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THE APPLICATION OF GAME THEORY IN ENERGETICS – RELATIONSHIP BETWEEN POLAND AND RUSSIA****

Abstract: Energetics as a science of energy transformations studies how to exploit and apply various energy resources. In the economy, the energy sector is mostly characterized by the oligopolistic market system, whose competitiveness is the basic precondition for market liberalization. The focus of this research paper is on the Polish energy system, whose structure has changed significantly since the early 1990s. The biggest problem and threat to the Polish energy system is the huge import dependence on Russia, from which gas through the gas pipeline Yamal comes to Poland and also supplies the market of Western Europe. To reduce the dependence on Russian energy sources, the Swinoujscie LNG terminal was built, the largest Polish energy company PGNiG took over majority ownership over Yamal gas pipeline, and in the end Poland would import American gas into the LNG terminal. However, PGNiG, because of the lower cost, complements its energy market by Russian gas. Mutual 'games' between the two largest energy companies, Polish PGNiG and Russian Gazprom, are presented through game theory. In the analysis, game theory finds optimal solutions and presents all available strategies. Two forms of game theory are presented: non-cooperative game in the form of a 'prisoner's dilemma', and a cooperative game.

Key words: energetics, import dependency, game theory, (non) cooperative game.

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Introduction

Energetics plays a significant role in the economy of each country. Today, the energy sector is mostly characterized by an oligopolistic market system, while in the early 1990s the energy system was mostly a natural vertically integrated state-owned monopoly. In Poland, the majority of energy companies remain state-owned. Although Poland is considered to have significant gas resources, most of natural gas and oil comes from Russia. For this reason, Poland seeks to reduce its import dependence on gas from Russia and it does it in various ways, with the majority shareholding of the largest energy company PGNiG over the Yamal main gas pipeline, the construction of the LNG (Liquefied natural gas) terminal Swinoujscie, the import of US gas, etc. Polish PGNiG and Russian Gazprom are mutually 'conning' each other in gas distribution policy, and there is a paradoxical situation in which the import of Russian gas to the Polish market grows year after year, despite the public's aspirations to reduce Russian gas supply. Their mutual "games" in this paper will be presented by game theory. Game theory is a mathematical tool for analyzing situations where two or more subjects make decisions that will affect mutual benefit or damage. An example of Polish-Russian energy relations will be presented through a non-cooperative game of prisoner's dilemma and a cooperative game.

The idea of the paper was to present the game theory and its use in the analysis of the energy sector. All the information in the analysis is based on the assumptions of rationality in game theory and is not empirically proven.

Energy sector – liberalization, restructuring and organizational models

Energetics is the science of energy transformations important for the overall social and general economic development. It studies ways and modes of exploitation and application of various sources of energy resources. This is an extremely wide discipline that occurs at various levels, from quantum, to biosphere, and to the universe. It also embraces numerous scientific areas, from natural, technical, social sciences, with a special emphasis on the field of economics and the energy economics as scientific discipline.

Today, energetics is one of the most important global issues because globalization has given a strong boost to the growth in production and consumption of energy resources and services worldwide. The energy sector itself is characterized by an oligopolistic market system in which a small number of economically powerful companies supply a large number of

consumers. The energy sector contains some special characteristics compared to other oligopoly branches, and some of them are¹:

- a sufficient number of competitors who are preventing an oligopoly agreement;
- the size and cost structure of the producer must be similar to the cost of energy transfer and should not be a barrier to the competition of distant producers;
- in the sector there must be a surplus of production capacity over its demand as a stimulus to reduce costs and competition in general.

Although the energy sector includes more subsectors such as electricity, oil and gas, coal, and others, below is a brief overview of the power and gas subsectors that are most heavily involved in the liberalization process.

Until the early 1990s, the electricity sector was a natural vertically integrated state-owned monopoly. In former socialist economies, energy prices were more social and less economical category, and that was the reason there was no interest of private investors in the sector, and the efficiency of monopoly enterprises without the encouragement for competition was low. The monopoly as a model for the organization of the electricity market has proved to be inefficient in securing real electricity prices and stimulating investment activity and technological advancement². It became clear that the precondition for any kind of stimulation of competitiveness is actually liberalization of the market³ and restructuring of the sector. This has led to the development of more sophisticated structural models of the electricity market with different levels of competition. The four basic models of the power sector organization are⁴:

1. vertically integrated monopoly in which there is no competition either in production or in the sale of electricity.
2. a purchaser or a purchasing agency (monopsony) where a purchasing agency is permitted or required to acquire the electricity from multiple producers in order to encourage competition on the market.
3. the wholesale market where distribution companies are allowed to choose their supplier, which introduces competition among producers while retaining monopoly power over end-consumer retailers.
4. a retail store that allows all customers to choose their own vendor, which implies full competition.

¹ I. Teodorović, Z. Aralica, D. Redžepagić, *Energetska politika EU i hrvatske perspektive*, „Ekonomija“, vol. 13, № 1, 2006, p. 199.

² N. Vlahinić-Dizdarević, *Restrukturiranje i liberalizacija tržišta električne energije: gdje je Hrvatska?*, „Računovodstvo i Financije“, vol. 57, № 8, 2011, p. 100.

³ I. Teodorović, Z. Aralica, D. Redžepagić, op. cit., p. 199.

⁴ N. Vlahinić-Dizdarević, op. cit., p. 102.

The European Union's gas markets are characterized by overall declining domestic production and increasing demand, and thus they will need to rely on more imports. In November 2005 European Commission has published its first big evaluation of the process of market liberalization according which many countries-members have recorded very weak progress towards an open and competitive market. Meanwhile, the EU agencies for the protection of market competition have started an investigation of the energy sector by publishing sharp objections considering the lack of real competition on the gas market and finding huge obstacles in introducing new gas providers. Liberalization of the energy sector market wasn't taking place in the expected time primarily because the gas price was burdened by two factors: growing of oil price and a decrease of gas production in the EU⁵. The key element of gas market liberalization was giving eligible customers the freedom to choose their gas suppliers. This means that the unbundling process, which is a separation of energy supply and generation from the operation of transmission and distribution networks, has been conducted. Because of its favorable characteristics and highly efficient application technologies, natural gas will be placed as a fuel of choice and will continue to make a growing contribution to energy supply of many EU Member States.

However, despite of a number of directives from the EU considering liberalization of the energy sector, there are still big differences in the level of openness among the countries that are members of the European Union.

Game theory and its application in the energy economics

Game theory is a scientific discipline which describes different situations of conflict and finds suitable models for their resolution. It uses general mathematical techniques for analyzing situations in which two or more subjects make decisions that will affect both sides⁶. Founders of the modern game theory are considered to be John von Neumann and Oscar Morgenstern. It is applied in many social and natural sciences, which is why it has a more and more important role in economy, politics, mathematics, evolutionary biology, information technology, psychology, philosophy, etc.

In economy, game theory is mostly used in modelling of the behaviour of competitors in the oligopolic market and in other market relations characterized by a small number of players, in the area of international relations (various

⁵ Lj. Cerović, M. Donadić, T. Galović, *Liberalization of EU gas sector: impacts and perspectives for future development*, „Poslovna Izvrnost“, vol. 3, № 1, 2009, p. 80.

⁶ I. Barković Bojanić, M. Ereš, *Teorija igara i pravo*, „Pravni Vjesnik“, vol. 29, № 1, 2013, p. 59.

national customs policies, making of customs unions, international kartels, extraction of common property resources, coalitions, and international negotiations), and others⁷. Basic components of game theory are players, strategies, moves, and a presumption of rationality of each player⁸. In addition, few other notions and kinds of game theory also have to be emphasized because of their great importance: Nash's equilibrium, the game of prisoner's dilemma, dominant strategy, and Pareto optimal result, as well as the basic distinction on cooperative and noncooperative games. In cooperative games players coordinate their strategies by making contracts and sharing profit⁹. On the other hand, in noncooperative games players have conflicting interests and they try to work for their own benefit, while doing harm to the competitor, so the attention is directed at strategic choices of every player.

Polish-Russian energy relations – the application of game theory

The structure of Polish energy sector has dramatically changed since the early 1990s, after the fall of the communist block. Some companies have been privatized, but the state has kept the majority ownership in the biggest companies.

There are six companies in the sector of oil and gas production in Poland. Polish oil and gas company PGNiG, which is mostly state-owned, is far the biggest and it provides 98% of oil and gas production, mostly from the drillholes on the mainland. It governs almost all of the gas import and owns all of the transport pipelines and underground storage spaces.

Poland is considered to have significant unconventional resources, especially slate gas¹⁰, whose reserves size is estimated around 148 trillion cubic feet. However, Poland imports two thirds of natural gas, 80% of which comes from Russia.

⁷ L. Brkić, *Temeljni koncepti teorije igara u međunarodnoj ekonomiji*, „Politička Misao“, vol. 39, № 3, 2002, p. 75.

⁸ O. Jadreškić, Lj. Cerović, A. Šegota, *Game theory and its application in analysis between labour market and educational system*, 18th International Scientific Conference ESD, Zagreb, 2016, p. 127.

⁹ P. Kapor, *Teorija igara: sistemski pristup i razvoj*, „Megatrend Revija“, vol. 14, № 1, 2017, p. 265.

¹⁰ Unconventional sources of oil and gas are oil from the bituminous sands, oil shale, oil made from tight oil, oil made from coal, wet gas, gas from the coal seals, gas from tight layers, gas from broken shale, and gas hydrate (www.zmergo.hr, (18.11.2017)).

The most important pipeline in the country is Yamal. Through this pipeline the gas is brought from Russia over Belarus and Poland to the countries of western Europe. In this way Poland imports up to 11 billion m³ of gas¹¹. The pipeline is under the administration of EuRoPolGaz company whose components are Polish PGNiG with 52% of ownership share and Russian Gazprom with 48% of ownership share. Precisely in this combination of ownership share lies the ground of serious political 'games' between Russia and Poland. By taking 52% of ownership share in EuRoPolGazu in 2015, PGNiG is in fact taking control over Yamal pipeline.

To reduce the dependence on Russian gas, in 2011 Poland has started to build a liquified natural gas (LNG) terminal Swinoujscie considering that the terminal would enable a better negotiational position with Gazprom in a new gas delivery contract¹². Incentives to build an LNG terminal were the break of Gazprom's gas delivery to Belarus in 2007 and gas crises between Russia and Ukraine in 2009.

With respect to the fact that Gazprom determines gas price, as well as rules and conditions of delivery, gas price in Poland is among the highest in Europe. According to the latest data from Russian *Fund for national and energy security*, the price of Russian gas for Polish market is between 195 and 213 dollars per 1.000 m³. On the other hand, average gas price in European countries, according to the data from *International Monetary Fund*, is 188 dollars per 1.000 m³.

To keep reducing its energy dependency on Russia, in spring 2017 Polish PGNiG is negotiating about the import of liquified gas with the only American company for the export of liquified gas, company Cheniere. The first delivery of an American tanker of liquified gas came on June 7, 2017 at the Swinoujscie terminal¹³. However, there are certain deficiencies with respect to the import of American gas. The main deficiency is the price of 266 dollars per 1.000 m³. The second deficiency is the quantity – one LNG tanker can carry only 100-150 million m³ of liquified gas at once, while Poland imports the same amount from Russia in only 5-7 days¹⁴.

Alongside the efforts to reduce its energy dependency on Russia, the awareness of the importance of using renewable energy sources is also rising in Poland as another possibility for reducing energy dependency on Russia. During

¹¹ www.energetika-net.com/vijesti/plin/pgnig, (18.11.2017).

¹² D. Pavlović, M. Golub, Z. Jerolimov, *Prikaz načela bitnih za odabir terminala za uplinjavanje u Republici Hrvatskoj temeljem usporednih elemenata LNG terminala u Poljskoj i Litvi*, 28th International scientific meeting of gas experts, Opatija, 2013, p. 9.

¹³ www.energetika-net.com/vijesti/plin/prvi, (18.11.2017).

¹⁴ www.geopolitika.news, (18.11.2017).

2012 company GDF Suez¹⁵ builds the world's biggest biomass powerplant in Polaniec in the southeast of Poland, replacing an already existing powerplant. The new powerplant was supposed to produce 80% of energy from wooden material and 20% of energy from agricultural waste¹⁶. By the end of 2016 the company is producing 5% of electrical energy in Poland¹⁷. However, despite the efforts to increase the percentage of renewable energy sources in the overall energy consumption, while reducing fossil energy sources, the percentage of renewable energy sources in Poland in 2015, according to the Eurostat data, was only 11,8%. According to this, Poland belongs to the group of countries with the least used renewable energy sources in the overall energy consumption. Though Poland is one of the signatories of the Paris Agreement on Climate Change¹⁸, at the Paris summit it claimed a special status for coal and fossil fuels because its national economy is by large dependent on the coal industry¹⁹. Considering everything said, it is hard to expect that Poland will achieve the goal of Europe 2020 Strategy, and that is an increase of renewable energy sources for 20%.

In game theory, based on the presented Polish-Russian energy relations, two kinds of games are possible, noncooperative and cooperative. In the case of a noncooperative game, each player makes his own decision, and this kind of game is presented in the form of a prisoner's dilemma. In the game of prisoner's dilemma, according to the basic presumption of rationality, every player makes a choice for herself that she thinks maximizes her utility. However, when making these decisions, players have to take into account potential decisions of other players, because of a danger that in repeated games they don't bring themselves into a worse position than the initial one is, which is known as *tit for tat* strategy²⁰. Implicit threat hidden in the *tit for tat* strategy requires players to

¹⁵ GDF Suez – big French energy company which in 2015 changed its name to Engie, to reflect better the inclusion in reducing the level of CO₂ emission (www.energypress.net, 18.11.2017)).

¹⁶ www.obnovljivi.com, (18.11.2017).

¹⁷ www.ir.enea.pl, (18.11.2017).

¹⁸ Paris Agreement – global agreement on climate change made on December 12, 2015 in Paris. The agreement includes a plan of action whose goal is to limit global warming at the level 'significantly smaller' than 2°C. It includes the period from 2020 onwards (www.consilium.europa.eu, (18.11.2017)).

¹⁹ www.poslovni.hr, (18.11.2017).

²⁰ *Tit for tat* strategy is used if one of the players breaks the tacit agreement, and reactions can be multiple, to threats and blackmailing. The first move of this strategy is cooperation, while the next moves are simply repeating previous moves of the competitor.

stick to the agreement²¹. Another limit of noncooperative games comes out of a decision of players to maximize exclusively their own benefit, without taking care for how their decision will reflect on the community's wellbeing.

In this article, the game of prisoner's dilemma between PGNiG and Gazprom is possible to present through a model of competition in price. Both companies are individually determining the price of gas, but the circumstances of the determination of price are different. PGNiG will, considering its goal of a reduced Russian gas import, and under the presumption of rationality, determine its price according to the expenses of investing in its own gas infrastructure, expenses of gas import from other sources, expenses of gas distribution inside the country, and according to expected profit, taking into account the price policy of competing companies in Poland. On the other hand, Gazprom will form its price as an export gas price, taking into account the prices for other export markets, and prices of other potential gas providers for Polish market.

Both companies have the possibility to determine a higher or a lower price. In this case, the demand for gas will not be determined only by the price, but also by the chosen strategy of the competitor. If one company determines a high gas price, while the other offers a lower gas price, then the first company will lose a part of the profit because of the loss of a part of the market, while the other company will expand its market, i.e. it will increase its profit based on that. In the case that both companies lower their gas prices, probably both of them will have a lower profit because the market share will not change, and the price will fall. Moreover, the demand for gas is not elastic or is less elastic to the changes in gas price²², since it is necessary goods, and in these circumstances a decrease in price doesn't imply a significant increase of the demanded amounts. For the same reason, in the case of the higher and lower price strategy of the two companies, in the end more profit will go to the company that set a high price. Though from the perspective of companies the focus is on profit, from the perspective of the state, the focus is on social wellbeing, end therefore on lower prices.

²¹ S. Rakočević, *Teorija igara kao osnov ekonomskog ponašanja*, „Montenegrin Journal of Economics“, vol. 2, № 3, 2006, p. 169.

²² T. Gelo, *Ekonometrijsko modeliranje potražnje za plinom*, „Ekonomski Pregled“, vol. 57, № 1-2, 2006, p. 80.

Table 1. Matrix of the two companies based on the game of prisoner's dilemma

PGNiG (A)	Gazprom (B)		
	Price	0,2 \$/m ³	0,4 \$/m ³
	0,3 \$/m ³	A = 300 000 000 \$ B = 200 000 000 \$	A = 300 000 000 \$ B = 400 000 000 \$
0,5 \$/m ³	A = 500 000 000 \$ B = 200 000 000 \$	A = 500 000 000 \$ B = 400 000 000 \$	

Source: Author's interpretation.

It is possible to present the situation in the following way. With the first assumption, the price of Russian gas in Poland is on average 0,2 \$/m³, while the gas price in Poland that includes domestic gas and gas from other sources would be a bit higher, and amount to 0,3 \$/m³. The other assumption suggests a calculation of earnings at the level of monthly delivery of one billion m³ of gas²³. The matrix of prisoner's dilemma would look like in table 1.

In the analyzed example Nash's equilibrium²⁴ is in the point in which the profit is the biggest. However, the strategy of price increase pays off (for both companies) only if both companies consistently apply the strategy of price increase. Companies have to decide whether they will engage in rivalry, i.e. competition to individually win as bigger market share as possible, or they will decide for a weaker level of competition maintaining the existing market share with a mutual agreement on the forming of prices. If companies would decide for a multiple repetition of the game, they would see that in the end the best strategy is mutual cooperation. If the game is played only once, then Nash's solution is optimal. If the game is repeated unlimited number of times, then it leads to Pareto optimal result^{25 26}. Mutual cooperation includes cooperative game. Its outcome is the situation where a single player's strategy induces another player to adapt and accept a cooperative plan. Strategy matrix in the cooperative game would look like this (Table 2).

²³ Yearly consumption of natural gas in Poland in 2012 was 14 billion m³ of gas (www.pgz.hr, (18.11.2017)).

²⁴ Nash's equilibrium (basics of game theory) got its name after American mathematician John Nash. Basic premise of Nash's equilibrium is that every change or choice of a new strategy affects also the strategies of the other player or players. Players make the best possible decision by taking into account also the decisions of other players (O. Jadreškić, Lj. Cerović, A. Šegota, op. cit., p. 127).

²⁵ Pareto optimal result is such a result of a game in which the result of one player might be better only if the result of another player would get worse.

²⁶ S. Rakočević, op. cit., p. 169.

Table 2. Strategy matrix of two companies according to cooperation

PGNiG (A)	Gazprom (B)		
	STRATEGY	Cooperation	Noncooperation
	Cooperation	Joint decision-making	Gazprom independently determines the terms of gas delivery, potential <i>tit for tat</i> strategy
Noncooperation	PGNiG boycotts Gazprom, potential <i>tit for tat</i> strategy	Position status quo	

Source: Author's interpretation according to: M. F. Popescu, G. Hurduzeu, *Energy challenges for Europe – scenarios of the importance of natural gas prices from a game theory perspective*, “Journal of Game Theory”, vol. 4, № 2, 2015, p. 26-35.

In cooperative game optimal strategy would be mutual cooperation between PGNiG and Gazprom. In that case, an agreement is made to bring the greatest possible benefit to both sides. As PGNiG strives to reduce energy dependence on Russia, it can improve its own supply system by certain actions. It can be diversification of gas import, investment in its own energy infrastructure, improvement of the connection between domestic producers and gas distributors etc. On the other hand, Gazprom tries to keep a strong position on the Polish energy market. It can be achieved by changing price strategy and improving transparency and conditions of management.

In case of strategy when one player cooperates, and another player doesn't want cooperation, the biggest danger is huge probability of *tit for tat* strategy by cooperative player. Player who refuses cooperation will be punished for his actions. In case when PGNiG would refuse cooperation, boycott Gazprom and refuse its gas delivery, because of insufficient own stock, many Polish households, companies and other business subjects could stay without gas power, and Gazprom could initiate sanctions to PGNiG and Poland because of realised losses. On the other hand, if Gazprom refused to cooperate and independently ordered the delivery of gas that would not match PGNiG in quantity and price, then PGNiG could initiate sanctions against Gazprom and Russia. As Poland receives most of its gas from Russia, this would mean turning to other, more expensive sources of gas by force, which would ultimately lead to the loss of PGNiG or Poland. In case of disagreement, mutually incompatible strategies would lead to the status quo position, which would support the current state. In this situation it is possible that two companies involved are further aggravated by unsolved energy issues.

The current real situation in Polish-Russian energy relations is the status quo. Although Poland has been trying to reduce energy dependence on Russia for almost a decade, the latest data from the European Gas Inspection Agency (GIE) does not support this. Just in the period when the first American vessel with liquefied gas was awaiting, the GIE reported that PGNiG regularly fills its Russian gas storage facilities and that gas imports have raised by 21 million m³ per day, almost twice as much as 2016. This leads to a paradoxical situation in which Poland first opened its LNG terminal to accept American gas, while Russian gas imports continue to grow year after year. Also, PGNiG's sales of gas to consumers have increased its gaining. In 2016, EBIT grew by 50% to 1.28 billion zlotys (\$ 320 million)²⁷.

Poland still doesn't give up on reducing Russian gas imports in the future. In June 2017, together with Denmark, Poland signed a memorandum on the construction of the so called 'Baltic Pipeline' to get gas from Norway. The gas pipeline should be built by 2022, after which, according to the Polish government, gas import from Gazprom should end. But many energy experts are skeptical of building the gas pipeline. Namely, today Poland can import gas from Scandinavian countries, but the amount of imported gas is still increasing from Gazprom. Also, the Polish energy company Gaz-System, which accounts for more than half costs of gas pipeline construction (total gas pipeline costs 1.7 billion EUR), does not exclude the possibility of gas supply in reverse in the potential joining of the future gas pipeline and LNG terminal. As Russian gas is the cheapest gas imported by Poles, it is not excluded that Poland will eventually resell Russian gas in Scandinavia²⁸.

Conclusion

Today, as one of the most important global issues, energetics is characterized by an oligopolistic market system in which a small number of economically powerful companies supply a large number of consumers. In order to stimulate competitiveness, it is necessary to liberalize the market, which is achieved through the development of more sophisticated structural models of the energy sector organization.

The first part of the research paper enters into the basic concepts of energetics and the ways in which it functions, with particular emphasis on the electricity and gas sectors. After that the Polish energy system was introduced, characterized by the fact that most of its gas and oil were imported from Russia

²⁷ www.geopolitika.news, (18.11.2017).

²⁸ www.logicno.com, (18.11.2017).

via Yamal gas pipeline. Poland's efforts to reduce its energy dependence on Russia are described, and the first step was the construction of the Swinoujscie LNG terminal. Also, the largest Polish power company PGNiG will take over majority ownership over Yamal gas pipeline in 2015, and the first delivery of liquefied American gas at the LNG terminal was also received. Although everything suggests a reduction of Russia's energy dependence on Russia, Russian gas is still largely imported into the Polish energy market. Also, although there is a tendency to replace part of the fossil energy sources with renewable energy sources, there is no significant progress from year to year, so it is hard to believe that Poland will achieve the ultimate goal of Europe 2020 strategy, which is an increase in share of the renewable energy resources in total energy consumption to 20%.

The second part of the paper is about game theory as a scientific discipline that describes conflict situations and finds appropriate models for solving them. In this research paper, the applicability of game theory is presented through an analysis of Polish-Russian energy relations in the form of noncooperative and cooperative games between energy companies, Polish PGNiG and Russian Gazprom.

A noncooperative game is presented as prisoner's dilemma game in which players make their own decisions separately, without cooperation. In the prisoner's dilemma game, Nash's equilibrium is at the point where the earnings of both players are greatest. By analyzing the game, it was found that ultimately the optimal strategy for both companies is cooperation, presented through the game of cooperation. However, actual relations between PGNiG and Gazprom are not Pareto optimal, and their mutual 'games' are not ending.

The idea of the paper was to present the game theory and its use in the analysis of the energy sector. All the information in the analysis is based on the assumptions of rationality in game theory and is not empirically proven.

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ZASTOSOWANIE TEORII GIER W ENERGETYCE – ZALEŻNOŚĆ MIĘDZY POLSKĄ A ROSJĄ

Energetyka jako nauka o przetwarzaniu energii bada sposoby wykorzystania i zastosowania różnych zasobów energii. W gospodarce sektor energetyczny charakteryzuje się przede wszystkim oligopolistycznym systemem, którego konkurencyjność jest podstawowym warunkiem wstępnym liberalizacji rynku.

W artykule skoncentrowano się na polskim systemie energetycznym, którego struktura od wczesnych lat 90. znacznie się zmieniła. Największym problemem i zagrożeniem dla polskiego systemu energetycznego jest ogromne uzależnienie importu od Rosji, z którego gaz przez gazociąg Jamał importowany jest do Polski, a także na rynek Europy Zachodniej. W celu ograniczenia zależności od Rosyjskich źródeł energii wybudowano w Świnoujściu gazoport. Największa polska firma energetyczna PGNiG przejęła większościową własność polskiego odcinka Gazociągu Jamalskiego, a na koniec Polska mogłaby sprowadzać amerykański gaz przez gazoport. Jednak ze względu na niższe koszty PGNiG uzupełnia rynek energetyczny rosyjskim gazem. Wzajemne „gry” pomiędzy dwoma największymi przedsiębiorstwami energetycznymi, polskim PGNiG i rosyjskim Gazpromem, prezentowane są w teorii gier. W przeprowadzonej analizie w zakresie teorii gier poszukiwano optymalnych rozwiązań i zaprezentowano wszystkie dostępne strategie. Przedstawiono dwie formy teorii gier: grę niekooperacyjną w formie „dylematu więźnia” i grę kooperacyjną.

Słowa kluczowe: energetyka, zależność od importu, teoria gier, gra (nie)kooperacyjna.