Research on AGC ancillary service transaction mode in China at present stage

Yongxiu He [a], Qian Chen [a], Yan Chang [a], Xiao Gao [b], Peipei You [b]*

[a] School of Economics and Management, North China Electric Power University, Beijing 102206, China

[b] State Grid Energy Research Institute, Beijing 100052, China

*Corresponding author: Qian Chen, Master's degree, 18146539756, 1559065389@qq.com

Abstract

The ancillary service plays an important role in the development of electricity market and the optimal allocation of power resources as the guarantee of power supply reliability and power quality. This paper takes automatic generation control (AGC) as an example, to explore its transaction mode. Firstly, analyse the feasible trading mode in centralized market and decentralized market respectively. Then, based on the characteristics of ancillary service market in China, the analytic network process (ANP) method is used to determine the index system and weight, and finally get AGC ancillary services applicable trading model ranking.

Key words: *AGC ancillary service; ANP; transaction mode; comprehensive evaluation*

1 Introduction

AGC refers to the generator set in the specified range of output adjustment, tracking power dispatch instructions, and adjusting the power output to meet the power system frequency and contacting line power control requirements of the service.

YAO Peng et al.[1] deployed the AGC service based on analytic hierarchy process（AHP）, according to its performance-price ratio, the performance, capacity price, energy price and position of AGC service; *Huang Yonghao et al.*[2] put forward the operation of ancillary services mechanism and the transaction process and other specific details of the operation; *Zou Jianping et al.*[3] proposed cost allocation methods and pricing mechanism of reactive power ancillary services in the competitive electricity market environment.

2 AGC ancillary service available trading mode

2.1 Centralized transaction ancillary service trading mode

Mode I: Centralized trading, uniform clearing.

Mode I is that the market operators release AGC market demand in advance, and accept the AGC service providers' declaration, and then adjust the ranking price of each AGC service supplier, and form the uniform marginal price of the market on the basis of meeting the demand of AGC. The details are shown in Fig.1 as below.
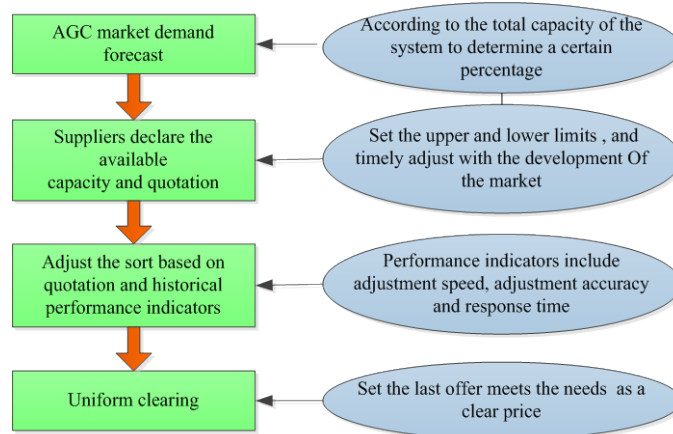

Fig. 1 – Trading pattern of Mode I

Mode II: Listing transactions.

This mode refers to that the dispatching organization or power plants who can provide the AGC service, list at the trading center according to the AGC demand forecast, and delist by the power plants who meet the demand and checked by the dispatching organization, as shown in Fig. 2 as below.
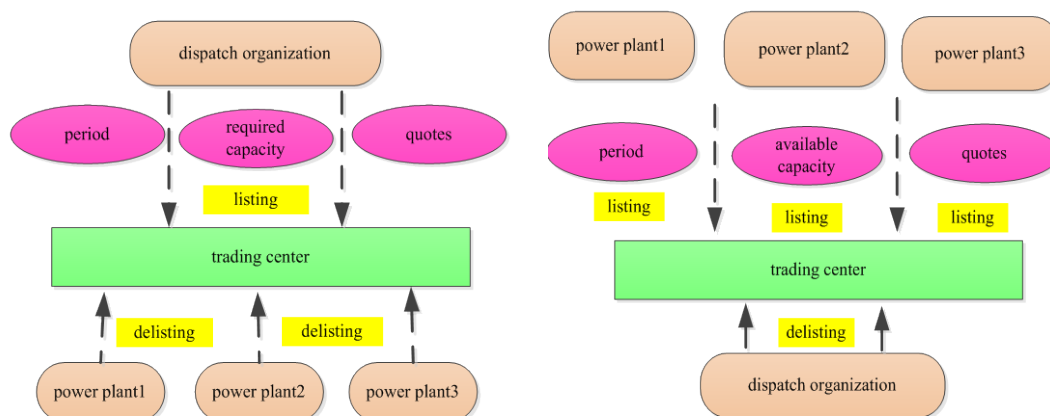

Fig. 2 – Trading pattern of Mode II

2.2 Decentralized transaction ancillary service trading mode

Mode III: Matching trading, uniform clearing

The mode refers to the sellers and the buyers offer bidirectional quoted, the trading center to match, and use the uniform clearing method to settlement, which is shown in Fig. 3 as below.
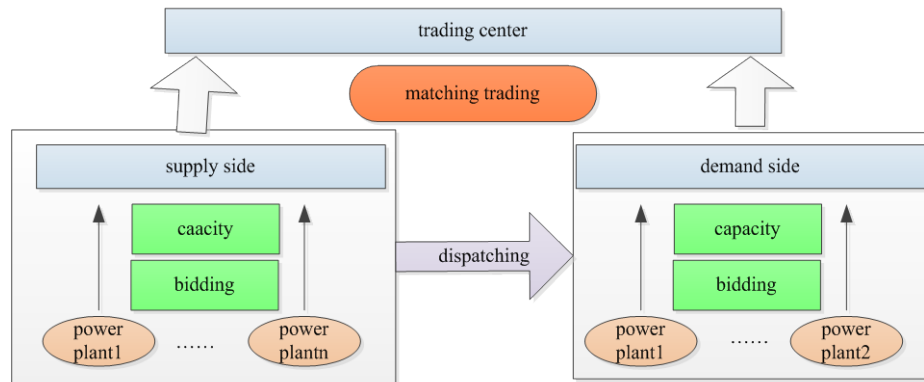
Fig. 3 – Trading pattern of Mode III

Mode IV: Listing transactions in decentralized transaction

The mode refers to that the power plants list in the trading center according to their own AGC demand forecast, and delisted by the power plants who meet the demand, then, the security agencies check the security before the transaction, the price of settlement is the delisting price.

Mode V: Bilateral negotiation transactions

The mode refers to that the AGC ancillary service demand side and the supply side negotiate at first, and after agreeing, the dispatching capacity, the adjustment time and the contract price will be reported to the dispatching organization, and the dispatching organization should check the security before completing the transaction according to the contract.

3 Comprehensive evaluation system of ancillary service market transaction mode

3.1 Construction of evaluation index system of ancillary service market transaction mode

ANP is applicable to complex decision-making systems with internal dependencies and feedback relationships that are developed on the basis of AHP; using the combination of ANP and Delphi method to determine the weight of the indicators[4], the evaluation index system is shown in table 1 as below.

Table 1 –Evaluation index system of ancillary service market transaction mode

Target layer(A)	Primary targets	Secondary index
evaluation index system of ancillary service market transaction mode	technical indicators（B1）	Enforceability(C1)
		convenience(C2)
		promotion level(C3)
	market indicators(B2)	market participation(C4)
		market transaction electricity(C5)
		trading price volatility(C6)
	social benefit indicators(B3)	total social surplus(C7)
		buyer satisfaction(C8)
		seller satisfaction(C9)
		policy support(C10)
	power grid efficiency indicators(B4)	transmission efficienc(C11)y
		scheduling cost(C12)
		power supply reliability(C13)

3.2 Evaluation of the weight of evaluation index of ancillary service market

Using the Super Decisions software to calculate and compare the scores of experts, the relationship between the evaluation indicators at all levels is shown in Fig. 4, the weight coefficient is shown in Table 2.
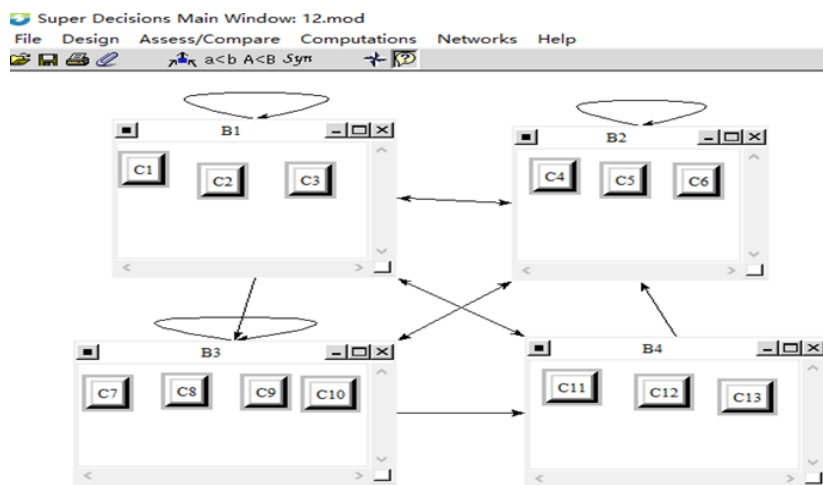

Fig. 4 –The relationship between the evaluation indicators at all levels

China is currently in a variety of trading patterns coexist in the market transition period, with the continuous development of the market and the technology continues to mature and other factors change, the indicators of the property values are shown in the table 3 as below：

Table 2 –The weight coefficient of evaluation indicators

Target layer(A)	Primary targets(B)	weight	Secondary index(C)	weight
evaluation index system of ancillary service market transaction mode	technical indicators（B1）	0.149	Enforceability(C1)	0.333
			convenience(C2)	0.109
			promotion level(C3)	0.558
	market indicators(B2)	0.447	market participation(C4)	0.556
			market transaction electricity(C5)	0.239
			trading price volatility(C6)	0.204
	social benefit indicators(B3)	0.283	total social surplus(C7)	0.298
			buyer satisfaction(C8)	0.086
			seller satisfaction(C9)	0.086
			policy support(C10)	0.528
	power grid efficiency indicators(B4)	0.121	transmission efficienc(C11)y	0.18
			scheduling cost(C12)	0.069
			power supply reliability(C13)	0.751

Table 3 –The attribute value of each index after processing

Secondary index(C)	Mode I	Mode II	Mode III	Mode IV	Mode V
Enforceability(C1)	9	8	9	7	5
convenience(C2)	7	6	8	7	8
promotion level(C3)	6	3	8	2	4
market participation(C4)(%)	40	10	70	30	50
market transaction electricity(C5)(billion kWh)	20	10	60	25	20
trading price volatility(C6)(%)	2	3	4	3	1
total social surplus(C7)(billion yuan)	6	2	8	5	3
buyer satisfaction(C8)(%)	60	70	85	80	100
seller satisfaction(C9)(%)	75	70	90	85	100
policy support(C10)	6	5	8	7	10
transmission efficiency(C11)(billion yuan)	2	1	6	3	0. 5
scheduling cost(C12)	7	6	3	2	1
power supply reliability(C13)(%)	99. 2	99. 1	99	98. 5	98. 8

The original data is processed in a dimensionless and consistent manner, which is as follows:

$$U_i = \frac{X_i - X_{\min}}{X_{\max} - X_{\min}} \times 40 + 60 \tag{1}$$

For indicators the smaller the better, the following formula is used:

$$U_i = \frac{X_{\max} - X_i}{X_{\max} - X_{\min}} \times 40 + 60 \tag{2}$$

where U_i indicates the normalized data, X_i is the original data value, X_{max} is the maximum value in the data, X_{min} is the minimum value in the data.

On the basis of each index and corresponding weight, calculate the comprehensive evaluation value, the formula is:

$$S = \sum_{i=1}^{n} w_i s_i \tag{3}$$

where S is the comprehensive evaluation value and w_i is the weight of the index i, s_i is the value of the index i.

The data after standardized processing is shown in table 4 as below:

Table 4 –The attribute value of each index after processing

Secondary index(C)	Mode I	Mode II	Mode III	Mode IV	Mode V
Enforceability(C1)	100	90	100	80	60
convenience(C2)	80	60	100	80	100
promotion level(C3)	86. 67	66. 67	100	60	73. 33
market participation(C4)(%)	80	60	100	73. 33	86. 67
market transaction electricity(C5)(billion kWh)	68	60	100	72	68
trading price volatility(C6)(%)	86. 67	73. 33	60	73. 33	100
total social surplus(C7)(billion yuan)	86. 67	60	100	80	66. 67
buyer satisfaction(C8)(%)	60	70	85	80	100
seller satisfaction(C9)(%)	66. 67	60	86. 67	80	100
policy support(C10)	68	60	84	76	100
transmission efficiency(C11)(billion yuan)	70. 91	63. 64	100	78. 18	60
scheduling cost(C12)	60	66. 67	86. 67	93. 33	100
power supply reliability(C13)(%)	100	94. 29	88. 57	60	77. 14

4 Results and discussions

According to the above formulas and the weight of each index and the value of each index, we can calculate the above five kinds of AGC auxiliary service transaction model comprehensive evaluation value in table 5 as follows:

Table 5 –The final score and ranking of comprehensive evaluation

feasible mode	the total score	ranking
Mode I	80.282	3
Mode II	66.759	5
Mode III	92.110	1
Mode IV	72.869	4
Mode V	83.294	2

It can be seen from the above table that the model III has the highest score in the comprehensive evaluation of the feasible mode of the AGC auxiliary service, followed by the pattern five, the mode one, the mode four, the mode two,

5 Conclusions

Above all, we can infer that the mode III "matching trading, uniform clearing" in the decentralized is more suitable for Chinese present ancillary service period.

Acknowledgements

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