MAKE IN INDIA

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SOLAR ENERGY SOLUTIONS

Grid-Connected Solar PV Systems

INTRODUCTION

The Sun is the source of energy and life for us. Most of the energy we use has undergoes various transformations before it is finally utilized, but it is also possible to tap this source of Solar Energy as it arrives on the Earth's surface. There are many applications for the direct use of Solar Thermal and Photovoltaic Energy. It is a technology which is well understood and widely used in many countries throughout the world. The most common use for Solar Photovoltaic technology is generating power for lighting (Appliances, Computers and Televisions, etc.), pumping water, generating grid quality power, etc. As world oil prices vary, it is a technology which is rapidly gaining acceptance as it results in an energy saving measure in both domestic and commercial sector.

Solar energy is the energy that is in sunlight. It has been used for thousands of years in many different ways by people all over the world. As well as its traditional human uses in heating, cooking, and drying, it is used today to make electricity where other power supplies are absent, such as in remote places. It is becoming cheaper to make electricity from solar energy and in many situations it is now competitive with energy from coal or oil.

There are basically two types of Solar PV systems namely Off-grid and Grid-connected.

1. **Off-grid Solar PV Systems:** Off-grid Solar PV system works with batteries. The solar energy is stored in the battery and used to feed building loads after conversion from DC to AC power with a stand-alone inverter. These systems are generally used in remote areas without grid supply or with unreliable grid supply.

2. **Grid-connected Solar PV Systems:** Grid-connected Solar PV systems feed solar energy directly into the building loads without battery storage. Surplus energy, if any, is exported to Discoms Grid and shortfall, if any, is imported from the Grid. These guidelines apply to Grid-connected Rooftop Solar PV systems only.

Grid-connected solar PV Systems:

Grid-connected Solar PV systems is a photovoltaic system that has its electricity-generating solar panels mounted on the rooftop of a residential or commercial building or structure.

Solar Rooftop System is an arrangement of interconnected components installed on the roof of a building or work-shed with the purpose of converting sunlight into electricity. The installed solar panels absorb and convert solar energy directly into electricity. The DC electric current generated is converted into AC with the inverter.

Solar Rooftop PV systems have been widely accepted worldwide. Major Indian cities, such as Kolkata, Chennai, Delhi, Mumbai, Bangalore, Jaipur, Ahmedabad and Hyderabad have introduced Grid-connected Rooftop Systems. Rooftop Systems are being installed in various Educational, Medical, Residential, Commercial, Government and Community Institutions for reaping benefits of electricity saving.

Working principle of Solar PV System:

Solar Photovoltaic technology (SPV) enables direct conversion of sunlight into electricity. Photovoltaic cells, commonly known as solar cells, are used to convert light into electricity. A number of solar cells joined together make a Solar Photovoltaic module. The electrical output of a PV module is rated in terms of peak watt, which is the maximum power output that the PV module could deliver under standard test conditions of incident solar radiation of 1000 watts per square meter area, air mass 1.5 and ambient temperature 25°C. A combination of few solar modules makes a solar array.

Solar modules made of solar cells produce direct current electricity from sunlight, which can be used to power equipment or to recharge a battery. An inverter is required to convert a direct current (DC) into an alternating current (AC).

Most parts of India have about 285 sunny days. Average Solar radiation incident over the land is in the range of 4 -7 KWh per square meter per day. Solar Photovoltaic power plant can be installed in land, on rooftops or even in water as a floating body.

In Grid-connected plant, power generated from the plant is exported to the grid through inverter and export-import meter. Power generated from solar module is DC power which is converted to AC power using inverter before feeding it to the grid.

Requirements for installation of SPV Plant on rooftop:

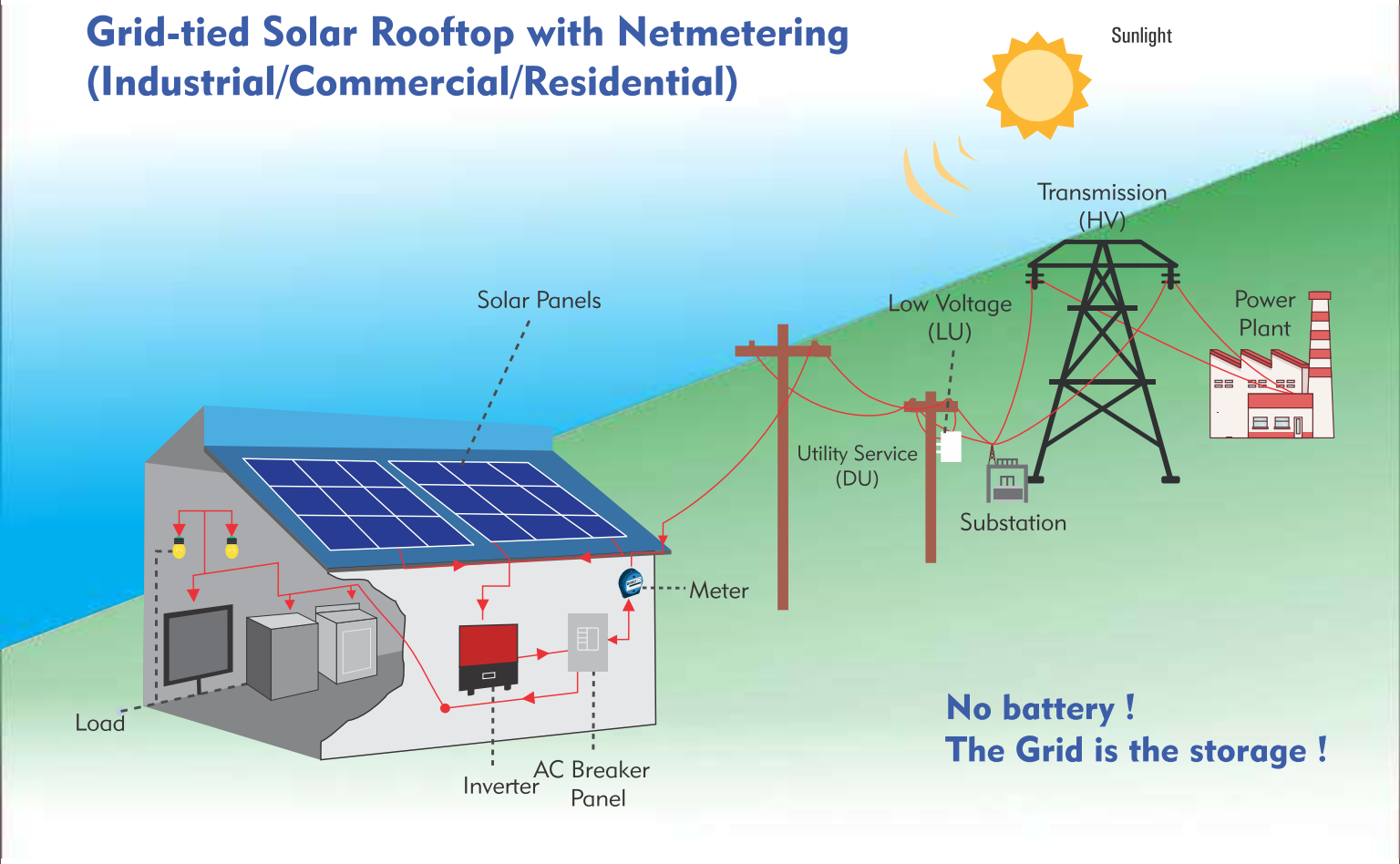
- A minimum vacant roof area of 10 -12 sq mtr or 100-120 sq ft is required for installation of 1 kWp SPV System.
- The Consumer shall have 3 Phase/ 1 Phase supply service connection.
- Mandatory safety precautions/ features shall have to be followed to install a SPV System as per the norms.
- A single bi-directional meter shall be installed for export and import of energy.
- The standard equipments as per the norms of MNRE shall only be installed.

System Components:

The Grid-connected SPV power plant consists mainly of the following components, but might not be restricted to the same:

- Solar Photovoltaic Modules (which are connected to an inverter).
- Module Mounting Structures
- Inverters (which converts the system's direct current (DC) electricity to alternating current (AC)
- Batteries (optional) to provide energy storage or backup power in case of a power interruption or outage on the grid.
- Grid Connect arrangements (Net Energy Meter)
- Cables and Connectors
- Lightning Protection and other protection devices
- Earthing
- Monitoring Systems

Grid-tied Solar Rooftop with Netmetering (Industrial/Commercial/Residential)



Benefits (Features) from the Grid-connected Rooftop Solar System:

- Reduce your electricity bills
- Earn benefits on electricity generation
- Surplus power is supplied to the Grid
- Reduction in electricity bill as the bill is prepared after adjusting import and export of power.
- MNRE, GoI provides 30% subsidy on installation of rooftop solar power plants in domestic sector and non-profit making institutions.
- Reduction in payback period after availing Generation Based Incentive (GBI).
- Contribute to the environment by reducing harmful emissions
- Natural cooling of the top floor
- Power from the Sun is clean, silent, limitless and free
- Photovoltaic process releases no CO_2, SO_2 or NO_2 gases which are normally associated with burning finite fossil fuel reserves and do not contribute to global warming.
- Photovoltaic are now a proven technology which is inherently safe as opposed to other fossil fuel based electricity generating technologies which reduces or avoids the necessity to build new transmission/ distribution lines or upgrade existing ones
- Solar Powered Grid-connected Plants can act as tail-end energizers, which in turn reduces the transmission and distribution losses
- Provides a potential revenue source in a diverse energy portfolio
- Guaranteed performance

Application:

Large utility-scale solar parks or farms are power stations and capable of providing an energy supply to large number of consumers. Generated electricity is fed into the transmission grid powered by central generation plants (Grid-connected or Grid-tied Plant), or combined with one,

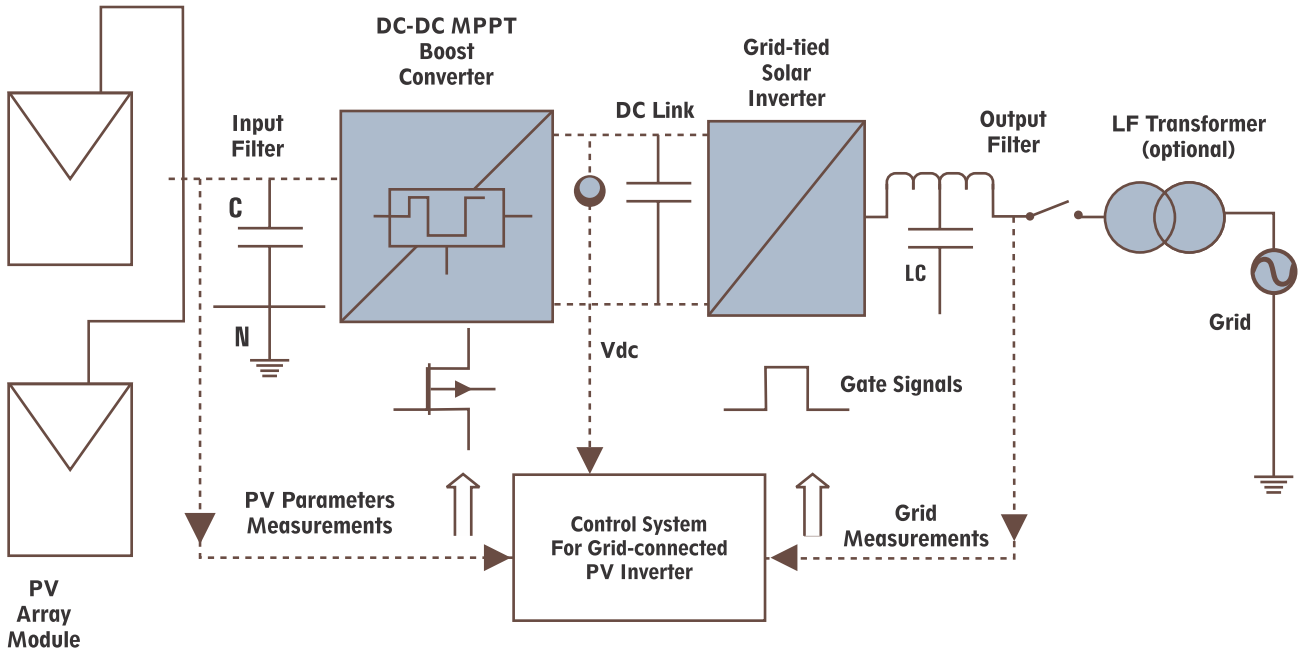
or many, domestic electricity generators to feed into a small electrical grid (hybrid plant). In rare cases generated electricity is stored or used directly by island/standalone plant. PV systems are generally designed in order to ensure the highest energy yield for a given investment. Some large photovoltaic power stations such as Solar Star, Waldpolenz Solar Park and Topaz Solar Farm cover tens or hundreds of hectares and have power outputs up to hundreds of megawatts.

A small PV system is capable of providing enough AC electricity to power a single home, or even an isolated device in the form of AC or DC electric. For example, military and civilian earth observation satellites, street lights, construction and traffic signs, electric cars, solar-powered tents and electric aircraft may contain integrated photovoltaic systems to provide a primary or auxiliary power source in the form of AC or DC power, depending on the design and power demands. In 2013, rooftop systems accounted for 60 percent of worldwide installations. However, there is a trend away from rooftop and towards utility-scale PV systems, as the focus of new PV installations is also shifting from Europe to countries in the Sunbelt region of the planet where opposition to ground-mounted solar farms is less accentuated.

Building-integrated:

In urban and suburban areas, photovoltaic arrays are commonly used on rooftops to supplement power use; often the building will have a connection to the power grid, in which case the energy produced by the PV array can be sold back to the utility in some sort of net metering agreement.

Block diagram of the Grid-connected SPV System



TECHNICAL SPECIFICATIONS:

S.No.	SPECIFICATION	PARAMETERS
1.	**Solar PV System Capacity Sizing**	The size of a Solar PV System depends on the 90% energy consumption of the building and the shade-free rooftop (or other) area available.
2.	**Solar PV Modules**	
a)	Type	Crystalline Silicon
b)	Origin	Manufactured in India
c)	Efficiency	>= 13%
d)	Fill factor	>= 70%
e)	Degradation warranty	Panel output (Wp) capacity to be >=90% of design nominal power after 10 years and >=80% of design nominal power after 25 years.
f)	Module frame	Non-corrosive and electrolytically compatible with the mounting structure material.
g)	Termination box	Thermo-plastic, IP 65, UV resistant
h)	Blocking diodes	Schottky type
I)	Module minimum rated power	The nominal power of a single PV module shall not be less than 300Wp.
j)	RF identification tag for each solar module	Shall be provided inside the module and must be able to withstand environmental conditions and last the lifetime of the solar module.
k)	RF identification tag data	a. Name of the manufacturer of PV module b. Name of the Manufacturer of solar cells c. Month and year of manufacture (separately for solar cells and module) d. Country of origin (separately for solar cells and module) e. I-V curve for the module f. Wm, Im, Vm and FF for the module g. Unique Serial No and Model No. of the module h. Date and year of obtaining IEC PV module qualification certificate i. Name of the test lab issuing IEC certificate j. Other relevant information on traceability of solar cells and module as per ISO 9000 standard
l)	Power output rating	To be given for standard test conditions (STC). I-V curve of the sample module shall be submitted.
m)	Compliance with standards and codes	IEC 61215 / IS 14286 IEC 61730 Part 1 and 2
n)	Salt Mist Corrosion Testing	As per IEC 61701

3.	**Solar PV Modules Mounting Structure**	
a)	Wind velocity withstanding capacity	150 km / hour
b)	Structure material	Hot dip galvanised steel with a minimum galvanisation thickness of 120 microns or aluminium alloy.
c)	Bolts, nuts, fasteners, panel mounting clamps	Stainless steel SS 304
d)	Mounting arrangement for RCC-flat roofs	With removable concrete ballast made of pre-fabricated PCC (1:2:4), M15
e)	Mounting arrangement for metal sheet roofs	Mounting directly on the sheet metal, ensuring stability and wind with standing capacity, or penetrating the sheet metal and fixing to the substructure, ensuring that the roof remains waterproof and ensuring stability and wind withstanding capacity.
f)	Mounting arrangement for elevated structures	The elevated structure has to be securely anchored to the supporting surface. Concrete foundations of appropriate weight and depth for elevated structures mounted directly on the ground; Bolted with anchor bolts of appropriate strength for elevated structures mounted on RCC surfaces.
g)	Mounting arrangement for ground installations	With removable concrete ballast made of pre-fabricated PCC (1:2:4), M15; assuring enough ground clearance to prevent damage of the module through water, animals and other environmental factors.
h)	Installation	The structures shall be designed for simple mechanical on-site installation. There shall be no requirement of welding or complex machinery at the installation site.
I)	Minimum distance between roof edge and mounting structure	0.6m
j)	Access for panel cleaning and maintenance	All solar panels must be accessible from the top for cleaning and from the bottom for access to the module junction box.
4.	**Solar Array Fuse**	The cables from the array strings to the solar grid inverters shall be provided with DC fuse protection. Fuses shall have a voltage rating and current rating as required. The fuse shall have DIN rail mountable fuse holders and shall be housed in thermoplastic IP 65 enclosures with transparent covers.
5.	**Solar Grid Inverter**	The solar grid inverter converts the DC power of the Solar PV modules to grid-compatible AC power. The recommended solar grid inverter capacity in kW shall be in the range of 95% - 110% of the Solar PV array capacity.
a)	Total output power (AC)	To match Solar PV plant capacity while achieving optimum system efficiency
b)	Input DC voltage range	As required for the Solar Grid-tied inverter DC input.
c)	Maximum power point (MPPT) tracking	Shall be incorporated

d)	Number of independent MPPT inputs	1 or more
e)	Operation AC Voltage	Single phase 230V or three phase 415 V (+ 12.5%, -20%)
f)	Operating Frequency range	47.5 – 52.5 Hz
g)	Nominal frequency	50 Hz
h)	Power factor of the inverter	>0.98 at nominal power
I)	Total harmonic distortion	Less than 3%
j)	Built-in protection	AC high / low voltage; AC high /low frequency
k)	Anti-islanding protection	As per VDE 0126-1-1, IEC 60255.5 / IEC 60255.27
l)	Operating ambient temperature range	-10°C to +60°C
m)	Humidity	0 – 95% Rh
n)	Inverter efficiency	>=95%
o)	Inverter weighted efficiency	>=94%
p)	Protection degree	IP 65 for outdoor mounting, IP 54 for indoor mounting
q)	Communication interface	RS 485 / RS 232 / RJ45
r)	Safety compliance	IEC 62109-1, IEC 62109-2
s)	Environmental Ttesting	IEC 60068-2 (1,2,14,30)
t)	Efficiency measurement procedure	IS/IEC 61683

u)	Cooling	Convection
v)	Display type	LCD for data display. LCD / LED for status display
w)	Display parameters to include	Output power (W), cumulative energy (Wh), DC voltage (V), DC current (A), AC voltage (V), AC frequency (Hz), AC current (A), cumulative hours of operation (h).
6.	**DC Combiner Box**	A DC combiner box shall be used to combine the DC cables of the solar module arrays with DC fuse protection for the outgoing DC cable(s) to the DC distribution box.
7.	**DC Distribution Box**	A DC distribution box shall be mounted close to the solar grid inverter. The DC distribution box shall be of the thermo-plastic IP65 DIN-rail mounting type and shall comprise the following components and cable terminations: • Incoming positive and negative DC cables from the DC combiner box • DC circuit breaker, 2 pole (the cables from the DC combiner box will be connected to this circuit breaker on the incoming side) • DC Surge Protection Device (SPD), class 2 as per IEC 60364-5-53 • Outgoing positive and negative DC cables to the solar grid inverter. As an alternative to the DC circuit breaker a DC isolator may be used inside the DC distribution box or in a separate external thermoplastic IP 65 enclosure adjacent to the DC distribution box. If a DC isolator is used instead of a DC circuit breaker, a DC fuse shall be installed inside the DC distribution box to protect the DC cable that runs from the DC distribution box to the solar grid inverter.
8.	**AC Distribution Box**	An AC distribution box shall be mounted close to the solar grid inverter. The AC distribution box shall be of the thermo plastic IP65 DIN rail mounting type and shall comprise the following components and cable terminations: • Incoming 3-core / 5-core (single-phase/three-phase) cable from the solar grid inverter • AC circuit breaker, 2-pole / 4-pole • AC surge protection device (SPD), class 2 as per IEC 60364-5-53 • Outgoing cable to the building electrical distribution board
9.	**Connection to the Building Electrical System**	The AC output of the solar grid-tie inverter shall be connected to the building's electrical system after the Discom service connection meter and main switch on the load side. The solar grid-tie inverter output shall be connected to a dedicated module in the Main Distribution Board (MDB) of the building. It shall not be connected to a nearby load or socket point of the building. For buildings or loads with diesel generator backup, the wiring of the solar grid-tie inverter shall be such that the solar grid inverter cannot run in parallel with the diesel generator.
10.	**Cables**	All cables shall be supplied conforming to IS specifications

11.	**Earthing**	➢ The PV module structure components shall be electrically interconnected and shall be grounded. ➢ Earthing shall be done in accordance with IS 3043-1986, provided that Earthing conductors shall have a minimum size of 6.0 mm^2 copper, 10 sq mm^2 aluminum or 70 sq mm^2 hot dip galvanized steel. Unprotected aluminum or copper-clad aluminum conductors shall not be used for final underground connections to earth electrodes. ➢ A minimum of two separate dedicated and interconnected earth electrodes must be used for the Earthing of the solar PV system support structure with a total earth resistance not exceeding 5 Ohm. ➢ The earth electrodes shall have a precast concrete enclosure with a removable lid for inspection and maintenance. The entire Earthing system shall comprise non-corrosive components.
12.	Combiner Box	Wires from individual PV modules or strings are run to the combiner box, typically located on the roof. These wires may be single conductor pigtails with connectors that are pre-wired onto the PV modules. The output of the combiner box is one larger two wire conductor in conduit. A combiner box typically includes a safety fuse or breaker for each string and may include a surge protector.
13.	**Surge Protection**	Surge protectors help to protect your system from power surges that may occur if the PV system or nearby power lines are struck by lightning. A power surge is an increase in voltage significantly above the design voltage.
14.	**Metering**	An energy meter (Kilowatt-hour Meter) shall be installed in between the solar grid-tie inverter and the building distribution board to measure gross solar AC energy production (the 'Solar Generation Meter').

We, **RS Power Systems Pvt. Ltd.** are glad to introduce ourselves as a leading player in providing Solar Energy solutions. We provide wide range of Solar Rooftop Plants (Off-Grid/On-Grid).

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