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An Analysis of One MW Photovoltaic Solar Power Plant Design

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ABSTRACT: We are well known that the rapidly growth of business and population are putting more and more pressure on world power resources. Photovoltaic Solar Power plant price will play a vital role in the larger development of solar power generation. So it is most importance that to developed new methodology and techniques for reduced cost of solar power plant.

How to reasonably utilize green energy and keep sustainable development is the most important challenge for use. As a huge green energy source generated from the sun, PV industry will gain the best opportunity to grow up. We should grasp the opportunity to build the most suitable environmental friendly PV power plant, and welcome a better tomorrow.

In this paper we study how to establish photovoltaic solar power plant Design as well as calculation of power production, base on that to further we find recommendation and techniques to optimized cost of PV solar power plant. To establishment of green and sustainable development of solar PV power plant to reduce a burden of state electricity board.

Keywords: photovoltaic, power plant Design.

I. INTRODUCTION.

India has very good conditions for the development of photovoltaic solar power systems due mainly to the high mean daily radiation and the high number of sunny days in most parts of the country. For this reason, the Administration and companies working in the sector are developing policies and investing in photovoltaic solar power systems. One of the best features of rooftop solar PV systems is that they can be permitted and installed faster than other types of renewable power plants. They are clean, quiet, and visually unobtrusive. Users won't even know that the rooftop plants are working there. Keeping in view the impending shortfalls in conventional power generating sources and growing demand of energy, it is important to go for non conventional sources.

In this research work to study renewable energy system which is uses PV modules to convert sunlight into electricity. Solar PV system is very reliable and clean source of electricity that can suit a wide range of applications such as residence, industry, agriculture, livestock, etc.

PV systems are designed and sized to meet a given load requirement. PV system sizing exercise involves the determination of the size and capacity of various components, like PV panels, batteries, etc. PV system design also involves a decision on which configuration is to be adopted to meet the load requirement. Once the system configuration is decide then the size or capacity of the various components are calculated. A low quality component (charge controller, for instance) may be cheaper initially but probably will be less efficient and may not last longer. On the other hand, a relatively expensive but higher quality component is more likely to perform better (saving energy and thus cost) and may be able to recover its cost in the long run.

II. COMPONENTS OF SOLAR PV SYSTEM

Solar PV system includes different components depended on your system type, site location and applications. The major components for solar PV system are solar charge controller, inverter, battery bank, auxiliary energy sources and loads (appliances).

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- Major Components of PV System.

    1. PV Module.
    2. Solar Charge Controller.
    3. Inverter.
    4. Battery Bank.
    5. Load.

Solar PV Module.
It is an assembly of photovoltaic (PV) cells, also known as solar cells. To achieve a required voltage and current, a group of PV modules (also called PV panels) are wired into large array that called PV array. A PV module is the essential component of any PV system that converts sunlight directly into direct current (DC) electricity. PV modules can be wired together in series and/or parallel to deliver voltage and current in a particular system requires.

Solar charge controller.
It is charge controller that is used in the solar application and also called solar battery charger. Its function is to regulate the voltage and current from the solar arrays to the battery in order to prevent overcharging and also over discharging. There are many technologies have been included into the design of solar charge controller. For example, MPPT charge controller included maximum power point tracking algorithm to optimize the production of PV cell or module. Solar charge controller – regulates the voltage and current coming from the PV panels going to battery and prevents battery overcharging and prolongs the battery life.

Inverter.
Inverter converts DC output of PV panels or wind turbine into a clean AC current for AC appliances or fed back into grid line. Inverter is a critical component used in any PV system where alternative current (AC) power output is needed. It converts direct current (DC) power output from the solar arrays or wind turbine into clean AC electricity for AC appliances. Inverter can be used in many applications. In PV or solar applications, inverter may also be called solar inverter. To improve the quality of inverter's power output, many topologies are incorporated in its design such as Pulse-width modulation is used in PWM inverter.

Battery.
In stand-alone photovoltaic system, the electrical energy produced by the PV array cannot always be used when it is produced because the demand for energy does not always coincide with its production. Electrical storage batteries are commonly used in PV system. The primary functions of a storage battery in a PV system are:

1. Energy Storage Capacity and Autonomy: to store electrical energy when it is produced by the PV array and to supply energy to electrical loads as needed or on demand.
2. Voltage and Current Stabilization: to supply power to electrical loads at stable voltages and currents, by suppressing or smoothing out transients that may occur in PV system.

Supply Surge Currents: to supply surge or high peak operating currents to electrical loads or appliances.

DC-DC Converter.
DC-DC converters are power electronic circuits that convert a dc voltage to a different dc voltage level, often providing a regulated output. The key ingredient of MPPT hardware is a switch-mode DC-DC converter. It is widely used in DC power supplies and DC motor drives for the purpose of converting unregulated DC input into a controlled DC output at a desired voltage level. MPPT uses the same converter for a different purpose, regulating the input voltage at the PV MPP and providing load matching for the maximum power transfer. There are a number of different topologies for DC-DC converters. In this thesis we are using BUK, BOOST, BUKBOOST dc-dc converter as it is obtained by using the duality principle on the circuit of a buck boost converter.

Load.
Load is electrical appliances that connected to solar PV system such as lights, radio, TV, computer, refrigerator, etc.

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III. SOLAR PV SYSTEM SIZING

Determine Power Consumption Demands

The first step in designing a solar PV system is to find out the total power and energy consumption of all loads that need to be supplied by the solar PV system as follows:

- **Calculate total watt-hours per day each appliance used.**

  Add the Watt-hours needed for all appliances together to get the total Watt-hours per day which must be delivered to the appliances.

- **Calculate total Watt-hours per day needed from the PV modules.**

  Multiply the total appliances Watt-hours per day times 1.3 (the energy lost in the system to get the total Watt-hours per day which must be provided by the panels.

Size the PV modules

Different size of PV modules will produce different amount of power. To find out the sizing of PV module, the total peak watt produced needs. The peak watt (We) produced depends on size of the PV module and climate of site location. We have to consider "panel generation factor" which is different in each site location. For Example Thailand, the panel generation factor is 3.43. To determine the sizing of PV modules, calculate as follows.

- **Calculate the total Watt-peak rating needed for PV modules**

  Divide the total Watt-hours per day needed from the PV modules by 3.43 to get the total Watt-peak rating needed for the PV panels needed to operate the appliances.

- **Calculate the number of PV panels for the system**

  Divide the answer obtained in Calculate total Watt-hours per day needed from the PV modules by the rated output Watt-peak of the PV modules available to you. Increase any fractional part of result to the next highest full number and that will be the number of PV modules required.

Result of the calculation is the minimum number of PV panels. If more PV modules are installed, the system will perform better and battery life will be improved. If fewer PV modules are used, the system may not work at all during cloudy periods and battery life will be shortened.

Inverter sizing

An inverter is used in the system where AC power output is needed. The input rating of the inverter should never be lower than the total watt of appliances. The inverter must have the same nominal voltage as your battery.

For stand-alone systems, the inverter must be large enough to handle the total amount of Watts you will be using at one time. The inverter size should be 25-30% bigger than total Watts of appliances. In case of appliance type is motor or compressor then inverter size should be minimum 3 times the capacity of those appliances and must be added to the inverter capacity to handle surge current during starting.

For grid tie systems or grid connected systems, the input rating of the inverter should be same as PV array rating to allow for safe and efficient operation.
Inverter size = 1MW/1.3 = 1.3MW.

Battery sizing

The battery type recommended for using in solar PV system is deep cycle battery. Deep cycle battery is specifically designed for to be discharged to low energy level and rapid recharged or cycle charged and discharged day after day for years. The battery should be large enough to store sufficient energy to operate the appliances at night and cloudy days. To find out the size of battery, calculate as follows:

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1. Calculate total Watt-hours per day used by appliances.
2. Divide the total Watt-hours per day used by 0.85 for battery loss.
3. Divide the answer obtained in item 4.2 by 0.6 for depth of discharge.
4. Divide the answer obtained in item 4.3 by the nominal battery voltage.
5. Multiply the answer obtained in item 4.4 with days of autonomy (the number of days that you need the system to operate when there is no power produced by PV panels) to get the required. Ampere-hour capacity of deep-cycle battery.

- ***Battery Capacity (Ah)*** *= Total Watt-hours per day used by appliances x Days of Autonomy (0.85 x 0.6 x nominal battery voltage)*

Solar charge controller sizing

The solar charge controller is typically rated against Amperage and Voltage capacities. Select the solar charge controller to match the voltage of PV array and batteries and then identify which type of solar charge controller is right for your application. Make sure that solar charge controller has enough capacity to handle the current from PV array.
For the series charge controller type, the sizing of controller depends on the total PV input current which is delivered to the controller and also depends on PV panel configuration (series or parallel configuration).

According to standard practice, the sizing of solar charge controller is to take the short circuit current (Isc) of the PV array, and multiply it by 1.3

Solar charge controller rating = Total short circuit current of PV array x 1.3

IV.ONE MW SOLAR PV POWER PLANT DESIGN CALCULATION

One MW Solar PV power Plant Design		
Power Plant Capacity	1	MWp
Avg. Sun hrs per Day Whole Year	5	Hrs
Total Power/ Day	1	MWp
Total Watt-hrs per Day	1*1000*1000	W-h/day
Maxi. Solar Insolation at the site	6.18	KW-h/m²/day
Total Watt-hrs per Day / Insolation	161812.3	
Total PV panal Energy needed (1.3 time energy lost in system)	210356	W-h/day
Solar PV arrangement		
Watt (Wp)	300	Wp
DC Voltage (Vmp (V))	36.72	V
DC Currant (imp (A))	8.17	A
Open Currant Voltage (Voc (V))	45.5	V
Short Circuit Currant (Isc (A))	8.65	A
No of PV Panel		
The Total No of PV panel to be Use	701.1866	Nos
Total PV Panel	701	Nos
No of PV Panel Group		
No of Group of PV Panel	4	Nos
Each Group containing No of Panel	175.25	Nos
Total No of PV Panel each Group	175	Nos

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No of Strings	25	Nos
Each Strings contains No of solar Panel	7	Nos
Electrical Calculation		
Output Voltage of each String	257.04	VDC
Output Current of Each String	8.17	ADC
Output Voltage of each Group	257.04	VDC
Output Current of Each Group	204.25	ADC
DC Output Calculation		
output Power Of Each String	2100.02	2.1 KW
output Power Of Each Group	52.5	53 KW
Output power of 4 groups	13.25	13 KW
Inverter Sizing		
4 No of 3 Phase inverter is Chosen	325000	325 KW
Battery Size		
Day of Autonomy	1	Day
18 v Battery Sizing for groups	4	Groups
Total Watt hours per Day used by battry loss	0.85	%
Depth discharge by battery	0.6	%
18 v Battery Sizing for each groups	35403.05	Ah
Total 18 v and 1 Day Autonomy Battery	3600	Ah
Solar Charge Controller Sizing		
Total short circuit Current of PV array	8.65	A
No of Strings	25	Nos
Solar Charge Controller Ratting	281	A

V. CONCLUSION.

How to reasonably utilize green energy and keep sustainable development is the most important challenge for use. As a huge green energy source generated from the sun, PV industry will gain the best opportunity to grow up. We should grasp the opportunity to build the most suitable environmental friendly PV power plant, and welcome a better tomorrow.

We study to how to establish photovoltaic solar power plant Design as well as calculation of power production, base on that to find recommendation and techniques to optimized cost of PV solar power plant.

To establishment of green and sustainable development of solar PV power plant to reduce a burden of state electricity board.

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