Research on the minimum startup mode based on typical sending-end power grid

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Abstract. Based on the typical ac/dc hybrid sending-end power grid, this paper provides the minimum startup method of thermal power under the influence of multiple factors, which has far-reaching significance for enterprises to ensure the safety of heating and realize the maximum benefit.

1. Introduction
As a modern power grid, strong smart grid has the characteristics of strong, reliable, economic, effective, clean, environmental protection, transparent, open, friendly and interaction, which is based on the coordinated development of ultra-high voltage transmission backbone and multi-level voltage grid. Strong smart grid is supported by communication information, it contains generation, transmission, distribution and dispatch of power system and covers all voltage level, which achieves highly integration of power flow, information flow and traffic flow [1].

In sending-end power grid, the total generation capacity is larger than the load demand in this area, so that it has the ability to transmit active power to other networks. When sending huge power to the receiving grid, it is necessary to consider the safety and stability of the sending-end power grid in modern AC/DC hybrid power grid, which is meaningful for constructing the strong smart grid.

Minimum startup mode of thermal power refers to minimum startup mode and load in order to satisfy the requirements of safe heating and safe power supply, which can Provide reliable guarantee for regional protection of people's livelihood and power supply. So Achieving the most powerful minimum operation mode of generating units has far-reaching significance for enterprises to ensure the safety of heating and realize the maximum benefit.

2. Overview of target power grid units
The target grid is a typical AC/DC hybrid sending-end power grid, which contains 165 thermal power generating unit with a capacity of 51 million 640 thousand kW. There are 50 500kV regional units with a capacity of 24.86 million kW and 115 220kV regional units with a capacity of 26.78 million kw..

3. boundary condition
The target grid peak load is expected to reach 2845 million kW in 2018, the AC UHV tie line delivers 1 million Kw of power and the DC UHV delivers 4.5 million kW, at the same time, the 500kV lines send 12.5 million kW to the outer zone [2]. The new energy output consideration rate is 0%.

(1)The base mode is the heavy load mode in the year of 2018, considering that the motor load ratio is 60%.
Load classification: according to the typical mode of peak load, flat load and valley load in the target network. In this paper, the load is classified as 28.45 million, 25.64 million and 21.46 million.

(3) The thermal stability condition should satisfy that the device N-1 is not overloaded.

(4) Criterion for transient voltage stability is based on the file of (Q/GDW 1404—2015), Voltage stability margin under a certain mode is defined as (grid load under the transient voltage stability - grid load in this mode)/ grid load in this mode.

(5) Consider the N-1 fault of all main transformer, line and bus equipment at 220kV and above, the three phase permanent fault of N-1 and N-2 in double-loop line are also considered[3].

(6) At different load levels in different areas, this paper uses the condition of that the devices N-1 is not overload to analyze the startup requirements of each partition. At the same time, the limit load level satisfying the voltage stability condition is calculated.

(7) Stability criterion

Three load conditions adopt the following thermal stability limits: The north power grid adopts the thermal stability limit of 35 degrees, and the south central power grid adopts the thermal stability limit of 40 degrees. Criterion for transient voltage stability is described as that the bus voltage should be restored to 0.75pu within 1 second, and the steady-state voltage should not be lower than 0.9pu.

4. Minimum startup analysis

4.1. Peak load mode

4.1.1. Minimum startup under power flow thermal stability limit. Peak load in the target grid is expected to reach 28.45 million kW in 2018. Subjected by the N-1 thermal stability limit of main transformer and line power flow in the target grid, The minimum startup number of generators in the target grid is 44 after checking.

4.1.2. Maximum load of grid under minimum startup mode and voltage stability constraint. Under the mentioned minimum startup mode, the fault of main transformer N-1, lines N-2 and bus three phase permanent fault N-1 is checked. Under the voltage stability constraint, The maximum load of the target grid is 357.5 gW.

The constraint fault is the east bus fault of 220kV Yunshan station, the results show that the bus voltage of 110 kV side of Yunshan station cannot be restored to 0.9pu in the medium and long term.

the stability margin of peak load in the target grid is 25% after calculating.
4.2. **Flat load mode**

4.2.1. **Minimum startup under power flow thermal stability limit.** Flat load in the target grid is expected to reach 25.64 million kW in 2018. Subjected by the N-1 thermal stability limit of main transformer and line power flow in the target grid, the minimum startup number of generators in the target grid is 33 after checking.

4.2.2. **Maximum load of grid under minimum startup mode and voltage stability constraint.** Under the mentioned minimum startup mode, the fault of main transformer N-1, lines N-2 and bus three phase permanent fault N-1 is checked. Under the voltage stability constraint, the maximum load of the target grid is 343.7 gW.

The constraint fault is the east bus fault of 220kV Yunshan station, the results show that the bus voltage of 110 kV side of Yunshan station cannot be restored to 0.9pu in the medium and long term. The stability margin of flat load in the target grid is 30% after calculating.

![Figure 1](image-url)
4.3. Valley load mode

4.3.1. Minimum startup under power flow thermal stability limit. Valley load in the target grid is expected to reach 25.64 million kW in 2018. Subjected by the N-1 thermal stability limit of main transformer and line power flow in the target grid, the minimum startup number of generators in the target grid is 22 after checking.

4.3.2. Maximum load of grid under minimum startup mode and voltage stability constraint. Under the mentioned minimum startup mode, the fault of main transformer N-1, lines N-2 and bus three phase permanent fault N-1 is checked. Under the voltage stability constraint, the maximum load of the target grid is 339.6 gW.

The constraint fault is the east bus fault of 220kV Yunshan station, the results show that the bus voltage of 110 kV side of Yunshan station cannot be restored to 0.9pu in the medium and long term. The stability margin of valley load in the target grid is 41% after calculating.
4.4. Minimum startup considering other factors

During the winter heating period, the generators operate in the mode of “determining power generation by heat”, some thermal power generators must be started up to meet people's heating needs, the minimum startup number of generators is 71. the power grid of peak, flat and valley load all meet the operation requirements after checking.

5. Conclusion

Based on the analysis, the conclusion of minimum startup is as follows: The minimum startup number of generators in the target grid is 44 considering the peak load. Limited by the failure instability of the east bus fault in Yunshan station, the voltage stability margin of power grid is 25%.

The minimum startup number of generators in the target grid is 33 considering the flat load. Limited by the failure instability of the east bus fault in Yunshan station, the voltage stability margin of power grid is 30%.

The minimum startup number of generators in the target grid is 22 considering the valley load. Limited by the failure instability of the east bus fault in Yunshan station, the voltage stability margin of power grid is 41%.

The stability margin is large in order to meet the minimum startup of the target grid, which accord with the characteristics of sending-end power grid. Based on the typical ac/de hybrid sending-end power grid, this paper provides the minimum startup method of thermal power under the influence of multiple factors, which has far-reaching significance to the safety and stability of the power grid.

References

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