Design and study of distributed photo-voltaic power generation system in sewage treatment plant

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Abstract. With the rapid development of the global economy, solar photovoltaic power generation has attracted wide attention all over the world. With the rapid development of all kinds of new energy in the world, photovoltaic power generation has a huge international market and broad prospects for development. This paper analyzes the feasibility of the distributed photovoltaic power generation system in this city, based on the actual situation of a photovoltaic power generation project in a certain place. Through the type selection of a variety of solar cell groups, component installation, operation mode selection, and inverter selection, Therefore, a more reasonable PV module and electrical part(The design and study of the first part, the two part of the electrical system and the lightning protection measures) are designed. The research shows that the comprehensive value of photovoltaic power is very high, and the distributed photovoltaic power station can be built in the areas where the geographical conditions are suitable and the light is sufficient. After the completion of the above power generation projects, the local solar energy resources will be fundamentally transformed into economic advantages.

1 Introduction

With the rapid development of the global economy, the demand for electricity in every country in the world is increasing year by year. The clean and green energy such as solar energy, wind energy and geothermal energy has been widely recognized and concerned worldwide [1]. At present, the core technology of photo-voltaic power generation has been slowly mature track, the rapid development of solar photo-voltaic power generation technology to the national economy played a crucial role in the global energy highly stressful situations, this technology can also meet the people of new energy demand. Taking a city in China as an example, the city is one of the most developed areas of China's solar energy resources. The transparency in the atmosphere is relatively high, and its total radiation value is basically in a certain range. Solar energy can be sustained output, and fully meet the necessary conditions for solar energy development. The city carries out the planning and construction of the photo-voltaic power plant project, which will vigorously promote the high speed development of the local distributed photo-voltaic power plant construction [2].

2 Research On Pv Distributed Generation System

2.1 Solar cell assembly

The solar cell component is the most basic structure unit in the distributed generation system. single solar cell is rarely used for power supply. Instead, the batteries are connected in series or in parallel to be packaged into different power solar photo-voltaic components. As the core part of the system, the quality and cost of solar cell components represent the basic parameters of grid connected power generation system to a large extent. The solar photo-voltaic components with reliable quality, stable performance and good encapsulation can work for 20 years in a wet and humid environment [3].

2.1.1 Types and properties of solar cells

The performance of various types of photo-voltaic cells is different, and the performance of each type of solar cells is more detailed in Table 1.

Table 1. Three kinds of common so lar battery control

	Crystal silicon solar cell	Thin film solar cell	Amorphous silicon solar cell
Component conversion efficiency	14%	6%	Less than 14%
Land area /1MW	Less than 30 mu	More than 40 mu	About 35 Mu
Comprehensive cost	low	Middle	high
Life	long	Middle	short
contaminated	nothing	Metal pollution	nothing

It can be seen from table 1: crystalline silicon solar cell has longer operation life than thin film solar cell and amorphous silicon, and the cost is relatively low and no pollution. It is more economical and reliable for large and medium-sized photo-voltaic power station.

2.1.2 Selection of solar cell components

Large photo-voltaic grid connected power plants should choose the types of PV modules with mature technology, high conversion efficiency, large-scale production and widely applied engineering. They are mainly monocrystalline silicon photo-voltaic modules and polycrystalline silicon photo-voltaic modules. The main difference between the two components in the engineering application is that the photoelectric conversion efficiency of the monocrystalline silicon cell is slightly higher, and the layout aspect is slightly more economical. In practical applications of photo-voltaic power stations, monocrystalline silicon cells and polysilicon batteries are available. The total installed capacity of the project is 4.9218MWp, and the area of the project is tense. It is appropriate to choose the high efficiency double side component as far as possible. In addition, this area is located in the southern region, with more humid and hot climate. In addition, PV modules are arranged above the anaerobic pond and sedimentation tank of the sewage treatment plant. The PV modules are in a high temperature and high humidity environment for a long time. The use of double glass modules can effectively prevent the generation of PID. Therefore, this article selects 300Wp (positive power) /60P double double glass component.

2.2 Type selection of inverters

Grid connected inverter plays a very important role in the conversion efficiency and reliability of the system. In order to improve the efficiency of the system, the cost of power generation should be reduced to a minimum[4].The internal structure of the inverter and its control method are studied, which is one of the differences between the grid connected inverters and the other inverters. The parameters of the two inverters are compared as shown in Table 2.

Table 2. Comparison of the parameters of two inverters

Inverter Parameters	Centralized Inverters	String Inverters
Rated output power	100-500kw	10-50kw
Protection grade	Indoor IP20, outdoor IP54	IP65
Cooling method	Air blast cooling	Natural heat dissipation
system composition	Step by step confluence	Non fuse design, external fan

From table 2, it can be obtained: By comparing group string and centralized application scenarios in distributed photo-voltaic. Centralized, series type and inverters can meet the requirements of the power grid access. In terms of reliability, the series inverter has high protection level, no fuse, no external fan free maintenance design, easy maintenance, small failure influence surface, and it can bring more benefits. Therefore, this project selects a series of series inverters. According to the characteristics of the project, the 50kW series inverter is used in this photo-voltaic power generation project, and the inverter should have the anti PID device.

2.3 The design of a photo-voltaic array

The solar cell components often used in the photo-voltaic power station include a fixed bracket, an inclined single axis tracking bracket, a horizontal single axis tracking support, and so on. This project is located in the South and near the regression line, and the effect of the tilting fixed lifting slope radiation is low. Because the project is to use the sewage treatment plant's anaerobic pond, sedimentation tank, discharge area and other areas, flexible support is used to arrange photo-voltaic modules over it, so the installation and adjustment of components is very difficult. In consideration of the project, it is recommended to use fixed array operation mode.

2.3.1 Unit system scheme and configuration

The total station consists of four sets of series inverter power generation units, each of which is composed of a

photo-voltaic array, a inverter and a confluence device. In the series inverter power generation unit, every seven photo-voltaic groups are connected by 1x4mm2 photo-voltaic cable to a series of series inverters. Every six sets of series inverters are connected by a 3x25 cable to an AC confluence box. Every 4/6 AC junction box is connected by 3x150mm2/3x240mm2 cable to 1 box changes. The group series inverter is distributed evenly in the PV array and installed on the outdoor photo-voltaic scaffold. In order to save the cable and reduce the loss, the box type substation is arranged in each unit near the overhaul road [5] .

2.3.2 Series parallel connection scheme of PV module

The maximum allowable input voltage Udcmax of the PV grid inverter is 1100V, and the input voltage MPPT operating range is 200~1000V. The rated open circuit voltage of PV module is Voc 39.6V, and the open circuit voltage and temperature coefficient is -0.29%. The rated peak power and voltage Ve is 32.9V, and the peak power and working voltage temperature coefficient is 0.38%. The maximum allowable system voltage is 1100V. According to the calculation, the number of photovoltaic components in this project should be less than 25 and more than 8. For example, table 3:

Table 3. Group number calculation range

	N <=	25.80379
7.5523944	<= N <=	27.71003

The number of group strings should be even 18, 20, 22, 24, etc. The operating voltage range of the group is all within the voltage range of the inverter MPPT, which is helpful to improve the efficiency of the inverter. For example, table 4:

Table 4. Series voltage calculation table

	20	21	22	23	24
Open circuit voltage of minimum ambient temperature group(V)	852.6	895.2	937.8	980.5	1023.1
Maximum ambient temperature group working voltage(V)	531.6	558.2	584.8	611.4	638
Maximum ambient temperature group working voltage(V)	721.7	757.8	793.9	830	866.1

It is visible from the data in Table 4: When twenty-four components are selected in series, the open circuit voltage of the photo-voltaic group string is 1023.1V. The voltage value is less than the maximum DC voltage 1100V of the inverter, but it is higher than the maximum insulation tolerance voltage 1000V of the PV module. When twenty-two components are selected in series, the open circuit voltage of the photo-voltaic group string is 937.8V. The voltage value is less than the maximum voltage 1100V of the DC side of the inverter and the maximum insulation withstand voltage 1000V of PV module, and the inverter and PV module can work normally. Therefore, the selection of twenty-two photo-voltaic components in series in this project has the best technical and economic performance. The number of parallel circuits of solar cell string: Calculation of rated power capacity of each component in series is 300Wp * 22=6600Wp, Each series of series inverter is parallel to seven sets of series, each photo-voltaic area is equipped with a 35~37 power inverter with a power of 50kW, and each 4/6 inverter is connected to a confluence box. Each photo-voltaic area is arranged with 244~252 clusters, and the single area capacity is respectively: 244x6600=1.6104MWp; 252x6600=1.6614MWp; 250x6600=1.65MWp.

2.4 Design of square array connection

2.4.1 Array layout

The design of connection principle of series boost, two stages parallel converge, in-situ inverter and local boost are adopted to photo-voltaic module. The connection of the series connection should pay attention to the matching of the working current of each photo-voltaic module in the loop. The working current is mainly influenced by the solar irradiance. The working current of the PV module on the same oblique plane at the same time is the same. The parallel connection should pay attention to the matching of the working voltage of the series circuit. The working voltage is mainly influenced by the working temperature of the battery. The working voltage of the series circuit is also affected by the voltage loss on the wiring cable. In order to reduce the difference in the working voltage of the series circuit, the series circuit with similar position is parallel in parallel. When the series inverter is arranged, it is considered in the middle position of the series circuit.

2.4.2 PV module wiring

The total station consists of 3 series of series inverter power generation units. Each square array of photo-voltaic cells is composed of a photovoltaic group string, a inverter device and a confluence device. In the series inverter power generation unit, every 7 photo-voltaic groups are connected by 1x4mm2 photo-voltaic cable to 1 series of series inverter. Every 6 sets of series inverters are connected to 1 AC confluence boxes from 3x25 cable. Every 4/6 AC junction box is

connected by 3x150mm2/3x240mm2 cable to 1 box changes.

2.4.3 Series connection and parallel connection

For large photo-voltaic grid connected power generation system, in order to reduce the connection between PV modules and inverters, facilitate maintenance and improve reliability, two level confluence plans are generally needed.

For group series inverter, it is two level AC confluence. The first stage confluence is located in the series inverters which there are the 8 circuit input circuit. The second level confluence is located at the exchange box [6].

2.4.4 Series connection inverter connection

The series inverter adopts single bus connection, which is more than one out. The main technical parameters and functions are designed as follows.

1) Input side (8 ways):

The input side has a DC input switch which the rated current is 16A and the rated voltage DC is 1000V. The position signal of DC switch hopping switch are sent to the main control room.

2) Output side (1 way): The main circuit has 3 pole plastic case circuits breaker which the rated current is 80A and the rated voltage AC is 600V. The position signal of the jump lock of the plastic shell circuit breaker is sent to the main control room.

2.4.5 AC junction box wiring

A single bus connection is used for the exchange box. The main technical parameters and functions of the confluence box components are designed as follows.

1) Input side (6 ways): There are 3 pole plastic case circuits breaker which the rated current is 80A and the rated voltage AC is 600V on input side.

2) Output side (1way): There are 3 pole plastic case circuits breaker which the rated current is 400A and the rated voltage AC is 600V on output side.

3 Electrical design part

3.1 Electrical primary connection

In general, the electrical primary schematic diagram is shown in Figure 1.

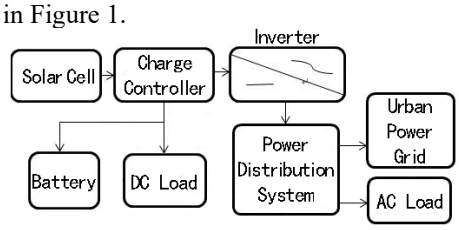

Figure 1. A schematic diagram of the primary principle of distributed photo-voltaic power generation system

As shown in Figure 1, the city grid connected by the distributed photo-voltaic power system is based on its voltage level and access device [7]. An independent metering device for the power supply line of the distributed photo-voltaic power generation system is set up.

There are 1 1.6104MWp, 1 1.6614MWp and 1 1.65MWp photo-voltaic power units in this PV power station. They set 3 double winding combination boxes change.

Each 10kV box becomes separate to10kV PV line cabinet. They are 3 feeder cabinets. The ZC-YJV22-8.7/15kV- 3x50 cable is sent to the first class of the switch station, and then the 1 back line is connected to the total distribution room of the sewage treatment plant.

3.1.1 General layout of electric plane

The general layout is clear, compact and reasonable. It is easy to make out the line, reduces the area of land and saves the investment. The PV array is a square array with each 1.6104MWp /1.6614MWp/1.65MWp, with a total of 3 square arrays. The series inverter is installed on the photo-voltaic support. The box is arranged in the middle of the photo-voltaic area and closes to the road layout, it convenient for transportation, maintenance and maintenance. Prefabricated cabin cloth is placed on the west side of the adding room, near the general distribution room.

10kV distribution device: A metal armored handcar of type switch-gear is arranged in a single prefabricated cabin Station power: this station has a 50kVA station transformer and one low voltage distribution screens in the first cabin. Lighting: in order to meet the night inspection requirements of the staff of the sewage treatment plant, this project increases the lighting lamp under the photo-voltaic support of the biological pool. The lighting and ventilation of the prefabricated and box changes are all provided by the equipment manufacturers.

3.2 Electrical part two

In this project, 1 main control rooms are set up in the switch station, which is used to place measurement and control, protection, measurement, DC screen, operator workstation, microcomputer five workstation, video and environmental monitoring system, time synchronization system, AC uninterruptible power supply and two times screen cabinets. Each battery pack screen is arranged in the main control room. 10kV protection measurement and control device and meter are distributed in 10kV high voltage switch-gear. The monitoring method used in this photo-voltaic power generation system is centralized control. The main monitoring technology is computer network monitoring and control system of microcomputer protection device, which can complete the data acquisition of the whole station mechanical and electrical equipment. The collected data are used to monitor, control, measure, protect and so on. By uploading to a specific monitoring computer in the network, remote monitoring can be realized. The time

recording function of the computer monitoring system is completed by the GPS device.

3.3 Lightning shielding measures

Solar photo-voltaic power generation has emerged as an environment-friendly power generation industry in recent years. There is no clear specification in China to explain how to carry out the lightning protection design of the photovoltaic power plant. The division of the lightning protection area is shown in Figure 2.

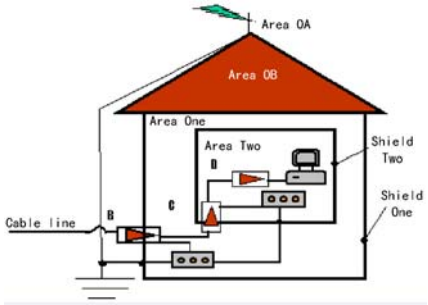

Figure 2. Division of lightning protection area

A protected area can be divided into a different level of protection from outside to inside, and the most dangerous area is the outermost level zero. It is clear that the inverter room in the power station has only a layer of shielding, because it has only one wall between the area zero. The space in the complete set of machine rooms is defined as the area one. The outer shell of the electrical equipment in the machine room becomes a layer of shielding, and the space in the electrical equipment is defined as area two. A large number of cables in the solar cell array are exposed to the outdoors and are easily exposed to direct lightning, which can easily damage the cable. Therefore, within the scope of the actual circumstances, the cable should be laid along the cable slot box, the bridge frame and the bridge cover plate, which can be a good protection for the cable and prevent the strike of direct lightning [8].

4 Conclusion

The scale of the project is about 4.9218MWp, which belongs to the medium-sized photo-voltaic power generation project. The total solar radiation of the level of the project is 4338MJ/m2 a. The solar energy is rich and has the development conditions. After the photo-voltaic power station was built, the first year's power generation is 5.1976 million kw.h. 25 years of power generation accumulative 118.2452 million kw.h. The average power generation capacity of 25 years is 4.7298 million kw.h. The average annual use hour is 946.472 hours. Solar photo-voltaic power station has a large investment, low operating cost and high cost of power generation. According to China's national conditions, we can build photo-voltaic grid connected power stations in China with abundant solar energy resources, and appropriately increase the subsidy amount of grid connected photo-voltaic generation, so as to promote the development of all aspects of photo-voltaic industry, thus promoting the effective development of photo-voltaic power generation in China.

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