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Generating Company Decision Making under Different Behavior Strategies of Competitors

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***Abstract*—The management decisions acceptance with an individual player is necessary to be selected in accordance with specific market conditions and long-term targets of the company. With this problem it is really important to recognize the situation on the wholesale market and modeling the different strategies of the players. In each several situation the generating company should choose theirs own specific strategy.**

***Index Terms*: strategy, generating company, price, competitors.**

I. Introduction

The market mechanism's nature is built on the conflict of participant's interest. To increase its efficiency the generating companies (GC) may use different pricing strategies as a method of competition fight, namely:

1) "Sincere" strategy or bid price submission which reflects the objective cost of produced electricity and which is close to the relative increase inputs characteristic;

2) A strategy of price wars means the part of market aggressive takeover on condition to reduce the product price;

3) A strategy of price leadership, dominates in oligopoly markets. One of the firms because of their size or position in the market becomes as a natural leader. This leader takes pricing decisions, but other attended firms on the market, declare these decisions and follow them [1].

II. Strategies Formulation

One of the most striking examples of calculation-analytical methods of risk assessment is the use of game theory. The aim of the game is to choose the strategy which corresponds to equilibrium point. The equilibrium strategy is the strategy of reliability. In games theory, however, quit reasonable is also to choose the strategy, which differs from the equilibrium and connected with certain risk [2, 3].

In order to consider participants different strategies is need to draw up the matrix of the game. In the matrix rows mean possible decisions which is taken by the player, but columns are possible condition of economic environment. The matrix element a_{ij} means the outcomes of the situation when player chooses strategy i at the environment condition j. Game matrix is called as the game solvency matrix (Tab. 1) [2, 4].

TABLE 1

THE GAME SOLVENCY MATRIX

	The market environment condition				
Participant strategy		F_1	F_2	...	F_n
	A_1	a_{11}	a_{12}	...	a_{1n}
	A_2	a_{21}	a_{22}	...	a_{2n}
	...	...	...	...	...
	A_m	a_{m1}	a_{m2}	...	a_{mn}

In game theory it is assumed that among "players" is at least one who acts consciously and purposefully, the rest may be guided by a random choice, but in that case, it is considered that they have "chosen" the strategy independently of other games players.

Companies prices at different strategies presented in Tab.2.

TABLE 2

PARTICIPANTS PRICES IN THE MARKET AT DIFFERENT BEHAVIOR STRATEGIES

	Price at sincere strategy, *Ls/MW*	Price at price war strategy,*Ls/MW*	Price leadership strategy, *Ls/MW*
1 participant	21,00	20,370	22,050
2 participant	18,54	17,984	19,467
3 participant	22,37	20,129	23,48
4 participant	21,61	20,529	22,69

Different strategies of the generating companies presented in Fig.1.

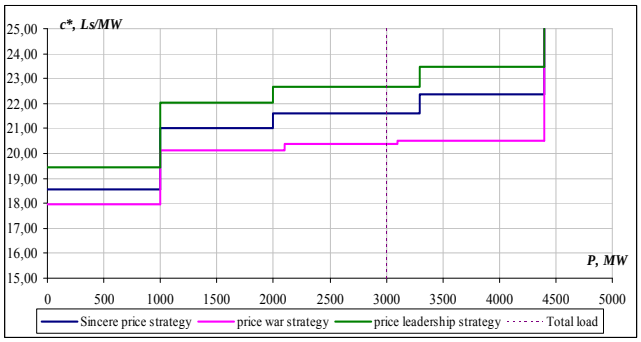

Fig. 1. Power distribution between participant considering price strategy of each

We define for first power producer the optimal behaviour strategy taking into account the expected strategies of other participants in the electricity market. The total load is 3000 MW. We assume that in the market is three different prices strategy. The 1st generating company can produce maximum – 1000 MW, 2nd – 1000 MW, 3rd -1100 MW and 4th – 1300 MW. For the first instance F1(1,1,1) (power producers adheres to the sincere strategy) all participants take part with sincere strategy) respectively prices equal to $c_{1,1}$=21 Ls/MW, $c_{2,1}$=18,54 Ls/MW, $c_{3,1}$=22,37 Ls/MW and $c_{4,1}$=21,61 Ls/MW. For the first instance, power distributed as: P_{g2}=1000 MW, P_{g1}=1000 MW (so enter to the Tab.1 first column value for first GC) and P_{g4}=1000 MW (3rd participant dropped out from market). When the first GC reduces the price (2nd strategy) then depending on the strategies of other players is changing their loading. The power distribution for the first GC is shown in Tab.3.

TABLE 3

THE POWER DISTRIBUTION FOR THE FIRST GC DEPENDING OF BID PRICES OF COMPETITORS

	F_1	F_2	F_3	F_4	F_5	F_6	F_7
	1,1,1	1,1,2	1,2,1	1,2,2	1,1,3	1,2,3	1,3,2
Sincere strategy, c_1=21,0 Ls/MW	1000	700	900	0	1000	900	700
Price war strategy c_2=20,37 Ls/MW	1000	1000	900	900	1000	900	1000
Price leadership strategy c_3=22,05 Ls/MW	700	700	0	0	1000	900	700
	F_8	F_9	F_{10}	F_{11}	F_{12}	F_{13}	F_{14}
	1,3,3	1,3,1	2,1,1	2,1,2	2,2,1	2,2,2	2,1,3
Sincere strategy, c_1=21,0 Ls/MW	1000	1000	1000	700	900	0	1000
Price war strategy c_2=20,37 Ls/MW	1000	1000	1000	1000	900	900	1000
Price leadership strategy c_3=22,05 Ls/MW	1000	700	700	700	0	0	1000
	F_{14}	F_{15}	F_{16}	F_{17}	F_{18}	F_{19}	F_{20}
	2,1,3	2,2,3	2,3,1	2,3,2	2,3,3	3,1,1	3,1,3
Sincere strategy, c_1=21,0 Ls/MW	1000	900	1000	700	1000	1000	1000
Price war strategy c_2=20,37 Ls/MW	1000	900	1000	1000	1000	1000	1000
Price leadership strategy c_3=22,05 Ls/MW	1000	900	700	700	1000	700	1000
	F_{21}	F_{22}	F_{23}	F_{24}	F_{25}	F_{26}	F_{27}
	3,3,1	3,3,3	3,3,2	3,1,2	3,2,3	3,2,1	3,2,2
Sincere strategy, c_1=21,0 Ls/MW	1000	1000	700	700	900	900	0
Price war strategy c_2=20,37 Ls/MW	1000	1000	1000	1000	900	900	900
Price leadership strategy c_3=22,05 Ls/MW	700	1000	700	700	900	0	0

Depending on the pricing strategies of other producers are calculated the profit variants for first company, which summarizes in the solvency matrix (Tab.4) taking into account expected value of looses.

III. THE OPTIMAL SOLUTION FINDING

The optimal strategy selection of production and selling based on the use of games models which based on the minimax strategies of risk and losses, and i - number of lines – possible strategy selection; j - the column number - politics of other generating companies; a_{ij} - the outcome of the situation.

TABLE 4

THE SOLVENCY MATRIX OF FIRST GENERATING COMPANY

1st GC prices	The amount of profit, depending on the different strategies of competitors, Ls						
	1,1,1	1,1,2	1,2,1	1,2,2	1,1,3	1,2,3	1,3,2
c_1=21,000 Ls/MW	2990	2090	2690	-10	2990	2690	2090
c_2=20,370 Ls/MW	2360	2360	2123	2123	2360	2123	2360
c_3=22,050 Ls/MW	2825	2825	-10	-10	4040	3635	2825
b_j=max a_{ij}	2990	2825	2690	2123	4040	3635	2825
1st GC prices	The amount of profit, depending on the different strategies of competitors, Ls						
	1,3,3	1,3,1	2,1,1	2,1,2	2,2,1	2,2,2	2,1,3
c_1=21,000 Ls/MW	2990	2990	2990	2090	2690	-10	2990
c_2=20,370 Ls/MW	2360	2360	2360	2360	2123	2123	2360
c_3=22,050 Ls/MW	4040	2825	2825	2825	-10	-10	4040
b_j=max a_{ij}	4040	2990	2990	2825	2690	2123	4040
1st GC prices	The amount of profit, depending on the different strategies of competitors, Ls						
	2,2,3	2,3,1	2,3,2	2,3,3	3,1,1	3,1,3	3,3,1
c_1=21,000 Ls/MW	2690	2990	2090	2990	2990	2990	2990
c_2=20,370 Ls/MW	2123	2360	2360	2360	2360	2360	2360
c_3=22,050 Ls/MW	3635	2825	2825	4040	2825	4040	2825
b_j=max a_{ij}	3635	2990	2825	4040	2990	4040	2990
1st GC prices	The amount of profit, depending on the different strategies of competitors, Ls						a_i= min a_{ij}
	3,3,3	3,3,2	3,1,2	3,2,3	3,2,1	3,2,2	
c_1=21,000 Ls/MW	2990	2090	2090	2690	2690	-10	-10
c_2=20,370 Ls/MW	2360	2360	2360	2123	2123	2123	2123
c_3=22,050 Ls/MW	4040	2825	2825	3635	-10	-10	-10
b_j=max a_{ij}	4040	2825	2825	3635	2690	2123	

- In order to find the true player strategy in the electricity market would be considered the maximin criterion, which is based on fact that decision-maker chooses a strategy which guarantees him the highest (maximum) of all worst (minimum) outcomes for each strategy, taking into account the risks and losses. From Tab.4 are chosen the worst outcomes of strategies: $a_i = \min_i a_{ij}$. The values a_1, a_2, a_3 show the security level of each strategy because the receiving of worse variant

excluded. On this basis, the best solution is one that guarantees the best of the worst set of outcomes, so:

$$S_{opt2} = \max_j a_i = \max_j [\min_i a_{ij}] = 2123\ Ls. \quad (1)$$

The result will be no worse than S_{opt} at different competitive environment. That value is called by lower game price, as well as the principle of maximum guaranteed result on the basis of Wald criteria.

For finding the worse result of the best set is made similar analyses, as:

$$a'_1 = \max_{i=1} a_{1j} = 2990\ Ls;$$

$$a'_2 = \max_{i=2} a_{2j} = 2360\ Ls;$$

$$a'_3 = \max_{i=3} a_{3j} = 4040\ Ls\ .$$

$$S_{opt2} = \min_j a'_i = \min_j [\max_i a_{ij}] = 2360\ Ls. \quad (2)$$

The value in (2) is called by high games price (or minimax).

- The index of the risk r_{ij} is input for estimation as far as environment condition affects to the outcome. It is determined by the difference between maximum possible win for the selected market condition and win of the chosen strategy [4, 5]:

$r_{ij} = b_j - a_{ij}$, where $r_{ij} \geq 0$ un $b_j = \max_j a_{ij}$.

That index is the basis of Sevage criteria under which is chosen such strategy R_i at which the value of risk takes minimum in the most unfavorable situation:

$$R = \min_j r_i = \min_j [\max_i r_{ij}]. \quad (3)$$

TABLE 5

THE INDEX OF THE RISK FOR FIRST GC AT DIFFERENT COMPETITOR'S STRATEGIES

1st GC prices	1,1,1	1,1,2	1,2,1	1,2,2	1,1,3	1,2,3	1,3,2	1,3,3
c_1=21,000 *Ls/MW*	0	735	0	2133	1050	945	735	1050
c_2=20,370 *Ls/MW*	630	465	567	0	1680	1512	465	1680
c_3=22,050 *Ls/MW*	165	0	2700	2133	0	0	0	0
	1,3,1	2,1,1	2,1,2	2,2,1	2,2,2	2,1,3	2,2,3	2,3,1
c_1=21,000 *Ls/MW*	0	0	735	0	2133	1050	945	0
c_2=20,370 *Ls/MW*	630	630	465	567	0	1680	1512	630
c_3=22,050 *Ls/MW*	165	165	0	2700	2133	0	0	165
1st GC prices	2,3,2	2,3,3	3,1,1	3,1,3	3,3,1	3,3,3	3,3,2	3,1,2
c_1=21,000 *Ls/MW*	735	1050	0	1050	0	1050	735	735
c_2=20,370 *Ls/MW*	465	1680	630	1680	630	1680	465	465
c_3=22,050 *Ls/MW*	0	0	165	0	165	0	0	0
1st GC prices	3,2,3	3,2,1	3,2,2	max(r_{ij})		min[max r_{ij}]		
c_1=21,000 *Ls/MW*	945	0	2133	2133		1680		
c_2=20,370 *Ls/MW*	1512	567	0	1680				
c_3=22,050 *Ls/MW*	0	2700	2133	2700				

The amount of risk is minimal value in the worse situation. In that example the guarantee risk (financial charges) of second strategy is 1680 *Ls*.

- When choose the solution from two extremes (from most optimistic and most pessimistic) it is advisable to stick with some intermediate position, the border of which is regulated by the pessimism-optimism index of Hurwitz criteria [6]:

$$S_{opt} = \max_j \{\lambda \cdot \min_i a_{ij} + (1-\lambda) \cdot \max_i a_{ij}\}. \quad (4)$$

By varying this parameter can be determined decision-making strategy at different degree of risk profile of taking those decisions (from 0 to 1, where 0- better outcome from the best, 1 – the better outcome from worse):

$$S_{opt2} = \max_j \{S_1, S_2, S_3\} = 2241{,}499\ \ Ls.$$

According to the Hurwitz criteria should be selected second strategy.

- Accordingly the Bayes criterion the optimal strategy is chosen when the average win is maximizing or average risk minimizing.

The corresponding selection rule can be interpreted as follows: solution matrix of [a_{ij}] is supplemented with one more column which contains the mathematical expectation of each row values. Is chosen only variants in which lines is the greatest value of this column

$$S_{opt} = \max_j \Sigma(a_{ij} \cdot q_j). \quad (5)$$

In our case q_i equals to $q_1 = q_2 = ... = q_j = 1/n = 1/27$. Multiply the a_{ij} (from Tab.4) on q_j

$$S_{opt3} = \max_j \{S_1, S_2, S_3\} = 2554{,}999367\ \ Ls.$$

According to the Bayes criterion choose 3rd strategy and it brings around 2555 *Ls*.

- The maximax criterion (the optimistic criterion). According to this criterion the best solution is that, which gives the maximum benefit:

$$S_{opt} = \max_j \left[\max_i a_{ij} \right] = 4039{,}999\ Ls \quad (6)$$

The criterion corresponds to the risk of aspiration from the part who takes decision.

According to the maximax criterion much more profitable is third strategy.

- Criterion Hodge-Lehmann relies both on the MM-test and the Bayes-Laplace. With the help of the *n* parameter expresses the degree of confidence of used probability distributions. If confidence is big, then dominate the Bayes-Laplace criterion, otherwise MM criterion.

Such variant of calculation will be selected, which on column will be greatest value of line [6].

$$S_{opt} = \max_j \{n \cdot \sum(a_{ij} \cdot q_j) + (1-n) \cdot \min_i a_{ij}\} \quad (7)$$

At *n*=1 criterion is converted to the Bayes-Laplace criterion, but at *n*=0 becomes to the Wald criterion. In that way, the *n* parameter choice influenced by subjectivism(*n*=0,5). Additionally without attention is the number of realizations. Therefore, this criterion is rarely used in making technical decisions.

$$S_{opt} = \max_j \left\{ n \cdot \sum (a_{ij} \cdot q_j) + (1-n) \cdot \min_i a_{ij} \right\} = 2202 \ Ls.$$

By Hodge-Lehmann criterion should be selected second variant of decision making.

- Germeier criterion focused on the magnitude of losses (the negative value of all a_{ij}) [3, 5].

$$S_{opt} = \max_j \left[\min_i (a_{ij} \cdot q_j) \right] = 78{,}63 \ Ls \ . \qquad (8)$$

Germeier criterion as the Wald criterion is extreme pessimism of player, but unlike the Wald criterion the player making decision with maximal discretion with taking into account probabilities of the states of nature.

By Germeier criterion should be chosen the second strategy.

The comparison of results of different criterion is shown in Table 6.

TABLE 6

COMPARISON OF STRATEGIES SELECTION BASED ON DIFFERENT CRITERIA

Criterion	Strategy
Wald	A-2
Savage	A-2
Hurwitz	A-2
Bayes-Laplace	A-3
Maximax	A-3
Hodge-Lehmann	A-2
Germeier	A-2
Strategy selection	A-2

The optimal strategy of pricing policy selection for first producer (GC) is A-2 – second strategy, because it brings minimum risk of looses.

IV. CONCLUSION

The considered results of game theory are used in the decision making show that most efficient for first company to follow “price war” strategy, because such variant of the game bring smallest losses.

Based on the fact that the “price war” strategy leads to deterioration of financial indexes all market’s entity, but “price leadership” strategy leads to GC profitability increase at the expense of pinching of the consumers interests, it follows that “sincere” strategy is most appropriate for all market participants. But since in a competitive market, each player tries to get the maximum profit, then it becomes a question of the correct strategy choosing of interested person regardless of the competitors.

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Renāta Varfolomejeva, Anatolijs Mahņitko. Lēmuma pieņemšana ģenerējošā uzņēmumā konkurentu dažādas uzvedības stratēģijas apstākļos
Rakstā tiek apskatīta ģenerējošās kompānijas ekonomiskās efektivitātes novērtēšanas metodika, atkarībā no konkurentu reakcijas. Visu analīzes rezultātā iegūto caurspīdīgo un uzskatāmīgo spriedumu izskatam, balstoties uz ģenerējošā uzņēmuma (ĢU) triju cenu stratēģiju. Ģenerējošo kompāniju konkurences cīņai tiek pieņemtas trīs cenu stratēģijas: "patiesā" stratēģija, "cenu karu" stratēģija un "cenu līdera" stratēģija. "Patiesā" uzvedības stratēģija paredz, ka ģenerējošais uzņēmums, veidojoties cenas pieteikumam, orientējas uz izmaksu raksturlīknes relatīvu pieaugumu un fiksētu peļņas normu. "Cenu kara" stratēģijai raksturīgs cenas pieteikuma samazinājums. "Cenu līdera" stratēģijas rezultātā elektroenerģijas cena tirgū pieaug atkarībā no uzņēmuma-līdera pieņemtā lēmuma. Parādītie aprēķinu rezultāti, kuri iegūti, izmantojot spēļu teoriju lēmumu pieņemšanai izvēlētās stratēģijas iesniegtajiem cenu piedāvājumiem, parādīja, ka aplūkojamam ĢU visefektīvākā ir „cenu kara” stratēģija, jo šāds spēles variants rada vismazākos zaudējumus. Atkarībā no cenu piedāvājumu mijiedarbības stratēģija var būt arī citāda. Tā kā „cenu karu” stratēģija izraisa finansiālā stāvokļa pasliktināšanos visiem tirgus dalībniekiem, bet „cenu līdera” stratēģija noved pie ģenerējošo uzņēmumu peļņas palielināšanās uz patērētāju interešu rēķina, „patiesā” stratēģija ir vispiemērotākā visiem tirgus dalībniekiem. Tā kā konkurences tirgus

apstākļos katrs spēlētājs cenšas iegūt maksimālo peļņu, tad ĢU optimālās stratēģijas izvēle ir paša uzņēmuma prerogatīva un nekādā mērā nav saistīta ar konkurentu uzvedību.

Рената Варфоломеева, Анатолий Махнитко. Принятие решения генерирующей компанией в различных условиях стратегий поведения конкурентов.

Рассматривается методика оценки экономической эффективной деятельности генерирующей компании в зависимости от реакции конкурентов. Для наглядности и прозрачности анализа получаемых результатов все рассуждения иллюстрируются для случая трех ценовых стратегий ГК. В работе рассмотрены ценовые стратегии в качестве метода конкурентной борьбы генерирующих компаний - «искренняя» стратегия, стратегия «ценовых войн» и стратегия «ценового лидерства». «Искренняя» стратегия поведения предполагает, что генерирующая компания при формировании ценовой заявки ориентируется на характеристику относительного прироста затрат и фиксированную норму прибыли. Стратегия ценовых войн определяется занижением ценовой заявки. При стратегии «ценового лидерства» завышается ценовая заявка в зависимости от принятия решения компании лидера на рынке.

Приведенные результаты расчета с использованием теории игр для приведенных цен выбранных стратегий в принятии решений показали, что наиболее эффективным для рассматриваемой ГК является стратегия "ценовой войны", потому что такой вариант игры приносит наименьшие потери. В зависимости от взоимоотношений между ценовыми заявками, стратегия может быть другой.

Исходя из того, что стратегия "ценовой войны" приводит к ухудшению финансовых показателей для всех участников рынка, а стратегия "ценового лидерства" приводит к увеличения прибыли генерирующей компании за счет ущемление интересов потребителей, следует, что «искренняя» стратегии наиболее подходит для всех участников рынка. Но так как в условиях конкурентного рынка каждый игрок пытается получить максимальную прибыль, то решение вопроса выбора правильной стратегии ГК, является прерогативой самой ГК, никаким образом не связаным с поведением конкурентов.