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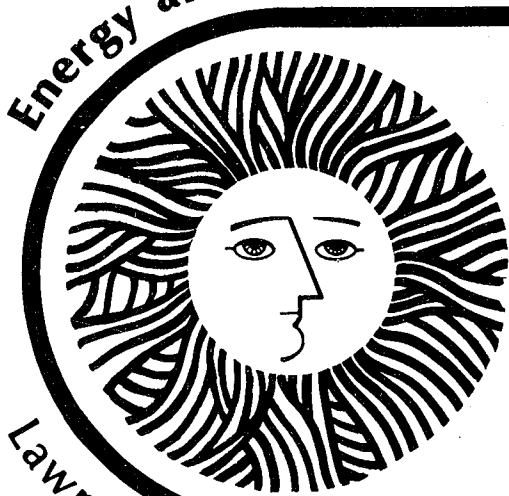
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**ANALYSIS OF THE CALIFORNIA
SOLAR RESOURCE***

Volume 1: Executive Summary

P. Berdahl, D. Grether,
M. Martin, and M. Wahlig

Lawrence Berkeley Laboratory University of California/Berkeley

Prepared for the U.S. Department of Energy, Division of Solar Energy,
under Contract No. W-7405-ENG-48 and for the California Energy Commission

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Analysis of the California Solar Resource is a three-volume work:

Volume 1: Executive Summary

Volume 2: Final Report

Volume 3: Appendices

All three volumes are available from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

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ANALYSIS OF THE CALIFORNIA SOLAR RESOURCE

VOLUME 1: EXECUTIVE SUMMARY

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INTRODUCTION

This Executive Summary is a brief presentation of the main points, conclusions, products and recommendations of this project. It is not intended to be a comprehensive summary of the work performed; that purpose is served by Volume 2, the Final Report.

Accordingly, this Executive Summary is presented in brief explanatory phrases, so it can be read and understood in a few minutes. The new resurgence of the solar energy field is but a few years old, and already the amount of paperwork generated is staggering. If a report is not brief enough to be read before it is put down, it is likely never to be read at all. We have endeavored to meet this brevity criterion and at the same time communicate the highlights of this project.

For those who would seek the background material behind these statements, each is keyed by reference to the appropriate Section in the Final Report.

PROJECT OVERVIEW

- **DETERMINED NEED FOR SOLAR RADIATION DATA**
 - Made direct contacts with potential data users (Section 2.2)
 - Ascertained data inputs required for solar design techniques (Section 2.3)
 - Conducted analysis to determine sensitivity of system design and economics to errors in solar data (Section 2.4)
 - Summarized conclusions and recommendations of previous studies (Section 2.5)

- **DETERMINED CURRENT STATUS OF CALIFORNIA SOLAR DATA**
 - Assessed the availability and quality of existing solar data (Section 3.1)
 - Acquired and corrected usable data (Section 3.2)
 - Identified and characterized current solar data networks (Section 4.1)

- **FORMULATED FUTURE SOLAR DATA PROGRAM THAT WOULD SATISFY USERS' NEEDS**
 - Specified appropriate instrumentation, its accuracy and calibration requirements (Section 4.2)
 - Assessed present state-of-the-art of techniques for spatial interpolation of solar radiation data (Section 4.3)
 - Formulated options for desirable actions dealing with data collection, analysis, dissemination, and interpolation (Section 4.4)
 - Made recommendations for actions by the state (Section 4.5)



MAJOR PRODUCTS OF THIS PROJECT

1. SUMMARY OF USERS' NEEDS FOR SOLAR RADIATION DATA (SECTION 2.7)
2. SUMMARY AND DESCRIPTION OF ALL PAST AND PRESENT CALIFORNIA SOURCES OF SOLAR RADIATION DATA (SECTIONS 3.1, 4.1, AND APPENDICES F AND G)
3. CALIFORNIA SOLAR DATA MANUAL (SECTION 3.3)
4. SPECIFICATION OF THE REQUISITE COMPONENTS OF A SOLAR DATA PROGRAM THAT WILL SATISFY USERS' NEEDS (SECTIONS 4.2, 4.3 AND 4.4)
5. PRESENTATION OF OPTIONS FOR ACTIONS THAT WOULD SATISFY SOLAR DATA NEEDS (SECTION 4.4)
6. RECOMMENDATIONS FOR ACTION BY THE STATE (SECTIONS 4.4 AND 4.5)

Highest Priority Items—For Immediate Implementation

Deferred Priority Items—For Implementation After One Year

Lower Priority Items—For Possible Future Implementation



1. SUMMARY OF USERS' NEEDS FOR SOLAR RADIATION DATA (SECTION 2.7)

- TOTAL SOLAR RADIATION ON SURFACE OF ANY TILT AND ORIENTATION
- DIRECT NORMAL SOLAR RADIATION
- ACCURACY OF 10% OR BETTER
- DATA RECORD OF AT LEAST FIVE YEARS
- TIME RESOLUTION OF ONE HOUR IS SUFFICIENT



2. SUMMARY AND DESCRIPTION OF ALL PAST AND PRESENT CALIFORNIA SOURCES OF SOLAR RADIATION DATA

- IDENTIFIED 145 SOLAR DATA STATIONS, THE PERIOD OF RECORD, AND TYPE OF INSTRUMENT USED (SECTION 3.1 AND APPENDIX F)
- PROVIDED ADDITIONAL DETAILS FOR THE 78 STATIONS THAT USED THERMOPILE-TYPE PYRANOMETERS; ONLY 22 STATIONS HAVE DATA RECORDS OF FIVE YEARS OF MORE (SECTIONS 3.1 AND APPENDIX F)
- CARRIED OUT AND DOCUMENTED SITE VISITS TO 24 SELECTED DATA STATIONS TO IDENTIFY PROBLEMS ASSOCIATED WITH INSTALLATION, OPERATION, MAINTENANCE, AND CALIBRATION (SECTION 3.1 AND APPENDIX G)
- DESCRIBED THE MAJOR SOLAR DATA NETWORKS NOW OPERATIONAL IN CALIFORNIA (SECTION 4.1)

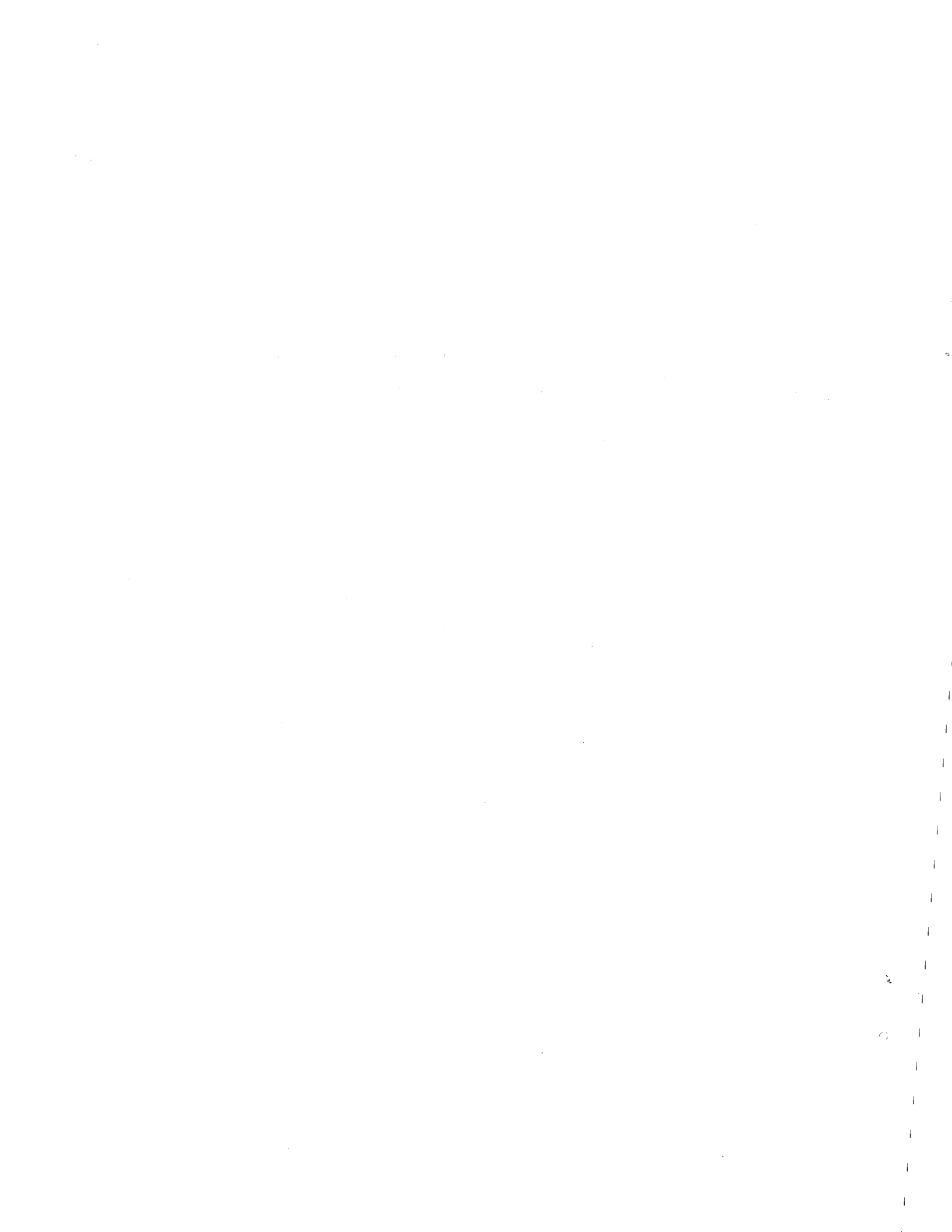
3. CALIFORNIA SOLAR DATA MANUAL (SECTION 3.3)

- CONTAINS CORRECTED TOTAL HORIZONTAL MONTHLY AVERAGE SOLAR RADIATION VALUES FOR 19 CALIFORNIA LOCATIONS
- INCLUDES CALCULATED VALUES (AND THEIR UNCERTAINTIES) OF DIRECT NORMAL SOLAR RADIATION AND TOTAL SOLAR RADIATION ON TILTED SURFACES
- INCLUDES NEARBY CLIMATE DATA: TEMPERATURES, WIND SPEED AND DIRECTION, PRECIPITATION, AND HUMIDITY
- SPECIFIES 15 CALIFORNIA SOLAR ZONES AS GUIDES TO THE GEOGRAPHIC EXTENT OVER WHICH SOLAR DATA FROM A PARTICULAR STATION CAN BE USED (SEE SECTION 4.3 AND APPENDIX I)
- INCLUDES SUPPLEMENTARY INFORMATION, SUCH AS A GUIDE TO SIMPLIFIED PERFORMANCE CALCULATIONS, SKY CHARTS, AND SUN LOCATION RELATIONSHIPS



4. SPECIFICATION OF THE REQUISITE COMPONENTS OF A SOLAR DATA PROGRAM THAT WILL SATISFY USERS' NEEDS

- A NETWORK OF SOLAR DATA STATIONS (SECTION 4.2)
 - Instruments required at each station to achieve needed accuracies
 - Essential maintenance and calibration procedures
- INTERPOLATION METHODS FOR DETERMINING SOLAR RADIATION VALUES AT LOCATIONS BETWEEN DATA STATIONS (SECTION 4.3)
- AN ORGANIZATIONAL STRUCTURE THAT CAN ASSURE DATA QUALITY AND DISSEMINATE THE RESULTING SOLAR RADIATION DATA (SECTION 4.4)



5. PRESENTATION OF OPTIONS FOR ACTIONS THAT WOULD SATISFY SOLAR DATA NEEDS (SECTION 4.4)

- OPTIONS ARE ORGANIZED INTO FOUR CATEGORIES:
 - Data collection (building upon the strengths of the currently existing DOE/NOAA, West Associates, and PG&E/LBL networks)
 - Calibration and data analysis (routine calibration and checks on data quality as well as independent clear-noon-type analysis)
 - Data Dissemination (periodic updating of the *California Solar Data Manual*, providing tapes of hourly solar data, and responding to special requests for data sets)
 - Interpolation analysis (application of interpolation techniques to California Solar Data, validation of these techniques, and development of new ones if necessary)

- THE COST, BENEFIT, AND RESULTING PRIORITY ARE PRESENTED FOR EACH OPTION

6. RECOMMENDATIONS FOR ACTION BY THE STATE (SECTIONS 4.4 AND 4.5)

Highest Priority Items—for Immediate Implementation

- IMPROVE THE SIX PG&E SOLAR DATA STATIONS BY REPLACING EXISTING EQUIPMENT WITH BETTER AND MORE COMPLETE SETS OF INSTRUMENTS, AND INSTALL A CENTRAL DATA RECEIVING FACILITY (COST: \$95,000)
- CARRY OUT ROUTINE EQUIPMENT CALIBRATIONS AND DATA QUALITY CHECKS FOR THE PG&E SOLAR DATA NETWORK (COST: \$20,000 START-UP PLUS \$40,000 YEARLY)
- PERIODICALLY (EVERY THREE TO FIVE YEARS) UPDATE AND REISSUE THE *CALIFORNIA SOLAR DATA MANUAL* (COST: \$40,000, ONCE EVERY THREE TO FIVE YEARS)
- IMPROVE SELECTED WEST ASSOCIATES STATIONS BY ADDING TILTED PYRANOMETERS (COST: \$10,000)
- CARRY OUT A CLEAR-DAY OR CLEAR-NOON ANALYSIS TO CHECK ALL SOLAR DATA THAT ARE COLLECTED, AND PERFORM CORRECTIONS IF NECESSARY (COST: \$20,000 YEARLY)
- PROVIDE TAPES OF HOURLY SOLAR DATA TO THE DOE/NOAA ASHEVILLE FACILITY, WHICH WILL MAKE THE DATA AVAILABLE TO USERS ON REQUEST (COST: \$10,000 YEARLY)
- ESTABLISH A STATE-WIDE SOLAR DATA QUALITY ADVISORY COMMITTEE WITH REPRESENTATION FROM ALL THE MAJOR DATA-COLLECTING ORGANIZATIONS TO MONITOR NETWORK OPERATIONS IN GENERAL, AND CALIBRATION AND MAINTENANCE PROCEDURES IN PARTICULAR (NO ADDITIONAL COST)

**6. RECOMMENDATIONS FOR ACTION
BY THE STATE (continued)
Deferred Priority Items—for Implementation
After One Year**

- APPLY TO CALIFORNIA SOLAR DATA THE RESULTS OF INTERPOLATION STUDIES BY OTHER (NON-CALIFORNIA) GROUPS, AND USE THESE TECHNIQUES IN REVISING THE *CALIFORNIA SOLAR DATA MANUAL* (COST: \$30,000, ONCE EVERY THREE TO FIVE YEARS)
- DETERMINE THE ADEQUACY OF THESE NEW INTERPOLATION TECHNIQUES FOR CALIFORNIA APPLICATIONS; HERE ADEQUACY REFERS TO THE GOAL OF 10% ACCURACY (COST: \$40,000)
- ADD SEVERAL SOLAR DATA STATIONS TO THE PG&E NETWORK TO OBTAIN SOLAR DATA AT LOCATIONS WHERE PRESENT COVERAGE IS POOR OR ABSENT (COST: \$44,000)



6. RECOMMENDATIONS FOR ACTION BY THE STATE (SECTION 4.4)

Lower Priority Items—For Possible Future Implementation

- PROVIDE TAPES OF HOURLY SOLAR DATA DIRECTLY TO CALIFORNIA USERS (COST: \$20,000 YEARLY)
- RESPOND TO REQUESTS FOR NON-STANDARD DATA SETS OR DISTRIBUTIONS; MAKE RESULTS PUBLICLY AVAILABLE (COST: \$20,000 YEARLY)
- DEVELOP AN INTERPOLATION TECHNIQUE, USING CALIFORNIA SOLAR DATA, THAT IS SPECIFICALLY APPLICABLE TO CALIFORNIA'S NEEDS (COST: \$80,000)
- ADD SOLAR DATA STATIONS IN REGIONS OF CALIFORNIA BEYOND THE CURRENT PG&E AND WEST ASSOCIATES NETWORKS, WHERE THERE IS NO PRESENT COVERAGE (COST: \$60,000)



This report was done with support from the Department of Energy. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

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