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RESEARCH ARTICLE

ENERGY REMEDIATION BY ALTERNATE DISSEMINATION: SPV/PSO POWER IN INDIA

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ABSTRACT

Electrical energy plays pivotal role to human advances in industry, smart city planning, food, agriculture, health and economic growth. The diminishing fossil/ bio fuel, coal, associated environmental issues and squat hydropower generation cannot level the increasing energy demand of modern man. To improve the lag, the renewable energy sources such as wind, solar, micro-hydel and geothermal *etc.* are to be harnessed. Solar photo voltaicmodules (SPVM) plants are proved popular and abundant source for generating huge electricity. Solar photo voltaic power by modern technology has reduced the cost of purchase and installation of SPVM. India has electricity in 96.7% Villages but in-house supply is only 69% and 4billion people were deprived of electricity by 2014. Houses in Peninsular eastern states have conventional electric power 20hrs/day are Jharkhand (2%), UP (5%), Bihar (8%), Odisha (23%) and MP (26%). The present research compare the history and Solar photovoltaic (SPV) technology development, present status in India with other solar power producing countries generating solar power. For easy access to the technology, for choice of different SPV plants, design of SPV/PSO unit from 1KW, 2KW, 5KW, 10KW (both on grid and off grid) for various population areas has been done. For small townships to cottage industries, the SPV power plants of size 1MW and 5MW are also designed. Attempt has also been made to take suggestive measures for reduction in cost of installation and unit cost of generation to make the SPV industry popular.

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INTRODUCTION

The solar energy,an indefinite source proved it to be a primary font of electricity replacing conventional sources like biofuels, coal, fossil fuel *etc*.. It does not have issues like accessibility, availability, raw material sources, andatmosphericpollution as experienced with other energy harvesting resources.It is the green energy that is sustainable and can combatthe challenges of electrical crunch. The other renewable energy sources are wind, hydro, biomass, nuclear and geothermal. TheSun is radiating incessantly in average 500 trillion KWH for last $4x10^9$ years. Theconverged solar radiation can generate heat, light and electricity from 7^{th} Century. India was capable to generateelectricity5.0 GW by Photo Voltaic Modules (PVM) todaywhen world's generation was 310 GW by 2016.But India has generated 9.566GWof SPVM power by Feb-17 http://mnre.gov.in/mission-and-vision-2/achievements. India is the 2nd largest demographic country of the earth, next to China. The economy and industrial growth of India is far behind China mainly due to lag in power sector Fig 1.Construction of new hydro and thermal power plants are almost stagnant today due to environmental, social and political issuesandacute shortage of coal and fossil fuel. It is high time to harness the abundant renewable energy resources for India's rapid economic growth. Among the renewablesources, SPVM power source can generate the highest power Fig 1(b). Considering the necessity, availability, abundance, green and smart solar energy source, it isneeded to develop methodology, technology and design processes which could harvest more solar electricity. The generationshould be cost-effective, popular, micro to mega installations. Photovoltaic cells in hilly underdeveloped tribal areasby grid electricity are difficult to provide. PV Solar sources can be a better option there. This paper makes an attempt to analysis and design process for a 10MW photovoltaic solar power plantto meet the augmented need of an inaccessible, non-electrified (even upto 2016) hilly cluster of tribal villages on mountainous EGB hills range. Sarada Panchayatin Samabalpur district of Odisha, is such an area, on the hill top, located in

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high potential solar irradiance zone have been selected for study. Economically the wind and the geothermal sources are viable but are location specific. The electricitygenerated from solar heat, photovoltaic cells, solar thermal energy, solar architecture and artificial photosynthesis is higher than the wind source (Fig 2). This easy accessible energy source is well accepted as it is clean, silent, endless, not visually obstructive, no size limitation, portable, ecofriendly and no mining,no carbonaceous residueand harvesting like other renewable sources over weighs the cost and stellar irradiation variabilityand production of toxic wastes of Cadmium and Arsenic.

Study Area

India is a place of geologic topographic bio-diversity. According GOI data the number of un-electrified villagesare 4166, 3878, 2105, 1757, 1564, in states Rajasthan, Odisha, Jharkhand, Bihar and Arunachal Pradesh respectively by May-2015. The percentage of electrified villages in India as a whole was 96.7% as on 31-05-2015 https://community.data.gov.in/un-electrified-villages-as-on-31-05-2015/. Malapur, (2015)[1] from Shakti Sustainable energy foundation and The Council on Energy, Environment and Water (CEEW) with Columbia University, US, have reported that 714 villages in 51 districts

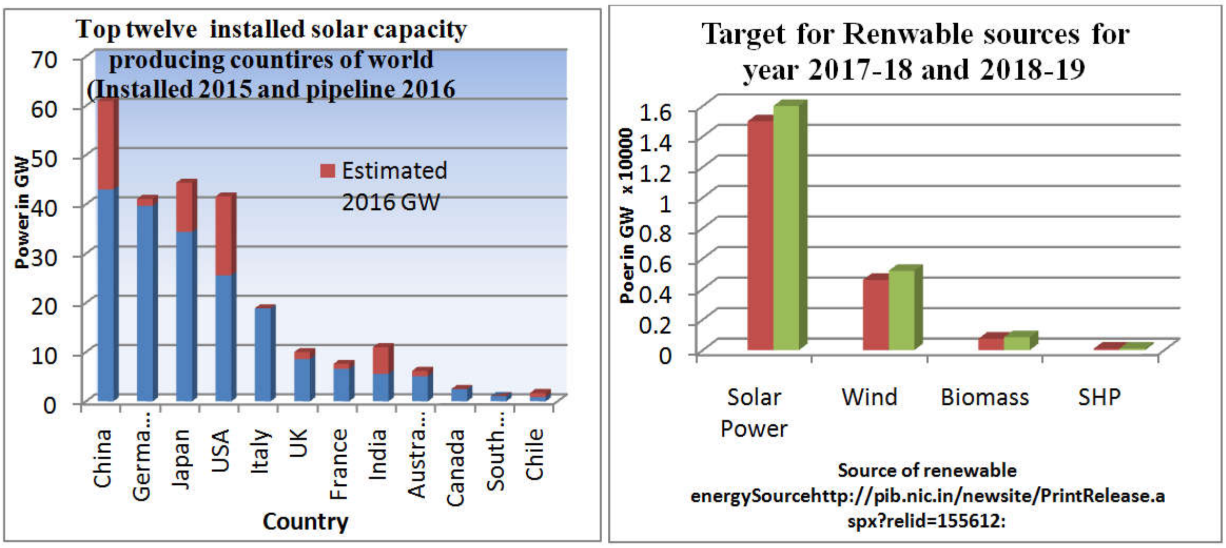

Fig. 1. Top twelve SPV generating countries of the earth

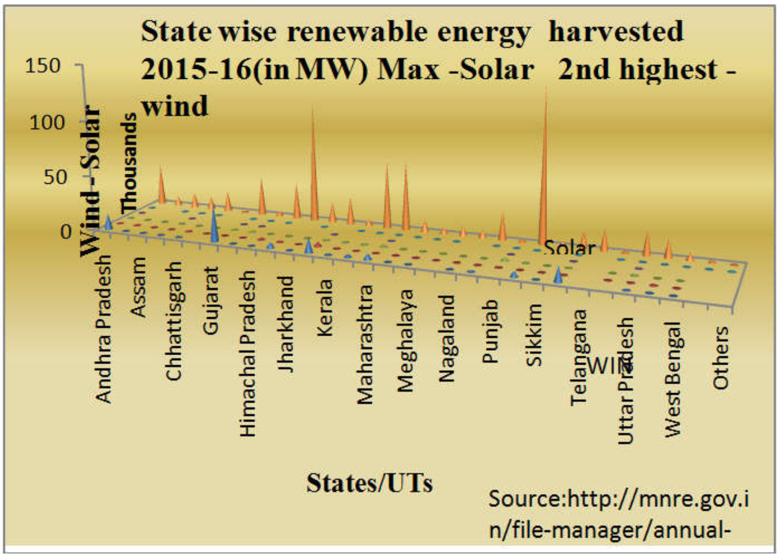

Fig. 2. Statewise electric renewable sources showing SPV moudle is more than wind source in India

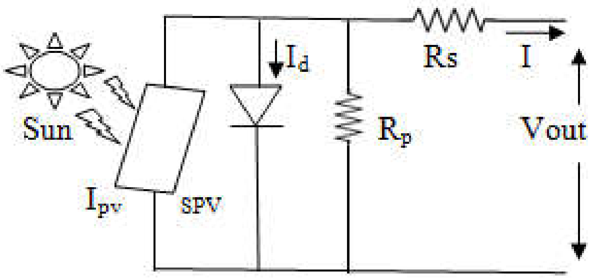

Fig. 3. An equivalent circuit for Si, SPV cell

of UP, Bihar, MP, Jharkhand, Odisha and WB including 8,566 houses do not have access to electricity and clean cooking. Though 96% of villages in India are electrified, yet only 69% houses have electricityhttps://scroll.in/article/759215/india. The electricity is available to the household more than 20hours a day are Jharkhand (2%), UP (5%), Bihar (8%), Odisha (23%) and MP (26%). In the acute conventional energy crisis, the renewable energy mostly solar energy is the only alternative in the eastern part of peninsular India.India could generate total solar power by March/2016 was 6.74GW and have generated 9.566GWPVM powerby 2/2017.

Review of Literature

Meisen *et al*., (2006) reported that the central India has huge solar potential as the av temperature lies between 25°C – 27.5 °C and lies between the Equator and Tropic of Cancer (Madras to Calcutta).Toub(2006) mentioned that a PV module act as a solar power house basing upon semiconductor principle where PV cells captivate photons and convert to DC current through an inverter which alters the signal to 120 or 240-volt and can be used in AC gadgets.Sharma Atul, (2011) mentioned that India have 300 sunny days (location specific) with average irradiation of daily solar energy ranges from 4-7kWh/m^2 which can have a total generation potential of 500,000 TWh/year International Renewable Energy Agency (IRENA) (2012) [International Renewable Energy Agency (IRENA), 2012]. Reported on the installed cost and efficiencies of PV cells in the year 2010 were 3800 which is reduced to 5800 USD in 2015 where as the efficiency have increased from 14% to 17% respectively. Ong *et al*., (2013) reported that the land needed for small and large Photo voltaic installations are from 1Ha to 5Ha/MWac, with capacity-weighted average of 3Ha/MWac and for CSP it ranges from 1Ha to 6Ha/MWac, with a capacity-weighted average of 2.5Ha/MWac.Khera *et al*., (2013) stated that the PV solar source of power is most expensive still the solar capacity of India has been increased from 20 MW in 2012-13 toaddedcapacity of 1000 MW in 2014-15.Kundan Ku *et al*., (2013), reported that 214Mw Charnak Solar Park in Gujarat. Tarai *et al*., 2016 told that balangir district in Odisha has 300 sunny days, daily average solar irradiation 5.5 kWh/m2 with a renewable energy potential 53820MW. Gangopadhya *et al*, (2013), India receives averagesolar irradiation @ 200 MW/Km^2 in an area of 3287 Km^2 and the total generation capacity $8x10^6$ MW which is 5909 million tons of fossil oil equivalent/year Sundarray *et al*. (2014). To meet the power requirement of the weaver community, Chandel *et al* (2014), designed a SPV unit of 2.5MW of 22230 modules (16modules in each row), seven numbers of MPPT controllers of capacity 3.5MW, 431781 Ah battery bank over an area of 13.11acres.To long term energy saving and cost reduction.Verma *et al*., (2015) suggest touse high quality components in SPV Unit for long life of SPV plants. On monthwise performance study of Solar photovoltaic (SPV) system done by Vasisht *et al*. (2016) gave result that maximum performance of SPV units in winter at 55^0 C. The performance of PV module deplete with summer temperature >45^0 C by 0.08%, monsoon ($35 < T_{mod} < 45^0$ C). 04% and post monsoon (>38^0 C) by 0.06%. Since PV modules are consumer specific, the PV installations is most popular in Germany followed by Italy and India find place nowhere India has a renewable energy poser potential of 896603 MW out of which 102772 MW (11.46%) from wind, 19749 MW (2.20%) from small hydro-power, 17,538 MW (1.96%) from biomass and the highest from solar power amounting to 748990 MW (83.54%) in the year 2015 (Energy statistics 2016, GOI).

MATERIALS AND METHODS

Solar photovoltaic usessilicon PV modules to convert sunlight into electricity. The electricity generated can be stored/ used directly (Off grid), fed back into grid line (On grid) or combined.SPVM plant is a reliable and clean source of electricity has wide range of uses such as domestic, industrial, agri-front and for livestock. SPVM cells have the advantages of nonuse of fuels or gasses, no wear and tear, instantaneous response, no pollution, works at normal temperature, high conversion efficiency, little maintenance, high power to weight ratio, decentralized installation and wide power handling capabilities (from few KW to GW). The construction material, Silicon isthe second most available material of the earth. Modern technology and mineralogy advances made the cost of SPV modules cheaper and solar installation is growing popular particularly on roof tops and inaccessible hilly areas.Rooftop PV modules are stressed in India with estimated generation of 700MW which is 15% of the total generation of electricity (https://renewablesnow.com /news /india-to -install-700.....). The largest PV solar park generates 214MW (discrete installed over 1150Ha) in Charanaka in Patan district of Gujarat, and Golmund solar park in Tamil Nadu shall produce 824MW. Solar park projects, on pipe line are sixteen and estimated to generate 176MW in India. The SPVM converts light energy (photons) to electrical energy using silicon solar photovoltaic cells (SSPC). The SSPC is a PN junction device created by process of doping on a silicon wafer with p and n silicone nodes and SiO_2 act as electrical insulators (Fig 3 and fig 4).

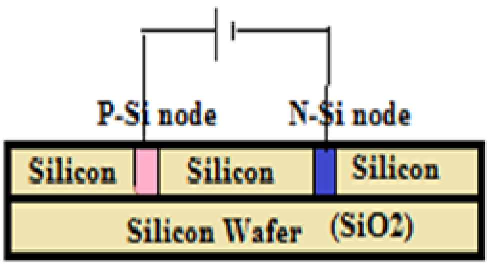

Fig. 4. Single SSPC, SPV cell

Solar PV Module (Components)

Photovoltaic cells are thin squares/discs/films of Silicon semiconductors which generates electricity. Solar PV modules are assembly of photovoltaic (PV) cells of conductors and laminated between clear super-strata and further in encapsulating substrate.Solar modules use photons from solar radiation and emit electricity by the photovoltaic effect.A single solar cell produces electricity by photo-electric emission of only about 0.5V. A 300 watts panel has of 72 numbersof cells, 36.2 V, 8.3A, 44.9 V with Maximum Power Voltage, Maximum Power Current, Open Circuit Voltage respectively. PV modules may be costly, space efficient microcrystalline, Polycrystalline or modern thin films. PV array are the group of PV modules with mounting connected togetherat a required voltage and current.

Mathematically $I = I_L - I_D$ $and\ I = I_L - I_0 \left[exp\left(\frac{eV}{KT}\right) - 1\right]$ ... (1)

Where, I- electric current, I_L=solar light generated current, I_D= diode current, I_0= saturation current, e= electron charge, V= voltage across the junction, K=Boltzmann's constant and

T= absolute temperature.

SPV module Model

The equivalent circuit of a SPV cell is shown in Fig3. The block diagram and all accessories are shown in Fig 5 (a) and Fig 5 (b)

The characteristics equation is

$$I = I_{PV} - I_0\left[e^{\left(\frac{V+IR_S}{A*V}\right)} - 1\right] - \frac{V+IR_S}{R_P} r^2 \qquad \text{.........(2)}$$

Where IPV = the current generated in the Photo Voltaic cell, I0 is the saturation current of the semiconductor diode, Rs series resistance in the SPV cell, RP Parallel resistance in the SPV cell, A= Quality factor of the semiconductor diode, and V is the outputvoltage. The majority of modules used are wafer-based crystalline silicon cells (Fig.4) or thin-film cells based on cadmium telluride or silicon. System incorporates photovoltaic panels, inverter system, and controls circuit depending on the application. PV modules can be wired together in series and/or parallel to deliver voltage and current as required in a particular system. Solar array frames are tilted (as per the latitude value of the place) so that modules directly face the sun to receive more irradiation. In India, modules are installed to face south east with latitude angel (Ex: latitude value of Bhubaneswar is 20.296059). Adjustable frames allow the tilt angle to be varied manually to maximize output throughout the year.

Power generation of a SPVM plant depend upon the solar radiation incident upon the panels. Since government is emphasizing renewable energy generation, subsidy is given to the stakeholder on installation. The cost of the plant with backup is given in Table 1. If no back up provided then the cost of installation shall be reduced by 20-25% per generation of one KW power. In India the installations are roof top and hilly areas, the cost of land is not included in the estimates.

Batteries used in SPV system

Batteries, the storage devices, may be dry and liquid type.The primary functions of a storage battery in a SPV system are: a) Energy Storage Capacity and Autonomy, b) Voltage and Current Stabilization: Lead acid battery has maximum efficiency 80%, but used in general. Sealed maintenance free battery has maximum efficiency 85% and is maintenance free.Lithium-Ion batteries have maximum efficiency 95% but higher in cost. The batteries are rated as volt/ Ah. The lifecycle of batteries ranges from 500-1500 cycles, depth of discharge (DoD) to be 80% (total rated capacity). Common batteries for SPVM power plant used are C5 and C10 as the average sunny hours are 7hours/day and maximum 10hours/day during summerin India.

Solar Charge Controller

Different technologies used in the design of solar charge controllerare Pulse Width Modulation (PWM) or maximum power point tracking (MPPT). The MPPT algorithm is used commonly to optimize maximum power of PV cell or module. Solar charge controller regulates the voltage and current coming from the PV panels going to battery and prevents battery from overcharging and prolongs the battery life. MPPT

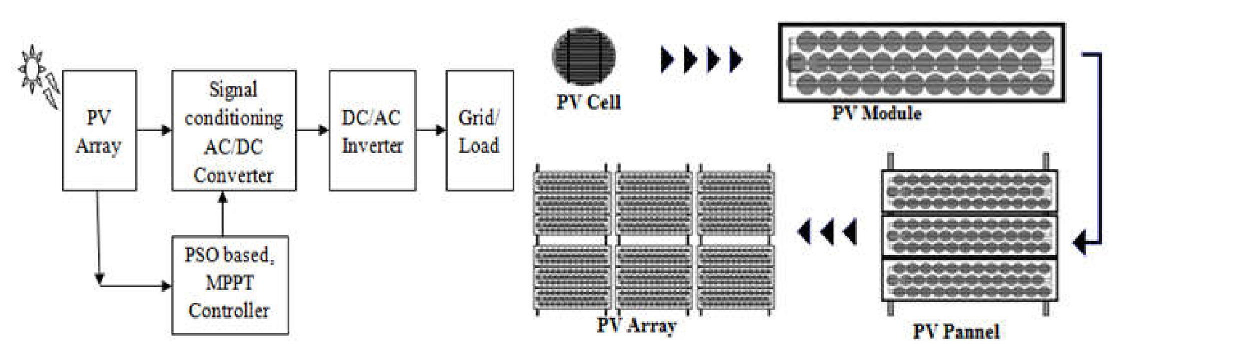

Fig 5 (a) The block diagram of a solar power unit (b) Diagram of solar cell to Array formation

Table 1. Properties of different types of cells available in the market and unit cost/KW

PV cell properties	Mono-crystalline	Polycrystalline	Thin film
Efficiency	Moderate (10-14%)	High (20-23%)	Low (6-9%)
Cost (on grid with backup)	High (100 Th)	Moderate (75-85 Th)	Low (50-65 Th)
Area occupied per KW	Moderate (11-13m^2)	Lowest (10-12m^2)	High (15m^2)
$Max^{m}temp^{re}$ performance	50^0C	50^0C	50^0C
Generation/day(avg.)	Moderate (5units/day)	High (7units/day)	Low (4units/day)

Materials for Solar Module

Materials used for making of solar panels are, Wafer based Si Solar Cell, Mono-crystalline, Multi-crystalline or Thin films ofamorphous Si, Cd, Te, CIGS and many others. The present solar panels are made up of thin film Crystalline Si (More than 90%). The properties and the cost of panel of the different types of cells available are in Table 1.

charge controller with PSO is better for high current control and commonly used for SPV power plants.

SPV/PSO system

Particle Swarm Optimization (PSO) is a stochastic method that employmeta-heuristic algorithm of swarm technique.The P-V characteristic curve of equivalent PV cell (Fig. 5) indicates different quality and faults in theMPPT (Maximum Power Point Tracking) ofSPV installations. PSO optimizes the operating points of SPV systems using multivariable objective functions. PI controllers are used after tracking the reference values so that response time is reduced, steady state errors are eliminated, and optimum duty cycle can be found.

A.Average Life of one SPV module

Basic design criterions of a solar PV system are the total power to be generated and energy consumption by all loads supplied by the solar PV system. As per Central Electricity Regulatory Commission (CERC), under Tariff regulation for Renewable energy 2012, Sec 2(1) (aa) the useful life of SPV Power plant is 25 years, so also the same tariff period, Sec 6(b). The average life span of present solar panels used in India is of 25years. The silicon cells used is 15-20 kg weight and can be heated to >100^0C. Dry synthesized solar cells (DSSC) and Organic Photo Voltaic cells (OPV), inorganic quantum dot solar cells (IQDS) are in research process which will replace the silicon SPV cells in near future

B. SPV design and calculation for one house (A/C minimum Appliances used):

SPV design and calculation for one household

Example: A house has four 12 Watt LED/CFL bulbs used 5 hours per day, two 40 Watt fan used for 10 hours per day and one 75 Watt refrigerator that runs 24 hours per day with compressor run 12 hours and off 12 hours.The system will be powered by 12 Vdc, 100 Wp PV modules.

Solar PV system sizing

1.*Determine power consumption demands*:The designing of a solar PV system involves to find the total power and energy consumption of all loads that need to be supplied by the SPVM:

a. Total load = (4x12 W x 5 hours) + (2x40 W x 10 hours) + (75W x 24 x 0.5 hour) = 1940Wh/day.

b. Total energy required drawn from PV panel's =1940 x 1.3= 2522 Wh/day.
Where 1.3 (for PWM) is the energy lost in the system or 1.2 times for MPPT controller.

2.*Size the PV modules*: Number of PV modules required i.e2522/100 = 25.22 which is fraction so we will take as 26. It means that this system requires twenty-six 100Wp modules of 12 volts battery.

3. *Inverter sizing*: The input rating of the inverter should never be lower than the total watt of appliances. The inverter size should be 25-30% bigger than total Watts of appliances. So, 1940 x 1.30= 2522 Watt or 2.5 kW or 3Kw inverter size is needed. If DC appliances are used there is no need of inverter in the system.

4.*Battery Capacity (Ah)* = (Total Watt-hours per day used by appliances x Days of autonomy)/(0.85 x 0.6 x nominal battery voltage) i.e. (1940*2)/(0.85*0.6*12) = 633.98 Ah.So the battery should be rated as 12V, 650Ah, 2 days autonomy. The calculation above was done manually and it can also be done in software (PVsyst).

Solar street light design and calculation

ForStandard Street light, the panel is 40W/20V and 4A, the CCR is 12V, 3A battery or12v 10Ah (tubular). This setting can activate a 10W and a 15W LED/CFL bulb can light for 12 and 8 hours respectively. A SPVM model with specificationPanel: 40 W, 20V, 4 A, charge controller: 12V 3A&battery: 12V 10A Tubular (C 10) was made and the performance was tested during Oct-2016.The output Characteristic curve was shown in Table 2 and the VI characteristic curve is shown in Fig 6. The test was conducted as the performance of the SPVM cell plays vital role.

Table 2. The performance analysis results of the 40W SPVM model

S.No.	Time	Voc	Isc	Vsc	Vbattery
1	8:30 AM	5 V	2.0 A	13.2 V	12.1 V
2	10.00 AM	20.80v	2.1A	14.12V	13.7V
3	10.35 AM	10.10 V	2.1 A	14.10V	13.2V
4	11.00 AM	19.96V	1.6A	14.28V	13.86V
5	12.45 PM	20.10V	0.21A	20.10V	12.3V
6	2.20 PM	21.00V	0.2A	20.40 V	12.3V
7	3.00 pm	20.70V	0.22 A	20.60 V	12.3V

Design of small SPV power units

Once the load, size of the SPV module, batteries, panel and the capacity of inverter is fixed then according to number of users and their total power demand is ascertained as per technical specification http://www.nrhmassam.in. As per the accessibility, the grid is designed. Off grid supply is done in secluded, low demand and in-accessible areas. Then provision of inverter and battery with or without PSO is made. In off grid system the cost is high. Design of small SPV units both grid and off grid systems for different loads are given in table 2

Design of 1MW SPV Power plant

If the area is large with higher population and power is needed for Cottage Industries, in hill top towns higher SPV generating units are needed. So the design for 1MW and 5MW are shown. The distribution system can be on grid or off grid. Generally the lower command SPV plants use of grid system for dissemination of output power Table 3. Polycrystalline materials are commonly used as generation is high, more efficient and durable in comparison to thin film.The grid/ the transformer specification for 1MW model is in Table 5.

Design of 5MW SPV Power plant

The design of a 5MW SPVM power plant with all accessories and arrangements is in Table 6.

Cost effectiveness

The cost of panel of a SPV module, the cost as per market survey is between Rs 30/- to Rs 50/- per watt of power generation. The rate also depends upon quantity/ quality/ type and bulk of purchase from local market. Ministry of New and Renewable Energy (MNRE), GOI provide subsidy on purchasing to promote. www.bijlibachao.com/solar/solar-panel-cell-cost-price-list-in-india.html. A comparison of cost

Table 3. The solar panel, inverter, batteries, controllers and area and cost of the mini SPV plants

#	Plantsize	Ongrid/off grid	Solar panel (Structure: GI Channel)	Size of inverter	Size of battery	Area needed	Av.Cost (ThRs)	Remark
1	1 Kw	Off grid	200W x 5pcsor 250Wx4pcs	1.5 KW x1pc	12V/200Ah Lead acid1pcs	25m^2	85	48V/40A MPPTX1pc
	1Kw	On-grid	200Wx5pcs	1.5KWx1pc	Nil	22m^2	75	AC/DC box
2	5Kw	Off grid	200Wx20 pcs	6KWx 1pc	12V-200Ah 16pcs or 12V-150Ah 8-10pcs	40 m^2	475	96 V/50A MPPTx1pc
3	5Kw	Ongrid	200Wx 24 pcs	6KWx 1pc	Nil	38 m^2	400	AC/DC box
4	10Kw	Off grid	200 W, 50 Pcs	13KWx1pc	12 V/200 Ah x32 Pcs	75 m^2	900	96V/100 A, 1 Pcs
5	10Kw	On grid	200 W, 50 Pcs	13KWx1pc	Nil	70 m^2	850	AC/DC box

Table 4. Details of arrangement and numbers of PV panel grid (1.0 MW) SPV power plant

1 MW SPVM Design	Solar PV arrangement and grouping		
Power Plant Capacity 1 MWp Avg. Sun hrs per Day Whole Year 6-7 Hours Total Power/ Day 1 MWp Total Watt-hrs per Day 1*1000*1000 W-h/day Max. Solar Isolation at the site 6.18 KW-h/m²/day Total Watt-hrs per Day / Isolation 161812.29 Total PV panel Energy needed (1.3 time energy lost in system)210355.99 W-h/day	Solar PV Specification		No of PV Panel Group Group of PV Panel=5 nos Each Group containing No of Panel= 140 nos Strings/Arrays35 nos Each Strings/Arrays contains No of solar Panel 4 nos Area needed: 2-3 Ha Installation cost for polycrystalline panel of avg. area 1.5Ha to 2Ha is 45 to 50 million INR, Thin film panel of area 3Ha and avg. cost 40-45 million INR
	Watt (Wp)	300 Wp	
	DC Voltage (Vmp	36.72 V	
	DC Current (imp (A))	8.17 A	
	Open Current Voltage (Voc (V)	45.5 V	
	Electrical output Calculation		
	Voltage of each String	146.88VDC	
	Current of Each String	8.17 ADC	
	Voltage of each Group	146.88VDC	
	Current of Each Group	285.95ADC	
	DC Output Calculation		
	Power of each String	1.2 KW	
	Power of each Group	42 KW	
	Power of 5 Groups	9 KW	

Panel size= Number of PV Panels needed= (210356) W-h/day /300Wp= 702 number of 300W PV panels or modules needed for the system
Inverter size: 30% extra of1MW =1.3MW.3 phase inverter is needed.
Battery Capacity (Ah): =(1,000,000X2)/(0.85X(0.6X18))= 217864.93 Ah. provide
18 V, 217865 Ah for 2 days autonomy batteries.
Solar charge controller rating =Total short circuit current (Isc) of PV array x 1.3= 8.65A x 1.3=11.245 A. PV array x 1.3= 8.65A x 1.3=11.245 A.

Table 5. Details of GRID and Transformer specification for all the PVM plant design

Grid Specification		Transformer specifications (KVA)		Use
No of phases	3-phase	No of phases	3 phase	The use of on grid distribution is optional from 1MW to 5MW. But higher SPV plants must use grid power distribution
Voltage rating	400 Volts AC	Frequency	50 Hz	
Frequency	50 Hz	Primary voltage	11 kVA	
		Secondary Voltage	440 V	
		Efficiency	Almost 95 %	
		Extra Features	Air cooled	

Table 6. Design details of the SPV plant, arrangement and numbers of PV panel grid

5 MW solar PV power plant		**Solar PV arrangement and grouping**			
Power Plant capacity	5 MWp	Solar PV Specification		No of PV Panel Group	
Avg. Sun hrs per Day Whole Year	6-7 Hours	Watt (Wp)	300 Wp	Group of PV Panel	10 nos
Total Power/ Day	5 MWp	DC Voltage (Vmp (V))	36.72 V	Panel/Each Group	350 nos
Total Watt-hrs per Day	5*1000*1000 Wh/day	DC Current (imp (A))	8.17 A	No of Strings/Arrays	88 nos
Maxi. Solar Isolation at the site	6.18 KW-h/m²/day	Open Current Voltage (Voc (V)	45.5 V	Each Strings/Arrays contains No of solar Panel	4 nos
Total Watt-hrs per Day / Isolation	809061.48	**DC Output Power**		Area needed:- 10 - 15 ha Installation cost for polycrystalline panels of avg. 230 million INR (No land cost). Thin film of average 190million INR(No land cost)	
Electrical output Calculation		Power/ String	1.2 KW		
Output Voltage/string	146.88VDC	Power/ Group	106 KW		
Output Current/ String	8.17 ADC	Power/5 Groups	11 KW		
Output Voltage / Group	146.88VDC				

Number of PV Panels = (1051779.92) W-h/day /300Wp= 3506 number of 300W PV panels or modules needed for the system.
Inverter size: 30% extra of 5MW =6.5MW, 3 phase inverter.
Battery size: Battery Capacity (Ah) = =(5,000,000X2)/(0.85&X&(0.6&X&18))= 1089325 Ah, Provide 18 V, 1089325 Ah for 2 days autonomy.
Solar charge controller size: = Total short circuit current(Isc) of PV array x 1.3= 8.65A x 1.3=11.245 A., But 88 strings are there, so solar charge controller rating is 88 nos x11.245A=989.56A, Provide 18 V, 990 A rated solar charge controllers.

of SPV modules 1975 to 2000 is given in fig 6.Reduction of solar cell/panel manufacturing cost is depending onReduction in the cost of principal raw material, ban toforeign solar panel exporters (from China and Japan), Indigenous technological innovations, reduction in cost of Transportation and fuel cost, Government initiation and Government investment policies. For installation of one 1MW SPVM power plant the installation cost approximated in India is given in Table 6.

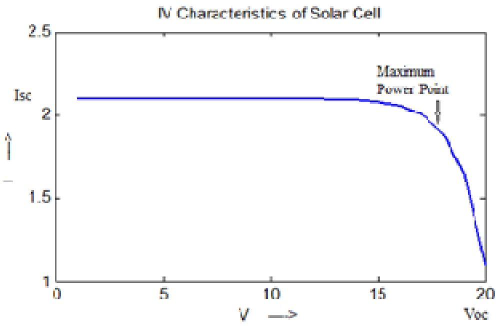

Fig. 6. The V/I characteristic curve for the 40W SPVM model

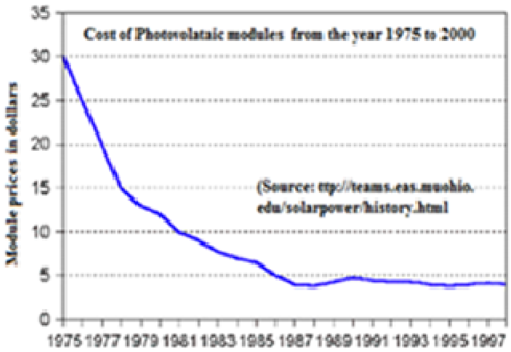

Fig. 7. Reduction of installation cost (India)

Table 7. Investment model for 1 MW Solar Plant All over India

S. No.	Specification	Rating/Value 1 M W SPVM plant
1	Poly Crystalline Panel	702 nos 300 W
2	Cost	4.5 Corers (Avg.)
3	Temperature	Min 15^0 and Max 50^0 c
4	Tilt angel	Altitude Angel
5	Wind speed	120 Km/h
6	Generation (Expected/year)	17.50 Lakhs Units/MW (Avg.)
7	Degradation: 1st 10years	0.05%
8	11-25 years	0.67%
9	Debt Percentage	70%
10	Equity Percentage	30%
11	Percentage of Indian Loan	70%
12	O&M cost/MW: 1st year	8.0 Lakhs/MW
13	Depreciation	5.28%
14	Corporate Tax	30.28%
15	Minimum Alternate Tax	18.38%

Investment Model for 1 MW Solar Power Plant

We see a huge demand for information for investment models for setting up a 1 MW Solar Plant. It is decided to create a 1MW – 10 MW estimate model and verify the its cost in India with subsidy.To mitigate the demand for information for investment models for setting up a 1 MW SPVM power Plant, it is decided to create a 1MW – 10 MW estimate series is given in Table 7. In spite of high installation cost, in long run with a life span of 25years a PVM power plant is much cheaper and ecofriendly. On decentralized to cope up the transmission loss and installation cost per megawatt from any other sources like hydro, thermal and atomic power plants is less. The plant once installed is far away from huge labour, material, men and machinery expenditure and continues without deteriorating the environment. The cost of photoelectric modules globally have reduced a lot and shown fig 6.

Conclusion

The paper studies how to establish photovoltaic solar power plant design as well as calculation of power production. Based on site conditions in India, design of SVM plants are madeto find recommendation and techniques at optimized cost. In order to establish green and sustainable development of the environment, the solar PV power plant is the best alternative. The estimationof the power requirement, followed by calculation of storage capacity is done. Further, the calculation of CCR, solar PV panel, and inverter designs are considered for a cost effective SPVM power plants in India..The paper helps ingrasping the opportunity to build the most suitable, cost effective, remediated, solar PV power plant and welcoming a better tomorrow.

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