ANTI-ICING AND DISASTER-MITIGATING COPING STRATEGIES FOR HUBEI POWER GRID

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Abstract: **Based on studying the key skills of anti-icing and disaster-mitigating for power grid at home and abroad, as well as fully considering the advancement and practicability of these skills, anti-icing and disaster-mitigating strategies for Hubei power grid are proposed.**

1. Introduction

According to State Grid demands for four aspects including power grid anti-icing and resisting icing disaster, monitoring icing disaster, handling icing emergency, and restoring after disasters, anti-icing and disaster-mitigating strategies are studied based on foundation of key anti-icing and disaster-mitigating technologies, considering the icing disaster condition and operating experience as well as advanced technologies of resisting icing disaster at home and abroad. This study is of great significance for Hubei power grid conducting the practical application.

2. RESULTS AND DISCUSSION

This paper firstly discusses the causes and effected scope of the two icing disasters in southern China. Both are due to the convection of north cold air flow and north warm-moist air flow at the site of mountain Wuyi and mountain range Nanling.

And then, the application of anti-icing and disaster-mitigating technologies and operating schemes of Hubei power grid are proposed. They involve ice observation and emergency mechanism startup, power transmission and transformation equipment anti-icing and de-icing technical requirements, Hubei power grid technical requirements during ice disaster and recovery after blackout, anti-icing disaster prevention measures. For each part, the author discuss in detail.

3. CONCLUSION

Anti-icing and disaster-mitigating coping strategies for Hubei power grid are discussed as below.

Focus on prevention of tower failure and disconnection in western Hubei which is seriously iced. Middle and eastern districts are seriously impacted having high density of power grid with high pollution grade, and focus on preventing accidence caused by insulator flashover. The main protection areas are: Enshi, Yichang, Jingmen, Jingzhou, and Xianning, followed by Wuchang, Xiaogan, Ezhou, and Huangshi.

Build transmission line icing monitor system, monitor ice and snow climatic changes, provide reliable data and information for the Emergency preplan instant startup.

Avoid iced insulator flashover, towel failure and disconnection according to demands of electrical instruments anti-icing technology.

According to demands of electrical instrument de-icing (melting) technology and self condition, choose advanced technology practical application which is operation economical, in order to guarantee the electrical instruments safe operation.

According to technological demands for protecting transmission line from sleet jump accident, reduce secondary disasters during the ice melting process.

According to recovery plan for break out caused by ice disaster, select the optimal black-start scheme to minimize the loss.

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***Abstract*—Based on studying the key skills of anti-icing and disaster-mitigating for power grid at home and abroad, as well as fully considering the advancement and practicability of these skills, anti-icing and disaster-mitigating strategies for Hubei power grid are proposed.**

Keywords- power grid; disaster-mitigating; coping strategies

I. INTRODUCTION

According to State Grid demands for four aspects including power grid anti-icing and resisting icing disaster, monitoring icing disaster, handling icing emergency, and restoring after disasters, anti-icing and disaster-mitigating strategies are studied based on foundation of key anti-icing and disaster-mitigating technologies, considering the icing disaster condition and operating experience as well as advanced technologies of resisting icing disaster at home and abroad. This study is of great significance for Hubei power grid conducting the practical application.

II. THE CAUSES OF ICING DISASTER AND THE EFFECTED SCOPE

Two icing disasters in southern China in 2004 and 2008 are both due to the convection of north cold air flow and north warm-moist air flow at the site of mountain Wuyi and mountain range Nanling, producing freezing rain whose intensity is gradually weakened from south to north. Southwestern and southeastern areas are influenced in Hubei province.

Figure1. The causes of icing disaster and the effected scope

There are certain rules from the meteorological characteristics of the two snow weather:

(1) Hubei district locates at the end of the large range freezing rain and snow area in southern china. Compared with the Hunan district, the level of icing disaster is low.

(2) The actually influenced area by icing disaster is along the Yangtze River and its southern district.

(3) The districts most seriously afflicted are: Enshi, Yichang, Jinmen, and Xianning, followed by Wuchang, Xiaogan, Ezhou, and Huangshi.

(4) According to survey, power grid of Shiyan, Xiangfan, Suizhong, Hankou, and Huanggang is a little affected by freezing rain and insulator surface shows hanging ice due to the snow melt.

III. THE APPLICATION OF ANTI-ICING AND DISASTER-MITIGATING TECHNOLOGIES AND OPERATING SCHEMES OF HUBEI POWER GRID

Focus on prevention of tower failure and disconnection in western Hubei which is seriously iced. Middle and eastern districts are seriously impacted having high density of power grid with high pollution grade, and focus on preventing accidence caused by insulator flashover. The main protection areas are: Enshi, Yichang, Jingmen, Jingzhou, and Xianning, followed by Wuchang, Xiaogan, Ezhou, and Huangshi.

(1) According to the determined distribution map of Hubei district ice cover, as well as considering five distribution maps[1] of ice zone, fog zone, wind zone, pollution zone, and thunder field, focus on southwest and southeast of Hubei based on the principle of comprehensive consideration and classified prevention.

(2) Build transmission line icing monitor system, monitor ice and snow climatic changes, provide reliable data and information for the Emergency preplan instant startup.

(3) Avoid iced insulator flashover, towel failure and disconnection according to demands of electrical instruments anti-icing technology.

(4) According to demands of electrical instrument de-icing (melting) technology[2] and self condition, choose advanced technology practical application which is operation economical, in order to guarantee the electrical instruments safe operation.

(5) According to technological demands for protecting transmission line from sleet jump accident, reduce secondary disasters during the ice melting process.

(6) According to recovery plan for break out caused by ice disaster, select the optimal black-start scheme to minimize the loss.

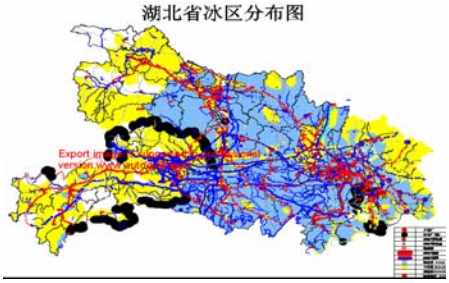

Figure2. Distribution map of Hubei province ice cover

IV. Ice Observation And Emergency Mechanism Startup

A. Ice Observation

(1) Install on-line monitoring device at EnyiJingjing power grid and the seriously-icing Xianning region which is the border between eastern Hubei and Jiangxi province.

(2) Parameter demands of transmission line on-line monitoring system

Wire, main monitor characteristic quantities: ice load, deviation of wind, unbalance tension.

Insulator string, main monitor characteristic quantities: video image[5]

Atmosphere, environment, including meteorological condition, main characteristic quantities: wind speed, wind direction, air temperature, humidity, precipitation, air pressure, etc.

(3) Principle of installation site of icing on-line monitoring device:

a. mountain, based on the altitude, install respectively at height of 400m, 500m, 600m, 700m, 800m, and ⩾1000m of 220kV lines.

b. plain, install at isolate slope and tuyere position of 220kV lines.

c. install at the lines and tower which have occurred the disconnection and tower failure.

B. Emergency Mechanism Startup Criterion

According to the statistic analysis, emergency mechanism should be started when these following required conditions meet simultaneously in the weather of snow and rain:

(1) Temperature of air and instrument surface is below 0 degree Celsius.

(2) Air relative humidity is 85% and above.

(3) Wind speed is above 1.0m/s.

The time between electric equipments get iced and emergency occurs is short. According to operation experiences of Hubei grid, the shortest time is 18 hours. Thus, power grid dispatch and de-icing (melting) schemes implementation are most effective at the initial stage of icing.

V. Power Transmission And Transformation Equipment Anti-icing Technical Requirements

A. Transmission Line Anti-icing Technical Requirements.

(1) Avoid the heavy icing zone when choosing line path. Otherwise, increase the design thickness of transmission line.

(2) According to the operation experience, improve fortification criteria based on the principle of discrepant planning and design of Hubei power grid at the tiny terrain section such as high, outstanding, exposed, or mountain ducts, bealock, airflow-elevating windward slopes, easily get iced region as well as local area of big difference in relative height and continuous up-down hills.

(3) For heavily iced line, strained tower and reinforced linear tower should be installed at proper place among strain section to avoid the chain damage caused by tower failure. Strain section is shorter than 3km.

(4) For intermediate or above iced line, use Hardware tool, and ground wire trestle must be strengthened

(5) Install Anti-icy (snow) ring and waterproof ball on the line at the Tuyere area of intermediate iced[3].

(6) For intermediate or above iced lines, V-shape composite insulator string is adopted preferentially. For I-shape insulator string line, add interphase spacer at place where sleet jump has easily happened.

(7) As for the icing Galloping transmission line, especially Yijinjin district, take measures to prevent the sleet dance according to operation experience. The main ways are using de-tuning pendulum bias hammer, double pendulum damper, monolithic bias hammer, Combined-type interval stick and dance-Preventing whip[4].

B. Substation Equipment Anti-icing Technical Requirements

(1) Site selection for newly-constructed substations should avoid isolated slope and tuyere position.

(2) For newly-constructed substations at the heavily icing area, choose the anti-icing insulator for high voltage electrical equipment preferentially.

(3) As for important substations which have been in operation at the area of intermediate or above iced area, electrical equipment outer insulation, sheds and RTV paint are needed.

VI. Power Transmission And Transformation Equipment De-icing Technical Requirements

A. *Transmission Lines De-icing Technical Requirements*

(1) During ice disaster, increase line load by changing operation mode of power grid to use load current thermal-effect to make line current above melting ice critical current. According to the test research experience, the critical current is related to air temperature, and proportional to wire diameter (D) mm, approximately I = 26.5 D. The test data is: I is 600A for 400mm2 cross-section wire, I is 800A for 720mm2 cross-section wire.

(2) Take active measure for dc current ice melting work which is better than ac short-circuit way. Focus on developing mobile dc ice-melting technology. Mobile ice-melting device parameters mainly used for 220kV lines: 25MW/12.5kV/2kA.

Mobile ice-melting device should be emphatically installed in western and eastern Hubei.

(3) During the early ice cladding period, remove tower ice manually before the ice thickness exceed tolerance value, following principle that from up to down

B. *Substation Equipment De-icing Technical Requirements*

(1) In the substation, remove ice manually before the ice of electrical equipment surface gets through, it's simple and feasible. But the relevant procedures should be formulated. If insulator surface ice completely gets through, determine whether or not to cut power to remove ice based on ultraviolet test results.

(2) Adjust operation mode, transfer the load.

(3) Retreat hot standby equipment

VII. Hubei Power Grid Technical Requirements During Ice Disaster

(1) Keep Important Contact Line Unobstructed

(a) Guarantee safe and reliable operation of the 500kV contact line between Hubei power grid and Henan power grid (Xiangbai Ⅰ, Ⅱ,and Xiaocha Ⅰ, Ⅱ).

(b) Ensure at least one important contact line unobstructed within province, and prefer line of Sanxieyouyi-Jiangling-Xinglong-Xianning-Fenghuangshan, followed by line of Sanxiezuoyi-Longqun- Douli-Xiaogan.

(2) For heavily iced area, places where ice thickness does not meet practical requirements and tower failure has happened, dismantle aerial earth wire temporarily before expected ice disaster comes.

(3) Usage of UV testing technology[6]

Use UV testing technology for advanced diagnosis of substation ice disaster.

VIII. Hubei Power Grid Technical Requirements For Ice Disaster Recovery After Blackout

(1) Use the Tiantang pumped-storage power plant to experiment on black-start to restore eastern Hubei grid.

(2) Use the Wangfuzhong hydraulic power plant to experiment on black-start to restore western Hubei grid.

(3) Use 500kV Xiangbai Ⅰ Ⅱ connecting with Henangrid and 500kV Xiaocha Ⅰ Ⅱ to restore northwestern and eastern Hubei grid at the same time.

IX. Anti-icing Disaster Prevention Measures

(1) For the low fortification criteria problems exposed In 2005 and 2008 ice disasters at typical micro meteorological area, carry out comprehensive management, and improve power transmission and transformation equipment anti-ice ability. Especially for lines and substations where have happened sleet dance, ice flashover, icing disconnection, ground wire galloping, damage of insulator, hardware tool, tower and tower failure.

(2) Strengthen the equipment maintenance and defect management. Improve 220kV substation outer insulation anti-icing flashover ability. Because of pillar porcelain rupture and busbar blackout caused by heat bilges cold shrink obstruction of frigid tube in winter, sliding type hardware is needed. Strengthen work of cleaning power transmission and transformation equipment at heavy and intermediate ice disaster area. Adapt creep distance and fasten tower screw. Liquidate line channel timely to prevent harm to wire and tower due to the tree dumping. Strengthen the defective equipment management, and power transmission and transformation equipment major, emergency defect rate are required to be 100%.

(3) Carry out specific programs vigorously, and eliminate equipment safe hidden danger. For the problem that there is not enough distance for overhead lines from ground due to decreasing sag caused by ice cover, high wind, and heavy load, eliminate obstacles under overhead lines fully clean and clear.

(4) Carry out renovation work of power circuit in important substation to guarantee the reliable power supply within substation.

(5) Adopt advanced technology to monitor Equipment running status under severe climate. Establish and improve ultraviolet detection technology, ice cover online monitor, traveling wave fault location system for transmission line above 220kV.

(6) According to "Hubei power grid production equipment spare parts management information rules", complete the spare part preparation.

(7) Implement emergency plan. Especially the EHV company, provincial power transmission project company, and the company which is in micro meteorological area and easy to occur wire ice cover and dancing, such as Jingmen, Yichang, Jingzhou and Xianning company, make sure the

preparatory work and accident prevention measures are put in place.

(8) Improve accident repair mechanisms. From Hubei Power Grid Company to each power supply company, make fully preparation for emergency including command system and emergency repair personnel, repair vehicles, homework tools and preparation for repair materials, in order to guarantee the minimum accident hazard at the shortest time.

(9) Launch the emergency response plan timely, to deal with severe weather. The first is to strengthen power transmission and transformation equipment special tour in severe weather, keep watch on the dancing area and on-pole check, take reinforcement measure timely. The second is to use UV camera means to closely monitor the substation equipment ice cover and discharge, remove ice as soon as emergency shows. The third is electrified ice remove of substation equipment avoiding icing and melting flashover.[7] The fourth is to eliminate oil filled equipment hidden danger timely when oil level is low, and pillar porcelain flange shows defect.

(10) Strengthen duty institution and product information reporting system during severe weather. Pay close attention to the change in the weather, establish production information report system. Each unit shall promptly report the critical, major defects and accident of prime power transmission and transformation equipment. Communicate information timely and analyse the situation, response rapidly, ensure emergency command system instructions unblocked and implementation of various organizations technical measures.

(11) strengthen post-disaster equipment patrol.

(a) Line: check the transmission line which has happened the over dancing and sleet jumping, so as to avoid the following phenomenon happen, such as wire injury off shares, joint deformation, abrasion of tap and hardware, bolt looseness, slip of spacer and damper, bend, misshape, tilt of tower, stay line looseness.

(b) Substation: substation patrol focuses on pillar porcelain flange and the pedestal frost crack problem, the damage of metal parts of the breaker, switch, sealing, porcelain, the cement base. Focus on detecting porcelain that has occurred icing creepage.

(c) Auxiliary facilities: patrol of auxiliary facilities stresses lightning arrester base Breaker flanges, cement tower joints, osculum, foundation, protection slope, etc. Handle frost crack of cement components and other structure due to water seepage comprehensive, to prevent new crack and crack expanding.

(d) Communication facilities: communication facility patrol focuses on the light cable that have ice cover during ice disaster, check its intact state thoroughly, a comprehensive test of optical attenuation is needed, handle the abnormal situation when occurs.

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