



Design and Sizing of Solar Photovoltaic Systems

An Online Continuing Education Course for Engineers

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Design and Sizing of Solar Photovoltaic Systems

A. Bhatia, Mechanical Engineer

Photovoltaic (PV) systems, or PV systems, convert sunlight into electricity using semiconductor materials. A photovoltaic system does not need bright sunlight in order to operate. It can also generate electricity on cloudy and rainy days from reflected sunlight.



PV systems can be designed as Stand-alone or grid-connected systems.

A "standalone, or off-grid" system means that the system is the sole source of power to your home, or other applications such as remote cottages, telecom sites, water pumping, street lighting or emergency call box on highways. Standalone systems can be designed to run with or without battery backup. Battery backup system store energy generated during the day in a battery bank for use at night. Standalone systems are often cost-effective when compared to alternatives such as utility line extensions.

A "grid-connected "system works to supplement existing electric service from a utility company. When the amount of energy generated by a grid-connected PV system exceeds the customer's loads, excess energy is exported to the utility, turning the customer's electric meter backward. Conversely, the customer can draw needed power from the utility when energy from the PV system is insufficient to power the building's loads. Under this arrangement, the customer's monthly electric utility bill reflects only the net amount of energy received from the electric utility.

Benefits of PV Systems

- a. **Environmentally friendly:** They have zero raw fuel costs, unlimited supply, and no environmental issues such as transport, storage, or pollution. Solar power systems produce no air or water or greenhouse gases and produce no noise. Solar systems are generally far safer than other distributed energy systems, such as diesel generators, and are thus the most suitable technology for urban onsite generation. PV is the only commercially available renewable technology generation option for urban areas.
- b. **Reliability:** With no fuel supply required and no moving parts, solar power systems are among the most reliable electric power generators capable of powering the most sensitive applications, from space satellites to microwave stations in the mountains and other remote, harsh environments. Solar panels typically carry warranties of 20 years or more.
- c. **Scalable and modular:** Solar power products can be deployed in many sizes and configurations and can be installed on a building roof or acres of the field, providing wide power-handling capabilities from microwatts to megawatts. The installation is quick and expanded to any capacity.
- d. **Universal Applications:** Solar PV is the only renewable energy technology that can be installed on a truly global scale because of its versatility and because it generates power under virtually all conditions, i.e., even in overcast light conditions
- e. **Peak Shaving:** Have a rapid response achieving full output instantly. The output of solar systems typically correlates with periods of high electricity demand where air conditioning systems create peak demands during hot sunny days. PV can shave peak-load demand when energy is most constrained and expensive and, therefore, can move the load off the grid and alleviate the need to build new peak generating capacity.
- f. **Dual-use:** Solar panels are expected to increasingly serve as both a power generator and the skin of the building. Like architectural glass, solar panels can be installed on the roofs or facades of residential and commercial buildings.

- g. **Low Maintenance Cost:** It is expensive to transport materials and personnel to remote areas for equipment maintenance. Since photovoltaic systems require only periodic inspection and occasional maintenance, these costs are usually less than with conventionally fuelled equipment alternatives.
- h. **Cost advantages:** Solar power systems lower your utility bills and insulate you from utility rate hikes and price volatility due to fluctuating energy prices. They can be used as building materials and can increase the character and value of the building. Purchasing a solar power system allows you to take advantage of available tax and financial incentives.

Challenges

The main challenges or constraints to approach PV projects are

- a. Budget constraints: Building a system within your target budget
- b. Space constraints: Building a system that is as space-efficient as possible
- c. Energy offset: Build a system that offsets a certain percentage of your energy usage

Design Constraints

Design constraints are the key to the system's successful outcome. They provide clear direction and reduce the scope of economic and system analyses and should be continually referenced throughout the design process. Typical design constraints apply to any system and are modified, expanded, and "personalized" for a specific application. Some typical questions inherent in design constraints are

- a. Will the system output be AC or DC or both?
- b. How pure must the electricity be for the load?
- c. Will the generated thermal energy be used?
- d. How much of the electric- or thermal-load profile can be economically matched with the available area?
- e. Is a utility interface available at the location?
- f. Will there be unavoidable shadow?

- g. Will the system be actively cooled?
- h. Will the collectors be flat-plate or concentrating?
- i. Will the collectors be fixed or tracking?
- j. Does the work proposal specify a type of system or specific design feature?

This course covers the fundamental principles behind the working of a solar PV system, the use of different components in a system, the methodology of sizing these components, and how these can be applied to building integrated systems. It includes detailed technical information and a step-by-step methodology for the design and sizing of off-grid solar PV systems.

The information presented is aiming to provide a solid background and a good understanding of the design. The course will be beneficial to electrical & mechanical engineers, energy & environment professionals, architects & structural engineers, and other professionals looking to enter the solar industry or interact with solar projects in their current line of work.

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To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.

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