STUDY ON VARIOUS SCALE ON-GRID SOLAR PV POWER PLANTS

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Abstract— Energy Is Very Important Need In Todays Life For All Human Beings And All Industries. Now A Days Demand of Energy (Electricity) Is Goes on Increase Continuously. But the energy produce and use should sulabh (accessible power), sasti (cheap), swachh (clean power), and surakshit (empowering each citizen of India with securing future). In India the power is produce from thermal power generation is highest (68.22%) from fossil fuels. Among fossil fuels coal and gas are two major components. Coal available in India is not sufficient enough to feed existing thermal power plants, in addition to poor quality due to low calorific and high ash content. That is why we need to import quality coal from Australia. On other hand available gas is also not sufficient to meet future demand. Nuclear power (1.83%), it is not suitable for us. Its raw material and technology are imported. There are serious dangers in handling left over of nuclear fuels after processing. We did not forget the Russia and japans recent nuclear power house cases. Such incidents in densely populated India may cause havoc. From hydroelectric power (14.04%) produced. But because of unpredictable weather condition besides high initial cost and ittakes 5-10 years to complete project. Hydro take back seat.

1. INTRODUCTION

Renewable power is new hope for us, it has seen huge growth all over the world in less than decade. Government of India is on its way to achieving 175 GW target for installed renewable energy capacity by 2022. India attains global 4th and 6th position in global wind and solar power installed capacity. By November 2017, a total of 62 GW renewable power installed. Historic low tariffs for solar (2.44/unit) and wind (2.64/unit) achieved through transparent bidding and facilitation. India expanded its solar generation capacity prime minister set prestigious target for solar power i.e. 100 GW by 2022 (60 GW utility scale and 40 GW roof top).In January 2016, narendra modi and French president laid foundation stone for headquarters of Isa in Gurgaon. India is blessed with rich solar energy and if exploited efficiently, the country has the potential of producing big amount of electricity. Sunlight is converted to electricity directly when made to fall on solar photovoltaic (SPV) modules. Systems /devices are made for various applications based on SPV modules connected with suitably these systems/devices are designed to work in off-grid mode (usually supported with batteries to allow use whensunlight is low or during night). In recent years solar PV systems became viable and attractive. Utility scale plants are being set up worldwide with promotional mechanisms which are set up on ground surface. Available roof-top area on the buildings can also be used for setting up solar PV power plants, and thus dispensing with the requirement of free land area. The electricity generated from SPV systems can also be fed to the distribution or transmission grid after conditioning to suit grid Integration. Currently, whole world is in the midst of an energy revolution that is fundamentally changing the future of rural electrification.

2. LITERATURE REVIEW

Global warming and energy policies have become a hot topic on the international agenda in the last years. Developed countries are trying to reduce their greenhouse gas emissions. For example, the European Union has committed to reduce their greenhouse gas. In this context, photovoltaic (PV) power generation has an important role to play due to the fact that it is a green source. The only emissions associated with PV power generation are those from the production of its components. After their installation they generate electricity from the solar irradiation without emitting greenhouse gases. In their life time. Also, they can be installed in places with no other use, such as roofs and deserts. They can produce electricity for remote locations, where there is no electricity network.The latter type of installations is known as off-grid facilities and sometimes they are the most economical alternative to provide electricity in isolated areas. However, most of the PV power generation comes from grid-connected installations, where the power is fed in the electricity network. In fact, it is a growing business in developed countries such as Germany which is world leader in PV power generation followed by Spain, Japan, USA and Italy. On the other hand, due to the equipment required, PV power generation is more expensive than other resources.Solar cells are the basic components of photovoltaic panels. Most are made from silicon even though other materials are also used. Solar cells take advantage of the photoelectric effect: the ability of some semiconductors to convert electromagnetic radiation directly into electrical current.

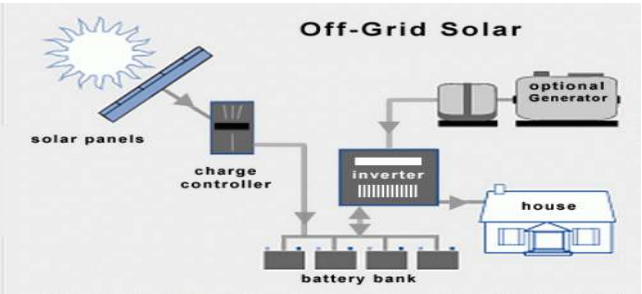
3. TYPES OF SOLAR PV SYSTEM

3.1 PV DIRECT SYSTEM-

They only power the load when sun is shining. They are appropriate for few these are the simple most of solar pv system. With few components. The solar panel and load. Because they don't have batteries and are not hooked up to the application.

3.2 OFF-GRID SYSTEM–

Also referred as stand-alone system, it is designed to be independent of the power grid. Batteries are used to store energy when the sun is not an available during cloudy days or at night. This type of system will require regular attention to battery electrolyte levels and terminal corrosion.



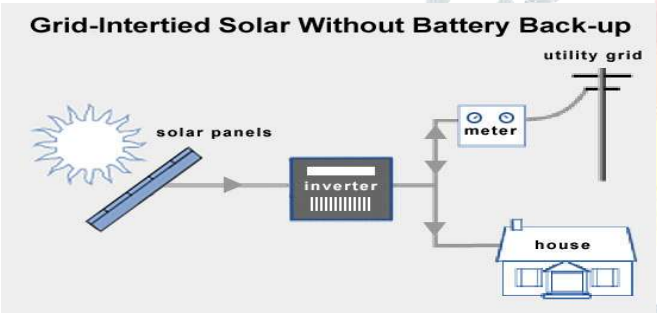
(Fig 1, off-grid, ref-enerzytech)

IMPORTANT –
Independent from utility grid. Not subject to terms /policies of the utility company. Rate increases, blackouts do not apply. In remote area, it is cost effective than extending a grid. Batteries require maintenance and has limited life. It is more expensive than a grid –direct system

3.3 HYBRID SYSTEM–
Hybrid system tries to combine multiple sources of power to maximize sources of power to maximize availability of power. It may source energy from, sun wind and back up it with battery.

IMPORTANT –
Multiple sources of generation allows for complementary sources and back up.When it is sunny PV array will charge the battery, if it is cloudy and windy, a wind turbine can charge the battery.More complex system design and installation.Maintenance and cost is increases..

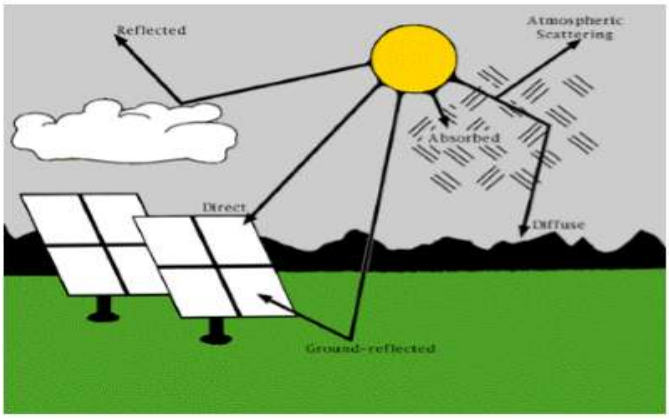
3.4 GRID TIED SYSTEM –
This system are most common type of PV systems. They are also known as on-grid, grid-tied, or grid-direct system. They generate solar electricity and route it to the loads and the grid, offsetting some of electricity usage. System components comprised of the PV array and inverter. Grid connected system is similar to regular electric powered system except that some or all electricity comes from sun. The drawback of these battery less systems is that they provide no outage protection when the utility grid fails, these systems cannot operate.



(Fig 2, grid-tied system, ref-enerzytech)

IMPORTANT – Increased design flexibility because the system does not have to power all of the homes loads. It is less expensive compared to stand alone.It requires the least amount of maintenance. If system produce more than the loads need, then the extra energy is exchanged with the utility grid.Grid tied systems have higher efficiency because batteries are not part of the system.Higher voltage means smaller wire size.Electricity costs are fixed for the life of your system.There is no power to home when grid goes down.

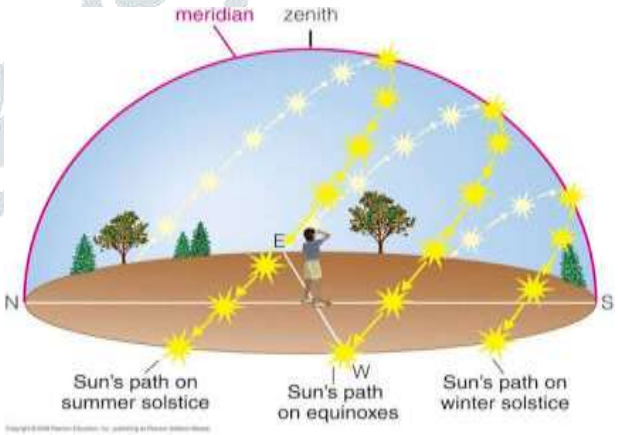
4. RADIATION
All substances solid, liquid, gas at temperature above absolute zero, emit energy in the form of electromagnetic waves. This energy is called radiation. Radiation which is most important is emitted from sun. For designing solar devices knowledge of suns path in sky and radiation on various days is very important. Solar radiation is fuel for solar PV technology. Power received by earth is 1.7*10^17 W.



(Fig.no-03 Illustration of sun radiation, ref-world energy resource 2016)

Direct radiation: solar radiation received on earth's surface without change in direction is called direct radiation.
Diffuse radiation: Radiation received on a terrestrial surface scattered by dust clouds etc. is known as diffuse radiation.
Sun at zenith: It is position of the sun directly overhead.
Air mass: It is the ratio of path length of beam radiation through atmosphere, to the path length if sun at zenith.
Goble horizontal irradiation: Total amount of solar energy incident on a horizontal surface. It is important parameter foe photovoltaic applications.
Direct normal insolation: Amount of radiation incident on surface that kept perpendicular to direct solar beam. It is important for csp plants.

4.1 Solar panel facing direction: Sun rise from east and sun set in west, but sun moves from east to west from south, that's why solar panel installed at any location in earths northern hemisphere face south direction and panels installed in southern hemisphere face north direction



(Sun path fig no – 04, ref-exposing pseudo astronomy podcast)

4.2 Tilt angle of solar panel: There are two systems sun tracking system and fixe array type. In tracking system panel moves as sun to face always maximum radiation. In fix array type system panel has permanent angle, therefore this angle should give best output thought year. So to get best output for year the angle of panel is same as latitude of location. If you required more output in summer then reduce your tilt angle from your latitude angle. And if you required more output in winter then increase your tilt angle of panel from latitude angle.

5. CAN SOLAR PV COMPLETE ENERGY REQUIRMENT

Sun is massive source of light and heat we receive 4-7 kw/m2.We consume very less energy than the potential of sun energyFor an example installation of solar panel on India 5% land provide electricity to entire country.India electricity consumption density is 0.35 kwh/m2/year and annual solar energy density is in range of 1000-2500 kw/m2/year. Electricity-(2005)56.7Eexajoule.Solar – 3850000 EJ.

(Fig 5, area required for solar to power world, ref- landartgenerator)

6. COMPONENTS

6.1 SOLAR PANEL–Solar panel is made up of numbers of cells, when it is made to stand in light it converts that radiation into dc electricity.

Types of solar panels – monocrystalline (20% efficiency), polycrystalline (15% efficiency), thin film amorphous silicon solar cell (7-10% efficiency).

Layer required for packing of cells into one module –

(Fig 07, solar panel layer, ref- wagan crop blog all about solar)

1. First layer- made up of 4mm thick glass (safety glass), which not only impact, pressure and temperature resistant but also shock proof. Applying antireflective coating to cover glass will reduce reflections.
2. Upper encapsulating film (Eva) - a plastic layer made from Eva (ethylene vinyl acetate) is inserted as upper moisture barrier layer. A plastic film is laminated onto solar cell at 150 degree temp forming water proof corrosion protection. 3. Solar cell- single solar cell interconnected with each other produce electric power. (Bus bar thin strip of copper or aluminum is use to conduct electricity from cells.) 4. Lower encapsulating film (Eva)-
5. Tedlar laminated film- a plastic layer made from polyvinyl fluoride better known under trade name tedlar and icosolar use as finish on back side.
6. The junction boxes are to be provided in the PV array for termination of connecting cables.
7. Frame – to give stability to different layers and to facilitate the assembly, model is an enclosed in an aluminum frame.

IMPORTANT –

Maximum impact sustain without any breakage or damage for panel i.e. of toughen glass is 4500 to 5000 Pascale.

(Fig 08, Rfid tag on solar panel, ref- ruddersoft)

a. Name of the manufacture of the PV module b. Name of the manufacture of Solar Cells. c. Month & year of the manufacture (separate for solar cells and modules) d. Country of origin (separately for solar cells and module) etc. Tests for module – standard tests done on module certified by mnre are IC 61701, IC 61730, IC 61213, ETC.

6.2 INVERTER –

As SPV array produce direct current electricity, it is necessary to convert this direct current into alternating current and adjust the voltage levels to match the grid voltage. Conversion shall be achieved using an electronic Inverter and the associated control and protection devices. All these components of the system are termed the "Power Conditioning Unit (PCU)". In addition, the
PCU shall also house MPPT (Maximum Power Point Tracker), an interface between Solar PV array & the Inverter. Inverter output should be compatible with the grid frequenc. PCU / inverter shall be capable of complete automatic operation including wake-up, synchronization & shutdown.Anti-islanding (Protection against Islanding of grid).

6.3 ARRAY STRUCTURE –

Hot dip galvanized MS mounting structures may be used for mounting the modules / panels / arrays. Minimum thickness of galvanization should be at least 120 microns. The Mounting structure shall be so designed to withstand the speed for the wind zone of the location where a PV system is proposed to be installed (wind speed of 150 kM/ hour). The total load of the structure (when installed with PV modules) on the Terrace should be less than 60 kg/m2. The minimum clearance of the structure from the roof level should be 300 mm. .

(Fig 09, array mounting structure, ref- sakal office plant)

6.4 DC DISTRIBUTION BOARD -

DC Distribution panel to receive the DC output from the array field. DC DBs shall have sheet from enclosure of dust & vermin proof conform to IP 65 protection. The bus bars are made of copper of desired size. Suitable capacity MCBs/MCCB shall be provided for controlling the DC power output to the PCU along with necessary surge arrestors.

6.5 AC DISTRIBUTION BOARD –

AC Distribution Panel Board (DPB) shall control the AC power from PCU/ inverter, and should have necessary surge arrestors. Interconnection from ACDB to mains at LT Bus bar while in grid tied modeAll switches and the circuit breakers, connectors should conform to tests.

6.6 LIGHTNING PROTECTION –

The SPV power plants shall be provided with lightning &overvoltage protection. The main aim in this protection shall be to reduce the over voltage to a tolerable value before it reaches the PV or other sub system components. The source of over voltage can be lightning, atmosphere disturbances etc.the entire space occupying the SPV array shall be suitably protected against Lightning by deploying required number of Lightning Arrestors.

6.7EARTHING PROTECTION:-

• Each array structure of the PV yard should be grounded/ earthed properly as per IS: 3043-1987. In addition the lighting arrester/masts should also be earthed inside the array field.

CABELS–

All cables and connectors for use for installation of solar field must be of solar grade which can withstand harsh environment conditions including High temperatures, UV radiation, rain, humidity, dirt, salt.
Cables and wires used for the interconnection of solar PV modules shall be provided with solar PV connectors (MC4) and couplers.
Temp. Range: –10oC to +80oC.
Voltage rating 660/1000V

6.9 GRID ISLANDING:-

• In the event of a power failure on the electric grid, it is required that any independent power-producing inverters attached to the grid turn off in a short period of time. This prevents the DC-to-AC inverters from continuing to feed power into small sections of the grid, known as "Islands." Powered Islands present a risk to workers who may expect the area to be unpowered, and they may also damage grid-tied equipment. The Rooftop PV system shall be Equipped with islanding protection. In addition to disconnection from the grid (due to islanding protection) disconnection due to under and over voltage conditions shall also be provided.

7. CASE STUDY

Visit to 10 kW on grid solar PV power plant

Name of place –Triambak hotel warunse
Capacity-10 kW
Date -11 Feb 2018

GEO-COORDINATE

Latitude-19.9322 N
Longitude-73.5306 E

7.1 Technical specification
(Table no. 01)

Capacity	10 KW
Shadow free area	_
Type of area	Roof
Type of roof	Flat
Tilt angle of panels	25 degree
Module	Polycrystalline ,Pv power tech,250 W.
Inverter	Abb ,10 Kw

7.2 Technical details
(Table no. 02)

Total system capacity dc side	10 KW
Total system capacity ac side	10 KW
Installed on	Roof of hotel
SOLAR PV MODULE	
Area of panel	1m*2m
Make	PV power tech
Model no	eco series
Rated power at stc	250 w
No of modules	40
Open circuit voltage Voc	37 V
Short circuit current Isc	8.55 A
Rated voltage Vmpp	30.95 V
Number of cell per module	60
Cell type	poly-crystalline silicon solar cell
Performance warrantee	90% up to 10 years, 80% up to 25 yrs.
Certifications	IEC61215 & IEC 61730
INVERTER	
Make	Abb
Model no	pvi-10.0
Rated power ac output	10000 w
Quantity	1
Nominal AC voltage range	320-480 V
Ac grid frequency and range	50,60 Hz
Maximum output current	16.6A
Efficiency	97.7 %
Mppt voltage range	300-750 v
DC CABLE	cu conductor, insulated (polycab)
AC CABLE	ng cable 001cu conductor insulated (polycab)

Name of place	Total plant capacity in kw	Module use (polycrystalline, Capacity, no of panel)	Inverter use (make, capacity, no of inverter)	Tilt angle of solar panel	One day generation
Sushil eye hospital	20	Renewsys, DESERV 3M6-315. 315 Watt. 64.	Solar edge. 20 kw. 01.	20 degree	98 units
Sakal regional office at satpur midc	150	Qcells, Q power l-G5320. 320 watt. 460.	SMA. 30 kw. 05.	3 degree	706 units.
Sandip foundations ,siem collage	100	Goldi green,GOLDI305PM. 305 watt. 328	SMA. 25 kw. 04.	18 degree	470.58 units
Nashik engineering cluster	100	Vikramsolar, ELDORA VSP.72.315.03.04. 315 Watt. 322.	Zigor. 20 kw. 05.	4 degree	430 units.
Bedmutha petrol pump, ambad link road	10	Jain irrigation systems limited ,JJ-M72. 310 Watt. 32.	Growatt. 10 KW. 01.	21 degree	42 units.
Satpur petrol pump	11	Vikramsolar, 315 Watt. 38	Ksolare. 11 KW. 01	23 degree	46 units.
Warunse hotel,	10	Pv power tech, 250 watt, 40	Abb, 10 KW, 01	25 Degree	43 units

Table shows description of plants visited (on-grid, roof top) (Table no. 03)

Location and Station Identification

Requested Location	Nashik
Weather Data Source	(IN) Gridded 10km Satellite Data 6.0 km
Latitude	20.05° N
Longitude	73.75° E

PV System Specifications *(Commercial)*

DC System Size	10 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	25°
Array Azimuth	180°
System Losses	14%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Economics

Average Cost of Electricity Purchased from Utility	8.00 ₹/kWh

Performance Metrics

Capacity Factor	18.2%

(Fig 10, Location and station identification, ref pvwatt.com)

Radiation available and calculated output, ref-pvwatt.com

(Table no. 04)

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)	Energy Value (₹)
January	6.66	1,482	11,853
February	7.30	1,413	11,307
March	7.35	1,562	12,498
April	7.14	1,459	11,671
May	6.58	1,428	11,427
June	4.97	1,108	8,868
July	4.08	981	7,846
August	4.09	985	7,878
September	5.28	1,191	9,524
October	6.41	1,437	11,498
November	6.77	1,460	11,681
December	6.63	1,480	11,840
nnual	6.11	15,986	₹ 127,891

Visit photo–

(Fig 12, roof top plant visit, ref-hotel warunse)

8. FUTURE SCOPE

There is huge scope in the field of solar photovoltaic. It is one of the field that creates large amount of jobs. Also scope for innovations like in installation type, combination of two system, to develop robots for cleaning purpose of panels efficiently, use of latest technology to get maximum output etc. There are so many ideas on which experiment is going on and has huge scope in future that are, mounting of solar panel on hyper loop trains capsule surface, to install solar tiles on roof of home, use of colored solar panels for both energy and aesthetics of buildings. Now a day's only focus is on installation but after completing life of system how to handle that material, so this is another issue has future scope for recycling of panels and all components after completing life.

9. CONCLUSION

Solar photovoltaic power plants will play an important role in overall energy supply. Solar radiation data is available from several sources including satellite simulations. The collect and simulation is complex procedure and can have inaccuracies. The most reliable data is ground measured with accurate instruments.

The performance depends on several factors including the solar radiation, temperature, air velocity apart from module type and quality, angle of tilt (or tracking), design parameters to avoid cable losses and efficiency of inverter and transformers.

All visits in Nasik and all are roof top plants. Roof top plants are utilizes area of your roof which is not use for other. Some user install panels at height and make them leak proof so use as roof. People not serious about cleaning, they don't clean panels periodically. Also somewhere cleaning is done at afternoon, but panels very hot at afternoon so shrinkage damage may occur.

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