Research on Decision Method of Power Grid Project Considering Regulatory Constraints

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Abstract. A method for selecting power grid investment projects considering the regulatory specifications of transmission and distribution prices is proposed, and the plan is analyzed to provide a better implementation method for power grid planning for power grid companies in market reform.

Keywords: Regulatory Constraints, Power Grid Project, Decision.

1. Background and basic concepts
As an important infrastructure, the transmission grid plays a key supporting role in improving the operation of modern society [1]. With the gradual improvement of the level of social and economic development and the continuous advancement of urbanization, the development of power grids is facing new opportunities and challenges. The most worthwhile study is how to ensure the balance of power grid reliability and economy [2, 3]. Project portfolio theory is adapted to power grid companies. Market-oriented reforms provide useful ideas.

In the power grid investment structure, there are some projects set up mainly to achieve power grid development targets, mainly including investment in the construction and transformation of the main network and distribution network[4]. In the investment structure of this article, such projects are referred to as "basic investment projects"; Some of the projects are mainly to achieve the business objectives of power supply enterprises, including the power grid investment in a subordinate position other than the main distribution network investment such as information construction upgrades, metering equipment upgrades, etc., which are called "economic investment projects" here.

2. Project portfolio optimization ideas
Under the regulation of transmission and distribution prices, the grid business of power grid companies will also be divided into "regulated business" and "non-regulated business". Within the investment scale that the power supply company has decided, the regulated business sector (power grid regulated by transmission and distribution prices) Investment business), new projects are arranged with "strengthening investment effectiveness" as the core; the non-regulated business segment (power grid investment business that is not subject to the regulation of transmission and distribution prices) is divided into market-based business and non-market-based business, and the market-based business segment uses capital The rate of return is based on the arrangement of new projects, and the non-market business sector is based on the regulation principle.
In regulated power grid investment, “investment effectiveness” means that the planned grid investment scale does not exceed the permitted investment scale and is included in the effective asset category according to a certain proportion. Therefore, the optimization design is as follows: The premise of the total investment scale of the known power supply company; next, according to the main idea of lean investment management, the basic investment scale and economic investment scale are determined, so the hierarchical optimization idea can be used to optimize the projects in sequence.

The first step is to establish and review the priorities and investment categories of various investment projects (Distinguish the category of the projects) during the preparation and review stage of the project feasibility study. Basic investment and economic investment are divided on the basis of priority.

The second step is to determine the investment needs of reserve projects in the project database that are in the basic investment priority according to the annual investment planning reports and the current scale and predicted load of the power grid. Furthermore, the basic investment requirements of the power grid can be met.

The third step is to determine the key data of the economic investment priority reserve project in the project database according to the annual planning report and the current scale and predicted load of the power grid. So as to calculate the economic investment demand of the power grid.

The fourth step is to optimize the investment structure in layers according to the project arrangement method that the basic investment must be resolved and the economic investment comprehensive evaluation optimal.

Design the grid investment structure optimization analysis tool as shown in Figure 1. The vertical queue represents the dimension of the investment's centralized professional category, and the horizontal queue represents the project after optimization and sorting. Cumulative value of investment in different professional project queues.

![Figure 1. Optimization analysis of grid investment structure](image)

First of all, through the project optimization ranking and rigid investment division results, the calculation formula for determining the rigid investment results of regulated power grid investment is

$$I_{r,fix,y} = \sum_{i=1}^{f_r} I_{x_i,y}$$

(1)
In the formula, $I_{r,\text{fix}_y}$ is the total amount of rigid investment for regulated power grid investment of category $y$, $f_y$ is the number of projects that are classified as rigid investment for the corresponding professional reserve project queue in the project database.

Furthermore, the scale of grid economic investment can be obtained, that is, the allowable investment scale is used to deduct the rigid investment scale.

$$I_{r,\text{economy}} = I_r - I_{r,\text{fix}}$$

In the formula, $I_{r,\text{fix}}$ represents the scale of investment in the rigid grid of regulated businesses, $I_{r,\text{economy}}$ represents the scale of regulated economic investment.

$I_r$ needs to consider different situations under the constraints of allowable investment scale when optimizing the investment structure, and further judge the calculated value of economic investment scale.

3. Situation analysis

Situation 1: $I_{r,\text{economy}} \geq 0$

At this time, the permitted investment scale is greater than the rigid demand for power grid investment, and the permitted investment scale can meet the basic needs of power grid development. On this basis, economic investment projects can be appropriately arranged. Based on "construction", the use of investment structure analysis and optimization diagrams can effectively arrange the total Economic investment projects of scale $I_{r,\text{economy}}$.

Situation 2: $I_{r,\text{economy}} < 0$

At this time, the permitted investment scale is smaller than the rigid demand for grid investment, and the permitted investment scale cannot meet the basic needs of grid development. The permitted investment scale here is based on the result of the optimization of the grid investment scale in 5.1, that is to say, this situation is an investment The scale optimization strategy has failed. At this time, it is necessary to make some adjustments to report the actual user load growth and corresponding grid investment needs to the regulator. The regulator is urged to expand the scale of grid investment in the current period, and formulate the planned investment scale according to the investment plan of the rolling revision of the grid plan. The target transmission and distribution price shall be submitted to the regulatory authority for approval.

If the regulator allows mid-term adjustments, given the permitted investment scale, adjusting the transmission and distribution price will select different professional projects from the project library. At this time, the adjusted new assets are included in the current new permitted income, which is an ideal situation.

A more likely mode of behavior for regulators is to allow power supply companies to expand a certain scale of grid investment, but do not include grid investment that exceeds the permitted scale in the permitted grid investment in this cycle, and do not adjust transmission and distribution prices. Among them, the adjustment of the permitted investment scale is included in the new effective assets in the next cycle, and no income is accrued in this cycle, and the income is accrued in the next cycle.

A rare case is that regulators are not allowed to expand the scale of investment, and power supply companies are squeezing investment. In order to adapt to the permitted investment scale, some rigid investment projects are reduced. This will cause the power grid operation level to drop and the operation and maintenance fee rate to soar.

After calculating regulated power grid investments, unregulated power grid investments can be made. These investments can be selected based on a comprehensive evaluation of factors such as business market size, profitability, and company business can be configured appropriately.
4. Case analysis

In the actual situation, we selected a city’s power grid investment plan. The total investment scale revealed in the 2019 plan is 6.808 billion yuan. According to the established power grid investment strategy, the project classification and project ranking are carried out. The results show that 5.263 billion yuan is Regulated power grid investment, 817 million yuan is unregulated power grid investment, and the approved investment scale that has been approved is 4.935 billion yuan. It can obviously calculate $I_{r,economy} > 0$, but $I_{r,economy}$ is very small, which shows that the investment situation directed by regulatory rules is relatively tight, and grid companies should strengthen the intensive use of power grid investment funds, revise the power grid investment plan, and try to point the investment plan towards effective asset investment.

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