Renewable Energy Technologies for Federal Facilities

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FEDERAL ENERGY MANAGEMENT PROGRAM

Sandia National Laboratories/PIX1472

PV-powered security lighting at Roosevelt Lake in Arizona.

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Photovoltaics

Converting Sunlight into Electricity Serves Varied Power Needs

Photovoltaic (or PV) cells are devices that use semiconductor material to convert sunlight directly into electricity. Individual solar *cells*, most commonly squares of silicon, are wired together and laminated within a thin, protective glass case to make a *module*. In other cases, a very thin layer of noncrystalline silicon is coated on an inexpensive base. Though the thin-film material is less efficient at converting sunlight to electricity compared with other systems, its low cost and simplicity are perfect characteristics for certain applications. These modules can then be joined to form PV *arrays*. The amount of electricity generated by an array increases as more modules are added.

PV systems range from very simple to complex. They can also be either

remote or connected to the electric utility grid. In remote (or off-grid) applications, PV power is independent of existing utility lines and power grids. There are numerous examples of cost-effective PV applications within the federal government today, most of which are off-grid.

The simplest PV system generates direct-current electricity when the sun is shining and runs equipment such as water pumps or fans. A power inverter can be used to

convert direct current to alternating current. And for powering equipment in remote locations, PV systems include batteries that store electricity for use at night or when the sun isn't shining. The primary uses for PV today are for telecommunications, security and lighting systems, water pumps, and load management.

In some cases, power must be available on demand, or perhaps the electricity required occasionally exceeds the PV system's supply. Here, an electric generator can work effectively with PV to supply the load. Remote locations where loads are currently supplied by diesel generators alone are good candidates for PV systems with generators. Sites in national parks and national forests present good opportunities for PV/hybrid systems.

PV systems have many benefits:

- *Portability*—can move PV units easily to other locations
- *High reliability*—PV modules operate reliably for long periods of time with virtually no maintenance
- *Low operating costs*—fuel is free, and there are no moving parts
- *Low environmental impact*—non-polluting and quiet
- *Stand-alone capability*—for remote areas not served by a utility power grid
- *Modularity*—energy output can easily be increased or decreased by changing the number of panels
- *Safety*—not flammable
- *Versatility*—appropriate for virtually any climate.

What are the opportunities?

Photovoltaics should be considered for any remote application with a daily electrical load of a few watt-hours up to about 100 kilowatt-hours.

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What are the important terms?

Balance of System—all components and factors other than the PV modules that contribute to the cost of the system: design costs, land, site preparation, system installation, support structures, power conditioning, operation and maintenance costs, and indirect storage.

Break-Even—the cost of a PV system at which the value of electricity it produces exactly equals the cost of electricity from an alternative source plus the delivery of this electricity to the site. A break-even *distance* is the distance a power line can be extended to match the installation cost of PV.

Concentrator Collector—a PV module that uses optical elements to increase the amount of sunlight striking a PV cell, thus yielding better efficiencies than flat-plate systems. Concentrating arrays must track the sun and use only the direct sunlight because diffuse light cannot be focused onto the PV cells.

Efficiency—the percentage of available sunlight converted to electricity by a module or cell. Technically, this is the ratio of electric power produced by a cell at any instant to the power of the sunlight striking the cell.

Flat-Plate Array—a PV array that consists of non-concentrating elements. It uses direct and diffuse sunlight, but if the array is fixed in position, some portion of the direct sunlight is lost because of oblique sun-angles in relation to the array.

Peak Watt—maximum "rated" output of a cell, module, or system. The amount of power a PV device will produce at noon on a clear day with the sun approximately overhead when the cell is facing directly toward the sun.

On a first-cost basis, PV systems' installed costs can be less than the cost of utility service. For larger loads where utility power exists, PV may still be applicable. For example, the

reliability of the utility's power may be too low for a particular application. Or a federal agency may have higher electricity charges for midday use of electricity.

The National Park Service has 455 existing PV systems primarily associated with equipment for monitoring resources. And other cost-effective, widely demonstrated residential and commercial *off-grid* applications include

- Street lights for highways
- Offshore drilling platforms
- Campgrounds and marinas
- Water-supply disinfection
- Remote-area fans and lights
- Remote monitoring equipment
- Communications equipment/facilities (e.g., emergency roadside phones, microwave repeater stations)
- Weather stations
- Cathodic protection
- Highway/warning signs
- Fire watch towers
- Landscape lighting
- Security systems
- Livestock watering pumps and irrigation systems
- Transmission tower beacons
- Emergency power during crises.

What is required?

- Modules need to face south and be unshaded
- Modules can be mounted on the application itself, on the roof, or on the ground
- Batteries require maintenance and are usually needed to meet peak loads or nighttime usage
- The system needs a power inverter if the load requires alternating current
- PV system must be evaluated on cost, system performance, system reliability, and maintenance requirements.

What does it cost?

On a 20-year life-cycle cost basis, the cost of a remote PV system ranges from 25¢-50¢ per kilowatt-hour. For off-grid sites, there are numerous examples in the federal government where PV is

more cost effective than the alternative fuel sources. Also, PV equipment is available from companies listed on the General Service Administration's Federal Supply Schedule.

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For More Information

For additional information about photovoltaics, contact:

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