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Research on security risk assessment model of power system

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ABSTRACT

From the perspective of blackout risk, the thesis established a set of index system and assessment model of power system based on risk management theory and gray correlation analysis method. The weight of each index is determined by analytic hierarchy process method. The validity of the model is proved by examples.

KEYWORDS

Security risk assessment; Index system; Power system; Gray correlation analysis method; Analytic hierarchy process method.

INTRODUCTION

With the deeply understanding of stability and operation safely of power system, Security risk assessment of power system has been paid more and more attention. The scale of electric power system has been increasing, and the stability problem has been outstanding gradually. This requires a set of security risk evaluation method. With the development of the modern risk theory, it is introduced to the power system security assessment system.

STUDY ON THE PRESENT SITUATION OF SECURITY RISK ASSESSMENT OF POWER SYSTEM

The policy of "safety first" is always followed in the production and operation process of electric power enterprises[1]. Therefore, security assessment is very important. With the development of technology, security theory has been understood continuously deepening. The theory and method of power system security assessment is also advancing with the times. As the whole, Its development experienced two stages: the stage of reliability assessment and risk assessment stage.

However, the scale of power system is more and more complex, and there are various uncertain factors on the electric power system. Both of these make the power system become the world's largest and nonlinear complex system. The traditional reliability assessment methods can not fully meet the need for security analysis of power system. Risk theory takes into consideration two aspects of the probability of the accident and its consequences[2]. It makes the results more reasonable and has guiding significance. And it overcomes the shortcomings of traditional reliability assessment of certain procedures. At present, the security risk assessment of power system is a hotspot for experts and scholars. The thesis set up index system based on security risk assessment theory[3].

INDEX SYSTEM AND EVALUATION MOEDL

Risk assessment index is the key for risk assessment. Only by establishing scientific, reasonable and practical evaluation index system, security risk assessment for power system would be objective and accurate. Risk assessment method is based on risk management. According to the overall objectives of risk assessment, and combining with the characteristics of electric power system, the associated factors are evaluation index. This method can essentially reflect the risk factors associated with system. It can not only understand the risk level of the overall system in the macroscopic angle, but also analysis concretely the weak based on the index system.

The construction principle of risk assessment index

To set up the evaluation index is ultimately can be attributed to three aspects: structure, technology and equipment. So the thesis mainly established security risk assessment index from the three aspects for power system.

The establishment of security risk assessment index

Based on the domestic and international power industry existing experience, fully considering the possible fundamental factors of large area blackout, a set of hierarchical evaluation index system is established. The general goal of assessment is the large area blackout risk. Index of security risk assessment of power system can be from three aspects of structure risk, technology risk and the equipment risk, as shown in TABLE 1

The establishment of security risk assessment model

There are many methods for evaluation of power system security risk. The thesis adopts the improved grey relational analysis method. The traditional grey relational analysis determines the weight of each index with mean value. In this study, the model adopts analytic hierarchy process method instead to determine the weight. Comparing the evaluation results, the risk value of power system in different regions is ranked. Evaluation steps are as follows[4].

Firstly, sequences to be analyzed are determined.

Provided that indexes m composes the index system of customer value evaluation and customers n are to be appraised, the original index value of every customer constitutes a m-dimension-arrange vector. Then n vectors constitute a matrix:

$$(X_1', X_2', \cdots, X_n') = \begin{bmatrix} X_1'(1) & X_2'(1) & \cdots & X_n'(1) \\ X_1'(2) & X_2'(2) & \cdots & X_n'(2) \\ \vdots & \vdots & \vdots & \vdots \\ X_1'(m) & X_2'(m) & \cdots & X_n'(m) \end{bmatrix}$$

Secondly, dis-dimension is derived:

TABLE 1 : Security risk evaluation index system for power system

Guideline layer	Guideline layer	Sub-guideline layer
Structure Risk	Structure risk of power supply	Power supply risk assessment
		Structure risk assessment of power primary energy
		Risk assessment of power peaking capacity
		Natural disasters risk assessment of power outage
	District grid structure risk	Partition power supply risk assessment
		The important primary equipment failure risk assessment
		Risk evaluation of security power allocation
	Power grid operation risk	Risk assessment division of power supply scheme
		The important element of heavy overload risk assessment
Technology Risk	Relay protection technology risk	The main protection assessment of transmission line on the same tower
		Evaluation of protective chain action of large load transfer case
		The main channel assessment protection for 500kV transmission line
	Security and stability control system	Security and stability control system technology assessment
		Splitting technology assessment
		Low-frequency load reduction technology assessment
		Low voltage load shedding technology assessment
	Dispatching and protection technology risk	Dispatching operation safety technical risk assessment
		Safety protection technology risk assessment for natural disaster
		Secondary power system security protection technology risk assessment
Equipment Risk	Risk of key ;primary equipment	Turbine and auxiliary equipment evaluation
		Power transformer assessment
		Bus and ancillary equipment evaluation
		Overhead transmission line assessment
		Circuit breaker evaluation
		A DC primary equipment evaluation
	Risk of key secondary equipment	Relay protection equipment evaluation
		The security and stability evaluation of automatic device
		Dispatching automation system risk assessment
		Power grid communication equipment evaluation

$$(X_1, X_2, \cdots, X_n) = \begin{bmatrix} X_1(1) & X_2(1) & \cdots & X_n(1) \\ X_1(2) & X_2(2) & \cdots & X_n(2) \\ \vdots & \vdots & \vdots & \vdots \\ X_1(m) & X_2(m) & \cdots & X_n(m) \end{bmatrix}$$

Thirdly, consulting sequence is determined.

All maximums of the evaluation indexes chosen from its m-dimension-arrange vector constitute the consulting sequence.

$X_0 = [X_0(1), X_0(2), \cdots, X_0(m)]^T$, Therein: $X_0(i) = \max_{1\le j\le n}\{X_j(i)\},\ i = 1,2,\cdots m$

Fourthly, grey relational coefficient, maximum difference and least difference are determined.

According to formula

$\Delta_{0i}(k) = \left|X_0(k) - X_i(k)\right|$,therein: $i = 1,2,\cdots n; k = 1,2,\cdots m$

Difference matrix is obtained:

$$\begin{bmatrix} X_{01}(1) & X_{02}(1) & \cdots & X_{0n}(1) \\ X_{01}(2) & X_{02}(2) & \cdots & X_{0n}(2) \\ \vdots & \vdots & \vdots & \vdots \\ X_{01}(m) & X_{02}(m) & \cdots & X_{0n}(m) \end{bmatrix}$$

$\Delta(\max) = \max\{\Delta_{0i}(k)\}$, $\Delta(\min) = \min\{\Delta_{0i}(k)\}$

Therein: $i = 1,2,\cdots n; k = 1,2,\cdots m$

Fifthly, relational coefficient is determined.

Relational coefficient is determined according to formula (1).

$$\xi_{0i}(k) = \frac{\Delta(\min) + \rho\Delta(\max)}{\Delta_{0i}(k) + \rho\Delta(\max)} \qquad \textbf{(1)}$$

Therein: $\rho = 0.5, i = 1,2,\cdots n.$

Then the relational coefficient matrix is obtained as follows:

$$\begin{bmatrix} \xi_{01}(1) & \xi_{02}(1) & \cdots & \xi_{0n}(1) \\ \xi_{01}(2) & \xi_{02}(2) & \cdots & \xi_{0n}(2) \\ \vdots & \vdots & \vdots & \vdots \\ \xi_{01}(m) & \xi_{02}(2) & \cdots & \xi_{0n}(n) \end{bmatrix}$$

Sixthly, the gray relational degree (GRD), which is determined according to the following formula, is calculated:

$$\gamma_{0i} = \sum_{k=1}^{m} \xi_{0i}(k)\omega_k \ ,\ i = 1, 2, \cdots, n$$

Therein: ω_k is confirmed by AHP method and listed in TABLE 2 as follows.

APPLICATIONS

Taking five regional power systems as an example, experts are invited to assess its security risk respectively. The criteria of each index how to score are shown in TABLE 3, scores between 0-1. The higher the score, higher risk. The risk can be evaluated through the improved grey relational analysis method. The appraisement results are listed in TABLE 4 as follows.

The grey relational degree is its risk degree, from which the relative level of risk can be clearly understood. Comparing risk degree, the appraisal object can be ranked. Aiming at the high risk assessment object, its weak should be analyzed concretely. Then put forward the corresponding improvement measures.

TABLE 2 : Weight of each index by AHP

Guideline layer	Guideline layer	Sub-guideline layer	The compositive weight of each index
Structure Risk 0.279	Structure risk of power supply 0.506	Power supply risk assessment 0.4181	0.0590
		Structure risk assessment of power primary energy 0.2266	0.0320
		Risk assessment of power peaking capacity 0.0742	0.0105
		Natural disasters risk assessment of power outage 0.2811	0.0397
	District grid structure risk 0.254	Partition power supply risk assessment 0.1062	0.0075
		The important primary equipment failure risk assessment 0.2605	0.0185
		Risk evaluation of security power allocation 0.6333	0.0449
	Power grid operation risk 0.24	Risk assessment division of power supply scheme 0.4824	0.0323
		The important element of heavy overload risk assessment 0.5176	0.0347
Technology Risk 0.285	Relay protection technology risk 0.386	The main protection assessment of transmission line on the same tower 0.3	0.0330
		Evaluation of protective chain action of large load transfer case 0.6	0.0660
		The main channel assessment protection for 500kV transmission line 0.1	0.0110
	Security and stability control system 0.224	Security and stability control system technology assessment 0.4228	0.0270
		Splitting technology assessment 0.2184	0.0139
		Low-frequency load reduction technology assessment 0.1794	0.0115
		Low voltage load shedding technology assessment 0.1794	0.0115
	Dispatching and protection technology risk 0.39	Dispatching operation safety technical risk assessment 0.4415	0.0491
		Safety protection technology risk assessment for natural disaster 0.3112	0.0346
		Secondary power system security protection technology risk assessment 0.2473	0.0275
Equipment Risk 0.436	Risk of key primary equipment 0.5832	Turbine and auxiliary equipment evaluation 0.2162	0.0550
		Power transformer assessment 0.2056	0.0523
		Bus and ancillary equipment evaluation 0.1621	0.0412
		Overhead transmission line assessment 0.1028	0.0261
		Circuit breaker evaluation 0.1164	0.0296
		A DC primary equipment evaluation 0.1519	0.0386
	Risk of key secondary equipment 0.4168	Relay protection equipment evaluation 0.3584	0.0651
		The security and stability evaluation of automatic device 0.2317	0.0421
		Dispatching automation system risk assessment 0.2916	0.0530
		Power grid communication equipment evaluation 0.1183	0.0215

TABLE 3 : Criteria that how to score

Score	Large area blackout risk degree	Security level
0.1	Very low	
0.2	Low	Secure
0.3	Relatively low	
0.4	Medium to low	
0.5	Medium	Alert
0.6	Medium to high	
0.7	Relatively high	
0.8	High	Danger
0.9	Very high	

TABLE 4 : Grey relational degree ($\rho = 0.05$)

Item	A	B	C	D	E
Risk degree	0.3621	0.7248	0.6439	0.1836	0.4919
Order	4	1	2	5	3

CONCLUTIONS

Based on the large area blackout risk and fully considered the possible fundamental factors, a set of index system and security risk assessment model are set up for power system. The system is the link between risk assessment theory and practice. Incorporated it into the daily risk management, It is conducive to timely grasp the system risk level and recognize the weak. Then take some improvement measures to prevent large area blackout. The further study is the decomposition of index system and its data source and the process of calculation. Thus the accuracy of model and calculation can be improved continuously.

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REFERENCES

[1] George Anders, Alfredo Vaccaro; Innovations in Power Systems Reliability. Springer **(2011)**.

[2] Fei Xiao, McCalley; J.D.Power system risk assessment and control in a multi-objective framework, IEEE Transactions on Power Systems, **24(1)**,78-85 **(2009)**.

[3] Y.G.Zuo, X.M.Zheng; An Empirical Study on the Affecting Factors of Tourists' Sense of Security in Tourist Destinations—Case Study of Quanzhou, Fujian Province, Tourism Tribune, **27**, 49-57 **(2012)**.

[4] Hanyun Wang, Kangyuan Wang, Yunxiao Zhang; Research about Online Security Warning and Risk Assessment of Power Grid Based on Energy Management System, Energy and power engineering, **3**, 485-487 **(2009)**.