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ETS PRICES AND RENEWABLE ENERGY SOURCES SHARE IN THE ENERGY MIX – EXAMPLE OF LITHUANIA, LATVIA AND ESTONIA

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ABSTRACT: ETS (CO_2 Emissions Trading Scheme) is one of the mechanisms that allow for controlling and striving to reduce greenhouse gas emissions worldwide. However, it is also another cost for CO_2 emission producers, affecting the final price of energy. The aim of the article is to enrich the discussion by explaining the relationship between ETS prices and the level of share of renewable energy sources in the overall energy mix of the countries selected for analysis (Lithuania, Latvia, Estonia). The research covered the period 2000-2022. It was conducted using the following methods: literature studies, descriptive analysis of statistical data and deduction. The analysis led to the conclusions: the increase in CO_2 emission allowance prices (ETS) forced a change in energy policy in Lithuania, Latvia and Estonia. In 2008, the ETS price was EUR 25/tonne of CO_2, while in 2023, it was around EUR 50/tonne of CO_2. An increase in the share of renewable energy sources was noted in the analysed countries. In Lithuania, wind, solar, and biomass energy are the most developed, while in Latvia, further investments were made in hydroelectric power plants. The situation was the worst in Estonia, from the development point of view, as solar and wind power plants were developed to a small extent. In 2000, the share of renewable energy in the overall energy mix was for Estonia: at less than 1%, Lithuania at around 3%, and Latvia at 68%. In 2022, under the influence of ETS fees, the renewable energy source indicator increased for: Estonia: to 45%, Lithuania: 74.7%, Latvia 72% in the overall energy mix.

KEYWORDS: ETS, Lithuania, Latvia, Estonia, energy prices, energy mix

Introduction

The European Union aspires to be a leader in climate change in Europe and the world. Climate change is influenced by the energy sector, which generates CO_2 due to the burning of fossil fuels such as coal, oil and gas. Improvements in the energy sector can have a decisive impact on slowing down climate change. Such a policy is facilitated by the use of low-emission and ecological energy sources by countries that have a significant share of them in the energy balance.

To date, research on the ETS has focused on the undermining the cost-effectiveness of the ETS (Amundsen & Mortensen, 2001; Böhringer & Rosendahl, 2010; De Jonghe et al., 2009; Fankhauser et al., 2010; Hindsberger et al., 2003; Jensen & Skytte, 2003; Linares et al., 2008; Meran & Wittmann, 2012; Paltsev et al., 2009; Requate, 2015), the share of the ETS in the overall costs of the electricity system (Knopf et al., 2015), the impact of RES policies on the well-being of individual societies (Fischer & Newell, 2008; Gawel et al., 2017; Jaffe et al., 2005; Kalkuhl et al., 2012; Kverndokk & Rosendahl, 2007; Lehmann, 2013; Lehmann & Söderholm, 2018; Schmidt & Marschinski, 2009), the impact of RES policies on the reduction of greenhouse gases (Gawel et al., 2014; Kalkuhl et al., 2013; Lecuyer & Quirion, 2013; Palmer & Burtraw, 2005; Ulph & Ulph, 2013).

So far, research has focused on the overall impact of the ETS on climate policy, costs and the well-being of societies. They do not present how ETS fees may affect the development of renewable energy sources in individual countries. There is no study in the global scientific literature on the direct impact of ETS prices on the development of renewable energy sources in Lithuania, Latvia and Estonia. The authors in this article tried to fill the existing research gap.

The aim of the paper is to enrich the discussion with an explanation of the relationship between ETS prices and the level of share of renewable energy sources in the overall energy mix of Lithuania, Latvia, and Estonia.

The selection of countries for the study was due to the lack of interest of the existing researchers in the changes that will be forced by the ETS in the energy sectors of Lithuania, Latvia and Estonia. Each of these countries has to go through a different path because renewable energy sources are developing in this area at different rates. The easiest situation is in Latvia, which used hydropower in the previous period. It is much more difficult in Estonia, which uses oil shale in its energy sector, and in Lithuania, which, after the closure of the nuclear power plant, used imported gas. ETS fees will force the acceleration of changes in the energy mix of the surveyed countries and the selection of renewable energy sources. Each of the analysed countries has chosen a strategy for the development of renewable energy sources and is trying to implement it.

The research covers the period from 2000 to 2022. The choice of the research period was influenced by the desire to present the situation of the energy sector of Lithuania, Latvia and Estonia before the introduction of the ETS and changes in the energy mix after their introduction in 2005. The availability of data from the following institutions also contributed to the selection of the research period: International Energy Agency, European Environment Agency, Our World in Data (a project of the Global Change Data Lab, a registered charity in England and Wales) and the website Energy Instrat (2024).

Some studies, e.g. ETS fees, were deliberately presented in a shorter period of 2008 – 2022 due to the availability of statistical data. Presenting the costs of electricity production in selected power plants in 2019 and 2040 in the EU region (USD/MWh), the authors used a publicly available forecast to show changes in the price of MWh using coal, gas, nuclear energy, photovoltaics, wind and water. The authors deliberately do not address the problem of final energy in their deliberations, as this is not the purpose of the article.

The research methods used by the authors include: literature studies, descriptive analysis of statistical data and deduction. The article does not use classical statistical inference based on descriptive statistics and statistical correlation between explanatory variables due to limitations in access to detailed data on the daily share of selected sources in energy mixes and ETS prices on the exchange.

The article has been divided into four parts. The first part presents a literature review that takes into account the latest items on the subject analysed in the article (including works on the development of photovoltaics, hydropower and CO_2 emission prices – ETS). The second part is the genesis and presentation of ETS fees. In the third part, the energy mix of the surveyed countries was analysed. The fourth part contains conclusions from the conducted analyses and recommendations.

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Literature review

The ETS is a system of tradable authorisations (fees), the concept of which was first analysed in detail by Hahn and Hester (1989). An early research at the largest EU economies suggests that lower emissions occurred among French (Wagner et al., 2014) and German manufacturing companies due to increased energy efficiency (Petrick & Wagner, 2014). Bayer and Aklin (2020) emphasize that the threat of future price increases could encourage companies to reduce emissions even when prices remain low.

Młynarski (2014) writes about the impact of EU ETS fees on changes in the energy sector and the economic effects of these changes. The author pointed out that the ETS did not force too many investments in capital-intensive eco-technologies until 2014 (Regulation, 2014). However, this can be done by adopting new reduction targets in the new time horizon of the year 2030, as the higher price of CO_2 emission allowances will increase the pressure on global powers and the need to invest in less carbon-intensive energy sources (Landis & Heindl, 2019). Moreover, if the EU succeeds in this period, convincing Member States to reduce emissions may become a new factor in increasing the EU's competitiveness in the global economy (Byskov Lindberg, 2019). Zhang and Wei (2009) point out that coal-fired power generation will become much more expensive over time compared to carbon-intensive companies due to high fees. By introducing fees, the EU contributes to stimulating investment in the short term. Earlier, however, Oberndorfer and Rennings (2006) stressed that the ETS was not designed to boost the European economy but to ensure that European CO_2 emissions meet the Kyoto targets at minimal cost to EU industry. Numerous studies have not shown a significant negative impact of the EU ETS on the competitiveness of companies covered by it in the initial phase of the introduction of fees (Chan et al., 2013).

Martin et al. (2014) argue that the free allocation of allowances at the beginning of the EU ETS implementation leads to inefficient overcompensation compared to the optimal allocation that the authors identify to avoid emissions and maintain employment in the EU. Based on data from the Community Independent Transaction Log, Betz and Schmidt (2016) conclude that most companies participating in the ETS did not transfer allowances in Phase I, which calls into question the effectiveness of the instrument at the earliest stage. Based on the assumption that the impact of the EU ETS on competitiveness is limited, Joltreau and Sommerfeld (2019) decided to analyse the problem. The main argument they give is the large number of freely assigned certificates in phase I and II. The findings on the limited impact of the EU ETS on both the competitiveness of companies and carbon elimination were confirmed in a review of related econometric literature by Verde (2020).

The literature also highlights the role of CBAM, which is a mechanism for adjusting prices at the borders taking into account CO_2. A study by Antimiani et al. (2013) on the impact of the border tax on reducing CO_2 emissions in non-EU countries does not support this thesis. However, many authors consider CBAM to be an effective way to reduce (relocation of production to other countries where EU regulations do not apply) CO_2 emissions (Fischer & Fox, 2012; Bohringer et al., 2012). The authors of De Nederlandsche Bank (2021) also concluded that as a result of the introduction of CBAM, both the prices of imported and domestically produced goods will increase and that the impact can vary significantly across EU Member States. On the contrary, Delbeke et al. (2021) concluded that the CBAM would provide only limited protection against carbon usage. Designing EU environmental policies that encourage their implementation beyond the EU's borders is of strategic importance and poses a specific challenge. When promoting a green strategy outside the EU, two constraints must be taken into account: firstly, the most polluting products are already produced abroad and imported into the EU, and secondly, the EU's share of global emissions is only 8%, while the US and China together account for 44% of global emissions (Jung & Song, 2023). For this reason, companies outside the EU can find alternative markets and bypass EU tariffs instead of using low-carbon technology that complies with EU regulations (Böning et al., 2023).

EU ETS fees can have different impacts on the economies of EU member states (Anke & Most, 2019). According to the projections reported by EU Member States in 2019 under the EU ETS emissions are projected to fall further in the light of PaMs. The decrease in emissions under the EU ETS is expected to take place mainly in the energy sector, while emissions from production and construction installations are expected to remain stable until 2030.

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ETS fees can also affect energy security, which is a key issue in the provision of energy services and one of the most important priorities of energy policy in the European Union. The specificity of Lithuania, Latvia and Estonia is the synchronisation of the power system with the area of the former USSR (Bariss et al., 2021; Krūmiņš & Kļaviņš, 2022).

Estimating the prospects for changes in the energy policy of the Baltic states in connection with the EU's climate commitments, it was emphasised that Estonia must reduce the high share of oil shale in fuel consumption. In Latvia, the need to support emission reduction measures in the non-ETS sector was emphasised, including support for the development of renewable energy sources that are unable to compete with imported fossil energy. The main obstacle to reducing greenhouse gas emissions in Lithuania is the lack of financial resources (Lu et al., 2020). The gas emission reduction policy is geared towards the supply sector and focuses on huge and costly supply-side measures (Roos et al., 2012).

Figure 1. ETS in the years 2008-2024 (euro/tonne CO_2)

Source: authors' work based on Energy Instant [03-03-2024] and EEA [04-03-2024].

As already noted, the EU ETS (Emissions Trading System) is one of the mechanisms that allow to control and strive to reduce greenhouse gas emissions in the world. Spot market prices are subject to various factors affecting supply and demand, leading to price volatility (e.g. after the outbreak of the war in Ukraine, the ETS, like other financial assets, was subject to market speculation). In particular, factors such as falling gas prices, delays in the process of issuing free allowances, the phenomenon of "short squeeze" on the forward market and greater use of renewable energy may affect price developments. In addition, changes in global industrial and economic trends, such as the growing importance of renewable energy, the energy crisis, or even trends in commodity markets, have a significant impact on the prices of allowances.

Detailed forecasts of the energy markets of Lithuania, Latvia and Estonia, including prices and share of renewable energy sources, were presented by Galinis et al. (2020).

For years, the rate for CO_2 emissions under the ETS oscillated around EUR 10 per tonne of CO_2. After 2018, the price began to rise to reach a record value of around EUR 90 per tonne in 2022-23. This was due to the global crisis related to the outbreak of war in Ukraine. Since the end of 2023, the price of the ETS has been steadily, albeit slowly, falling.

The forecasts assume a decreasing share of fossil fuels in the energy mix of EU countries. An additional reason why countries will give up fossil fuels for those that do not emit CO_2 is the fact that the price of ETS allowances will increase.

Until 2025, the prices of ETS should not exceed EUR 70. However, 2026, when the prices of ETS should be above EUR 85, may prove to be a breakthrough for many EU economies (KOBiZE, 2024).

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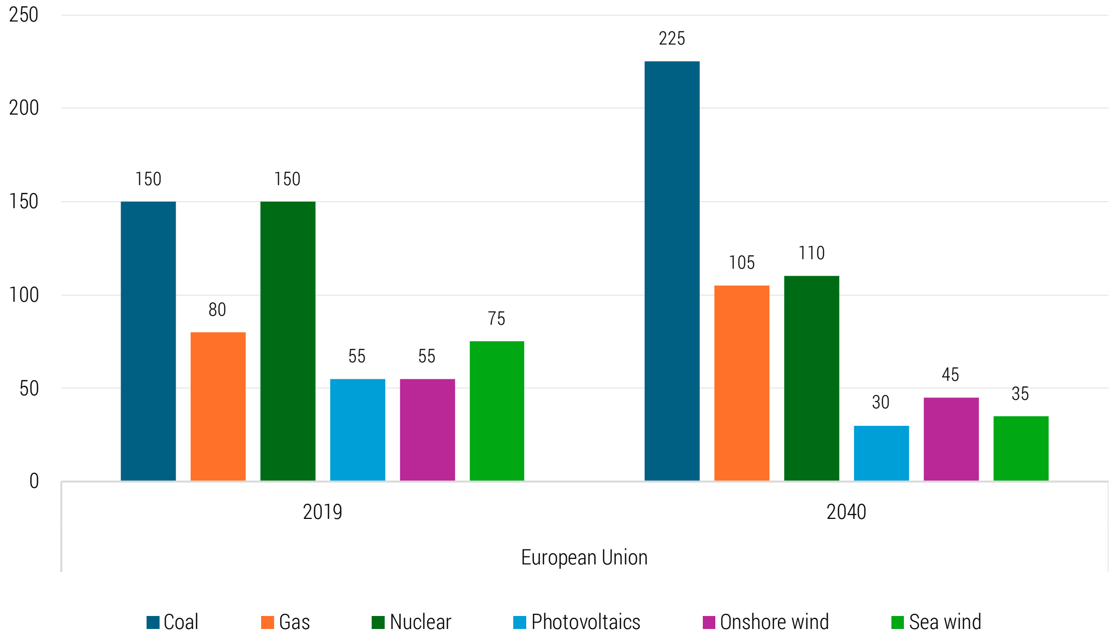

Figure 2. Costs of electricity production in selected power plants in 2019 and 2040 in the EU region (forecast) (USD/MWh)

Source: authors' work based on LCOE according to WEO (sustainable development scenario), IEA, October 2020 for Wysokienapiecie.pl.

Moreover, according to the IEA forecasts presented in Figure 2, the price of energy obtained from coal will constantly increase – from USD 150/MWh to USD 225/MWh in 2040. The increases will also apply to energy obtained from gas (USD 80/MWh and USD 105/MWh, respectively). However, according to forecasts, energy obtained from alternative sources will be cheaper. Energy from nuclear power plants will become cheaper by 2040 from USD 150/MWh to USD 110/MWh, wind energy will be cheaper by about USD 10/MWh, and energy from photovoltaic installations will be cheaper by USD 25/MWh. Energy from sea wind will be the most expensive, by USD 40/MWh.

This growth will be supported by the phasing out of additional sales of allowances under REPowerEU, the full inclusion of emissions from the maritime sector and the 100% auctioning of aviation, or the gradual abandonment of free allowances in the CBAM sectors. Prices should return to the level of EUR 100 in 2028. In 2030, the prices of allowances will approach the limit of EUR 120 (KOBiZE, 2024).

The EBRD Diagnosis Report for Lithuania, Latvia and Estonia (European Bank for Reconstruction and Development, 2022) shows that Estonia was the fourth largest carbon dioxide emitter among the EBRD economies in 2018 due to the production of electricity based on oil shale. While carbon dioxide emissions in Latvia and Lithuania are significantly lower than the EU, OECD and EBRD averages, transport and industry in Lithuania remain the main sources of carbon dioxide emissions in these countries (Arlinghaus, 2015). 35 % of the energy consumed comes from petroleum products. Biofuels played an important role in Latvia (27%), mainly in heating, while Lithuania used 22% of gas to generate energy and imports it via the LNG terminal in Klapeida from Russia (European Bank for Reconstruction and Development, 2022).

In addition to the ETS fee system, the EU also introduces other financial tools, including environmental taxes (Degirmenci & Yavuz, 2024). Their aim is to stimulate specific behaviours of consumers and electricity producers and to promote clean, stable and safe energy sources (Kuzior et al., 2023).

Energy mix of the analysed countries

The Baltic states, in particular Estonia, need to make significant efforts to achieve the 2030 energy and climate targets (Kaaret et al., 2022) and Latvijas Stratēģija Klimatneitralitātes Sasniegšanai Līdz 2050 (Ministru kabinets, 2019). The current development of energy systems in analysed countries is contrary to increasing the share of RES, reducing greenhouse gas emissions, maintaining the competitiveness of local industry and increasing energy security (Baskutis et al., 2021). Investments in renewable energy sources are unprofitable when the prices of imported energy are low. However, an increase in the price of carbon dioxide emissions may cause significant changes in these countries' energy markets. They may result in the earlier decommissioning of power plants using oil shale, coal and oil, faster growth of electricity production in wind farms, earlier modernisation of hydroelectric power plants and increase their efficiency, increase in the installed capacity of interconnections and their more intensive use in RES installations (Galinis et al., 2020). Investments in renewables are still largely covered by various forms of support schemes. However, the need for support is determined by the cost competitiveness of the RES technology, which has improved significantly over time. The Baltic States (Lithuania, Latvia, Estonia) and Poland were also written about in the context of the development of photovoltaics, which is an important element of the activities aimed at the development of renewable energy sources. (Chomać-Pierzecka et al., 2022). The authors emphasised that the main reason for the development of photovoltaics is the economic aspect (such as installation costs, government subsidies and profit from energy sold to the system). The study showed that Lithuania is becoming a leader in photovoltaics in Central and Eastern Europe, with an impressive increase in interest in solar energy among its inhabitants. In the second decade of the 21st century, Estonia recorded an impressive increase in the popularity of photovoltaics. The sector developed particularly dynamically in 2017-2018 when the capacity of installed solar power plants increased from 11 MW to 110 MW, which means a 10-fold increase in just two years. Photovoltaics in Latvia is not popular, remaining the least developed form of renewable energy in the country. This is due to the dominant role of hydropower.

The cost of onshore wind and photovoltaic energy production has fallen dramatically over the last decade of the 21st century. The cost of production fell at a rate of 17% per year between 2010 and 2020, while for onshore wind, the annual reduction rate was around 8%. In the future, there is still potential to further reduce investment costs (Busch et al., 2023).

None of the three countries is considering the use of not too large geothermal resources (Chomać-Piasecka et al., 2023). In order to implement the new energy policy, changes in public awareness are needed (Štreimikiene et al., 2019).

However, some researchers note that it will be difficult and costly to meet the energy targets required by the EU in the short term (Holmgren et al., 2019).

Table 1. Share of electricity production by source (Estonia, Latvia, Lithuania)

		Coal	Oil	Gas	Bioenergy	Hydropower	Other renewables	Nuclear	Wind	Solar
2000	Estonia	0.00%	92.83%	7.05%	0.12%	0.00%	0.00%	0.00%	0.00%	0.00%
	Latvia	0.00%	4.59%	27.29%	0.00%	68.12%	0.00%	0.00%	0.00%	0.00%
	Lithuania	0.00%	5.89%	14.69%	0.00%	3.08%	0.00%	76.34%	0.00%	0.00%
2001	Estonia	0.00%	92.70%	7.06%	0.12%	0.12%	0.00%	0.00%	0.00%	0.00%
	Latvia	0.00%	3.28%	30.44%	0.00%	66.28%	0.00%	0.00%	0.00%	0.00%
	Lithuania	0.00%	5.04%	13.15%	0.00%	2.31%	0.00%	79.50%	0.00%	0.00%
2002	Estonia	0.00%	93.44%	6.21%	0.23%	0.12%	0.00%	0.00%	0.00%	0.00%
	Latvia	0.00%	4.53%	33.00%	0.25%	61.97%	0.00%	0.00%	0.25%	0.00%
	Lithuania	0.00%	3.21%	12.30%	0.00%	2.04%	0.00%	82.45%	0.00%	0.00%

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		Coal	Oil	Gas	Bioenergy	Hydropower	Other renewables	Nuclear	Wind	Solar
2003	Estonia	0.00%	94.58%	4.92%	0.30%	0.10%	0.00%	0.00%	0.10%	0.00%
	Latvia	0.00%	2.52%	38.54%	0.50%	57.18%	0.00%	0.00%	1.26%	0.00%
	Lithuania	0.00%	1.77%	13.50%	0.06%	1.71%	0.00%	82.96%	0.00%	0.00%
2004	Estonia	0.00%	94.67%	4.75%	0.29%	0.19%	0.00%	0.00%	0.10%	0.00%
	Latvia	0.00%	1.28%	30.49%	0.85%	66.31%	0.00%	0.00%	1.07%	0.00%
	Lithuania	0.00%	1.94%	14.48%	0.05%	2.26%	0.00%	81.27%	0.00%	0.00%
2005	Estonia	0.00%	93.63%	5.29%	0.39%	0.20%	0.00%	0.00%	0.49%	0.00%
	Latvia	0.00%	0.20%	30.28%	0.81%	67.69%	0.00%	0.00%	1.02%	0.00%
	Lithuania	0.00%	2.81%	21.25%	0.07%	3.16%	0.00%	72.71%	0.00%	0.00%
2006	Estonia	0.00%	93.12%	5.55%	0.41%	0.10%	0.00%	0.00%	0.82%	0.00%
	Latvia	0.00%	0.00%	42.94%	0.82%	55.22%	0.00%	0.00%	1.02%	0.00%
	Lithuania	0.00%	2.78%	20.72%	0.18%	3.37%	0.00%	72.87%	0.08%	0.00%
2007	Estonia	0.00%	96.06%	2.79%	0.25%	0.16%	0.00%	0.00%	0.74%	0.00%
	Latvia	0.00%	0.42%	40.34%	0.84%	57.35%	0.00%	0.00%	1.05%	0.00%
	Lithuania	0.00%	3.17%	18.14%	0.38%	3.17%	0.00%	74.31%	0.83%	0.00%
2008	Estonia	0.00%	94.14%	3.97%	0.38%	0.28%	0.00%	0.00%	1.23%	0.00%
	Latvia	0.00%	0.00%	39.09%	0.76%	59.01%	0.00%	0.00%	1.14%	0.00%
	Lithuania	0.00%	4.35%	15.51%	0.54%	3.06%	0.00%	75.55%	0.99%	0.00%
2009	Estonia	0.00%	92.60%	1.25%	3.53%	0.34%	0.00%	0.00%	2.28%	0.00%
	Latvia	0.00%	0.00%	36.09%	0.90%	62.11%	0.00%	0.00%	0.90%	0.00%
	Lithuania	0.00%	5.15%	14.61%	0.70%	2.93%	0.00%	75.50%	1.11%	0.00%
2010	Estonia	0.00%	89.59%	2.31%	5.71%	0.23%	0.00%	0.00%	2.16%	0.00%
	Latvia	0.00%	0.00%	45.10%	1.06%	53.09%	0.00%	0.00%	0.75%	0.00%
	Lithuania	0.00%	13.68%	67.16%	3.16%	11.37%	0.00%	0.00%	4.63%	0.00%
2011	Estonia	0.00%	88.91%	1.94%	6.05%	0.23%	0.00%	0.00%	2.87%	0.00%
	Latvia	0.00%	0.00%	49.43%	1.97%	47.45%	0.00%	0.00%	1.15%	0.00%
	Lithuania	0.00%	5.26%	66.92%	4.01%	12.03%	0.00%	0.00%	11.78%	0.00%
2012	Estonia	0.00%	86.62%	1.09%	8.36%	0.33%	0.00%	0.00%	3.60%	0.00%
	Latvia	0.00%	0.00%	33.39%	4.70%	60.13%	0.00%	0.00%	1.78%	0.00%
	Lithuania	0.00%	5.58%	66.97%	5.12%	9.77%	0.00%	0.00%	12.56%	0.00%
2013	Estonia	0.08%	89.98%	0.67%	5.05%	0.23%	0.00%	0.00%	3.99%	0.00%
	Latvia	0.00%	0.00%	43.06%	8.06%	46.94%	0.00%	0.00%	1.94%	0.00%
	Lithuania	0.00%	5.78%	55.76%	9.05%	13.07%	0.00%	0.00%	15.08%	1.26%
2014	Estonia	0.08%	88.20%	0.55%	6.10%	0.24%	0.00%	0.00%	4.83%	0.00%
	Latvia	0.00%	0.00%	45.53%	13.03%	38.72%	0.00%	0.00%	2.72%	0.00%
	Lithuania	0.00%	5.78%	50.58%	11.56%	11.56%	0.00%	0.00%	18.50%	2.02%
2015	Estonia	0.00%	84.04%	0.59%	8.07%	0.30%	0.00%	0.00%	7.00%	0.00%
	Latvia	0.00%	0.00%	49.82%	13.90%	33.57%	0.00%	0.00%	2.71%	0.00%
	Lithuania	0.00%	8.50%	49.50%	11.25%	8.75%	0.00%	0.00%	20.25%	1.75%

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		Coal	Oil	Gas	Bioenergy	Hydropower	Other renewables	Nuclear	Wind	Solar
2016	Estonia	0.00%	86.35%	0.58%	7.81%	0.33%	0.00%	0.00%	4.85%	0.08%
	Latvia	0.00%	0.00%	45.79%	12.77%	39.42%	0.00%	0.00%	2.02%	0.00%
	Lithuania	0.00%	9.38%	29.03%	12.90%	13.20%	0.00%	0.00%	33.44%	2.05%
2017	Estonia	0.15%	85.25%	0.46%	8.36%	0.23%	0.00%	0.00%	5.47%	0.08%
	Latvia	0.00%	0.00%	27.49%	12.35%	58.17%	0.00%	0.00%	1.99%	0.00%
	Lithuania	0.00%	6.57%	17.91%	14.93%	17.91%	0.00%	0.00%	40.60%	2.08%
2018	Estonia	0.00%	83.43%	0.49%	10.59%	0.08%	0.00%	0.00%	5.17%	0.24%
	Latvia	0.00%	0.15%	47.91%	13.99%	36.16%	0.00%	0.00%	1.79%	0.00%
	Lithuania	0.00%	8.00%	12.00%	19.64%	15.64%	0.00%	0.00%	41.45%	3.27%
2019	Estonia	0.00%	71.35%	0.53%	17.87%	0.26%	0.00%	0.00%	9.07%	0.92%
	Latvia	0.00%	0.00%	50.47%	14.44%	32.76%	0.00%	0.00%	2.33%	0.00%
	Lithuania	0.00%	4.78%	16.56%	16.87%	11.15%	0.00%	0.00%	47.77%	2.87%
2020	Estonia	0.00%	50.66%	0.49%	30.43%	0.49%	0.00%	0.00%	13.82%	4.11%
	Latvia	0.00%	0.00%	36.36%	15.04%	45.45%	0.00%	0.00%	3.15%	0.00%
	Lithuania	0.00%	5.74%	37.53%	13.02%	6.62%	0.00%	0.00%	34.22%	2.87%
2021	Estonia	0.00%	59.52%	0.56%	24.62%	0.28%	0.00%	0.00%	10.15%	4.87%
	Latvia	0.00%	0.00%	36.42%	14.70%	46.32%	0.00%	0.00%	2.39%	0.17%
	Lithuania	0.00%	7.91%	29.26%	16.55%	9.11%	0.00%	0.00%	32.61%	4.56%
2022	Estonia	0.00%	55.04%	0.59%	29.54%	0.24%	0.00%	0.00%	7.47%	7.12%
	Latvia	0.00%	0.00%	28.01%	13.41%	54.63%	0.00%	0.00%	3.75%	0.20%
	Lithuania	0.00%	10.74%	14.56%	15.75%	10.74%	0.00%	0.00%	37.95%	10.26%

Source: authors' work based on Our World in Data Date [03-03-2024].

According to the data presented in Table 1, the analysed countries in the analysed period mainly used energy sources based on fossil fuels. Although. at the beginning of the analysed period. i.e. in 2000, Estonia obtained 92.83% of its electricity from oil-fired power plants, the other two countries, Latvia and Lithuania, used non-emission sources – Latvia obtained 68.12% of its energy from hydroelectric power plants, while Lithuania obtained 76.34% from nuclear power plants. Over the analysed years. the share of individual sources has changed. At the end of the analysed period, i.e. 2022, in the case of Estonia, the share of alternative sources to oil, i.e. biomass. increased (29.54%); in the case of Latvia, the share of hydroelectric power plants in energy production decreased, mainly in favour of biomass. In the case of Lithuania, on the other hand, a nuclear power plant has not been used since 2010, which resulted in an increase in the share of other energy sources (in 2022, wind farms are the main source of energy in Lithuania).

The energy transition in the three Baltic states is also linked to the agreement between Estonia, Latvia and Lithuania to accelerate the integration of their electricity grids with the Continental European Network (CEN) and to disconnect them from Russia and Belarus. According to the declaration signed by the three countries, the synchronisation deadline has been postponed from the end of 2025 to February 2024.

Estonia

For a number of years, the main source of energy in Estonia was oil. Its share began to decrease significantly after 2017, mainly in favour of biomass. It can be noted that during this period. ETS emission prices also began to rise, which may indicate a coordinated effort to move away from fossil energy sources in connection with rising ETS emission prices. As in the case of all three countries

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analysed, in Estonia in the analysed period, practically no energy from hard coal was used (trace amounts in 2013-2014).

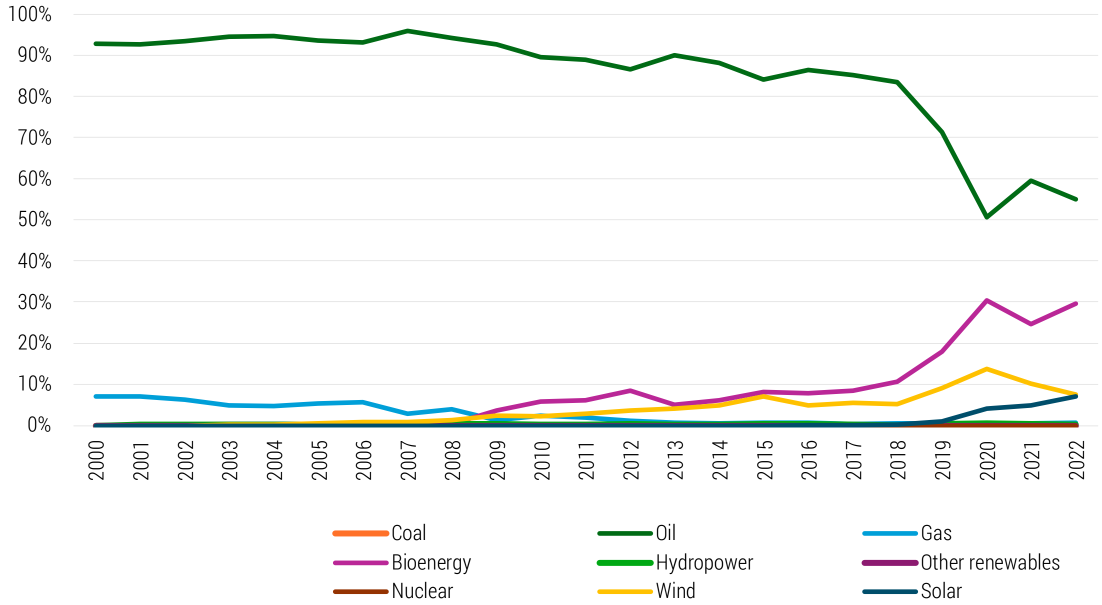

Figure 3. Share of electricity production by source in Estonia
Source: authors' work based on Our World in Data Date [03-03-2024].

In addition, as can be seen from the data presented in Figure 4. in the period under review (2000-2022), the source of electricity in Estonia came mainly from fossil fuels. However, its share began to decrease significantly after 2017.

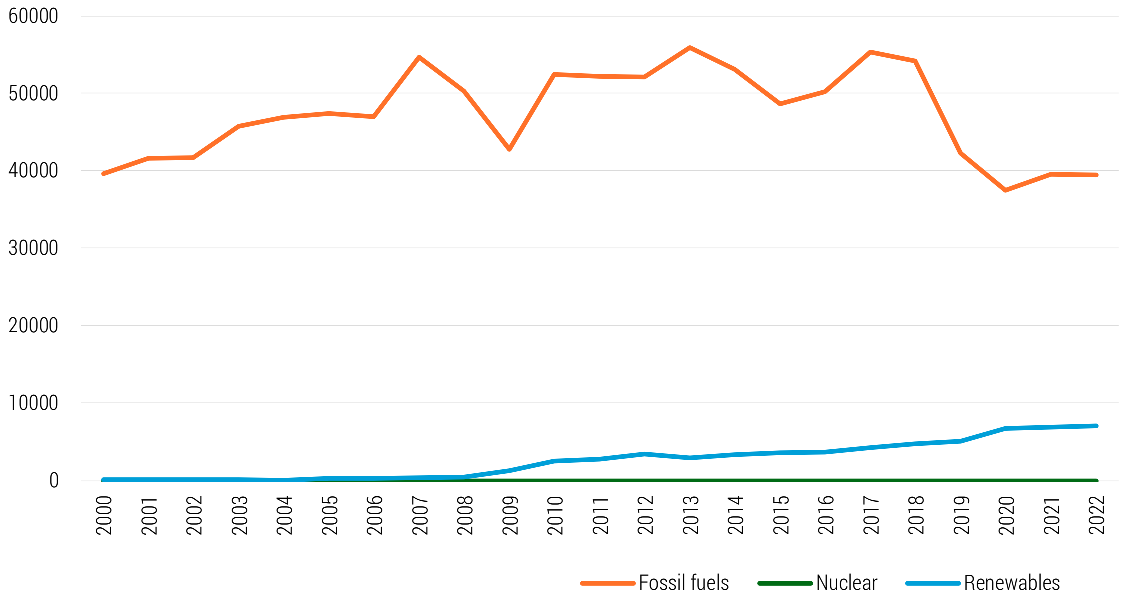

Figure 4. Per capita energy from fossil fuels. nuclear and renewables (kWh) in Estonia
Source: authors' work based on Our World in Data Date [03-03-2024].

Moreover, Estonia's energy efficiency is increasing. Although currently (2022), the amount of energy produced per capita is similar to that at the beginning of the analysed period. Estonia has managed to reduce the amount of energy consumed, especially after 2016, when record per capita energy consumption was recorded.

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Latvia

Latvia is characterised by a relatively large, although steadily decreasing. share of energy from hydroelectric power plants (in 2000, this share was around 70%; in 2022, it was around 55%). It should be noted that in the analysed period, the importance of gas in energy production increased and decreased, but in 2022, it was at a similar level as at the beginning of the period, i.e. about 30%. In the case of Latvia, the importance of biomass in energy production is clearly growing. Latvia began to use this source in 2011, so in 2022. the share of this raw material was around 11%.

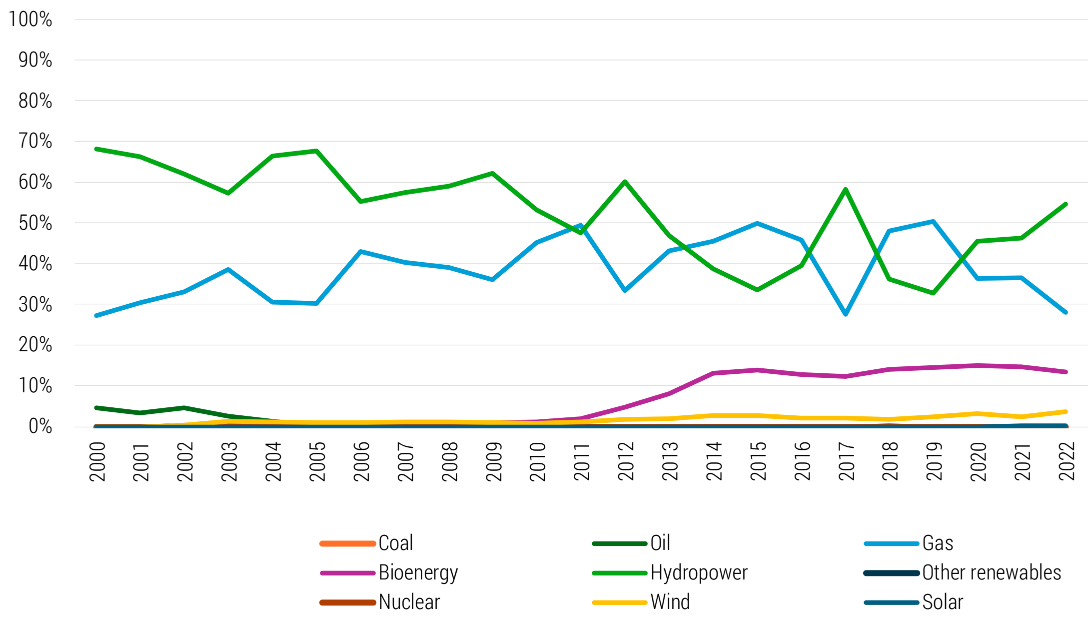

Figure 5. Share of electricity production by source in Latvia

Source: authors' work based on Our World in Data Date [03-03-2024].

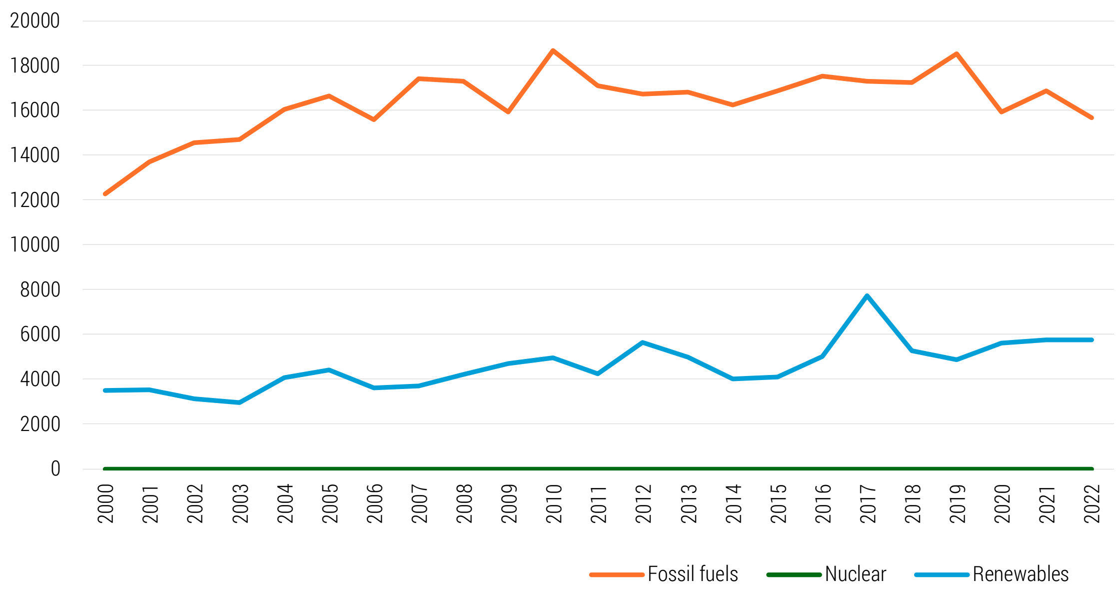

Figure 6. Per capita energy from fossil fuels. nuclear and renewables (kWh) in Latvia

Source: authors' work based on Our World in Data Date [03-03-2024].

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In the case of Latvia, however, it should be noted that electricity consumption per capita is increasing. As a rule, increased consumption can be caused by economic development; however, it can also be a result of decreased energy efficiency.

Nevertheless the importance of renewable energy sources in Latvia, similarly to other selected countries. is increasing. The biggest increase can be noted in terms of bioenergy sources of energy.

Lithuania

In the case of Lithuania, the energy mix is the most diverse. Until 2010. Lithuania obtained electricity from nuclear power plants. However, after 2010, after the Lithuanian nuclear plants were closed, the country had to change its source of energy. The increasing share of gas as well as wind power sources can be noted.

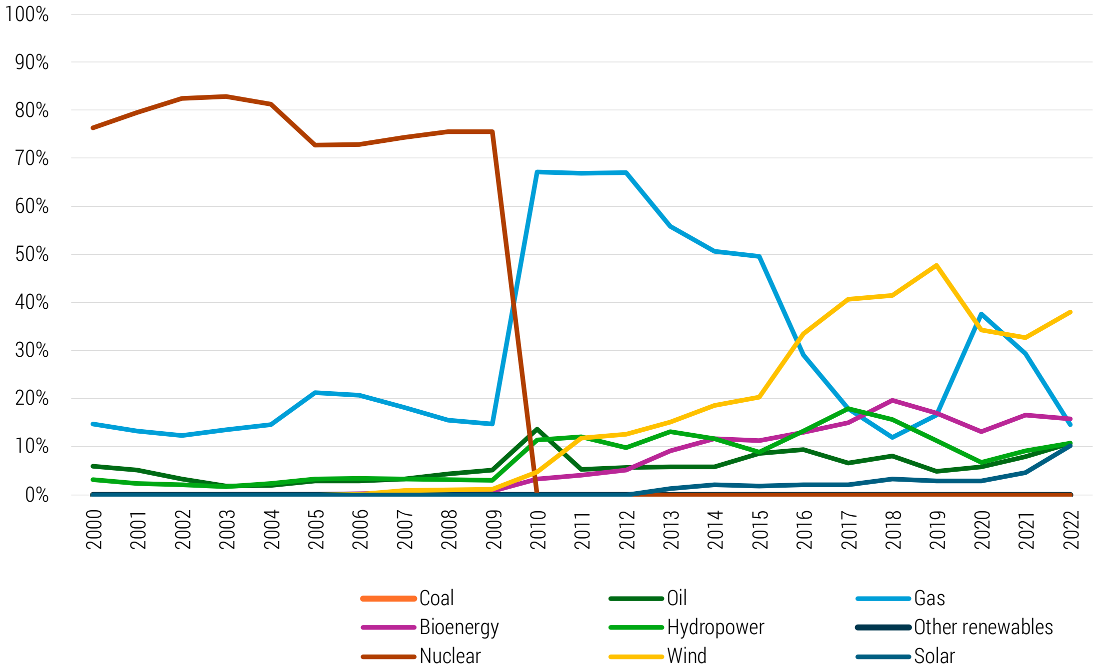

Figure 7. Share of electricity production by source in Lithuania

Source: authors' work based on Our World in Data Date [03-03-2024].

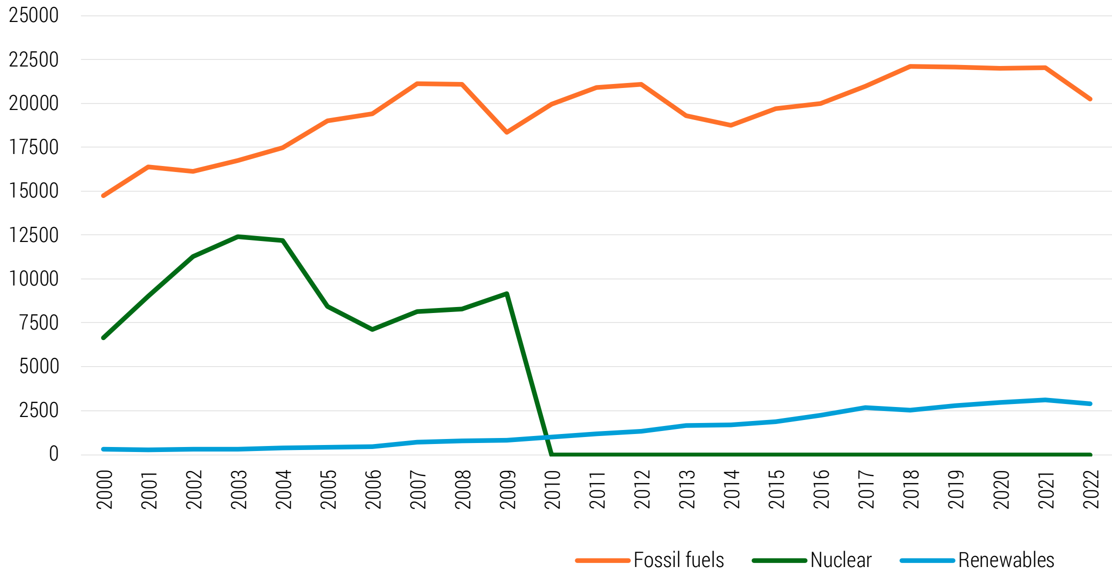

Figure 8. Share of electricity production by source in Lithuania

Source: authors' work based on Our World in Data Date [03-03-2024].

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In the case of Lithuania, it should be noted that when the nuclear power plant was shut down. the country had to find an alternative source of energy, which was gas. However. from year to year, the share of this fuel decreased. Renewable sources. mainly wind farms and bioenergy, were becoming more important.

Summary and Conclusions

The history of reducing CO_2 emissions dates back to 1997, when the Greenhouse Gas Protocol was adopted in Kyoto, Japan. Its main objective was to reduce greenhouse gas emissions in the years 2008-2012 by 5% compared to the level of 1990. The countries that have signed the Protocol have committed to monitoring the scale of greenhouse gas emissions since 2005 and to preparing annual reports. Then, the EU took its own steps in order to reduce CO_2 emissions, introducing particular aims for 2020, 2030, and 2050. The EU Emissions Trading System (EU ETS) was introduced in 2005. In the beginning, it covered only about 40% of CO_2 emissions – from electricity, heating, industry and aviation. More and more countries are recognising the need to transition to low-carbon sources of electricity generation. Meanwhile, Europe as a continent is responsible for about 10% of greenhouse gas emissions, and the EU is responsible for only about 8%. Therefore, other countries should also be involved in the process of changing the energy mix.

After the analysis, the authors conclude that:

1. Prices of CO_2 emission allowances increased significantly in the analysed period. This forced a change in policies regarding energy sources in the countries covered by the analysis, i.e. Lithuania, Latvia and Estonia.
2. The ETS price in 2008 was EUR 25/tonne of CO_2, while in 2023, it was twice as high, approximately EUR 50/tonne of CO_2. It should be noted. However, that after the outbreak of the war in Ukraine, the short-term speculation on ETS prices on global markets was resent, and the ETS price increased in 2022 to over EUR 90/ton of CO_2, which caused a crisis on the energy market.
3. The price for CO_2 emissions forecasted in the coming years will increase and will ultimately amount to approximately EUR 80/tonne of CO_2. This will mean a significant increase in the prices of electricity produced from non-renewable sources (such as oil, gas or coal).
4. This will force the governments of many EU countries to radically change their energy policy by increasing the share of renewable sources, e.g. sea wind hydropower.
5. All analysed countries have undergone a specific energy evolution. It is worth noting a clear increase in the share of renewable sources in all analysed countries (for example, in 2000, the share of renewable energy in the overall mix was for Estonia: less than 1%, for Lithuania about 3%, for Latvia 68%, and in 2022 this indicator was for Estonia: 45%, for Lithuania: 74.7%, for Latvia 72%). These countries meet the minimum share of renewable energy in the overall energy mix required by the EU.
6. In 2022, none of the analysed countries used coal or nuclear energy sources. It should be noted that Lithuania turned off its nuclear power plant in 2010, forcing the use of alternative sources. Initially, it was gas, but it was replaced by a more ecological source (photovoltaics, wind energy).

The increase in the prices of ETS certificates coincided with the adoption of the European Green Deal in 2019 and the European Commission's proposal of the Fit for 55 packages under the EGD, i.e. a 55% reduction in greenhouse gases by 2030 compared to 1990 and achieving climate neutrality by 2050. ETS prices will have to rise further, as according to the Fit for 55 assumptions, the withdrawal of emission allowances is expected to accelerate to 4.2%-4.4% per year, additionally covering other sectors of the economy. Many of the activities planned as part of the strategy to reduce greenhouse gas emissions will translate into increased costs for emitters, e.g. covering new sectors with the ETS system, including land transport emissions from buildings; therefore, other EU countries that do not meet the requirements for the share of renewable sources to such a significant extent, such as Lithuania, Latvia and Estonia, will have to undergo a rapid energy transformation.

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Contribution of the Authors

Conceptualization, K.G. and P.K.; formal analysis, K.G. and P.K.; literature investigation, K.G.; methodology, K.G.; project administration, K.G. and P.K.; resources, K.G. and P.K.; software, K.G.; supervision, K.G.; validation, K.G.; visualization, K.G.; data curation, K.G. and P.K.; literature investigation, K.G. and P.K.; writing original draft, P.K.

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CENY ETS I UDZIAŁ ODNAWIALNYCH ŹRÓDEŁ ENERGII W MIKSIE ENERGETYCZNYM – PRZYKŁAD LITWY, ŁOTWY I ESTONII

STRESZCZENIE: ETS (CO_2 Emissions Trading Scheme) jest jednym z mechanizmów pozwalających kontrolować i dążyć do redukcji emisji gazów cieplarnianych na świecie. Stanowi jednak również kolejny koszt dla producentów emisji CO_2, wpływający na ostateczną cenę energii. Celem artykułu jest wzbogacenie dyskusji o wyjaśnienie zależności między cenami ETS a poziomem udziału odnawialnych źródeł energii w ogólnym miksie energetycznym wybranych do analizy krajów (Litwa, Łotwa, Estonia). Badania objęły okres 2000-2022. Przeprowadzono je z użyciem metod: studiów literaturowych, deskryptywnej analizy danych statystycznych oraz dedukcji. Przeprowadzona analiza doprowadziła do wniosków: wzrost cen uprawnień do emisji CO_2 wymusił zmianę polityki w zakresie źródeł energii na Litwie, Łotwie i w Estonii. Odnotowano wzrost udziału odnawialnych źródeł energii w analizowanych krajach. W 2000 r. udział energii odnawialnej w ogólnym miksie wynosił dla Estonii: mniej niż 1%, dla Litwy około 3%, dla Łotwy 68%. W 2022 r. wskaźnik ten wynosił dla Estonii: 45%, dla Litwy: 74.7%, dla Łotwy 72%. Kraje te spełniają minimalny udział energii odnawialnej w ogólnym miksie energetycznym wymagany przez UE.

SŁOWA KLUCZOWE: ETS, Litwa, Łotwa, Estonia, ceny energii, energetyczny miks

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