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Evaluation of Regional Power Grid Investment Capacity Based on Transmission and Distribution Price Reform

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Abstract. The transmission and distribution price reform has changed the profit model of the power grid, and a reasonable assessment of the investment capacity of the regional power grid is critical to the future investment planning of the power grid. To this end, first of all, sort out the key index system of power grid investment capacity for transmission and distribution price reform. Then comprehensively consider the available distribution profit, depreciation and external financing of the power grid, and establish a quantitative model of power grid investment capacity; Finally, the ability to invest in the establishment of quantitative models to measure the ability of a power grid investment companies, investment capacity is calculated after the reform of the electricity transmission and distribution, in order to verify the ability to quantify the investment rationality and effectiveness of the model. Finally, taking three power companies as examples, the feasibility of the model and the rationality of investment capacity evaluation are verified.

1 Introduction

According to the "Several Opinions on Further Deepening the Reform of the Electric Power System" (Zhongfa [2015] No. 9) issued by the State Council of the Communist Party of China, the focus of the new round of power system reform is to orderly promote the reform of transmission and distribution prices [1]. Transmission and distribution prices are based on the principle of "permitted cost plus reasonable income" Accounting by voltage level, the supervision of transmission and distribution price will change the profit model of the regional distribution network, and the operating profit of the regional distribution network will be affected, thus affecting the investment capacity of the regional distribution network [2-3]. Reasonably assessing the investment capacity of the regional distribution network and judging whether the regional distribution network can meet future investment planning requirements is of great significance for the precise investment and development of the regional distribution network.

Quantitative analysis of regional distribution network investment capacity refers to quantifying the net cash flow generated by regional distribution network power companies through operating activities and financing activities, and based on this investment capacity to analyze whether the power grid has the ability to meet future investment needs. Consider the operation level and growth needs of the enterprise [4-5]. The current research on the investment capacity of regional distribution networks is mainly divided into two aspects: investment capacity evaluation and investment capacity quantification. Reference [6] established a grid investment capability index system from the perspectives of grid operation benefits, operating efficiency, development status, and social benefits, and evaluated grid investment capabilities based on a technique for order preference by similarity to ideal solution (TOPSIS). Reference [7] compared market evaluation indicators based on market structure, market performance, and market supply and demand perspectives, and analyzed the theoretical characteristics of various types of indicators and the advantages and disadvantages of their applications, laying a foundation for the analysis and evaluation of grid investment capabilities.

Quantitative analysis of grid investment capacity is still in the preliminary stage of investigation, and most literatures carry out quantitative calculation of investment capacity from the perspective of the source of investment funds. Literature [8] proposed a multi-region grid investment capacity measurement method based on the asset-liability ratio, combining the grid performance factors with asset factors to calculate the distribution coefficient, and the asset-liability ratio as the limit to calculate the grid investment capacity in different regions. Literature [9] analyzed the changes in transmission and distribution prices under the control of transmission prices based on the return on investment, price caps, and income caps, and the impact on grid investment capacity. Reference [10] calculates the external financing capacity of grid companies based on the asset-liability ratio, and calculates the grid investment capacity from the perspective of retained profits, depreciation and financing. Reference [11] based on the system dynamics, analyzed the relationship

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between grid investment and grid efficiency indicators, and built a measurement model for investment capacity. Literature [12] established a multi-objective optimization model to reduce network loss and improve voltage stability, while considering an investment planning method for environmental cost analysis.

This paper considers the impact of transmission and distribution price reforms, and combines key indicators such as electricity, electricity prices, and costs to build a quantitative model of grid investment capacity, and analyzes the grid's investment capacity based on the established quantitative model. Finally, the investment established in this article is analyzed. The capacity quantification model is applied to a certain grid company to verify the rationality and effectiveness of the investment capacity quantification model.

2 Construction of Key Indicator System for Regional Distribution Network Investment Capability Considering Transmission and Distribution Price Reform

The transmission and distribution price reform will affect the profitability of regional distribution networks, and the new regulatory system will also affect the investment capacity of regional distribution networks. Therefore, for the construction of the key indicator system for the investment capacity of the regional distribution network, in addition to the conventional indicators such as electricity, electricity prices, and profits, this paper also considers the original value of fixed assets, permitted costs, and permitted returns.

2.1. Transmission and Distribution Price Approval Principles

Under the new round of power market reforms, transmission and distribution prices were verified at different voltage levels in accordance with the "Provincial Grid Transmission and Distribution Pricing Method (Trial)" and the "permissible cost plus reasonable income" principle [16-18], which strengthened the operation of power grid enterprises In all aspects of cost and electricity supervision, the grid only charges "over-grid fees", which results in a change in the profit model of the grid. In addition, the approval of transmission and distribution prices is based on the effective assets of the grid. Current investments will affect future transmission and distribution. The transmission and distribution price actually determines the electricity sales price of the grid company to the user. The electricity sales price is y_{sh} and the transmission and distribution price is x_{xp}.

$$y_{sh} = x_{xw} + x_{xp} + x_{gj} \tag{1}$$

In the formula, x_{xw} is the feed-in tariff; x_{gj} is a government fund.

According to the provincial transmission and distribution price pricing method, the calculation formula for the transmission and distribution price is shown in the formula.

$$x_{sp} = r_x / Q_g \tag{2}$$

In the formula, r_x is the permitted income; Q_g is the total electricity.

Permitted income includes three parts: allowable cost, allowable income, and taxes. Depreciation expenses are calculated by multiplying the depreciated fixed assets by the comprehensive depreciation rate; operation and maintenance expenses can be obtained by multiplying the original value of fixed assets by the operation and maintenance expense rate; permitted income is generally obtained by valid assets multiplied by the permitted return rate. It can be seen that the approval of transmission and distribution prices depends to a large extent on the fixed assets of the power grid. Therefore, in the quantification of the investment capacity of the power grid, indicators such as the original value of fixed assets, permitted costs, and permitted returns need to be considered.

2.2 Quantitative model of investment capacity

Based on the three major financial statements of an enterprise, it is possible to sort out the internal operating indicators of the enterprise. Among them, the most important indicators affecting the investment ability of the enterprise are the cash flows from operating activities, investment activities, and financing activities in the cash flow statement. The investment capacity measurement model is based on the balance of the net flow of monetary funds invested by grid companies at the end of the year and the sum of the net flow of monetary funds generated by the financing activities, operating activities and investment activities of the current year (the current year is the forecast period). The relationship is as follows:

$$\mathrm{IC_m} - \mathrm{IC_c} = \mathrm{O_c} + \mathrm{F_c} + \mathrm{Q_c} + \mathrm{IA} - \mathrm{IA_c} \tag{3}$$

Where $\mathrm{IC_m}$ is the amount of monetary funds invested at the end of the year, $\mathrm{IC_c}$ is the amount of monetary funds invested at the beginning of the year, and $\mathrm{O_c}$ is the net cash flow from operating activities, and $\mathrm{F_c}$ is the net cash flow from financing activities, and $\mathrm{Q_c}$ is the net cash flow from other activities. In the formula, IA is the inflow of monetary funds from investment activities, and $\mathrm{IA_c}$ is the outflow of monetary funds from investment activities.

The value of the monetary capital outflow generated by the above-mentioned investment activities is the value of the grid company's ability to invest, which is, the investment capacity of the company, so the above relationship can be transformed into:

$$\mathrm{I_c} = \mathrm{O_c} + \mathrm{F_c} + \mathrm{Q_c} + \mathrm{IA} - \left(\mathrm{IC_m} - \mathrm{IC_c}\right) \tag{4}$$

In the formula, I_c is the investment capacity of the enterprise, and $(IC_m\text{-}IC_c)$ means is the safety reserve change amount of the enterprise.

2.3. Construction of Key Indicator System for Investment Capability of Regional Distribution Networks Considering Transmission and Distribution Price Reform

The measurement model based on the constrained asset-liability ratio measures the solvency of grid companies and is established on the basis of financial investment analysis.

$$I_c = O_c + F_c + Q_c + IA - BF \quad (5)$$

Where BF is the change in security reserve.

The model is further broken down as follows:

(1) Net flow of monetary funds from financing activities during the forecast period

$$F_c = \frac{L_{RD} \times QY \times L_z}{(1-L_z) \times FZ_s/DF_s + L_z \times L_R \times (1-L_J) \times (1-L_s)} - DF_S - SY \quad (6)$$

In the formula, LRD is the on-hand financing rate, and QY is the interest with interest, and LZ is the assessment asset-liability ratio, and FZs is the total debt of the previous year in the forecast period, and DFs is the balance of interest-bearing liabilities of the previous year in the forecast period, and LR is the financing cost rate, and LJ is the loan Interest capitalization rate, Ls is the income tax rate, and SY is the return on investment income.

(2) Net cash flow from operating activities of the company during the forecast period

$$O_c = R_{xs} \times (1 - L_s) + ZJ + X_{ZB} + ZS - GY - R_T \quad (7)$$

Where R_{xs} is the profit before interest and tax for the forecast period, L_s is the income tax rate, ZJ is the depreciation expense during the forecast period, X_{ZB} is the change in net working capital during the forecast period, ZS is the asset impairment loss during the forecast period, and GY is the gain from changes in fair value during the forecast period R_T is the investment income for the forecast period.

(3) Net cash flows from other activities during the forecast period

$$Q_c = Z_{QY} \quad (8)$$

In the formula, Z_{QY} accepts equity investment (fiscal funds, capital injection from headquarters, etc.) during the forecast period.

(4) Monetary capital inflows from investment activities during the forecast period are predicted based on data from previous year's cash flow statements.

(5) Changes in security reserves during the forecast period

The specific steps of gray prediction are as follows:

$$BF = BF_S - BF_Y \quad (9)$$

In the formula, BF_S is the minimum security reserve in the previous year in the forecast period, BF_Y is the minimum security reserve in the forecast period, and the minimum security reserve is the basic input index.

3 Example analysis

In this section, H, I, and T grid companies are used as examples. The investment capacity measurement model and sensitivity analysis model based on asset-liability ratio constraints are used to conduct empirical analysis of their investment capacity and sensitive factors.

The actual asset-liability ratio levels and investment scales of H, I, and T three grid companies from 2017 to 2018, and the planned data from 2019 to 2020 are shown in Table 1

Tab. 1 Basic data table (ten thousand yuan)

Enterprise	Index	2017	2018	2019	2020
H	Assets and liabilities(%)	56.83	54.95	55.50	55.00
	Actual investment	3461417	4334549	--	--
I	Assets and liabilities(%)	63.29	63.29	62.00	60.00
	Actual investment	2625895	2625895	--	--
T	Assets and liabilities(%)	73.79	71.15	69.98	69.36
	Actual investment	2596225	1690472	--	--

Based on the actual data of H, I, and T three grid companies from 2017 to 2018 and the planned data of 2019 to 2020, the investment capabilities of H, I, and T three grid companies are obtained under the constraint of asset-liability ratio levels As shown in Table 2.

Tab. 2 Analysis of investment capacity under rated asset-liability ratio (10,000 yuan)

Enterprise	Years	Measured investment	Amount of own funds	Amount of loan funds
H	2019	4282952.3689	3738977.9781	543974.3908
	2020	5332301.1680	4787869.3229	544431.8451
I	2019	4067585.8191	3590004.5213	477581.2978
	2020	4165929.7303	3846489.4544	319440.2759
T	2019	1372332.8376	1021132.0258	351200.8118
	2020	1248120.2641	822500.2510	425620.0131

According to calculations, under the constraint of a 55.50% asset-liability ratio in 2019, H grid companies have calculated an investment capacity of 42.83 billion yuan. In 2020, they have obtained an investment capacity under the condition of an estimated asset-liability ratio of 55.00%. It was 53.32 billion yuan. Under the constraint of an asset-liability ratio of 62.00% in 2019, I Power Grid Corporation has calculated an investment capacity of 40.68 billion yuan. In 2020, with an estimated asset-liability ratio of 60.00%, the estimated investment capacity is 41.66 billion yuan. Under the constraints of a 69.98% asset-liability ratio in 2019, T Grid Corporation's estimated investment capacity is 13.72 billion yuan. In 2020, with an estimated asset-liability ratio of 69.36%, the estimated investment capacity is 12.48 billion yuan.

4 Conclusion

Considering the impact of transmission and distribution price reform, this paper first establishes a new quantitative model of regional distribution network investment capacity. Based on the comprehensive consideration of conventional indicators such as available distribution profit, depreciation and external financing of regional distribution network, it constructs a key indicator system of regional distribution network investment capacity, and then calculates the investment capacity of regional distribution network. Finally, taking three power companies as examples, the feasibility of the model and the rationality of investment capacity evaluation are verified.

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