

A Review of Transmission Development Planning Based on Risk Evaluation

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Abstract. The paper summarizes the methods about the transmission development planning which considers risk factors. It introduces the transmission network flexible planning method based on the uncertain factors, the mathematical optimization method and a heuristic method. Then we discuss the way to deal with risks about transmission network planning. Given that, we proposed the future research direction.

Keywords: transmission development planning, risk index, constraints, risk factors

1 Introduction

On the premise of certainty, traditional transmission network planning designs a plan with a highest comprehensive level[1]. Since the huge reform in electricity market, the way of original planning from certainty to uncertainty, traditional method of certainty planning is no longer used. So the task of transmission development planning—according to the change of power supply and load growth during the planning period, based on the existing grid to build a suitable transmission line and with requirements of guarantee the safe operation—is to seek a more economical solution. The greater the time span, the more uncertain factors. Therefore, with these uncertain conditions, transmission network planning not only need to meet the requirements of the economy, but also make the planning scheme more scientific, reasonable, safe and reliable.

2 Transmission development planning method based on risk

2.1 Flexible planning method of the transmission network

According to the approach of uncertainty factors, it can be divided into two ways—the one based on multi scenario technique and the other one based on the uncertainty theory.

2.1.1 Programming method based on multi-scenario technique

The essence of the multi scenario planning model[2] is to transform the mathematical model which is difficult to express uncertainty factors into a multiple certain scenario which is easier to deal with, so as to avoid to establish the complicated power grid planning model and reduce the difficulty of modeling and solving.

(1) Multi-scenario technique based on decision preferences

In this method, the cost of several kinds of planning schemes in multiple scenarios is presented, and then the optimal scheme is given according to several common decision methods.

(2) Decision tree method based on scenario occurrence probability

The decision tree method means decomposition analysis for the occurrence probability of all kinds of uncertain factors, as a condition, melting the decision of the component steps into the decision-making process at the same time, quantizing the effects of the uncertain factors to the network planning during the decision analysis phase. In the case of flexible constraints[3], and this way would improve adaptability and robustness.

(3) Flexible network planning method based on the equal incremental principle

It is a method that is considered to deal with uncertainties of generator output and load growth. We can find that the optimal transmission network flexible planning scheme based on equal incremental rate criterion is not a best scheme in any scenes, but is really a "good" solution in most situations.

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2.1.2 Flexible planning method based on uncertainty theory

Compared with last method, this method would put continuous uncertain variables and some uncertain information that can't be described as scenes into planning model and solution of the model can learn from the existing mathematical theory. At present, this method mainly includes the following two kinds:

(1) A flexible programming model for transmission network considering the probability of uncertainties. For the flexible constraints which is described as probability form, when simulate the uncertain factors, usually, is solved by probabilistic load flow method[4] or Monte Carlo[5] method to seek for optimization.

(2) Flexible planning model of transmission network considering the uncertain factors of interval

Under interval uncertain information, transmission network planning model is solved by interval programming theory, using the Monte Carlo method and interval power flow simulations to testing whether if it could ensure safety of the system under uncertain environment or not.

Blind number theory[6] can get flexible planning scheme through blind number node power, constructing blind number power flow and corresponding operation. The theory of set pair analysis[7] includes the certainty and uncertainty information in the same system, quantitative analysis of the system inversely and describing the relationship between things comprehensively. It was introduced to deal with uncertainty factors in power system could combine economy and reliability of the power grid planning organically to achieve the best comprehensive benefits of the optimization scheme[8].

2.2 Mathematical optimization method

The mathematical optimization method is described by the optimization model and its algorithm is used to solve the network planning problem to obtain the optimal plan of the system.

Linear programming is a mathematical method which is perfect in the theory and solving method. Fuzzy programming[9] is use strict mathematical theory to deal with the problem of ambiguity, which is suitable to solve the problem of multi objective optimization and comprehensive evaluation of different dimension and conflicting data. We can use the way to solve the problems about the probabilistic uncertainty factor in power system. The gray theory[10] could combine with the artificial experience, but the whitening treatment of gray information lack of a rigorous mathematical basis. The main idea of dynamic programming[11] is to transform a problem into several sub problems.

2.3 Heuristic method

Compared with mathematical optimization method, the modern heuristic optimization algorithm is suitable for solving combinatorial optimization problems and non-differentiable nonlinear optimization problems in some

constrained conditions. Some researchers try to use this kind of algorithm[12][13] to solve the transmission planning problem and get a better result. So some researchers proposed that combine simulated annealing and genetic algorithm can overcome the problems of the traditional genetic algorithm which is difficult to solve the instability and local convergence.

3 Risk management in transmission planning

3.1 Adding new risk indicators

Adding the corresponding risk indicators for different risk is helpful to establish a more reasonable risk assessment system, and it plays an important role in the transmission planning [14].

Take the effect of risk factors on transmission network planning fully into consideration when we establish the comprehensive evaluation index system of transmission network planning. According to the increase of active power loss in transmission line fault system, the power loss increment risk index are put forward to be integrated into evaluation index system[15]. It is more scientific and feasible that the new constructed evaluation index system. Researchers believe that add the risk control strategy into the planning model, combine with the probability of system power flow and the probability of system power flow margin as a system security risk index to establish a transmission system multi object planning model whose objective function is total investment cost and safety risk index.

3.2 Adding new constraints

As to the possible risks for transmission development planning, compared with the way to increase new risk indicators, the increase of new constraints is also a good method. Adding new constraints can eliminate some of the unnecessary interference factors, so that improve the credibility[16] about the results of the risk assessment.

Many uncertainties in the power market environment have obvious randomness and fuzziness, would impact transmission planning largely. Chaos Quantum honey bee algorithm[17] is a fast and accurate method to solve the problem of constrained transmission planning. The transmission planning model based on uncertain programming theory is established[18], which can be used to find the optimal planning scheme at the minimum possible total investment cost.

3.3 Comprehensive assessment

In summary, each risk assessment method has its limitations, and using a single risk indicators or a single risk assessment approach always have some shortcomings. So we began to combine a variety of methods to together reasonably to achieve better results.

Some researchers take risk theory to evaluate the vulnerability of transmission line from the probability and impact of line fault. Firstly, they calculate the fault probability of each transmission line, and then study consequences of the network structure and the operation state, and finally evaluate vulnerability of the power transmission line comprehensively based on risk theory, it's proved that we obtain a good result. In recent years, some researchers have proposed a basic idea and general framework of smart grid risk assessment, for the uncertainty of smart grid, suggestion that combined with the engineering risk and financial risk to evaluate the transmission development planning[19].

4 Prospects

Because the long time span of transmission development planning, so the load fluctuation of long-term load forecasting should be considered. While In the medium and long term load forecasting is influenced by many factors, with more uncertainties, so it is more difficult to forecast accurately, and it has great influence on the risk assessment of transmission development planning. Therefore, it is necessary to consider medium and long term load forecasting in power transmission development planning. The reform of the electric power market has brought about the opportunity and also brings more uncertainty, so how to find the corresponding risk index according to the increasing uncertainty factor is a direction of our exploration. Also in recent years, with in-depth study of risk assessment methods, more and more new methods are proposed, but only take one method is difficult to meet the requirements, it would be a good way to combine or optimize multi methods. The power grid development plan for a long time prediction for the future, there must be many uncertain factors, and deal with these factors properly, is worthy direction to study. Finally, for the two aspects (the calculation speed and convergence) of the future power grid planning problems to be further studied. Of course, risk assessment and economic development in the transmission planning process is a problem worthy of attention.

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