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AN ANALYSIS OF 2 MW PV SOLAR POWER PLANT DESIGN

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ABSTRACT: Solar energy is one of the most important renewable energy sources on earth that have been gaining increased attention in recent era. It is the greatest availability compared to other sources of energy. The total amount of energy supplied to the earth by sun in one day has sufficient to power the total energy needs on the earth for one year. Solar energy is one and only cleans and free of emissions, since it does not produce pollutants or by-products harmful to nature. The conversion of solar energy into electrical energy has many application fields at present era. 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.

We study to 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.

I. INTRODUCTION

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).

Major Components of PV System

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

Solar PV Module

Solar Photovoltaic systems use solar panels to convert sunlight directly into electricity. System incorporates photovoltaic panels, inverter system, and control circuit depending on the application. Materials used for making of solar panels are, [1] Wafer based Si Solar Cell technologies- Mono-crystalline and Multi-crystalline. (Comparatively High efficiency High cost) [2] Thin film Technologies- Amorphous Si, Cd,Te, CIGS and many more. (Comparatively Low efficiency Low cost) [3] Future Technology- Thin film Crystalline Si. (High efficiency Low cost)

More than 90% of the solar cells produced at present are of crystalline silicon. Crystalline Si modules have higher efficiency compared to thin film technology. Commercial modules have efficiencies between 12% to 18% and laboratory cells have record efficiency of 24.7%.

MPPT 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. MPPT algorithms are necessary because PV arrays have a non linear voltage-current characteristic with a unique point where the power produced is maximum. This point depends on the temperature of the panels and on the irradiance conditions. Both conditions change during the day and are also different depending on the season of the year. Furthermore, irradiation can change rapidly due to changing atmospheric conditions such as clouds. It is very important to track the MPP accurately under all possible conditions so that the maximum available power is always obtained.

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 BUCK, BOOST, BUCK-BOOST 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.

II. 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:

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

III. MW SOLAR PV POWER PLANT DESIGN CALCULATIONS

2 MW Solar PV power Plant Design		
Power Plant Capacity	2	MWp
Avg. Sun hrs per Day Whole Year	10	Hrs
Total Power/ Day	2	MWp
Total Watt-hrs per Day	2*1000*1000	W-h/day
Maxi. Solar Insolation at the site	6.18	KW-h/m²/day
Total Watt-hrs per Day / Insolation	323624.595	
Total PV panel Energy needed (1.3 time energy lost in system)	420711.974	W-h/day
Solar PV arrangement		
Watt (Wp)	250	Wp
DC Voltage (Vmp (V))	31.41	V
DC Currant (imp (A))	7.96	A
Open Currant Voltage (Voc (V))	37.40	V
Short Circuit Currant (Isc (A))	8.59	A
No of PV Panel		
The Total No of PV panel to be Use	1682.8479	Nos
Total PV Panel	1682	Nos
No of PV Panel Group		

No of Group of PV Panel	8	Nos
Each Group containing No of Panel	210.25	Nos
Total No of PV Panel each Group	210	Nos
No of Strings	21	Nos
Each Strings contains No of solar Panel	10	Nos
Electrical Calculation		
Output Voltage of each String	314.1	VDC
Output Current of Each String	7.96	ADC
Output Voltage of each Group	314.1	VDC
Output Current of Each Group	167.16	ADC
DC Output Calculation		
output Power Of Each String	2500	2.5 KW
output Power Of Each Group	52500	53 kW
Output power of 8 groups	420000	420 kW
Inverter Sizing		
8 No of 3 Phase inverter is Chosen	325000	325 KW
Battery Size		
Day of Autonomy	1	Day
18 v Battery Sizing for groups	8	groups
Total Watt hours per Day used by battery 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	36000	Ah
Solar Charge Controller Sizing		
Total short circuit Current of PV array	8.59	A
No of Strings	21	Nos
Solar Charge Controller Ratting	234.5	A

IV. 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.

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