Research on Decision Support Methods for Risk Assessment of Important Transmission Channels

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Abstract. The technical research on decision support for risk assessment of important transmission channels is carried out with the aims of improving risk assessment efficiency of important transmission channels, upgrading the objective of risk assessment results and ultimately enhancing technological levels of risk assessment of important transmission channels. A set of reasonable decision support methods based on the principles of deciding the values of probability L, values of frequency E and values of consequence severity C of hazard events and in connection with guide rule requirements for risk assessment of important transmission channels is worked out, which lays the foundation for rationalized, standardized and programmed generalization and implementation of risk assessment of important transmission channels during operation and maintenance.

1. Introduction

Under the effect of global warming in recent years, abnormal climatic changes have seriously affected the safe operation of power grids. In China, the geographical and meteorological conditions vary greatly with different regions. Due to the wide distribution of transmission lines, the places where grid facilities are located often have quite harsh natural conditions and vulnerable to natural disasters such as ice damages [1; 2]. Important transmission channels of transmission lines, as an important part of the power grid, play an extremely important role. An important transmission channel of transmission lines consists of two or more important transmission line sections (as illustrated in Figure 1), which will have a serious impact on the core backbone frames, strategic transmission functions and important users[3; 4] once fails.

With the gradual advancement of power grid construction, especially the construction of AC/DC power grids of ultra-high voltage, the proportion of important transmission channels in the entire power grid has increased year by year. The situation that three or more AC/DC transmission lines (with voltage grade of 500kV and above) in a narrow section (as illustrated in Figure 1) has been normal.
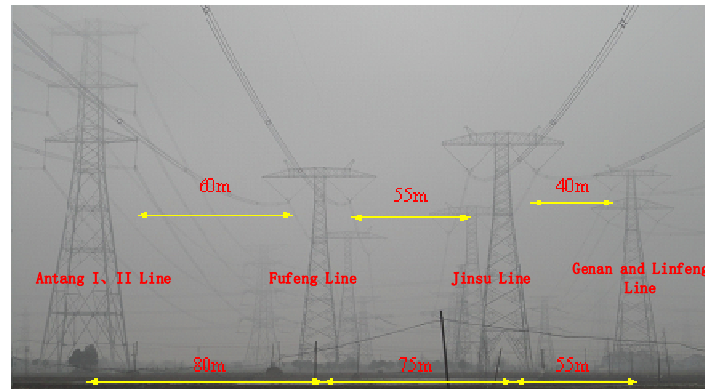
Figure 1. Photo of typical section of Jiahu important transmission channel II (Huzhou Section).

Aiming at obtaining operation conditions of wires, towers and clamps inside the channels in a real-time and accurate manner, some researchers and institutions have developed relatively impeccable online monitoring systems that can comprehensively monitor operating states of the channels and obtain real-time data [5-7]. On this basis, State Grid Corporation of China carried out the risk assessment work of important transmission channels based on eleven types of risk factors from 2014 to 2016 and completed the identification and assessment of the important transmission channels of the corporation level and the provincial company level, from which some conclusions were drawn. However, as there are many influence factors for the important transmission channels with complex rules of influences over each other, and some judging principles for probability L, frequency E and consequence severity C involve multiple logical levels, the existing risk assessment methods for important transmission channels are not easy to be mastered by the personnel. Therefore, the efficiency and accuracy of the assessment work are not high. For this reason, a set of decision support systems is in urgent need to provide technical support to the risk assessment of important transmission channels so as to improve risk assessment efficiency, upgrade the objective of risk assessment results and ultimately enhance technological level of risk assessment of important transmission channels.

2. Assisted Assessment Methods for Channel Risks

Firstly, risk identification options in the existing *Guide on Risk Assessment of Important Transmission Channel*[8] are sort out and all items of terminal risk factors are identified and input by the list of identification options; secondly, automatic matching between scores of risk factors L, E and C and fields of the identified items is realized according to the table of calculation logic relations of risks L, E and C. Then L, E and C scores of every risk factor are obtained by means of automatic calculation.

After that, the deductions of individual risk factors and deductions for comprehensive risk state of a channel are calculated in the following steps to achieve comprehensive state assessment of the important transmission channel (the calculation principle is derived from Guide on Risk Assessment of Important Transmission Channel)

1) Weight of technical factors

The probability that a technical factor causes synchronous failure outrage of an important transmission channel is classified into four levels from the minor to the severe, corresponding the weight of weight 1, weight 2, weight 3 and weight 4, and the scores of 1, 2, 3 and 4 (as listed in Table 1).

2) Calculation of risk values

A technical risk identification route is defined, and then the risks of the important transmission channel are identified to find out the risk section of technical factors.

The risk value of the risk section for the technical factor is calculated with formula (1) based on the risk itself and according to values of L, E and C given in Table 2-5.

$$R = L \times E \times C \qquad (1)$$

Wherein: R - Risk value, L - Occurrence probability of the event, E - Occurrence frequency of the event, C - Consequence of the event

3) Risk levels of technical factors

The risk levels of technical factors in s risk section are classified into four levels of I, II, III and IV from the minor to the significant based on the risk values. Corresponding risk values and basic deductions are as listed in Table 2.

Table 1. Table of Weight of Technical Factors.

Factor	Weight	Score
Forest Fire	4	4
Pollution Flashover	4	4
Ice Damage	4	4
Wave	4	4
Mechanical External Damage	3	3
Wind Damage	3	3
Geological Disaster	3	3
Tree Discharge	2	2
Foreign Matters	2	2
Bird Damage	1	1
Lightning Stroke	1	1

Table 2. Table of Risk Levels of Technical Factors.

Risk level	I	II	III	IV
Risk value (R)	$R < 30$	$30 \leq R < 70$	$70 \leq R < 200$	$200 \leq R$
Basic deduction	2	4	8	10

4) Deductions of technical factors

The deduction of a technical factor is jointly defined by risk level and weight of the technical factor, i.e. the deduction of the technical factor is equal to the basic deduction of the technical factor multiplied by the weight coefficient (see Table 3). No score is deducted if the technical factor has no risk.

Table 3. Table of Deductions of Technical Factors.

Risk Level of Technical Factor	Basic Deducted Value	Weight Coefficient			
		1	2	3	4
		Deduction			
I	2	2	4	6	8
II	4	4	8	12	16
III	8	8	16	24	32
IV	10	10	20	30	40

Deductions of all technical factors involved in the channel are added up and risk sections of the channel are divided in line with the principle that the total deductions of different technical factors are equal and continuous.

5) Determination of channel risk state

The risk state of an important transmission channel shall consider of the deduction of an individual technical factor and total deductions of all the technical factors. The risk state of a section is decided in accordance with the maximum individual deduction and the total deduction, which can be classified into four levels: normal level, low risk state, medium risk state and high risk state. The assessment criteria are as listed in Table 4.

Table 4. Table of Assessment Criteria for Risk State Assessment in Sections of the Important Transmission Channel.

State		Deduction
Normal State	Total Deduction	Less than 30
	Individual Deduction	10 and less
Low Risk State	Total Deduction	30-60
	Individual Deduction	12-24
Medium Risk State	Total Deduction	61-89
	Individual Deduction	30-32
High Risk State	Total Deduction	90 and above
	Individual Deduction	40

3. Assessment Cases

Risk assessment software for the important transmission channel is built on the basis of the above assessment rules and methods, of which the system architecture is as illustrated in the figure below.
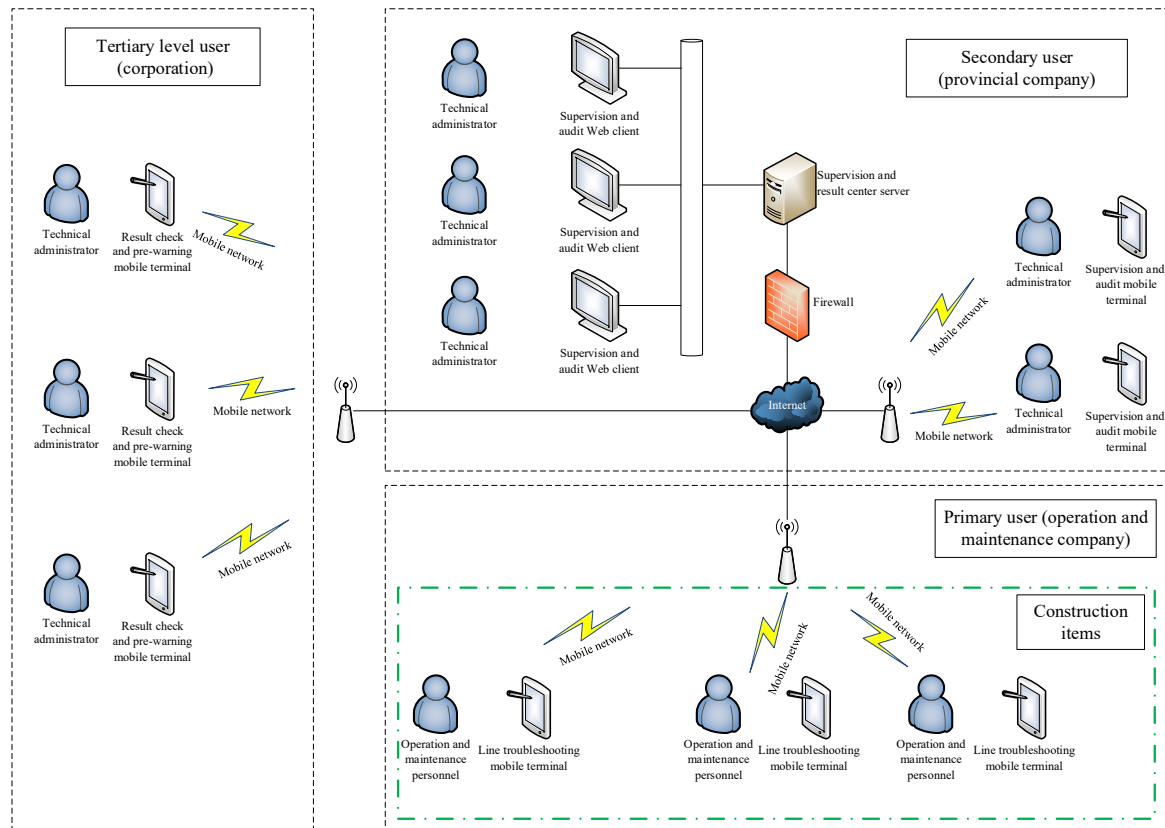
Figure 2. Architecture of Risk Assessment System for Important Transmission Channel.

Figure 3. Interface of Risk Assessment Software for Important Transmission Channels.

After a tour user inputs assessment information into the system, the system will automatically calculate risk value R and risk level with the algorithm and display the assessment information. In the meanwhile, the system will give hints on sections not assessed and incomplete input information; Here 1,000kV Fangshan Line I is taken as an instance, and the analysis table of its comprehensive risk factor level with forest fire and ice damage (no deduction is involved in other factors) as the major factors is as following:

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Table 5. Table of Risk States of Channel Sections.

No.	Channel Section	Total Deduction	Risk State	Remarks
1	1000kV Fangshan Line I 1# to 8#	24	Low risk state	Forest fire 16, ice damage 8
2	1000kV Fangshan Line I 8# to 10#	16	Low risk state	Forest fire 16, ice damage 0
3	1000kV Fangshan Line I 90# to 95#	24	Low risk state	Forest fire 8, ice damage 16
4	1000kV Fangshan Line I 95# to 100#	8	Low risk state	Forest fire 8, ice damage 0

The continuous tower sections involving the risk of several same factors are regarded as one channel section for assessment. The result indicates that risks in different channel sections have some differences, which is better to reflect the superiority and engineering applicability of the assessment method introduced in this paper.

4. Conclusions

The paper researches decision support technology for important transmission channels and information acquisition technology for risk factors. The risk conditions with different scores of the risk factors as listed in *Guide on Risk Assessment of the Important Transmission Channel* are decomposed to the maximized and optimized extents to form the unique conditional logical combination corresponding to every score of L, E and C that is capable of automatic matching; the decision support system for important transmission channels can be accessed to the information acquisition terminal for risk factors of the important transmission channels and able to make comprehensive analysis and assessment of basic data of the terminal in an automatic manner.

Assessment experiments are carried out for important transmission channels of typical lines. The conclusion with cases indicates superiority and engineering applicability of the assessment method so that it can be massively promoted and applied to projects.

Acknowledgments

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