

# Photovoltaic...

## Cell, Module, String, Array

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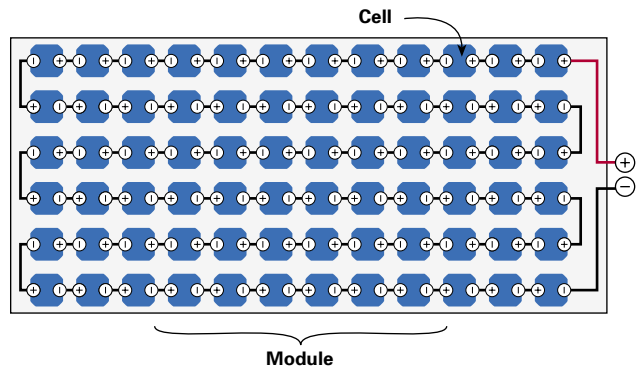


*Derivations: "cell" is from Latin cella, chamber; "module" is from Latin modulus, measure; "string" is from Latin stringere, to bind; "array" is from Old French areer, to put in order.*

Solar-electric systems make electricity from sunlight. The generating devices rely on the photovoltaic (PV) effect—the capability of certain combinations of materials to use the energy of photons from the sun to move electrons in an electrical circuit. PV systems include cells, modules, strings, and arrays. But what do all these terms mean?

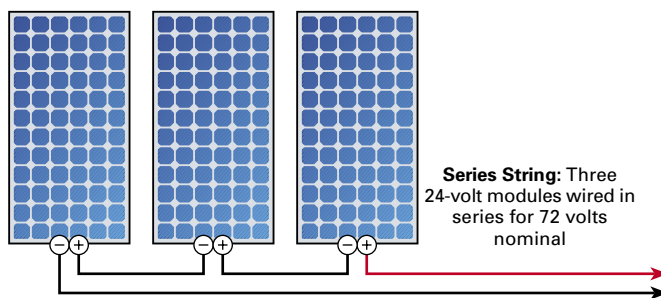
A photovoltaic **cell** (also called a "solar cell") is the basic building block. The most common type of cell is made from silicon doped with minute quantities of boron, phosphorous, gallium, arsenic, or other materials. Each cell develops about half a volt of DC electrical potential when exposed to light. The maximum amperage of the cell is proportional to its surface area, and depends on the intensity of the light. PV cells can produce electricity for 30 to 50 years, and generate the energy it took to manufacture them in a few years.

### Cell & Module



A PV **module**, sometimes called a panel, is a grouping of cells. Historically, modules with 36 cells have been most common, producing 18 to 22 volts for a 12-volt nominal output. More recently, we've seen 24-volt nominal modules for higher voltage systems, and modules designed specifically for high-voltage grid-tie inverters, with open-circuit voltages that can be even higher.

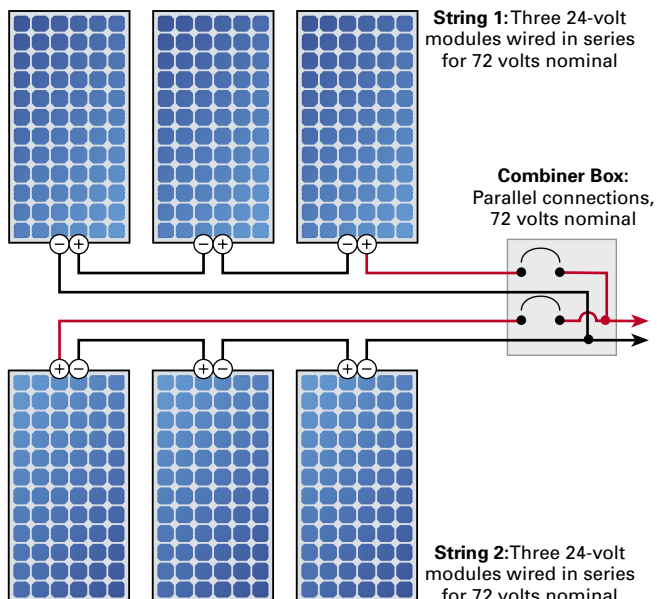
### Series String



**Series String:** Three 24-volt modules wired in series for 72 volts nominal

I've heard some people define a "panel" as a grouping of modules, but to me, this is a confusing use of the terminology. In fact, I think we might be better off avoiding the phrase "solar panel" altogether. It's confusing because it can be used to describe a solar-electric module, a solar hot water collector, or even a wiring and breaker panel in a solar-electric system. Using the word "module" is more precise, and it also reminds us of a key benefit of solar-electric systems—their modularity.

### PV Array



**String 1:** Three 24-volt modules wired in series for 72 volts nominal

**Combiner Box:** Parallel connections, 72 volts nominal

**String 2:** Three 24-volt modules wired in series for 72 volts nominal

A **string** is a grouping of modules wired in series. Basic electrical physics tells us that connecting electrical sources in series increases voltage, which is exactly the goal of a string. It's the same as when you put three D-cells into your big flashlight—they are in series to attain higher voltage.

Most modern solar-electric systems operate at 48-volts nominal, and high-voltage grid-tied systems use up to 600 volts. With 12- and 24-volt modules, this means joining together modules to attain the higher voltage. A series string can then be used on its own or paralleled with other series strings, either to charge batteries or feed the utility grid.

The term **array** describes the whole group of modules in a system. These can be modules in series or parallel, at low or high voltage, on a single rack or multiple racks. Sometimes the term "subarray" is used synonymously with "string." At other times, it is used to mean one rack of modules in a multiple-rack array.

Solar electricity is an amazing technology. Simple, durable, quiet, and long lasting, the collection devices just sit in the sun and make electricity for us. Understanding the basic terms—cell, module, string, and array—is one step along the road to making electricity with Earth's most abundant natural resource, sunshine.

**Access**

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