

Understanding the Basics of Solar PV Systems

Understanding the Basics of Solar Photovoltaic (PV) Systems

Designed as a quick-reference guide for students, technicians, and anyone new to solar energy.

1. What Is a Solar PV System?

Term	Definition
Photovoltaic (PV)	The technology that converts sunlight directly into electricity using semiconductor materials.
Solar PV System	An assembled set of components (modules, inverters, mounting structures, etc.) that harvests solar energy and delivers usable electric power.
Grid-connected	System feeds electricity to the utility grid and can draw power when solar output is insufficient.
Off-grid (stand-alone)	System stores excess energy in batteries and operates independently of the utility grid.
Hybrid	Combines grid-connection with battery storage for backup power.

2. Core Components & Their Functions

Component	Primary Function	Typical Specs / Options
Solar Modules (Panels)	Convert photons to DC electricity.	- Monocrystalline, polycrystalline, thin-film - Power rating: 250W–600W per panel - Efficiency: 15–23%
Mounting / Racking System	Secure panels at optimal tilt & orientation.	- Fixed-tilt, adjustable tilt, tracking (single/dual axis) - Roof-mounted, ground-mounted, pole-mounted
Combiner Box	Merges strings of modules; provides over-current protection.	Fuses or circuit breakers (typically 15–30A)

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Component	Primary Function	Typical Specs / Options
Inverter	Converts DC to AC, synchronizes with grid frequency, implements MPPT.	- String inverter, central inverter, micro-inverter, power optimiser - Efficiency: 95-99%
Electrical Disconnects	Isolate the system for safety/maintenance.	- DC disconnect (near modules) - AC disconnect (near inverter)
Monitoring System	Tracks performance, alerts faults.	Built-in inverter display, web portal, SCADA integration
Battery Bank (optional)	Stores excess energy for later use.	- Lead-acid, lithium-ion, flow batteries - Capacity expressed in kWh
Charge Controller (off-grid)	Regulates charging of batteries, prevents overcharge.	PWM or MPPT types

3. How a Grid-Connected PV System Works (Step-by-Step)

- Sunlight hits the PV cells** - photons excite electrons - DC current generated.
- Modules are wired in series/parallel** to form strings that meet voltage/current requirements.
- Strings feed a combiner box**, where fuses protect each string.
- DC power travels to the inverter** (via DC disconnect).
- Inverter performs Maximum Power Point Tracking (MPPT)** to keep modules operating at their optimal voltage/current.
- DC to AC conversion**; inverter synchronizes output with grid voltage and frequency.
- AC power flows through the AC disconnect** to the main service panel, feeding loads and exporting surplus to the grid.
- Utility meter** (net-metering) records energy exported vs. imported.
- Monitoring system logs performance data** for analysis and maintenance.

4. Key Design Parameters

Parameter	Why It Matters	Typical Design Target
**Irradiance (Sunlight) – kWh/m		