY) :0
SOLAR CELL COST(\$/KW) :500
ARRAY INSTALLATION COST(\$/SQM ARRAY):4.5

BASED ON MAX. INSOLATION OF 1.1KW/SQM, AND A CELL EFF.
OF 16%, THE CELL COST CONVERTS TO (\$/SQM).... 88.00
SOLAR CELL CAPITAL COST..... 49052396.88
ARRAY CAPITAL COST..... 61566332.22
COST PER ARRAY KWP..... 566.41
COST/PERF. INDEX..... .292196
NEW ARRAY DATA?(Y OR N)N

POWER CONDITIONER SPECS:

EFFICIENCY: 0.92
FLOOR SIZE(SQM/KWP):.2

POWER CONDITIONER CAPITAL COST FACTORS

P.C. COST(\$/KWP):108.6
P.C. COOLING COST(\$/KWP):0
P.C. INSTALLATION COST(\$/KWP):0

STORAGE BATTERIES NOT USED

FACILITY SPACE FACTORS

ARRAY/LAND FRACTION:.33
BUILDING/BUILDING LAND FRACTION:.2

FLOOR SPACE REQUIRED(SQM)..... 20000
LAND AREA REQUIRED(SQM)..... 1789132

FACILITY CAPITAL COST FACTORS

LAND COST (\$/SQM):.024
 SITE PREPARATION (\$/SQM):.2827
 BUILDING COST(\$/SQM):30

CONSTRUCTION COST FACTORS

CONTINGENCY & SPARES (DECIMAL):.2
 INDIRECT COSTS (DECIMAL):.1
 ANNUAL INTEREST RATE (DECIMAL):.085
 CONSTRUCTION PERIOD (MONTHS):24
 FIXED CHARGE RATE (DECIMAL):.18

SYSTEM CAPITAL COSTS

SUBSYSTEM COST.....	69917971.01
FACILITY COST.....	1149979.21
INSTAL. COST.....	2508361.20
CAPITAL COST.....	73576311.43
COST PER KWP.....	735.76
CONT.& SPARES.....	14715262.29
INDIRECT COSTS.....	7357631.14
IDC.....	7892579.25
TOTAL CAPITAL.....	103541784.11
CAPITAL BUSS BAR	
ENERGY COST (MILS/KWH)....	96.146

ARE O&M COSTS TO BE CALCULATED?(Y OR N)Y

ARRAY O&M COST FACTORS

ARRAY MAINTENANCE COST(\$/SQM):.23
 TRACKING MAINT. COST(\$/SQM ARRAY):0
 ANNUAL ARRAY REPLACEMENT (DECIMAL):.01

P.C. O&M COST FACTOR(\$/KWP):.3

BATTERIES NOT CONSIDERED

FACILITY O&M COST FACTORS

LAND MAINTENANCE & SECURITY(\$/SQM):0
 BUILDING HVAC, MAINTENANCE & SECURITY(\$/SQM):9.6

SYSTEM O&M COSTS

ARRAY	743868.45
POWER COND.....	30000.00
BATTERY.....	1.00
FACILITY.....	192000.00
TOTAL.....	965868.45
TOTAL PER KWP.....	9.66
O&M BUSS BAR	
ENERGY COST (MILS/KWH).....	4.983
CAPITAL BUSS BAR	
ENERGY COST (MILS/KWH).....	96.146
TOTAL BUSS BAR	
ENERGY COST (MILS/KWH).....	101.129

Summaries of IPS and CPS array costs and busbar energy costs obtained are shown in Tables 2.6.1 thru 2.6.4. Costs are generally provided for systems using single crystal silicon solar cells with 16% efficiency costing \$500/kW, and thin film CdS cells with 10% efficiency costing \$100/kW.

As can be seen from the vacant blocks on the table matrices, not all array/module combination were costed out. Only those which appeared promising or which were needed to generate parameteric data were persued.

Summary of IPS Busbar Energy Costs in Mills/kWh
(Investor-Owned Utility)

Table 2.6.1

Dwg. 6382A77

Array Module	Fixed At Latitude	Horizontal EW Axis NS Track	Horizontal NS Axis EW Track	Vertical Axis At Lat. Tilt	Vertical Axis At 50° Tilt	Contin- uous Two Axis Tracking	Lean-To	Windrow
Si Flat Plate	95 (43)						79 (39)	
Si V Trough								
Si CPC (3X)								
Si CPC (10X)								
Si Fresnel (10X)								
CdS Flat Plate							91 (48)	

Figures without parentheses are for cells costing \$500/kW
Figures with parenthesis are for cells costing \$100/kW

Summary of IPS Array Costs

Table 2.6.2

Dwg. 6382A77

Array Module	Fixed At Latitude	Horizontal EW Axis NS Track	Horizontal NS Axis EW Track	Vertical Axis At Lat. Tilt	Vertical Axis At 50° Tilt	Contin- ucus Two Axis Tracking	Lean-To	Windrow
Si Flat Plate	\$537/kW \$.28/kWh (\$176/kW) (\$.09/kWh)						\$382/kW \$.21/kWh (\$125/kW) (\$.07/kWh)	
Si V Trough	\$422/kW \$.26/kWh (\$184/kW) \$.11/kWh							
Si CPC (3X)	\$408/kW \$.37/kWh (\$245/kW) (\$.22/kWh)							
Si CPC (10X)								
Si Fresnel (10X)								
CdS Flat Plate	(\$252/kW) (\$.13/kWh)						(\$169/kW) (\$.10/kWh)	

Figures without parentheses are for cells costing \$500/kW
Figures with parentheses are for cells costing \$100/kW

Summary of CPS Array Costs

Table 2.6.3

Dwg. 6382A77

Array Module	Fixed At Latitude	Horizontal EW Axis NS Track	Horizontal NS Axis EW Track	Vertical Axis At Lat. Tilt	Vertical Axis At 50° Tilt	Contin- uous Two Axis Tracking	Lean-To	Windrow
Si Flat Plate	\$566/kW \$.29/kWh (\$205/kW) (\$.11/kWh)	\$622/kW \$.30/kWh (\$261/kW) (\$.12/kWh)	\$681/kW \$.25/kWh (\$286/kW) (\$.11/kWh)	\$625/kW \$.26/kWh (\$257/kW) (\$.11/kWh)	\$631/kW \$.24/kWh (\$268/kW) (\$.10/kWh)	\$687/kW \$.26/kWh (\$330/kW) (\$.12/kWh)	\$399/kW \$.22/kWh (\$142/kW) (\$.08/kWh)	\$607/kW \$.22/kWh (\$193/kW) (\$.07/kWh)
Si V Trough	\$465/kW \$.28/kWh (\$227/kW) (\$.14/kWh)	\$546/kW \$.26/kWh (\$308/kW) (\$.15/kWh)	\$599/kW \$.22/kWh (\$338/kW) (\$.13/kWh)	\$551/kW \$.23/kWh (\$315/kW) (\$.13/kWh)	\$559/kW \$.22/kWh (\$319/kW) (\$.12/kWh)	\$645/kW \$.24/kWh (\$410/kW) (\$.15/kWh)		\$422/kW \$.24/kWh (\$134/kW) (\$.08/kWh)
Si CPC (3X)	\$453/kW \$.41/kWh (\$291/kW) (\$.26/kWh)	\$541/kW \$.26/kWh (\$378/kW) (\$.18/kWh)	\$593/kW \$.22/kWh (\$415/kW) (\$.15/kWh)	\$548/kW \$.22/kWh (\$386/kW) (\$.16/kWh)	\$553/kW \$.21/kWh (\$390/kW) (\$.15/kWh)	\$649/kW \$.24/kWh (\$488/kW) (\$.18/kWh)		
Si CPC (10X)		\$558/kW \$.25/kWh (\$490/kW) (\$.22/kWh)	\$615/kW \$.22/kWh (\$540/kW) (\$.19/kWh)	\$567/kW \$.22/kWh (\$500/kW) (\$.19/kWh)	\$569/kW \$.21/kWh (\$502/kW) (\$.19/kWh)	\$695/kW \$.25/kWh (\$629/kW) (\$.23/kWh)		
Si Fresnel (10X)				\$770/kW \$.41/kWh (\$701/kW) (\$.38/kWh)	\$752/kW \$.34/kWh (\$685/kW) (\$.31/kWh)	\$886/kW \$.33/kWh (\$820/kW) (\$.31/kWh)		
CIS Flat Plate	\$693/kW \$.35/kWh (\$293/kW) (\$.15/kWh)				\$799/kW \$.31/kWh (\$406/kW) (\$.16/kWh)		\$465/kW \$.27/kWh (\$197/kW) (\$.11/kWh)	\$509/kW \$.31/kWh (\$190/kW) (\$.11/kWh)

Figures without parentheses are for cells costing \$500/kW
Figures with parentheses are for cells costing \$100/kW

Summary of CPS Busbar Energy Costs in Mills/kWh
(Investor-Owned Utility)

Dwg. 6382A77

Table 2.6.4

Array Module	Fixed At Latitude	Horizontal EW Axis NS Track	Horizontal NS Axis EW Track	Vertical Axis At Lat. Tilt	Vertical Axis At 50° Tilt	Contin- uous Two Axis Tracking	Lean-To	Windrow
Si Flat Plate	101 (48)				84 (43)		83 (41)	87 (40)
Si V Trough					77 (50)			
Si CPC (3X)								
Si CPC (10X)					75 (68)	35 (78)		
Si Fresnel (10X)								
CdS Flat Plate					103 (60)		97 (52)	109 (54)

Figures without parentheses are for cells costing \$500/kW
Figures with parentheses are for cells costing \$100/kW