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Study on Operational Risk Assessment of Transmission Lines Based on Fuzzy Evaluation and Qualitative Analysis

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Abstract: Transmission lines, an important part of power grid, are designed for carrying electricity from power source to electrical loads. Transmission lines are vulnerable to damages due to natural environmental forces and malfunction, which will ultimately hinder the grid's power transmission function. This paper proposed a method for operational risk assessment of transmission lines based on fuzzy evaluation and qualitative analysis. This method involves qualitative analysis of factors responsible for malfunction of transmission lines and performs risk assessment of transmission lines based on fuzzy evaluation in the hope of enhancing security of transmission lines.

Introduction

Transmission lines are important parts of power grid and designed for carrying electricity from power source to electrical loads. Most parts of transmission lines, including towers, hardware and insulators, are long exposed to air, thus suffering from both daily mechanical power, electrical power and various external environment factors, like wind, snow, lightning, environment pollution[1-2].All these factors will damage components of transmission lines, thus triggering line fault. According to surveys on major massive black out sharpened in China and causes for their occurrence in recent years, it can be seen that channel condition and meteorological environment are major factors that tend to trigger transmission line fault. Besides, it commonly takes a long time to have transmission lines repaired, which can easily lead to large-scale power outage accidents. Therefore, it is the basis of power grid stability to ensure the stability and security of transmission lines.

Currently, on-line monitoring equipment on the transmission line site management are the most commonly used method that helps collect real-time data from the transmission line site, playing a vital role in equipment management and risk prevention and control. Recent years has witnessed the application of drones for line inspection, which has enabled key line inspection to be much more efficient and accurate. Although many studies have been conducted on fault inspection, research on comprehensive risk assessment of transmission lines are far from being combined with fault data and monitoring status.

This paper conducts a qualitative assessment on factors that undermine operation of transmission lines and also performs operational risk assessment of transmission lines based on fuzzy evaluation.

Determine State Variables for Risk Assessment of Transmission Lines

Given the characteristics of transmission lines, the number of inspection and maintenance are commonly used to measure variables. State variables for line state assessment come from these closely related to transmission lines. Based on summarization and analysis [4], transmission line states can be divided into the following categories:

accounting information of lines, such as completion information; line failure, defects, testing, on-line monitoring, maintenance, family defects and other information;

line access and surrounding environment, including such crossing information as coming across railways, highways, rivers, power lines, pipeline equipment and buildings;

geological hazards, mining impact, growth of trees and bamboos, construction operations and other external factors;

information about line sections that tend to suffer from lightning damage, pollution flash, bird damage, dancing, icing, wind damage, mountain fire, outer skin damage;

line information with a significant impact on the security and reliable power supply of the grid;

important and special information about power-saving and special operation modes of power grid.

According to experts' rating assessment on the basis of the data collected through the number of inspection and maintenance and actual conditions in spot, this paper presented the risk coefficient of each category of information, ranging from 0 to 1.

Risk Assessment Model Based on Multilevel Extension

Determine the Domain of State Variables

P stands for the number of indexes for evaluation, $u=\{u_1,u_2,\cdots\cdots,u_p\}$. This paper mainly discussed four categories of information, which means the index p should be six.

Determine Grades of Risk Degree

$v=\{v_1,v_2,\cdots\cdots,v_p\}$ is the collection of grades. Each grade corresponds to a fuzzy subset. In this paper, risk states fell into four categories, namely, risk-free, mild risk, severe risk, danger.

Establish Fuzzy Relation Matrix R

Aftergrade fuzzy subsetsare constructed, objects for evaluation will be quantified in terms of each factor $u_i\left(i=1,2,\cdots\cdots,p\right)$. That means to determine the membership degree $\left(R\,|\,u_i\right)$ of objects in the grade fuzzy subsets from the perspective of one single factor and further formulate the following fuzzy relation matrix:

$$R=\begin{bmatrix} R\,|\;\; u_1 \\ R\,|\;\; u_2 \\ \cdots \\ R\,|\;\; u_p \end{bmatrix}=\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{p1} & r_{p2} & \cdots & r_{pm} \end{bmatrix}_{p.m}$$

Element r_{ij} in Line i, Row j of the Matrix R stands for the membership degree of one object in the v_j grade fuzzy subset from the perspective of Factor u_i, and the membership degree is determined in accordance with the risk coefficient of corresponding risk degree suggested by each state variables for evaluation [6]. This paper adopted qualitative determination method with the final membership degree being the mean value of all membership degrees presented by multiple experts.

Determine Weight Vector of Evaluation Factors

Weight vector of evaluation factors is determined by the following formula:

$A=\left(a_1,a_2,\cdots\cdots,a_p\right)$. This paper applied Analytic Hierarchy Process(AHP) to determine the sequence of all indexes for evaluation based on their importance, and further determined weight coefficients and normalized them before adding all vectors together.Formula: $\sum_{i=1}^{p} a_i = 1$, $a_i \geq 0$, $i=1,2,\cdots\cdots,n$.

Calculate the Resultant Vector of Fuzzy Comprehensive Evaluation (FCE)

B in the following formula represents the resultant vector of fuzzy comprehensive evaluation of all objects:

$$A \circ R = \left(a_1,a_2,\cdots\cdots,a_p\right)\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{p1} & r_{p2} & \cdots & r_{pm} \end{bmatrix} = \left(b_1,b_2,\cdots\cdots,b_m\right) = B$$

In this formula, b_1 is the result of A and Row j of R, representing the membership degree of objects in the grade fuzzy subset on the whole.Ultimately,risk degrees are determined on the principle of the maximum of membership degree.

Conclusion

This paper provided insight into the method for operational risk assessment of transmission lines based on fuzzy evaluation and qualitative analysis. It divided operational states of transmission lines into six categories and carried out risk assessment on them by means of qualitative risk coefficient identification and fuzzy comprehensive assessment.

Bibliography

[1]Li Bingran, Xia Linmin, Zhao Jingjing.Risk Assessment of Power Transmission Lines Based on Fuzzy Evaluation and Risk Matrix[J]. *Power& Energy*,2014,06:672-677.

[2]Mu Yongzheng, Lu Zongxiang, Qiao Ying, Wang Yang, Huang Han, Zhu Qinyong, Han Jiahui. A Comprehensive Evaluation Index System of Power Grid Security and Benefit Based on Multi-Operator Fuzzy Hierarchy Evaluation Method[J]. *Power System Technology*,2015,01:23-28.

[3]Wang Kongsen, Sheng Gehao, Wang Kui, Liu Yadong, Cui Ronghua, Jiang Xiuchen. Operation Risk Assessment ofTransmission Lines Dynamic Line Rating System [J].*Automation of Electric Power System*s,2011,23:11-15+21.

[4]Yang Jindong. *Study on the Health Status and Risk Assessment of Overhead Transmission Lines*[D]. Kunming University of Science and Technology,2013.

[5]XuKaili, Wang Yongjiu, Chen Baozhi. Multi-Objective Fuzzy Evaluation Models and Calculation Method of Assessment Grade [J]. *Journal of Northeastern University*,2001,05:568-571.

[6]Zhu Yihua, Luo Yi, Duan Tao, Shi Lin, Chen Jianjun, XieRui, Li Xiaolu, XiongWeibin, Li Mao. Online Risk Assessment for Static Security of Power System Based on Real-time Evaluation

Model of Transmission Lines [J]. *Electric Power Automation Equipment*,2014,07:150-156.