Analysis of the Causes of Large-Scale Power Outage Accidents Abroad and Suggestions on Measures to Improve the Safety of China's Power Grid

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Abstract. Large-scale blackout accidents are catastrophic events in the power system, causing serious impacts on national economic and social operations. Large-scale power outage accidents are often the result of a combination of many unfavorable factors. In this study, foreign large-scale power outage accidents with large impacts from 1991 to 2020 are selected for comprehensive analysis to provide reference for the prevention and control of power grid safety risks in China.

Keywords: blackout · Large-scale · power grid · safety risks

1 Introduction

As an important infrastructure of modern society, the electric power system provides stable power supply for industrial production, commercial activities and daily life. However, the large-scale power outages that have occurred in foreign countries in recent years have posed a huge challenge to the safe operation of the power system, seriously affecting the country's economic development and social order. These large-scale power outages have not only caused huge economic losses, but also may threaten people's life safety and social stability. It is necessary to summarize the profound lessons learned from overseas power outages and learn from them to improve the safety and reliability of China's power grid, to guard the lifeline of power grid safety and to protect the bottom line of people's livelihood.

2 The General Situation of Large-Scale Power Outage Accidents Abroad

From the historical process, the importance of large-scale power outages is closely related to the development of the electric power industry. In the early development of the power industry, the problem of grid safety was not prominent due to the small scale and independence of power systems and the low level of electrification in general. As

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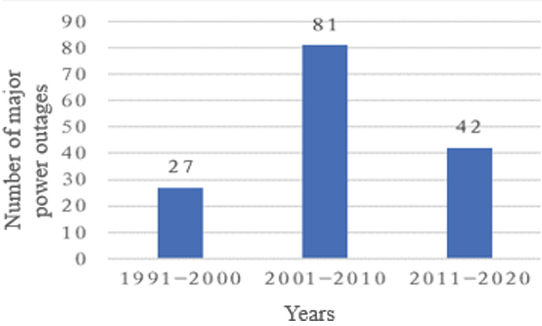


Fig. 1. Distribution of domestic and international blackouts by generation

the global power industry entered a phase of rapid expansion in the middle of the 20th century, the problem of large grid security began to be highlighted: on the one hand, with the strengthening of grid interconnection, the scope of a single accident was significantly expanded; on the other hand, with the increase of electrification, the impact of large-scale power outages was more serious [1]. This paper summarizes and compares 150 major outages as a sample pool for research and analysis, based on reference to authoritative research institutions and influential media reports at home and abroad, taking into account the proportion of load involved in major outages, the scale of affected users, the duration of outages, and the attention of public opinion.

Since the 1990s, there has been an overall upward trend in the number of major power outages that have had a large impact internationally, with the number of incidents occurring from 2000 to 2020 accounting for 125 out of a total sample of 150 major power outages. By region, North America is a frequent region for power outages, with 43 occurring in the United States and 6 in Canada; developing countries such as Brazil and Indonesia have also experienced numerous major power outages [2–12] (Fig. 1).

After 2000, the frequency of major power outages abroad has increased as the areas of occurrence have become more dispersed. The recovery time for most incidents is within a few hours, and the recovery time for outages caused by serious natural disasters often lasts for several days or longer.

3 Analysis of the Main Causes of Large-Scale Power Outage Accidents Abroad

By combing and analyzing a sample of 150 major power outages, it was found that there are four main categories of causative factors causing major power outages: natural disasters (typhoons, rainstorms, ice storms, lightning, geomagnetic storms, earthquakes, etc.), man-made attacks (physical attacks, network attacks, electromagnetic pulses, etc.), critical equipment failures and fragmented management systems. Natural disasters and man-made attacks have a huge impact on the power system and are characterized by a small probability of occurrence, but extremely serious consequences. Critical equipment failure and management system dispersion generally induce small-scale outages, and often gradually develop into large-scale outages under the combined effect of a series of improper technical measures and unreasonable grid structure [13–15].

3.1 Critical Equipment Failures and Natural Disasters Are the Most Significant Contributing Factors

Of the 150 initial causes of major power outages, critical equipment failure accounted for 82 and natural disaster causes accounted for 56. In addition, man-made attacks accounted for 8 times (including 3 physical attacks, 4 cyber attacks, and 1 EMP attack), and fragmentation of the management system accounted for 4 times (including 3 times for the California energy crisis in the United States). The chart below shows (Fig. 2).

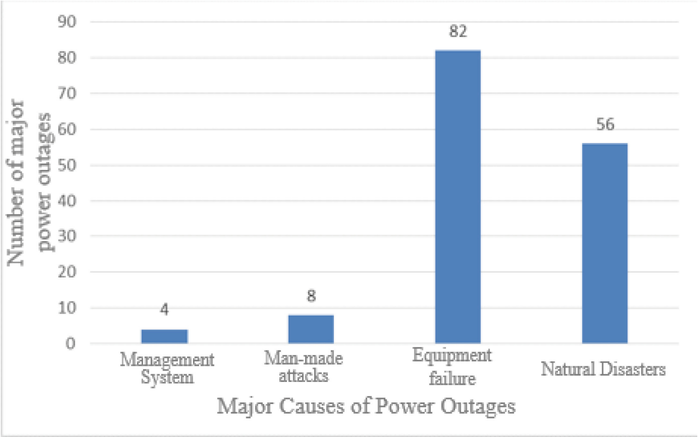
3.2 The "INherent Inadequacy" of the Power Grid Structure is an Important Reason for the Frequent Occurrence of Power Outages in Some Countries and Regions

Different grid structures have significant differences in their ability to withstand system failures and disturbances. The top countries and regions in terms of frequency of major outages often fail to effectively build a clear and reasonable grid structure due to historical development process and institutional reasons, and have inherent defects such as failure to realize effective stratification and zoning, many weak links in the grid, and easy expansion of accidents.

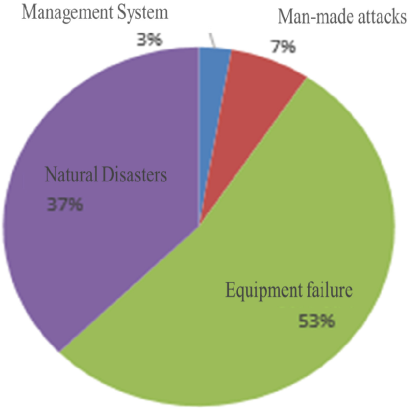
For example, the United States, which has had the most blackouts, has a long history of state-led development of power grids, lacking unified planning and confusing voltage levels, forming an unreasonable structure of long-distance, weak electromagnetic ring networks. Another example is Canada, which has repeatedly suffered major power outages, and its network structure with the United States is not reasonable, in which the Ontario power grid and the eastern U.S. power grid formed the first and last connected delivery and receiving end of the ring network structure, easy to make the system state further deteriorate in case of emergency. For example, in Venezuela, where several major blackouts have occurred, the country's eastern power base to the western load center transmission corridor single, long chain, the network structure is not very reasonable, a single failure is prone to large area blackouts, and the post-failure support is difficult and long recovery time. From the 2019 "8.4" Jakarta, Indonesia blackout, Indonesia's many islands between the grid interconnection degree is low, mutual aid capacity is insufficient, once a regional blackout, can not effectively use power outside the region for relief.

3.3 Decentralized Management System and Poor Dispatching Operation Mechanism Are the Deep-Seated Reasons Behind Many Major Power Outages

Under the power industry pattern and institutional mechanism of Europe and North America, it is very difficult to coordinate a large number of power enterprises and dispatch operation structures. The many large-scale power outages in these regions fully



(a)



(b)

Fig. 2. Analysis of the frequency (a) and proportion (b) of various causative factors in major power outage accidents abroad

demonstrate that the coordination management and data sharing mechanisms between countries, states, and enterprises in these regions are far from meeting the requirements of ensuring the overall operational safety of large power grids. In comparison, China's power grid has set the best record for safe operation of large power grids in the world. The fundamental reason for this is that China's power grid has long been under unified planning, unified dispatch, and unified management (the "three unifications"), which is an important feature and institutional advantage of China’s power industry and an important institutional guarantee for effective power risk prevention and control.

The “8.9” blackout in the UK and the “6.16” blackout in Argentina in 2019 revealed this deep-rooted problem. In the London blackout, the independent dispatching agency showed a lack of ability to coordinate and organize the power supply and grid, and some of the emergency gas units could not start normally after the failure, and the restoration of the distribution network companies was slow, leading to the expansion of the impact of the accident. In the Argentine blackout, the country’s power industry is completely separated from generation, transmission and distribution, forming a relatively decentralized power management system for transmission and distribution, with eight transmission companies and more than 70 distribution companies, making it difficult to coordinate quickly when a fault occurs.

3.4 The Main Reason for the Frequent Occurrence of Power Outages in Some Countries is the Long-Term Under-Investment and Over-Servicing of Power Facilities and Equipment

Most of the U.S. electric power companies belong to private enterprises or joint-stock enterprises, the pursuit of profit maximization, equipment aging problem is prominent, the operating age of more than 25 years of power equipment accounted for a high percentage. 2014, Bill Richardson, who was the U.S. Secretary of Energy and Governor of New Mexico, pointed out that the U.S. power system is stuck in the third world level, an assertion that is supported by the 2015 corroborated by the Quadrennial Technology Assessment report released by the U.S. Department of Energy in 2015, which counted that 70 percent of U.S. transmission lines and power transformers are more than 25 years old and 60 percent of circuit breakers are more than 30 years old. For example, the 2019 Argentina “6.16” blackout is closely related to the state of the local infrastructure, the country’s old power equipment, seriously affecting the reliable supply of electricity, the blackout occurred before the country’s power interruptions occur from time to time, the high risk of blackout accidents and even system collapse during the heavy load phase. Due to power plant failures, two rounds of widespread power restriction measures occurred in South Africa in 2019, exposing the country’s old power equipment lack of maintenance, the average life of the equipment is more than 37 years.

3.5 Improper Technical Measures Such as System Protection is the Direct Cause of Accident Expansion

From the results of the review and replay of several large outages, it is clear that most of these outages could have been avoided or the damage controlled to a small extent if reasonable and reliable safety calibration, system protection and safety and stability control strategies were adopted.

First, the system protection is not set properly. The analysis found that the distance protection in the areas with many blackouts generally did not achieve the oscillation blocking, and the protection was easy to operate during the accident because of power oscillation, which led to chain failures. For example, the United States did not consider the third section of distance protection until after the blackout in 1996, and the “7.30” and “7.31” accidents in India in 2012 were also due to the three sections of distance protection to remove the overload line, which led to power oscillations resulting in The accident of “7.30” and “7.31” in India in 2012 was also caused by a chain fault caused by power oscillation due to the action of three sections of distance protection to remove overloaded lines.

In the mid-1990s, the North American Electric Reliability Association promulgated the NERC Design Standard and proposed a “three lines of defense” similar to China’s. However, the operability of the last line of defense and its ultimate effectiveness were not satisfactory. However, the operability and ultimate effect of the last line of defense are not satisfactory. The “7.13” blackout in the United States in 2019 showed that the design of the regional urban grid violated the “N-1” principle, and the distribution automation system did not switch the power supply path in time after the equipment failure. In addition, the “8.3” in Malaysia in 1996 and the “3.31” nationwide frequency collapse in Turkey in 2015 were both directly related to their inadequate load shedding measures in emergency situations.

4 Example Analysis

This paper analyzes the risk evolution of transmission line tripping accidents by using Bayesian networks for four natural disasters, and derives countermeasures for tripping accidents through the synergy between source risks and risks, so as to prevent, handle and recover from transmission line tripping accidents based on the “situational response” disaster response strategy. Four typical natural hazards, namely mountain fire, lightning, strong wind and snow, are considered as the initial causes of tripping accidents, and the transmission line tripping accidents are divided into four subsets, including tripping caused by mountain fire, tripping caused by lightning, tripping caused by strong wind and tripping caused by snow and ice. The four types of transmission line tripping subsets of accidents are developed in detail in turn (Fig. 3). The definition and explanation of each level are detailed in the annex.

From the above figure, it can be seen that the Bayesian network structure of the power transmission line tripping accident induced by natural disasters established in this paper can be divided into 5 levels with a total of 71 nodes, and all nodes have only two node states of “yes” and “no”, and the specific node explanation and state The specific node explanation and state definitions are shown in the Appendix.

The prior probabilities of the root nodes and the conditional probabilities of the child nodes in Bayesian networks are obtained by performing statistics and calculations on historical data, as well as by expert scoring methods derived from the Delphi method.

Through scenario evolution analysis, the following conclusions were obtained from the key risk evolution path of hill fire triggered transmission line tripping: over 99% of hill fires are human caused and avoiding artificial ignition sources is the most critical part. Poorer lightning tolerance is the main cause of lightning-triggered transmission line trips compared to problems with lightning’s own high-voltage characteristics, high-frequency occurrence, and transmission line design. The key cause of snow and ice trips is pole tower tipping. Transmission line dancing is the result of wind excitation coupled with uneven ice cover on the transmission line. When the transmission line dance, the

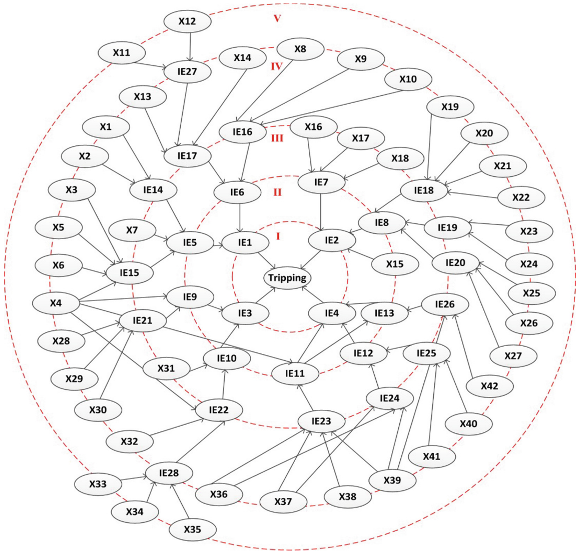


Fig. 3. Bayesian network structure based on transmission line tripping accident

peak of vibration can reach more than 10 m, which is very easy to cause flashover, resulting in line tripping and tower tipping, causing significant economic losses.

By identifying the key influencing factors through sensitivity analysis of Bayesian network nodes, the following conclusions were obtained: poor lightning protection configuration of node IE20 is the main cause of lightning tripping, transmission line dancing is the main cause of tripping accidents, and the severity of hill fire tripping accidents depends to a large extent on the hill fire itself.

A probabilistic risk analysis method for transmission line tripping incidents under natural disasters is established by FTA-BN, which can quantitatively reflect the impact of multiple natural disasters. Firstly, it qualitatively identifies the risk of tripping events on transmission lines and towers under the influence of natural disasters through an accident tree, secondly, it quantitatively analyzes the key risk evolution paths of power grid tripping through Bayesian networks, and proposes a "scenario- response" disaster response based on the key source risks and risk synergies under three scenarios. The current study has been conducted from a probabilistic perspective. The current study assesses the threat, risk management, and risk evolution paths of transmission line tripping from a probabilistic perspective, which can support emergency response-related decisions to effectively reduce the energy loss caused by high frequency of transmission line tripping incidents.

Based on the Bayesian network, the key influencing factors of the risk of transmission line tripping accident are found by sensitivity analysis. Since risks have different importance and degree of influence, a child node can have multiple parent nodes that influence its riskiness, so identifying the most critical risk of a child node in the Bayesian network can launch the key risk evolution path of natural disaster-induced power grid

Table 1. Key risk evolution paths for tripping incidents

Number	Trip type	Risk Evolution Critical Path
1	Hill fire tripping	Man-made ignition source – ignition source - hill fire – tripping
2	Lightning trip	Aging - poor lightning protection configuration - poor lightning resistance - tripping
3	Strong wind tripping	Inadequate consideration of the surrounding environment - Insufficient design safety clearance - Air gap breakdown - Wind deflection - Tripping
4	Snow and ice tripping	Strong wind action - transmission line dance - tower toppling - tripping

tripping and improve the efficiency of risk analysis. When sensitivity analysis is performed hierarchically from the tripping node to the root node, the most critical risk evolution path of the tripping accident can be identified, i.e., the parent node with the highest posterior probability in the previous hierarchy is identified in turn, and its corresponding sensitivity value is the highest. The higher the sensitivity value, the greater the influence of this parent node on this child node and the greater the importance. The key risk evolution path of natural disaster-induced grid tripping accident is as follows (Table 1).

5 Suggestions for Security Enhancement Measures for CHina's Power Grid

Combining detailed information on the evolutionary path of the risk of natural disaster-induced grid transmission line tripping and the analysis of the causes of power outages abroad, three relevant recommendations are made.

First, strengthen the integrated operation mechanism of power grid dispatching and enhance the technical guarantee capability of power grid security. China should continue to strengthen the integrated operation mechanism of power grid dispatching, based on the "three lines of defense" and other means, combined with the technical development trend of large scale power grid and its safe operation and control, focusing on the large-scale AC/DC hybrid power grid operation and the security of the grid transition period, further improve the monitoring, early warning and control capability of large scale power grid, and build The system will be coordinated in time and space to improve the ability of technology to ensure the security of the grid.

Second, from the power supply, power grid, load three sides to continue to improve the structure of the power system, improve the regional self-balancing capacity. On the power supply side, the regional self-balancing power supply is reasonably arranged to improve the self-balancing and emergency protection capacity of key protection areas. On the power grid side, draw on the experience of the United States, Japan and other smart grid construction, layout a number of flexible local grids with voltage levels of 220 kV and 110 kV, and study and improve the topological reconfiguration of the distribution network to enhance the resilience to resist, absorb and adapt to faults. On the user side, develop distributed power sources such as gas-fired triple-supply, photovoltaic and energy storage facilities according to local conditions to improve the system's emergency power supply capacity.

Third, strengthen local monitoring and increase microclimate movement monitoring. Wind deflection is a key cause of tripping triggered by strong winds compared to tower tipping. Insufficient designed safety clearance can lead to air gap breakdown. The long distance transmission of transmission lines means that the climate varies from place to place, but weather stations are generally fixed in certain places and can only observe the global climate. Therefore, establishing distributed small mobile weather stations to monitor and warn weather information can effectively prevent the effects of strong winds. The information provided by mobile weather stations can be used to fully consider the specific wind protection requirements of different locations when designing safe distances.

6 Conclusions

Large-scale power outages and severe power shortages can quickly affect the entire network, bringing the country's economy and society to a standstill in an instant, and the losses, consequences and impacts are incalculable. Electricity security is increasingly a matter of national security. In this paper, we summarize and analyze the causes of major blackout accidents in foreign countries to provide references for improving the safety and reliability of China's power grid and keeping the lifeline of power grid safety.

Appendix: Definition and Explanation of Each Level

(1) First level

Tripping: Tripping of power transmission lines on the grid. Transmission line trips are only considered to be caused by four typical natural disasters: mountain fires, lightning, strong winds, and snow and ice. "Yes" for a trip to occur, and "No" for the opposite.

IE1: Hill fire tripping. Mountain fire-induced tripping of grid transmission lines.
IE2: Lightning tripping. Lightning-induced tripping of grid transmission lines.
IE3: Strong wind tripping. Strong wind-induced tripping of grid transmission lines.
IE4: Ice and snow tripping. Ice and snow induced trips on grid transmission lines.

(2) Second tier

IE5: Mountain fires. Mountain fires, including both man-made and natural fires.
IE6: Discharge. For fire-induced transmission line tripping events, about 90% are caused by wire discharges to ground; about 9% are caused by wire discharges to towers.
X15: High voltage lightning. The physical nature of lightning is high voltage, and lightning can cause large induced currents in power lines.

IE7: Grounding wire design issues. Problems with the grounding wire in the wiring design make the wires more susceptible to lightning.
IE8: Poor lightning resistance. The transmission line grounding resistance is too high and the insulation capacity is weak to resist lightning strikes.
IE9: Pole tower collapse. Transmission towers toppled directly under the action of strong winds.
IE10: Wind deflection. A phenomenon in which an overhead transmission line changes its vertical position due to wind action.
IE11: Transmission line dancing. The phenomenon of low-frequency, large-scale self-excited vibration of ice-covered and unevenly loaded overhead lines under the action of lateral wind.
IE12: Ice flash. The phenomenon of flashing of insulator strings covered by ice.
IE13: Pole tower collapse. The tower pole collapses directly under the action of static and dynamic ice loads. Dynamic ice loads, i.e., load effects on transmission towers due to transmission line dances.

(3) Third tier

IE14: Ignition source. The initial source of the mountain fire.
IE15: Fire Dangerous Weather. Certain weather conditions can easily cause hill fires. There are 5 levels of fire danger according to the forest fire danger level. 1–2 levels are node "No" status, 3–5 levels are node "Yes" status.
X7: Dry vegetation. Dry, low moisture vegetation is susceptible to ignition.
IE16: Air insulation damage. The air insulation capacity of the air is lost due to the destruction of the air gap between the fire starting vegetation and the transmission line.
IE17: Electric field change. Under fire scorching, electrons escape from wires and towers causing electric field changes, i.e., electric field distortions, which eventually lead to electrical discharges.
X16: Open areas. If a transmission line is placed in an open area, which means that the surrounding vegetation is at a relatively low height, the line is more vulnerable to lightning strikes.
X17: Intersecting transmission lines. When different transmission lines intersect each other when lining up their alignment, they are more likely to be affected by adjacent transmission lines on lightning days.
X18: Large span transmission line structure. The designed arc sag distance is too large, and the transmission line is more dangerous in lightning weather.
IE18: High grounding resistance. Due to the high grounding resistance of the tower, the current cannot enter the ground, resulting in high potential at the top of the tower and poor lightning protection performance.
IE19: Insulator flashover. Lightning bypass faults on transmission lines cause insulator flashover.
IE20: Poor lightning protection configuration. The condition and configuration of insulator strings, transmission line overhead lightning cables and lightning rods are poor.
IE21: Defective line design. Poor design of transmission lines and towers, improper arrangement, and poor resistance to strong windy weather.

X31: Discharge. The electrical distance is shortened due to the influence of wind. When the electrical strength of the air gap cannot withstand the operating voltage of the system, a discharge occurs.
IE22: Air Gap Breakdown. The electrical distance of the air gap is not sufficient to maintain insulation.
IE23: Transmission line ice cover. Icing on transmission line surfaces due to snow and ice.
IE24: Insulator covered with ice. Ice covers the surface of insulator string due to snow and ice.
IE25: Climatic conditions. The formation of ice flashes always occurs under certain weather conditions and has weather-climate prerequisites.
IE26: Excessive static ice load. Ice loads covering transmission lines and towers sufficient to cause the towers to tip over and topple directly.

(4) Fourth tier

X1: Lightning. Lightning strikes can cause fires.
X2: Anthropogenic fires. Anthropogenic sources of fire include intentional fire setting, burning reclamation and ritual activities.
X3: High temperature. In rural areas in the summer, heat waves bring hot weather that can easily cause hill fires. A node status of "Yes" is defined as 5 or more consecutive days of sustained high temperatures, where the daily maximum temperature is 5 °C (9°F) or more above the average maximum temperature, otherwise the node status is "No".
X4: Strong wind. According to Beaufort wind level, the node status is "No" for wind level 0–5 and "Yes" for wind level 6–17.
X5: Low relative humidity. In summer, the node status is "Yes" when the relative humidity is less than 55%, and "No" when the relative humidity is more than 55%.
X6: Long-term drought. According to the classification of meteorological drought, the node status is "No" when the drought level is 1–2, and "Yes" when the drought level is 3–5.
X8: Reduced air density. The high temperature of the fireplace flames reduces the air density, resulting in a reduction in its insulation strength.
X9: Dense smoke. A hill fire under a transmission line produces a roll of smoke as it burns.
X10: Small height difference. When the vertical distance from the tree to the overhead transmission line is less than 3m-4.5m, the node status is "Yes", otherwise it is "No".
IE27: Electron escape. Electrons escape from transmission lines, poles and towers, creating a new electric field.
X13: Rising thermals. As the hot air from the burning mountain fire moves upward, the surrounding cool air is constantly replenished to create convection, thus creating a column of convection above the burning area.
X14: Soot particle adsorption. Smoke absorbed particles trigger the discharge.
X19: Man-made damage. The ground wire or grounding body of the pole tower is stolen or damaged by human beings.

X20: Chemical resistance reducing agent failure. Due to the influence of external environment, the failure of chemical resistance reducer will reduce the resistance reduction capability with the passage of time, thus increasing the grounding resistance.

X21: Damage by natural factors. For example, rain washes and destroys the landscape so that the grounding body is exposed to the ground and cannot touch the soil.

X22: Corrosion of the grounding body. Corrosion of the grounding body, especially in acidic or weathered soils in mountainous areas, is most prone to electrochemical corrosion and oxygen absorption corrosion. The most prone to corrosion is the connection between the grounding conductor and the horizontal grounding body. Different corrosion potentials cause galvanic corrosion.

X23: Lightning overvoltage. Lightning induced current acts through the line resistance to produce lightning induced voltage and high voltage to produce discharge phenomenon.

X24: Substandard overhead ground. The overhead ground wire is not set and installed or is not in standard compliance.

X25: Poor design. Lightning protection design errors, such as insufficient design distance between transmission lines and overhead ground lines.

X26: Poor insulation. The strength of the insulation strip of a transmission line is a direct factor in its strength against lightning strikes, which means that the number of insulators and the insulation of the lightning rod are crucial.

X27: Aging. The main external environmental factors are sunlight, oxygen, water, temperature and salt spray, which can make lightning protection facilities and equipment contaminated, aging, and no longer work as protection.

X28: Inadequate safety margin of design criteria. The margin of safety of the wind resistance design criteria is insufficient because the extent of wind damage cannot be fully estimated, which means that the wind resistance design criteria do not match the actual wind speed.

X29: Poor transmission line alignment. Choose a reasonable route and avoid crossing vents, rivers and lakes whenever possible.

X30: Insufficient mechanical strength for local strong wind area. For the local strong wind area, the mechanical strength of the pole and tower should be improved to avoid the pole and tower from tipping under the action of strong wind in the local area.

X32: Self-weight fixed load. Under the influence of strong wind, the fixed load generated by the self-weight of insulator strings and transmission lines may cause them to be displaced, which will affect the electrical distance between insulator strings and transmission lines.

IE28: Insufficient design safety clearance. Insufficient design safety clearance can result in insufficient electrical distance.

X36: Frost. Frost can cause insulators and transmission lines to freeze.

X37: Rain and snow. Rain and snow cause insulators and transmission lines to freeze.

X38: Sustained low temperature. Persistent low temperatures can promote and accelerate icing.

X39: Poor snow melting and de-icing operations. Unsuccessful ice- cover self-melting operations and ineffective manual de-icing operations on transmission lines aggravate transmission line icing.

X40: Persistent fog. Usually accompanied by fog during ice melt, which further increases the conductivity of the melting ice water by polluting particles in the atmosphere.

X41: Snow melting. During ice melt, the water film on the ice surface or ice crystals rapidly dissolves the electrolytes in the dirt and increases the electrical conductivity of the water film on the ice surface, thus ultimately reducing the flashover voltage of the ice-covered insulator string.

X42: Rare and extreme weather. Extreme snow and ice conditions can lead to the possibility of excessive ice loads that exceed the acceptable load criteria.

(5) Fifth level

X11: High temperature. This high temperature node represents the temperature in the burned area of the mountain fire, typically 400 °C to 900 °C.

X12: Prolonged combustion. The sustained burn time of accelerated electron escape is usually several days or even longer.

X33: Improper calculation of wind deflection angle. Improper selection of parameters when calculating the wind deflection angle of a suspension insulator string can result in a relatively small safety clearance.

X34: Inadequate consideration of the surrounding environment. The local microclimate at a point in a transmission line is completely different from the climate at other points along the line, and these microclimates cannot be observed as accurately as possible, so the local surroundings need to be fully considered.

X35: Underestimate extreme local weather. Harsh and extremely windy weather conditions in different locations need to be fully considered.

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