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PHOTOVOLTAIC TEST AND DEMONSTRATION PROJECT

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SUMMARY

The National Photovoltaic Conversion Program of the United States has been established by the Energy Research and Development Administration to develop economically viable photovoltaic power systems suitable for a variety of terrestrial applications. The NASA Lewis Research Center has been assigned management of the Photovoltaic Test and Demonstration Project, one part of the overall program. The primary objectives of this project are:

1. To determine operating characteristics for a variety of solar cell systems and subsystems.
2. To prove, through appropriate tests and demonstrations, that solar cell systems can satisfy the requirements of potentially attractive applications having national impact.
3. To devise and implement the methodology, techniques and equipment to make (a) accurate and reproducible measurements of solar cell and array performance, and (b) diagnostic measurements on solar cells, modules and arrays.
4. To determine the endurance of solar cell modules, component parts, and materials thereof under environmental conditions of their intended use.

Briefly, the following subprojects make up the project.

1. Applications will start with a series of tests and demonstrations in the residential applications category. Following these will be applications representing successively larger, more complex systems, e.g., commercial and industrial load centers. Concurrently, a series of smaller terrestrial applications will be identified and implemented. In support of these applications an outdoor facility, starting with a 10 kW array for testing systems, is being established at the LeRC.
2. Device Performance and Diagnostics involves the development of uniform standards and procedures for the testing and evaluation of solar cells and modules under terrestrial conditions.
3. Endurance Testing work is directed toward investigating the environmental durability of solar cell arrays. The work includes both accelerated and real time exposure testing.

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INTRODUCTION

The National Photovoltaic Conversion Program of the United States has been established by the Energy Research and Development Administration (ERDA) to develop low cost reliable photovoltaic systems suitable for terrestrial applications having a national impact, and to stimulate the creation of a

viable industrial and commercial capability to produce and distribute these systems for widespread use. The NASA Lewis Research Center has been assigned management of the Photovoltaic Test and Demonstration Project, one part of the overall program. Objectives of this project include the design, construction, testing, and demonstration of photovoltaic power conversion systems coupled to applications having national significance. The project will also establish and maintain the methodology and standards for measuring terrestrial solar cell performance as well as testing the endurance of solar cell arrays. The technical portion of the project is made up of three major subprojects:

Applications
Device Performance and Diagnostics
Endurance Testing

Each of these subprojects will be discussed in detail.

Applications

The objectives of this subproject are to determine the operating characteristics for a variety of photovoltaic conversion systems and subsystems and to confirm by tests and demonstrations that these systems can satisfy potentially attractive applications having national impact.

The general approach is to proceed from simpler, lower power applications to more complicated higher power applications. This approach is consistent with anticipated availability of solar cells, modules and arrays from the ERDA/Jet Propulsion Laboratory (JPL) Low Cost Silicon Solar Array Project of the national program. Initial activities include:

System Test Facility
Residential Applications
Near-Term Applications

System test facility. - The objective of this activity is to provide a place where photovoltaic systems may be assembled and electrically configured, without specific physical configuration, for operation and testing to evaluate their performance and characteristics. The System Test Facility allows for prompt preliminary in-house investigation and checkout of components, subsystems and systems before they are physically configured and mounted in more elaborate and visible field experiments and demonstrations.

The System Test Facility is now being constructed to accommodate systems with up to 10 kw (peak power) of solar array. It is planned to extend the capacity eventually up to 100 kw.

Residential applications. - Residential applications have obvious interest to the overall program and to the general public and, because it is the lowest power application which can have national energy impact, it can be investigated promptly and with minimal investment of resources. The results and experience of these experiments will, in addition to aiding res-

idential assessment, be invaluable to the planning and execution of later experiments for larger load center applications. Additionally, the operating experience and system test data will be used to corraborate the results of system analyses and to validate and refine the computational models used in the analyses.

A prototype residence experiment incorporating a photovoltaic power system capable of producing a significant portion of residential electrical energy needs is now being designed and will be erected at LeRC. Following the construction of this first residential experiment, other residential experiments will be designed and constructed on selected sites in the continental United States to provide experience and data on regionally dependent factors.

Near-term applications. - The objective of this activity is to stimulate market demand for solar cells by demonstrating suitability of solar cells for specific near-term applications which are now or soon will be cost competitive. Applications will be selected initially from government sectors. Additionally, the Lewis Research Center will support the implementation of photovoltaic power systems for Department of Defense applications by providing mechanical and electrical design, sizing, fabrication and preliminary testing of arrays to be used in their experiments and demonstrations.

The Lewis Research Center will identify candidate applications which offer early market penetration and leverage. Joint cost-shared test demonstrations will be formulated and implemented with potential users.

Device Performance and Diagnostics

The objective of this subproject is to ensure the availability of reliable test methods and information for all participants in the ERDA National Photovoltaic Conversion Program. This includes devising and implementing the methodology, techniques and equipment to make standardized measurements of terrestrial solar cell, module and array performance and related characteristics.

The subproject will be implemented by means of the following activities:

Standards, Measurements and Methodology
Measurement and Diagnostic Facilities
Insolation Measurement

Standards, measurements and methodology. - The purpose of this activity is to establish standard conditions, measurement procedures and methodology to be used by all participants in the National Photovoltaic Conversion Program. Work in this area was initiated with a Terrestrial Photovoltaic Measurements Workshop held on March 19-21, 1975. Workshop proceedings have been established.[1] Also as a direct outgrowth of the workshop, and with the concensus of U.S. investigators, an interim measurements procedures manual was prepared and distributed.[2]

As a follow-on to the March 1975 workshop a second workshop will be convened in November 1976, directed to updating the recommendations of the first workshop.

To establish standard reference conditions it is planned to determine the variation of solar intensity and spectrum for the entire range of terrestrial conditions. The performance of solar cells under these conditions will be calculated and compared to experimental measurements.

Also as part of this activity, an interim reference solar cell package is to be designed and fabricated. Calibration of the reference cells will be in accordance with the specifications agreed upon in the March 1975 workshop.

Measurement and diagnostic facilities. - Facilities have been set up for the calibration of cells for various photovoltaic investigators; for confirmatory measurements of solar cell and module performance; and to provide diagnostic measurements on cells and arrays.

Insolation measurements. - The objective of this activity is to develop a relatively inexpensive, automated insolation data acquisition system. Previous LeRC experience in utilizing solar cells and low-cost electronics for insolation measurements will be employed to develop a suitable system. It is planned to deploy insolation data systems at each photovoltaic power system test and demonstration site.

Endurance Testing

The objective of this subproject is to determine the endurance of solar cell modules and module materials under both accelerated and real-time environmental conditions of intended use. Tests by established environmental testing companies will evaluate the performance of solar cells, solar cell modules, and component materials to the terrestrial environment.

Accelerated outdoor exposure tests. - This activity is concerned with the testing of cells, modules, arrays and their component materials in concentrated sunshine. Accelerated testing of a number of solar cell encapsulent materials was started in July 1974 by the Lewis Research Center.[3] Additional work in this area will be expanded with tests being made over a series of controlled environmental conditions (i.e., temperature, humidity) and in the presence of atmospheric pollutants.

Real-time outdoor exposure tests. - The most accurate measure of life for solar cell arrays and materials is obtained from long-term tests under real exposure conditions. Established testing companies with solar insolation and climatic reporting capability will conduct the real-time tests. Since these testing companies are located primarily in the southern part of the United States, tests under other climatic conditions of interest will be located at selected government installations.

STATUS

The Photovoltaic Test and Demonstration Project was initiated in June 1975. Work has begun on all subprojects and activities of the project. The project is presently on schedule and plans call for completion of the initial system test facility, first residential prototype system test and implementation of a number of near term applications by the end of June 1976. Interim standards, methodology and reference cells have been established and distributed. In addition endurance testing which began earlier will be continued and expanded.

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