

ENERGY SECURITY AND EFFECTIVITY OF ENERGY COMPANIES

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Purpose: The purpose of the article is to empirically identify the effectivity of energy companies in crisis conditions. The aim was formulated based on a critical analysis of the literature and the identified gap.

Design/methodology/approach: The article focuses on the characteristics of energy security in terms of the need for effectivity of energy companies. The concept of energy security was defined, and the obligations of the energy company in the field of ensuring energy security in terms of effectivity were indicated. A literature review was then carried out and a research gap was identified. The research problem focused on answering the question: Does the crisis equally affect the effectivity achieved by energy companies, which determines their ability to ensure energy security? Empirical studies tested the following hypotheses: the crisis equally affects the efficiency achieved by energy enterprises, which determines their ability to ensure energy security and not all efficiency distributions in crisis conditions are identical. The research methods are as follows: desk research and Friedman test.

Findings: There is evidence that the crisis situation has an unequal impact on the effectivity achieved by energy companies. There are companies that are capable and companies that are not able to ensure energy security

Originality/value: Implementation of the postulate of effectivity in a practical approach using statistics. The article presents the authors' own research.

Keywords: Energy security, Management, Microeconomics, Research, Effectivity, Energy enterprise.

Category of the paper: Research paper.

1. Introduction

Energy security means having enough energy to meet demand and having a power system and infrastructure that are protected against physical and cyber threats (Department of Energy, 2004). Other definition of energy security includes a wider range of factors, often referred to as the “four As” of energy security – availability, affordability, accessibility and acceptability.

Availability ensures that energy supplies are available in sufficient amounts. Affordability aims to have these resources available at sufficiently-low prices. Accessibility focuses on ensuring all citizens have access to energy, which is to some extent about ensuring that reliable infrastructure is in place to ensure a robust supply for the end user, but this is generally interpreted in practice as ensuring that energy prices are kept low and fuel poverty is minimised. Acceptability is concerned with the negative impacts of energy, such as pollution and environmental damage, and ensuring that these impacts are minimised in order to make the energy acceptable to the customer (Jones, Dodds, 2017). Energy security is an important guarantor of national development (Ma, Feng, Chang, 2024). Meanwhile, reports on the results of monitoring the security of electricity supplies published by the Ministry of Climate and Environment show that already in 2030, the demand for power (net) at the annual peak in Poland will exceed 30.5 GW. At the same time, the power available in existing conventional units will decrease due to the decommissioning of obsolete units. The decrease in power will probably be so great that even the projected increase in power from renewable sources and possible nuclear units will not meet the country's growing needs (Rekord zapotrzebowania na energię pobity. Czy grozi nam blackout?). Achieving this security requires efforts to reduce risks to energy systems (Dreyer, Stang, 2013). In terms of the country's energy security, energy companies are subject to regulations in two areas: ensuring the security of the power system operation and ensuring fuel stocks in an amount ensuring the continuity of electricity supply to consumers (Dołęga, 2009). On the other hand, there is currently an energy crisis caused by the coronavirus pandemic, the war in Ukraine and Russian energy (Pawlowski, 2023). In November 2028, The Parliament declared a climate emergency asking the European Commission to adapt all its proposals in line with a 1,5°C target for limiting global warming and ensure that greenhouse gas emissions are significantly reduced (Green Deal, 2022). Carbon neutrality means having a balance between emitting carbon and absorbing carbon from the atmosphere in carbon sinks. Removing carbon oxide from the atmosphere and then storing it is known as carbon sequestration. In order to achieve net zero emissions, all worldwide greenhouse gas emissions will have to be counterbalanced by carbon sequestration. The European union committed to an ambitious climate policy. Under the Green Deal it aims to become the first continent to remove as many CO₂ emissions as it produces by 2050. this goal became legally binding when the European Parliament and council adopted the Climate Law in 2021. The EU's interim emission reduction target for 2030 was also updated from 40% to at least 55%. The EU is currently revising old legislation and setting new laws that will help deliver the 2030 goal of 55% cut in emissions. the package of legislation is known as "Fit for 55" and includes among others rules on emissions trading, national emissions reduction targets, carbon removal in the land use sector and transport emissions (What is carbon neutrality and how can it be achieved by 2050, 2019). Therefore, the efficiency of energy companies is important. The aim of the article is to empirically identify the effectivity of energy companies in crisis conditions. In the article, effectivity is understood as: the result of a specific project undertaken as part of

the business entity's activities, which is a factor in the relationship between the effects and the expenditure incurred: Bielski, 1992; Puszko, 2018.

A review of literature indicates that the energy industry in times of crisis is of interest to researchers in Poland. Literature review in 2019-2023 is presented in Table 1. The macronomic approach dominates (Kiciński, Czaja, 2021a, 2021b; Skotarek, 2023; Bojar-Fijałkowski, 2021; Kaznowski, Sztafrowski, 2023; Dylaget al., 2019; Manowska, 2019; Makuch, 2020; Sobieraj, 2023). Is being investigated whether the current state of the Polish energy system may lead to its crisis and in turn threaten the country's energy security (Cop, 2023), the energy crisis is a justification for postponing the EU climate targets (Sobieraj, 2023) or what should Poland do to meet the goals set out in the EU regulations (Bojar-Fijałkowski, 2021; Kaznowski, Sztafrowski, 2023): limiting the use of fossil fuels in the energy sector (Manowska, 2019), the development of large-scale photovoltaics, energy based on the combustion of primary forest biomass, the development of hydrogen energy (Naworyta, 2024), the final use, the end of coal use in electricity generation, the development of decarbonization (Czyżak, Hetmański, 2020). The premises and manifestations of innovation are emphasized (Stec, 2020; Kinelski, 2020; Pilipczuk, 2023). Few studies focus on energy companies and their effectivity (Pilipczuk, 2023; Kinelski, 2020). The research is qualitative in nature. There is a lack of research using statistical tests. This article fills this research gap. The article is a continuation of the authors' research in the field of effectivity. So far, the following publications have been published: Puszko, 2018; 2021a, 2021b, 2023a, 2023b, 2023c.

Table 1.

Literature review in 2019-2023

Item Reseacher's name	Literature review
	Note
Bojar-Fijałkowski T.	The article analysis the correlation between The European Green Deal and wind farm development projects in the polish part of the Baltic Sea.
Cop K.	The article aims to answer whether the current state of the Polish energy system may lead to its crisis and in turn threaten the country's energy security.
Czyżak P., Hetmański M.	The goal of the paper is to compare existing climate modelling results from major institurions (IPCC, IEA, Climate Analytics) in order to provide evidence for decarbonizing power generation sector in Europe and Poland in particular.
Dylağ A. et al.	The goal of the paper is to provide information about the current state of citinzens energy, its legal and socio-political environment in Poland.
Firlit A. et al.	The article attempes to present contemporary trends and chalenges in the area of power quality in the context of the development of intelligent power systems (smart grids) and distributed generation.
Jarosz S. et al.	The aim of the paper is to present the methods of financing inthe renewable energy sectors and the hard coal sector based on a comparative anlysis of the methods and sources of obtaining financing for capital groups in the enrgy sectos.
Jasic B.	The goal of the article is to outline and to analyse the key chalenges to be faced by the Polish energy market, as it is only at the begining of the energy transition process.
Kiciński J., Czaja P.	Energy sufficiency: various instytitions, organizations, scientists and publicts develop long-term scenarios, visions and recommendations in order to resolve one of the main problems of our civilisation e.g., energy sufficiency for future generations.

Cont. table 1.

Kiciński J., Czaja P.	Situation of Poland from the point of view of energy is specific. Poland has a national treasury in a form of coal, which is used and it provides Poland with energy security. Poland has also a green coal in a form of biomass and other RES that are used in a lesser than possible extend.
Kinelski G.	Industry 4.0 has the potential to transform economies, jobs, and societies. A characteristic technology widely associated with this transformation is Artificial Intelligence, which is increasingly being adopted by energy companies. Therefore, it is worth analysing the available possibilities, relationships, solutions, and efficiency measures used in this sector. Such analysis can help assess management effectiveness and, despite political and regulatory challenges, enable us to take advantage of the opportunities brought by the Fourth Industrial Revolution.
Kazanowski R., Sztafrowski D.	The article presents issues related to the problems that need to be overcome in order to achieve the goal of achieving a high share of renewable energy from wind and solar energy in the country's power system.
Kostecka- Jurczyk D., Marak K.	The aim of the article is to analyse the legal conditions for the functioning of energy cooperatives and energy clusters in Poland, as well as to point out the shortcomings of the current solutions and the desired changes that could accelerate the development of community energy.
Kozieł P.	The article discusses the role of customer value on the electricity market in Poland
Knop L., Staszewska J.	The aim of the article is to characterise the business models of energy companies in the context of building and maintaining their resilience applying climate neutral objectives within the framework of a sustainable development strategy.
Makuch K.	The purpose of the article is to present contentious points in the field of waste management hierarchy and waste to energy.
Manowska A.	The article analysis whether Poland will meet renewable energy obligations by 2020 under the current conditions, presents current energy consumption in the world and in the country, local conditions taken into account when creating the country's energy mix and forecast of renewable energy demand.
Mol B. et al.	The paper presents an analysis of possibility of use technical, organizational solutions that improve local energy security and reliability of customer supply, including those related to the creation of mini energy centers.
Naworyta W.	The paper critically evaluates selected technical solutions in the field of broadly understood energy sector.
Pilipczuk O.	The aim of the article is to determine the current main directions of research on the concept of the cognitive enterprise and its adaptation in energy enterprises. Nowadays, information technologies have become a tool for solving many problems arising in the energy industry, such as creating and managing removable technologies, saving energy and searching for new sources. Many new concepts are emerging, such as industry 5.0, society 5.0, smart city, smart enterprise and others. In turn, a few years ago, IBM introduced the concept of the "cognitive enterprise" instead of the "intelligent enterprise", which assumes, among others, using cognitive technologies to increase enterprise intelligence.
Prokopowicz D.	The paper identifies the key determinants and sources of the various economic, financial, other crises that have occurred since the beginning of the 21st century.
Skotarek K.	The presented text highlights the benefits of making parts of electricity market public comparing to the risks associated with the politicization, the most important problems arising from politicization (e.g investment delays, problems related to the characteristics of the production and connection of energy from renewable sources and insufficient use of the international integration potential of the power grid), the motivational function of market competition and globalisation processes.
Sobieraj K.	The aim of the article is to address the question (to dispel doubts) of whether the energy crisis is a justification for postponing the EU climate targets. The answer to this question must be sought in the nature of climate change and the nature of climate protection policy and law. The thesis of the paper is that, in the growing energy crisis, the importance of EU climate protection law immobilising Member States to take appropriately ambitious climate protection measures is growing.

Cont. table 1.

Stec S.	The article contains a synthetic description of activities related of innovation in the energy industry in the countries of Central Europe namely in the Czech Republic, Poland, Slovakia, Hungary.
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Source: Own study based on (Bojar-Fijałkowski, 2021; Cop, 2023; Czyżak, Hetmański, 2020; Dyląg et al., 2019; Firlit et al., 2023; Jarosz et al., 2022; Jasic, 2021; Kiciński, Czaja, 2021a, 2021b, 2020; Knop, Staszewska, 2024; Kostecka-Jurczyk, Marak, 2024; Koziel, 2020; Makuch, 2020; Manowska, 2019; Mól et al., 2022; Naworyta, 2024; Pilipczuk, 2023; Propokowicz, 2023; Sobieraj, 2023; Skotarek, 2023; Stec, 2020).

2. Characteristics of empirical research

Taking into account the fact that energy security can be considered from the subjective point of view, i.e. from the point of view of energy companies, the research problem focused on answering the question: Does the crisis equally affect the effectivity achieved by energy companies, which determines their ability to ensure energy security? The answer to this question requires testing the following hypotheses: H0: the crisis equally affects the efficiency achieved by energy enterprises, which determines their ability to ensure energy security and H1: not all efficiency distributions in crisis conditions are identical. Empirical research was carried out in the period January 2020 - June 2024. The item of empirical research consisted of: collecting information on the effects and expenditures of enterprises using the desk research method, calculation of enterprise efficiency according to the formula: $W_e = E / N$ (where E - the result of the enterprise's operations, N - expenditure incurred on the enterprise's operations (Adamczyk, Nehring, 1995) and implementation of the Fiedman test (Achel, 2000), (Szwed, 2008, p. 323). The subjective scope of the research is: 14 energy companies understood in accordance with the Energy Law (Act, 1997, Art. 3.12), present on the Stock Exchange. The characteristics of energy companies are presented in table 2.

Table 2.

The characteristics of organizations

Item Effects and expenditures (PLN thousand) in years	THE CHARACTERISTICS OF ORGANIZATIONS				
	year2019 (pln thousand)	year2020 (pln thousand)	year2021 (pln thousand)	year2022 (pln thousand)	year2023 (pln thousand)
I.ELEKTROCIĘPŁOWNIA BĘDZIN S.A.					
1. Sales revenue	222.655	161.529	244.295	322.081	244.114
2. Cost of manufacture of products sold	272.319	230.828	332.447	477.405	340.761
3. Sales costs	0	0	0	0	0
4. Management cost general	0	0	0	0	0
5. Other operating income	4.139	6.860	3.360	9.030	153.741
6. Other operating expenses	63.853	2.324	106.290	54.043	255.472
7. Financial income	1.636	754	234	137	7.531
8. Financial costs	37.040	53.190	8.937.801	55.850	61.460
II. ČEZ. S.A.					
1. Sales revenue	33.818.496	3.629.207	41.592.070	54.580.493	59.169.946
2. Cost of manufacture of products sold	29.915.092	35.167.810	37.903.540	35.072.520	42.115.385
3. Sales costs	0	0	0	0	0

4. Management cost general	0	0	0	0	0
5. Other operating income	2.014.720	1.812.076	549.635	1.443.294	738.956
6. Other operating expenses	1.488.623	1.167.323	1.260.035	1.157.044	2.927.856
7. Financial income	67.543	66.088	79.735	738.737	1.104.476
8. Financial costs	1.234.542	1.266.367	1.150.700	1.529.131	2.390.129
9. Other income (costs)	-176.818	380.050	576.645	342.957	318.907
III. COLUMBUS ENERGY S.A					
1. Sales revenue	204.249	657.110	704.347	593.375	459.324
2. Cost of manufacture of products sold	187.989	571.229	697.666	652.993	494.807
3. Sales costs	0	0	0	0	0
4. Management cost general	0	0	0	0	0
5. Other operating income	5.658	12.698	2.057	4.763	20.467
6. Other operating expenses	1.658	5.280	9.808	20.687	14.103
7. Financial income	0	0	3.023	3.226	10.177
8. Financial costs	5.382	11.479	12.845	48.589	41.237
9. Other income (costs)	12	4.689	-4.230	-3.379	-5.695
IV. ENEA S.A					
1. Sales revenue	16.401.298	18.176.505	21.210.647	30.117.52	48.183.419
2. Cost of manufacture of products sold	14.716.400	16.530.760	19.245.575	29.531.508	47.111.418
3. Sales costs	0	0	0	0	0
4. Management cost general	0	0	0	0	0
5. Other operating income	320.076	-3.178.180	229.612	215.329	266.337
6. Other operating expenses	148.454	173.824	127.317	223.433	382.659
7. Financial income	441.858	346.336	214.803	276.630	486.445
8. Financial costs	-607.512	-605.300	176.963	-247.153	-1.199.831

Source: Own study based on Biznesradar.pl

The information in Table 2, such as: sales revenue, cost of manufacture of products sold, management cost general, other operating income, other operating expenses, financial income, financial costs, other income (costs) were used to carry out the item scope of the research, i.e. the calculation of the efficiency of energy companies. Due to editorial requirements related to the number of pages of the article, table 2 presents the characteristics of selected organizations. Detailed information can be found on the website: Biznesradar.pl. The spatial scope of the research includes entities located in the following voivodeships: Masovia, Lesser Poland, Silesia, Greater Poland, West Pomerania, Lower Silesia, Podkarpackie, Kujawsko-Pomorskie, Lublin. The territorial scope of the research is presented in table 3.

Table 3.
Territorial scope of research

Item	Territorial scope research
Company name	Voivodeship
ELEKTROCIEPŁOWNIA BĘDZIN S.A.	Silesian voivodeship
ČEZ. S.A	Masovian Voivodeship, Lesser Poland Voivodeship, Silesian Voivodeship, Greater Poland Voivodeship, West Pomeranian Voivodeship
COLUMBUS ENERGY S.A.	Lesser Poland Voivodeship
ENEA S.A.	Greater Poland Voivodeship
ZESPÓŁ ELEKTROCIEPŁOWNI WROCLAWSKICH KOGENERACJA S.A.	Lower Silesian Voivodeship
MI SYSTEM S.A.	Podkarpackie Voivodeship
NOVAVIS GROUP S.A.	Masovian Voivodeship
ONDE S.A.	Kuyavian-Pomeranian Voivodeship
PHOTON ENERGY N.V.	Greater Poland Voivodeship, Masovian Voivodeship
POLENERGIA S.A.	Masovian Voivodeship
PGE S.A.	Lublin Voivodeship, Masovian Voivodeship

Cont. table 3.

RAEN S.A.	Masovian Voivodeship
TAURON POLSKA ENERGIA S.A.	Silesian Voivodeship
ZESPÓŁ ELEKTROCIĘPŁOWNI PAŃNÓW-ADAMÓW-KONIN S.A.	Greater Poland Voivodeship

Source: Own study based on Serwis informacyjno-usługowy dla przedsiębiorcy.

Therefore, the empirical research was carried out in energy companies from the largest Polish provinces. The time scope of the research is: energy crisis period - 2019-2023.

3. The Results of Empirical Research

The efficiency of energy companies in individual sub-periods of the period covered by the research was calculated. Effectivity of energy enterprises in 2019-2023 is shown in Table 4.

Table 4.
Effectivity of energy enterprises in 2019-2023

Item Effectivity in years Company name	EFFECTIVITY OF ENERGY ENTERPRISES IN 2019-2023				
	Year 2019	Year 2020	Year 2021	Year 2022	Year 2023
ELEKTROCIĘPŁOWNIA BĘDZIN S.A.	0,67	0,70	0,55	0,61	0,67
ČEZ. S.A.	1,09	1,03	1,06	1,51	1,29
COLUMBUS ENERGY S.A.	1,07	1,14	0,97	0,82	0,88
ENEA S.A.	1,05	0,85	1,10	1,00	0,98
ZESPÓŁ ELEKTROCIĘPŁOWNI WROCLAWSKICH KOGENERACJA S.A.	1,10	1,13	1,05	1,11	1,11
MI SYSTEM S.A.	1,03	1,08	1,01	1,00	0,98
NOVAVIS GROUP S.A.	0,26	1,04	0,91	1,44	2,36
ONDE S.A.	1,04	1,07	1,05	1,01	1,03
PHOTON ENERGY N.V.	1,02	0,81	0,87	1,06	0,83
POLENERGIA S.A.	1,05	1,07	1,11	1,02	1,06
PGE S.A.	0,89	1,00	1,09	1,05	0,95
RAEN S.A.	0,38	2,78	0,39	0,26	1,27
TAURON POLSKA ENERGIA S.A.	0,99	0,89	1,02	1,00	1,04
ZESPÓŁ ELEKTROCIĘPŁOWNI PAŃNÓW-ADAMÓW-KONIN S.A.	0,86	0,88	0,82	1,07	1,27

Source: Own study based on Biznesradar.pl, Adamczyk, Nehring, 1995.

The information in Table 4 shows that the effectivity of energy companies does not change much from year to year. The calculated effectivity allowed the implementation of the Friedman test methodology. Data for the Friedman test were presented in tabular form (Achel, 2000). The rows correspond to energy companies (there are 14 rows). The columns correspond to the effectivity achieved by energy companies in 2019-2023. Then the observations (efficiency of energy companies) were transformed into ranks. Auxiliary calculations are presented in table 5. In each cell of table 18 there is a rank, which is a function of the ordering within each row. The smallest observation in a row receives rank 1, the next one receives rank 2, 3, 4.

The largest observation receives a rank of 5. In the case of the same values (0,67; 1,11), the rank awarded was the arithmetic mean of two adjacent ranks, i.e. $(3+4)/2 = 3,5$.

Table 5.

Auxiliary calculations

Item Effectivity ranking in years Company name	AUXILIARY CALCULATIONS									
	year 2019		year 2020		year 2021		year 2022		year 2023	
	Effectivity	Rank	Effectivity	Rank	Effectivity	Rank	Effectivity	Rank	Effectivity	Rank
ELEKTROCIĘPŁOWNIA BĘDZIN S.A.	0,67	3,5	0,70	5	0,55	1	0,61	2	0,67	3,5
ČEZ. S.A.	1,09	3	1,03	1	1,06	2	1,51	5	1,29	4
COLUMBUS ENERGY S.A.	1,07	4	1,14	5	0,97	3	0,82	1	0,88	2
ENEA S.A.	1,05	4	0,85	1	1,10	5	1,00	3	0,98	2
ZESPÓŁ ELEKTROCIĘPŁOWNI WROCLAWSKICH KOGENERACJA S.A.	1,10	2	1,13	5	1,05	1	1,11	3,5	1,11	3,5
MI SYSTEM S.A.	1,03	4	1,08	5	1,01	3	1,00	2	0,98	1
NOVAVIS GROUP S.A.	0,26	1	1,04	3	0,91	2	1,44	4	2,36	5
ONDE S.A.	1,04	3	1,07	5	1,05	4	1,01	1	1,03	2
PHOTON ENERGY N.V.	1,02	4	0,81	1	0,87	3	1,06	5	0,83	2
POLENERGIA S.A.	1,05	2	1,07	4	1,11	5	1,02	1	1,06	3
PGE S.A.	0,89	1	1,00	3	1,09	5	1,05	4	0,95	2
RAEN S.A.	0,38	2	2,78	5	0,39	3	0,26	1	1,27	4
TAURON POLSKA ENERGIA S.A.	0,99	2	0,89	1	1,02	4	1,00	3	1,04	5
ZESPÓŁ ELEKTROCIĘPŁOWNI PAŃNÓW-ADAMÓW-KONIN S.A.	0,86	2	0,88	3	0,82	1	1,07	4	1,27	5

Source: Own study based on Biznesradar.pl, Achel, 2000.

The efficiency ranking was used to calculate the Friedman statistic (Szwed, 2008).

$$\chi_r^2 = \frac{12}{Nk(k+1)} \sum (R_j^2) - 3 \cdot N(k+1) \quad (1)$$

$$\chi_r^2 = 14,265$$

4. Discussion

The use of the Friedman test allows for testing hypotheses regarding the variability of the intensity of the studied variable depending on the conditions (Szwed, 2008, p. 284). On the basis of the presented empirical results, it is discussed that with $df = 5-1 = 4$ and $\alpha = 0.05$, the critical value of the statistic χ^2 is 9,488. Since the empirical value of the statistic χ^2 is greater than the critical value χ^2 read from the tables, the null hypothesis was rejected and the alternative hypothesis was accepted. The methodology for testing hypotheses was based on statistical literature (Szwed, 2008). The worsening energy crisis requires more than ad hoc measures to support. Action must be stepped up that can have long-term effects, including increasing the resilience of the EU and Member States to the negative economic and social impacts that future energy crises may cause. At the same time, the energy crisis should provide

a rationale for an appropriate choice of measures to implement climate protection actions, increase solidarity among Members States also in terms of bearing the burden of implementing actions to protect the common good (climate protection) (Sobieraj, 2023). Referring to the broader context, i.e. energy transformation, carbon neutrality, the European Union's decarbonisation policy, it is worth considering the efficiency in the territorial dimension, i.e. in the voivodeships in crisis conditions. Efficiency in voivodeships in the years 2019-2023 is presented in table 6. Based on the information presented in Table 6, it can be seen that the highest average efficiency was achieved in Masovian Voivodeship (4,46), and the lowest in West Pomeranian Voivodeship (0,23). The average efficiency in the voivodeships in 2019-2023 is presented in Figure 1.

Table 6.

Efficiency in voivodeships in the years 2019-2023

Item Efficiency in years Name of the Voivodeship	EFFICIENCY IN VOIVODESHIP					Arithmetic mean
	year 2019	year 2020	year 2021	year 2022	year 2023	
Greater Poland Voivodeship	3,29	3,03	3,10	3,51	3,58	3,30
Kuyavian-Pomeranian Voivodeship	1,04	1,07	1,05	1,01	1,03	1,04
Lesser Poland Voivodeship	1,27	1,34	1,17	1,12	1,13	1,20
Lower Silesian Voivodeship	1,10	1,13	1,05	1,11	1,11	1,10
Lublin Voivodeship	0,44	0,50	0,54	0,52	0,47	0,49
Masovian Voivodeship	2,84	5,99	3,58	4,07	5,82	4,46
Podkarpackie Voivodeship	1,03	1,08	1,01	1,00	0,98	1,02
Silesian Voivodeship	1,19	1,09	1,22	1,30	1,29	1,22
West Pomeranian Voivodeship	0,2	0,2	0,2	0,30	0,25	0,23

Source: Own study based on Biznesradar.pl, Achel, 2000.

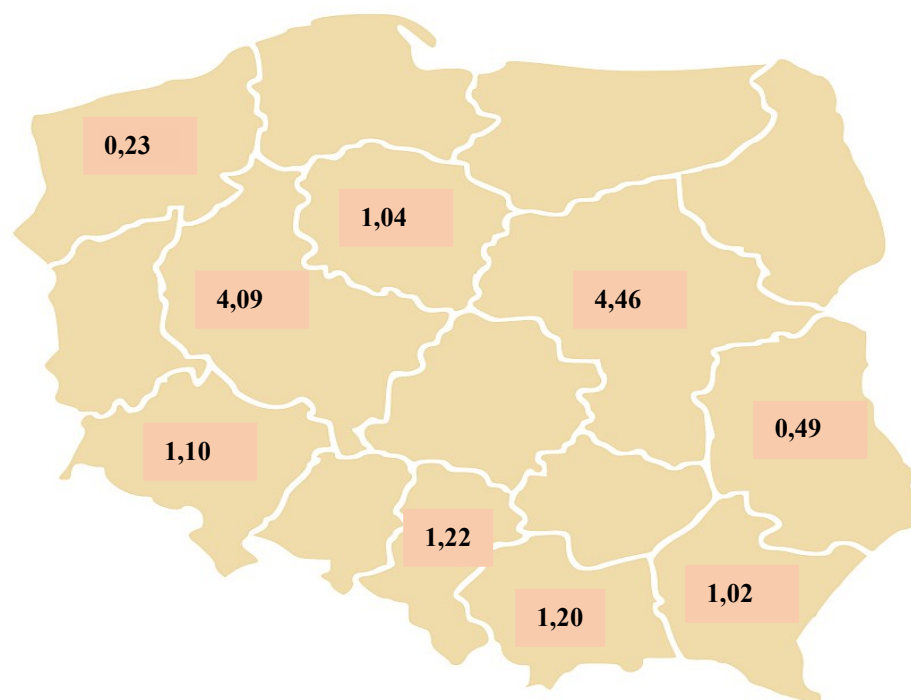


Figure 1. Average efficiency in Polish voivodeships.

Source: Own study based on Biznesradar.pl, Achel, 2000.

Figure 1 shows the differentiation of the efficiency and regional structure of the Polish energy sector. It is therefore worth examining whether the crisis has an equal impact on the efficiency achieved in the voivodeships, which is crucial for ensuring energy security? Auxiliary calculations are presented in table 7.

Table 7.
Auxiliary calculations

Item Effectivity ranking in years Voivodeship	AUXILIARY CALCULATIONS									
	year 2019		year 2020		year 2021		year 2022		year 2023	
	Effectivity	Rank	Effectivity	Rank	Effectivity	Rank	Effectivity	Rank	Effectivity	Rank
Greater Poland Voivodeship	3,29	3	3,03	1	3,10	2	3,51	4	3,58	5
Kuyavian-Pomeranian Voivodeship	1,04	3	1,07	5	1,05	4	1,01	1	1,03	2
Lesser Poland Voivodeship	1,27	4	1,34	5	1,17	3	1,12	1	1,13	2
Lower Silesian Voivodeship	1,10	2	1,13	5	1,05	1	1,11	3,5	1,11	3,5
Lublin Voivodeship	0,44	1	0,50	3	0,54	5	0,52	4	0,47	2
Masovian Voivodeship	2,84	1	5,99	5	3,58	2	4,07	3	5,82	4
Podkarpackie Voivodeship	1,03	4	1,08	5	1,01	3	1,00	2	0,98	1
Silesian Voivodeship	1,19	2	1,09	1	1,22	3	1,30	5	1,29	4
West Pomeranian Voivodeship	0,2	2	0,2	2	0,2	2	0,30	5	0,25	4

Source: Own study based on Biznesradar.pl, Achel, 2000.

$$X_r^2 = 0,86.$$

Since the empirical value of the statistic χ^2 is smaller than the critical value χ^2 read from the tables, it should be stated that the crisis equally affects the efficiency achieved in the voivodeships, which determines their ability to ensure energy security.

5. Summary

The aim of the article is to empirically identify the effectivity of energy companies in crisis conditions. The article focuses on the characteristics of energy security in terms of the need for effectivity of energy companies. The concept of energy security was defined, and the obligations of the energy company in the field of ensuring energy security in terms of effectivity were indicated. A literature review was then carried out and a research gap was identified. The research problem focused on answering the question: Does the crisis equally affect the effectivity achieved by energy companies, which determines their ability to ensure energy security? Empirical studies tested the following hypotheses: H0: the crisis equally affects the efficiency achieved by energy enterprises, which determines their ability to ensure energy security and H1: not all efficiency distributions in crisis conditions are identical. The efficiency in the years 2019-2023 was calculated and the Friedman test was performed.

Because the empirical value of the Friedman statistic is greater than the critical value read from the tables, the null hypothesis was rejected and the alternative hypothesis was accepted. There is evidence that the crisis situation has an unequal impact on the effectivity achieved by energy companies. There are companies that are capable and companies that are not able to ensure energy security. A crisis usually forces companies to review all activities. As a result, in the conditions of crisis, companies carry out many non-standard activities that ensure their functioning and development and, after a certain period of time, improve effectivity. Future research could focus on: the use of parametric statistical tests or developing an energy company effectivity model focusing on ensuring energy security.

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