Research on Power Grid Enterprises’ Investment Strategies on Incremental Power Distribution Projects in China

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Abstract. As the highlight of China’s new round of power reform, incremental power distribution reform has attract wide public attention. In order to adapt to the situation of reform, power grid enterprises need to develop investment strategies on the pilot projects, and determine the criteria for controlling, participating in or abandoning shares. This paper analyzes influencing factors for power grid enterprises’ investment decision, and build a investment-assisted decision-making model for incremental distribution reform. The investment-assisted decision-making model covers 5 dimensions of economic efficiency, project importance, development potential, government attitude, and image influence, with a total of 12 evaluation indexes. The authors also take four projects as examples for quantitative evaluation, proving the feasibility of decision-making model.

1. Introduction
Incremental power distribution reform is an important task for China’s new round of power system reform. By releasing incremental power distribution investment business to eligible market entities, the reform promote the development of distribution network construction and improve the efficiency of distribution operations. Four batches of 404 incremental power distribution pilot projects have been approved at the national level up to now.

Currently, incremental distribution reform has entered a stage of rapid advancement, with high social attention, high government expectations and intensified gaming among various stakeholders. It is necessary to study and propose investment strategies for incremental distribution business, to help power grid enterprises better adapt to power reform situation and promote the implementation of pilot projects.

2. Influencing Factors of Power Grid Enterprises' Investment Decision

2.1 Influencing factors
The key influencing factors for power grid enterprises’ investment decisions on incremental distribution projects include economic benefits, project importance, development potential, governments’ attitude, and image influence.

2.1.1 Economic benefits
It is the primary factor when power grid enterprise makes investment decisions for incremental power distribution projects. Economic benefit can be measured by the internal rate of return and investment payback period. The project's expected investment income must meet the requirements in the negative list of the SASAC's investment supervision (not less than the 5-year Treasury rate). In addition, the
total project investment can be used to measure the project investment risk, projects with high investment amount have greater risk.

2.1.2 Project Importance
It mainly reflects the impact of the incremental distribution project on power grid. The indicators include the importance in power grid, power grid enterprises' existing assets, and the highest voltage level. If the project is at a hub position in the power grid, or the voltage level is higher than 110 kV, the scope of the pilot may be expanded, which will have a large impact on the power grid enterprises. Power grid enterprises should strive for participating.

2.1.3 Development Potential
It mainly reflects the future development space of the incremental distribution project. The indicators include the distribution area, load level, electricity level, and the potential of value-added service. Projects with large distribution area, high load and electricity level have greater development, which will have a greater impact on the power grid enterprises. Power grid enterprises should participate more for long-term interests.

2.1.4 Governments’ Attitude
Government attitudes are the prerequisite for investment decisions. In some pilot projects, local governments excluded power grid enterprises when bidding. These factors are the boundary conditions for investment decisions.

2.1.5 Image Influence
It mainly reflects the impact of participating in the incremental distribution projects on the power grid enterprises' image. Since the government do not support power grid enterprises to be the controlling stockholder of the incremental distribution projects, for pilot projects with high image influence, it is recommended to be the participating stockholder and actively introduce social capital, to build the reform demonstration projects.

2.2 Criteria for controlling, participating and abandoning
The criteria for power grid enterprises’ decisions of controlling, participating in, or abandoning shares is based on various influencing factors as follows:

- **Controlling standards**: For projects with good economic benefits, good project development potential, and local government support, the power grid enterprises should strive for controlling shares; for projects with normal economic benefits, but located in hub position of power grid planning and development, or the power grid enterprises' existing assets are large, power grid enterprises should also seek controlling shares.

- **Participating standards**: For projects with general economic benefits, covering power grid enterprises' existing assets, with local governments’ great resistance to power grid enterprises' stake controlling, especially for projects including new energy, small hydro power, microgrid, with innovation potential, power grid enterprises should participate in shares.

- **Abandoning standards**: For projects with poor economic benefits, major problems left from history, which may affect power grid enterprises' image and operating risks, power grid enterprises should abandon participation.

3. Investment-assisted Decision-making Model
In order to help power grid enterprises make investment decisions on incremental power distribution, clarify the key influencing factors and boundary conditions for controlling, participating in or abandoning shares in pilot projects, this paper builds a investment-assisted decision-making model for incremental distribution reform. The investment-assisted decision-making model covers 5 dimensions of project economic efficiency, project importance, project development potential, government
attitude, and project image influence, with a total of 12 evaluation indexes. The projects can be classified through comprehensive evaluation and formulate investment strategies.

Table 1. Evaluation Index System of Investment-assisted Decision-making Model

| First-level index       | Second-level index                   | Index description                                      |
|------------------------|--------------------------------------|--------------------------------------------------------|
| Project economic       | Total investment                      | Excessive total investment has greater risk             |
| efficiency             | Internal rate of return               | Directly reflects the economic value of the project    |
|                        | Investment payback period             | Projects with long payback periods have lower value     |
| Project importance     | Importance in power grid              | More important if it is at the hub in a large grid     |
|                        | Power grid enterprises’ existing assets | Proportion of existing assets in 2020 distribution network planning scale |
|                        | Highest voltage level                 | Voltage levels can be used to measure project value    |
| Project development    | Distribution area                     | Reflect the scale of the project to some extent        |
| potential              | Load level                            | Forecasted load levels in 2020                        |
|                        | Electricity level                     | Forecasted electricity levels in 2020                  |
|                        | Potential of value-added service      | High investment value with predictable value-added services |
| Government attitude    | Local government attitude              | Boundary conditions for investment decisions           |
| Project image influence| Project image influence               | Projects with a large impact on image should be participated in shares |

The indexes are quantified into five grades, with full marks of 5. A higher score indicates an advantage for investment. Among them, the local government attitude index is a prerequisite for investment decisions which is not scored.

Table 2. Quantitative Indexes of Investment-assisted Decision-making Model

| Index                              | 0   | 1   | 2   | 3   | 4   | 5   |
|------------------------------------|-----|-----|-----|-----|-----|-----|
| Local government attitude          |     |     |     |     |     |     |
| Project importance                 |     |     |     |     |     |     |
| Importance in power grid           | -   | Unimportant | Less important | General | Important | Very important |
| Power grid enterprises’ existing assets (%) | 0   | 0-10% | 10%-20% | 20%-30% | 30%-50% | >50% |
| Highest voltage level              | <10kV | 10kV | 35kV | 110kV | ≥220kV |
| Project economic efficiency        |     |     |     |     |     |     |
| Total investment (million yuan)    | -   | ≥180 | 120-180 | 80-120 | 20-80 | <20 |
| Internal rate of return (%)        | <0  | 0-2% | 2%-3% | 3%-4% | 4%-5% | ≥5% |
| Investment payback period (year)   | ≥30 | 24-30 | 18-24 | 12-18 | 6-12 | <6 |
| Project development                |     |     |     |     |     |     |
| Distribution area                  | <5  | 5-10 | 10-30 | 30-60 | 60-100 | ≥100 |
4. Case Study

Taking the four projects as examples, use the investment-assisted decision-making model for quantitative evaluation. Different weight for each index is determined, and the comprehensive score of each project is as follows. In the case that the local government does not exclude power grid enterprises from participating, it is considered that the power grid enterprises should controlling shares when the comprehensive score is 2.5 or higher, participate in shares when the comprehensive score is 1.5-2.5, and quit participation when the comprehensive score is lower than 1.5.

Table 3. Quantitative Evaluation of Four Typical Projects

| index | A | B | C | D | Weight |
|-------|---|---|---|---|--------|
| Local government attitude | Exclude controlling | Exclude controlling |
| Project importance | | | | | |
| Importance in power grid | 4 | 1 | 3 | 3 | 0.1 |
| Power grid enterprises' existing assets (%) | 0 | 1 | 0 | 2 | 0.1 |
| Highest voltage level | 5 | 2 | 4 | 5 | 0.1 |
| Project economic efficiency | | | | | |
| Total investment (million yuan) | 3 | 5 | 3 | 1 | 0.05 |
| Internal rate of return (%) | 5 | 0 | 5 | 4 | 0.3 |
| Investment payback period (year) | 3 | 1 | 3 | 3 | 0.15 |
| Project development potential | | | | | |
| Distribution area | 2 | 1 | 4 | 5 | 0.05 |
| Load level (MW) | 4 | 0 | 1 | 3 | 0.05 |
| Electricity level (MWh) | 5 | 0 | 1 | 3 | 0.05 |
| Potential of value-added service | 5 | 1 | 3 | 4 | 0.05 |
| Comprehensive score | 3.8 | 0.9 | 3.25 | 3.45 |

Project A and C have scores of 3.95 and 2.95 respectively, so the power grid enterprises should control shares. Project D gets a score of 3.45, but the local government exclude power grid enterprises from controlling shares, it should be participated in shares. Project B have a score of 0.9, which should be abandoned.
5. Conclusion
This paper studies the power grid enterprises’ investment strategies on incremental distribution pilot projects. The following conclusions are drawn:

- The key influencing factors for power grid enterprises’ investment decisions on incremental distribution projects include economic benefits, project importance, development potential, governments’ attitude, and image influence.
- The investment-assisted decision-making model which covers 12 evaluation indexes of 5 dimensions can make quantitative evaluation for incremental distribution projects and help power grid enterprises make investment decision for controlling, participating in or abandoning shares.

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References
[1] The CPC Central Committee, the State Council. (2015) Several Opinions of the CPC Central Committee and the State Council on Further Deepening the Reform of the Electric Power System (Zhong Fa [2015] No. 9). <http://www.cec.org.cn/huanbao/xingyexinxi/fazhangaige/2015-03-25/135625.html>
[2] Ma, L., Huang, L., Xue, S., et al. (2017) Key Issues for Orderly Operation of China’s New Electricity Market Reform Pilot. Electric Power, 50(4): 17-22.
[3] Ma, L., Zhang, X., Yang, S., Xue, S., Qu, H. (2017) Recent Developments and Key Issues of China’s Retail Electricity Market. Electric Power, 50(7): 5-9.
[4] Wang, X., Wang, X., Chen, H. (2003) Electricity market foundation. Xi’an Jiaotong University Press, Xi’an.
[5] Gabriel, G., Toby, D. (2017) Investing in vertical integration: electricity retail market participation. Energy Economics, 67: 355-365.
[6] Zang, X., Xue, S., Yang, S., et al. (2016) International Experience and Lessons in Power Sales Side Market Liberalization. Automation of Electric Power Systems, 40(9): 1-8.
[7] Jukka, L., Tero, K., Juha, L., Jarmo, P. (2007) New Investment Strategies in the Modern Electricity Distribution Business - Reliability in the Long-Term Planning. In: 2007 IEEE Power Engineering Society General Meeting. Tampa, Florida. pp. 1-8.
[8] Astrid, C., Maria, N. (2016) Regulation and investment incentives in electricity distribution: An empirical assessment. Energy Economics, 57: 192-203.
[9] Rahmatallah, P., Tooraj, J. (2016) Determinants of investment under incentive regulation: The case of the Norwegian electricity distribution networks. Energy Economics, 53: 192-203.
[10] Yalin, H., Lennart, S. (2017) An investigation on the impacts of distributed generation curtailment regulations on distribution network investment. Electric Power Systems Research, 145: 175-184.
[11] Kaisa, K. (2006) Investment incentives: regulation of the Finnish electricity distribution. Energy Policy, 34(7): 853-862.
[12] Danny P., Goran S., Sotiris G., Panagiotis P. (2015) Strategic investment model for future distribution network planning. 23rd International Conference On Electric Distribution. Lyon. pp. 1-5.