

Safety Impact of Large-Scale Distributed PV Power Access to Power Grids

Hualing Han, Ning Chen, Linan Qu, Tao Shi, and Lingzhi Zhu

Abstract—Photovoltaic (PV) power generation is the fastest growing part of distributed generation technologies. Large-scale PV power connected to the grid is bound to the safe operation of the grid to bring new problems and challenges in China. Based on PSASP, combined with large-scale PV power access to the actual grid, this article establish PV model, do research on the characteristics of large-scale PV power stations and network system. In this article, the characteristics of PV grid-connected systems, stability and other issues accessing to large-scale PV system are discussed.

Index Terms—PV, power grid, stability, measure.

I. INTRODUCTION

China's PV industry has developed rapidly in recent years. The PV power generation has the shortcomings of low energy density, randomness, and uneven distribution[1-4]. As the quantities sizes and voltage level connected of the PV power plants continue to increase, the line voltage overrun phenomenon caused by short-term fluctuations and periodic changes of the irradiance begin to appear, which may affect the voltage stability of regional grid [5-8]. In addition, the function of fault ride-through of the large-scale PV power plants will also affect the voltage transient stability of the grid.

The research object of this article is the simulating and analysing the operating characteristics of the large-scale PV power plants. Combined with the grid structure and the LVRT function of PV power plants, this article analysis the problems of the grid-connected PV power generation, and give the method to improve system stability of the grid-connected PV power generation .

II. THE GRID MODE

Take the actual grid-connected PV power plants as an example analysis the impact on the stability of the system after accessing the large-scale PV power plants as Fig.1.

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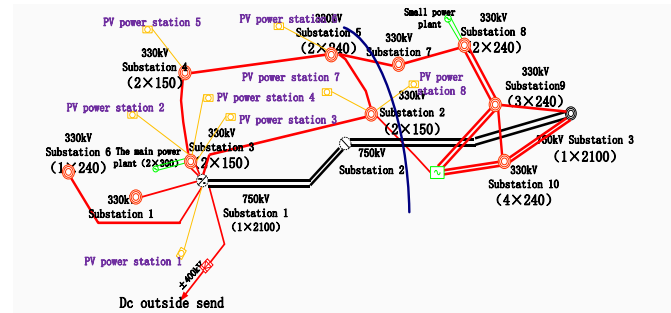
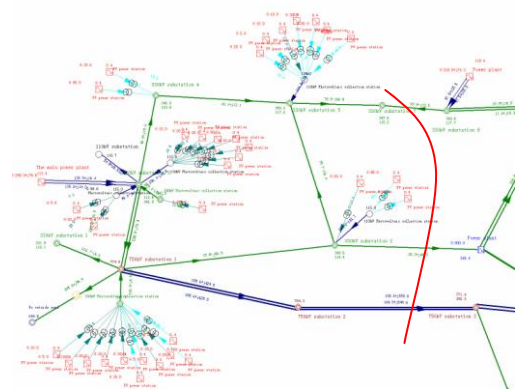
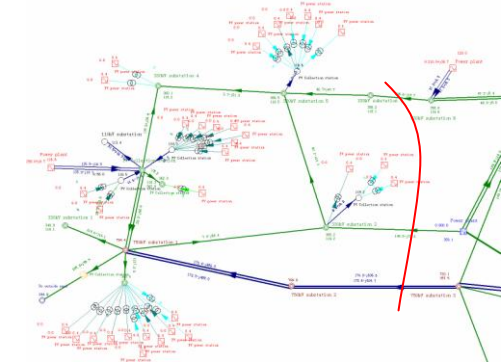


Fig. 1. The simulation grid model

Fig. 2 (a) and (b) is the diagram of power flow when the output active power of PV power plant is full-load and no-load. The red line represents cross-section between the regional power grid and the main grid. Before the PV power take into operation, the regional power grid need the power of 580MW. After the PV power plant put into operation, the regional power grid send probably 300MW.



(a) full-load capacity



(b) no-load capacity

Fig. 2. The power flow diagram of PV power plants running

III. THE SIMULATION ANALYSIS

Large-scale PV power station accessing to the system will bring significant impact on the grid.

A. PV System Output Characteristic Analysis

The power level of PV power station changes following with the irradiance. Take one of the capacity of 100MW PV power station as an example, in process of irradiance rapid changing, the irradiance, current, voltage, active, reactive change curve of PV power station as shown in Fig. 3.

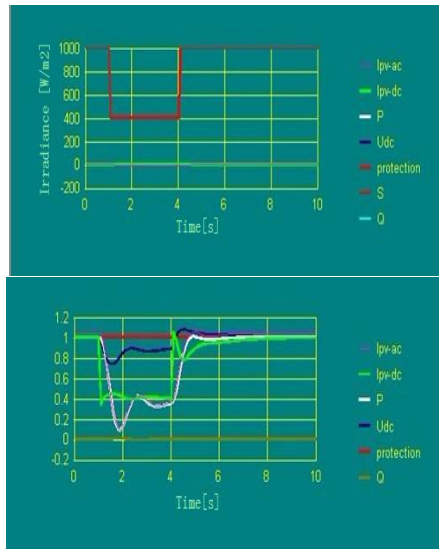


Fig. 3. The curve of parameters of the PV power station

Seen the above diagram:

- 1) I_{pv-dc} in Fig. 3 almost shows a linear relationship between the current output from PV array and irradiance.
- 2) There is the positive characteristic relationship between irradiance and active power output from PV power station.
- 3) Known from the curve, the effect of grid voltage caused by the step change of irradiance is so small which can be neglected.

B. The Analysis of Characteristic of Reactive Power and Voltage after PV Power Station Access to the System

Fig. 4 shows the curve of reactive power consumed PV power station after the voltage of 750kV main transformer in power grid trips.

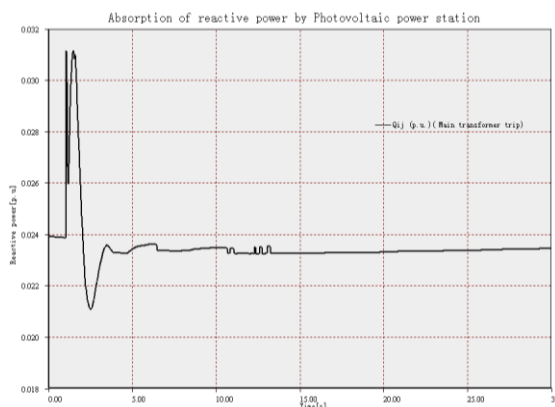


Fig. 4. PV power station absorption reactive power as 750kV main transformer fault change curve

Fig. 5 shows the curve of voltage changes of 330kV substation 1 and 2 in regional network as the capacity of PV power station access power increases. we can see that changing the capacity of accessing reactive power, PV power

station may lead the voltage of 330kV bus dropping more than 10 kV, it will cause the voltage of regional network staying on a low level, which will increase the difficulty of voltage recovery.

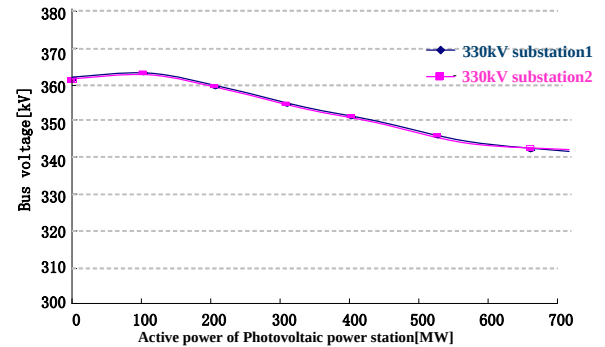
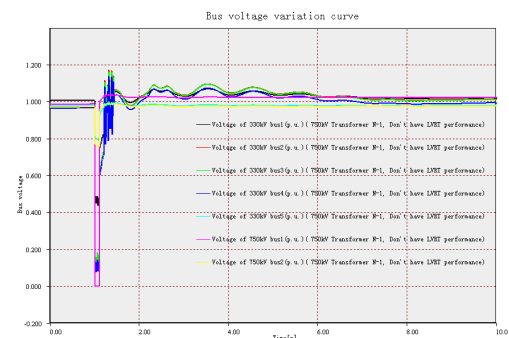


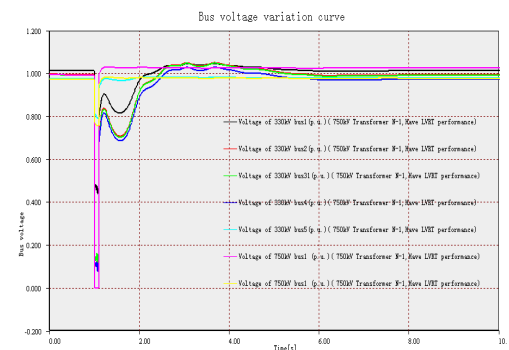
Fig. 5. The voltage of 330kV substation 1 and 2 as active power output of PV change curve

C. The Influence of System Stability for PV Power Station Has LVRT Performance or not

Fig. 6 shows two kinds of changing trends of the bus voltage of the PV power stations which have LVRT performance or not when the same grid fault occurs.



(a) have not LVRT performance



(b) have LVRT performance

Fig. 6. The voltage of the bus change curve

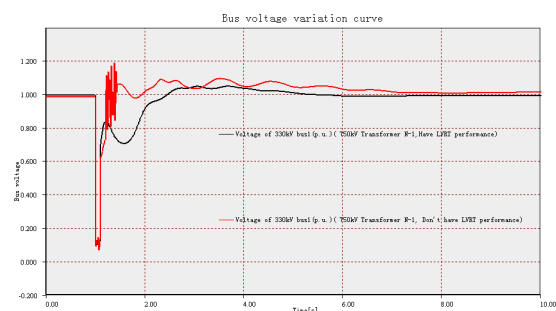


Fig. 6 (c) The voltage of the bus change contrast curve from

It can be seen that if PV power station does not have LVRT performance, it may cut off from the grid and cause overvoltage.

D. The Influence of Transient Stability for Large-Scale PV Access to Power System

Form the Fig. 3 of regional power network diagram, the output channel in this area assumed by strong network 750kV voltage class channel. Under the PV full connection mode, Fig. 7 gave respectively in the same fault the grid unit angle change curve when the PV power station is full-load and no-load.

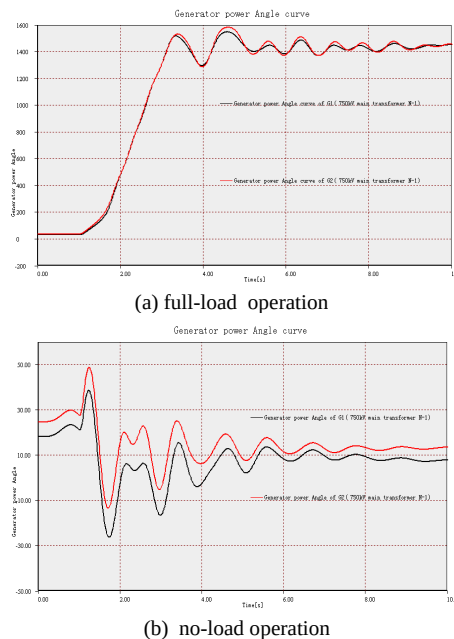


Fig. 7. Angle as main transformer trip change curve

Fig. 7 shows that when the PV power plants are running at full-load, operation, if the fault occurs, system angle will lose stability.

IV. SUMMARIES

Based on the PSASP platform, the article establishes the model of the large-scale PV power generation system, and make research on the operation characteristic of the large scale PV power station in actual network. The main conclusions are as follows:

- 1) The increase of capacity of the accessing PV power station may cause the power flow reversal, it will increase the difficulty of the system operation scheduling. And large-scale PV power station capacity accessing may cause area bus voltage drop more than 10 kV.
- 2) Under the same fault conditions, PV power station which does not have LVRT performance may cause the grid overvoltage. PV power station which have LVRT performance can improve the system stability against overvoltage risk. In addition, if the system node initial voltage level is high, taking off the net of PV power station will lead to light-load of the grid, which may cause the voltage push up to produce the over-voltage stability problem.

- 3) Under the condition of all large scale PV power station put into operation, if the local grid is weak, once major fault occurs, the system will face the problem of stability.

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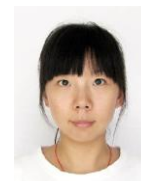
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