Analysis of the Influence of AVC Reactive Power Optimization on Line Loss in High Proportion New Energy Area

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Abstract. In order to effectively reduce line loss, this paper analyzes the impact of AVC reactive power optimization in high proportion new energy areas on line loss under typical mode, and calculates the impact of new energy output on line loss when net load changes, and summarizes the law of AVC reactive power optimization in high proportion new energy areas and the impact of new energy output changes on power grid line loss. The research results show that the line loss rate of the main grid and the line loss rate of each partial voltage tend to decrease in the three modes of new energy generation, small generation and zero generation.

Keywords. High proportion new energy; AVC reactive power optimization; line loss rate; power supply

1. Introduction
Photovoltaic power plants are intermittent, random and obviously periodic [1]. In sunny weather, the output shape of photovoltaic power station is similar to sine half wave [2], the output time is between 6 o'clock and 18 o'clock, and reaches the maximum at noon. In cloudy weather, due to the cloud cover, the irradiance data changes greatly, leading to short-term high-power fluctuation of photovoltaic power station output, resulting in the increase of power grid line loss, and the frequent random fluctuation of active energy output, leading to the power grid The distribution of active and reactive power flow changes frequently. It is more important to optimize the reactive power of AVC in new energy area. Therefore, it is necessary to study the specific impact of new energy generation on power grid line loss through AVC reactive power optimization.

2. Analysis of the impact of new energy generation on line loss of a power grid under AVC reactive power optimization in 2018
In 2018, the total installed capacity of new energy in a grid reached 12514.61 megawatts, accounting for 49.99% of the total installed capacity of the whole grid. 2585 megawatts more than that in 2017, including 8959.61 megawatts of photovoltaic installed capacity, accounting for 71.59% of the total installed capacity of new energy; 3270 megawatts of wind power installed capacity, accounting for 26.13% of the total installed capacity of new energy; 285 megawatts of photothermal installed capacity, accounting for 2.28% of the total installed capacity of new energy.
The main power grid in a certain area of high proportion new energy has realized AVC closed-loop management. The voltage of new energy grid has been controlled by AVC system, and the reactive power output has not been well controlled.

2.1. Three typical ways
Mode 1: new energy generation mode: considering that 2380.88mw is delivered from the Haixi section, and 5386.21mw is delivered from the Hainan section, the Haixi output is 3013.03mw, accounting for 57% of the Haixi suit machine, and the Hainan output is 3866.19mw, accounting for 88% of the Hainan installed machine;

Mode 2: small power generation mode of new energy, considering photovoltaic 0 output at night, wind power output 866.4mw, accounting for 30% of wind power installation, light and heat output 117.5mw, accounting for 50% of light and heat installation, Haixi section 1254.59mw, Hainan section 1018.88mw;

Mode 3: the new energy output is considered as 0, considering that 954.82mw is sent out from the Haixi section and 521.98mw is sent out from the Hainan section.

2.2. Calculation results of theoretical line loss rate in three ways
Calculation results of theoretical line loss rate in three ways is show in Table 1.

| Table 1. Calculations by Three Ways |
|-------------------------------------|
| partial pressure | Power supply | Line loss rate | Power supply | Line loss rate | Power supply | Line loss rate |
| Main network | 12265.27 | 2.28 | 9532.68 | 1.99 | 9021.51 | 1.81 |
| 750kV | 5706.17 | 1.29 | 4896.32 | 1.06 | 4551.86 | 0.97 |
| 330kV | 11528.76 | 1.41 | 8975.49 | 1.16 | 8607.65 | 1.06 |

The power supply comparison between large and small power supply is show in Fig 1.

![Power supply comparison](image)

**Figure 1.** Power supply comparison between large and small power supply modes (MWh)
The comparison of Line Loss Rate (%) between Big and Small Distribution is show in Figure 2.
3. Analysis of the influence of new energy generation on line loss under AVC reactive power optimization before and after major projects put into operation

Select the typical winter day of 2018 as the research grid, calculate the operation mode, new energy output, load and other fixed grid before and after the operation of 750 kV monthly tower line II project, analyze the impact of grid changes on line loss before and after the 750 kV monthly tower line II project, and analyze the change of line loss rate of new energy generation, small generation and zero generation mode under the existing AVC reactive power optimization control strategy. Based on the analysis of the influence of power flow change on line loss, the calculation results are as follows in Table 2:

![Line Loss rate (%)](image)

**Figure 2.** Comparison of Line Loss Rate (%) between Big and Small Distribution

Compared with the small power generation mode, the new energy output increases 5895.32 mw, the power supply of the main network increases 2732.59 mwh, and the theoretical value of line loss is 0.29 percentage points higher as a whole. Compared with the small power generation mode, the power supply of 750 kV power grid increases by 809.85 MWh, and the theoretical line loss rate is 0.23% higher; compared with the small power generation mode, the power supply of 330 kV power grid increases by 2553.27 MWh, and the theoretical line loss rate is 0.25% higher.

Compared with the zero output mode, the new energy generation mode increases 6879.22 mw, the main network power supply increases 3243.76 mwh, and the theoretical value of line loss is 0.47 percentage points higher as a whole. Compared with the zero output mode, the power supply of 750 kV power grid increased by 1154.31 mwh, and the theoretical line loss rate was 0.32% higher; compared with the zero output mode, the power supply of 330 kV power grid increased by 2921.11 mwh, and the theoretical line loss rate was 0.35% higher.

**Table 2.** The results of calculation in three ways

| Mode | Power supply | Line loss rate | Power supply | Line loss rate | Power supply | Line loss rate |
|------|--------------|----------------|--------------|----------------|--------------|----------------|
| Main network | 12265.15 | 2.30 | 9247.21 | 1.99 | 9022.14 | 1.82 |
| 750kV | 5703.91 | 1.35 | 4884.99 | 1.17 | 4552.33 | 0.97 |
The comparison of power supply before and after putting into operation of yueta line II project is show in Fig 3.

Figure 3. Comparison of power supply before and after putting into operation of yueta line II project (MWh)

The comparison of line loss rate before and after putting into operation of yueta line II project is show in Fig 4.

Figure 4. Comparison of line loss rate before and after putting into operation of yueta line II project(%)
maximum load of 9.42 million kilowatts, up 2.39% year on year. The newly added and restored load is about 220000 kW. Among them, 110000 kilowatts were added in Xining area, 90000 kilowatts were restored and added in Haixi area, and 20000 kilowatts were added in other areas. According to the electricity consumption market forecast, the electricity consumption of the whole network in the whole year was 73.37 billion kwh, an increase of 16.28% year on year.

Under the existing AVC reactive power control strategy, the typical representative day of 2017 Winter University in this paper is selected as the grid structure before load change, and the daily load is 89775.82mw. The predicted load in 2018 is selected as the changed situation, and the predicted load in 2018 is entered, and the daily load increases to 91576.23mw after the simulated change. As the operation mode, new energy output and grid structure are fixed, the calculation results of theoretical line loss rate under the three modes of new energy large power generation, small power generation and zero power generation after load growth are shown in Table 3.

| Table 3. Calculation results of three modes after load growth |
|---------------------------------------------------------------|
| partial pressure | Mode1 | Mode2 | Mode 3 |
| Power supply | Line loss rate | Power supply | Line loss rate | Power supply | Line loss rate |
| Main network | 11752.18 | 1.98 | 9276.19 | 1.74 | 8914.82 | 1.67 |
| 750kV | 5471.04 | 1.00 | 5345.87 | 0.89 | 4449.05 | 0.77 |
| 330kV | 9821.94 | 1.28 | 9242.17 | 1.05 | 8880.11 | 1.04 |

The power supply after load growth compared with that before load growth is show in Fig 5.

![Figure 5. Power supply after load growth compared with that before load growth (MWh)](image)

The compared with the front loss rate of load growth after load growth is shown in Fig 6.
After load growth, compared with before load growth, under the mode of new energy generation, the output of new energy increases by 0mw, the load increases by 1160.82mw, the power supply of main network increases by 1054.9mwh, and the overall theoretical line loss value of main network decreases by 0.16 percentage points; under the mode of new energy generation, the output of new energy increases by 0mw, the load increases by 1792.79mwh, the power supply of main network increases by 1603.2mwh, and the overall theoretical line loss value of main network In the mode of zero generation of new energy, the output of new energy is increased by 0mw, the load is increased by 1792.79mwh, the power supply of main network is increased by 1653.18mwh, and the overall theoretical line loss of main network is reduced by 0.02%.

5. Conclusions

In the area where a large number of intermittent fluctuation sources and loads of high proportion new energy are connected to the grid, the problem of voltage and reactive power is more prominent, and the optimization and setting of AVC parameters are very important. Through the evaluation of current AVC system operation state and the setting of AVC parameters, the problem of reactive power balance and voltage quality in high proportion new energy area can be better solved.

With the increase of new energy output, the main network line loss rate is on the rise. With the commissioning of yueta line II project, the impedance of yueta double circuit line has been reduced by half, which improves the power supply reliability of Tara substation. Under the three modes of new energy generation, i.e. large generation, small generation and zero generation, the overall loss rate of main network tends to decrease. It can be seen that the operation of yueta line II project reduces the line loss rate of the main network by a certain extent. Under the condition that the operation mode, grid structure, generator output and other factors remain unchanged, only before and after the load change, with the increase of load in the three modes of new energy generation, small generation and zero generation, the line loss rate of the main grid and the line loss rate of each partial voltage tend to decrease.

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6. References

[1] Liu SW 2012 Technical research on photovoltaic power station connected to power grid [D] Nanchang University 7 pp 541-551
[2] Zhou Q, Wang NB, He S, Ma YH, Liu GT and Wang XY 2012 Study on reasonable economic proportion and scale of wind, water, fire and external delivery of Jiuquan energy base [J] 2012 proceedings of Gansu Electrical Engineering Society 11 pp 633-642