

Overview of Solar PV Systems

Overview of Solar Photovoltaic (PV) Systems

Designed as concise, easy-to-read study notes

1. Basic Concepts

Term	Definition
Photovoltaic (PV) Effect	Direct conversion of sunlight (photons) into electricity within a semiconductor material.
Solar Cell	The smallest PV unit; typically a silicon p-n junction that generates a DC current when illuminated.
Module (Panel)	A group of series-connected solar cells encapsulated in a weather-proof frame.
Array	Multiple modules wired together to achieve the desired voltage and power rating.
Inverter	Converts the DC output of the array to AC for use by conventional loads or the grid.
Balance-of-System (BOS)	All non-module components: mounting structures, wiring, combiner boxes, disconnects, monitoring, etc.
Grid-Connected vs. Off-Grid	Grid-connected systems feed excess power to the utility; off-grid systems store energy in batteries for autonomous operation.

2. System Architecture

Sunlight → Solar Modules → DC Combiner → DC-DC Converter (optional) → Inverter → AC Load / Grid

2.1. Typical Subsystems

Subsystem	Main Functions	Typical Components
Array	Capture solar irradiance, generate DC power	Modules, mounting racking, tracking mechanisms (fixed or single/dual axis)
DC Wiring & Protection	Transfer power, protect against over-current & faults	DC cables, MC4 connectors, fuses, circuit breakers, surge protectors

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Subsystem	Main Functions	Typical Components
Combiner Box	Parallel-connect strings, centralize protection	String fuses, busbars, monitoring ports
DC-DC Converter (MPPT)	Maximize power extraction, adjust voltage levels	DC-DC buck/boost converters, Maximum Power Point Tracker
Inverter	DC-AC conversion, grid synchronization, safety isolation	String inverter, central inverter, micro-inverter, hybrid inverter
AC Distribution	Deliver usable AC power, ensure safety	AC disconnects, breakers, wiring, grounding system
Energy Storage (optional)	Store excess energy for later use	Batteries (Li-ion, lead-acid, flow), Battery Management System (BMS)
Monitoring & Controls	Real-time performance data, remote diagnostics	Data logger, communication module (Wi-Fi, cellular, Ethernet), SCADA or cloud platform

3. Design Parameters

Parameter	Influence on Design	Typical Design Target
Peak Sun Hours (PSH)	Determines required array size	Site-specific, e.g., 4–6h/day
System Voltage	Affects wiring losses & inverter selection	600V-DC (commercial) or 1500V-DC (utility-scale)
Module Efficiency	Higher efficiency → smaller area for same power	18%–23% (current commercial silicon)
Temperature Coefficient	Power loss per °C rise; important in hot climates	−0.3%/°C to −0.5%/°C
Tilt & Azimuth	Impacts annual energy yield	Tilt ≈ latitude; azimuth = true south (N-hemisphere)
Shading & Soiling	Reduces output, can cause mismatch losses	Minimize shading; schedule cleaning

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