

Credit Risk Evaluation of Large Power Consumers Considering Power Market Transaction

Li Fulin², Xu Erfeng³, Sun ke¹, Liu Dunnan³ and Shen Shuyi⁴

¹ State Grid Zhejiang Electricity Power Company, 8 Huanglong Road, Hangzhou, China

² Zhejiang Huayun Electric Power Engineering Design Consulting Company, 1 Huadian Road, Hangzhou, China

³ North China Electric Power University, 2 Beinong Road, Beijing, China

⁴ State Grid Zhejiang Economic Research Institute, 1 Nanfu Road, Hangzhou, China

Corresponding Author's E-Mail Address: 18810905481@163.com

Abstract. Large power users will participate in power market in various forms after power system reform. Meanwhile, great importance has always attached to the construction of the credit system in power industry. Due to the difference between the awareness of performance and the ability to perform, credit risk of power customer will emerge accordingly. Therefore, it is critical to evaluate credit risk of large power customers in the new situation of power market. Firstly, this paper constructs index system of credit risk of large power customers, and establishes evaluation model of interval number and AHP-entropy weight method.

1. Introduction

Power industry has always attached great importance to construction of credit system. With the development of power system reform, the types of power market transactions will become more diversified while power market environment will more variable and complex. Therefore, institution of power market regulation should evaluate credit risk of all market subjects urgently, which will provide decision-making basis for effective prevention of market risk and technical support for protection of market standardized operation and healthy and orderly development.

There are many researches on credit index system of power industry. Literature [1] has proposed a customer credit evaluation index system, including the status of industry, the financial situation of enterprises, payment status and so on. Literatures [2-4] have calculated the correlation coefficient between different credit categories. Literature [5] has evaluated the credit risk of power customers based on AHP. In literatures [6-7], power customer risk evaluation model has been constructed by entropy weight method and improved entropy weight method.

In this paper, firstly index system of credit risk evaluation is constructed. Then, based on interval numbers and comprehensive weights, a credit evaluation model is set up, which provides a theoretical reference for the evaluation of large power customer credit risk.

2. Construction of Credit Risk Index System for Large Power Customers

In this paper, credit analysis of large power customers is divided into four parts: external environment, production and operation, financial analysis and transaction credit analysis. As **Table 1** shown, credit evaluation index system for large power customers consists of 4 criterion layers, 9 primary factor layers, and 23 secondary factor layers.



Table 1. Credit Risk Evaluation Index System for Large Power Customers.

Target Layer	Criterion Layer	Primary Factor Layer	Secondary Factor Layer
Credit Risk of Large Power Customers	Credit Risk of External Environment	Policies and Regulations	Government Support Industrial Macro-Control Policies
		Industry Operation Status	Fluctuation of Supply and Demand Consolidated Price Increase
	Credit Risk of Production and Operation	Operation Risk	Market Share
		Production Risk	Corporate Social Impact
			Product Qualification Rate Safety Accident Rate
	Credit Risk of Financial	Profitability	Return on Assets Net Profit Margin on Sales Cost Profit Margin
			Asset Liability Ratio
		Solvency	Current Ratio
		Development Ability	Main Business Revenue Growth Rate Net Profit Growth Rate
	Credit Risk of Transaction	Direct Purchase of Large Power Consumers	Full Payment Rate
			Time Contribution Ratio Contracting Rate of Electricity Sales Contract Actual Power Completion Rate
			Contract Performance Rate
		Demand Side Response	Interruptible Load Contract Performance Rate Load Control Coordination
			Electricity Check Fit

2.1. External Environment Risk

Enterprises are affected by national environment at a macro level. Besides, the operation of industry and the state related to this industry should also be considered. Therefore, this paper will analysis the project from the aspects of policies and the running state of the industry.

2.2. Production and Operation Risk

The overall level of enterprises operated well is in a leading position, and the credit risk can reduce. While the enterprises operated poorly may face the risk of losses or failures. This paper will discuss from two perspectives of the production level and operating conditions of large power customers.

2.3. Financial Credit Risk

The financial situation of large power customers reflects the enterprise management level, will also affect the future development and the competitiveness of the enterprise. The financial risk can be divided into solvency risk, profitability risk and development capacity risk.

2.4. Transaction Credit Risk

The transaction credit risk can be divided into direct trade credit risk and demand side response to the credit risk according to the type of market transactions that large power customers participate in.

3. Credit Risk Evaluation Method for Large Power Customers

3.1. Determine Index Score by Interval Number Method

3.1.1. Dimensionless Treatment for Interval Numbers. Dimensionless treatment is to eliminate the influence of dimensional difference among different indicators on evaluation.

$$Y_{Max,ij}^P = X_{ij}^P / \sum_{i=1}^m X_{ij}^P, Y_{Max,ij}^Q = X_{ij}^Q / \sum_{i=1}^m X_{ij}^Q, Y_{Min,ij}^P = \frac{1 / X_{ij}^P}{\sum_{i=1}^m 1 / X_{ij}^P}, Y_{Min,ij}^Q = \frac{1 / X_{ij}^Q}{\sum_{i=1}^m 1 / X_{ij}^Q} \quad (1)$$

3.1.2. Value Transformation for Interval Numbers. Supposing that interval numbers are subordinated to normal distribution and exchanged into evaluation value by standardization.

$$u_{ij} = \frac{X_{ij}^P + X_{ij}^Q}{2}, \sigma_{ij} = \frac{X_{ij}^Q - X_{ij}^P}{6}, \sigma_{ij} = u_{ij} + \lambda \times (1 - \sigma_{ij}) \quad (2)$$

3.2. Credit Evaluation Process Based on AHP and Entropy Weight Method (EWM)

3.2.1. Determine Objective Weight by Entropy Weight Method (EWM).

(1) Calculate the proximity between each large power customer index and the optimal value.

$$x_{ij} = x_{ij} / x_j^*, x_j^* = \max(x_{ij}), x_{ij} = x_j^* / x_{ij}, x_j^* = \max(x_{ij}), d_{ij} = \frac{x_{ij}}{\sum_{j=1}^m \sum_{i=1}^n x_{ij}} \quad (3)$$

(2) Calculate importance entropy of index.

$$E_{ij} = -d_{ij} \times \ln(d_{ij}), e_{ij} = -\frac{d_{ij}}{\sum_{j=1}^m d_{ij}} \times \ln\left(d_{ij} / \sum_{j=1}^m d_{ij}\right), e_j = \frac{1}{\ln(m)} \times \sum_{j=1}^m e_{ij} \quad (4)$$

(3) Calculate weight of index.

$$u_j = (1 - e_j) / \left(n - \sum_{j=1}^n e_j\right) \quad (5)$$

3.2.2. Determine Objective Weight by AHP.

(1) According to the experience of experts and credit rating workers' opinion, criterion indexes are ranked by importance in pairs, which form a judgment matrix.

(2) Calculate weight feature vector.

$$M_i = \prod_{j=1}^n x_{ij}, \bar{W}_i = \sqrt[n]{m_i}, W_i = \bar{W}_i / \sum_{j=1}^n \bar{W}_i \quad (6)$$

3.2.3. Calculate Comprehensive Evaluation Value.

Calculate maximum eigenvalue of matrix and get comprehensive evaluation value.

$$\varphi_{Int} = 0.5 \times \varpi_{AHP} + 0.5 \times \varpi_{EWM}, \chi = D \times \varphi_{Int} \quad (7)$$

4. Credit Rating of Large Power Customers

According to the evaluation process above, subjective and objective weight are calculated to get integrated weight of large power customers, as shown in **Table 2**.

Table 2. Interval Number of Large Power Customer Evaluation Indexes.

Target Layer	Weight	Primary Factor Layer	Weight	AHP	EWM	Integrated Weight
Credit Risk of External Environment	0.0776	Government Support	0.2275	0.0043	0.0000	0.0021
		Industrial Macro-Control Policies	0.4834	0.0091	0.0000	0.0046
		Fluctuation of Supply and Demand	1.0798	0.0204	0.0425	0.0314
		Consolidated Price Increase	2.3280	0.0437	0.0425	0.0431
Credit Risk of Production and Operation	0.2010	Market Share	0.4396	0.0211	0.0450	0.0331
		Corporate Social Impact	0.9356	0.0435	0.0451	0.0443
		Product Qualification Rate	1.4270	0.0681	0.0422	0.0552
		Safety Accident Rate	1.4270	0.0681	0.0425	0.0553
Credit Risk of Financial	0.2010	Return on Assets	0.4956	0.0142	0.0487	0.0315
		Net Profit Margin on Sales	0.8806	0.0251	0.0379	0.0315
		Cost Profit Margin	1.5491	0.0444	0.0568	0.0506
		Asset Liability Ratio	0.4956	0.0142	0.0476	0.0309
		Current Ratio	0.4596	0.0142	0.0386	0.264
		Main Business Revenue Growth Rate	1.5491	0.0444	0.0841	0.0643
		Net Profit Growth Rate	1.5491	0.0444	0.0841	0.0643
Credit Risk of Transaction	0.5205	Full Payment Rate	0.9776	0.0635	0.0425	0.0530
		Time Contribution Ratio	0.5253	0.0341	0.0446	0.0394
		Contracting Rate of Electricity Sales Contract	0.9776	0.0635	0.0429	0.0532
		Actual Power Completion Rate	1.7587	0.1139	0.0425	0.0782
		Contract Performance Rate	1.7587	0.1139	0.0425	0.0782
		Interruptible Load Contract Performance Rate	0.9776	0.0635	0.0417	0.0526
		Load Control Coordination	0.5253	0.0341	0.0448	0.0394
		Electricity Check Fit	0.5253	0.0341	0.0412	0.0376

As **Figure 1** shown, comprehensive evaluation value of large power customer 3 is the highest, followed by large power customer 2. Credit rating of these two corporates is at a high level, which indicates that they have a certain reputation in the industry with good business development, high debt credit, strong resistance to external environmental impact and low default risk.

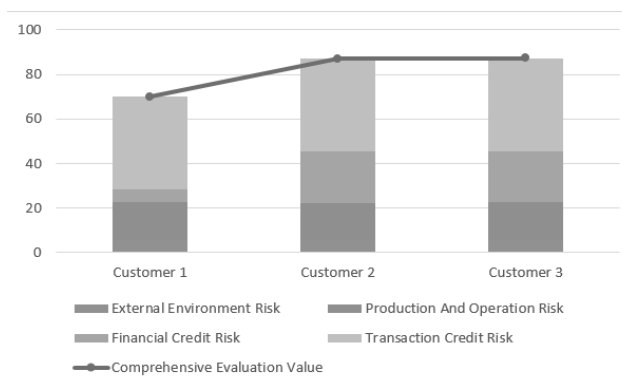


Figure 1. Evaluation Value of Large Power Customer Credit.

5. Conclusion

With the development of power system reform, credit problem in power industry will be more complicated. In this paper, a set of credit risk evaluation index and evaluation model based on comprehensive evaluation are constructed. As the results of the numerical examples shown, credit risk of large power customers is closely related to external environment risk, production and operation risk, financial credit risk and transaction credit risk. Also, we can compare and analyze the credit rating of different enterprises and the indicators to be improved. The model established in this paper provides a quantitative reference for the credit prevention of power market transactions.

References

- [1] Hao Yang. Research on Risk Management of Electricity Power Supply Enterprises in China. Beijing, North China Electric Power University, 2014.
- [2] Chen Yanchao. Study of the Credit Evaluation of Key Customer and the Risk Management of the Power Company. Beijing, North China Electric Power University, 2015.
- [3] Luo Yifan. Research on Electricity Customer's Credit Rating and Anti-stealing Power Considering Distributed Generation. Shanghai, Shanghai Jiao Tong University, 2015.
- [4] Streimikiene D, Ciegis R, and Grundey D. Energy Indicators for Sustainable Development in Baltic States. *Renewable & Sustainable Energy Reviews*, vol. 5, Dec 2007, pp. 877-893.
- [5] Niu Xiaomei, and Zhang Yinling. Assessment of Power Customer Credit Risk Based on Analytic Hierarchy Process. *Computer Simulation*, vol. 5, 2011, pp. 333-336.
- [6] Huang Yuansheng, and Shi Xiufen. Evaluation of Electricity Customers' Credit Risk based on Entropy Method and MADM. *Technoeconomics & Management Research*, vol. 2, 2010, pp. 24-27.
- [7] Lu Jianchang, Jiang Wei, and Liu Na. Study on Credit Evaluation of Power Consumers Based on Improved Entropy. *Journal of Electric Power*, vol. 5, 2008, pp. 368-370.

Acknowledgment

This work is sponsored and supported by National Power Grid Corp science and technology project *Research Application of Key Technologies for Power Grid Planning, Investment and Purchasing Power Optimization* (Contract No. SGZJJY00SJJS1600031).