# Photovoltaic Systems Reliability Improvement Program

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**ABSTRACT**

PV system reliability has improved significantly over the past ten years; however, by any definition system lifetime still falls far short of the DOE roadmap goal for 2004 "Validate 25-year lifetime for PV systems". In FY 2001 the DOE directed Sandia "to develop, in cooperation with industry, a systems and balance of systems (BOS) reliability". This paper briefly summarizes the result of that work. The plan is outlined and the direction of current work is discussed.

## 1. Introduction

The overall goal of this project is to make photovoltaic technology a preferred electrical energy supply option. Recently the PV market has been accelerated by Y2K and by the California energy shortfall. This accelerating force is unlikely to continue. To sustain the recent growth in PV sales, the public must view PV as a mature product; it should be expected to perform well and reliably. The approach is defined through 5 technical objectives:

1. reducing the life-cycle costs;
2. improving the reliability;
3. increasing & assuring the performance of fielded systems;
4. removing barriers to the use of the technology; and
5. supporting market growth for commercial U.S. photovoltaic systems.

All of these technical objectives interact with each other.

## 2. The Reliability Plan

In past months a reliability program outline has been drafted and circulated to a limited number of industry members. The outline was expanded into a draft plan and has been submitted to DOE for review and approval. Sandia will now disseminate the plan to a wider audience including the PV industry, utilities and users. It is intended that the bulk of the money invested in this program will pass directly to industry in the form of R&D contracts for product improvement.

The following paragraphs outline proposed activities conducted as part of a PV reliability program. The conceptual design of the program is shown in the figure below.

### A. Oversight and Coordination

Past metrics have concentrated more on installed cost and dollars/watt than on O&M or reliability. This lack of emphasis on reliability has resulted in a PV program where no single organization has the responsibility for reliability improvements. Thus reliability improvements have occurred happenstance, mostly in an incremental manner for individual components. Problems that limit the long-term potential of PV have been under emphasized. This is especially evident in the area of inverters. With the proposed approach, a system-based, focused, prioritized effort will be place upon developing a highly reliable inverter integrated with PV system design requirements.

In the Photovoltaic Systems Reliability Improvement Program: DOE will control the program through a program manager at Sandia National Laboratories. The program manager will be responsible for integrating the entire program and, with DOE concurrence, apportion resources and assign priorities. Sandia will be responsible for a continual exchange of information with the industry and with customers. DOE will place new emphasis on reliability, using tools provided by Sandia. Sandia will expand interaction with BIPV, RUS, and others (to be identified) so as to identify opportunities for dramatically expanding the use of PV.

### B. Inadequate Information

An incomplete picture of the root causes of problems in fielded systems exists. For many applications sufficient emphasis is not being placed on the operation and maintenance of systems that are in the field. Understanding fielded photovoltaic systems by quantifying O&M costs, performance, and reliability is critical for acceptance of PV as a dependable alternative energy source. Past information on reliability is largely anecdotal; there has been no long-term systematic effort to gather O&M and reliability data.

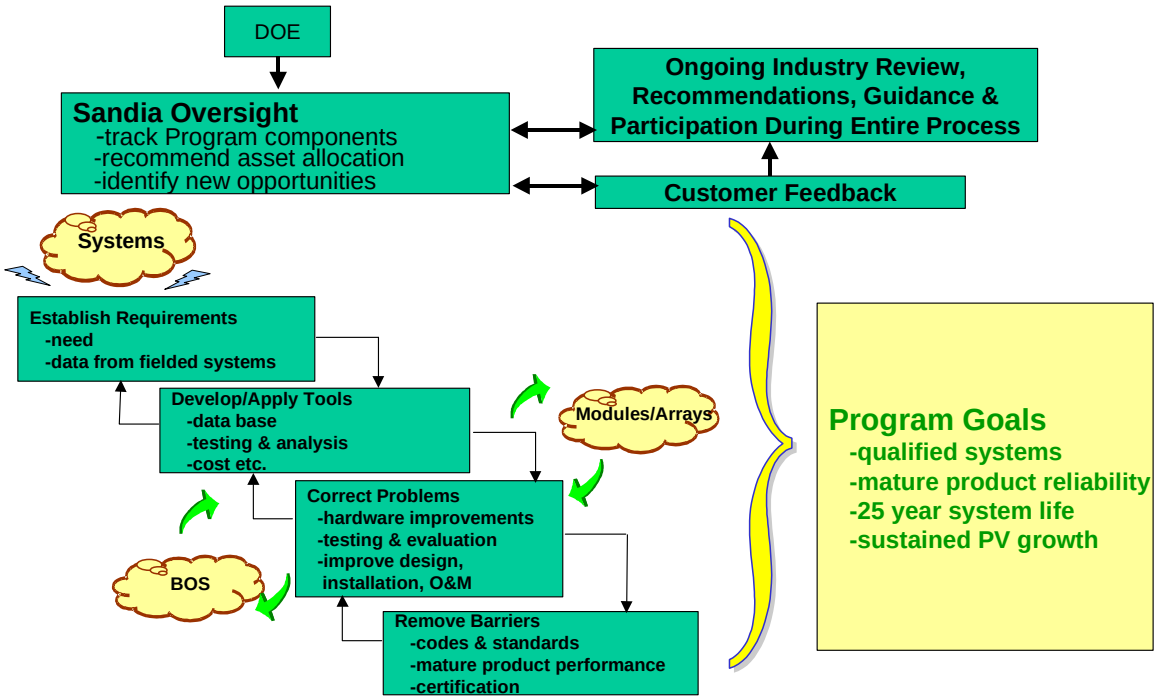
Sandia will accelerate the development of the Performance/Reliability Database. The study of data from fielded systems will provide information for researchers, individual users such as residential customers and utilities as well as manufacturers and dealers. The reliability and costs study includes:

- understanding 25 yr photovoltaic system lifetimes,
- identifying successful system designs,
- providing workable installation processes, and
- identifying robust component design.

### C. A Structured Program.

A structured PV reliability program will coordinate all aspects of the development of reliable PV systems while ensuring that priority problems are addressed first and that no important problem is overlooked. A primary goal is to validate 25-year lifetime for PV systems (5-year plan goal). An outline of the important issues follows.

- Define system lifetimes.
- Utilize a systems engineering design approach.
- Detailed investigation of field-aged systems. Initiate R&D programs with industry to solve particular problems.
- Expand a laboratory test program that supports industry.
- Systematic documentation & analysis of field reliability status.




### D. Hardware Problems

Product development. This program will target high priority reliability problems. The major new hardware development already identified is the development of a new inverter with at least a ten-year mean time to first failure (MTFF) and with lower cost.

Testing.

Testing, throughout the development cycle, is one of the best means for reliability improvement. The testing must be initiated during product development, with overstress tests such as HALT providing essential design information. Program Content. Testing of mature products benchmarks performance and identifies the need for further development. Particular emphasis will be placed on array degradation, performance of power electronics, and extending battery lifetime.

### E. Codes and Standards

To streamline the implementation of PV, especially grid-connected PV, a uniform and simplified set of codes and standards is essential. Certification efforts will receive additional consideration for hardware certification with an inverter test protocol for certification and continued but accelerated efforts for establishing a national practitioner certification program including providing startup for a national training center. Removing barriers and education outreach will continue with accelerated technical assistance and collaboration with high leverage programs such as the California Energy Commission's Research, Development and Deployment program.

### G. Mainstreaming PV as a DER Source

The use of distributed energy resources (DER) is increasingly being pursued as a supplement and an alternative to large conventional central power stations. Photovoltaics technology is well-suited to meeting needs for distributed energy systems and is significantly more "market ready" than the other new distributed energy resources. Numerous barriers to implementation have been identified; a program to remove these barriers is being formulated.

Sandia plans to partner with industry and users of the technology to ensure customers are ready and able to make use of PV technology whenever the economics or other drivers dictate that they should. Sandia further proposes to cost share with the partners as appropriate through CRADAs or other means to:

- define requirements,
- develop a system specification,
- quantify system economics,
- characterize the system components and the overall system, and.
- work with users and industry to develop the most effective installation and procurement methods.

## 3. References

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