

Research on the Measurement of Investment Capability of Electric Power Enterprises based on Financial Index and Investment Balance

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Abstract. The transformation of energy structure and the reform of electric power system bring new challenges to the investment mechanism of electric power enterprises. How to establish a scientific and effective estimation method of investment capability is the key to maximize the investment benefit of electric power enterprises. Based on the actual operation of a power enterprise in a certain area, considering the constraints of financial operation index, static and dynamic investment balance, the investment capability calculation model of electric power enterprises is established. On this basis, the above model is applied to calculate the investment capacity of electric power enterprises. The results of numerical examples prove the validity of the proposed model and provide decision support for power enterprises to maximize their investment benefits.

Keywords: maximize the investment; transformation of energy structure; static and dynamic investment balance; calculate the investment capacity model.

1. Preface

Under the influence of national macroeconomic regulation and adjustment of energy structure, the total consumption of electricity in China has been slowing down, and the risk of power grid investment has gradually increased. [1] On the one hand, the downward pressure of the economy increases the risk points of market investment, the importance of investment decision-making is increasingly prominent, and the difficulty increases accordingly. On the other hand, energy structure transformation and power system reform bring new challenges to the investment mechanism of electric power enterprises. The rapid development of clean energy makes enterprises need to consider more factors in investment decisions. [2] Therefore, a scientific and effective investment capacity measurement method is the key to maximize the investment benefit, and is conducive to accurately grasp the future development trend of power grid investment capability.

At present, there are many literatures on investment decision-making of electric power enterprises at home and abroad. Abakr YA et al. take the combined cycle power plant as an example to evaluate the fixed assets investment benefit of power generation enterprises.[3] Cabrera Tobar et al. predicted the investment capacity of large photovoltaic power plants and established the investment allocation model.[4] Zhao Huiru et al. introduced the concepts of return on investment and operation coefficient, and constructed a quantitative model of investment capacity of electric power enterprises.[5] Based on the theory of system dynamics, Wang Liang constructed a linkage model between grid investment planning and key value indicators.[6] In addition, Xu Xiaomin built an index system of influencing factors of investment capability, and studied the internal and external factors affecting the investment ability of power enterprises based on grey clustering analysis and path analysis.[7]

This paper makes an in-depth study on the prediction of investment capacity of power enterprises. First, taking asset liability ratio and total profit as constraints, and taking the maximization of investment capacity as the optimization objective, a single constraint investment capability calculation model is constructed. Considering the constraint of asset liability ratio and total profit constraint, a calculation model based on the constraint of operating level is established. Secondly, considering the sources of funds such as loans and distributable profits, a static investment balance

model is built. Based on this, considering the time value of loans and repayment, a dynamic investment balance model is established. Finally, the above model is applied to measure the investment capacity of power enterprises, and the results of numerical examples prove the validity of the proposed model.

2. Estimation of Investment Capacity based on Financial Operating Index Constraints Model

Usually, the construction investment of electric power enterprises mainly comes from loans and self-financing (i.e. profit distribution). The main factor affecting the loan is the asset liability ratio of the enterprise, which is directly related to the total liabilities. The main factor affecting the self-financing is the total profit of the enterprise, which is directly related to the electricity consumption, the electricity price and the operating cost from the distribution profit.

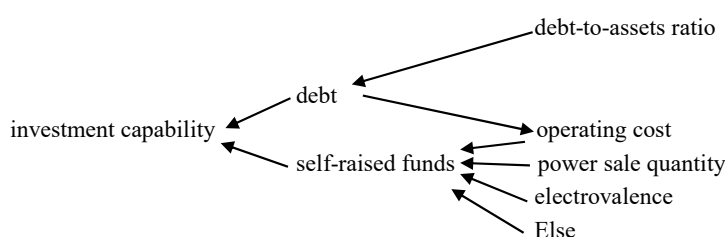


Figure 1. The relationship between the factors affecting the investment capacity

In order to simplify the calculation, the following assumptions are put forward when constructing the investment capacity measurement model of electric power enterprises.

Firstly, the operating expenses C_1 increase regularly and have nothing to do with the investment amount. Assuming that the growth rate of operating expenses m can be estimated through calendar year data, that is, the operating expenses of the year = the operating expenses of the previous year + the operating expenses of last year \times the growth rate of operating expenses. The operating expenses at the end of the year (1) are shown as follows:

$$C_1 \times (1+m) \quad (1)$$

Secondly, the management expenses C_2 increase regularly and have nothing to do with the investment amount. Assuming that the growth rate of management fees n can be estimated through calendar year data, that is, the management cost of the year = the management cost of the previous year + the management fee of last year \times the growth rate of administrative expenses. The cost of management at the end of the year (2) is shown as follows:

$$C_2 \times (1+n) \quad (2)$$

Third, the financial cost C_3 is related to the loan amount of the year, that is, the financial cost of the year = the financial cost at the end of the previous year - the interest expense reduced at the end of last year's repayment + the interest expense added to the loan that year. The financial costs C_3 of the end of the year (3) are as follows:

$$\begin{aligned} C_3^i &= C_3^{i-1} - H^{i-1}r + I_1^i r \\ &= C_3^{i-1} + (I_1^i - H^{i-1})r \quad i = 1, \dots, 5 \end{aligned} \quad (3)$$

In the form, $I_1^i - H^{i-1}$ represents the amount of loan required to calculate interest at the end of the year; C_3^i represents the financial cost at the end of the year i ; I_1^i indicates the loan amount at the beginning of the year; H_{i-1} indicates the amount of repayment at the end of the year $i-1$; r is the annual interest rate for the loan; H is the amount of repayment for that year; and I_1 is the amount of the loan that year.

2.1 Asset-liability Ratio-constrained Investment Capacity Measurement Model

(1). objective function

Asset liability ratio is the main factor that affects the loan of enterprises. The increase of loans will cause the increase of financial expenses, and to a certain extent, affect the scale of self-financing. Therefore, it is necessary to calculate the optimal investment scale at a certain level of asset-liability ratio. The model takes the maximum investment capacity of power enterprises as the optimization objective, and calculates the investment capacity of power enterprises under the constraint of given asset-liability ratio. The objective function (4) shows:

$$\max I = I_1 + I_2 \quad (4)$$

In the formula, I express the investment capacity of the year, I_1 indicates the amount of the loan in the year, and I_2 expresses the self-financing fund in the year.

$$I_1 = (f - f_0 + H) / (1 + \delta) \quad (5)$$

In the formula, f is the total amount of liabilities of the year; f_0 is the total liabilities of the company at the end of the year; H is the amount of repayment of the year; δ indicates that the other liabilities added in the year are δ times of the loan amount, the value depends on the operating conditions of different enterprises over the years.

$$\begin{aligned} I_2^i = & [(Q^i P^i + B^i) - (\frac{Q^i P_1^i}{1-\lambda} + C^i) - C_1(1+m)^i - C_2(1+n)^i \\ & - (C_3^{i-1} + (I_1^i - H^{i-1})r) - \frac{T^{i-1}}{Q^{i-1}P_1^{i-1} + B^{i-1}} \\ & \times (Q^i P^i + B^i) + O^i] \times (1 - 25\%) \quad i = 1, \dots, 5 \end{aligned} \quad (6)$$

I is the i year when the planning period begins; Q_i is the sales volume for the i year; P_i and P_1^i are the sales price (excluding tax) and the purchase price (excluding tax) of year i , respectively.

B_i and C_i are the other main business income and other main business costs in i , respectively; T_{i-1} is the main business tax and supplement for $i-1$; r is the annual interest rate for loans; O_i indicates other items, including investment income, off-business profit and loss of impairment of assets, etc. λ is line loss rate.

(2). constraint condition

a. The ratio of assets to liabilities should be less than a required maximum in order to obtain the maximum investment capacity under constraints.

$$\eta = \frac{f}{W} \times 100\% \leq \varepsilon \quad (7)$$

In the formula, η is the ratio of assets and liabilities; ε is the maximum asset liability ratio required; W indicates the total assets at the end of the year; the total liabilities at the end of the year f , is equal

to the amount of liabilities added at the beginning of the year plus the deduction of the amount of repayment of the year. That is:

$$f = f_0 + I_1(1 + \delta) - H \quad (8)$$

b. If the electric power enterprises invest in assets every year, the total assets at the end of the year = the total assets at the beginning of the year + the new assets in the year. Suppose that all loans were used for investment, and a certain proportion was drawn from the distributable profits for various investments. The total assets invested in that year amounted to a certain proportion of the total investment amount. The total assets at the end of the year i are:

$$W^i = W_0^i + (I_1^i + I_2^i e)\beta \quad i = 1, \dots, 5 \quad (9)$$

In the formula, W_i is the total assets at the end of the year i ; W_0^i are the total assets at the beginning of the year i ; $(I_1^i + I_2^i e)\beta$ is the total amount of new assets added in the year i ; e indicates the ratio of the investment cost extracted from the distributive profits; and β is the ratio of total assets investment to total investment.

2.2 Investment Capability Measurement Model with Total Profit Constraints

(1). objective function

Usually, the factors affecting the total profit of power enterprises mainly include electricity sales, purchase and sale price, cost and loan amount. Assuming that the price and quantity of electricity purchased and sold can be measured, the factors affecting the investment capacity of enterprises are cost and loan amount. The model takes the maximum investment capacity of power enterprises as the optimization objective, and calculates the investment capacity of power enterprises under the constraint of total profit. The objective function (10) shows:

$$\max I = I_1 + I_2 \quad (10)$$

(2). constraint condition

Total profit refers to pretax profit, that is, the sum of main business profits and other items. The main business profit = main business income - main business cost - all costs - taxes and fees. The total profit should be greater than a required minimum value in order to obtain the maximum investment capacity under constraints.

$$\begin{aligned} Y^i = & (Q^i P^i + B^i) - \left(\frac{Q^i P_1^i}{1 - \lambda} + C^i \right) - C_1(1 + m)^i - C_2(1 + n)^i \\ & - (C_3^{i-1} + (I_1^i - H^{i-1})r) - \frac{T^{i-1}}{Q^{i-1} P_1^{i-1} + B^{i-1}} \\ & \times (Q^i P_1^i + B^i) + O^i \geq \theta \quad i = 1, \dots, 5 \end{aligned} \quad (11)$$

$$\text{That is: } Y^i = \frac{I_2^i}{(1 - 25\%)} \geq \theta \quad (12)$$

In the formula, Y_i is the total profit of the year i ; θ is the target constraint of the minimum total profit (given).

2.3 Investment Capability Measurement Model Constrained by Operating Level

(1). objective function

This model takes the maximum investment ability of electric power enterprises as the optimization objective, and calculates the investment ability of electric power enterprises under the constraint of given asset liability ratio and total profit. The objective function (13) shows:

$$\max I = I_1 + I_2 \quad (13)$$

(2). constraint condition

a. the balance of assets and liabilities

The ratio of assets to liabilities should be less than a required maximum in order to obtain the maximum investment capacity under constraints. That is:

$$\eta = \frac{f}{W} \times 100\% \leq \varepsilon \quad (14)$$

$$f = f_0 + I_1(1 + \delta) - H \quad (15)$$

$$W^i = W_0^i + (I_1^i + I_2^i e) \beta \quad i = 1, \dots, 5 \quad (16)$$

b. constraint of total profit

The total profit should be greater than a required minimum value in order to obtain the maximum investment capacity under constraints.

$$\begin{aligned} Y^i &= (Q^i P^i + B^i) - \left(\frac{Q^i P_1^i}{1 - \lambda} + C^i \right) - C_1(1 + m)^i - C_2(1 + n)^i \\ &\quad - (C_3^{i-1} + (I_1^i - H^{i-1})r) - \frac{T^{i-1}}{Q^{i-1} P_1^{i-1} + B^{i-1}} \\ &\quad \times (Q^i P_1^i + B^i) + O^i \geq \theta \quad i = 1, \dots, 5 \end{aligned} \quad (17)$$

$$\text{That is: } Y^i = \frac{I_2^i}{(1 - 25\%)} \geq \theta \quad (18)$$

3. Investment Ability based on Static Investment Balance Calculation Model

The income and cost of self-financing (distributive profit) of electric power enterprises can be calculated according to the average growth rate of historical data, and the loan amount indirectly affects the self-raised funds through financial expenses. The loan amount of the model directly determines the annual investment capacity, and the loan amount can't be estimated through historical data, if the loan amount is known. The investment ability based on static investment balance is:

$$I = I_1 + I_2 \times e \quad (19)$$

In the formula, the ratio of investment cost to power enterprises e , that is, the proportion of investment cost derived from distributable profits, can be estimated according to the average value of investment cost ratio of enterprises over the past years.

4. Investment Ability based on Dynamic Investment Balance Calculation Model

The time value of loan amount and repayment amount is considered in the investment capacity calculation model based on dynamic investment balance. If the loan amount is given each year, the scale of investment is divided into two parts, one is the loan amount of the year, and the other is a certain proportion from the distributive profit.

$$I^i = I_1^i + I_2^i \times e^i \quad (20)$$

$$I_2^i = \left\{ (Q^i P^i + B^i) - \left(\frac{Q^i P_1^i}{1-\lambda} + C^i \right) - C_1(1+m)^i - C_2(1+n)^i - (C_3 + [\sum_{j=1}^i (I_1^j(1+t) - H^j)(F/P, t, j)]r) - \frac{T^{i-1}}{Q^{i-1}P_1^{i-1} + B^{i-1}} \times (Q^i P^i + B^i) + O^i \right\} \times (1-15\%) \quad i=1, \dots, 5 \quad 1 \leq j \leq i \quad (21)$$

In the formula, i is the i th year from the planning period; e^i is the proportion of the investment cost extracted from the profit in the i th year; t is the discount rate; r is the annual interest rate for the loan; λ is the line loss rate for the year; I_1^j is the loan amount at the beginning of j th year; H^j is the amount of repayment at the end of the j th year; Q^i represents the sale of electricity for the i th year; P^i and P_1^i indicate the electricity sales price (excluding tax) and Purchase price (excluding tax) for the i th year, respectively; B^i and C^i are the other main business income and other main business costs for the i th year; and other main business income and other main business costs of the year; T^{i-1} is the main business tax and surcharge for the $(i-1)$ th year; O^i is other items, including investment income and asset impairment losses.

5. An Example Analysis

According to the prediction of power enterprises' investment ability, according to the actual operation condition of an electric power enterprise in a certain area for 2012-2016 years, and based on the above investment capability calculation model, the investment capacity of 2017-2019 years is calculated.

5.1 Measurement and Analysis of Investment Capability based on Financial Index Constraints

(1). Calculation results of investment capacity constrained by asset and liability ratio

The results of investment capacity calculation based on different asset-liability ratio levels are shown in tables 1-3.

Table 1. Results of Investment Capacity Estimation in 2017 (10,000 yuan)

η	0.75	0.74	0.73	0.72	0.71
I	675651	666296	656941	647585	638230
II	522849	513092	503334	493576	483819
$I2$	152801	153204	153606	154009	154411
f	3293210	3249301	3205391	3161482	3117572

Table 2. The results of investment capacity measurement in 2018 (10,000 yuan)

η	0.75	0.74	0.73	0.72	0.71
I	701697	691703	681709	671716	661722
I_1	538885	528461	518038	507614	497190
I_2	162811	163241	163671	164101	164531
f	3518036	3471128	3424221	3377314	3330407

Table 3. The results of investment capacity measurement in 2019 (10,000 yuan)

η	0.75	0.74	0.73	0.72	0.71
I	693029	682602	672175	661747	651320
I_1	527378	516502	505626	494750	483874
I_2	165651	166099	166548	166997	167445
f	3670590	3621649	3572708	3523766	3474825

As can be seen from table 1~3, when the asset liability ratio changes from 0.7 to 0.75, the annual investment ability of power enterprises gradually decreases with the reduction of the ratio of assets and liabilities, but the rate of change is small, and the annual investment capacity can reach more than 6 billion yuan.

(2). The result of the calculation of the investment capacity constrained by the total profit

The profit is not negative as the minimum total profit requirement. It calculates the investment capacity under the total profit constraint of 2015 and 2016 (65510 yuan and 884 million yuan respectively). The result is shown in Table 4.

Table 4. Results of Investment Capacity Estimation for 2017-2019 (10,000 yuan)

Particular year	Y	0	65510	88400
2017	I	4227131	3085171	2686156
	I_1	4227131	3036038	2619856
	I_2	0	49132.5	66300
2018	I	4485844	3343881	2944867
	I_1	4485844	3294749	2878567
	I_2	0	49132.5	66300
2019	I	4543166	3401208	3002193
	I_1	4543166	3352075	2935893
	I_2	0	49132.5	66300

As can be seen from table 4, the annual investment ability of power enterprises gradually decreases with the increase of profit constraint amount, and the annual investment capacity can reach more than 40 billion yuan at the lowest level of profit.

(3). Calculation result of investment ability of management level constraint

This section considers the asset liability ratio and the total profit constraint. When the asset liability ratio is 0.75 and the total profit is 0, the investment capacity of the next 3 years is estimated. The results are shown in Table 5.

Table 5. The results of investment capacity estimates for 2017-2019 (10,000 yuan)

Particular year	2017	2018	2019
I	675651.3	701697.5	693029.6
I_1	522849.7	538885.7	527378.2
I_2	152801.6	162811.9	165651.4

After comparing and analyzing the table 1~5, we can see that under the constraint of asset liability ratio and total profit at the same time, the main factor that affects the investment ability of electric power enterprises is the asset liability ratio. The constraint condition of the total profit will not affect the result of the calculation model.

5.2 Measurement and Analysis of Investment Capability based on Static Investment Balance

The loan amount is given according to the estimated capital gap of the power enterprise every year. If the ratio of investment to be allocated from the distributable profit is =1, the static investment ability of the next 3 years is calculated. The result is shown in Table 6.

Table 6. The results of investment capacity estimates for 2017-2019 (10,000 yuan)

Particular year	2017	2018	2019
K	2064556.8	2122233.5	2029426.1
I_1	458790.4	471607.5	450983.6
I_2	155444.0	165587.1	168802.5
I	614234.4	637194.5	619786.1

Notes: In order to add new liabilities to each year; K

Because the income and cost in the distributive profit can be calculated through historical data, the annual loan amount indirectly affects the distributive profit through the financial cost. Therefore, the annual loan amount will directly determine the annual investment capacity, and the minimum annual investment capacity is 6.1 billion yuan.

5.3 Measurement and Analysis of Investment Capability based on Dynamic Investment Balance

According to the calculation method of the investment ability of static investment balance, after considering the time value of loan amount and repayment amount, the dynamic investment ability of the next 3 years is calculated. The result is shown in Table 7.

Table 7. Results of investment capacity estimates for 2017-2019 (10,000 yuan)

Particular year	2017	2018	2019
II	458790.40	471607.45	450983.58
I_2	113482.47	95503.27	82460.27
I	572272.86	567110.72	533443.84

From Table 6 to 7, we can see that the value of investment capacity based on dynamic investment balance is slightly lower than that based on static investment balance, but the difference is not obvious.

6. Conclusion

Aiming at the problem of investment capability prediction of electric power enterprises, this paper establishes a set of investment capability estimation model based on the actual operation situation of enterprises. Starting from the constraints of financial management indicators, static investment balance constraints and dynamic investment balance constraints, a forecasting system of power enterprises' investment ability including three seed models is constructed. In the example analysis, we calculate the investment ability of a regional power enterprise in the next 3 years, and get the conclusion under different constraints. The effectiveness of the proposed method is verified by an example. In addition, there are still some deficiencies in the research content of this paper. For example, in the investment capability calculation model based on financial operation index constraint,

we can consider a variety of financial indicators comprehensively, to realize the comprehensiveness of factors.

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