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Analysis of Capacity for Distributed Photovoltaic Power Station Accessing to Power Distribution Network in Central Tibet

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Abstract – *It's very significant that the capacity of distributed photovoltaic power station accessing to power distribution network, during the designing, should meet the relevant requirements and take into the consideration the effect on the power flow of power distribution network and voltage deviation. According to the characteristics of the power distribution network grid structure in central Tibet, this paper builds the typical simulation model of the power distribution network and analyzes the effect on the power flow of distribution network and voltage deviation when the distributed photovoltaic power station accesses to 10KV power distribution network with adopting three plans respectively. The analysis reveals that (1) when adopting dedicated access with the installed capacity of 5.2MWp, the distributed photovoltaic power station has no effect on the power flow of distribution network and voltage deviation, (2) when adopting T access with the installed capacity of 1.5MWp, the power flow of distribution network changes and voltage deviation meet the related requirements, (3) when adopting the consumers side access with the installed capacity lower than 0.2MWp, has no effect on the power flow of distribution network and voltage deviation.*

Keywords – Distributed photovoltaic; capacity; power distribution network in central Tibet.

1. INTRODUCTION

Tibet autonomous region has the most affluent solar energy resource in our country. Recent year, stimulated by the policy of renewable energy and promoted by Tibet government at all levels for photovoltaic (PV) power generation, the domestic enterprises are motivated to invest the solar power station in Tibet [1]-[8]. As of June 2012, the total amount of installed capacity of solar photovoltaic arrive 100MW, occupying 10.6% of total amount of grid power. During the 12th Five-Year Plan, it's estimated that the new added installed capacity of solar photovoltaic will surge to above 300MW. According to the medium and long term, the total amount is expected to exceed 1800 MW.

These factors of the distributed photovoltaic power station such as interconnected location, interconnected capacity, and network structures and so on, determine the size and orientation of the power flow of distribution network. After the distributed photovoltaic power station accessing to the traditional radial distribution systems and without any power sources accessing to consumers side, the power network changes from radiation type to networks with the multiple power supplies and the power flow of distribution network no longer flows, uniaxially, from buses of transformer substation to every loads but appears various complex distributed conditions of the voltage [9]-[11]. In condition of steady state operation, the voltage of every load point of the traditional power distribution network decreases gradually along the direction of the power flow. Because of the distributed power supply accessing to the traditional power distribution network, lead to voltage increase of each load point, which do great effect on the voltage deviation of each load point. According to the characteristics of the power distribution network grid structure in central Tibet, this paper builds the typical simulation model of the power distribution network and analyses the effect on the power flow of distribution network and voltage deviation when the distributed photovoltaic power station accesses to 10KV power distribution network with adopting three plans respectively.

2. MATERIAL AND METHODS

2.1 Overview of the Power Distribution Network in Central Tibet

2.1.1 High Voltage Distribution Network

The connection mode of high voltage distribution network in the central power grid of Tibet is mainly tree radial structure.

2.1.2 Medium Voltage Distribution Network

During the medium voltage distribution network of the city, in addition to Lhasa city which forms the open operation network of "hand in hand" to support and contact each other, any other else cities in Tibet hasn't formed segmentation or supporting each other.

During the medium voltage distribution network of the countryside, the medium power line of 10KV mainly centers on substation and adopts the connection mode of single radiation without forming segmentation or the network structure of mutual support and handshaking. The power supply radius of lines is too long and the wire cross-section is too small, so the power supply quality becomes lower.

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2.1.3 Secondary Voltage Distribution Network

The connection mode of secondary voltage distribution network in the central power grid of Tibet is mainly tree radial pattern.

2.2. Simulation Model of Power Distribution Network

The connection mode of high voltage distribution network in the central power grid of Tibet is mainly tree radial structure, while the power supply model of "hand in hand" is less. So this paper explores through example of the wiring diagram of 10KV power grid which adopts the connection mode of single radiation, as the figure 1 shown. Using the model of constant active power load to calculate the total load of the power line, with the limiting conditions that the length of the overhead line is 5km, load rate is set to 75% and the nodes among the power line is equal length, the result is proximately 3.326MW.

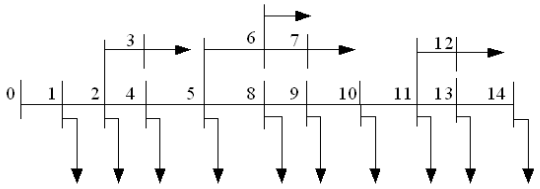

Fig. 1. Typical grid model of distribution network.

3. RESULTS

3.1 Access Principle

Combing the characteristics of the power distribution network grid structure in central Tibet, the access principle of the distributed photovoltaic power station are as follows:

A. The principle to determine the point of grid connected is that the power grid can transmit electricity effectively after the photovoltaic power station access to the power grid and can ensure the security and stability operation of the power grid.
B. When the point of common coupling access to more than one photovoltaic, we should take into consideration their influence overall.
C. The power distribution, to which the distributed photovoltaic power station access, can't occur the situation of nodes voltage exceeding specified limit.

3.2 Access Solution

The capacity of distributed photovoltaic power station accessing to power distribution network, during the designing, should meet the related requirements. The selection of the access point of photovoltaic should take overall into account grid structure and parameter, the capacity of photovoltaic power station, the mode of operation of the power distribution network and other actual operation conditions. The photovoltaic power station should be differentiated according to the installed capacity, match the load of the power line, and access to different location of the power distribution network, avoiding the misdistribution. The photovoltaic power station accessing to the power distribution network adopts three plans as follow: dedicated access, T access and grid connected of consumer side.

(1) In the respect of access way, it's appropriate that the photovoltaic power station accesses to the utility grid with the dedicated circuit. If the condition doesn't permit, the T access is allowed.
(2) In the respect of penetration level, when adopting the dedicated circuit, the total capacity of the photovoltaic power station had better not exceed 25% of the maximum load of the upper stage transformers within the supply region in principle.

The distributed photovoltaic power station accesses to the power grid by T mode, of which the total capacity should be control within 30% of the maximum transmission capacity of the accessed grid lines. When the 10KV lines need access many photovoltaic powers by the T mode, the access points should be close to the power supply with the centralized access. The amount of the photovoltaic power station which accesses to the radial lines of single-ended power supply by the T mode should be control within 3. But in the ring network of the double-ended or multi-ended power supply, the amount should be control within 5.

When adopting grid connected of consumer side to access, the total capacity of the photovoltaic power station had better not exceed 25% of the maximum load of the accessing supply region in principle. Besides the special needs, the grid-connected voltage class of photovoltaic power station is shown in Table 1.

Table 1. Access voltage of distributed photovoltaic generation

Access voltage	Installed capacity of PV power station	Access mode
35kV	6MWp～18MWp	Accesses to 35kV power network
10kV	1.5MWp～6MWp（≤6MWp）	Accesses to 10kV power network
	0.2MWp～1.5MWp（≤1.5MWp）	Adopting T access to 10kV power network
0.4kV	0.05MWp～0.2MWp（≤0.2MWp）	Adopting the consumers side access to power network

4. DISCUSSION

When analysing the access solutions of the distributed photovoltaic power stations with different capacity, we should take into consideration the effect on the power flow distribution and voltage deviation under the

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extreme conditions that the distributed photovoltaic power station accesses to the end of the feeder at full capacity. Then, if the result of the influence meets the relevant standards, so do other conditions.

When there is no distributed photovoltaic power station accessing to, the distribution of power flow of the typical power distribution network is shown in Figure 2.

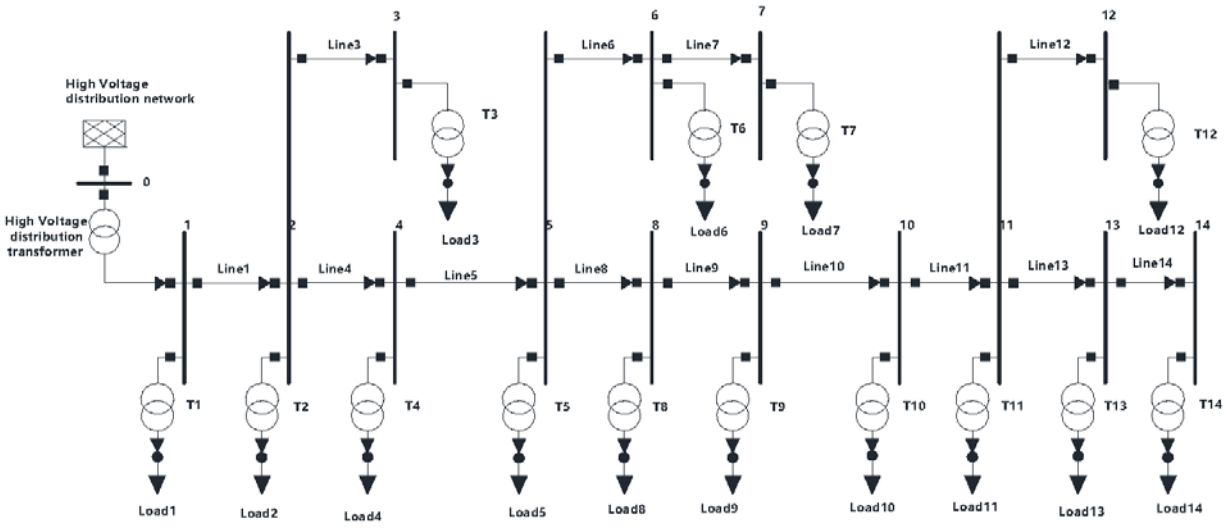

Fig. 2. The typical power flow of the power distribution network.

Because adopting the similar method to analyze the effect on the power flow of distribution network and voltage deviation when the distributed photovoltaic power station accesses to 35KV, 10KV and 0.4KV power distribution network, hereinafter we only take 10KV medium voltage distribution network as a case.

(1) Setting the capacity of the 35/10 KV (110/10) KV transformer substation as 31.5MVA, regarding the limits of load rate (70%) of transformer substation and the maximum capacity of the photovoltaic power station being 25% of the maximum load of the upper stage transformers, the maximum installed capacity of the distributed photovoltaic power station adopting the dedicated is proximately 5.2MWp. After grid connected of dedicated access, the distribution of the power flow in 10KV lines doesn't change, nor does the voltage deviation of every node.

(2) According to the line parameter of the typical simulation model of power distribution network and capacity limitation shown in Table 1, the distributed photovoltaic power station adopting the T access can reach the maximum access capacity 1.5MWp. After the distributed photovoltaic power station accesses to the end of the feeder at 1.5MWp, the distribution of the power flow in 10KV lines will change. In other words, when the distributed photovoltaic power station access to power distribution network, the power flow is from the head to the end; when doesn't access, the direction of the power flow is from node 1 to node 5 and from node 14 to node 5, meaning that the feeder between node 5 and node 14 arises the power flow in the opposite direction. The distribution of the power flow is shown in Figure 3.

(3) According to the line parameter of the typical simulation model of power distribution network and capacity limitation shown in Table 1, the installed capacity of the distributed photovoltaic power station adopting the consumer's side access should lower than 0.2MWp. After consumers side of dedicated access, the distribution of the power flow in 10KV lines doesn't change, nor does the voltage deviation of every node.

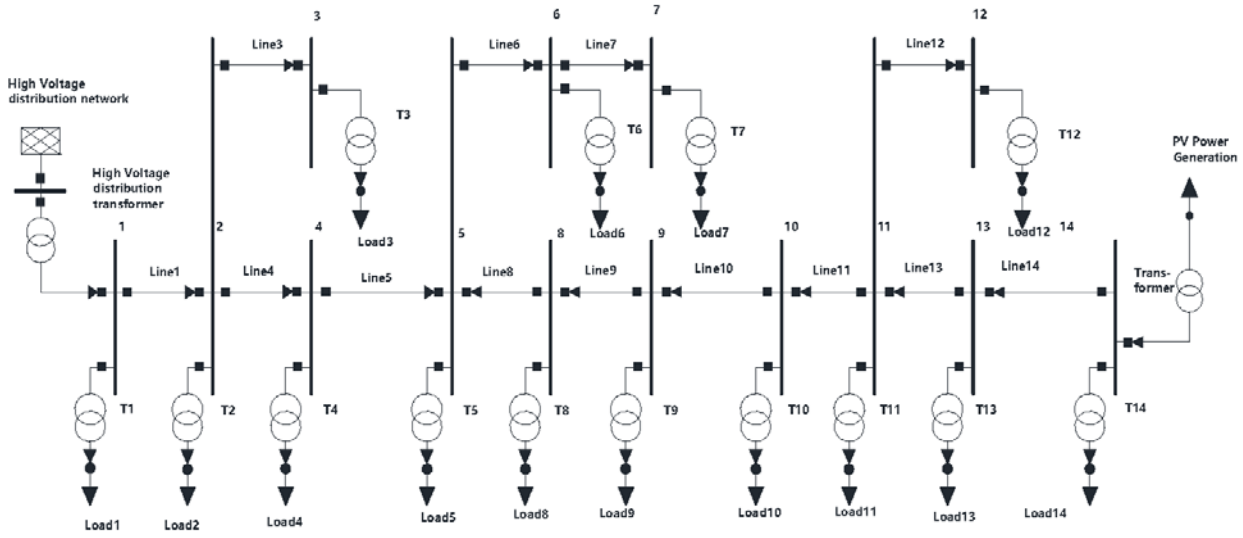

Fig. 3. The distributed photovoltaic power station adopting T access with the installed capacity

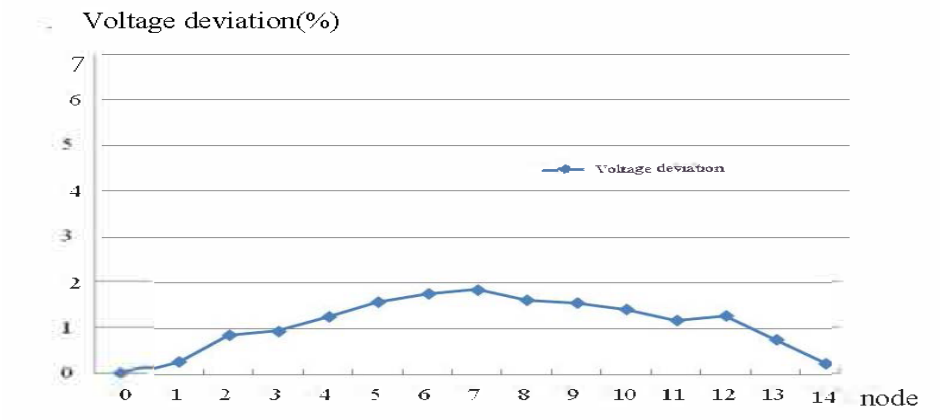

Fig. 4. The voltage deviation T access to power distribution network.

5. CONCLUSION

The connection mode of power distribution network in the central power grid of Tibet is mainly tree radial network structure. This paper takes 10KV power grid of single radiation as a typical case to analyze. The result reveals that when the distributed photovoltaic power station accesses to power distribution network, the effects on the distribution of the power flow and voltage deviation are within the permissible limits. However, along with the continuous increasing of the capacity of photovoltaic power station in Tibet, after the distributed photovoltaic power station accessing to power distribution network, we should take into consideration the designing, planning, operating, the stability of the operation, relay protection and other aspects of the power distribution network to conduct further research.

ACKNOWLEDGEMENTS

Young Teacher Innovation Support Project of Tibet (QCZ2016-59).

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