Research on optimal allocation of multi level resources in large power grid enterprises

Haiyun Song*, Xiaofeng Zhang, Rui Li
State Grid Energy Research Institute Co., Ltd, Beijing 102209, China

*Corresponding author: songhaiyun@sgeri.sgcc.com.cn

Abstract. China's large power grid enterprises often need to achieve optimal allocation of resources between different levels. This paper establishes a multi-level resource allocation model of large-scale power grid enterprises based on the difference of hierarchical demand, and puts forward the allocation strategy of multi-level resource optimal allocation, and thinks that it is necessary to establish and improve the cross level power market to promote the optimal allocation of resources at different levels of power grid enterprises.

Keywords: large scale power grid enterprises, multi level, optimal allocation of resources

1. Introduction
The order of hierarchy determines the trend of resource allocation, and the upper level can seize the resources of the next level through the priority of resources. The higher level generally obtains and intercepts more resources, such as projects, funds, land indicators, etc., while the resource allocation and utilization of the lower level is relatively restrained.

There are many levels in the organizational structure of large enterprise groups. The problems of multi-level governance and optimal allocation of resources should be paid attention to. Li Xia (2017) studied the multi-level corporate governance and capital optimal allocation of state-owned enterprise groups. Wu Liping (2014) studied the multi-level internal capital market function of pyramid enterprise groups. Li Dan (2019) studied a multi-level supply chain equilibrium optimization method. However, there are few literatures on the optimal allocation of multi-level resources in large-scale power grid enterprises.

The organizational structure of China's large-scale power grid enterprises generally belongs to the straight-line functional system, and its management levels are divided into four levels: Headquarters (branches), provincial companies, prefectures and cities, and counties. From the perspective of hierarchy, the allocation of key resources of the company is affected by power grid management system, local protection and electricity price system. Due to the lack of perfect market mechanism in cross level transaction of power resources, when the situation of power supply and demand is relatively relaxed, these problems directly affect the optimal allocation of resources. Therefore, it is of great significance to study the optimal allocation of multi-level resources in large-scale power grid enterprises.
2. Resource allocation model based on hierarchy demand difference of large power grid enterprises

2.1. Problem description
The essence of multi-level optimal resource allocation of large-scale power grid enterprises is to meet the resource requirements of different levels of power companies in provinces, cities and counties. The resource requirements of different levels are different in different stages.

The problem of resource quantity allocation considering the demand difference can be described as how to determine the resource utilization \( m_t \) and individual allocation \( p_i^t \) of each stage when the total amount of resources \( m \) is insufficient. The individual (hierarchy) difference is reflected in the declared demand for total resources, and the multi-stage change of resource demand is considered to reflect the rapid growth of low-level resource demand.

2.2. Model building
The model is as follows:

\[
\text{Lexmax } p \\
p^{t-1} \prec_c p^t \\
\sum_{i=1}^{n} p_i^t \leq m \quad t = 1,2,\ldots,k \\
c_i^t \leq p_i^t \leq d_i^t \\
p_i^t \in \mathbb{Z} \quad i = 1,2,\ldots,n; \quad t = 1,2,\ldots,k
\]

Where: \( i \) represents the demand area, \( i = 1,2,\ldots,n \). \( t \) represents the demand stage, \( t = 1,2,\ldots,k \); \( m \) represents the total amount of resources, \( p_i^t \) represents the allocation amount of stage \( t \), \( c_i^t \) represents the lower limit of resource allocation in stage \( t \), \( d_i^t \) represents the demand of stage \( t \), and \( \prec_c \) represents the order symbol of size, if \( p_i^j \leq p_i^t \), then \( p_i^j \prec_c p_i^t \).

The objective function (1) indicates that the dictionary order is dominant, and the constraint condition (2) indicates that the resource allocation amount of the next stage is not less than that of the previous stage, (3) represents the resource allocation constraint, (4) indicates that the allocation amount is not greater than the demand quantity, and (5) indicates that the decision variable is an integer. When a multi-stage allocation scheme \( p^* \) cannot find another scheme \( P_t \), such that for all \( t = 1,2,\ldots,k \). If there are both \( p^* \) and \( pol \) (Pareto optimal in lexicographic order) strategy, then \( p^* \) is called lexicographic dominant scheme, and all dictionary order dominated schemes are called pol (Pareto optimal in lexicographic order) strategy.

The core problem of the multi-stage model is to determine all the conditions of the resources used in each stage. The steps of multi-stage resource allocation are as follows: firstly, the upper limit (hierarchical demand), the lower limit (the upper level allocation) and the range of resources of each stage should be determined; secondly, the improved water filling method is adopted The algorithm computes the allocation results corresponding to different allocation upper and lower limits and resource amount, eliminates some of the allocation that does not meet the conditions, and finally obtains all pol policies.

3. Multi level resource allocation strategy for large power grid enterprises
If large-scale power grid enterprises attach importance to the rapid growth of resource demand in low-level areas such as county-level power supply companies, they should reserve some resources in the early stage for later allocation to areas with rapid growth in demand, so as to form a more balanced resource allocation of provincial, municipal and county-level companies in the later stage. The more resources are
reserved in the early stage, the more resources can be allocated to low-level areas in the later stage. The more equitable the distribution results are, the higher the satisfaction of city and county-level areas is.

If large power grid enterprises pay more attention to the efficiency of resource utilization, they should make full use of all resources as early as possible. Because the demand of provincial and municipal power grid companies with more developed economy in the early stage is more sufficient, the early resources always gather in such areas. The more resources are used in the early stage, the less resources can be allocated in the later stage, and the difference of resource allocation between provinces and counties is greater.

In the multi-level resource allocation of large-scale power grid enterprise group, the most appropriate allocation scheme can be selected according to the tolerance of efficiency and fair loss, and the total amount of resources invested in different stages and the resource allocation in different levels of regions can be determined.

Among all the Pareto optimal strategies, the most effective allocation strategy always makes the gap between the resources obtained by cities and counties close to the gap of their demand, and the increased resources give priority to the cities and counties with lower demand. The fairest allocation strategy can ensure that the resource allocation of cities and counties with low demand is at least the same as that of higher demand areas, until the total resources increase to fully meet their needs.

4. Promoting multi-level resource optimal allocation by cross level electricity market

In view of the problem of multi-level resource optimal allocation in large-scale power grid enterprises, multi-channel and multi-source governance should be adopted. The market is an effective mechanism to realize the optimal allocation of resources. It is necessary to establish and improve the cross level power market to promote the multi-level optimal allocation of resources in large power grid enterprise groups.

The construction of cross level market is not to inhibit or replace the development of all levels of market, but to form Pareto improvement of each level market and realize the optimization of resource allocation in a larger range. The focus is to weaken the power of the provincial market, build a win-win market, and promote the high-quality development of the national power market. The purpose of building a cross level market is not to replace the national or provincial market, but to stimulate the coordinated development of the market at all levels by means of the market on the basis of the national and provincial market, and finally form a win-win situation of the national power market.

Cross level market is conducive to further weakening the market power of national and provincial markets, allowing users more choices, and promoting the optimal allocation of resources with full competition. At the same time, it is beneficial to realize the benefits of complementary power structure, reserve sharing and load staggering among different levels in the market way.

5. The conclusion

In this paper, a multi-level resource allocation model of large-scale power grid enterprise group based on demand difference is studied, and its resource allocation strategy is proposed. This paper holds that the efficiency and fairness of resource allocation should be considered in the multi-level resource allocation of large-scale power grid enterprise groups, and the most appropriate allocation scheme should be selected according to the tolerance degree of efficiency and fair loss, so as to determine the total amount of resources invested in different stages and the resource allocation in different levels of regions. In addition, this paper also proposes to establish and improve the cross level power market, and promote the large-scale power grid enterprise group to realize the optimal allocation of multi-level resources.

Acknowledgments

This work was financially supported by the science and technology project of the headquarters of State Grid Corporation of China, "Research on Corporate Planning Methods and Collaborative Optimization Techniques for the Development Stage of Global Enterprises". So I would like to express my gratitude to all those who have helped me during the writing of this paper.
References

[1] Xia Li, “Multi level corporate governance and capital optimal allocation of state-owned enterprise groups: a case study of COFCO”, Beijing Jiaotong University, 2017.

[2] Liping Wu, “Multi level internal capital market function of pyramid enterprise groups: a case study based on China Guodian Group”, Beijing Jiaotong University, 2014.

[3] Dan Li, “Multi level supply chain equilibrium optimization simulation under complex logistics network”, Computer simulation, 2019.