Evaluation of Investment Benefits of Distribution Network Based on System Dynamics

Ming Zhao, Chenghua Wang, Yang Wang, Li Chen
State Grid Anhui Power Company Chuzhou Power Supply Company, Anhui, China.

Abstract. All manuscripts must be in English, also the table and figure texts, otherwise we cannot publish your paper. Please keep a second copy of your manuscript in your office. When receiving the paper, we assume that the corresponding authors grant us the copyright to use the paper for the book or journal in question. Should authors use tables or figures from other Publications, they must ask the corresponding publishers to grant them the right to publish this material in their paper.

Key words: Open market environment, transmission and distribution price regulation, power grid investment, benefit evaluation.

1. Research background on investment benefit of distribution network
At present, China's power system reform has entered the stage of deepening the implementation, power market construction has achieved rich results, the provincial power market has been put into operation, electricity price transmission mechanism further sound. In the field of distribution network, "Incremental distribution network Project" has been be open to social capital, whether it is to the traditional grid enterprises or to invest in the expansion of the network industry chain of other market players, are good investment opportunities.

In the research field of power grid investment income evaluation, the main research methods are comprehensive evaluation, such as literature [1] in this paper, the evaluation model of distribution network investment benefit is constructed from the aspects of overall investment benefit and individual project investment benefit. Literature [2] constructs the evaluation index system of power grid operation efficiency, evaluates the operation efficiency of power system by analytic hierarchy process, analyzes the main factors that affect the operation efficiency of power grid, and provides technical support for improving the operation and management of power grid investment. However, the research is mainly the internal evaluation of the operation and management of the grid enterprises, but rarely consider market competition. The evaluation which considering the market competition conditions of the power grid investment benefit is less, only the corresponding operational evaluation analysis, such as the literature [3] on the basis of summarizing the operation research and concrete work of active distribution network, analyzes the operation mode adjustment of the active distribution network under the power market environment, and puts forward the prospect of the development direction of the distribution network. Literature [4, 5] analyzes the complex environment of distribution network operation, constructs the matrix model of power distribution network operation capability analysis based on the
SWOT method, and provides the analysis framework for power distribution network operation evaluation.

It can be seen that the traditional power grid investment management takes into account the new regulation mechanism of transmission and distribution price and market competition rarely, therefore, it is urgent to construct the power grid project investment benefit evaluation tool under the open market environment, aims at supporting the investment decision of the power grid project, improving the investment decision level of the power grid project.

2. analysis on Investment benefit index of distribution network

Table 1. Evaluation Index System of benefit of distribution network.

| Data type              | Basic Data metrics                  | Key feature indicators     | Benefit evaluation indicators |
|------------------------|-------------------------------------|-----------------------------|------------------------------|
| Asset data             | Original value of fixed assets      | Depreciation Fee            |                              |
|                        | Rate of retirement of fixed assets  |                              |                              |
|                        | Conversion coefficient of fixed assets |                              |                              |
|                        | Investment scale                    |                              |                              |
|                        | Depreciation Rate                   |                              |                              |
| Operation Maintenance Fee | Material fee                      | Operation Maintenance Fee   |                              |
|                        | Repair costs                        |                              |                              |
|                        | Other fees                          |                              |                              |
|                        | Staff remuneration                  |                              |                              |
| Rate of return data    | Ratio of assets to liabilities      | Permitted rate of return    | Fixed asset yield            |
|                        | Cost of debt capital                |                              |                              |
|                        | Cost of equity capital              |                              |                              |
| Tax rate data          | Income tax rate                     | Taxes                       |                              |
|                        | VAT Rate                            |                              |                              |
|                        | Urban Construction maintenance tax  |                              |                              |
|                        | and education surcharge             |                              |                              |
| Operational data       | Transmission and Distribution Quantity |                              |                              |
|                        | Coefficient of line loss            | Transmission and distribution income |                              |
|                        | Approved transmission and distribution price |                              |                              |
|                        | Power Network Reliability           |                              |                              |

The Fixed asset yield is also called fixed asset profit margin, refers to the enterprise in a certain period (generally one year), the realization of profit as a percentage of the value of fixed assets, this index can reflect the effectiveness of the use of fixed assets.

The influence of the new electricity and comprehensive energy service on the investment business of the distribution network is analyzed, and the effect of the regulation mechanism and the comprehensive energy service market has been incorporated into the system in the form of index.

Using this index to analyze the economic benefit of the project, it can reflect the effect of the enterprise's fixed assets comprehensively. The Fixed asset yield is affected not only by production quantity, but also by transmission and distribution, transmission and distribution price, operation maintenance cost and depreciation cost. If the grid company wants to increase the rate need to do two things, on the one hand minimize the occupation of fixed assets, on the other hand to increase production, improve quality, reduce costs, do a good job marketing.

With the help of the fixed assets yield index, the power grid asset management level and performance management level can be accurately evaluated in real time, so the influence of the enterprise's operating target on the investment structure is measured by the fixed asset yield, and the expectation of the net
The equations in the model are shown in table 2:

**Table 2. The relationship of variables in the model.**

| Equation                                                                                       |
|-----------------------------------------------------------------------------------------------|
| 1. Net profit=Annual income-Annual cost-Annual tax                                           |
| 2. Fixed assets of unit transmission and distribution quantity=Fixed assets scale /Over net electricity(Time) |
| 3. retirement of fixed assets=Fixed assets scale*Rate of retirement of fixed assets(Time)     |
| 4. Fixed assets scale= INTEG (New fixed assets-retirement of fixed assets, Original value of fixed assets) |
| 5. Fixed asset yield=Net profit/Fixed assets scale                                           |
| 6. Repair fee= INTEG (Increase of repair fee-Repair fee*Rate of retirement of fixed assets(Time),Repair fee reference value) |
| 7. Material fee= INTEG (Increase of material fee-Material fee*Rate of retirement of fixed assets(Time),Material fee reference value) |
| 8. Staff remuneration= INTEG (Increase of salary of employees, Reference amount of employees ' remuneration) |
| 9. Other fees= INTEG (Increase of other fees-Other fees*Rate of retirement of fixed assets(Time),Other fees reference value) |
| 10. Increase of repair fee=Coefficient of added repair fee(Time)*New fixed assets             |
| 11. Other fees reference value=GET XLS CONSTANTS('test4.xls','sheet2','B11')                 |
| 12. Increase of other fees=New fixed assets*Additional fee factor added(Time)               |
| 13. Other fees reference value=GET XLS CONSTANTS('test4.xls','sheet2','B11')                 |
| 14. Increase of material fee=New fixed asset factor (Time)*New fixed assets                  |
| 15. Increase of salary of employees=Reference amount of employees * Growth rate of workers’ salary(Time) |
| 16. Reference amount of employees’ remuneration=GET XLS CONSTANTS('test4.xls','sheet2','B8') |
| 17. Operation maintenance fee=Repair fee + Other fees + Material fee + Staff remuneration   |
| 18. Urban construction and education additional tax=(Annual income*VAT Rate(Time)-Material fee)*Urban construction and education additional tax rate(Time) |
| 19. Annual income=Approved value of transmission and distribution price(Time)*Power Network Reliability(Time)*Over net electricity(Time)/10000 |
| 20. Power Network Reliability=GET XLS LOOKUPS('test4.xls','Sheet1','2','B10')              |
| 21. Power Network Reliability=GET XLS LOOKUPS('test4.xls','Sheet1','2','B10')              |
| 22. New fixed assets=Investment scale(Time)*Conversion coefficient of fixed assets(Time)    |
| 23. Depreciation fee=(Fixed assets scale-New fixed assets)*Depreciation Rate+0.5*New fixed assets*Depreciation Rate |
| 24. Over net electricity=GET XLS LOOKUPS('test4.xls','Sheet1','2','B4')                    |
| 25. Income tax=Annual income*Income tax rate(Time)                                           |
| 26. Approved value of transmission and distribution price(GET XLS LOOKUPS('test4.xls','Sheet1','2','B3')) |
| 27. Annual tax=Urban construction and education additional tax+Income tax                    |
| 28. Annual cost=Operation maintenance fee+Depreciation fee                                   |
| 29. Investment scale(GET XLS LOOKUPS('test4.xls','Sheet1','2','B6'))                        |
| 30. Original value of fixed assets=GET XLS CONSTANTS('test4.xls','Sheet2','B3')             |
| 31. Repair fee reference value=GET XLS CONSTANTS('test4.xls','sheet2','B10')                |
| 32. New material fee factor(GET XLS LOOKUPS('test4.xls','Sheet1','2','B14'))               |
| 33. Additional fee factor added=GET XLS LOOKUPS('test4.xls','Sheet1','2','B16')             |
| 34. Material fee reference value=GET XLS CONSTANTS('test4.xls','sheet2','B9')               |
| 35. Coefficient of added repair fee= GET XLS LOOKUPS('test4.xls','Sheet1','2','B15')        |
| 36. Rate of retirement of fixed assets(GET XLS LOOKUPS (test4.xls, 'Sheet1', '2','B8'))    |
| 37. Income tax rate= GET XLS LOOKUPS('test4.xls','Sheet1','2','B21')                       |
| 38. Urban construction and education additional tax rate( GET XLS LOOKUPS ('test4.xls','Sheet1','2','B22'))|
| 39. Conversion coefficient of fixed assets (GET XLS LOOKUPS (test4.xls,'Sheet1', '2','B22')) |
| 40. Depreciation Rate=GET XLS CONSTANTS('test4.xls','sheet2','B4')                         |
| 41. Growth rate of workers’ salary=GET XLS LOOKUPS('test4.xls','Sheet1','2','B18')         |
| 42. VAT Rate=GET XLS LOOKUPS('test4.xls','Sheet1','2','B23')                               |
The research object of system dynamics is mainly social economic system, the method of analyzing and solving the problem is not to set up a set of differential equations to solve, but to analyze the interaction between system structure and system variable (drive, feedback relation), and to quantify the delay effect of resource driven in the driving relationship, Then, an intuitive model and computer simulation are established to solve the problem. System dynamics is a kind of theoretical thinking and analytical tool which is good at solving dynamic, delay-effect and complex nonlinear system problems.

The application of the system dynamics method in the benefit evaluation of the distribution network is based on the following four considerations: Frist, It can effectively process complex related variables, so that the evaluation model more accurate effectively, avoiding omission and negligence; the second, It can effectively solve the stock and flow problems, so that the evaluation model can be applied to new projects, reconstruction projects and the operation of the project; Third, the method can reflect the global relationship effectively, intuitive and comprehensive display of asset changes, operating maintenance costs cap, project revenue and other data; fourth, it can effectively deal with dynamic relationship, facilitate real-time dynamic evaluation, improve the timeliness of evaluation.

4. Example Analysis

input data use 2017 year end of the asset data, transmission and distribution price set to fixed value, reference " 2016-2018 local distribution price list " 1–10kv electricity Price ", staff compensation, materials, repair and other fees according to 2014–2016 average annual data as a reference value, the rates of new employees' salaries, materials, repairs and other fees are set according to the given rate parameters in the power transmission and distribution pricing method, and the distribution and investment scale refer to the "X Industrial power grid layout and supply and Demand planning Research report", assuming that the investment was converted into fixed assets Model data input format for Excel, input mode Vensim simulation software.

Core indicator output as shown 4-3 shown, you can see 2017 years to 2020 The index of the Fixed asset yield rises first and then decreases.2017 the Fixed asset yield of the distribution project 8.8% , 2018 year up to 10.29% , 2019 The year rose slightly to 10.59% , to 2020 annual fixed asset yield falls to 7.2% , while the amount of fixed assets of unit transmission and distribution is exactly the same as
the change direction of fixed Assets return index, it is the first descent and then rise, which reflects the profound effect of the asset scale on the benefit of the distribution network.

Judging from the change of the fixed Assets Yield index, 2017 years and 2018 Annual project Fixed Assets management level is better from 2019 to 2020, 2019 years and the Annual investment amount is high, but the load growth is not high, there is the situation that the fixed assets growth and the load growth is wrong match., needs attention.

From the result of example analysis, it can be seen that the performance of model of the distribution network is in good condition, the evaluation results are credible, the model can be used to evaluate the benefit of the distribution network, and to evaluate the efficiency of the existing campus power grid.

Assuming that the load does not reach the predicted level, to the market risk analysis. It can be seen that the impact of load level on the project is relatively strong, 70% under the load forecasting level, the return rate of project fixed assets is lower than 8%, worthy of concern. Therefore, in the rolling management of project investment plan, we must closely follow the load growth and adjust the investment plan in time to ensure the income level of the project.

It’s can be seen that the distribution network asset management is the key to the economic benefit of the investment of the distribution network project, the market risk is the main source of the distribution network project.
5. Conclusion
After analyzing the example, we can see that the model can effectively evaluate the operation status of the distribution network, evaluate the economic performance of project, which has a strong practical value for the operation management and planning adjustment of the distribution network under the background of the deepening of the current reform of power industry marketization

References
[1] Liu Shengli, Caoyang, Feng Yue Light, and so. Research and application of investment benefit evaluation and decision model of distribution network [J]. power system Protection and control, 2015 (2): 119-125.
[2] Liu D, Guo L, Wang S, et al. Multi-level comprehensive evaluation Model of power Grid Efficiency[j]. Procedia Computer Science, 2017, 107:325-331.
[3] Yang, Lu Yuhua, Sun Yu, and so. analysis and prospect of active distribution network operation in power Market [J]. Sci-tech innovation leader, 2017, 185-188.
[4] Lorrell, Liu Mei Recruit. Analysis of distribution network operation capability based on Operation strategy Matrix [J]. power and Energy, 2016 (6): 824-827.
[5] Feng Sanyong. Shanxi power grid Construction Enterprise SWOT Analysis [J]. Shanxi Construction, 2008, 205-206.