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The guarantees of origin as a market-based energy transition mechanism in Poland

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Abstract: A transition from generating electricity from conventional sources to generating it from renewables is one of drivers leading us towards a circular economy. Electricity is a specific product and regardless of where and how it is produced, it takes the same form.

A novel aspect of the research is the examination of correlations and relationships between guarantees of origin.

The research objective is to analyse the market for the guarantees of origin in the volatile price environment that we had late 2021 and early 2022. Therefore, we analysed demand for the guarantees in January 1, 2020 to June 30, 2022 and the correlation between the price of electricity and guarantees of origin. It was based on the secondary data analysis method and the use of Pearson's correlation coefficient and a linear regression function.

The authors of the study made a hypothesis that the trading volume would increase during the study period and that there would be a positive correlation between the price of energy and the guarantees of origin.

A key finding of the study revealed a steady increase in the purchase of guarantees despite the rise in prices. The buying of the guarantees is not a top-down requirement, but rather a bottom-up action, which indicates growing social expectations towards enterprises to consume energy from renewable sources.

Keywords: energy sector, energy production, energy trading, guarantee of origin, renewable energy sources

INTRODUCTION

In Poland, the growing demand for energy is a consequence of the economic development and it requires a reasonable balance not only between supply and demand but also technological solutions linked to the development and its management (Marks-Bielska and Bielski, 2013). The introduction of RES technologies in the sector seems to be a current response to energy production deficits. Initially, these technologies require more investment which translates into the need to support it with public funds. Undeniably, this is justified in the context of the goals set by circular economy and environmental responsibility concepts which include improving air quality and significantly reducing the impact of conventional fuel combustion on climate (Borowski and Malec, 2016). What should be considered though is the fact that no universal mechanism for community support to RES have been developed so far in the EU. Therefore, each member state has its own environmental and energy policy (Sulewski, Majewski and Wąs, 2017). In the case of Poland, co-firing of biomass with substantial contribution of imported biosmass in large power units is the main contributor to the increase in the share of RES in the energy mix (Sulewski, Majewski and Wąs, 2017).

The introduction of the guarantee of origin mechanism by the Energy Regulatory Office (Pol. Urząd Regulacji Energetyki – URE) allows electricity consumers to influence suppliers since the certificate holder may obtain support through preferential financial products. This is an additional advantage considered while making investment decisions. The above also applies to rural areas, which, according to 2020 figures, accounted for 93% of the territory and were inhabited by approximately 40% of the country's population. The positive demographic outlook for these areas, caused in particular by natural growth and migration from cities, makes it an attractive topic to be analysed in the field of energy (Woźniak, 2018; GUS, 2022).

In rural areas, agricultural production, administration, and cultural facilities and households are primary energy consumption drivers (Otoliński and Wielicki, 2003). Agriculture is an extremely high energy-intensive area of the economy; however, it has a potential to become a significant producer of renewable energy, especially in terms of biomass and biofuel components (Wójcicki, 2006). What should be taken into account is the fact that rural areas are characterised by considerable dispersion of buildings and technical infrastructure, as well as low density of transformer substations, their poor technical condition, and significant operational overload (Directive, 2009). Consequently, the implementation of solutions based on distributed energy generation and prosumers (Wielewska, 2014; Drygas and Nurzyńska, 2015) should improve the energy sector in rural areas. Moreover, rural buildings, characterised by low lifetime energy requirements, is part of environmentally friendly low-energy economy (Laskowski, 2008). Extensive literature on the subject emphasises that the main objective of sustainable energy management in rural areas and agriculture is the adaptation of existing facilities to low-energy requirements, development of renewable energy sources, introduction of low-energy technologies into agricultural practice, and a sustainable and environmentally responsible household energy consumption approach (Piwowar and Dzikuć, 2015).

Electricity as a product has uniform characteristics. Regardless its source, the end product is the same. The same energy can be produced from conventional energy sources (such as coal-fired power plants) or from renewable energy sources (such as photovoltaics, wind or hydropower). Therefore, one may wonder how an electricity user, be it a company or household, knows where it comes from. The problem is that he does not know.

In order to solve this dilemma, the European Commission introduced the guarantees of origin for electricity from renewable energy sources (further referred to as GO or GoO). The guarantees are defined by Article 15 of European Directive 2009/28/EC and they are established to mark electricity from renewable sources so that end consumers are aware of the source of electricity they consume.

Since it is impossible to mark energy transmitted, the guarantee of origin system focuses on energy that has been produced. Figure 1 illustrates the combined process for both physically transmitted energy and guarantees of origin.

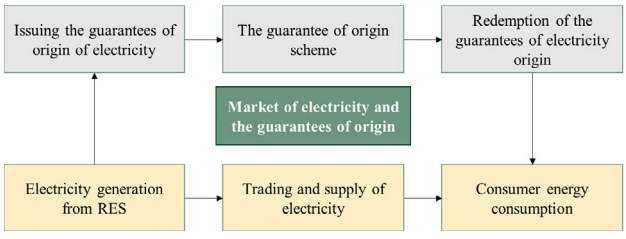

Fig. 1. Electricity trading and guarantees of origin; source: own study based on Gkarakis and Dagoumas (2016)

Figure 1 shows that the guarantee settlement scheme is independent of the energy actually delivered. In Poland, the producers of electricity from renewable energy sources apply to the Energy Regulatory Office requesting the latter to issue guarantees of origin (URE, 2016) which are then recorded in the Guarantees of Origin Register operated by the Polish Power Exchange (TGE, no date a). Trading in the guarantees and their redemption are possible as part of the register operation. This is regulated by the Renewable Energy Sources Act, which in Article 124a item 2 states that "*The holder of the guarantee of origin, understood as the generator or any other entity to the benefit of which the generator has sold the guarantee of origin, shall redeem it by submitting an order for redemption to the guarantee of origin register.*" Each guarantee of origin issued has a validity period of 12 months (Ustawa, 2022). This means that from the termination of the production period, for which the guarantee of origin was applied for, the holder of the guarantee must redeem it within 12 months or it is automatically redeemed at the end of that period.

The system of the guarantees of origin for electricity from renewable energy sources in Poland is shown in Figure 2.

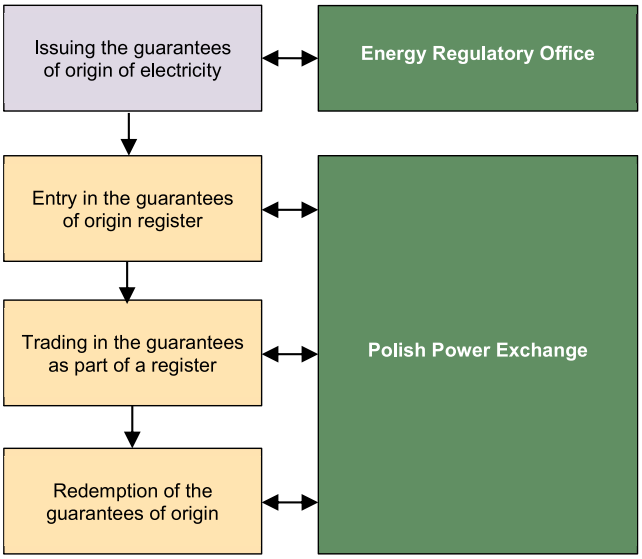

Fig. 2. Guarantees of origin system; source: own study based on the Ustawa (2022)

Pursuant to the Renewable Energy Sources Act of February 20, 2015, the enforcement bodies within the Renewable Energy Guarantee of Origin mechanism include the Energy Regulatory Office and the Polish Power Exchange. The option of importing and exporting the guarantees of origin is also an important aspect within the framework of the research. In the European Union, the European Energy Certificate Scheme (further referred to as EECS-GO) was developed (Raadal, Nyland and Hanssen, 2009). The European Union, through the Association of Issuing Bodies (AIB), aims to unify standards for guarantees of electricity origin to enable international trade in the guarantees (AIB, no date). Only 14 European countries are members of the AIB. Poland has never been a member of the AIB, so the guarantees of origin issued in Poland can be redeemed in Poland only. The import and export of the guarantees of origin cannot affect the results, so the research under this study provides viable results of how popular the guarantees of origin are in Poland and how their development is progressing.

The purpose and applications of the guarantees of origin are described by Lise *et al.* (2007). The main objectives set by the European Union for the guarantees of origin include:

- providing information to end users about the origin of electricity;
- monitoring the fulfilment of targets for the share of energy from renewable sources in the energy mix (Directive, 2018).

Additionally, the guarantees of origin enable electricity consumers to put pressure on suppliers owing to the fact that holding the guarantee of origin from renewable sources can be an additional asset and benefit for end customers (Markard and Truffer, 2006) and acts as a communication bridge between consumers and electricity suppliers. Moreover, companies that meet the criteria are often able to benefit from preferential financial products.

The objective of the study was to analyse the guarantee of origin market in Poland. The significant increase in energy prices in the third and fourth quarters of 2022 resulted in a number of changes and complexities in the functioning of the energy market both in Poland and Europe (TGE, no date b). This, however, provided an opportunity to analyse the behaviour of the market in the volatile environment of the electricity price shock.

Two main objectives of the study were as follows:
- objective 1: to analyse the demand for the guarantees of origin in the period of January 1, 2020 and June 30, 2022;
- objective 2: to investigate the relationship between the price of electricity and the price of guarantees.

The following hypotheses were formulated as part of the study:
- H1: trading of the guarantees of origin increased during the study period;
- H2: there was a positive correlation between the price of energy and the guarantees of origin for renewable electricity.

Guarantees of origin influence land development through their direct impact on energy prices, promotion of RES, and profitability. The above has impact on the extraction of fossil fuels and their replacement by renewable energy sources, sustainable use of the Earth's natural resources, and the promotion of green, environmentally friendly energy.

MATERIALS AND METHODS

The scheme and methods of the study conducted are shown in Figure 3.

The research utilised data from the monthly reports of the Polish Power Exchange for the period between January 2020 and June 2022 (TGE, no date c). Based on these data, a detailed analysis and aggregation of sub-data were performed. Subsequently, the aggregated values for the respective periods were compared and the trading volume of the guarantees of origin was analysed. When examining the relationship between the prices of the guarantees and electricity prices, Pearson's linear correlation coefficient was applied. Based on the results, a statistical significance test for $\alpha = 0.01$ was performed. A scatter plot analysis was also conducted and a linear regression function was derived.

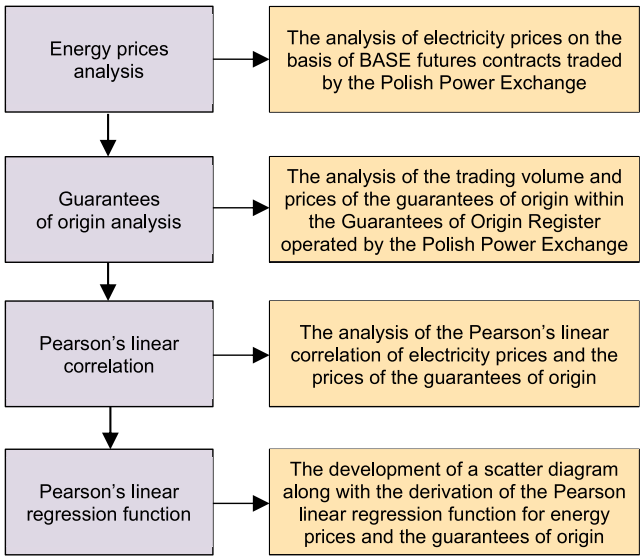

Fig. 3. The scheme of the study; source: own study; BASE features = arithmetic mean of 24 volume-weighted average prices, calculated for individual hours of electricity delivery in a given month

RESULTS AND DISCUSSION

GENERAL INFORMATION

In Polish literature, the topic of guarantees of origin is discussed mainly in terms of the mechanism (Olejarczyk, 2016) and legal regulations (Kapalski, 2019). So far, no one has analysed prices of the guarantees on the Polish market. Hence, the research results are of a pioneering nature. For comparison, in the European literature one can find studies on the justification of the mechanism of guarantees of origin (Hamburger, 2019), but none of the authors analyses the demand and the correlation between energy prices and guarantees of origin.

ENERGY PRICES AND GUARANTEES OF ORIGIN

In the European Union, there is a growing interest in the guarantees of origin. Their prices and trading volumes are increasing (Hamburger, 2019). Since Poland is not a member of the AIB, the study is limited to the Polish market only.

Electricity prices and the guarantees of origin in Poland were analysed first. Figure 4 shows the average quarterly prices of futures contracts with physical delivery of BASE electricity. As it can be noticed, prices, especially from the third quarter of 2021 to mid-2022, increased significantly. In the first quarter of 2021, 1 MWh cost was PLN 271.28, whereas a year later buyers had to pay PLN 629.94 for the same amount of energy.

This constitutes a year-on-year increase of 132.21%. As a consequence, the authors decided to observe how the prices of the guarantees ranged over the same period and what their trading volume was. The average quarterly prices for the guarantees is shown in Figure 5 whereas the trading volume of the guarantees in Figure 6.

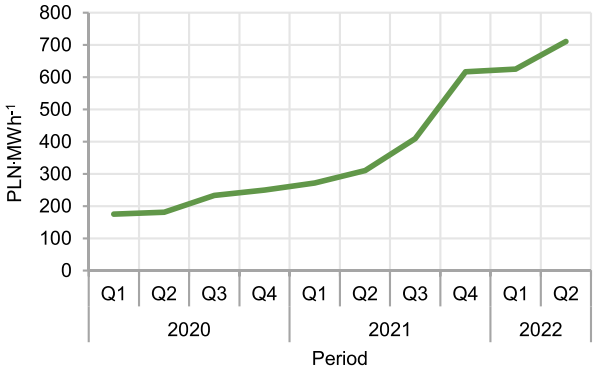

Fig. 4. Average BASE price (PLN·MWh^{-1}); source: own study based on TGE (no date c)

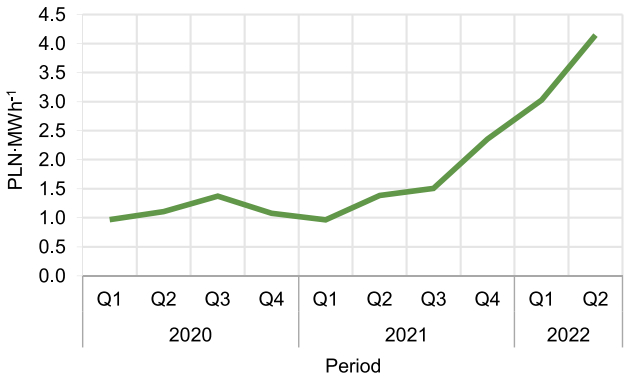

Fig. 5. Average price of the guarantees of origin (PLN·MWh^{-1}); source: own study based on TGE (no date c)

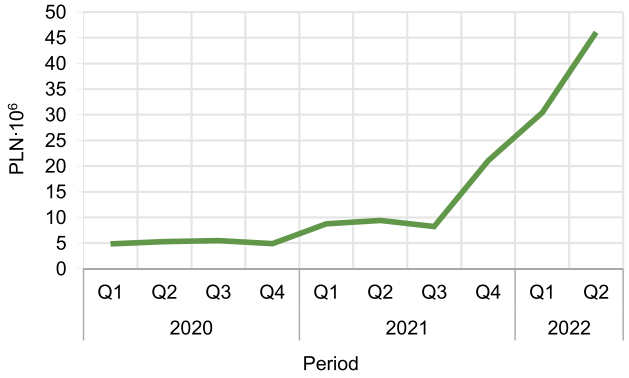

Fig. 6. Trading volume of the guarantees of origin (PLN·10^6); source: own study based on TGE (no date c)

The average quarterly guarantee prices also increased from PLN 0.96 per MWh in Q1 2020 to PLN 4.14 in Q2 2022. In addition, the trading volume of the guarantees (also calculated quarterly) increased from PLN 4.85 mln in Q1 2020 to PLN 46.06 mln in Q2 2022. This demonstrates the growing popularity and demand for the guarantees in Poland.

CORRELATION OF ENERGY PRICES AND GUARANTEES OF ORIGIN

In the subsequent part of the study a Pearson linear correlation analysis for electricity prices and the guarantees of origin was performed – data from Table 1.

Pearson's linear correlation coefficient was calculated in accordance with the formula for the adopted sample of ten quarters r = 0.924. This indicated a strong, positive correlation between energy prices and the guarantees of origin of energy from renewable sources. The following hypotheses were adopted to confirm statistical significance: H0: there is no positive correlation between energy prices and prices of guarantees of origin, H1: there is a positive correlation between energy prices and prices of the guarantees.

A two-sided critical area was assumed at α = 0.01.

To determine the test statistic, the following formula was adopted:

$$t = \frac{r}{\sqrt{\frac{1-r^2}{n-2}}} \tag{1}$$

Table 1. Average quarterly price of BASE futures contract and the guarantees of origin for the period of January 01, 2020 to June 30, 2022

Period – month	Energy price	Guarantee price
	PLN	
	X	*Y*
Jan–Mar 2020	174.79	0.97
Apr–Jun 2020	180.19	1.11
Jul–Sep 2020	233.09	1.37
Oct–Dec 2020	250.24	1.08
Jan–Mar 2021	271.28	0.96
Apr–Jun 2021	310.05	1.38
Jul–Sep 2021	410.32	1.50
Oct–Dec 2021	622.94	2.36
Jan–Mar 2022	629.94	3.03
Apr–Jun 2022	702.47	4.15

Source: own study based on TGE (no date c).

where: t = test statistic, r = Pearson correlation coefficient, n = number of items, in a sample.

For the study sample t = 6.831.

$$df = n - 2 = 8 \tag{2}$$

$$t_{0.01}(8) = 3.356 \tag{3}$$

where: df = degrees of freedom of $|t| > t_\alpha$ the hypothesis H0 is rejected: $|6.831| > 3.356$.

Based on the above, there was a basis for rejecting H0 and accepting hypothesis H1.

DISTRIBUTION OF CHARACTERISTICS AND LINEAR REGRESSION

As part of the study, a regression equation was derived, defined by the formula:

$$Y = a_1 X + a_2 + e_i \tag{4}$$

where: Y = price of the guarantee of origin, X = the price of electricity, a_1 = directional coefficient of the regression function, a_2 = free term, e_i = random error component.

The following regression function formula was obtained:

$$Y = 0.0049X - 0.0593 \tag{5}$$

The coefficient of determination of the regression function amounted to R^2 = 0.8537.

Figure 7 shows the regression function plotted on the point distribution of energy prices and the prices of guarantees of origin. Based on the above data, an upward trend and a clear relationship between the described values can be observed. The linear relationship between the discussed values means that along

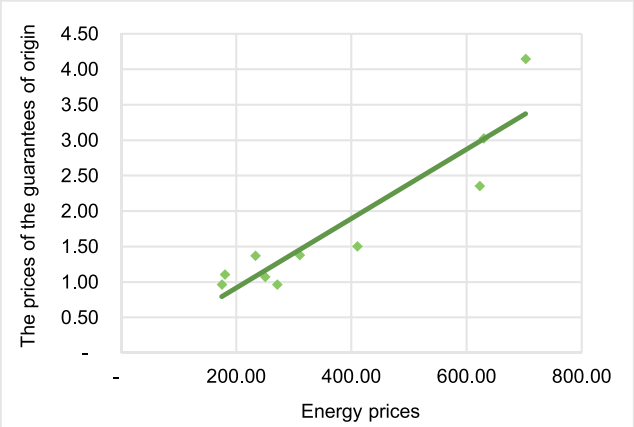

Fig. 7. Linear regression function with point distribution of energy prices and the prices of the guarantees of origin; source: own study based on TGE (no date c)

with the increase in energy prices, there is an increase in GoO prices, which, being traded, become particularly attractive for sales transactions.

CONCLUSIONS

The prices of the guarantees of origin in Poland show very strong positive correlation with the prices of electricity. On average, a PLN 1 increase in the price of MWh of electricity results in a PLN 0.0049 increase in the price of the guarantees of origin for renewable energy. It is worth noting that the trading volume of the guarantees in Poland grew steadily in the period concerned, even in the face of growing energy prices. Taking into account the fact that the guarantees of origin, as opposed to certificates of origin, are not mandatory, it can be concluded that the mechanism defined by European Directive 2009/28/EC is effective in Poland and it is becoming increasingly popular. Moreover, in view of the imbalance in the electricity market and the focus of energy policy on green energy, the mechanism also offers development prospects in rural areas. The guarantees of origin will have a direct impact on agricultural production and processing sectors, as well as on households.

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