

Research on project post-evaluation of wind power based on improved ANP and fuzzy comprehensive evaluation model of trapezoid subordinate function improved by interval number[☆]

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ABSTRACT

The safety operation and economic benefits of wind farms are paid more attention by industry and society. Therefore, it's necessary to evaluate the wind power projects to find the deviation between actual situation, forecast target and first-class level. The commonly used methods of post-evaluation are AHP and fuzzy comprehensive evaluation which have three problems to be solved. The first is AHP method can't represent the correlation among the indexes. The second is the uncertainty of project data and experts' judgment. The third is the rectangle membership function can't realize data classification between adjacent levels. ANP can describe the relationship between indicators to eliminate deviation caused by independent calculation. The trapezoidal membership function is useful for rapid classification data between adjacent levels by maximum membership degree. And the interval can utilize imperfect information to solve the limitation of point estimation. So this paper proposes ANP model and fuzzy comprehensive evaluation model based on trapezoid membership which are all improved by interval numbers to evaluate projects. The paper makes a calculation of Pinglu wind farm, and the result shows new model is more stable with accuracy and applicability for post-evaluation which can solve the problems such as incomplete information, data fluctuation and subjective judgment.

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1. Introduction

As a renewable clean energy, wind energy is being paid more attention in the world, and China has natural development advantages with rich wind energy resource.

After 2006, the wind power installed capacity in China has showed an explosive growth. In 2015, the new installed capacity was 23.2 GW that was up 44.2% from the same period and the accumulative installed capacity was 114.6 GW which is in the 25.4% year-on-year growth, and the two data are ranked first in the world. In 2016, the new installed capacity was up to 30.5 GW with 31.5% year-on-year growth. However, compared with conventional power generation, the wind power still account for a relatively small proportion in China. The construction of wind farms should

improve the technology level, evaluation level, decision-making level, construction efficiency and construction quality of the five power generation companies and power companies in China. But there are differences between these wind farms. So the problems of the safe operation, economic benefits, social influence and so on have been paid more attention by the industry and society. Therefore, it is necessary to evaluate the wind power projects which have been put into operation. On the one hand, post-evaluation can help the wind farms to find out the deviation between the actual situation, forecast target and even the first-class level construction. On the other hand, the improvement measures can be put forward to increase the comprehensive benefits of China's wind power projects based on the analysis of the deviation so as to provide support for future investment decisions and power construction.

Currently, some scholars are studying and practicing on project post-evaluation and putting forward variety of evaluation models, which mainly include mathematical models, statistical models and intelligent models. At present, the main methods of post-project evaluation are comparative evaluation, success degree evaluation,

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analytic hierarchy process, principal component analysis, data envelopment analysis and fuzzy evaluation [1]. Saaty proposed an analytic hierarchy process (AHP) for project management in 1976 which has epoch-making significance to the research on post project evaluation [2]. The fuzzy mathematics was introduced into the multi-objective comprehensive evaluation in the early 80s and the fuzzy comprehensive evaluation method was formed [3]. The reference [4] pointed the grey system theory can expand the source of information so as to improve the credibility of evaluation results. The theory and method of post evaluation of electric power construction project are discussed in Ref. [5], and the idea of process network is put forward for post evaluation management. In the economic evaluation, the DEA method is used to evaluate the relative effectiveness. The literature [6] has studied different kinds of multiple attribute decision making methods, including interval number fuzzy decision matrix, intuitionistic fuzzy decision matrix, triangular fuzzy number decision matrix and trapezoid fuzzy number decision matrix.

At present, there are three problems of the project post-evaluation research to be solved. The first is that the AHP method can't represent the correlation among the indexes. The second is the uncertainty of the project data and the expert judgment, and point estimation can't make full use of the data. The third is that the rectangle membership function can't solve the problem of data classification between adjacent levels. The reference [7] put forward a decision-making method of subordinate hierarchical structure with adaptive factors in order to solve the complex and multi factor decision-making which is based on AHP and it is called the network analytic hierarchy process (ANP). And in the field of construction engineering, ANP has been applied to the evaluation of the project after the construction of the power grid [8], power customer satisfaction [9], bridge construction bidding [10] and so on. Besides, ANP has been used to selection of R & D projects [11], product design decision [12], selection of supply chain partners [13], performance evaluation [14] and other aspects in the field of management. All of the above studies show ANP model is a practical management tool. The structure of ANP is diverse so that it can describe the relationship of real complex system well and the determined elements relative ranking vectors are more persuasive. However, with the further research of traditional theory and application practice, there are still some shortcomings in traditional ANP such as that its relative importance expression can't eliminate subjective judgment uncertainty through the way of point estimation which results in ANP's failure of meeting actual needs. To tackle this problem, the literature [15] proposed an improved ranking method based on "interval estimation + DEA model" for the CSII type system (a typical ANP structure), and an improved ANP algorithm based on fuzzy exponential scaling method was proposed in the reference [16]. Although the above methods have a strong theoretical basis, the calculation processes are too complicated. Research shows that ANP can find out the relationship between indicators to eliminate the deviation caused by independent calculation, and the trapezoidal membership function is quite useful in rapid classification for the data between the two adjacent levels according to the maximum degree of membership. In addition, the interval data can make full use of imperfect information to solve the limitation of "point estimation".

In the post evaluation, the index system is not a simple hierarchical structure because the indicators can often affect each other which is similar to network structure. The ANP fully considers the relationship between the various factors which is better than AHP [17]. Combined the advantages and disadvantages of each model, this paper introduces the interval number to improve ANP method and fuzzy comprehensive post evaluation method, and then constructs a new post-evaluation method for power grid construction

projects with the two evidence improvement models. The traditional membership function doesn't consider the randomness of decision-makers' subjective judgement so that there are some shortcomings such as the difficulty of determining the function parameters, the single way of determining and the inexplicit transformation of fuzzy concepts. Moreover, the wind farms in different regions of the country are not in same situation which will bring a range of issues for evaluation with the unified standard. Therefore, the membership function parameters should be represented by interval number which considers more circumstances in the scope of the evaluation results. To summarize, the paper proposes an improved ANP model by interval numbers to determine the index weight, and then uses fuzzy comprehensive evaluation model based on interval number to evaluate the wind power project. The new model solves the defects caused by point estimation on the basis of fully explore the relationship between index, and the evaluation results will be classified to the appropriate grades through calculating time after time which represents objective and scientific evaluation result so as to put forward the reasonable proposal for wind power projects.

2. Improved ANP model based on interval number

2.1. ANP model

ANP model is based on the analytic hierarchy process (AHP) with the same research target for dealing with the diversity of these influence elements. The ANP also considers the interrelationship between index groups and indexes which is more scientific and theoretical than AHP. The control layer indicates ANP's research objective and the code that affect the degree of decision or goal realization. The network layer is the basis element based on the corresponding target criterion which are the most basic factors affecting the target or decision. Therefore, using ANP can calculate the weight by a two time programming, then get the total ordering by using the limit super matrix which can make up for the defect of the independent requirement among the indexes of AHP. The typical structure of ANP is shown in Fig. 1.

The calculation steps [18] of relative weight using ANP are as follows:

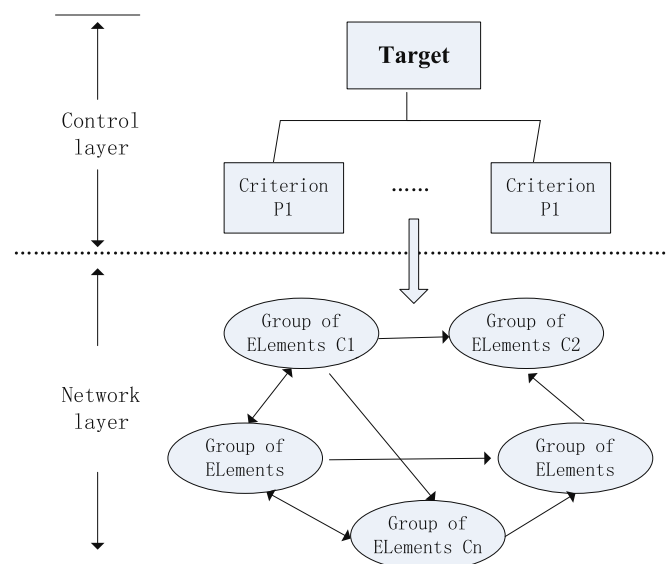


Fig. 1. Typical structure of ANP.

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