Project classification and ordering optimization model of power grid company based on entropy weight and improved analytic hierarchy process

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Abstract. At present, the power grid investment should be developed in the direction of reasonable scale, structure optimization and scientific timing. In this paper, starting from the comprehensive deepening of the precise investment of power grid companies, based on the analysis method of entropy weight order relationship combining subjective and objective, the paper constructs the project evaluation model of power Grid Company with five indicators of policy, urgency, risk, economy and strategy. The model adapts to the requirements of comprehensive policies and development reform, meets the characteristics of regional development, and supports the precise investment control of enterprises. It can ensure the realization of accurate investment in power grid, and give full play to the important role of power grid investment in stable growth, structural adjustment, making up for weaknesses and benefiting people's livelihood.

1. Introduction
Recently, there have been great advances in internet of things and wireless sensor networks leading to the fourth industrial revolution in power grid, namely, Smart grid[1].Smart grid has paved way for a systematical deployment of the modernised power grid to fulfil the continuously growing energy demand of the 21st century. The smart grid paradigm offers power supply in an efficient, sustainable and economical manner with minimal impact on the environment and can meet the future energy demands[2-3]. Project investment optimization management is the key to the safe development of power grid and the healthy development of enterprises. The contradiction between the rigid growth of cost and the slowing down of electricity growth and the difficulty of benefit growth is becoming increasingly prominent, which makes it more difficult to maintain steady operation and achieve profit target. All of these put forward higher requirements for power grid investment decision-making. Therefore, it is of great significance to carry out the research on power grid investment priority under the new investment situation[4]. It can ensure that the investment scale is reasonable, the direction is accurate, the structure is optimized, the timing is scientific, and the inefficient investment is strictly controlled and the invalid investment is eliminated.
2. Research on optimization of company project investment

2.1. General idea and process of project investment optimization
This paper will build a scientific and efficient project investment optimization index system for the company's planned investment projects. The project investment optimization method combining subjective and objective is adopted to optimize the investment of all kinds of projects, and the order of importance of projects is clarified [5].

In this paper, a project investment optimization model based on entropy weight order relation method is constructed
(1) This paper analyzes the principles of project investment optimization and some factors affecting the results of investment optimization. This part builds a scientific theoretical basis and detailed index sequence for the construction of a scientific and reasonable index system.
(2) Establish the index system of project investment optimization. This paper constructs the power grid from five aspects: the economic system, the importance of the project and the optimization of the risk.
(3) Based on the entropy weight order relation method, this paper puts forward the index combination weighting method of project hierarchical ranking, obtains the comprehensive score result of the company's project, and optimizes the investment of the project according to the result.

The project investment optimization flow chart of the company is as shown in Figure 1:

![Figure 1. Company project investment optimization flow chart.](image)

2.2. Construction of optimization index system of company project investment
This section takes the power grid production technology transformation and production overhaul project as an example, and constructs a three-level power grid project investment optimization index system from five aspects of policy, urgency, risk, economy and strategy[6].

The investment optimization index system of production technology transformation and production overhaul project can be divided into urgent importance, risk, economy and strategic indicators. Among them, the urgent importance index can be subdivided into the type of project solving problems and the index of equipment reliability level. Risk index can be subdivided into social risk and financial risk index. Economic index can be subdivided into economic benefit and fund utilization index. Strategic indicators can be subdivided into the contribution to the strategic objectives of enterprises and the emerging frontier technical indicators. The specific indicators of investment optimization are as shown in Figure 2:
First grade | Second grade | Third grade
--- | --- | ---
Urgency | Type of problem solved by the project | Natural disaster
 | | Equipment hidden danger
 | | The equipment does not meet the safety requirements
 | | Backward technical level
 | | Others
 | Equipment reliability level | Duration of service | Social risk
 | | Mean time between failure | Financial risk | Energy saving and environmental protection level of equipment
 | | Start-up reliability | | Asset-liability ratio
 | | Unplanned outage factor
Risk | Social risk | Cumulative net present value
 | | Financial risk | Internal rate of return
 | | Economic benefit | Payback period
 | | Capital utilization | Fixed asset input
 | | Degree of contribution to the strategic objectives of the enterprise | Number of strategic goals achieved
 | | Emerging frontier technology | Equipment operating efficiency
Strategy | Degree of contribution to the strategic objectives of the enterprise | Number of strategic goals achieved
 | | Emerging frontier technology | Equipment operating efficiency

**Figure 2.** Investment optimization index system of production technology transformation and production overhaul project.

(1) Security requirements

With the continuous development of the economy, China's electricity consumption structure is constantly being adjusted. In order to improve the safety and reliability of power grid operation, equipment and systems, such as power plant equipment, primary equipment, relay protection and safety automatic devices, automatic control equipment, power communication systems, plant station automation systems, and scheduling automation systems, require production technology transformation and production equipment overhaul. The security needs of production technology transformation and overhaul projects are mainly reflected in the following aspects.

① The requirements of restoring or improving the reliability of transmission, substation and distribution equipment. The related indicators include the duration of service, mean time between failure, start-up reliability, and unplanned outage coefficient.

② The requirement of improving the reliability of secondary system equipment such as grid dispatching, communication, relay protection, safety automatic devices, and automation. The related indicators include the duration of service, mean time between failure, start-up reliability and unplanned outage coefficient.

③ The requirement of improving the stable operation of auxiliary systems. The relevant indicators include the duration of service, mean time between failure, start-up reliability and unplanned outage coefficient.
The requirements for emergency measures and accident prevention measures.

Economic requirements

1. The requirements of reducing the line loss, coal consumption, water consumption, and other losses. In order to improve the utilization efficiency and economy of the equipment, it is necessary to reduce the line loss, coal consumption, water consumption and other losses through production technical transformation or production overhaul. The related indicators include the line loss rate, coal consumption rate, water consumption rate, and equipment operating efficiency.

2. The requirements of tapping the potential of equipments and reducing equipment operating costs. The related indicators include equipment operating efficiency and equipment operating costs.

3. The requirement of reducing maintenance costs. Maintenance cost is a large proportion of the expenditure in the power grid operation. Special attention needs to be paid to reducing maintenance costs in the process of production technical transformation and production overhaul. The related indicators include maintenance costs.

Technical policy requirements

1. The requirements of controlling environmental pollution and environmental protection. At present, China’s environmental pollution situation is still severe, the power grid enterprises are also moving towards green, environmental protection direction. In order to effectively control the emission of pollutants and promote the process of green development, enterprises should combine current advanced technologies to carry out production technological transformation and production overhaul. The related indicators include CO₂ emissions, NOₓ emissions.

2. The requirements of promotion and application of advanced technology. A large part of the reason for the production technological transformation is the improvement of technical level. The equipment needs to be improved to meet the demands of advanced productivity, thus improving the effectiveness of business operations. The related indicators include equipment operating efficiency.

2.3. Index combination weighting method for project investment optimization based on entropy weight order relation method

In this paper, the index combination weighting method based on entropy weight priority relationship is used to optimize the combination of subjective weight and objective weight to solve the optimal combination coefficient. This method makes the weight value of the index take into account the advantages of subjective weight and objective weight, so that the results of project investment risk assessment of the company are more real and effective, and conform to the actual situation.

Entropy weight method is an objective weighting method[7]. The entropy weight method determines the entropy value of each index by analyzing the change trend of each index, and then uses the entropy weight to modify the weight of each index, so as to obtain a more objective index weight.

Order relation method is a kind of subjective weighting method. Its central idea is to compare the importance of each index[8]. However, it does not compare the importance of all indicators and construct a judgment matrix. In this way, the disadvantages of the analytic hierarchy process (AHP) caused by too many indicators are avoided. The specific methods are as follows[9-11]:

(1) Quantitative treatment of indicators

According to the subjective evaluation index value, the corresponding evaluation membership degree \( V = \{V_1, V_2, ..., V_n\} \) is determined. The division of evaluation sentence should be appropriate, not too coarse or too fine. Generally 3-5 is advisable. In this paper, the subjective indexes are divided into \( V = (V_1, V_2, V_3, V_4, V_5) \). The normalized value of subjective index \( x_{ij} \) is obtained by formula 2-1.

\[
x_{ij} = \begin{cases} 
\frac{c_i - (P_i - 0.8)}{0.8}, & \text{max}(0, P_i - 0.8) \leq c_i < P_i \\
\frac{(P_i + 0.8) - c_i}{0.8}, & P_i \leq c_i \leq \min(1, P_i + 0.8) \\
0, & \text{Others.}
\end{cases}
\] (1)
Where, \( x_{ij} \) is the value of index membership degree; \( P_j \) is the parameter corresponding to the \( j \)-th comment. \( P_1 = 0, P_2 = 0.2, P_3 = 0.5, P_4 = 0.8, P_5 = 1 \), respectively.

(2) Subjective and objective empowerment
Let \( w_j \) be the weight of the \( j \)-th index item after the combination of G1 method and entropy weight method with the advantages of subjective and objective weighting method, and \( w_j \) is expressed as the linear combination of weight coefficient obtained by G1 method and weight coefficient \( w_j^p \) obtained by entropy weight method:

\[
 w_j = aw_j^p + (1-a)w_j^s
\]

In the formula, \( w_j^s \) is the \( j \)-th index weight after the combination of G1 method and entropy weight method. \( w_j^p \) is the weight coefficient obtained by G1 method. The weight coefficient of \( w_j^s \) is obtained by the entropy method. \( a \) is the subjective coefficient, which is used to adjust the degree of the subjective and objective factors affecting the overall weight coefficient. The value range is 0-1, and the value of \( a \) can be selected according to the needs. When \( a = 0.5 \), the influence of subjective and objective factors is similar.

According to the combination weight obtained by G1 entropy weight, the final score of each evaluation index is determined. If \( s_i \) is the score of the \( i \)-th composite index, then:

\[
 s_i = w_j x_{ij} \times 100
\]

Where, \( x_{ij} \) is the standardized data of the \( j \)-th sub index of the \( i \)-th index, and \( s_i \) is the final score.

(3) Comprehensive evaluation is worth giving
Due to the various attributes and types of project investment optimization index system of the company, the unit of each characteristic variable is different, and the value range is very different. Therefore, it is necessary to standardize the original measurement data and convert the attribute values of different characteristic variables into the interval \([0,1]\), so as to improve the accuracy and calculation stability of the algorithm.

\[
 x_{ij}^s = \begin{cases} 
 \frac{(x_{ij} - x_{ij}^{\min})}{(x_{ij}^{\max} - x_{ij}^{\min})}, & x_{ij} \text{ is the positive index.} \\
 \frac{(x_{ij}^{\max} - x_{ij})}{(x_{ij}^{\max} - x_{ij}^{\min})}, & x_{ij} \text{ is the negative index.} 
\end{cases}
\]

Where, \( x_{ij}^{\prime} \) is the standardized index value, \( x_{ij} \) is the \( j \)-th index value of the \( i \)-th scheme, \( x_{ij}^{\min} \) is the minimum value of the \( j \)-th index, and \( x_{ij}^{\max} \) is the maximum value of the \( j \)-th index. \( x_{ij}^{\min} \) and \( x_{ij}^{\max} \) can be obtained by searching the historical running database, and can also be determined according to the relevant mechanism analysis.

(4) Comprehensive results of project investment optimization
Based on standardized index value \( x_{ij}^{\prime} \) and combination weight weight \( r_j \), the comprehensive evaluation value of the \( i \)-th project is as follows:

\[
 y_i = \sum_{j=1}^{n} (x_{ij}^{\prime} \cdot r_j) \quad i = 1, 2, \ldots, m
\]

By ranking the scores of a single project, the investment optimization results of a single project can be obtained.

3. Conclusions
Based on the background of the new normal of power grid, from the perspective of reasonable investment in the company's project, considering the urgency and importance of the project, the risk degree of project implementation and other factors, this paper constructs the project investment...
optimization index system of the company. The evaluation model of power grid project investment is
obtained by using the combination weighting method based on entropy weight order relationship, so as
to achieve the score of each proposed investment project. This study is helpful to realize the
investment optimization of the project, strictly control the inefficient investment, eliminate the invalid
investment, and ensure the investment scale is reasonable, the direction is accurate, the structure is
optimized, and the timing is scientific.

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