TELKOMNIKA Indonesian Journal of Electrical Engineering
Vol. 12, No. 11, November 2014, pp. 7571 ~ 7577
DOI: 10.11591/telkomnika.v12i11.6055

High Limit Penetration in Wind Power Research and Analysis of Static Voltage Stability Characteristics of the Regional Grid

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Abstract

This paper established the high limit penetration power of a certain area including wind power grid model in 30.084% value, in the high limit penetration power transmission network by small disturbance voltage influence. Through the power flow calculation power flow distribution of the viewing area, with the reactive power compensation voltage were optimized. The impact on the system voltage load disturbance by PV-QV curve analysis. And its system reactive power margin and other issues. By the above calculation, the grid is analyzed in access high wind power penetration limit under the feasibility and reliability of operation, and its impact on the static voltage grid system analysis. Make wind power grid reliable access high penetration power frontier research.

Keyword: *wind farms, high limit penetration power, flow calculation, PV-QV curve*

1. Introduction

Increasing depletion of the original energy, with the new clean energy development and utilization, it is has bring gradually a new test on the grid. Large-scale wind power in the grid, the ultimate penetrating power of the regional power grid is increasing. In the original concepts, taking into account the instability of wind power have bring that the wind power into the regional grid should meet certain limit penetration power. However, with the development of new energy, more wind power incorporated or grid will make the grid at the high limit penetration power test be accepted grid formation.

Studies at now stage for wind power grid lies on the calculation of the limit through the power of the wind farm, such as literature [1-4], respectively, to take a different method to calculate the ultimate penetrating power value. Access high-limit penetration power of the wind farm for the regional grid system is still in its infancy. This article focused on the impact of the high limit penetration power of the wind farm to the regional power grid. View the trend of the regional power grid distribution flow calculation using reactive power compensation voltage optimization; analysis by PV-QV curve of load on the system voltage and reactive power margin and other issues. By the above calculation, analysis of the feasibility and reliability of wind power grid access high limit penetration power running, and impact analysis of static voltage grid system.

2. High Limit Penetration Power of a Wind Farm Feasibility and Voltage Stability (PV / QV) Defined

Due to the clean energy of the original energy (wind and solar), intermittent and non-controllable (can not control how much energy), when connected to the grid, access capacity can not be too large, that limit penetration power value cannot exceed a certain value [5-6]. Focus in most of the previous research on clean energy into the grid in the calculation of the

Received April 4, 2014; Revised June 22, 2014; Accepted July 20, 2014

value of the limit of penetration power, but with the expansion of the grid and intelligent, clean energy power forecasting techniques and the corresponding original energy control technology (such as pulp moment angle change control of the fan, solar panels, pitch control), improved energy storage stabilize control of clean energy research, can be improved to some extent a limit penetration power of clean energy connected to the grid. At the same time along with the country facing the problem of carbon dioxide emissions and environmental pollution problems, the original energy has begun to depletion, also contributed to the growing number of clean energy incorporated into the power grid. Resulting containing reliable high penetration power of clean energy grid stability analysis and research, this paper focuses on a regional grid access static voltage stability problems containing high penetrating power of the wind farm.

PV and QV curve is obtained through a series of AC power flow. PV curve represented by: When switching power increase of the two systems, which causes a change in voltage; QV curve represents is: when the voltage level changes, a busbar or busbar reactive power demand. Investigated the power system in normal and non-normal steady-state operating conditions, all the buses within the system to maintain the capacity of the voltage stability. PV and QV curve: (1) Grid the busbar voltage collapse point; (2) Prior to the voltage collapse point to study the maximum power exchange between the bus; (3) Estimate the required reactive power compensation device can prevent voltage collapse on the bus size; research voltage change of generators, load, reactive power compensation device [7-9].

So this article analyzes the receiving side load growth mode of generation side generator power scheduling way analysis the the corresponding wind farm busbar point, the corresponding problem of the stability of the wind farm margin.

3. The Establishment of Wind Farm Grid Model with a High Limit Penetrating Power

This grid model have involve in 1 busbar connection wind farm six followed by capacity with is 49.5,250,200,100.5,49.5,170 MW; busbar connected wind farm three the turn capacity 49.5,49.5,100.5 (MW); the busbar connection wind farm four werecapacity 100,49.5,99,100.5 (MW), a load of 84 + j40 (MVA); 4 No. busbar connection three were capacity 100.5,200,49.5 MW wind farm, a load of 23.7 + j324 (MVA); No. 8 buscoupled to two thermal power plants in turn capacity of 400, 1400 MW; 9 busbar connection a thermal power plant capacity of 1200MW; 10 busbar connection capacity of 1200MW thermal power plants; 11 busbar connection capacity of 800MW thermal power plants; No. 5 busbarload on the 2005 + j457 (MVA); No. 6, bus load of 3124 + j118 (MVA); No. 7 bus load 474 + j175 (MVA). Various bus voltage 220KV imputed to the same voltage level.

Wind Power Penetration refers to the wind farm installed capacity accounted for the proportion of the total load of the system. Wind Power Penetration Limit is defined as the percentage of the access system, the largest wind farm installed capacity and system maximum load.

Wind Power Penetration Limit the regional power grid can be calculated as 30.084%.

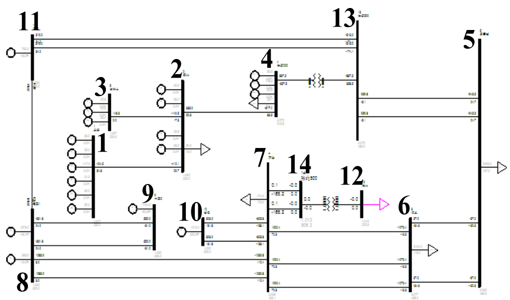


Figure 1. A Region with High Penetration Power Grid under Wind Farms Diagram

3 Model Example Simulation Analysis
3.1. Reactive Power Compensation Device Voltage Compensation
The No. 10 bus is balanced nodes. Grid wind power the high limit penetration power flow calculation, convergence generally low voltage. The key bus node connected wind farm is added to the reactive power compensation device, so the voltage to meet the grid requirements. Reactive power compensation device access: the 1st bus access 50Mvar B-SHUNT reactive power compensation, the output-j54.8Mvar; access on the No. 2 bus 50 (MW) G-SHUNT +150 (Mvar) B-the SHUNT contribute 50.9-j152.7 (MVA); the 5 bus bar access the 200Mvar B-SHUNT reactive power compensation, output for-j185.0Mvar. Both cases the trend calculated voltage results such as shown in Table 1.

Table 1. If Add the Reactive Power Compensation Device Node Voltage

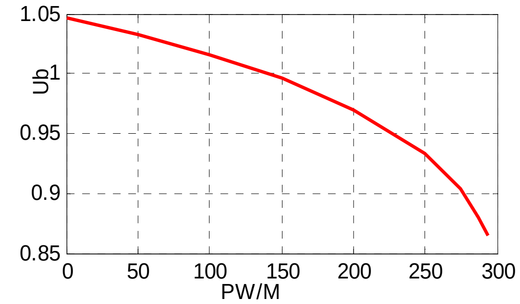
NO. bus	System voltage (pu.)	Plus the voltage reactive power compensation (pu.)
1	0.8263	1.0167
2	0.8478	1.0089
3	0.9137	1.0066
4	0.9307	0.9716
5	0.933	0.9619
6	0.9634	0.9766
7	0.9973	0.9982
8	1	1
9	1	1
10	1	1
11	1	1
12	1.0117	1.0126
13	0.9315	0.972
14	1.0117	1.0126

The bus voltage can be seen from the table, the reactive power compensation device traditional thermal power plants (8, 9, 10, 11 bus) bus connection is very stable, running at the rated voltage. Reactive power compensation device for access bulbar point of the wind farm reactive power compensation, such as bus 1, 2, 3, 4.

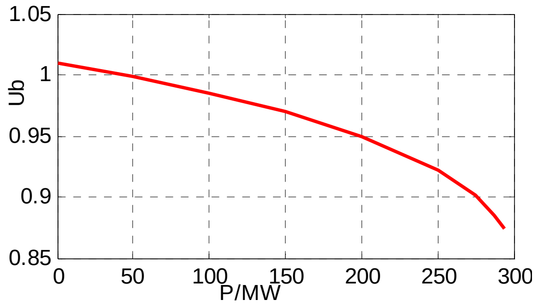
In the situation of high penetration wind farm ultimate power, reactive power compensation voltage of the wind farm access point to the normal level to improve the situation well.

3.2. The Grid P / V-Q / V Curve Analysis
3.2.1. P / V Curve of the Regional Power Grid
The case of (1) Consider the receiving side load growth mode of generation side generator power scheduler, the election 1,2 busbar PV analysis. The system does not receive the disturbance node PV curve in the base case.

P / V curve under the 1st bus normal starting voltage 1.047, voltage fell 0.9pu, active power is 270MW; the active power 150MW 0.95pu; 2 busbar normal P / V curve, the voltage droppedthe 0.9pu, the active 275MW; By dropped 0.95pu active 200MW; be seen on the 1st bus circumstances more vulnerable, in the voltage 0.95pu largest power exchange is 150MW, less than the 2nd bus.



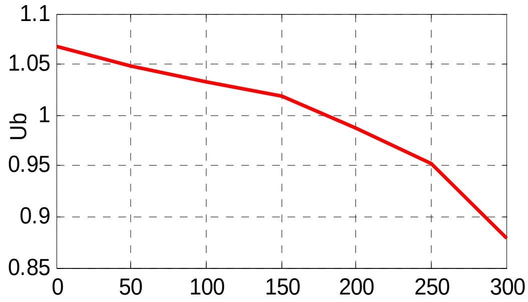
a) No. 1 bus



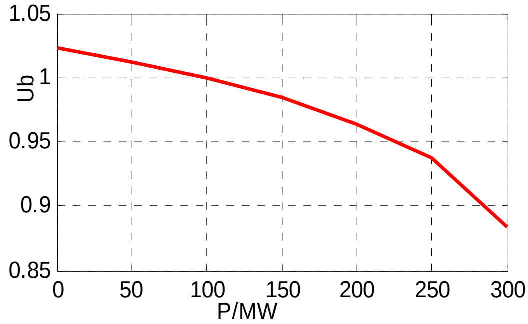
b) No. 2 bus

Figure 2. 1, 2 Bus Normally P/V Curve

The case of (2) lost load 300MW, the load on the bus 2 becomes 0, important nodes PV;



a) P / V curve of the 1st bus in the case of (2)

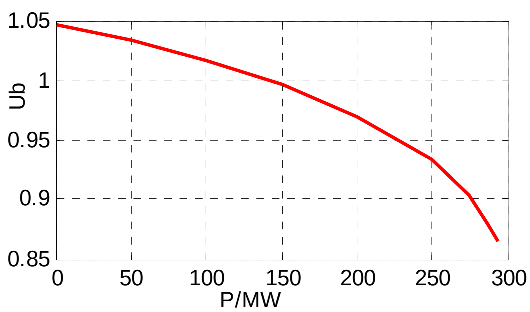


b) P / V curve of the 2nd bus in the case of (2)

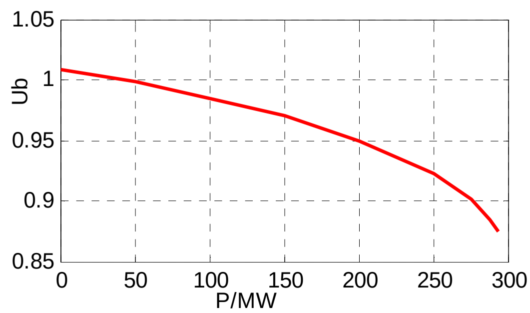
Figure 3. 1, 2 Bus in (2) Cases P/V Curve

The case of (2) disturbance, the 1st bus starting point voltage 1.063pu, (2) disturbance, starting the voltage exceeds 1.05pu, more than the voltage limit; the voltage 0.9pu, active 287.5MW; the voltage 0.95pu, active power for250MW; No. 2 bus, starting voltage 1.023pu, when when the voltage 0.9pu is active 283MW the the voltage 0.95pu, the active power is 224MW; more vulnerable at this time No. 2 bus, voltage maximum switching time 0.95puThe power is 224MW.

The case of (3) 2 bus load increased to 500MW, loss of load each bus the PV curve as shown below:



a) P / V curve of the 1st bus in the case of (3)



b) P / V curve of the 2st bus in the case of (3)

Figure 4. 1, 2 Bus in (2) Cases P/V Curve

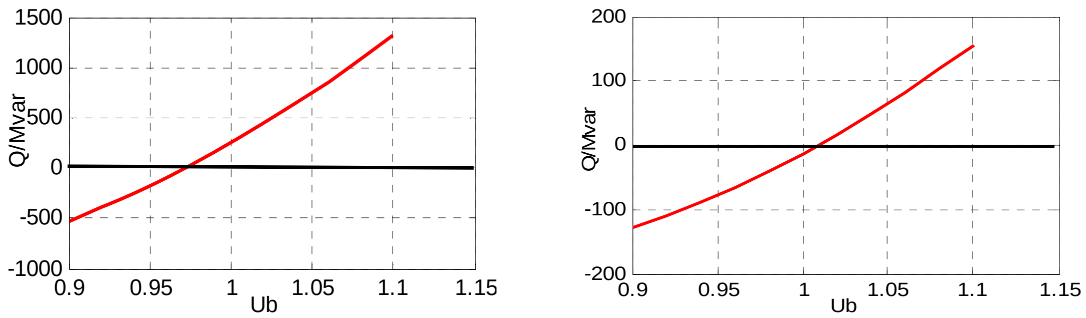
The case of (3) disturbance, the No. 1 busbar starting point voltage for 1.047pu, the voltage 0.9pu, active power is 275MW; the voltage 0.95pu, active 223MW; No. 2 bus, starting voltage 1.009pu When the voltage 0.9puthe active power is 275MW, the By voltage 0.95pu active 200MW; more vulnerable at this time No. 2 bus, the voltage maximum exchange 0.95pu power is 200MW.

3.2.2. Regional Grid Q / V Analysis

Reactive voltage purpose of the analysis is to analyze the situation with the voltage level of reactive power balance and found the weak link of the voltage and reactive power, develop hierarchical partition of voltage and reactive power control strategy, reactive local balance to ensure normal maintenance and special way eachthe voltage level of the bus voltage can be controlled at a reasonable level, and flexible means of voltage regulation.

The same case, the key nodes QV analysis, selected bus 4, a large number of wind turbines and outlets.

(3) Baseline case NO. 1,2 bus QV curve.



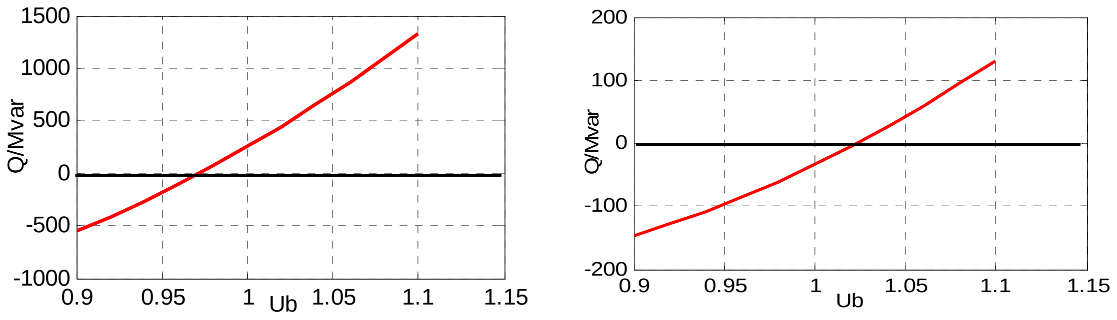
a) No. 1 bus voltage collapse inflection point (0.9, -532.62)

b) No. 2 bus voltage collapse inflection point (0.9, -129.08)

Figure 5. 1, 2 Bus in (1) the Next QV Curve

From the above chart we can see in the (1) case, the 2nd bus voltage operating point; smaller the 2nd bus voltage and reactive power margin, the 1st bus reactive power margin is more than twice that of the 2nd bus.

(2) The 7th bus load into a 500MW 1,2 No. busbar QV curve.



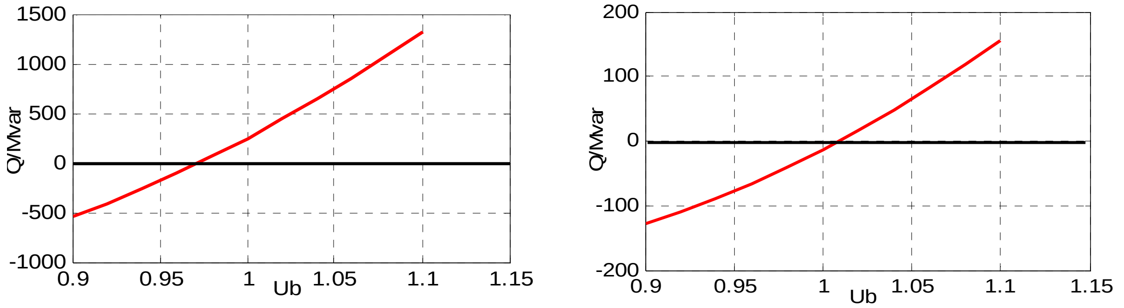
a) No.1 bus voltage collapse inflection point (0.9, -541.51)

b) No. 2 bus voltage collapse inflection point (0.9, -146.04)

Figure 6. 1, 2 Bus in (2) Next QV Curve

In the case (2), (1), the reactive power of the 2nd bus margin than somewhat increased, but at this time is small compared to the power margin of the 1st bus reactive power.

(2) No. 2 bus load becomes 0 MW 1,2 No. busbar QV curve.



a) No.1 bus voltage collapse inflection point (0.9, -539.84)

b) No.2 bus voltage collapse inflection point (0.9, -129.03)

Figure 7. 1, 2 Bus in the (3) QV Curve

In case (3), the reactive power of the 2nd bus margin has been reduced compared with the case (2), with the flat case (1), then smaller than that of the 1st bus reactive power margin.

By more than the results of the simulation analysis, the No. 1 bus Voltage and Reactive power margin in the case corresponding to over 2 busbar big. The reason is that the wind farm on the 1st bus access to the 2nd bus, the 2nd bus on the presence of wind farms and wind farm on the 3rd bus connection, the 2nd bus 1,3, bus orderwire. No. 2 on the bus the total wind farm capacity is 1368MW wind farm capacity on the No. 1 bus is 819.5MW. Thereby No. 2 on the bus voltage and reactive power power margin is low, the bus node reactive power margin, with the point of access to the wind farm capacity.

4. Conclusion

Based on PSS / E on the regional power grid to its high the ultimate penetration power under the wind farm voltage static characteristics comprehensive analysis and research, the above analysis results can be obtained:

(1) High limit penetration power grid connection of wind farms in the calculation of the trend, specific bus node access reactive power compensation device. The output of the wind farm is random fluctuations in wind turbine control system today is in the control of the output of the wind turbine, wind turbine wind energy source is the change in volatility, uncontrollable. Thus the regional grid wind farm capacity and stability is difficult to achieve high limit penetration power output of the wind turbine is not with the mobilization of load fluctuations. Grid prescribed area wind farm grid access capacity limit penetration power in less than 20%.

(2) This paper analyzes the regional grid Wind Power Penetration Limit can reach up to 30.084%, flow calculation reactive power compensation device improved the voltage. After improving the voltage reaches normal levels, then the above limit access to high penetration power of the wind farm area to the next grid PV, QV perturbation analysis, perturbation analysis in each case the maximum transmission grid stabilization active value, and voltage stability reactive power margin. In order to analyze the penetration limit access to high-power wind farms regional power grid, the static voltage stability of the grid. (2) In the case under the 2nd largest bus transport active value 224MW.

(3) PV, QV curve analysis function can be easily derived system access high limit penetration power, the ability to maintain voltage stability and voltage stability critical point distance.

Acknowledgements

Project Supported by National Natural Science Foundation of China (51267020); Supported by International Science & Technology Cooperation Program of China (2013DFG61520); Supported by 2012 Higher Specialized Research Fund for the Doctoral

Program jointly funded doctoral class project "Wind Chu complementary improve short-term wind power prediction precision key technology research" (20126501110003).

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