THE UNITED STATES DEPARTMENT OF DEFENSE TERRESTRIAL PHOTOVOLTAIC PROGRAM - A 1994 STATUS REPORT

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ABSTRACT

The United States Department of Defense (DoD) has an aggressive, wide-ranging strategy to broaden photovoltaics (PV) use for military purposes. The DoD potential market is immense. Some estimates have placed this market as high as 3800 megawatts (MW) over the long term. The key organization to develop and implement a PV utilization strategy is the DoD PV Review Committee. Funding for PV in the DoD is through the Energy Conservation Investment Program (ECIP), the Strategic Environmental Research and Development Program (SERDP), the Federal Energy Management Program (FEMP), and through operations and maintenance budgets. Procurement actions are (or about to be) initiated for ten separate projects representing nearly 1.4 MW of PV during 1994 or early 1995. These range in size from 60 to 450 kilowatts (kW) and are primarily intermediate-sized PV-diesel hybrid systems with one large grid interactive project.

ORGANIZATION

The DoD Photovoltaics Review Committee

To assist the DoD in introducing and using PV on a wide scale, the DoD has established the Photovoltaics Review Committee. This committee is composed of a Chairman and a member from each of the three principal military departments (who are co-authors of this paper). Sandia National Laboratories directs required technology development and provides technical assistance to committee members. Procurement management for specific projects is tailored to the end-user and is managed by the respective military organizations [1], [2].

Approach

The DoD is the largest single energy user in the world resulting in substantial pollution emissions. The primary purpose of the DoD PV program is to reduce those emissions substantially. The potential PV application base within DoD is estimated at over 50 MW for small remote systems (less than 25 kW), over 400 MW for intermediate to large remote systems (25 to 1000 kW) and over 3300 MW for large grid interactive systems (greater that 500 kW). Various DoD organizations purchase many small systems. Typical applications include lighting, cathodic protection, power for various electronic instrumentation, and as a battery charger for a wide variety of equipment. We estimate that to date approximately 2 MW of PV are in use at various DoD installations—almost all of it for small applications. The Department of Defense's position is that small applications are proven technology; therefore decisions to buy or not to buy are at the option of the respective military decision makers; there is no centrally directed program to procure these systems. As an example, the Army has recently announced the purchase of the first of ten monthly shipments of a $2.0 million ManPac module manufacturing contract with Photocomm Inc.[3].

In the intermediate to large classes, the DoD will initiate ten separate projects to purchase nearly 1.4 MW of PV during 1994 or early 1995. Most of these projects are PV-diesel hybrid systems ranging in size from 60 to 350 kW. The emphasis is on intermediate to large remote systems and grid interactive systems for remote "isolated" grids that generate their own power. An important complementary development project sponsored by the SERDP is the load leveling and uninterruptible power for large utility grids.

The approach is to: (1) define DoD unique energy requirements; (2) identify the application classes and market potential for DoD; (3) define the needed technology advancements to meet those requirements; (4) perform the R&D necessary to make the required technology advances; and (5) validate the technology transfer, thereby leading to widespread implementation of PV [4].

FUNDING

Federal funding allocations are primarily from the ECIP, a component of the Military Construction Program, and SERDP, a joint DoD-DOE-EPA program that addresses environmental issues. In addition, there are many systems procured at the installation level (usually from operation and maintenance budgets) that are not centrally tracked. In FY1995, it is possible that some PV projects will be funded through the Federal Energy Management Program (FEMP). SERDP funds are the primary vehicle for technology development and evaluation while ECIP (and possibly FEMP) funds are the primary vehicle for technology validation and technology transfer. All ECIP projects are required to be life cycle cost-effective as part of the internal DoD project approval process. Funding history and projections for the DoD PV program are summarized in Table 1 [4], [5].

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First WCPEC; Dec. 5-9, 1994; Hawaii
TABLE 1 - FUNDING FOR PV IN THE DOD $(000)

<table>
<thead>
<tr>
<th>Funding Source</th>
<th>FY93</th>
<th>FY94</th>
<th>FY95</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECIP</td>
<td>6,000a</td>
<td>6,500b</td>
<td>7,000b</td>
</tr>
<tr>
<td>SERDP</td>
<td>4,000</td>
<td>4,000</td>
<td>1,975</td>
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<tr>
<td>Miscellaneousa</td>
<td>14,895</td>
<td>16,500</td>
<td>20,000</td>
</tr>
<tr>
<td>DoD R&amp;D</td>
<td>930</td>
<td>900</td>
<td>900</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>25,825</td>
<td>27,900</td>
<td>29,875</td>
</tr>
</tbody>
</table>

*a FY 1992 appropriation; received in FY 1993
b Includes other (than PV) renewable energy projects

SPECIFIC PROJECTS CURRENTLY IN PROCUREMENT OR INSTALLATION
(Summary in Table 2)

Superior Valley, China Lake, California. (SERDP Project) On September 16, 1994, a $3,570,850 contract was awarded to Photocomm, Inc. to design, manufacture, and install a PV-diesel hybrid system at the bombing complex at Superior Valley on the Naval Air Warfare Center at China Lake, California. The system is comprised of a 350 kW PV array with associated power processing equipment, battery storage system, and a diesel generator. PV was an attractive option because the Superior Valley location is remote from the grid and other Center functions. The system is being designed by Photocomm; the modules to be used are the ASE-DG/50 four foot by six foot modules supplied by ASE Americas, and the power conditioning will be sub-contracted to Abacus. This project is a research and development project designed to advance power processing technology to allow “ganging” of multiple power processing units to achieve the power capacity required for the larger DoD applications. The system also provides increased power capacity required by the expanding mission of the facility [6].

Mountain Home Air Force Base, Grasmere Range. (ECIP Project) This project is to provide electrical power to electronic equipment located on Grasmere Range, approximately 80 miles from Mountain Home Air Force Base and many miles from the nearest grid. Previously, power had been furnished by diesel engines. The expanding mission of the Grasmere Point Facility now requires year-round power with 24-hour power during the winter. Because of the severe winter weather at the site, 24-hour power with diesels alone is impractical. This project allows the Air Force to reduce the diesel engine run time thereby providing power year-round at a reasonable cost [7]. A contract has been awarded to Idaho Power to install a PV-hybrid system for equipment at the Grasmere Range. It is expected to be operational in December 1994. System engineering will be done by Idaho Power; the module supplier is Solarex; and the power conditioning equipment supplier is AES.

Ascension Island Runway Lighting. (ECIP Project) This project will result in the construction of a 75 kW PV-island grid interactive system that will provide power for the runway lighting system with the additional ability to also supply power into the base distribution system. The project is 100 percent designed and is scheduled to be advertised in January 1995 and awarded in February 1995. The project will save approximately 1400 barrels of fuel oil that would otherwise have to be used to produce power [8].

Range Electronic Warfare Simulator (REWS), San Clemente Island, California. (ECIP Project) Most of the facilities on San Clemente Island are served by a group of diesel generators that produce power for the island grid. However, the REWS facility is isolated even from the island grid and depends on a series of generators to provide power to the equipment and housekeeping loads at the facility. The proposed system addresses the excessive costs associated with providing 24-hour power with diesel generators. The PV array will be about 100 kW. The system will provide autonomous operation during weekends which will substantially reduce operation costs [9]. The procuring office is the Naval Facilities Command Southwest Division (SWDIV) in San Diego.

Junction Ranch, China Lake. (ECIP Project) Junction Ranch is a radar cross section test complex many miles from the grid that serves the main complex at China Lake and has historically been served by diesel generators. The PV-diesel hybrid system is expected to improve power quality and reliability, thereby avoiding equipment damage. Schedule slippages, caused by unforeseen power outages, are expected to decrease. An initial scoping notice has appeared in the Commerce Business Daily and the request-for-proposal (RFP) is due to be released in December 1994. The procuring agency is the Naval Facilities Command in San Bruno, California.

Yuma Proving Ground. (ECIP Project) The project at Yuma Proving Ground will use approximately 450 kW of PV. It is being built to provide a demonstration for a grid interactive renewable energy source and to take advantage of a favorable arrangement on rates with the Western Area Power Administration. It addresses the need to reduce the peak power demand at the Yuma Proving Ground. Data from the Yuma project will be reported as part of the PVUSA data collection system.

Marine Corps Air Ground Combat Center, Twentynine Palms California, Range 500. (ECIP Project) Range 500 is a remotely located tank target practice range isolated from the grid that serves the base proper. Presently, diesel generators power a mechanism that drives tank pop-up targets along a track. PV will supplement those generators and provide improved power quality and reliability. It is expected that the PV array will be about 80 kW. The procuring agency is the Naval Facilities Command SWDIV. The RFP is expected to be released in January 1995.
<table>
<thead>
<tr>
<th>Project/Location/Service</th>
<th>System Type</th>
<th>PV System Size - kW</th>
<th>Procurement Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior Valley; China Lake-Navy</td>
<td>Hybrid PV-Diesel</td>
<td>350</td>
<td>Contract Awarded September 1994, Photocomm</td>
</tr>
<tr>
<td>Grasmere Point Air Combat Range; Mountain Home Air Force Base, ID</td>
<td>Hybrid PV-Diesel</td>
<td>78</td>
<td>Contractor: Idaho Power. Operational December 1994</td>
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<tr>
<td>Runway Lighting; Ascension Island - Air Force</td>
<td>Isolated Grid Tied</td>
<td>75</td>
<td>RFP - January 1995</td>
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<tr>
<td>Range Electronic Warfare Simulator; San Clemente Island - Navy</td>
<td>Hybrid PV-Diesel</td>
<td>100</td>
<td>RFP - January 1995</td>
</tr>
<tr>
<td>Junction Ranch Horizontal Radar; China Lake - Navy</td>
<td>Hybrid PV-Diesel</td>
<td>100</td>
<td>RFP - December 1994</td>
</tr>
<tr>
<td>Grid Support; Yuma Proving Grounds - Army</td>
<td>Utility Tied</td>
<td>~450</td>
<td>RFP - November 1994</td>
</tr>
<tr>
<td>Range 500 - Artillery Range; Twentynine Palms-Marine Corps</td>
<td>Hybrid PV-Diesel</td>
<td>100</td>
<td>RFP - January, 1995</td>
</tr>
<tr>
<td>Mobile Power Center; Camp Pendleton - Marine Corps</td>
<td>Mobile Hybrid</td>
<td>3.5</td>
<td>Prototype under construction at NRaD, San Diego</td>
</tr>
<tr>
<td>Fort Carson; Colorado-Army</td>
<td>Multiple Well Pumping</td>
<td>14</td>
<td>Contract Award, December 1994; Remote Power Inc.</td>
</tr>
<tr>
<td>Wild Horse Mesa; China Lake-Navy</td>
<td>Hybrid PV-Diesel</td>
<td>200</td>
<td>RFP - First Quarter, 1995</td>
</tr>
</tbody>
</table>

### Mobile Power Center
(SERDP Project) For the 1st Marine Expeditionary Force at Camp Pendleton, California, a mobile power center (MPC) is under development. It is designed to interface with utility and conventional generators and will have about 3.5 kW of PV, 1 kW of wind, and 6 kW AC output, and 60 kWh energy storage. The MPC is a research and development project designed to incorporate hybrid capabilities in a mobile package that is compatible with standard military equipment and suitably robust for military operations. The unit addresses the need to simplify the logistics of power requirements for tactical military exercises as well as enhance the reliability of the missions. A prototype unit is under construction at the Naval Research and Development (NRaD) unit in San Diego.

### Fort Carson Water Pumping
(ECIP Project) Aging windmills are presently used for pumping water throughout Fort Carson. Many wells are remotely located, making it impractical and prohibitively expensive to run the electrical grid to these small, dispersed loads. Engine-driven pumping systems are inappropriate because of the relatively low level of pumping required and the environmental hazards they present. The scope of this project is to design, procure, and install 40 PV-powered water pumping systems. Additionally, the project calls for relocating a 6 kW PV system from an EPA facility in Alabama. A contract will be awarded to Remote Power in December 1994.

### Wild Horse Mesa, China Lake, California
(ECIP Project) As with the other projects at China Lake, this is a remotely located facility on the China Lake Complex that has historically been served by diesel generators. The RFP is expected to be released by March 1995. It is expected to require 200 kW of PV. The procurement office is the Naval Facilities Command Southwest Division (SWDIV) in San Diego.

### Complementary Activity
The following projects are complementary to the PV system procurement activity summarized previously:

### Load Leveling Technology Development Project at Yuma Proving Ground
The purpose of this project is to evaluate (on an operational PV system) ganged power processing plus stand-alone/parallel technology advancements. This will be a competitively procured effort. The procurement office is to be the Naval Air Weapons Center procurement office at China Lake. The RFP is expected in the first quarter 1995.
SERDP Technology Development Engineering Efforts at Sandia National Laboratories. These efforts include both technology development through engineering contracts to hardware manufacturers and hardware evaluation and acceptance testing at Sandia's unique systems level test facility for power processing and control hardware. Prototype hardware currently under evaluation includes: (1) the Abacus bi-mode power processing unit (similar to the unit selected for Superior Valley), (2) the Abacus array maximum power tracker (also selected for Superior Valley), and (3) the Daystar "Fuzzy-logic" system controller. The Omnion stand-alone/parallel power processing unit with seamless transfer capability is nearly complete and will be evaluated within the next several months along with a smaller version of the AES unit selected for the Grassmere Point project. The test facility at Sandia allows for evaluation and testing under near-actual site conditions that are beyond the manufacturer's testing capabilities. The facility has proven invaluable at identifying operational problems and provides the manufacturers the capability to test hardware modifications before the units are fielded [10], [11].

Analytical Tool to Quantify Life-Cycle Environmental Savings. This tool is being developed by the Environmental Protection Agency as a part of the SERDP program. Software refinement and database development are underway. Software is based on the EPA guidelines for lifecycle inventory analysis and can be applied to any alternative energy technology with the proper information added to the database. Completion of the final product is scheduled for mid-1995.

Demand-Side Management at Military Facilities. The Environmental Protection Agency (EPA) is a partner in the SERDP program and is sponsoring a PV-demand-side-management project. It complements the already existing EPA program, but extends it to military installations. The RFP is scheduled to be released in December 1994.

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The principal near-term result of these developments will be building block inverter/rectifier (battery charging) units that can be ganged to the capacity required for the application with the capability to operate either in parallel with conventional sources or in a stand-alone mode with "soft" seamless transfer between all modes. If successful, this program will establish viable electrical generation and energy storage technology for widespread applications within DoD with significant applications to other classes of potential applications. The long-term benefits include substantial environmental savings, economic savings, and reduction in consumption of fossil fuels. Current estimates indicate that PV can reduce costs by $1,600 million per year and reduce emissions associated with electricity generation by up to 37 percent (CO\textsubscript{2} emissions by 37 percent, CO emissions by 83 percent, NO\textsubscript{x} emissions by 10 percent, and SO\textsubscript{x} emissions by 53 percent) if fully implemented in DoD. Estimates indicate that PV can reduce dependence on fossil fuels by 800,000 MWh of electricity per year. PV can also substantially reduce the hazards associated with the transport and handling of liquid fossil fuel as diesel generators are phased out, increase mission capability and reliability, and increase energy security [4].

REFERENCES


