Discussion on Problems and operation and maintenance of distributed photovoltaic power stations in Tibet

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Abstract. Due to the vast area of Tibet, where farmers and herdsmen live scattered, and the construction sites of solar distributed photovoltaic power stations are relatively scattered, which makes the operation and maintenance of the system more difficult. At the same time, due to the lack of practical experience of technical personnel, even if there are problems in photovoltaic power stations, they can not get timely feedback and solution. Over time, many distributed photovoltaic power stations are forced to be abandoned because of no maintenance and repair. These phenomena also restrict the application of photovoltaic power in Tibet to a certain extent. Based on the field investigation of distributed photovoltaic power stations in Tibet, this paper finds out the common faults and existing problems of photovoltaic power stations, analyzes the causes of the failures, and puts forward suggestions for operation and maintenance. The purpose of this paper is to build a solar distributed photovoltaic power station with high reliability and easy maintenance in Tibet, so as to provide a certain scientific basis for the existing photovoltaic power station and the later construction of photovoltaic power station.

Keywords: Tibetan regions; Photovoltaic power station; Existing problems; Suggestions for operation and maintenance.

1. Introduction

As the country pays more and more attention to the development of new energy technology, the construction number of photovoltaic power stations has also increased sharply. By the end of 2019, the total installed capacity of photovoltaic power stations in China has reached 205GW, which is the world's largest photovoltaic application country [1]. In order to improve the power generation efficiency of photovoltaic power station, photovoltaic power station has gradually changed from large-scale development to large-scale operation and maintenance mode, and the operation and maintenance ability of photovoltaic power station will have a decisive role in the power generation cost, and has a certain impact on the stable operation of photovoltaic power station. In the face of such a large installed capacity, how to improve the power generation efficiency, reduce the operation and maintenance cost through operation and maintenance, and how to ensure the maximum revenue of photovoltaic power station has become the most important problem [2]. As the Tibet Autonomous Region with the richest light resources in China, the distributed photovoltaic power station has been scientifically constructed and...
applied, which has improved the power consumption of farmers and herdsmen in counties, townships and villages in Tibet Autonomous Region. At present, it has solved the problem of electricity consumption in the area without electricity of more than 500,000 people, and its social benefits, regional economic benefits and ecological benefits are remarkable. However, the harsh operating environment, such as high altitude, high cold and hypoxia, large temperature difference between day and night, and weak power grid, has also put forward new requirements and challenges for the operation and maintenance of distributed photovoltaic power stations. At the same time, due to the lack of understanding of environmental factors, lack of design experience, and relatively imperfect technology of photovoltaic system, some distributed photovoltaic systems built in the past 20 years are still in normal operation, some are abandoned due to various reasons, and even parts are removed and used for other purposes by local residents.

This paper investigates 13 distributed photovoltaic power stations in Tibet, analyzes the existing problems of photovoltaic power stations, and puts forward suggestions for the operation and maintenance of power stations in the future.

2. Existing problems

2.1. Problems of photovoltaic array

The failure of photovoltaic array can be divided into: One is caused by environmental factors, such as buildings, trees, clouds, dust, bird excreta, etc; The other is module short circuit, open circuit and photovoltaic module mismatch caused by long-term operation of photovoltaic array. These faults can be divided into hard fault and soft fault. Hard fault means that the fault does not change with time, such as dust, bird excrement and short circuit and open circuit fault, so it needs to be eliminated in time. Soft fault refers to that the fault changes with time, such as the cloud passing by or the shadow of the building, which does not need to be eliminated [3]. In this investigation, the problems of photovoltaic array are found as shown in Figure 1. The photovoltaic array is extremely uneven. The photovoltaic module is installed on the bracket with aluminum alloy pressing block. Under the condition of high wind pressure, the relative vibration between the module and the bracket is easy to occur, which makes the aluminum alloy block loose or even deform, resulting in the loosening and falling off of the photovoltaic module, and finally causing the uneven arrangement of the photovoltaic array. At the same time, there is no spring gasket installed in the fixing screw at the connection of the photovoltaic array bracket, and the screw is loose. And the environment where weeds regenerate, garbage everywhere.

![Fig. 1 Problems of photovoltaic array](image-url)

At the same time, there is a lot of dust on the surface of photovoltaic modules, and even the photovoltaic array is seriously damaged, resulting in the module hot spot phenomenon is extremely obvious. Basically, one hot spot will appear every 3-4 photovoltaic modules, and some module backboards are even burned through, as shown in Fig. 2 and Fig. 3.
2.2. Problems of combiner box
As the most widely used equipment in photovoltaic power station, combiner box is prone to a variety of failures, so the operation and maintenance personnel need to find out the fault point through patrol inspection. Generally speaking, the patrol inspection of the combiner box is mainly through the appearance inspection, and the internal sampling inspection is adopted, so it is difficult to conduct in-depth investigation. The only way to find the fault is through the current value of the station control system. However, the actual situation is that the operator on duty can only check the power generation status of the inverter. For the combiner box, the data volume of the combiner box is large and not intuitive, and there is no fault equipment so it is very difficult for the monitoring personnel to locate and trace accurately. In this investigation, it is found that there are only grounding facilities for junction box in PV array, and the module has no independent grounding facilities, but only relies on the module frame for grounding treatment. The protection pipeline of output line of junction box is extremely rough and simple, and there is a large area of rust, as shown in Fig. 4. At the same time, lightning protection measures are simplified and formalized. Most of the rooms where inverters, photovoltaic controllers and batteries are stored in photovoltaic power stations only use a metal short rod which is only a section higher than the roof for lightning protection.

Fig. 2 Thermal spot of photovoltaic array caused by ash deposition

Fig. 3 Thermal spot caused by damage of photovoltaic array
2.3. Problems of battery

The battery is a kind of chemical battery that converts the chemical energy contained in its own materials into electrical energy. However, compared with other types of chemical batteries, the most significant advantage of the battery is that it can regenerate its internal chemical substances by charging after the discharge of the chemical energy inside the battery, so as to achieve the effect of effective storage of electric energy[4]. In this investigation, it is found that the battery voltage displayed by the controller of a power station is inconsistent with the actual measured working voltage of the battery. However, the battery voltage at the controller end is consistent with the working voltage measured by the battery by using a multimeter, so the controller has been damaged. The battery charging controller is a 6-channel photovoltaic controller with input current of 100A and single-channel input current of 16.7A. The photovoltaic power station adopts the connection mode of photovoltaic module array connected in parallel in the combiner box. The photovoltaic module array adopts three-way parallel connection or four-way parallel connection. When it is three-way parallel connection, the current is 16.53A; when it is four-way parallel connection, the current is 22.04A, which is close to or exceeds the maximum current of the controller. Therefore, in the case that the controller is in one way of over-current for a long time and there is no load left, it is very easy to fault. So the design is unreasonable. At the same time, the room storing inverter, charging controller and battery is a simple room with color steel tile, without heating and insulation treatment. In the natural environment with low temperature and large temperature difference between day and night in high altitude area, the equipment and battery are lack of protection, which is easy to cause the battery temperature too low in winter night and affect the battery life. As shown in Figure 5.
3. Operation and maintenance suggestions

3.1. Management of spare parts
The spare parts work can replace the fault or damaged parts in the first time, greatly shorten the maintenance time, make the electrical equipment start running again at the fastest speed, minimize the output loss caused by the fault, and ensure the economic benefits of the photovoltaic power station. At the same time, through the summary and analysis of fault experience, find out the high incidence point of electrical equipment failure, so as to purchase and store spare parts. In addition, it can also establish effective communication with equipment suppliers, understand the characteristics of various equipment and their prone places of failure, and refer to these information for spare parts. For the purchased spare parts, a special person shall be assigned to take care of the spare parts. The condition of the spare parts shall be inspected regularly, and each spare part shall be coded and registered. The storage and delivery records of spare parts shall be done strictly to ensure their traceability. And through the construction of a sound and scientific technical document file management system, the management, analysis and utilization of the design and construction drawings of the power station, the daily operation and maintenance situation of the power station, the patrol inspection situation of the power station, and the operation and maintenance application technology of the photovoltaic power station are realized.

![Fig. 6 Site photos of missing PV modules](image)

3.2. Establish and improve the maintenance management mode
Due to the large number of equipment in distributed photovoltaic power station, it is difficult to carry out the maintenance work orderly, which often brings a lot of unnecessary workload. Therefore, it is necessary to establish and improve the maintenance system. Especially in Tibet, since most photovoltaic power stations are set up in some remote agricultural and pastoral areas, for these remote places, the management of user's residence should be combined with the government planning, and the nomadic people's residential areas should be concentrated near the power supply area, so as to ensure that the nomads can also use electricity conveniently. And according to the actual situation of power supply, in order to ensure the effective supply of electricity at the same time, improve the efficiency of resource utilization. At the same time, the connection detection between photovoltaic modules should be carried out regularly, and the weak connection should be handled in time; attention should be paid to the maintenance of photovoltaic modules, timely replacement and problem handling. Secondly, do a good job of battery maintenance work regularly, usually need to carry out 1~2 times inspection and maintenance every year, through the appearance inspection, performance test, record and master the battery parameter information, and timely replace the existing battery. In addition, during the operation and maintenance of the photovoltaic power station, the inspection of overhead lines should be strengthened to check whether there are inflammable materials or garbage piling up on the overhead lines; And whether there are problems of line guide fracture, damage and broken strand; whether there are loose and damaged insulator installation.
3.3. Strengthen the training of equipment operation and maintenance personnel

The relevant operation and maintenance personnel of photovoltaic power station are still in the shortage stage, and the existing personnel are generally lack of experience, so it is difficult to effectively deal with various accidents. Therefore, it is necessary to strengthen the training of operation and maintenance personnel. In the process of training, we should pay attention to the integration of various training forms, theoretical knowledge and practical operation can not be ignored, so as to ensure that the operation and maintenance personnel have enough familiarity with the equipment, so that they have theory in mind and can operate with hands. Relevant technical personnel can be organized to visit the equipment supplier regularly for on-site observation and practical operation practice of photovoltaic equipment, or the manufacturer can be responsible for regularly organizing professional technical personnel to go to each photovoltaic power station for on-site explanation and training. By strengthening the training of equipment operation and maintenance personnel, the overall quality of operation and maintenance personnel can be improved, and experience can be expanded, which is conducive to training operation and maintenance personnel and gradually filling the current talent vacancy. At the same time, we should pay attention to information sharing. In this regard, we can rely on information technology, communication technology and other advanced technologies, contact with experienced professional and technical personnel, build a perfect and scientific information system, and provide a platform for the communication and exchange of power station operation and maintenance operators, power station operation and maintenance management personnel, and equipment manufacturing enterprises. In order to improve the quality of equipment application, so as to ensure the timely detection, reporting and processing of power station faults.
4. Conclusion
As a relatively new form of power generation, solar distributed photovoltaic power station is widely used. In recent years, the number of photovoltaic power stations in China is increasing, and the scale is also gradually expanding. Under the guidance of government policies, photovoltaic power stations tend to be diversified. In order to improve the quality of power generation services and ensure the safety of power station operation, the later operation and maintenance technology is particularly important. At the same time, the operation and maintenance management mode of photovoltaic power station also needs to form a system as soon as possible. Scientific and efficient operation and maintenance management means is an important premise to ensure the good operation of photovoltaic power station. In this regard, it is necessary to fully combine the actual production experience, maintain good communication with equipment suppliers, and jointly summarize and explore the appropriate operation and maintenance management mode, so as to accelerate the development of photovoltaic power generation.

Acknowledgments
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