

Statistical Analysis of Meteorological Disasters in the Jiangsu Power Grid and Prevention Methods

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Abstract. With the obvious global climate change and the rapid development of an industrial economy in Jiangsu, the number of failures in power equipment caused by meteorological disasters has been increasing every year, especially contamination flashover faults and wind deflection faults. Based on extensive investigation and analysis, this paper conducts a statistical analysis of the temporal and spatial distribution of the typical meteorological conditions in the Jiangsu area. This paper also analyses the effects of the main meteorological disasters and defensive measures that have been taken to prevent them in recent years, and the paper summarizes the characteristics of the faults in a typical case. Finally, the paper gives some overall advice for preventative measures from the perspective of design planning, applications of new technology, disaster warnings and so on. These recommendations may provide an important reference for the design, maintenance and accident prevention for power grids that experience similar meteorological disasters.

1.Introduction

Jiangsu Province is located in a subtropical and warm temperate climate transition zone. Under the combined effects of solar radiation, atmospheric circulation and its specific geographical location, this province experiences a variety of meteorological disasters. The meteorological disasters that have the greatest affect on power grids include wind, lightning, thunderstorms, fog, haze, floods, ice and snow. Wind, fog and hazy weather often cause disasters. Due to global warming, Jiangsu's climate has changed significantly in recent years, and network failures caused by meteorological disasters are also increasing every year. Therefore, collecting meteorological information and planning for disaster prevention are essential for the safe and stable operation of power grid.

2.Main Meteorological Disasters and Defense Situations

2.1 Wind Disasters

2.1.1 Influence of Wind Disasters on Jiangsu Power Grid. According to statistics, winds may occur each month in Jiangsu, and they mainly occur in March, April, July and August. Regional winds occur an average of 22.4 days per year. The year with the most wind was 1965, with 78 days, and the years with the least were 1995 and 1999, with continuous six days.

On August 9, 2013, the 500kV East-III-line in Jiangsu was successively tripped due to winds. The instantaneous squalling of the wind was at level 12, with speeds of 33.0 m/s, which is the most powerful wind Jiangsu has had in recent years. The strong wind exceeded the designed maximum wind speed of the tower (30m/s) and resulted in the discharge of an insulator string with an "I" shape on the tower body, as shown in Fig. 1. On August 10, 2013, severe convective weather with strong winds and thunderstorms appeared in Wuxi, and the maximum wind speed was 29 m/s, which was greater than the tower's



designed wind speed of 25m/s, and caused the No. 25, No. 26 and No. 27 towers in the 110kV Xi-Ting-line to fall down.

Historical data shows other incidences of wind damage to 500kV transmission towers in Jiangsu; for example, the collapse of several 500 kV towers in the Ren-Shang- 5237-line, which is an important line for the area's West-to-East transmission channel. This accident caused 10 transmission towers to collapse in a row, causing power failure across a very large area[1].



Fig.1. Discharge traces of wind deflection fault on the East -III- line

In addition to transmission line tower collapse caused by tornadoes and squall line winds, damage caused by typhoons has also occurred on the grid. In recent years, when a typhoon has passed by, winds from level 7 to level 10 and heavy rains have occurred in Jiangsu and caused much damage to the distribution network equipment [2].

2.1.2 Wind Disaster Prevention.(1) Consider the local environment when designing transmission equipment to ensure the design standards conform to wind prevention standards.

(2) Carry out wind observations at different heights and topographical features and discuss the selection of the meteorological conditions that were considered during the design process.

(3)Comprehensively check the air gap of AC and DC lines after adjusting insulation, or use long-type insulators according to wind zone figures and weather conditions.

(4) Define technical parameters such as the maximum instantaneous wind speed, the uneven coefficient of wind pressure and the line's trajectory in strong winds by studying the meteorological parameters of transmission towers and the online wind-deflection monitoring system of the transmission lines.

2.2 Thunderstorm Disasters

2.2.1 Influence of Thunder Disasters on Jiangsu Power Grid. Affected by environment and location, lightning activities in Jiangsu province are very frequent [3]. Areas with an unusual amount of lightning activities are Jiangsu's north, coastal areas and a part of Jiangsu's south. Lightning activities mainly appear in June and August each year. Thunder activities increased greatly in 2011 and were the highest in recent years, as shown in Fig. 2. According to spatial distribution data, lightning activities in the areas of Huai'an, Suzhou, Yancheng and Nantong are higher than average.

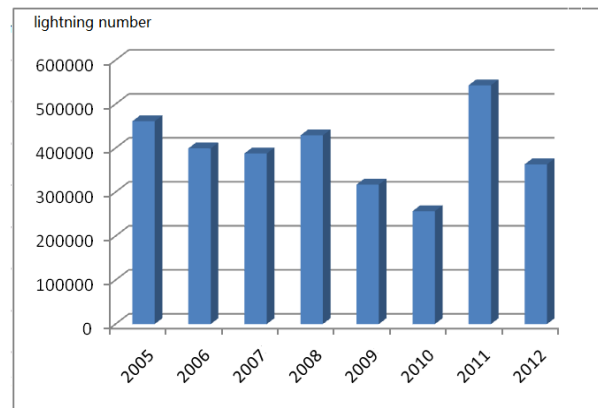


Fig.2. Temporal distribution of lightning in a recent 8-year-period

According to statistics, lightning-hit faults on transmission lines of 220kV and above occurred 304 times from 2005 to 2013, including 67 times on 500kV lines and 237 times on 220kV lines. Lightning-hit faults on 35kV and 110kV lines occurred 408 times and the percentage is 93.36. The number of lightning-hit faults is much higher in mountainous areas, areas with high soil resistivity and complex terrain. The variation of lightning hit faults in 220kV and above transmission lines in Jiangsu in recent years is shown in Fig. 3.

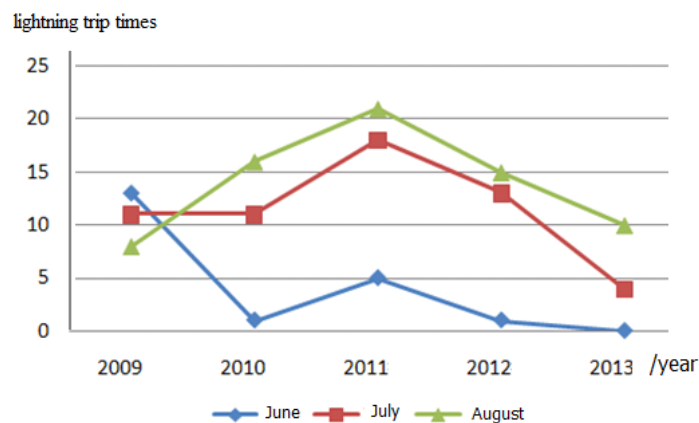


Fig.3. Changes in lightning trip times in 220kV and above lines in a recent 5-year period

2.2.2 Thunderstorm Disaster Prevention. (1) Collect meteorological data near transmission lines and make systematic analyses during the design phase to avoid areas with more lightning activity.

(2) Strengthen inspection of protection facilities and grounding devices in areas with more lightning activity in the operation phase.

(3) Install line-type lightning arresters on important 500kV and above transmission lines, including on backbone grids, important transmission channels for large power transfers, and high towers in mountain areas, which are vulnerable to lightning.

(4) Set up coupling ground wires for 35kV-110kV lines which flashover frequently because of lightning-hits.

(5) Use lightning locating technology and warning systems to locate lightning-faults, and to identify and warn about lightning-faults quickly.

2.3 Haze Weather

2.3.1 Influence of Haze Weather on Jiangsu Power Equipment. There are two main aspects of hazy weather that affect power equipment. First, humidity dampens the external insulation surface of equipment and causes flashovers. Second, hazy grime increases the contamination of the insulation;

when coupled with high humidity, this may also cause flashovers[4].Haze is most frequent in autumn and winter in Jiangsu, and its conditions are quite different in different areas because of the different locations, terrain and surroundings.

2.3.2 Haze Disaster Prevention. (1)Adjust the insulation distance of partially polluted lines, replace porcelain insulators with composite insulators or increase the number of insulators according to tower size.

(2)Strengthen statistical analysis of various meteorological information to provide a basis for design, operation and maintenance. For example, try to avoid pollution sources and strengthen the inspection of the equipment.

(3)Establish an updated mechanism to identify pollution sources and properly shorten the revision period of polluted area maps. A management unit should adjust the anti-polluting-flash strategy according to the newest polluted area map.

(4)Establish a grid pollution warning system and analyze the current situation of pollution flashover.

2.4 Ice

2.4.1 Influence of Ice Disaster on Jiangsu Power Grid Equipment. There are few ice disasters in Jiangsu and the ice disaster in 2008 did not affect the Jiangsu power grid. But in 2009, an ice disaster occurred in a small area of Nanjing. According to fault locations, most fault lines were in vertical alignment and discharge points were in the spans where the line was high and exposed. According to investigations, the terrain was close to the Yangtze-River and located in place with a tuyere, so the ice coating was formed in a micro-landform.

2.4.2 Ice Disaster Prevention. (1) Adopt reasonable planning and designing methods.The planning and design department should select the line path appropriately to avoid areas where ice is easily created, such as near rivers and lakes. If it is impossible to avoid such areas, take necessary measures to improve ice disaster prevention, such as increasing the ice-overload capacity of tension tower[5].

(2)Adopt effective measures of melting ice and deicing.Deal with ice-coated equipment quickly using current-melting technology, mechanical deicing and passive deicing methods [6].

(3)Take measures to prevent iced-lines waving.Install inter-phase anti-wave devices such as interval rods, double waving suppressors and clamp-rotary-type interval rods to inhibit uneven ice-coated waving and jumping when ice falls off.

(4)Take effective measures of ice monitoring and observation.

2.5 Other Disasters

In addition to the main meteorological disasters discussed above, there are have also been snow storms, heat, hail, rainstorms and other disasters in Jiangsu caused by abnormal climate conditions in recent years. The bad weather has also influenced power grids [7][8].For example, in November of 2009, Nanjing's lines were hit by a blizzard and several 35kV and above transmission lines broke.

3.Meteorological Disasters Prevention Advice

3.1 Strengthen Meteorological Survey and Information Collection; Raise Disaster Relief Design Level of Equipment Scientifically and Reasonably. Collect meteorological information on elements such as wind, lightning, ice and temperature from meteorological stations near to electric grids and consider wind zone figures, ice figures, polluted area maps, lightning location systems and operating experience comprehensively. Define designed wind speed, designed ice-thickness, insulation creep distance, thunderstorm days and temperature, and eliminate various meteorological factors.

3.2 Deepen Research on Disasters; Explore new Technology and new Devices to Actively Improve the Disaster Prevention Ability of Power Grid.Make further study of disasters such as lightning, typhoons and ice, and build fault probability models to assess the effects of disasters on power grid equipment.

Cooperate with meteorological departments and deploy new wind resistance technologies to prevent collapses accidents [9].

3.3 Strengthen On-line Monitoring of Grid Disasters; Establish Warning, Emergency and Rapid Recovery Mechanisms. Carry out accurate monitoring systems, collect basic data and make risk assessments. Research typhoons, thunderstorms, freezing conditions, fog and other disasters that may cause large-area faults. Combine geographical data, attribute data and results of evaluation with GIS technology, establish an early warning system for meteorological disaster accidents [10],[11],[13], set up emergency mechanisms and post-disaster quick recovery and reconstruction mechanisms.

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