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Functioning of the Energy Sector Under Crisis Conditions—A Polish Perspective

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Abstract: In the context of the coronavirus pandemic and the armed conflict between Russia and Ukraine, energy security is essential to economic challenges nowadays. The basis for the proper operating of the energy sector is to ensure a stable supply of energy to end users and to secure finances of energy companies, so that they can operate sustainably in times of uncertainty. In our studies, we have addressed this issue with the main objective of assessing the state of energy security from the perspective of the stability of the financial situation of energy sector companies in the context of the global energy crisis and a sustainable energy future. Financial indicators and a canonical variable analysis were used to examine the financial situation of companies in the energy sector and to describe links between selected groups of energy companies. Such companies operating during political and economic instability did not record worse financial results than in the year 2018. It was found that in case-studied firms, total debt decreased and moreover, liquidity and return on assets improved. Companies have focused on securing their financial health and ensuring the stability of their energy supplies and the issue of the environmental impact of energy production has unfortunately become a secondary concern. Nevertheless, in the event of further crises, it is reasonable to assume that a focus on maintaining liquidity and generating profits for energy companies will be more important to companies than environmental challenges and the fight against climate change.

Keywords: renewable energy; fossil fuel energy; companies; energy crisis; financial analysis

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1. Introduction

Energy affects many aspects of economic, social, and political life and is fundamental to the functioning of modern societies and economies [1]. The global population growth followed by anthropogenic changes in semi-natural and modified ecosystems and subsequent need for wider access to electricity cause at the present time unusual pressure on governments and the power sector. In view of growing demand for energy, caused as well by such factors as economic development, increased industrial production, and technological advancement and development, the main challenges include, first of all, ensuring the availability of energy at prices that do not adversely affect the development and competitiveness of the economy. On the other hand, one of the main challenges is to ensure the stability of the electricity supply, and thus energy security for the global population [2].

Additionally, environmental expectations of societies are sometimes difficult to meet as it is not possible to generate electricity without any influence on the environment, even utilizing green power, which is just a low-emission source of energy. Taking into account the global total amount of supplied energy in the year 2021, most of the energy was produced using oil (182,226,123 TJ), than coal (168,145,398 TJ) and natural gas

(145,989,141 TJ) [3]. The next places were taken by biofuels and wastes (58,488,932 TJ); nuclear power plants (30,660,087 TJ); wind, solar, geothermal, and biomass sources considered together (16,825,239 TJ); and finally hydropower (15,456,239 TJ). The year 2021 was a breakthrough because it was the first time that hydropower generated a smaller amount of energy than all the other renewable sources. In 2020, hydropower was generating a bit more energy than renewable energy source (RES) power plants together [3]. It is worthy to mention that in 2021, the share of oil and coal in electricity supply was near 55%, the RES share was equal to 14.18%, and the nuclear share was only 4.79%. In the year 2022, the situation was similar to 2021 with electricity supply based on oil equal to 187,902,349 TJ, coal to 171,902,932 TJ, hydropower to 15,660,642 TJ, and wind and solar together to 19,018,259 TJ [4]. The increasing global role of renewable sources causes many technological challenges. For instance, in the case of solar power plants and wind farms, there is a need to develop storage systems due to daily and seasonal fluctuations in energy production. The adapting of the transmission grid for the distributed generation of electricity is also an important issue to be solved in most countries. On the other hand, companies from the energy sector are often familiar with historical or actual problems with the maintenance of financial situations naturally affected by law changes, regional conflicts, and socio-economic aspects.

The definition of energy security contained in the Polish legislation and strategic documents does not deviate from European definitions and defines it as a state of the economy that enables the "current and future satisfaction of consumer needs for fuels and energy in a technically and economically justified manner, while complying with environmental protection requirements. It means ensuring the present and future security of supply of raw materials, production, transmission and distribution of energy, i.e., the whole energy chain" [5,6]. In view of the growing role and importance of energy in countries' economic systems, the need to ensure energy security is increasingly being considered as part of a country's national security, as a reliable and permanent access to the sources of energy that are affordable to the public is an essential element of any modern economy [2]. The entities that ensure the country's energy security are companies in the electricity generation, transmission, distribution, and trading sector. This sector includes enterprises generating energy in various ways and from various sources. In Poland, about 70% of gross electricity production and about 52% of installed capacity come from four power supply groups (D1–D4 companies), while the remaining 30% is generated by other enterprises including RES. In comparison to 2018, the share of gross electricity production in other units increased by 4 percent and the installed capacity increased by 13 percent (Figure 1).

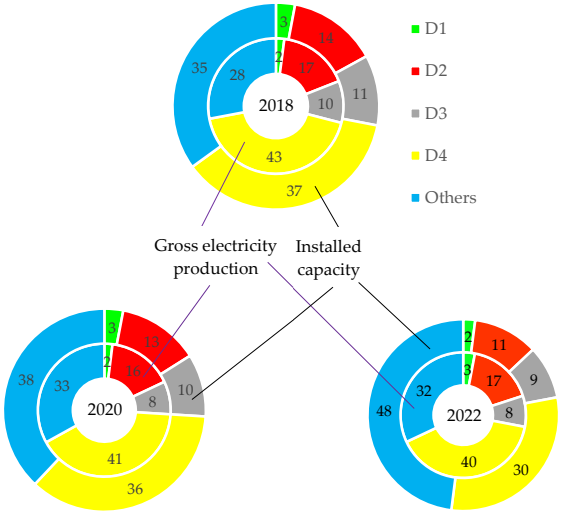


Figure 1. Structure of gross electricity production and installed capacity [%] in Poland in 2018, 2020, and 2022. Source: own elaboration based on [7–10].

Future trends in global energy sustainability are directed towards a transformative path towards cleaner, more effective, and diverse energy systems. This includes a transition from traditional fossil fuel economies to a dynamic mix of renewable energy sources and energy efficiency improvements. This transition is driven by a shared commitment to tackle climate change, reduce carbon footprints, and support sustainable development. Trends in economic development include the rapid growth and integration of RES such as solar, wind, and hydropower sources combined with advances in energy storage technologies [11,12]. There are many recent works in the literature on the sustainability of the energy sector, energy security, and the impact of crisis situations on the sector [13,14]. Few studies are considering this problem multidimensionally, i.e., from the perspective of the energy security of consumers as well as the financial situation of the generating companies themselves.

In the time of the pandemic and the early days of the energy crisis, it was a challenge to maintain stable financial situations of companies operating in the energy generation sector, while meeting the requirements of sustainable development and ensuring energy security. This article aims to assess a country's energy security from a view of the stability of the financial situation of companies in the energy sector in the context of the global energy crisis and a sustainable energy future.

In the meeting of the presented objective, the paper poses the following research questions:

- How does the energy crisis affect the financial situation of power generation companies in Poland?
- Are energy companies in Poland able to respond to the growing demand for electricity while meeting environmental requirements, and how will this affect their financial condition?

2. Literature Review

In the 2020s, a time marked by economic and political uncertainty—the coronavirus pandemic, the Russian–Ukrainian war, and inflation turning into stagflation in many markets—the need to ensure energy security is particularly important [15,16]. Nevertheless, the crises of the COVID-19 pandemic and the Russian–Ukrainian war occurred as back-to-back crises at a time when the world economy was beginning to show positive growth rates after the worldwide economic crisis of 2008 [14]. The pandemic situation and consequent lockdown introduced the perception of scarcity into economic life [17] in personal care products, food, and the supply of essential goods and services and caused extraordinary fluctuations in energy demand. It led to oil price shocks and disruptions in energy supply chains and has also prevented the development of new investment in the energy sector. The end of lockdown and the lifting of restrictions have increased demand for energy carriers, driving up electricity prices. The Russian–Ukrainian conflict, on the other hand, showed the possibilities of using oil and natural gas supplies as a weapon. The physical blockade and sanctions imposed on Russia disturbed energy trade and led to further prompting and significant increases in energy prices [13].

Research shows that successive closures of the economy have negatively affected the financial situation and security of businesses, including the energy sector. This is particularly true for small- and medium-sized enterprises (SMEs) [18,19]. Weber and Kokott [20] argue that compared to other organizations, SMEs tend to be less prepared for crises. In contrast, a study by Zimon et al. [21] shows that energy companies operating during the COVID-19 pandemic did not experience worse financial performance than in 2019. Smal and Wieprow [2] note that the financial condition of energy companies in Poland in 2021 has even improved. On the basis of a comparative analysis, Osiichuh [22] showed that renewable energy suppliers are steadily improving their financial position after 2019 and appear to be well positioned to compete with conventional fossil fuel generation. High debt levels increase the vulnerability of companies to the economic shocks during crises, which could even lead to bankruptcy [23]. In 2019, the average total debt of small- and medium-sized enterprises in the energy sector was equal to 76.9% [24]. Zimon [21] showed that the

overall debt ratio of renewable energy SMEs remained almost the same in 2020. This means that entities behave with restraint in a crisis in terms of debt management. Reducing the level of debt by the surveyed entities seems to be the right thing to do, because as Abbas et al. [25] report, a high level of debt would limit their flexibility and financial stability during economic recessions, making them more vulnerable to financial difficulties. Asset management is another tool to ensure the continuous and steady functioning of the enterprise. Companies that manage their assets more efficiently achieve higher profitability [26]. Companies generating sufficient returns on assets more easily settle their liabilities [27]. Higher profitability provides more funds to meet short-term obligations, thus ensuring financial stability of enterprises [25]. Increasing revenue or reducing costs can also increase profitability [26]. Mikulik and Niekurzak point out that renewable energy companies can seek to reduce costs by, for example, storing the excess energy produced by photovoltaic power plants in batteries using a charge controller [12]. A study of the Massachusetts Institute of Technology [28] indicates that co-locating energy storage with shutdown power plants can reduce the cost of energy storage by reusing existing grid connections. The authors also emphasize that the cost and impact of reusing existing facilities on the thermal storage system and other possible options should be investigated. The EU is also paying attention to the same issue as evidenced by the 2020 resolution on a comprehensive European approach to energy storage. This document lists several storage methods, such as chemical storage, electrochemical storage, mechanical storage, and thermal storage [29]. Again, the distance between the electricity sources and the storage system, the efficiency of the storage, and minimizing the impact of generation intermittency are important financial issues. Moghadam et al. [11] analyzed these variables for hybrid energy storage systems in studies on two different virtual power plant management scenarios.

High profitability ensures that enterprises can service interest and repayments on time and are less likely to default on loans, thereby ensuring liquidity and financial stability [30] and improving their competitiveness in the market [31]. The literature reports that liquidity management is one of the most important areas in corporate financial management during a financial crisis since it directly impacts the company's profit [32,33]. Rapid changes in financial liquidity are characteristic of periods preceding a financial crisis, and some studies show that liquidity is crucial to surviving a crisis [25,34,35]. Burcă et al. [36] emphasize that firms facing liquidity problems before the crisis are likely to suffer from severe financial constraints, including higher interest rates and, even worse, restrictions on external sources of finance. The COVID-19 pandemic has led companies to adopt a more conservative policy towards customers and suppliers in order to better protect their liquidity. This is suggested by the research of Zimon and Dankiewicz [37], who highlight the relationship between liquidity and trade credit management. On the other hand, these dependencies in times of an emergency are a sign of preserving solvency, maintaining financial security and business continuity.

A stable financial situation ensures the continued operation of companies, including those that produce energy, which is a key factor in the country's energy security. Financial stability is achieved when the financial system is able to withstand an economic crisis and the company is able to perform its financial tasks correctly. It can be defined as the ability of a company to generate a sufficient amount of money, maintain adequate liquidity, man-age debt effectively, and ensure profitability and growth [27]. A safe and stable financial situation allows companies to invest in modern energy infrastructure, which helps to ensure continuity of energy supply and increase production efficiency. It is particularly important at a time of an energy crisis caused by the pandemic and the war in Ukraine.

3. Economic Situation in Energy Sector

Both events, COVID-19 and the war between Russia and Ukraine, have led to a tendency for crude oil prices to show a high degree of volatility and rapid changes. For example, Basediks et al. [14] found that West Texas Intermediate crude oil future prices fell into negative values for the first time on 20 April 2020. The Russia–Ukraine war and

subsequent events led to a rapid increase in crude oil prices. The average sales price of electricity in Poland on the competitive market increased by 39% in 2020 compared to 2013, and by 188% in 2022 (Figure 2). According to a study by Smal and Wieprow [2], a number of factors have contributed to the price increase, including an increase in gas prices on world markets and in the European Union (EU) but also extreme climatic conditions associated with global warming, which have increased the demand for energy used in cooling systems.

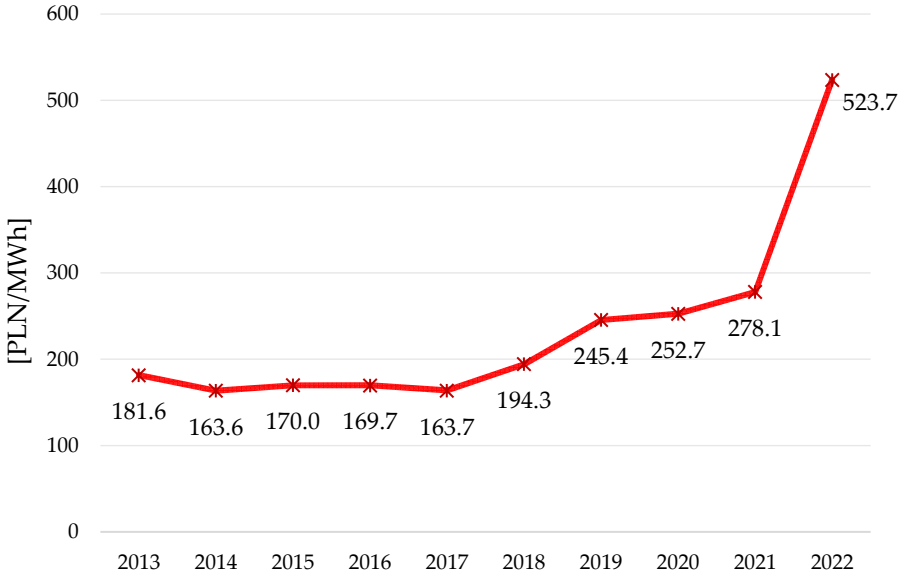


Figure 2. Average selling price of electricity on competitive market in years 2013 to 2022. Source: own elaboration based on [38].

Highlighting the vulnerability of global supply chains and the importance of energy resources as a political tool, both the COVID-19 pandemic and the armed conflict between Russia and Ukraine have posed major challenges to energy security [13,14]. In this context, energy security should be seen as the resilience of the energy system to exceptional and unpredictable events that could threaten the physical integrity of energy flows or lead to an uncontrollable increase in energy prices, regardless of the economic basis. To meet the challenges of rising energy demand and challenges such as climate change and geopolitical tensions, governments need to implement comprehensive strategies that include energy diversification, infrastructure modernization, protection against risks, and international cooperation. This approach aims to ensure both the stability of supply and the affordability of energy, which is essential for the sustainable development of the economy and society. The climate crisis and increasing environmental requirements from the EU play an important role in ensuring energy security. Climate and energy policy at the EU level is based on three pillars: (a) the share of renewable energy in final energy consumption, (b) the reduction in greenhouse gas emissions compared to 1990 levels, and (c) improved energy efficiency [39]. In light of recent events, energy independence is becoming a new important pillar of climate and energy policy, which aims to make Poland and other EU countries independent of fuel imports from the Russian Federation as soon as possible. An important tool for assessing energy sovereignty and thus analyzing a country's energy security is the Energy Dependency Index. The higher its value, the lower the level of energy security in a given country. As the ratio of net energy imports to gross domestic energy consumption plus stored energy increases, the level of energy security decreases.

Based on the data shown in Figure 3, it can be concluded that Poland is characterized by a high level of energy security against the background of EU countries. This is due to the possession of a rich resource base, more specifically hard coal and lignite deposits. Unfortunately, more than 70% of the installed capacity in the National Energy System dates

back to 30 years ago. This is reflected in much lower efficiency and a higher frequency of capital-intensive repairs [40]. Poland's coal reserves can provide electricity and heat for the next 25–50 years [41]. Due to international obligations, in particular those related to the decarbonization of the electricity sector [42], the share of solid fuels, i.e., hard and brown coal, in the energy mix in Poland decreased from 85% in 2013 to 68% in 2022 (Figure 4). Forecasts predict a further decline to 28% by the year 2040 [5]. It is worth noting that despite coal's declining share in the energy balance, this particular fuel will continue to play a crucial role in the energy sector, acting as a stabilizer of the country's energy security, which is principally important taking into account the Polish economy's dependence on gas (78% in 2022) and oil (97% in 2022) imports.

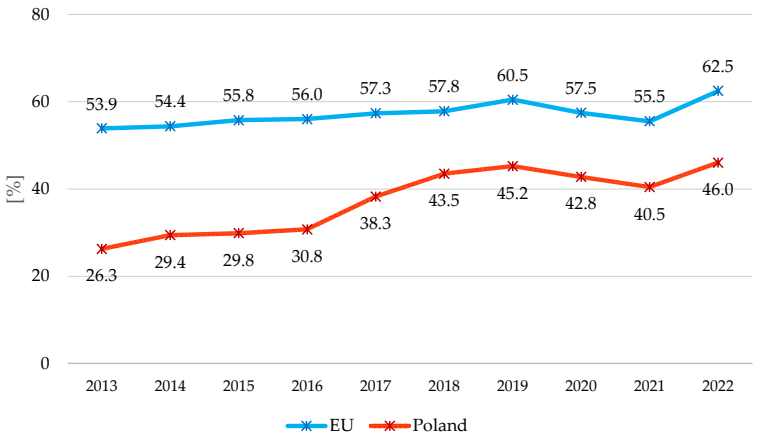


Figure 3. Energy dependency values in Poland and in the EU in the years 2013 to 2022. Source: own elaboration based on [43].

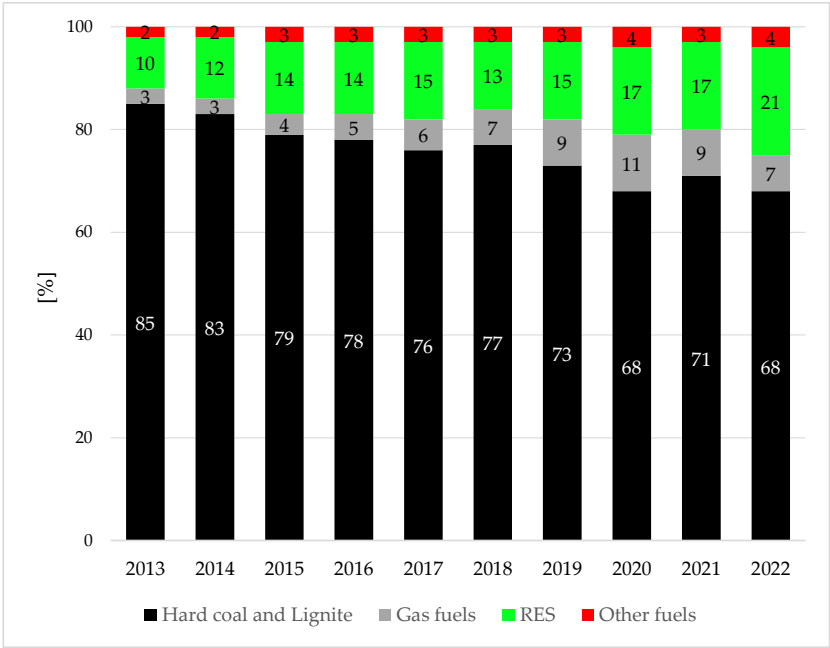


Figure 4. Electricity generation structure sorted by medium in Poland in years 2013 to 2022. Source: own elaboration based on [44].

Constant calls from scientists and worried citizens to protect the environment have led to growing interest in the development of renewable energy technologies [24]. Renewable energy is considered a very important factor by countries looking to achieve environmental sustainability, improve public health, and avoid global climate change. The RES plays a

fundamental role in the current political and social framework for minimizing effects of climate change [45,46]. In Poland, for several years, there has been a systematic increase in the production of energy from renewable sources. In 2013, the share of renewable energy in the national energy mix was 10% and it rose to 21% by 2022 (Figure 4). The first wave of the COVID-19 pandemic led to a decrease in electricity demand, resulting in lower productions of fossil fuel power plants and an increase in the share of energy sourced from renewable sources [47]. This increase was mainly seen in wind and solar power. Photovoltaic systems are the most popular RES in Poland according to Kryszk et al. [48] and Kuś and Kuś [49]. Furthermore, there is a view in the literature that RES development is a response to the economic recession caused by the COVID-19 pandemic forced many countries to implement policies that inspire investment in renewable energy and digital energy systems [50]. Russia's invasion of Ukraine was also a catalyst for some countries to accelerate the transition to clean energy. Zakarei et al. [13] found that Germany, one of the countries with a high dependence on fossil fuel imports, has accelerated its transition to renewable energy to cope with a possible reduction in energy imports from Russia. The interest in renewable energy is demonstrated by the growth in investment in renewable energy, starting from USD 9.9 billion in 2010 to USD 18.6 billion in 2016 [51]. This progress is a response to the needs of the energy transition, the reduction of CO_2 emissions, and the pursuit of sustainable development. On the other hand, armed conflicts have forced many European governments to suspend their more ambitious climate policies as a result of reduced gas supplies from Russia. Germany has delayed the closure of some coal-fired plants and the Netherlands has increased the allowable share of coal in the energy mix. Austria decided to reopen a previously closed coal-fired power plant, as highlighted by Borowski's research [52]. Adding to the tragic consequences that the invasion of Ukraine by Russian forces has had, one of the accidental effects may be the acceleration of energy transition towards renewable energy sources [53]. The war has made many countries, especially in Europe, aware of the dangers of dependence on external energy sources, as Russian oil and gas are very important for many European countries [54]. This situation could be a turning point for energy policy across the EU, as it has reinforced the need to diversify energy sources and increase energy independence. This is also supported by the research of Hemrit et al. [55], who point out that suitable policies can transform the risks of uncertainty associated with the pandemic and war, among others, into huge opportunities for renewable energy markets. Investors are not only thinking about solving oil price risk, but can also benefit from portfolio diversification by investing in renewable energy. Research shows that renewable energy is of strategic importance for overall social and economic development [56–60]. One of the indicators used to measure this progress is the share of energy from renewable sources in gross final energy consumption [61]. Figure 5 shows the share of RES in gross final energy consumption in Poland and the EU over the last nine years. The share of renewables in gross final energy consumption in EU countries increased from 16.7% in 2013 to 23.0% in 2022. However, it is an average result for all EU countries.

In terms of the sources used to produce electricity, the economies of the EU are very diverse [62,63]. The undisputed leaders are Sweden (66.0%), Finland (47.9%), Latvia (43.3%), Denmark (41.6%), and Austria (33.8%) (Figure 6) [64]. What is more, Sweden, Finland, Austria, Latvia, and Denmark profit from favourable climatic conditions that correlate with the lack of fossil fuel resources and determine the minimization of energy consumption [39].

However, the EU countries also include those where renewable energy is not yet sufficiently important and the share of renewable energy remains low—Ireland (13.1%), Malta (13.4%), Belgium (13.8%), and Luxembourg (14.4%) [39,65].

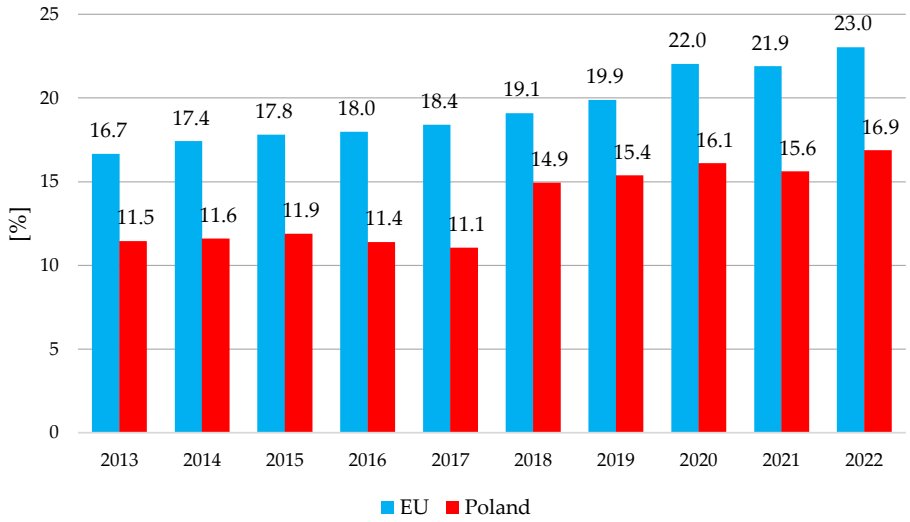


Figure 5. The share of energy from renewable sources in the gross final energy consumption in Poland and the EU in the years 2013 to 2022. Source: own elaboration based on [40].

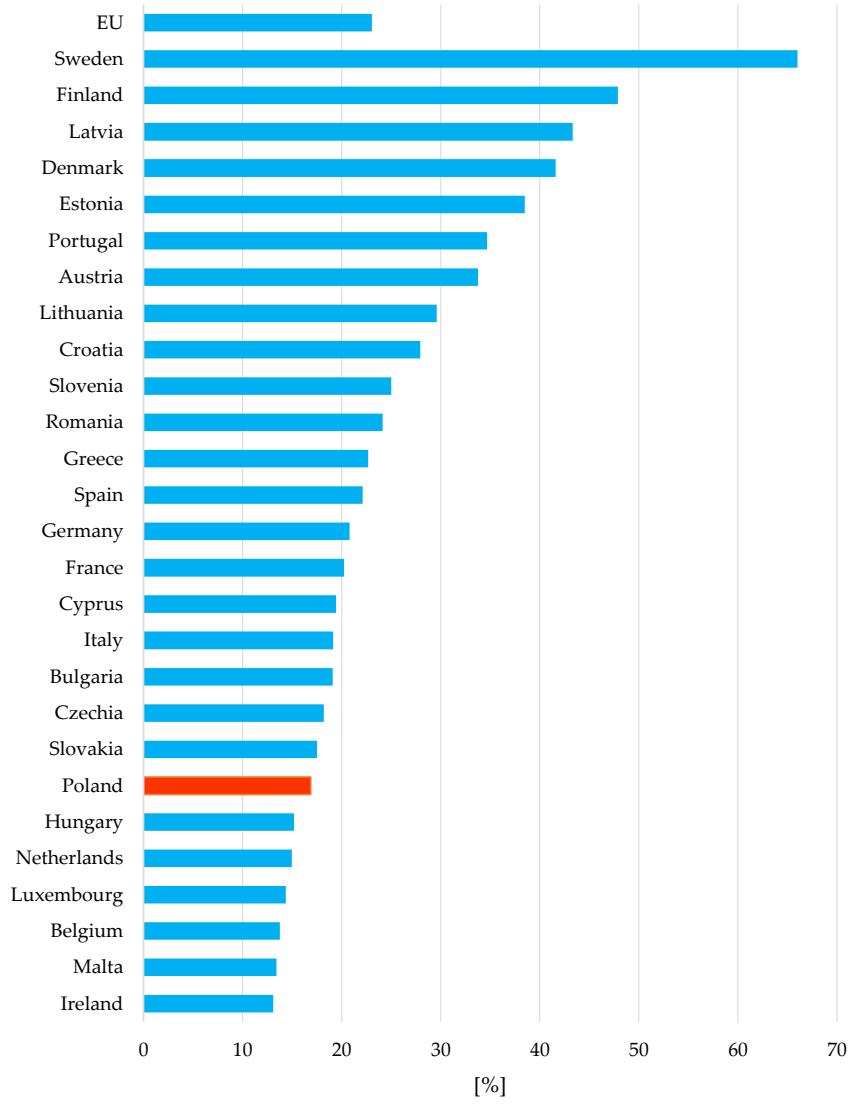


Figure 6. Share of RESs in gross final energy consumption [%] in EU countries in 2022. Source: own elaboration based on [40].

The share of RESs in the gross final energy consumption of Poland in 2022 was equal to 16.9% [48]. Investing in renewable energy sources such as wind, solar, and biomass sources not only reduces greenhouse gas emissions, but also makes it possible to become less dependent on unstable supplies of raw materials. The assessment of energy security should be considered from two perspectives. First is from the point of view of consumers, who should be provided with a relatively constant level of energy to meet their minimum life needs, at a cost that does not exceed the ability of the average consumer to pay. On the other hand, it is necessary to take into account the financial situation of the energy companies, which, in order to carry out their task successfully, must survive in the market and maintain their financial indicators at an appropriate level [2].

4. Materials and Methods

4.1. The Data Collection

The information necessary for the presentation and assessment of the financial situation of the companies studied was attained from individual annual reports of the companies available at the National Court Register [66]. The financial statements of 2018, 2020, and 2022 were included in the study. These years were selected for the study as we wished to capture the behaviour of electricity generation companies under different economic conditions. The first studied year was a period of relative economic stability in which entities were able to carry out their current and developmental activities. Moreover, in Poland, this period was preceded by many years of economic growth, which contributed to a significant demand for energy. The next two periods were a series of events affecting the economic situation, including the energy security of Poland and the world, and the financial situation of the companies themselves. These events can be described in 2020 as a crisis in the healthcare sector, linked to the global COVID-19 pandemic, and in 2022 as a military–political crisis, mainly associated with the Russian invasion of Ukraine [67]. For energy companies, the climate crisis, which has clearly intensified in these years, also remains important. As it was noted earlier, energy security is a relatively complex issue and depends on many factors and a number of legal and billing adjustments are being introduced in individual countries. An example of such adjustments and an important one for this research is the accounting for energy production from renewable sources introduced in Poland in 2022 from net metering to a new net-billing system [68]. The factors cited here force companies in the energy sector to secure the stability of their energy supply; urge a shift from energy production based on conventional fuels to production based on renewable sources; and influence the rules of the 'market game' and affect the creation, maintenance, and development of the value of an organization and its financial situation [21].

Initially, 45 enterprises were selected for the research but some of them were rejected due to the lack of complete information in the financial statements for 2018–2022. In the assumptions for the selection of enterprises, it was assumed that the study would include enterprises that continuously conducted business activities in 2018–2022 and prepared and published financial statements in the National Court Register. Finally, 28 enterprises were included in the survey in 2018 and 2020 and 26 enterprises in the year 2022. From the group of enterprises included in the survey, 24 enterprises in 2018 and 2020 and 22 enterprises in 2022 represented energy production exclusively from different renewable energy sources, i.e., onshore wind, offshore wind, geothermal, solar, and biogas plants. The remaining four enterprises were companies that had diversified energy production based on both renewable and conventional sources. They operate in the Polish energy market and produce about 70% of the country's energy (Figure 1). The number of the enterprises by the year and type of energy sources used for energy production is shown in Table 1.

Table 1. Number of studied entities by energy source, 2018, 2020, and 2022.

Group of Enterprises	Quantity (N_i)		Mark
	2018 and 2020	2022	
Onshore wind power plants	5	4	WPP
Offshore wind power plants	2	2	OWPP
Onshore wind power plants with installation of systems	1	1	WPPI
Geothermal heat plant	2	2	G
Solar power plants	3	3	S
Solar power plants with installation of systems	2	2	SA
Biogas plant	8	7	BG
Biogas plant with solar power	1	1	BGS
Large companies with diversified energy production	4	4	D

4.2. Financial Analyses

The functioning of business entities in a modern market economy requires a constant monitoring and evaluation of the financial phenomena occurring within the enterprise and in its environment. Knowledge of the financial situation of the enterprise determines the conditions of its operation and development and is an essential prerequisite for the sustainable and secure existence of the organization on the market [69]. A prerequisite for the smooth operation of the enterprise in the market is the analysis of the economic results achieved, which can be carried out with the help of financial analysis tools [70]. The most widespread application for assessing the financial condition of a company is the traditional method of a financial analysis, in which the main carriers of financial information are financial ratios [71]. A ratio analysis makes it possible to assess four basic areas of an enterprise's operations: liquidity, operating efficiency, debt, and profitability [26,72,73].

Financial liquidity is the foundation for building a strong enterprise [74]. It allows us to determine whether the business unit demonstrates the ability to pay short-term obligations on time; its possession determines the solvency and continued operation of the entity [69]. From the group of many indicators describing liquidity, this study uses the current ratio (y_1), which is determined by dividing total current assets by total current liabilities [75,76]. The correct value of the indicator should match the range of 1.2–2.0 [2].

A favourable financial situation is demonstrated not only by the ability to meet current liabilities, but also by the ability to generate sales and the efficiency of the management of owned assets [24]. The last is assessed on the basis of the total asset turnover ratio (y_2). It is calculated as the ratio of sales revenue to total assets [72,77]. The asset turnover ratio indicates how efficiently a company uses its assets, which can further positively affect profitability [78]. Its value depends on the particular aspects of the industry and is recommended when comparing the efficiency of companies in the same industry [26]. In order to stay in the market and ensure stable development, companies also need to benefit from long-term debt, which has to be repaid on a continuous basis [79,80]. Then, another area for assessing the financial situation in this research is solvency, understood as the ability of an economic entity to repay all its debts.

One of the basic solvency ratios is the total debt ratio (y_3), which defines the ratio of short-term and long-term debt (total debt) to the assets of an enterprise [2,75]. The total debt ratio indicator should be in the range of 0.57–0.67 [2,24,81]. A low value indicates a high proportion of equity. A value above 0.67 indicates high credit risk [2]. Smaller companies may have limited resources, face higher borrowing costs, and be more cautious about taking on debt, while larger companies may have more resources to manage their debt [82]. The capital structure is linked to profitability usually measured in terms of return on assets or sales [81]. Profitability ratios were used to measure the ability to generate profits and reflect success or failure [83]. Of the many profitability ratios this work uses the return on assets ratio (y_4), which is calculated as net profit divided by total assets. This ratio measures the rate of business return on all existing assets [76,84]. The growth of the

ratio relates to the efficiency of the company's use of assets. The higher the ratio, the better the financial condition of the enterprise [80].

The formulas of the utilized indicators are shown in Table 2.

Table 2. Name and construction of indicators.

Name of the Indicator	Mark	The Formula of the Indicator
Current ratio	y_1	$(CA)(CL)^{-1}$
Total asset turnover ratio	y_2	$(S)(TA)^{-1}$
Total debt ratio	y_3	$(TD)(TA)^{-1}$
Return on assets	y_4	$(NP)(TA)^{-1}$

Explanation: *CA*—total current assets; *CL*—total current liabilities; *S*—sales revenue; *TD*—total debt; *TA*—total assets; *NP*—net profit. Source: own elaboration based on [72,75,83].

4.3. Statistical Analyses

The financial analysis of the companies was conducted taking into account a number of relevant characteristics. For each of these, a two-way classification model was applied to account for the variability arising from differences between the indices for the years and groups of companies considered. Assume that the p-th financial ratio ($p = 1, \ldots, P$; here, $P = 4$) of the k-th enterprise ($k = 1, \ldots, N_i$) for the j-th predefined group of companies ($j = 1, \ldots, J$; here, $J = 9$) in the i-th year ($i = 1, \ldots, I$; here, $I = 3$) has the structure

$$y_p(i,j,k) = \mu_p + \xi^1_{pi} + \xi^2_{pj} + \xi^{12}_{pij} + e_{pijk}, \quad (1)$$

where for the p-th selected (one of four) financial indicator, μ_p is the general mean, ξ^1_{pi} is the i-th year effect, ξ^2_{pj} is the j-th group effect, ξ^{12}_{pij} is the ij-th interaction effect, and e_{pijk} is the random error. In order to take into account the interdependencies between the financial indicators characterizing four economic activities, multidimensional tools were used for the comparative analyses [24,80]. The multivariate model can then be written in the form

$$\mathbf{Y} = \mathbf{1}_N \boldsymbol{\mu}' + \mathbf{X}_1 \boldsymbol{\Xi}_1 + \mathbf{X}_2 \boldsymbol{\Xi}_2 + \mathbf{X}_{12} \boldsymbol{\Xi}_{12} + \mathbf{U}, \quad (2)$$

where $\mathbf{Y}$ is the result matrix; N is the number of analyzed enterprises; $\boldsymbol{\mu}$ is the vector of general means; $\boldsymbol{\Xi}_1$ is the matrix of year effects; $\boldsymbol{\Xi}_2$ is the matrix of group effects; $\boldsymbol{\Xi}_{12}$ is the matrix of interaction effects; $\mathbf{X}_1$, $\mathbf{X}_2$, and $\mathbf{X}_{12}$ are design matrices; and $\mathbf{U}$ is the matrix of errors [24]. For the financial ratios, a canonical variate analysis was carried out, which made it possible to visualize the effect of the indicators on different groups of companies in an orthogonal space. In this case, the analysis is based on the matrix

$$\widehat{\mathbf{C}\boldsymbol{\Xi}}_{12} = \mathbf{C}\left(\mathbf{X}'_{12}\mathbf{X}_{12}\right)^{-1}\mathbf{X}'_{12}\mathbf{Y}. \quad (3)$$

Using the $\mathbf{C} = \mathbf{I}_{IJ} - (IJ)^{-1}\mathbf{1}_{IJ}\mathbf{1}'_{IJ}$ matrix, the differences between the average indices for individual groups in particular years and the general means are analyzed. To study the relationships between the companies, the canonical variate analysis based on the matrix transformation $\widehat{\mathbf{C}\boldsymbol{\Xi}}_{12}$ by the linear combination method [85] and singular value decomposition [86] was used [24,80]. These methods were applied similarly as in chemical [87] and life sciences [88,89] where the matrix of sums of squares and products between groups and the matrix of sums of squares and products within groups were analyzed [85]. To compare different groups of companies, the Mahalanobis squared distances between rows of matrix $\widehat{\mathbf{C}\boldsymbol{\Xi}}_{12}$ were calculated on the basis of financial indicators [24,86].

5. Results

5.1. The Comparison of the Financial Situation Among Groups of Companies in the Energy Sector

Figure 7 shows the relationship between scores representing groups of companies generating energy from different sources in the years studied and the indices characterizing

their financial situation. The figure shows that the groups of companies of solar power plants and solar power plants with the installation of systems in 2018 were characterized by the most different values of all indices compared to the general mean of ratios. Analyzing the distribution of points representing indices describing financial situations, two indices, i.e., the total debt ratio (y_3) and return on assets (y_4), show the highest variability over the three years considered. A particularly high level of debt is observed in the year 2018 in the groups of solar power stations, onshore wind power stations, offshore wind power stations, and solar power stations with the installation of equipment (Table 3). The average value of the total debt ratio (y_3) for these groups in that year was 191.2%, 123.3%, 127.9%, and 94.5%, respectively. In the following years, i.e., 2020 and 2022, considered to be the crisis period, the level of debt decreased, but still stayed above average in these groups of companies. The lowest values of the total debt ratio (y_3) during the entire period were in the groups of companies of geothermal heat plants and biogas plants with solar power. The average value of this ratio in these company groups in 2018 was 12, 2% and 50.0%, respectively; in 2020, it was 15.0% and 37.7%; and in 2022, it was 19.6% and 33.8%. The total debt ratio (y_3) is inversely proportional to return on assets (y_4). A significantly higher return on assets (y_4) than the average of the company sample was observed in the company groups of geothermal heat plants and solar power plants with the installation of systems in 2018 and 2022, and in the group of onshore wind power plants in 2020 and 2022 (Table 3). The average rate of return over the whole study period was 2.1% for the geothermal group, 11.5% for the solar group, and 3.43% for the onshore wind group.

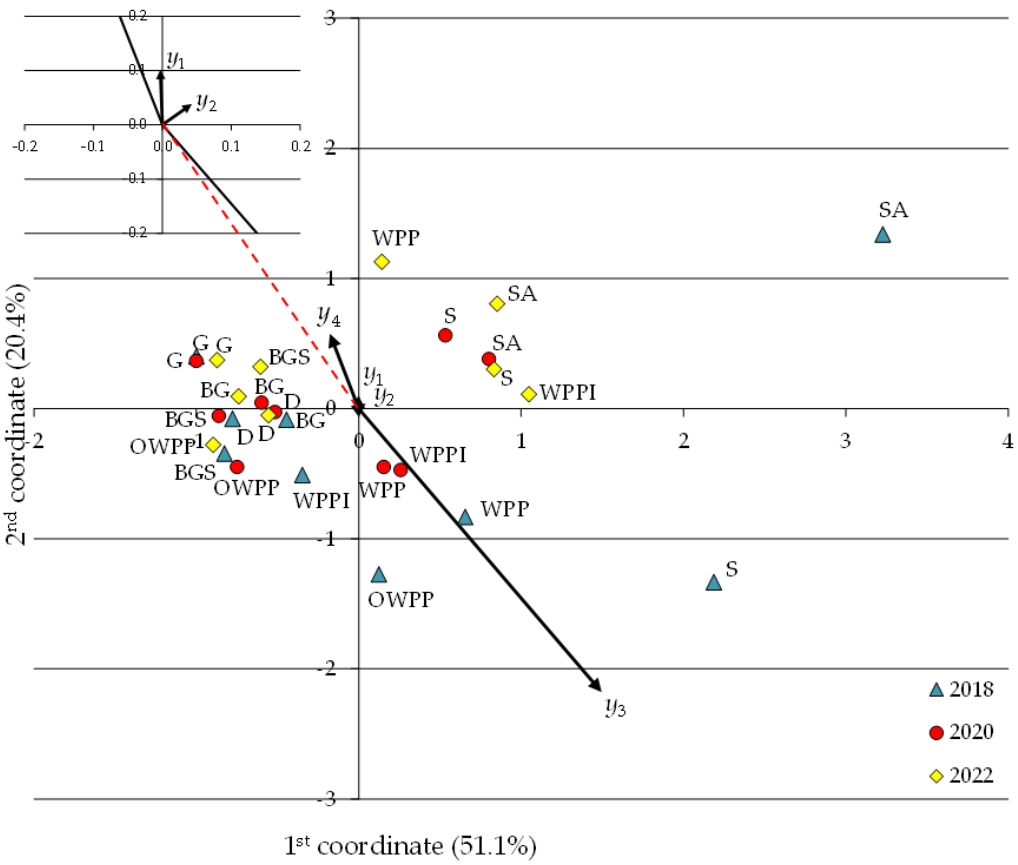


Figure 7. The canonical variate analysis presentation of the relationship between the groups of enterprises and the financial indicators.

Table 3. Estimates of group effects $(\hat{\mathbf{C}\Xi}_{12})$ in terms of financial indicators.

	y_1			y_2			y_3			y_4		
	2018	**2020**	**2022**	**2018**	**2020**	**2022**	**2018**	**2020**	**2022**	**2018**	**2020**	**2022**
WPP	0.08	2.21	11.03	−0.23	0.01	0.28	60.0	27.5	−25.2	−12.66	9.63	9.99
OWPP	0.37	−0.73	−0.96	−0.96	−0.90	−0.86	64.6	−3.3	−16.4	−10.50	0.71	3.19
WPPI	−1.35	−1.48	−1.44	−0.53	0.03	1.15	10.0	26.0	22.6	−0.14	−1.61	−0.58
G	−0.62	−0.92	−0.51	−0.69	−0.64	−0.57	−48.8	−48.3	−43.7	−0.37	1.27	0.33
S	−1.93	−0.48	−0.52	0.40	1.28	0.55	128.4	−14.2	13.0	−36.20	14.00	−15.81
SA	0.28	−0.98	−0.04	4.18	1.53	1.33	31.5	0.4	−12.1	11.78	16.18	1.42
BG	0.74	1.20	1.81	−0.49	−0.60	−0.53	−7.8	−17.3	−23.9	1.50	1.30	8.66
BGS	−2.14	−1.29	1.36	−0.82	−0.76	−0.47	−13.4	−25.6	−29.6	0.47	0.13	0.80
D	−1.26	−1.22	−1.23	−0.74	−0.58	−0.37	−21.7	−15.4	−17.4	−1.55	−5.41	3.47
General mean		2.57			1.04			63.4			1.65	

In the years under review, the current ratio (y_1) was characterized by relatively lower volatility compared to the indices analyzed above. The average value of the current ratio (y_1) in the studied companies was 2.24. Values of the current ratio (y_1) in the studied groups of electricity-generating companies were proportional to the return on assets (y_4) and inversely proportional to the level of total debt (y_3). The values of the current ratio (y_1) and return on assets (y_4) increased in 2020 and 2022 compared to 2018.

The total asset turnover ratio (y_2) showed the smallest variability. The value of this ratio was low, indicating a low turnover of assets involved in the business. The reason for this situation was a large share of fixed assets (technical equipment, machinery, and buildings and structures) on which the activities of companies in the energy sector are based.

5.2. Diversification of Power Generation Companies in Terms of Financial Situation

This part of the study identifies the variability of generators in terms of their financial situation in each year of the analysis.

In 2018, there was a noticeably greater variation amongst groups of companies and companies within groups in terms of financial situations than in other years (Figure 8). One company in the group of solar power plants with the installation of systems was a clear outlier this year. This company was characterized by high liquidity, debt levels, and losses. The high liquidity was due to the high value of current assets, which consisted of short-term receivables (90% of current assets) and short-term investments including cash (8%). This situation was a consequence of the ongoing photovoltaic installation services. The high total debt ratio was a consequence of long-term liabilities, which contributed to the high interest value. These factors, together with the high cost of salaries and external services, contributed to the loss generated and the loss-making activity. The company's situation improved in the following years. In 2018, the outliers from the average were the solar power plant and the onshore wind power plant (Figure 8). All these entities were characterized by a loss and a relatively high level of debt.

Mahalanobis squared distances were calculated to indicate differences in 2018 between groups of companies in terms of the analyzed financial indicators, as shown in Table 4. The largest Mahalanobis squared distances in 2018 occurred between the group of companies of solar power with the installation of systems and the group of geothermal companies and was 20.19 (Table 4). In contrast, the smallest Mahalanobis squared distances occurred between the group of large companies with diversified energy production and biogas plants with solar power plants (0.21). These enterprises were characterized by a low proportion of liabilities, mainly short-term, and slow turnover of assets. It is worth noting that these two groups of companies used the same source for energy production—biomass. The dataset shows that in 2018, the group of large companies with diversified energy production differed most in the value of financial indicators from the groups of solar power plants with the installation of systems and solar power plants. The values of the indicators of large

companies with diversified energy production were most similar to those of the groups of biogas plants with solar power, biogas plants, and geothermal plants (Table 4).

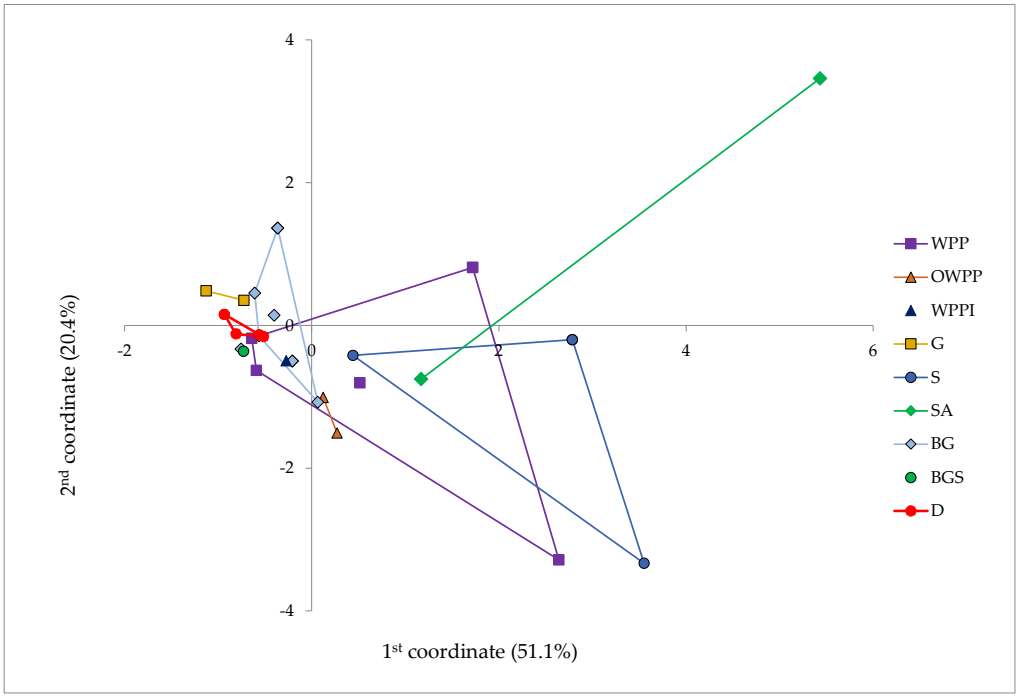


Figure 8. Differentiation of enterprises in 2018.

Table 4. Mahalanobis squared distances amongst particular energy groups of companies based on financial ratios in 2018.

OWPP	0.67							
WPPI	1.40	1.14						
G	4.93	5.61	2.21					
S	3.43	6.06	8.79	13.45				
SA	12.22	17.35	16.36	20.19	10.87			
BG	1.81	1.94	0.30	1.20	9.52	16.07		
BGS	2.80	2.43	0.35	1.13	11.37	19.51	0.39	
D	2.93	3.11	0.73	0.42	10.99	18.75	0.34	0.21
	WPP	**OWPP**	**WPPI**	**G**	**S**	**SA**	**BG**	**BGS**

In 2020, the situation clearly changed. Less variability was observed between groups and within groups. It means that a greater number of entities were characterized by values close to the general mean of ratios. But still, solar power plants and onshore wind power plants remained the largest outliers (Figure 9). The abovementioned changes indicate an improvement in the financial situation of power industry entities, particularly in the areas of profitability, liquidity, and debt levels. The first two ratios increased, while the total debt ratio (y_3) decreased. In 2020, a lack of significant changes was observed in the calculated Mahalanobis squared distances between the groups of large enterprises with diversified energy production and biogas plants with solar power, biogas plants, and geothermal plants. However, the differences between the groups of large enterprises with diversified energy production and solar power plants with the installation of equipment and solar power plants decreased (Table 5). This means that the index values of the companies in the groups of solar power stations with the installation of systems and solar power

stations approached the average values of the group of large companies with diversified energy production.

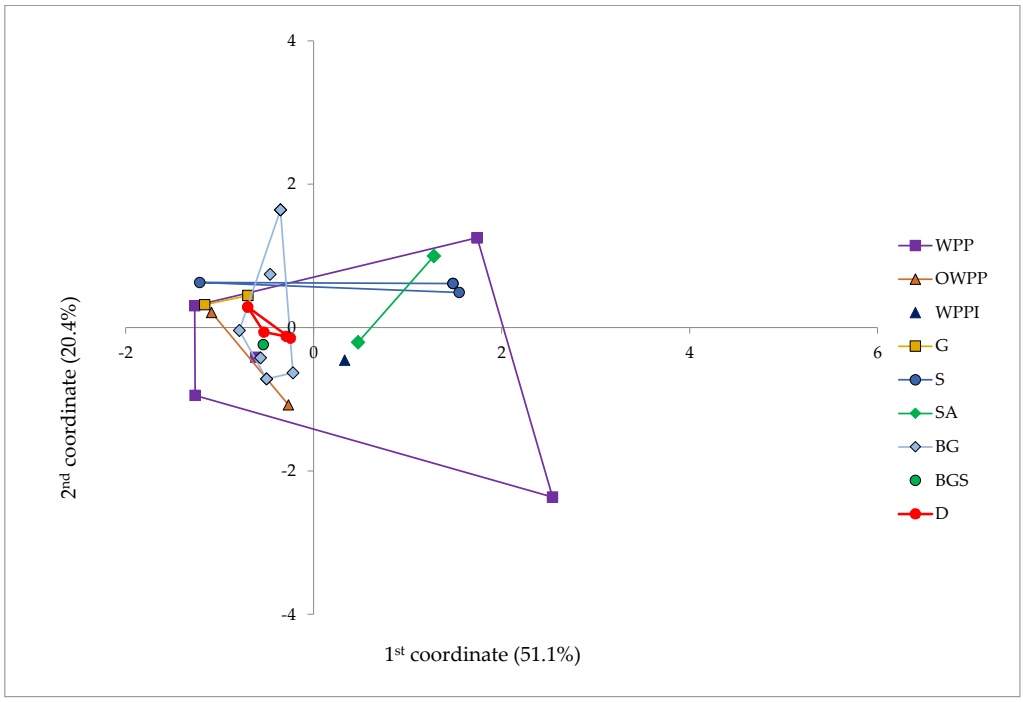


Figure 9. Differentiation of enterprises in 2020.

Table 5. Mahalanobis squared distances amongst particular energy groups of companies based on financial ratios in 2020.

OWPP	1.88							
WPPI	1.02	1.04						
G	5.28	1.34	3.01					
S	2.04	2.97	1.30	3.75				
SA	1.82	3.90	1.59	5.65	0.25			
BG	2.43	0.40	1.27	0.65	2.38	3.67		
BGS	3.43	0.39	1.71	0.30	3.07	4.50	0.25	
D	3.85	0.84	1.54	0.40	2.88	4.40	0.34	0.24
	WPP	**OWPP**	**WPPI**	**G**	**S**	**SA**	**BG**	**BGS**

In 2022, the volatility of the indicators was similar to that in 2020 (Figure 10). The directions of the changes in the values of the indicators point to an improvement in the financial situation of the companies included in the analysis (Table 6). Observed changes also indicate a significant improvement in profitability and a reduction in the companies' debt, and their liquidity also improved. This may mean that the companies had better control over costs, receivables, and payables during the period of the energy crisis and legal changes being implemented. Changes were most evident in the case of the onshore wind power group.

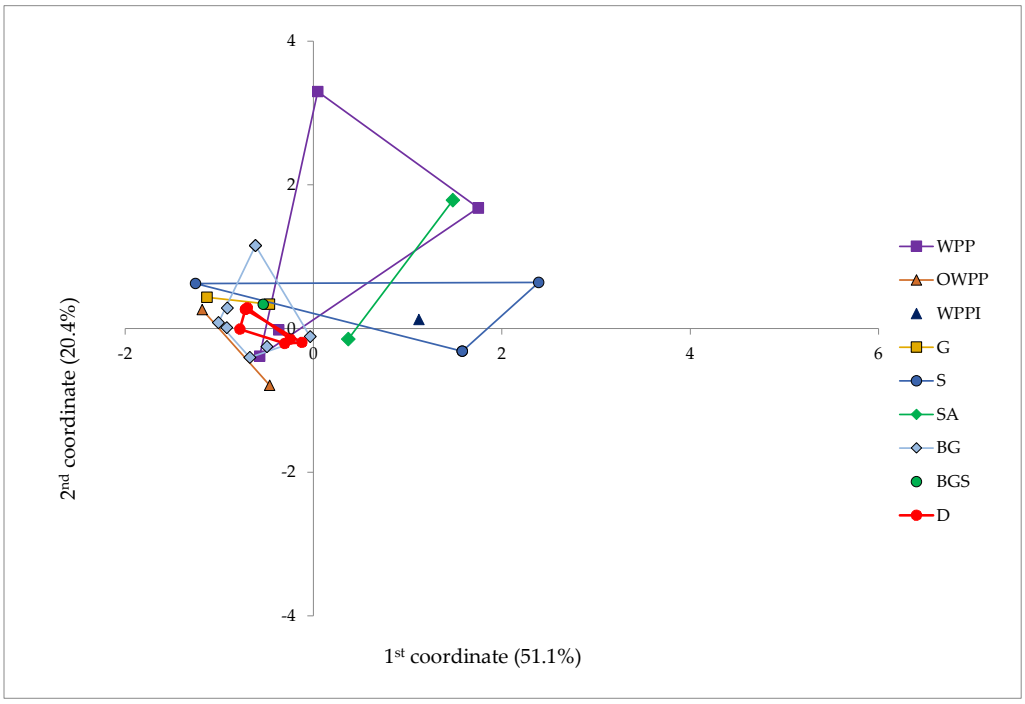


Figure 10. Differentiation of enterprises in 2022.

Table 6. Mahalanobis squared distances amongst particular energy groups of companies based on financial ratios in 2022.

OWPP	5.81							
WPPI	5.23	3.98						
G	4.82	1.01	4.18					
S	5.16	5.37	1.85	3.37				
SA	3.94	4.62	0.76	3.19	0.97			
BG	3.71	0.31	3.55	1.13	5.15	3.87		
BGS	3.25	0.84	3.19	0.22	2.85	2.52	0.63	
D	4.99	0.19	2.60	0.73	3.86	2.98	0.33	0.51
	WPP	**OWPP**	**WPPI**	**G**	**S**	**SA**	**BG**	**BGS**

Based on Mahalanobis squared distances, it was found that the differences in index values between years for each group of companies (Table 7) were higher in comparison to the differences between these groups of companies within years. The largest differences were observed in the groups of solar power plants, solar power plants with the installation of systems, and onshore wind power plants. It was shown that values of financial indicators in the geothermal heat plant group were similar in all studied years. This indicates that these entities, both in periods of calm and danger, had a stable financial situation and the activities carried out throughout the period were profitable. Noteworthy is that the power generation of these companies is based on a single source of renewable energy, which is relatively stable. Further down, the values of financial indicators did not change significantly in the group of biogas plant entities. These small changes were more obvious in the comparison of results from 2022 to 2020, than in 2020 to 2018. The changes in 2022 were mainly related to profitability and liquidity.

Table 7. Mahalanobis squared distances between years for particular energy groups of companies based on financial ratios.

Groups of Enterprises	2018 vs. 2020	2018 vs. 2022	2020 vs. 2022
WPP	1.84	5.60	5.12
OWPP	1.70	2.40	0.06
WPPI	0.37	2.41	1.04
G	0.02	0.03	0.02
S	9.22	4.68	3.70
SA	7.06	6.79	2.20
BG	0.07	0.22	0.24
BGS	0.16	0.86	0.36
D	0.14	0.21	0.44

A characteristic group of companies were large companies with diversified energy production, in which there were also no large changes in the values of financial indicators between studied years. In the case of these small differences, more significant changes were in the results of 2022 compared to 2020 and the difference was mainly in profitability. The average value of return on assets (y_4) in 2022 in this group was 5.1%, and in 2020, it was equal to −3.7%. Liquidity in these entities was assured. The average value of the indicator was 1.34 in 2022, and 1.25 in 2020. It should be emphasized that this is a group of companies with large-scale operations securing 70% of total energy demand in Poland. These companies generate energy from both conventional and renewable sources. However, conventional fuels such as coal and lignite remain the main raw material for energy production (Figure 11).

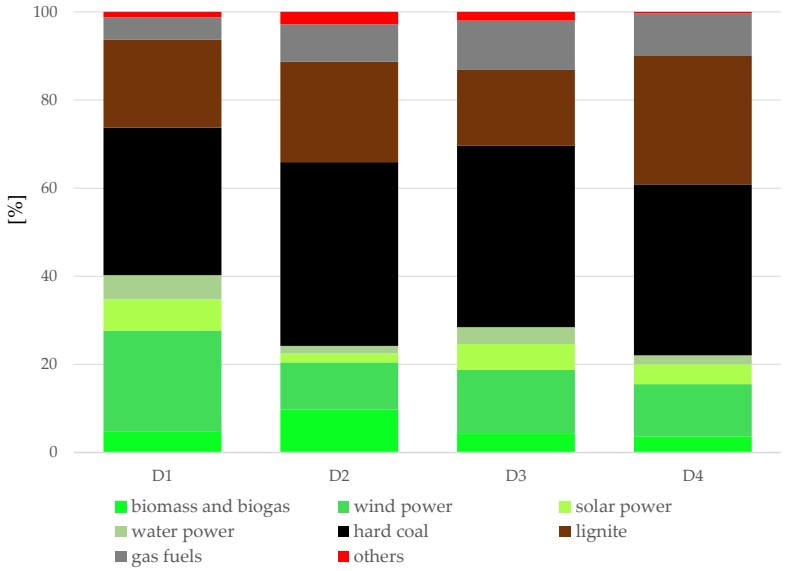


Figure 11. The structure of fuels and other primary energy carriers consumed to generate electricity sold in 2022 in large energy groups. Source: own elaboration based on [7–10].

6. Discussion

In a financial analysis, multiple regression is used to examine simple relationships between analyzed variables [90]. The result of this analysis is the determination of the predicted value of the dependent variable on the basis of the analyzed characteristics. In order to increase the accuracy of predictions, non-linear functions are used in the analysis, e.g., probit and logit methods [90,91]. The disadvantage of this approach is that correlations between independent variables are not taken into account. One of the solutions is to use principal components, which linearly transform analyzed characteristics to an orthogonal space [92]. In this case, the consideration should be limited to a homogeneous group.

Additionally, the canonical variate analysis should be used to include differences existing due to the distinctiveness of the groups [80] and variability between fixed study periods [24]. The article focuses on the issues of how crisis conditions affect the development of the financial situation in various companies in the energy sector. Based on our analyses, it was found that the surveyed energy companies reacted differently to the emergencies that occurred in crises. The directions of these changes in different groups of companies varied and studies conducted by other authors also indicate that companies react differently to crisis situations [2,18,19,21,93,94]. Susilowati et al. [93] and Morina et al. [94] showed the negative impact of the COVID-19 pandemic on the stock market return of selected energy companies. On the other hand, Zimmon et al. [21] and Smal and Veprov [2] found that financial situations did not worsen during the crisis, which is also confirmed by our study. During the peacetime year 2018, the situation in each group of energy companies was more diverse than in the years 2020 and 2022. The financial indices were also more diverse. This was manifested first by a higher level of debt, which gradually decreased in subsequent years, which can be considered an improvement in the financial situation. A similar result is presented by Mayasari and Wulandari [95], who report that prior to the 2007–2008 economic crisis, the debt of many companies in Indonesia reached unprecedented levels, which forced companies to repay loans and affected their financial situation. The financial structure also indicates how efficiently a firm manages its assets [96]. This finding was confirmed by our research, which showed that debt levels were decreasing and asset profitability was clearly improving. The improvement in profitability was the result of reduced costs, including financial costs and better asset management. Cost control allowed the companies we studied to move out of the area of losses and enable debt repayment as manifested by a reduction in the total debt ratio. Cost control should not only concern financial costs but also costs related to core operations. It is increasingly emphasized that of this group of costs, energy storage costs should be given primary attention [11,12,28,29]. According to these authors, such storage should reduce the currently high cost of energy storage and importantly, be environmentally friendly. Cost reductions lead to an improvement in profitability research. Our research shows that higher profitability was achieved by companies producing energy from renewable sources, including geothermal heat plants, solar power plants with the installation of systems, and onshore wind power plants. Similar results on the basis of one-dimensional statistical tests were obtained by Osiichuk [22]. He shows that after the year 2019, renewable energy companies generate significantly higher returns on assets and incur higher capital expenditures than their conventional counterparts. At the same time, the profitability and financing needs of renewable energy companies are more sensitive to electricity prices than those of conventional energy companies. Our study shows that the improved profitability of the companies surveyed is linked to the rise in energy prices. On the other hand, this increase in energy costs has had a negative impact on the financial health of consumers—households and businesses in other sectors. Another factor in assessing the financial health of companies is liquidity. In times of a crisis, companies take a more restrictive approach to trade credit customers and in effect ensure that they can maintain their liquidity. This is also confirmed by our research. In the year 2018, the current liquidity ratios of most of the companies we surveyed were lower than the overall average. In 2020 and 2022, however, they rose significantly. Their values in a period of equilibrium and economic calm could even be considered as over-liquidity and excessive cash collecting. Zimon [97] argues that maintaining high current liquidity and the same level of profitability is a new and very good approach to business management, especially in SMEs in Poland during the COVID-19 pandemic. Our research confirms that this pattern continued in Polish energy companies in the following years. Bei and Wijewardana [98] and Vahid et al. [99] stress that the use of such a liquidity management strategy can have a negative impact on profitability. Zimon [97], on the other hand, emphasizes that this phenomenon is not observed in renewable energy SMEs. Our research also confirms that green energy SMEs have higher liquidity, which changes in proportion to the profitability of the assets involved, i.e., return on assets.

7. Conclusions

The paper addresses the problem of assessing the financial situation of energy companies in Poland in the context of the global energy crisis and sustainable energy future. Based on the presented objective and in the searching of answers to the research questions, we formulated the following conclusions:

- In a period of economic uncertainty caused by a pandemic and armed conflict, energy companies were concerned about their financial position and sought to ensure energy security, while the problem of mitigating the negative impact of energy production on the environment became a secondary concern.
- The improvement in financial performance occurred both in RES enterprises where energy production was generally based on a single source and in enterprises with diversified activities. This is due, among other issues, to rising energy prices and regulatory changes.
- This situation can contribute to the sustainable development of the whole sector and to a larger diversification of the energy market, which in the long term could increase the country's energy security.

Looking to the future, sustainability and environmental care should become the basis for the upcoming development of the modern energy sector. Improvements in the efficiency of operations in the energy sector should therefore be aimed at improving the performance of the renewable energy segment, which can be achieved by combining technological progress with the management of corporate assets and finances. Priority should continue to be given to measures that, among other things, reinforce the development of storage of generated energy, especially by RES producers. Investment in RES should also be increased, which will help diversify energy sources and reduce dependence on fossil fuels.

This study makes a strong contribution to the field of research on the financial health of energy sector companies. However, it does not answer all our questions and does not fill all existing gaps in scientific knowledge. Such areas include identifying the impact of changes in regulatory authorization schemes, which are determinants of the financial health of energy sector players. Further studies should focus on recognizing the impact of RES development regulations on the sustainable performance of power generation entities. It can lead to much deeper and broader conclusions from the studies carried out and the recognition of financial dependencies in other sectors.

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References

1. Stavytskyy, A.; Kharlamova, G.; Giedraitis, V.; Šumskis, V. Estimating the interrelation between energy security and macroeconomic factors in European countries. *J. Int. Stud.* **2018**, *11*, 217–238. [CrossRef]
2. Smal, T.; Wieprow, J. Energy Security in the Context of Global Energy Crisis: Economic and Financial Conditions. *Energies* **2023**, *16*, 1605. [CrossRef]
3. IEA Monthly Electricity Statistics. Revised Historical Data, Years 1990–2021. Available online: https://www.iea.org/data-and-statistics/data-product/monthly-electricity-statistics (accessed on 19 September 2024).

4. IEA World. Energy Supply. Available online: https://www.iea.org/world/energy-mix (accessed on 23 November 2024).
5. Energy Policy of Poland Until 2040 (EPP2040). Available online: https://www.gov.pl/web/ia/polityka-energetyczna-polski-do-2040-r-pep2040 (accessed on 29 August 2024).
6. Act of 10 April 1997—Energy Law. Available online: https://www.ure.gov.pl/pl/urzad/prawo/ustawy/17,Ustawa-z-dnia-10-kwietnia-1997-r-Prawo-energetyczne.html (accessed on 29 August 2024).
7. Integrated Report 2018, 2020, 2022 of the Company Tauron. Available online: https://raport.tauron.pl/en/ (accessed on 14 August 2024).
8. Integrated Report 2018, 2020, 2022 of the Company GK PGE. Available online: https://raportzintegrowany2022.gkpge.pl/en/ (accessed on 14 August 2024).
9. Integrated Report 2018, 2020, 2022 of the Company ENEA. Available online: https://raport2022.esg.enea.pl/en/ (accessed on 14 August 2024).
10. Integrated Report 2018, 2020, 2022 of the Company ENERGA. Available online: https://grupa.energa.pl/en (accessed on 14 August 2024).
11. Moghadam, M.; Ghaffarzadeh, N.; Tahmaseb, M.; Pasupuleti, J. Virtual power plant management with hybrid energy storage system. *Unconv. Resour.* **2025**, *5*, 100107. [CrossRef]
12. Mikulik, J.; Niekurzak, M. Assessment of the Profitability of a Photovoltaic Installation Cooperating with Energy Storage Using an Example of a Medium-Sized Production Company. *Energies* **2024**, *17*, 4740. [CrossRef]
13. Zakeri, B.; Paulavets, K.; Barreto-Gomez, L.; Echeverri, L.G.; Pachauri, S.; Boza-Kiss, B.; Zimm, C.; Rogelj, J.; Creutzig, F.; Ürge-Vorsatz, D.; et al. Pandemic, War, and Global Energy Transitions. *Energies* **2022**, *15*, 6114. [CrossRef]
14. Basdekis, C.; Christopoulos, A.G.; Katsampoxakis, I.; Xanthopoulos, S. Trends and Challenges after the Impact of COVID-19 and the Energy Crisis on Financial Markets. *Energies* **2024**, *17*, 3857. [CrossRef]
15. Witkowska-Dąbrowska, M.; Świdyńska, N.; Napiórkowska-Baryła, A. Reviewing the Situation and Prospects for Developing Small Renewable Energy Systems in Poland. *Energies* **2023**, *16*, 7339. [CrossRef]
16. Toborek-Mazur, J.; Partacz, K.; Surówka, M. Energy Security as a Premise for Mergers and Acquisitions on the Example of the Multi-Energy Concern PKN Orlen in the Face of the Challenges of the 2020s. *Energies* **2022**, *15*, 5112. [CrossRef]
17. Mauro, M.R. Energy Security, Energy Transition, and Foreign Investments: An Evolving Complex Relationship. *Laws* **2024**, *13*, 48. [CrossRef]
18. Grondys, K.; Ślusarczyk, O.; Hussain, H.I.; Androniceanu, A. Risk Assessment of the SME Sector Operations during the COVID-19 Pandemic. *Int. J. Environ. Res. Public Health* **2021**, *18*, 4183. [CrossRef]
19. Rathore, U.; Khanna, S. From Slowdown to Lockdown: Effects of the COVID-19 Crisis on Small Firms in India. *SSRN Electron. J.* **2020**, 32. [CrossRef]
20. Weber, M.M.; Kokott, P. Organizational Resilience and the Attention-Based View of the Firm-Empirical Evidence from German SMEs. *Sustainability* **2024**, *16*, 4691. [CrossRef]
21. Zimon, G.; Tarighi, H.; Salehi, M.; Sadowski, A. Assessment of Financial Security of SMEs Operating in the Renewable Energy Industry during COVID-19 Pandemic. *Energies* **2022**, *15*, 9627. [CrossRef]
22. Osiichuk, D. The Obstacles to the Growth of the Renewable Energy Industry in the European Union. *Sustainability* **2023**, *15*, 14612. [CrossRef]
23. Anuara, H.; Chin, O. the development of debt to equity ratio in capital structure model: A case of micro franchising. *Procedia Econ. Financ.* **2016**, *35*, 274–280. [CrossRef]
24. Kayzer, D.; Czerwińska-Kayzer, D.; Florek, J.; Staniszewski, R. Financial Security as a Basis for the Sustainable Development of Small and Medium-Sized Renewable Energy Companies-A Polish Perspective. *Sustainability* **2024**, *16*, 5926. [CrossRef]
25. Abbas, A.A.; Hadi, A.A.; Abbas Muhammad, A. Measuring the Extent of Liquidity's Impact on the Financial Structure. *Int. J. Multicult. Multireligious Underst.* **2021**, *86*, 365–389.
26. Florek, J.; Stanisławska, J.; Czerwinska-Kayzer, D. The financial situation of the food industry in Poland in comparision with 2005 and 2010. *Ann. Pol. Assoc. Agric. Agribus. Econ.* **2015**, *17*, 41–48. Available online: https://rnseria.com/article/123393/en (accessed on 1 September 2024).
27. Abdlkareem Ibrahim, N.; Salehi, M.; Amran Naji Al-Refiay, H.; Lari Dashtbayaz, M. A Financial Stability Model for Iraqi Companies. *Risks* **2024**, *12*, 140. [CrossRef]
28. Massachusetts Institute of Technology. The Future of Energy Storage—An Interdisciplinary MIT Study. 2022. Available online: https://energy.mit.edu/wp-content/uploads/2022/05/The-Future-of-Energy-Storage.pdf (accessed on 6 June 2023).
29. European Parliament, European Parliament Resolution of 10 July 2020 on a Comprehensive European Approach to Energy Storage—A Comprehensive European Approach to Energy Storage (2019/2189(INI)) P9_TA(2020)0198 Official Journal of the European Union, 15 September 2021. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020IP0198 (accessed on 29 October 2024).
30. Aslam, E.; Ijaz, F.; Iqbal, A. Does Working Capital and Financial Structure Impact Profitability of Islamic and Conventional Banks Differently? *Islam. Bank. Fin. Rev.* **2016**, *3*, 50–67. Available online: https://ssrn.com/abstract=2820277 (accessed on 1 September 2024). [CrossRef]
31. Moudud-Ul-Huq, S.; Halim, M.A.; Sobhani, F.A.; Karim, Z.; Nesa, Z. The Nexus of Competition, Loan Quality, and Ownership Structure for Risk-Taking Behaviour. *Risks* **2023**, *11*, 68. [CrossRef]

32. Brunnermeier, M.K. Deciphering the liquidity and credit crunch 2007–2008. *J. Econ. Perspect.* **2009**, *23*, 77–100. [CrossRef]
33. Nguyen, C.T.; Hai, P.T.; Nguyen, H.K. Stock market returns and liquidity during the COVID-19 outbreak: Evidence from the financial services sector in Vietnam. *Asian J. Econ. Bank.* **2021**, *5*, 324–342. [CrossRef]
34. Huang, W.; Goodell, J.W.; Goyal, A. In times of crisis does ownership matter? Liquidity extraction through dividends during the 2007–2009 financial crisis. *J. Int. Financ. Mark. Inst. Money* **2021**, *73*, 101380. [CrossRef]
35. Svatošová, V. Identification of Financial Strategy in Small and Medium-sized Entrepreneurship. *Acta Univ. Agric. Silvic. Mendel. Brun.* **2017**, *65*, 1435–1453. [CrossRef]
36. Burcă, V.; Bogdan, O.; Bunget, O.-C.; Dumitrescu, A.-C. Corporate Financial Performance vs. Corporate Sustainability Performance, between Earnings Management and Process Improvement. *Sustainability* **2024**, *16*, 7744. [CrossRef]
37. Zimon, G.; Dankiewicz, R. Trade Credit Management Strategies in SMEs and the COVID-19 Pandemic—A Case of Poland. *Sustainability* **2020**, *12*, 6114. [CrossRef]
38. Urząd Regulacji Energetyki. Available online: https://www.ure.gov.pl/pl/energia-elektryczna/ceny-wskazniki/7852,Srednia-cena-sprzedazy-energii-elektrycznej-na-rynku-konkurencyjnym-roczna-i-kwa.html (accessed on 1 October 2024).
39. Simionescu, M.; Păuna, C.B.; Diaconescu, T. Renewable Energy and Economic Performance in the Context of the European Green Deal. *Energies* **2020**, *13*, 6440. [CrossRef]
40. Woźniak, M.; Badora, A.; Kud, K. Expectations of the Inhabitants of South-Eastern Poland Regarding the Energy Market, in the Context of the COVID-19 Crisis. *Energies* **2023**, *16*, 5530. [CrossRef]
41. Marks-Bielska, R.; Bielski, S.; Pik, K.; Kurowska, K. The Importance of Renewable Energy Sources in Poland's Energy Mix. *Energies* **2020**, *13*, 4624. [CrossRef]
42. Pfenninger, S.; Keirstead, J. Renewables, nuclear, or fossil fuels? Scenarios for Great Britain's power system considering costs, emissions and energy security. *Appl. Energy* **2015**, *152*, 83–93. [CrossRef]
43. Eurostat Database. Available online: https://ec.europa.eu/eurostat/data/database (accessed on 25 August 2024).
44. Energy Statistics in 2021 and 2022. Available online: https://stat.gov.pl/en/topics/environment-energy/energy/energy-statistics-in-2021-and-2022,4,18.html (accessed on 31 July 2024).
45. Pinedo-López, J.; Baena-Navarro, R.; Durán-Rojas, N.; Díaz-Cogollo, L.; Farak-Flórez, L. Energy Transition in Colombia: An Implementation Proposal for SMEs. *Sustainability* **2024**, *16*, 7263. [CrossRef]
46. Sobczak-Malitka, W.; Sobczak, A. Farmers' Attitudes Towards Renewable Energy Sources. *Ann. Pol. Assoc. Agric. Agribus. Econ.* **2022**, *24*, 175–187. [CrossRef]
47. Halbrügge, S.; Schott, P.; Weibelzahl, M.; Buhl, H.U.; Fridgen, G.; Schöpf, M. How did the German and other European electricity systems react to the COVID-19 pandemic? *Appl. Energy* **2021**, *285*, 116370. [CrossRef]
48. Kryszk, H.; Kurowska, K.; Marks-Bielska, R.; Bielski, S.; Eźlakowski, B. Barriers and Prospects for the Development of Renewable Energy Sources in Poland during the Energy Crisis. *Energies* **2023**, *16*, 1724. [CrossRef]
49. Kuś, A.; Kuś, A. Photovoltaic Companies on the Warsaw Stock Exchange-Another Speculative Bubble or a Sign of the Times? *Energies* **2023**, *16*, 692. [CrossRef]
50. Elavarasan, R.M.; Pugazhendhi, R.; Shafiullah, G.M.; Kumar, N.M.; Arif, M.T.; Jamal, T.; Chopra, S.S.; Dyduch, J. Impacts of COVID-19 on Sustainable Development Goals and effective approaches to maneuver them in the post-pandemic environment. *Environ. Sci. Pollut. Res.* **2022**, *29*, 33957–33987. [CrossRef]
51. Chrzanowski, M.; Zawada, P. Fraction separation potential in the recycling process of photovoltaic panels at the installation site-A conceptual framework from an economic and ecological safety perspective. *Energies* **2023**, *16*, 2084. [CrossRef]
52. Borowski, P.F. Mitigating Climate Change and the Development of Green Energy versus a Return to Fossil Fuels Due to the Energy Crisis in 2022. *Energies* **2022**, *15*, 9289. [CrossRef]
53. O'Riordan, T.; Sandford, B. War and the Politics of Energy and Climate Change. *Environ. Sci. Policy Sustain. Dev.* **2022**, *64*, 2–6. [CrossRef]
54. Steffen, B.; Patt, A. A historical turning point? Early evidence on how the Russia-Ukraine war changes public support for clean energy policies. *Energy Res. Soc. Sci.* **2022**, *91*, 102758. [CrossRef]
55. Hemrit, W.; Benlagha, N. Does renewable energy index respond to the pandemic uncertainty? Renew. *Energy* **2021**, *177*, 336–347. [CrossRef]
56. Davidson, N.; Maksimova, E.; Mariev, O. How does renewable energy consumption affect economic growth? Evidence from the European Union countries. In Proceedings of the 21st International Scientific Conference Globalization and its Socio-Economic Consequences, Zilina, Slovakia, 13 October 2021. [CrossRef]
57. Chang, T.; Gupta, R.; Inglesi-Lotz, R.; Simo-Kengne, B.; Smithers, D.; Trembling, A. Renewable energy and growth: Evidence from heterogeneous panel of G7 countries using Granger causality. *Renew. Sustain. Energ. Rev.* **2015**, *52*, 1405–1412. [CrossRef]
58. Sadorsky, P. Renewable energy consumption and income in emerging economies. *Energy Policy* **2009**, *37*, 4021–4028. [CrossRef]
59. Gyamfi, B.A.; Bein, M.A.; Bekun, F.V. Investigating the nexus between hydroelectricity energy, renewable energy, nonrenewable energy consumption on output: Evidence from E7 countries. *Environ. Sci. Pollut. Res.* **2020**, *27*, 25327–25339. [CrossRef]
60. Rafindadi, A.A.; Ozturk, I. Impacts of renewable energy consumption on the German economic growth: Evidence from combined cointegration test. *Renew. Sustain. Energ. Rev.* **2017**, *75*, 1130–1141. [CrossRef]

61. European Commission. Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy Efficiency, Amending Directives 2009/125/EC and 2010/30/EU and Repealing Directives 2004/8/EC and 2006/32/EC. *Off. J. Eur. Union* **2022**, *L 315/1*, 1–56. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012L0027&from=EN (accessed on 12 August 2024).
62. Yu, B.; Fang, D.; Yu, H.; Zhao, C. Temporal-spatial determinants of renewable energy penetration in electricity production: Evidence from EU countries. *Renew. Energy* **2021**, *180*, 438–451. [CrossRef]
63. Kacperska, E.; Łukasiewicz, K.; Pietrzak, P. Use of renewable energy sources in the European Union and the Visegrad Group Countries-Results of cluster analysis. *Energies* **2021**, *14*, 5680. [CrossRef]
64. Brodny, J.; Tutak, M.; Bindzár, P. Assessing the level of renewable energy development in the European Union Member States. A 10-year perspective. *Energies* **2021**, *14*, 3765. [CrossRef]
65. Gajdzik, B.; Nagaj, R.; Wolniak, R.; Bałaga, D.; Žuromskait, B.; Grebski, W.W. Renewable energy share in European industry: Analysis and extrapolation of trends in EU countries. *Energies* **2024**, *17*, 2476. [CrossRef]
66. National Court Register. Available online: https://web.archive.org/web/20230327163623/https://www.arch.ms.gov.pl/en/national-registers/national-court-register/ (accessed on 30 August 2024).
67. Arimany-Serrat, N.; Montanyà, O.; Amat, O. Sustainability as a Resilience Factor in the Agri-Food Supply Chain. *Sustainability* **2024**, *16*, 7162. [CrossRef]
68. Dz. U. 2021 poz. 2376. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20210002376 (accessed on 30 September 2023).
69. Altman, E.I.; Hotchkiss, E. *Corporate Financial Distress and Bankruptcy, Predict and Avoid Bankruptcy, Analyze and Invest in Distressed Debt*; John Wiley & Sons, Inc.: Hoboken, NJ, USA, 2006; p. 384.
70. Wasilewski, M.; Ganc, M. A dynamic and static view of the financial security of dairy cooperatives. *Ann. Pol. Assoc. Agric. Agribus. Econ.* **2021**, *23*, 109–119. [CrossRef]
71. Pitera, R. *Financial Ratios as a Source of Information about the Company's Financial Condition*; Silva Rerum: Poznań, Poland, 2015; p. 112.
72. Zenzerović, R.; Benazić, M. The Impact of Selected Financial Ratios on Economic Value Added: Evidence from Croatia. *J. Risk Financ. Manag.* **2024**, *17*, 338. [CrossRef]
73. Al-Rjoub, S. A financial stability index for Jordan. *J. Cent. Bank. Theory Pract.* **2021**, *10*, 157–178. [CrossRef]
74. Zimon, G. Financial Liquidity Management Strategies in Polish Energy Companies. *Int. J. Energy Econ. Policy* **2020**, *10*, 365–368. [CrossRef]
75. Panova, E. Determinants of capital structure in Russian small and medium manufacturing enterprises. *Equilib. Q. J. Econ. Econ. Policy* **2020**, *15*, 361–375. [CrossRef]
76. Czerwińska-Kayzer, D.; Kleiber, T.; Wolna-Maruwka, A.; Frankowski, P.; Staniszewski, R.; Kayzer, D. Sustainable Use of Organic Matter Obtained from the Bottom of a Post-Mining Pit Reservoir—A Case Study on the Creation of Raduszyn Lake in Poland. *Energies* **2023**, *16*, 2223. [CrossRef]
77. Wang, G.; Bai, J.; Xing, J.; Shen, J.; Dan, E.; Zheng, X.; Zhang, L.; Liu, P.; Feng, R. Operational Efficiency and Debt Cost: The Mediating Effect of Carbon Information Disclosure in Chinese Listed Companies. *Sustainability* **2023**, *15*, 1512. [CrossRef]
78. Duhita, M.Y.; Rizkianto, E. The Impact of Financial Ratios on The Value of Companies that Conducted M&A which Registered in IDX on 2016–2021. *Dyn. Manag. J.* **2023**, *7*, 189–203. [CrossRef]
79. Kramoliš, J.; Dobeš, K. Debt as a financial risk factor in SMEs in the Czech Republic. *Equilib. Q. J. Econ. Econ. Policy* **2020**, *15*, 87–105. [CrossRef]
80. Czerwińska-Kayzer, D.; Florek, J.; Staniszewski, R.; Kayzer, D. Application of Canonical Variate Analysis to Compare Different Groups of Food Industry Companies in Terms of Financial Liquidity and Profitability. *Energies* **2021**, *14*, 4701. [CrossRef]
81. Barburski, J.; Hołda, A. Determinants of the Corporate Financing Structure in the Energy and Mining Sectors; A Comparative Analysis Based on the Example of Selected EU Countries for 2012–2020. *Energies* **2023**, *16*, 4692. [CrossRef]
82. Tarighi, H.; Zimon, G.; Sheikh, M.J.; Sayrani, M. The Impact of Firm Risk and the COVID-19 Crisis on Working Capital Management Strategies: Evidence from a Market Affected by Economic Uncertainty. *Risks* **2024**, *12*, 72. [CrossRef]
83. Jaworski, J.; Czerwonka, L.; Mądra-Sawicka, M. The relationship between profitability and financial liquidity in food manufacturing industry in Poland. *Ann. Pol. Assoc. Agric. Aribus. Econ.* **2018**, *20*, 41–51. [CrossRef]
84. Kamar, K. Analysis of the Effect of Return on Equity (Roe) and Debt to Equity Ratio (Der) On Stock Price on Cement Industry Listed In Indonesia Stock Exchange (Idx) In the Year of 2011–2015. *Int. J. Bus. Manag.* **2017**, *19*, 66–76. [CrossRef]
85. Krzanowski, W.J. *Principles of Multivariate Analysis: A User's Perspective*, 2nd ed.; Oxford University Press: New York, NY, USA, 2000; p. 608.
86. Lejeune, M.; Caliński, T. Canonical analysis applied to multivariate analysis of variance. *J. Multivar. Anal.* **2000**, *72*, 100–119. [CrossRef]
87. Sajnóg, A.; Koko, E.; Kayzer, D.; Barałkiewicz, D. Chemometric approach to find relationships between physiological elements and elements causing toxic effects in herb roots by ICP-MS. *Sci. Rep.* **2021**, *11*, 20683. [CrossRef]
88. Kupiec, J.M.; Staniszewski, R.; Kayzer, D. Assessment of water quality indicators in the Orla river nitrate vulnerable zone in the context of new threats in Poland. *Water* **2022**, *14*, 2287. [CrossRef]

89. Kayzer, D.; Frankowski, P.; Zbierska, J.; Staniszewski, R. Evaluation of trophic parameters in newly built reservoir using canonical variates analysis. In Proceedings of the XLVIII Seminar of Applied Mathematics, Boguszów-Gorce, Poland, 9–11 September 2018; Volume 23, p. 00019. [CrossRef]
90. Huo, Y.; Chan, L.H.; Miller, D. Bankruptcy prediction for restaurant firms: A comparative analysis of multiple discriminant analysis and logistic regression. *J. Risk Financ. Manag.* **2024**, *17*, 399. [CrossRef]
91. Chen, L.; Bai, J.; Xu, S.; Cheng, Z.; Chen, J. Financial literacy, Fintech, and risky financial investment in urban households—An analysis based on CHFS Data. *Mathematics* **2024**, *12*, 3393. [CrossRef]
92. Khoza, F.; Makina, D.; Makoni, P.L. Key determinants of corporate governance in financial institutions: Evidence from South Africa. *Risks* **2024**, *12*, 90. [CrossRef]
93. Susilowati, D.; Ernayani, R.; Yudaruddin, Y.A.; Yudaruddin, R. Performance of energy sector companies in time of pandemic COVID-19; International evidence. *Res. Glob.* **2023**, *7*, 100177. [CrossRef]
94. Morina, F.; Lyroudi, K.; Balomenou, C. The Economic Impact of the Coronavirus Pandemic (COVID-2019): Implications for the Energy Sector. In *Energy Transition*; Springer: Singapore, 2022; pp. 193–213. [CrossRef]
95. Mayasari; Wulandari, N. Pengaruh Financial Stability, Efektivitas Internal Control, Dan Auditor Change (Fraud Triangle) Terhadap Financial Statement Fraud. *J. Bisnis Manaj.* **2022**, *2*, 128–142. Available online: https://journal.moestopo.ac.id/index.php/jmb/article/download/2348/1086 (accessed on 1 September 2024). [CrossRef]
96. Eisdorfer, A.; Giaccotto, C.; White, R. Capital structure executive compensation and investment efficiency. *J. Bank. Financ.* **2013**, *372*, 549–562. [CrossRef]
97. Zimon, G. An Analysis of Working Capital Management Strategy in Small Enterprises Operating within Group Purchasing Organizations. In *Eurasian Economic Perspectives*; Springer: Cham, Switzerland, 2020; pp. 103–111.
98. Bei, Z.; Wijewardana, W. Working capital policy practice: Evidence from Sri Lankan companies. *Proced. Soc. Behav. Sci.* **2012**, *40*, 695–700. [CrossRef]
99. Vahid, T.K.; Elham, G.; Mohsen, A.K.; Mohammadreza, E. Working Capital Management and Corporate Performance: Evidence from Iranian Companies. *Procedia Soc. Behav. Sci.* **2012**, *62*, 1313–1318. [CrossRef]

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