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Energy crisis and companies' investment in renewable energy sources: case of Metal Processing Cluster

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Abstract

Motivation: Improving the energy efficiency of enterprises is now not only a postulate of inter-national and national energy transition strategies towards climate neutrality, but also a requirement for maintaining their profitability and competitive capacity. Rising energy fuel prices and the unstable geopolitical situation, and above all, the war in Ukraine, are causing many enterprises to take energy-saving actions (ESA's). One of them is investing in renewable energy sources (RES) for their own consumption, understood as investing in future energy purchase savings.

Aim: The article aims to identify the involvement of enterprises affiliated with the Metal Processing Cluster (MPC), which has the status of the Polish Key National Cluster, in RES investments in the context of the energy crisis. It also attempts to verify the hypothesis: greater interest in investing in RES is shown by enterprises that have seen a strong negative impact of energy price increases on their operations. The research was carried out on the basis of literature studies, analysis of Polish Central Statistical Office statistical data and analysis of reports of various institutions. Empirical verification

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of the hypothesis was possible on the basis of the results of surveys conducted in the enterprises of the MPC.

Results: The research showed that in 2022, more than half of the surveyed companies affiliated with the MPC felt the negative (very strong and strong) effect of rising energy prices. It primarily had an impact on the decline in their profitability. In 73% of the surveyed companies, this situation influenced the decision to start investments in renewable energy sources, with the majority of these investments being in photovoltaic panels. The survey contributes to the knowledge of the impact of the energy crisis on RES investments in metal companies.

Keywords: energy crisis; energy efficiency; renewable energy sources; companies' investment; metal industry
JEL: D22; D25

1. Introduction

Access to energy and natural resources is a fundamental factor in economic development. Energy security also determines the conduct of economic activity and affects the competitiveness of the economy. Poland mainly uses energy from non-renewable sources. In 2020, the share of energy from renewable sources in gross final energy consumption was 16.1%, increase by 0.7 percentage points from the previous year and 9.2 percentage points from 2004 (Wyszkowska et al., 2022, p. 31). This means that Poland has reached the 15% target set, in accordance with EU commitments for 2020. Given that the main source of energy in Poland is non-renewable sources, and the fact that Poland was 60% dependent on imported energy in 2020, the increase in energy prices caused by the geopolitical situation after Russia's attack on Ukraine had a significant impact on the economic situation in the country (Eurostat, 2023). Wholesale electricity prices, which reached a record high in 2022, are directly related to gas and hard coal prices, which are primarily imported. European Union countries imported 375 million square meters of gas in 2021, with most of the imports coming from Russia (Eurostat, 2023). Russia's deliberate restriction of the supply of primary energy sources to the EU is being used by Ukraine's aggressor as a weapon and an instrument of pressure. The increase in price of all fossil fuels in mid-2022 has fueled inflationary pressures and created a real risk of recession.

The energy crisis, described by the International Energy Agency (IEA, 2022, p. 19) as the first global crisis of unprecedented scale and complexity, which is also one of the greatest risks of the modern world according to the World Economic Forum (WEF, 2023), has significantly affected metal industry companies. Poland is the fifth-largest producer of steel in the European Union and the second-largest producer of copper among other EU countries. In recent years, the metal industry in Poland has grown rapidly — in 2005, there were about 32,000 enterprises in the broad metal sector, and by 2021 their number reached almost 51,000. The metal industry is also highly dispersed, with only

4.12% of enterprises employing more than 250 people (Rozkrut et al., 2023). The basic metals manufacturing sector employed 64.2 thousand people in 2021, accounting for about 2.2% of the country's total industrial workforce (Rozkrut et al., 2023). Poland is the third-largest country employing such a high number of workers in this sector in the entire EU countries, with only Germany (253.9 thousand workers) and Italy (117.7 thousand workers) employing more (Stepan, 2022. p. 18). The largest segment in the metalworking sector is steel and iron production. In 2020, producers of iron, steel, ferroalloys and products of first processing of steel, accounted for 65% of the total revenue of the entire sector. The value of sold production was in 2016, 2017, 2018, 2019, respectively: PLN 44.4 billion, PLN 54.9 billion, PLN 60.1 billion, PLN 56.7 billion. Closing 2020 at PLN 51.5 billion of the value of sold production accounted for 3.6% of sold production in industrial processing in general and 2.2% of the country's GDP (Stepan, 2022, p. 17). At the same time, according to the CSO, the value of sold production of the metalworking sector in Poland fell by 11.7% in 2020 compared to the previous year. The COVID-19 pandemic, broken supply chains and the global recession are considered the main reasons for this decline (Stepan, 2022, p. 10). The COVID-19 pandemic also affected metal trade performance. Both imports and exports of base metals and base metal products fell in 2020 — the former by 1.2% y/y, and the latter by 0.9% y/y. The largest declines were in exports of iron and steel (down 5.9% y/y) and imports of iron and steel products (down 4.6% y/y) (Stepan, 2022, p. 10). Thus, the metal industry was significantly affected by the pandemic. At the same time, due to its high share of total direct energy consumption in the manufacturing industry, amounting to about 12% in 2021 (Rozkrut et al., 2023), the increase in energy prices exacerbated the economic problems of many enterprises.

The operation of enterprises under the conditions of the energy crisis, on the one hand, is accompanied by challenges arising from the implementation of EU and national strategies related to the transformation of the European economy towards climate neutrality — on the other. In February 2023, the European Commission (2023) presented a modified (under the influence of the COVID-19 pandemic and the energy crisis) industrial strategy entitled A Green Deal Industrial Plan for the Net-Zero Age. It assumes a further reduction in energy consumption, and one of its priorities is to modernize and decarbonize energy-intensive industries and improve energy efficiency. Taking the above into account, it seems relevant to ask whether the energy crisis will become an driver or a barrier to the energy transition? Do enterprises undertake and will they continue to undertake investments related to the improvement of energy efficiency, including i.a. into renewable energy sources (RES)? Taking the above into account, the purpose of the article is to identify the involvement of enterprises in RES investments in the context of the energy crisis. Metalworking companies affiliated with the Metal Processing Cluster (MPC), which has the status of the Polish Key National Cluster, were used as an empir-

ical example. The article was written based on a critical analysis of the literature on the subject, reports and survey results.

The first part of the article presents a review of the literature on research in the field of energy efficiency (EE) of enterprises and the factors determining its improvement, with a particular focus on investments in RES. The next part describes the methodology of the research, including the characteristics of the MPC and the results of surveys conducted in the Cluster's member enterprises. These results were contrasted with those obtained by other researchers and presented in the discussion section. A summary of the considerations and conclusions are presented in the conclusion.

2. Literature review

Investment in RES can be categorized as a method of improving EE. This concept, due to its importance in low-carbon economic growth, in shaping energy security and in strengthening the competitiveness of businesses, has been the focus of many researchers and various scientific disciplines for several decades. It is also considered at different levels (global, national, regional, local, sectoral) and in different contexts (environmental, economic, social, technical, etc.). With regard to enterprises, i.e. at the microeconomic level, publications in this field can be divided into three areas concerning: the essence and measurement of EE, methods to increase this efficiency, and factors determining the decisions of enterprises to improve EE.

In the broadest sense, EE is understood as an improvement in the ratio of outputs to energy input, i.e. a reduction in the energy required to produce the same or more outputs with the same energy input. This is the definition used by the European Commission (2019). Patterson (1996) almost three decades ago pointed out the many definitional problems associated with measuring the components of energy efficiency, i.e., products obtained and energy input. In this context, he distinguished four groups of metrics: thermodynamic, physical-thermodynamic, economic-thermodynamic and economic, analyzing their suitability for measuring the EE of a process, system or economic sector. From a system and enterprise perspective, economic metrics, which are based on the prices of both effects and energy inputs, appear to be the most relevant. However, a study by Xu & Lin (2022) found that prices do not always reflect market value, and that eliminating factors that distort the relative prices of inputs can significantly improve EE. On the other hand, Na et al. (2021), emphasize that while energy efficiency is an extremely important indicator for studying energy savings and consumption reductions, traditional methods of evaluating EE for the process industry lack an in-depth consideration of whole-system energy use. The need to properly define EE for meaningful measurement and evaluation in industry is also pointed out by Tanaka (2008), while Dunlop & Völker (2023) examine how the processes of politicization and depoliticiza-

tion in the formulation of EE indicators contribute to the realization of the very object of management that is EE.

Among EE methods, the literature generally distinguishes those that lead to a reduction in energy consumption. An extensive review of publications in this area is presented by Abdelaziz et al. (2011, pp. 150–168), dividing energy-saving strategies (also called energy-saving activities ESAs) into three groups: energy management, energy-saving technologies, and regulations/policies aimed at saving energy. In the first group, they look at energy audits, energy-saving courses and training, and concern for the working environment (housekeeping). In the second group — technical solutions to reduce energy consumption. And in the third — legislation, international treaties, incentives to investment, agreements, guidelines for energy conservation, taxation, EE standards, energy guide labels. Studies by Liu et al. (2012, pp. 79–89), as well as May et al. (2015, pp. 46–61) and Yajima et al. (2022) confirm that important methods of improving EE of SMEs enterprises are the level and quality of energy management and internal training in energy conservation. In turn, Obrist et al. (2022), Ramirez-Portilla et al. (2014) and Shabbir et al. (2022) emphasize the great importance of modern technology and innovation.

Increasingly, the method of increasing EE in enterprises is investing in RES. In enterprises for which energy production is not an object of activity, these investments are treated as future savings related to energy purchases. Modern technologies that allow the use of the power of wind, sun, water, biomass become not only a source of green energy for enterprises operating in a variety of industries, but also affect many other areas of the company's operation such as the implementation of sustainable development strategies, the level of innovation in the organization, brand image and brand value (Liczmańska-Kopcewicz et al., 2020; Stawicka, 2021).

The issue of factors determining the decisions of enterprises in the field of EE is considered widely both on theoretical and empirical grounds. In addition to the mere discussion of the essence of these factors treated as barriers or driving forces (drivers), many researchers classify them (compare Chitimiea et al. 2021; Reddy, 2013, pp. 403–416; Trianni et al., 2017, pp. 199–215; Venmans, 2014, pp. 133–142). For example, Palm & Thollander (2010) divide the barriers limiting the implementation of EE improvement solutions into economic ones (e.g., asymmetric information, externalities) based on neoclassical economics, behavioral ones (e.g., inability to process information, form of information, trust, inertia) based on transaction cost theory, psychology or decision theory, among others, and organizational ones (related to the energy management process, broadly defined) explained based on organizational theory.

Attempts to classify factors are also accompanied by studies regarding their relevance in influencing the improvement of enterprise EE. For example, Wang et al. (2018, pp. 866–879) in their research conducted in enterprises of China's Beijing-Tianjin-Hebei region, analyzed the mechanism for improving the EE of an enterprise from three different perspectives (implementation stages, fac-

tors and actors) and identified its main factors at each stage of the decision-making process. Their research shows that EE improvement is influenced by both economic and regulatory factors. On the other hand, Trianni et al. (2014, pp. 1252–1255) study of 64 SME companies involved in the production of basic metals shows that economic factors of an external nature play a dominant role. Thus, it can be surmised that these include the price of energy-efficient technologies and access to capital and subsidies. Thollander et al. (2013, pp. 636–643) came to similar conclusions based on their study of 65 foundries (foundry) in Finland, France, Germany, Italy, Poland, Spain, and Sweden. They show that among the factors determining companies' decisions to improve EE, financial factors play the most important role, especially: energy taxes including taxes on sulphur, Nox and CO2, threat of rising energy prices, cost reductions from lowered energy use, beneficial loans for EE investments, investment subsidies for EE technologies. Also, Apeaning & Thollander (2013, pp. 204–213), Hochman & Timilsina (2017), Liu et al. (2012, pp. 79–89), Rohdin & Thollander (2006, pp. 1836–1844), Trianni et al. (2017) and Venmans (2014, pp. 133–142), based on their studies, point to rising energy prices as a driver of business decisions. Azhgaliyeva et al. (2023, pp. 71–87), on the other hand, emphasize that energy prices and the cost of technology increase companies' interest in investing in RSE.

Based on a review of the literature, it can be concluded that economic and, in particular, financial factors play a special role in the EE decisions of enterprises. In general, from the perspective of companies, the most important benefits of increasing EE are lower energy consumption, savings in operating costs associated with energy purchases, implementation of modern technologies, increased safety of the production process through less dependence on the supply of external energy sources (Sonsale et al., 2023; Xu et al., 2022), as well as lower costs of environmental emissions, or improved consumer perceptions in connection with CSR (Cowan et al., 2010), etc. Thus, companies' investments in EE are a function of the availability of funds, historical and expected returns, and the current economic environment. The energy crisis and especially rising energy prices for energy-intensive manufacturing (such as the metal industry, among others) increase the operating costs of the business, which in turn affect the profitability and competitiveness of companies (Xu et al., 2022). At the same time, investments in RES allow companies to reduce the cost of purchasing energy, the cost of harmful emissions, and generate additional benefits, mainly of a marketing nature (Chang et al., 2017). While it is possible to find results of studies on the impact of various public policies on business investment in RES (e.g. Liu et al., 2023; Wu, 2023), in principle, studies on the impact of the energy crisis expressed in the increase in energy prices on such decisions are scarce. Therefore, this article fills the gap in this regard.

3. Methods

Based on the literature review presented for the study, a hypothesis was formulated: greater interest in investing in RES is shown by enterprises that have seen a strong negative impact of energy price increases on their operations. Empirical verification of the hypothesis was made possible by surveys conducted in February 2023 at enterprises affiliated with the Metal Processing Cluster (MPC) located in Bialystok, which has had the status of a Polish Key National Cluster since 2015. Clusters are defined as regional and territorial clusters of enterprises that produce complementary or similar products or services (Porter, 2001, p. 214). A Key National Cluster (KNC), on the other hand, is a cluster of significant importance to the country's economy and high international competitiveness. Such clusters are identified at the national level. There are currently 20 KNC in Poland. MPC is an initiative of the Center for Promotion of Innovation and Development, which brings together 114 companies operating mainly in the metal and machinery industry in services, production and trade, as well as 23 strategic partners: vocational schools, universities, business environment institutions and local authorities. Among the cluster's members are national leaders in the metal industry (SaMASZ Ltd, Malow Ltd, MetalFach Ltd) with high potential for innovative development. The structure of enterprises includes 94% of SMEs and 6% of large enterprises according to EU criteria. More than 80% belong to the metal and machinery industry. The remaining enterprises are engaged in IT services, robotics, automation and 3D printing.

Since 2019, the cluster has been using a tool (electronic surveys) referred to as the MPC Barometer (B-MPC), with the help of which a continuous diagnosis of the economic situation among MPC entities is carried out. The results of the B-MPC serve as: a set of baseline information to support the decision-making process in MPC enterprises; a set of baseline information within the decision-making process of the MPC Coordinator and Office as to the directions and scope of support for cluster entities; and as an element of a compendium of knowledge about development trends in the cluster population and the metal industry. Courtesy of the developers of the B-MPC, questions were added to the tool to diagnose the impact of energy prices on the economic situation of the company and the involvement of the cluster's enterprises in RES investments made in 2022 and planned for implementation in 2023. Throughout the B-MPC survey, 34 questions were asked of which 6 were related to RES investments in the context of the energy crisis. The questions were of a closed one-choice or Likert scale nature. Responses were received from 41 enterprises, i.e. 36% of correctly completed questionnaires were returned. In the next steps of the survey, cross-tabulations were created, the 2 test and Cramer's coefficient were calculated.

4. Results

Among the companies surveyed, 90% are micro, small and medium-sized enterprises, and 10% are large companies. 51% of the surveyed enterprises indicated that they have experienced a strong or very strong negative impact of the increase in energy prices on their business, expressed primarily in a decrease in profitability (10% are large enterprises, 70% SMEs and 20% micro-enterprises). 32% of respondents indicated that they had already undertaken investments in RES (27% of companies have already invested in photovoltaic panels and 5% in heat pumps) in 2022, and 41% indicated that they planned to undertake such activities in 2023 (65% planned invested in photovoltaics and 35% in heat pumps). In order to examine the relationship between price increases and RES investments, a cross-tabulation table was created, in which the strength of the negative impact of energy price increases on businesses and RES investments undertaken in 2022 was tabulated. The Cramer coefficient was then calculated. The coefficient equal to 0.53 (the correlation of the studied variables was statistically significant — 2= 11.44, p=0.022) indicated a fairly strong relationship between the strength of the negative impact of energy price increases on businesses and investments in RES in 2022. In the next step, another cross-tabulation was created, in which the strength of the negative impact of energy price increases on businesses and planned investments in 2023 was tabulated. The calculated Cramer's coefficient was 0.67 (the relationship between the variables under study was statistically significant — 2= 18.45, p=0.001) and indicated a strong relationship between the strength of the negative impact of energy price increases on businesses and planned RES investments in 2023. Thus, it is possible to confirm the hypothesis set forth in the article by indicating that there is a strong relationship between the strong negative impact of energy price increases on enterprises' operations and their investments in RES. In addition, the relationship between company size and RES investments in 2022 and investment plans in 2023 was also examined. The results indicated that there was no statistically significant relationship in the study group. Due to the method used in the study, it is not possible to determine the direction of the relationship. The method is suitable for a small number of variables, however, if a larger number of dependent values were examined the method used would not be suitable — the greater the number of rows and columns used for the study the faster the value of Crammer's coefficient will rise to 1, despite the lack of strong reasons for a significant correlation.

5. Conclusion

Since no studies have been identified that can be directly compared to the results obtained, the comparisons can only be indirect. A study conducted in late 2022 by Business at OECD (2022) (the study includes more than 200 SMEs from more than 30 countries) found that almost half were strongly affected by the en-

ergy crisis. This result is therefore similar to MPC. In response to a question about what companies are doing about high energy prices, 21% of respondents said they are diversifying investments to reduce energy consumption, while cost reduction is a priority for 67%. The result regarding the involvement of surveyed companies in RES investments (solar panels, geothermal, power generation, etc.) is interesting — 14% of companies indicated that they made such decisions due to the "desire to survive", and 22% due to achieving financial benefits. So in this case as well MPC's results are very similar. In addition, a number of media publications indicate that the interest of RES companies is very high. Neptun Energy, based on its estimates, indicates that one in three Polish companies wants to invest in RES. This means that the MPC results obtained confirm the above trend. The study shows that the energy crisis, especially the increase in energy prices, has significantly affected companies, including the metal industry, which has a high level of energy intensity. The result is a decline in their profitability. As a result, these companies are looking for opportunities to increase EE, including by investing in RES. In the MPC surveyed, one-third of companies have already made such investments, and another 40% will start doing so in 2023. Similar results were obtained by Business at OECD (2022). Thus, the hypothesis that companies that have seen a very strong and powerful impact of energy price increases on their operations show more interest in investing in RES is confirmed.

Undoubtedly, a limitation of the study is its small scale, but the example of MPC may illustrate the increasingly common trends associated with the so-called green or energy transformation. However, while investing in green energy has so far been associated with an image issue, it is now becoming a way of balancing corporate budgets and building greater resilience to uncertainty and energy challenges. Thus, answering the question posed in the introduction, it is prudent to say that the energy crisis is the impetus for the energy transition. The results expands the current knowledge of RES investments in the metal and machinery industry in Poland. The research conducted provides a basis for the development of further research directions, e.g., by surveying companies from outside the cluster and comparing the results of the resulting surveys, it is possible to indicate whether there is a difference in the approach to investment in RES. The research can also be extended to other sectors. Future work could explore the world of non-energy-intensive businesses and see what impact the energy crisis has had on RES investment decisions. What's more, it would be interesting to deepen the survey to include among enterprises the question of why many of them are still not investing in RES.

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Appendix

Survey questions

1. Have you seen a negative impact of energy price increases on your company in 2022?

a. Yes, very strong
b. Yes, strong
c. Yes, medium
d. Yes, weak
e. Yes, very weak
f. No negative impact was felt

2. Please identify one main element that was affected by the price increase:

a. Decrease in profitability,
b. Liquidity problems,
c. Lack of funds to undertake investments/development
d. Other:

3. Have you undertaken investments in renewable energy sources in 2022 due to the price increase:

a. Yes
b. No, because I already have such solutions
c. No, because I do not see such a need

4. If you answered "yes" in the previous question. Then please answer this question. What renewable energy sources have you invested in?

a. Heat pumps
b. Photovoltaic panels
c. Wind farms
d. Other:

5. With the increase in energy prices, do you plan to start investing in renewable energy sources in 2023?

a. Yes
b. No, because I already have such solutions
c. No, because I do not see such a need

6. If you answered "yes" in the previous question. Then please answer this question. What renewable energy sources do you plan to invest in during 2023?

a. Heat pumps
b. Photovoltaic panels
c. Wind farms
d. Other: