In Class 1:

Translate PV System Verbal Description into List of Details to be Designed

Organization

Break into five groups
These five groups will stay together for the next class sessions
Do, and report on the in-class problem
Turn in materals produced, with names of participants, for credit

Background Information

The class design problem calls for a PV electric generating system connected to the power grid
The building sketch provided in the design problem proposes only the layout of the PV panels.

Discussion / Writing (use the overhead projector transparencies)

Review the printed material describing the PV system and components

1. Propose, and list, all the components required for the PV system
2. Describe their likely dimensions and locations in the building
3. Describe and list the impact of these components on the details of the envelope, interior finishes, and structure

Sketching (use overhead projector transparencies)

1. Do a sketch showing the details to be designed to integrate the PV panels and roof system
2. Do a sketch showing the details to be designed between the PV and grid power supply and the wall system

Presentation: Report out your results to the class

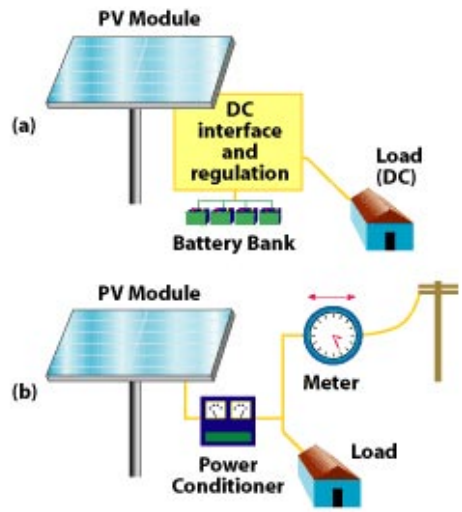
EERE: Energy Basics

Flat-Plate Photovoltaic Balance of System

Complete photovoltaic (PV) energy systems are composed of three subsystems.

- On the power-generation side, the first subsystem of PV devices (cells, modules, and arrays) converts sunlight to direct-current (DC) electricity.
- On the power-use side, the second subsystem consists of the load, which is the application of the PV electricity.

Between these two, a third subsystem enables the PV-generated electricity to be properly applied to the load. This subsystem is often called the *balance of system*, or BOS.



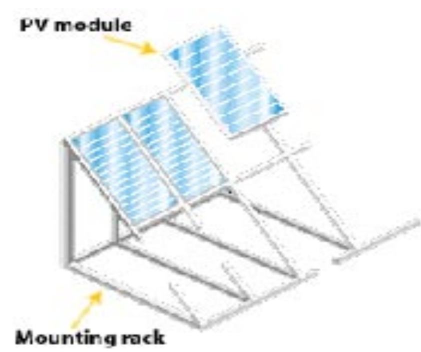
This illustration shows the elements needed to get the power created by a PV system to the load (in this example, a house). The stand-alone PV system (a) uses battery storage to provide dependable DC electricity day and night. Even for a home connected to the utility grid (b), PV can produce electricity (converted to AC by a power conditioner) during the day. The extra electricity can then be sold to the utility during the day, and the utility can in turn provide electricity at night or during poor weather.

The BOS typically consists of structures for mounting the PV arrays or modules and power-conditioning equipment that adjusts and converts the DC electricity to the proper form and magnitude required by an alternating-current (AC) load. The BOS can also include storage devices, such as batteries, so PV-generated electricity can be used during cloudy days or at night.

Mounting Structures

PV arrays must be mounted on a stable, durable structure that can support the array and withstand wind, rain, hail, and other adverse conditions. Sometimes, this mounting structure is designed to track the sun. However, stationary structures are usually used with flat-plate systems. These structures tilt the PV array at a fixed angle determined by the latitude of the site, the requirements of the load, and the availability of sunlight.

Among the choices for stationary mounting structures, rack mounting may be the most versatile. It can be constructed fairly easily and installed on the ground or on flat or slanted roofs.



A typical PV array mounting rack.

There are two basic kinds of tracking structures: one-axis and two-axis. One-axis trackers are typically designed to track the sun from east to west. They are used with flat-plate systems and sometimes with concentrator systems. The two-axis type is used primarily with PV concentrator systems. These units track the sun's daily course and its seasonal course between the northern and southern hemispheres. Naturally, the more sophisticated systems are the more expensive ones, and they usually require more maintenance.

Power Conditioners

Power conditioners process the electricity produced by a PV system so it will meet the specific demands of the load. Although most equipment is standard, it is important to select equipment that matches the characteristics of the load. Power conditioners may:

- Limit current and voltage to maximize power output
- Convert DC power to AC power
- Match the converted AC electricity to a utility's electrical network
- Have safeguards that protect utility personnel and the electrical network from harm during repairs.

Specific requirements of power conditioners depend on the type of PV system they are used with and the applications of that system. For DC applications, power conditioning is often done with regulators, which control output at some constant level of voltage and current to maximize output. For AC loads, power conditioning must include an inverter that converts the DC power generated by the PV array into AC power. Many simple devices—for example, ones that run on batteries—use DC electricity. However, AC electricity, which is what is generated by utilities, is needed to run most modern appliances and electronic devices.

Electricity Storage

Electricity is needed at night and on cloudy days, when PV power generation may not be possible. If tapping into the utility grid is not an option, a battery backup system is necessary for energy storage. However, batteries lower the efficiency of a PV system because only about 80% of the energy that goes into them can be reclaimed. They take up considerable floor space, pose a few possible safety problems, and require periodic maintenance. Still, they provide one way to store PV electricity for later use.

Like PV cells, batteries are DC devices that are directly compatible only with DC loads. However, batteries can also serve as a power conditioner for these loads by regulating power. This allows the PV array to operate closer to its optimum power output.

Charge Controllers

Inverter convert the DC electricity generated by the PV array into AC electricity, and charge controllers protect batteries from overcharging and excessive discharge. Most batteries must be protected from overcharge and excessive discharge, which can cause electrolyte loss and even damage or ruin the battery plates. Most charge controllers also have a mechanism that prevents current from flowing from the battery back into the array at night.

An inverter (left) and charge controller (right) are the power conditioning components of a PV system.

More Information

Also see:

- Flat-Plate Photovoltaic Systems
- Flat-Plate Photovoltaic Modules

Visit the Energy Savers Web site for information on residential small solar electric systems.

Energy Savers

How Small Solar Electric Systems Work

Solar electric systems, also known as photovoltaic (PV) systems, convert sunlight into electricity.

Solar cells—the basic building blocks of a PV system—consist of semiconductor materials. When sunlight is absorbed by these materials, the solar energy knocks electrons loose from their atoms. This phenomenon is called the "photoelectric effect." These free electrons then travel into a circuit built into the solar cell to form electrical current. To see a simulation of the photoelectric effect, please view our animation. Only sunlight of certain wavelengths will work efficiently to create electricity. PV systems can still produce electricity on cloudy days, but not as much as on a sunny day.

The basic PV or solar cell typically produces only a small amount of power. To produce more power, solar cells (about 40) can be interconnected to form panels or modules. PV modules range in output from 10 to 300 watts. If more power is needed, several modules can be installed on a building or at ground-level in a rack to form a PV array.

PV arrays can be mounted at a fixed angle facing south, or they can be mounted on a tracking device that follows the sun, allowing them to capture the most sunlight over the course of a day.

Because of their modularity, PV systems can be designed to meet any electrical requirement, no matter how large or how small. You also can connect them to an electric distribution system (grid-connected), or they can stand alone (off-grid).