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From energy islands to EU grid: Baltic progress through the lens of the Energy Trilemma Index during 2000–2023

Tomas Karpavicius *, Tomas Balezentis
Lithuanian Centre for Social Sciences, Vilnius, Lithuania

Abstract. The article analyses how Lithuania, Latvia and Estonia's positions on the Energy Trilemma Index (ETI), which assesses the national-level progress in three areas - energy security, energy justice and environmental sustainability - have evolved over the period 2000-2023. With reference to World Energy Council data, the paper provides a detailed analysis of the dynamics and challenges of the ETI components in the three Baltic States. The results show that Estonia has made the most progress during the period under review and is now among the top ten in the world in terms of ETI. In the meantime, Lithuania and Latvia have also significantly improved their position but face specific challenges such as high levels of energy imports or energy access problems. The study also discusses the strengths and weaknesses of the ETI methodology.

Keywords: Energy trilemma; Lithuania; Latvia; Estonia; Energy security; Energy independence.

1. Introduction

In the context of the ongoing discourse on the need to address the challenges of energy security and climate change, the concept of the energy trilemma has emerged – the aspiration of a sustainable energy system, which implies the availability and affordability of energy resources, but at the same time presupposes environmental sustainability (Song et al., 2023).

The Energy Trilemma concept is particularly relevant for the Baltic States—Lithuania, Latvia and Estonia—which have long been characterised by the huge dependence of post-Soviet infrastructure on Russia (Kojala & Keršanskas, 2015) and where the concept is contextualised in the context of the ongoing energy transformation and the energy crisis resulting from Russia's aggression in Ukraine (Streimikiene, 2023).

It can be noted that the Baltic States have been dealing with a number of transitions directly related to the energy trilemma. These transitions were often linked to geopolitical crises (Kalis, 2024), and the fact that they have recently been disconnected from the Russian controlled IPS/UPS system is a testament to their determination to continue to consistently pursue the energy trilemma concept. Russia's war in Ukraine is believed to provide a new lens to look at the energy trilemma in the Baltic Sea region, as the need to stop importing fossil fuels from

* Corresponding author, tomas@voltronas.lt
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Russia opens a window of opportunity for green energy production in the region, thus achieving energy security without negatively affecting the environment (Kleinberga, 2024). The long and volatile journey of the Baltic States on the road to energy security is thus noteworthy and to some extent exemplary: the energy trilemma index, which measures the progress of the energy trilemma, now places the Baltic States in the top 25 countries that are implementing the energy trilemma concept, compared to much lower scores only ten years ago (World Energy Council, 2025). The aim of the article is to analyse how the positions of Lithuania, Latvia and Estonia in the energy trilemma index have changed between 2000 and 2023 and identify the key challenges for energy security there.

2. Literature review

There is a growing body of publications and research in the literature on the implementation of the energy trilemma concept, emphasising that it is a response to the challenges of energy security and climate change that have emerged in the early 21st century (Xia et al., 2020). On the other hand, the complexity of the concept is determined by the fact that it formulates and declares three competing, often contradictory or difficult to reconcile, objectives: (1) energy security of the world's countries; (2) equal/equitable access to energy resources; and (3) environmental protection in the energy sector (Liu et al., 2022; Khan et al., 2022).

To assess the progress of individual countries and regions on the energy trilemma, the World Energy Council has been publishing an annual Energy Trilemma Index (hereinafter referred to as "ETI") since 2010 (Gasser, 2020, Podbregar et al., 2020; Khan et al., 2022; Abdullah et al., 2022). The general structure of the ETI is depicted in Fig. 1.

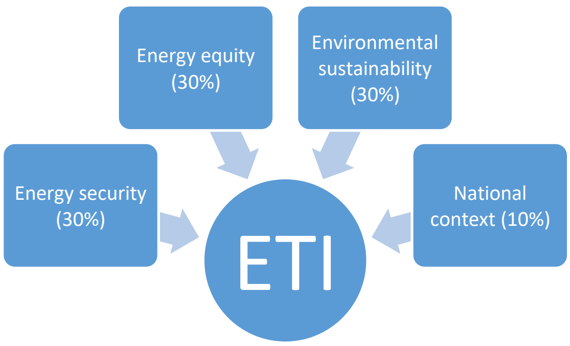

Figure 1. Energy Trilemma Index structure.
Source: designed by the authors based on Šprajc et al. (2019)

As shown in Figure 1, the ETI index assumes a 30% contribution for each of the three main components – energy security, energy justice and environmental sustainability. The remaining 10% is allocated to country-specific context (Kang, 2022). This framework allows one to take into account diverse criteria of security situation for a certain state (Sobik, 2023). The context of a certain country is described in the sense of energy efficiency and sustainability, institutional quality (energy policies and regulatory frameworks), capability to support research and innovation, and to attract investment in the energy sector (Mikalauskienė, Streimikienė & Mikalauskas, 2017).

According to Parović and Kljajić (2022), the history of the use of ETIs shows that the most successful countries in terms of managing the energy trilemma are those that manage to diversify their energy systems and are able to manage energy demand by applying energy efficiency programmes. Mathematically, each country's ETI is defined as a weighted average of the four components. The maximum value of the ETI stands at 100. The countries are also assigned with balance sheet scores comprising four elements with the best one being AAAa and the worst one being DDDd. The four elements of the rating represent energy security, energy equity, environmental sustainability, and country context (Naumenkova, Mishchenko, Mishchenko, 2022).

It should be observed that there is still no consensus in the academic literature on the ETI as a methodological instrument to measure progress in the energy trilemma: there are both *supportive* and *opposing* arguments for the use of this index. For example, apologists for the use of the ETI refer to it as a "generally accepted and reliable indicator of the dynamics and progress of energy sector transition" (Sobick, 2023), whose methodology is 'unique' compared to other indices in that it takes into account three core elements of the energy sector at the same time: equity in the allocation of energy resources, environmental sustainability and energy security (Alola, Adebayo, Olanipekun, 2023).

According to Davtyan and Khachikyan (2022), the ETI is a sufficiently comprehensive indicator of sustainable development in the energy sector to quantify different countries in terms of their ability to ensure the security of their national energy systems, energy equity and environmental sustainability, while also looking at socio-economic and political development. It also provides an quantitative benchmark of global, regional and national progress in towards the development of the energy sector and has a number of advantages over other indices such as the International Energy Security (IES) Index (Davtyan ir Khachikyan, Valeeva, 2023). The same argument is highlighted by Shirazi (2022), who considers that other similar indices are not as 'precise'.

In the view of Zhao, Dong and Dong (2022), the ETI is particularly suited to developed countries, which traditionally have a strong orientation towards energy sustainability. According to Fu et al. (2022), the ETI is currently 'the most reliable of all the indices in use', and according to Song et al. (2023), the ETI is a good test of the progress of the management of the energy trilemma.

Critics of the ETI point out that the reliability of this index is questionable and has a number of serious shortcomings, including a low Cronbach's alpha value. Furthermore, energy security policy-making should not be based on indicators alone without a deeper understanding of the index and its methodology (Šprajc, Bjegović, Vasić (2019).

According to Emblemsvåg and Osterlund (2023), the ETI does not represent the desired compromise/balance between the key elements of the ET. Ponomarenko, Reshneva and Mosquera Urbano (2022) point out that the idea of measuring and evaluating energy security using one or another index is debatable and that the ETI instrument is most suitable for business and think tanks analysing energy industry management issues and making appropriate decisions. According to Parović and Kljajić (2022), the main systemic problem with the ETI is the lack of universality of the methodology.

According to Mikalauskienė, Streimikienė and Mikalauskas (2017), one of the major shortcomings of the ETI index is that it is not able to reveal the nuances of specific energy policy decisions associated with the pursuit of sustainable and secure energy development. Davtyan and Khachikyan (2022) argue that some of the most important shortcomings of the ETI Index are the limited availability of data and the vagueness of the methodology used to assess countries. To remain relevant, the ETI needs to be continuously improved to include indicators that best reflect the rapidly evolving and changing energy sector (Lowe et al., 2021).

According to Zhao, Dong, Dong (2022), the ETI is not suitable for assessing developing countries' progress in ET governance. In the view of Sobick (2023), the current ETI methodology does not sufficiently elicit country-specific categories and variables that assess the country context. According to Polish researchers Kopeć and Lach (2021), the current ETI methodology is not in line with the European Commission's as well as the OECD's (2008) recommendations on the development of cross-cutting indices and indicators.

Kopeć and Lach (2021) argue that ETI is best suited to a hybrid model based on a combination of recognised statistical methods, where the weights of the ETI categories and variables are calculated using scientifically validated, and therefore reliable, statistical methods. On the other hand, the authors consider that the ETI weights could also be determined by a socialised model. The authors suggest that 'secondary ranking' models could facilitate the monitoring of the progress of a country's energy transformation and provide a more adequate picture of the country's progress in managing ET (Kopeć & Lach, 2021).

In the opinion of Mastepanov and Chigarev (2020), a permanent working group should be created in each country to analyse the subtleties of the ETI methodology and adapting this methodology to its national context, to develop and propose to the government a national ETI methodology. According to the authors, the synergy between national methodologies and a common EIT methodology could significantly liberalise the paradigm of ET governance, leading to the generation of statistical information on ET governance of the highest possible quality, in line with reality.

As Koçaslan (2020) believes, it is worth developing integrated ETI models that can measure the progress of ET management in terms of months, seasons and years. The author believes that the ETI methodology also needs to incorporate factors that assess energy security risks (external and internal) in specific countries. Parović & Kljajić (2022) suggest that the content of the ETI should include indicators of a country's readiness for energy transformation/transition.

3. Methods

This study aims to analyse and compare the changes in the positions of Lithuania, Latvia and Estonia based on the Energy Trilemma Index (ETI) for the period from 2000 to 2023. In this regard, a quantitative comparative analysis was applied, based on officially available statistical data and secondary sources.

The analysis was conducted based on the ETI indicators released annually by the World Energy Council, which include three main assessment sub-scores: energy security, energy equity and environmental sustainability. In order to ensure the completeness and reliability of the data, statistical data from Eurostat, the International Energy Agency (IEA), as well as publications of the respective energy ministries of the Baltic countries, independent energy studies and scientific literature were additionally used.

The study used both annual and average indicator values, which were visualized through time-varying index graphs and additionally interpreted by quantitative comparison. When analysing individual ETI components, their dynamics and factors that could have influenced changes in the indices were also studied - such as infrastructure changes, political decisions, synchronization with European electricity networks or reducing dependence on fossil fuels.

In order to provide a more accurate context, some indicators were additionally interpreted taking into account social and economic changes on a regional scale. The results of the study are presented in tables, graphs and textual analysis, which allow not only to quantitatively assess the development of ETI components, but also to distinguish fundamental differences between the energy policy directions and rates of progress of the three countries.

4. Results

Based on 2023 data, Estonia is the highest scoring Baltic country in terms of the overall ETI indicator (Table 1). Estonia's ETI in 2023 was 80.2 (ranked 7th) and the country's energy balance was rated ABA. Latvia's energy trilemma balance in 2023 was similar to Estonia's (ABA), but the country's overall ETI was a little lower at 76.3 and its ranking was 19th. Lithuania's balance sheet is rated BBAa and its ETI indicator is 75 (25th).

Table 1
Baltic States' ETI in 2023

Country	Trilemma ranking	Trilemma score	Balance grade
Estonia	7	80.2	ABAa
Latvia	19	76.3	ABAa
Lithuania	25	75	BBAa

Source: compiled by the authors based on World Energy Council (2023). Latvia; World Energy Council (2023). Lithuania; World Energy Council (2023). Estonia.

The ETI ranking has been published regularly since 2011. The evolution of the Baltic ETI ranking between 2011 and 2023 is shown in Figure 1.

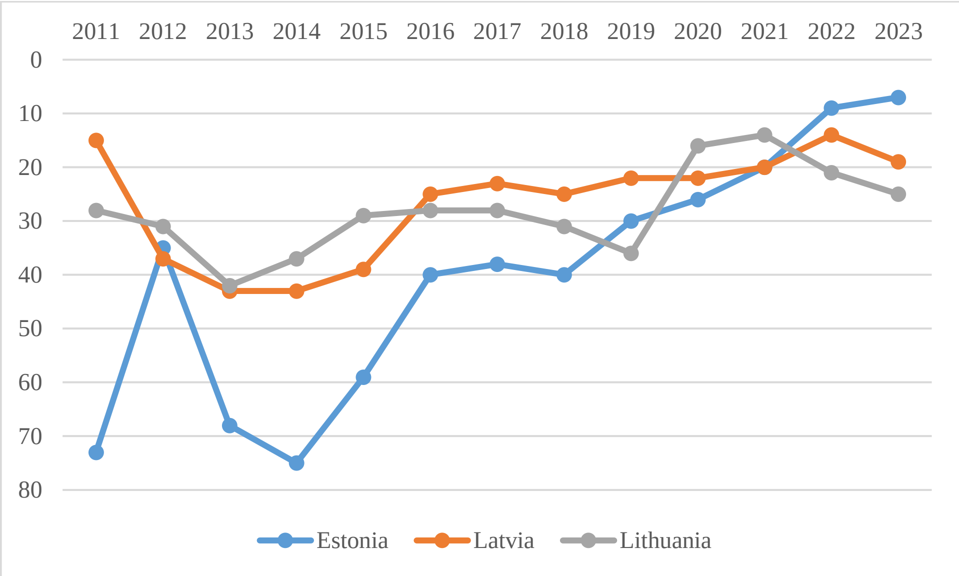

Figure 1. Ranks of the Baltic States based on the ETI between 2011 and 2023. Source: compiled by the authors based on World Energy Council (2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023).

Analysis of Figure 1 shows that Estonia has made the most progress in the energy trilemma among the three Baltic States, ranking 75th in the ETI a decade ago, and now (2023) ranking seventh in the ETI. Lithuania's ETI ranking has been the most stable over the period under review and has not fallen below 37. Latvia made the most progress between 2014 and 2017, when its ETI ranking rose from 43rd (2014) to 23rd (2017). What has led to these results can be more adequately understood by examining in more detail the elements of the energy trilemma of Lithuania, Latvia and Estonia—energy security, energy equity and environmental sustainability—and how they have evolved over the 2000-2023 period.

4.1. Energy security dynamics for 2000-2023

Following the ETI methodology, the progress of the energy security element is determined by (a) security of energy supply and sub-classes, and (b) stability of energy systems (Kang, 2022; Mikalauskienė et al, 2017). A comparison of the Baltic countries in terms of the indicators of this element for the period 2000-2023 is presented in Figure 2.

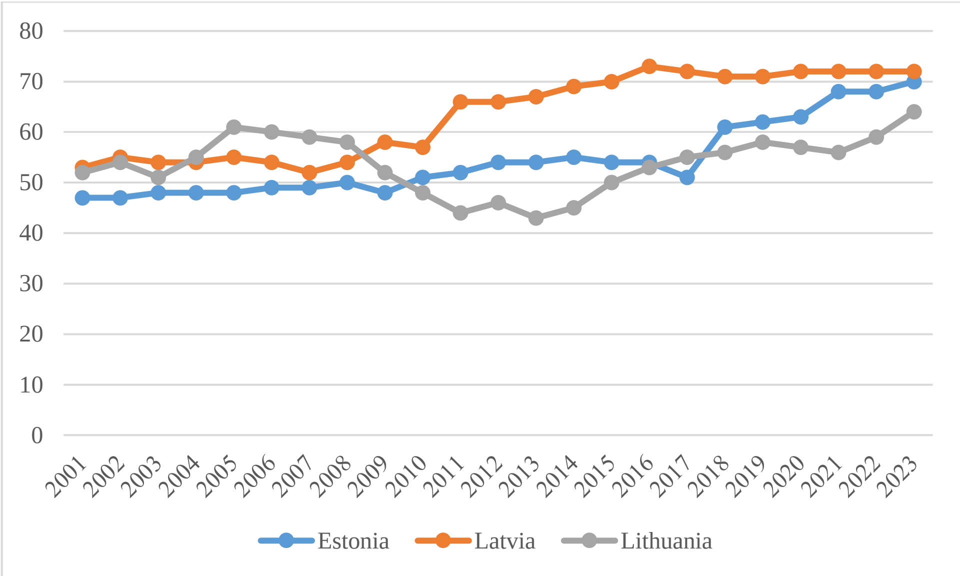

Figure 2. Comparison of ETI Energy Security Indicators for 2000-2023.
Source: compiled by the authors based on World Energy Council (2023).

Figure 2 suggests that Lithuania's 'energy security' element was higher than Latvia's and Estonia's and exceeded 60 until 2004-2005. However, between 2007 and 2012, Lithuania's indicator dropped sharply, while Estonia's and, in particular, Latvia's increased markedly. After 2012, Lithuania managed to increase this indicator, but according to the 2023 data, it is still lower than that of its Baltic neighbours, at 63.63 (72.11 for Latvia, 69.85 for Estonia) and is ranked as B (whereas for Latvia and Estonia it is A). The Estonian 'sweep' between 2017 and 2023 is also noteworthy, with Estonia's 'energy security' increasing from 51 to 69 points.

The diversity of the main energy sources, as well as the level of dependence on energy imports, etc., are of particular importance for the Energy Security element. In terms of the diversity of energy sources, the gas sector accounted on average for around 30% of Lithuania's energy mix until 2014. After 2014, the country has managed to diversify its energy sector (see below) and gas now accounts for 18.6% of the country's energy consumption. Latvia and Estonia have traditionally been less dependent on gas and currently account for 7% and 15% respectively. In all three Baltic countries, the ETI methodology is the best measure of progress in the renewable energy sector (*World Energy Council,* 2025. Latvia; *World Energy Council,* 2025. Lithuania; *World Energy Council,* 2025. Estonia. A detailed structure of the Latvian, Estonian and Lithuanian energy sources is shown in Figure 3.

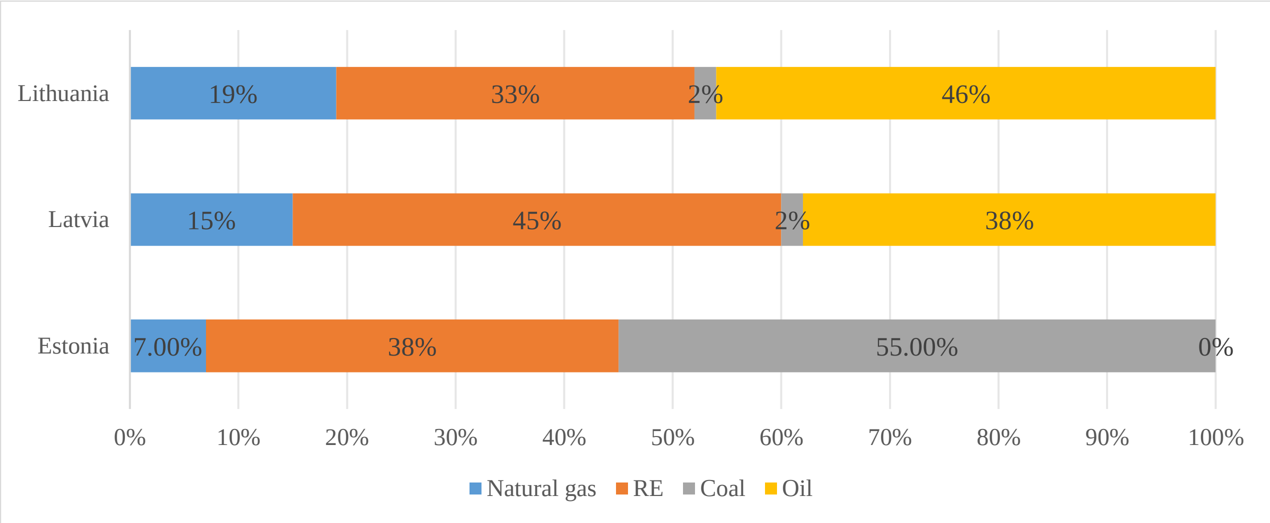

Figure 3. Diversity of Baltic energy sources in 2023.
Source: compiled by the authors based on IEA (2025a, 2025b, 2025c).

Figure 3 shows that in 2023, Lithuania has the highest share of oil and gas based energy of all the Baltic States, with 65%, while Estonia has the lowest (7%). Latvia has the highest share of renewable energy (RES) in its energy system (45%). On the other hand, Lithuania (33%) and Estonia (38%) also have a high share of renewable energy, accounting for 1/3 of total energy resources. It should be noted that Estonia still relies on coal for more than half of its energy (55%).

It should be pointed out that for a long time after the restoration of independence, the Baltic States have been referred to as the 'energy islands' of the European Union, with the following characteristics (Švedas, 2017):

- dependence on a single supplier;
- dependence on a single main energy source;
- dependence on a single supply route, increasing energy consumption, limited or no energy market.

It is argued that Lithuania, Latvia and Estonia in 1990-2009 and in 2010-2013 partially and fully corresponded to the EU's characteristics of an energy island, while the dominant energy supplier, the Russian Federation, has abused the situation and pursued a policy of coercion in the field of energy, which has resulted in an objective threat not only to energy security, but also to economic and national security. However, 2015 is considered to be a turning point in the Baltic countries' path to energy independence (Švedas, 2017). The genesis of energy independence in Lithuania, Latvia and Estonia is presented in more detail in Table 2.

Table 2
The genesis of Baltic energy independence

Period	Regulation	Infrastructure
1991-2008		Estlink 1, the only electricity link between Estonia and Finland (350MW, 2007)
2009	Baltic Energy Market Interconnection Plan signed	
2010-2015	Establishment of a single electricity market and integration into the Nord Pool Spot market. Estonia, Latvia, Lithuania: implementation of the EU's Energy Package 3 in the electricity sector. Lithuania: Implementation of the EU's 3rd energy package in the gas sector. Strengthening the internal electricity and gas systems	Implementation of electricity interconnections: Estlink 2 (Estonia and Finland, 650 MW, 2014); NordBalt (Lithuania and Sweden, 700 MW, 2015); LitPolLink Part 1 (Lithuania and Poland, 500 MW, 2015).
2015-2020	Memorandum of Understanding on an Enhanced Baltic Energy Market Interconnection Plan. Estonia, Latvia: implementation of the EU's 3rd energy package in the gas sector. Lithuania-Poland gas pipeline GIPL (planned 2019, delayed until 2022). Further reinforcement of internal electricity and gas systems. Synchronisation of electricity systems with continental European grids (UCTE). Commercial flow of power from Russia is halted for the Baltic States (2022)	The Klaipėda LNG terminal, which arrived in Lithuania in autumn 2014, became operational in 2015. LitPolLink Part 2 (Lithuania and Poland, 500 MW). Creation of a single gas market. Offshore gas pipeline from Estonia to Finland, starting in 2020.
2025		Disconnection of the Lithuanian, Latvian and Estonian electricity grids from the Russian-controlled IPS/UPS system and synchronisation with continental Europe

Source: compiled by the authors based on Švedas, 2017; Augutis, 2016; Streimikienė, 2023; World Energy Council, 2025; Kleinberga, 2024

According to Augutis et al. (2016), after the closure of the Ignalina NPP, the situation in the Lithuanian energy sector has changed since 2010, as the predominant source of electricity generation has shifted from gas-fired power plants to gas-fired power plants. Gas supply has been the weakest link in Lithuania's economic and geopolitical context, and the dominance of gas as the only fuel for power generation reduces energy security. The opening of the liquefied natural gas terminal in Klaipėda in 2015 and the opening of electricity interconnections with Poland and Sweden should be seen as the creation of alternative routes for the transport of natural gas and electricity, which ultimately eliminated the country's energy dependence on the dominant external supplier, Russia, and resolved Lithuania's problem of being an EU energy island.

Latvia has traditionally been at the forefront of hydropower development. Still, as Kleinberga (2024) noted, the environment may face a relatively high impact as Latvia's energy strategy still foresees a serious contribution of fossil fuels towards the energy-mix besides the development of renewables. Accordingly, such measures as increased competition in gas supply and the commission of a liquefied natural gas terminal in Latvia. In other words, fossil fuels remain to be considered as a key part of Latvia's fuel mix. Such a situation may render energy dependency and subdued transformation towards sustainable energy system in the long term (Kleinberga, 2024).

Estonia has been diversifying its energy mix since independence and aims to completely eliminate its historical dependence on oil shale by 2035, replacing it with gas and renewables. An offshore gas pipeline from Estonia to Finland has been in operation since 2020. Also, the public support via a fixed-rate subsidy has been a vital factor behind a steep increase in solar power generation. By 2020, electricity generation from oil shale has been significantly reduced. The Estonian government has announced a complete phase-out of oil shale in electricity generation by 2035 and shale oil by 2040 (IAE, Estonia 2025). Despite quite tangible progress towards energy independence, all three Baltic countries are currently energy importers (Table 3).

Table 3
Share of imports in energy resources

Country	Net energy imports (%) in 2023	Change in energy imports (%) over 2000-2023
Lithuania	72.1	77
Estonia	1.8	52
Latvia	33.8	31

Source: compiled by the authors based on IEA (2025a, 2025b, 2025c).

Over the period 2000-2023, Lithuania's dependence on imported energy resources has increased by 77%, Latvia's by 31% and Estonia's by 52%. On the other hand, Estonia has now (2023) reduced its negative energy exports/imports ratio to 1.8%, Lithuania's energy import dependence is currently (2023) 72.1% and that of

Latvia is 33.8%. Thus, Lithuania's overall energy dependence is many times higher than Estonia's and more than twice as high as Latvia's.

Analysing the experience of each country, it should be noted that after the closure of the only nuclear power plant, *Lithuania* went from being a net exporter of electricity to a net importer of electricity. Lithuania wants to halve its electricity imports by 2030 and generate 70% of its electricity needs from domestic sources. The synchronisation of the Baltic energy systems with the continental European electricity system is considered to be a major step, as mentioned above. (IAE, Lithuania 2025)

The same is true for *Estonia*, which, by reducing its dependence on electricity generation from domestic oil shale while pursuing a policy of reducing CO_2 emissions, has transformed itself from an electricity-exporting country into an electricity-importing one (IAE, Estonia, 2025). Meanwhile, Latvia has been an importer rather than an exporter of energy resources over the entire period 2000-2023 (IAE, Latvia, 2025).

The study of the Baltic countries' energy security by the Lithuanian researcher Streimikienė (2021; 2023) leads to the following conclusions about the Baltic countries' energy security:

- Lithuania is the worst performer in terms of net energy imports, but the best performer in terms of electricity interconnections.
- Latvia is the worst performer in electricity interconnection but the best performer in the low carbon transition.
- Estonia is the worst performer on the supplier concentration index and on the low carbon energy transformation indicators, but is the best performer in terms of dependence on net energy imports.

4.2. Energy equity

Energy equity element of the ETI is determined by the level of energy accessibility, energy prices, energy poverty and other indicators (Kang, 2022; Mikalauskienė, Streimikienė, Mikalauskas, 2017). A comparison of the Baltic countries in terms of progress on the energy equity element between 2000 and 2023 is shown in Figure 4.

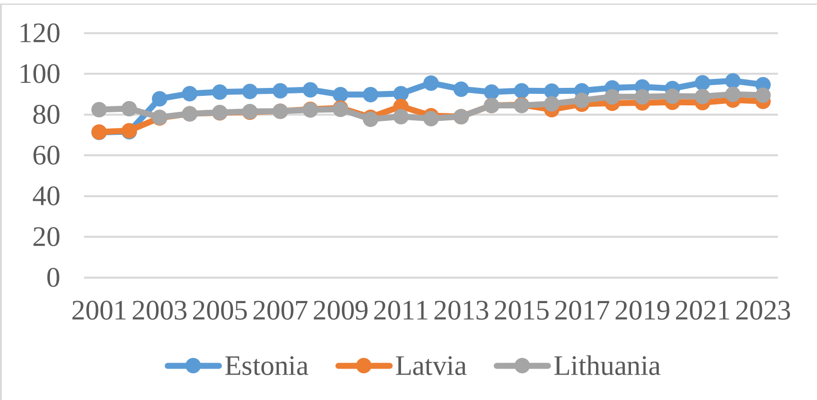

Figure 4. Comparison of ETI Energy Equity indicators for 2000-2023.
Source: compiled by the authors based on World Energy Council (2023).

Figure 4 shows that since 2002, Estonia's progress in meeting the energy equity target has become evident. On the other hand, since 2014 Lithuania and Latvia have started to narrow the gap and currently (2023) the difference between the countries is not very significant: the three Baltic States' energy equity score according to the ETI's methodology ranges between 86-94 and all three graduate with a B level. This means that, according to the ETI methodology, the Baltic countries have some problems in meeting the energy equity target. What are these problems? First of all, the dynamics of electricity prices in the Baltic countries should be discussed (Fig. 5).

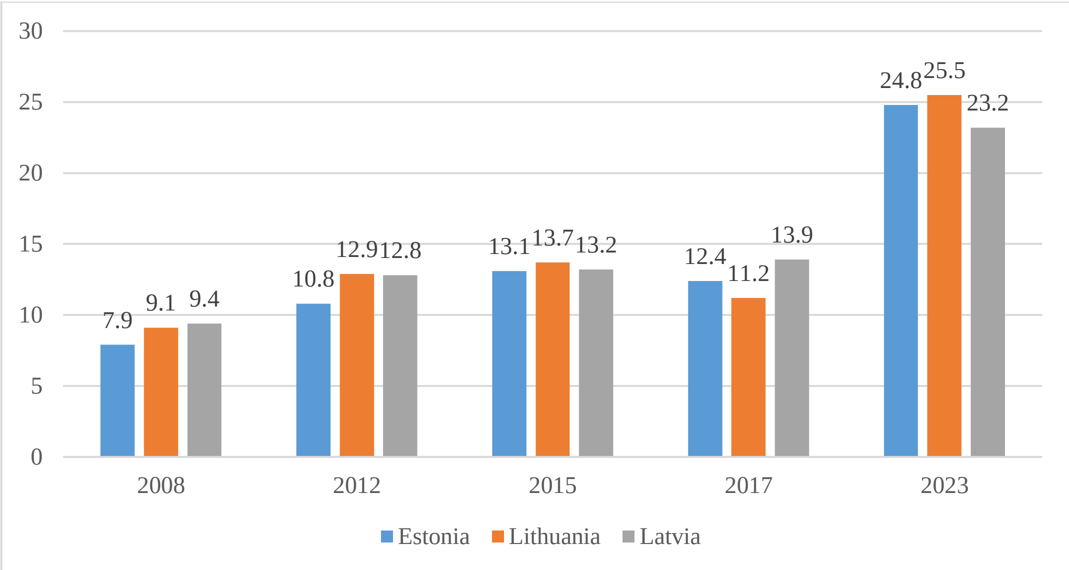

Figure 5. Electricity price comparison for consumers, EUR cent/kWh.
Source: Compiled by the author based on National Lithuanian Energy Association (2018), Baltic Energy Market Review (2017).

In Fig. 5, two main periods can be distinguished: 1) 2008-2012 and 2) 2017-2023, when the price per kWh of electricity in the Baltic States grew the most. In the first period (2008-2012), the increase in electricity prices was primarily due to the closure of the Ignalina Nuclear Power Plant (INPP) at the end of December 2009, which affected the whole region: for example, in the Lithuanian context, the market price of electricity doubled (Bobinaitė & Juozapavičienė, 2012). It is noted that prior to the closure of the IAE, the energy market opening project and the establishment of the wholesale electricity market and restructuring of the sector resulted in 2 consecutive years of declining electricity prices for Baltic consumers. Following the closure of the first unit of Ignalina Nuclear Power Plant, prices rose even until 2014 (Šikšnelytė, 2016).

In the second period (2017-2023), changes in electricity prices were partly influenced by the increased need for funds for infrastructure maintenance, synchronisation projects and other investments (National Energy Regulatory Council, 2019). However, the fundamental cause of the 'energy crisis' in 2021-2022 was the

20-30% lower than normal European storage capacity, which was caused by the economic pressure exerted by Russia even before the war in Ukraine, and later by the war itself and the disruption of the Russian-German energy links, which significantly increased the demand for energy resources and caused a price shock (Lithuanian Free Market Institute, 2023).

According to the data for 2023, one KWh of electricity will cost 25.5 ct. in Lithuania, 23.1 ct. in Latvia and 24.8 ct. in Estonia, while the EU average is 24.2 ct. (Lithuanian Energy Agency, 2024).

Electricity and other energy prices are relevant to the directly related issue of energy equity – energy poverty. Energy poverty is a condition in which people are unable to maintain a sufficient level of heating in their homes due to financial hardship, or are paying so much for energy that it threatens other areas of their lives (Lithuanian Confederation of Trade Unions, 2025). There are three main indicators related to energy poverty (Measuring Energy Poverty, 2017):

1. *The household arrears on payment of utility bills* indicator shows the proportion of the population living in households that were in arrears on utility bills due to lack of funds.
2. *Failure to provide adequate home heating* due to lack of resources indicates the proportion of the population living in households that could not afford adequate home heating in cold weather due to lack of resources.
3. *The share of income spending on energy* represents the proportion of all households whose share of energy expenditure (electricity, gas, other fuels, heat) in disposable income was more than 2 times the median share.

A comparison of the Baltic countries in terms of households' utility arrears is shown in Figure 6.

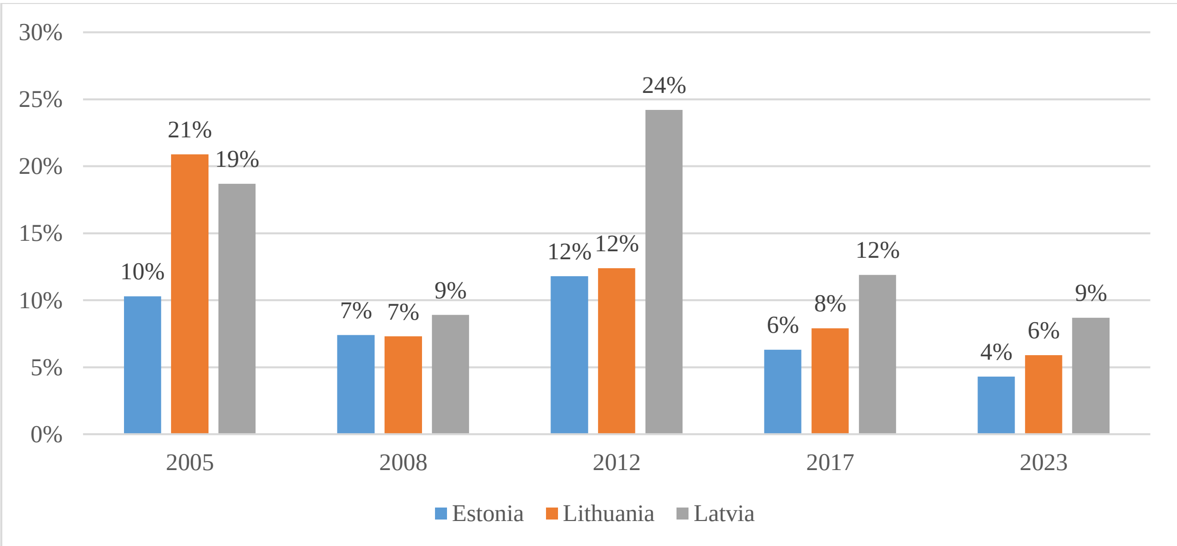

Figure 6. Proportion of people living in households unable to pay utility bills on time due to lack of money.

Source: compiled by the authors based on Measuring Energy Poverty (2017), Lithuanian Confederation of Trade Unions (2025)

One can see that all three Baltic countries have significantly reduced the share of people living in households that are unable to pay their utility bills on time due to lack of money between 2005 and 2023. This is especially the case in Lithuania and Latvia, where in 2005 about 1/5 of households were unable to pay their utility bills on time due to lack of money. Nowadays, in Lithuania (5.9%), Latvia (8.7%) and Estonia (4.3%), the figure is below 1/10th of households. It should also be noted that the EU average is 7% (Lithuanian Confederation of Trade Unions, 2025). A comparison of countries by share of income spent on housing maintenance is shown in Figure 7.

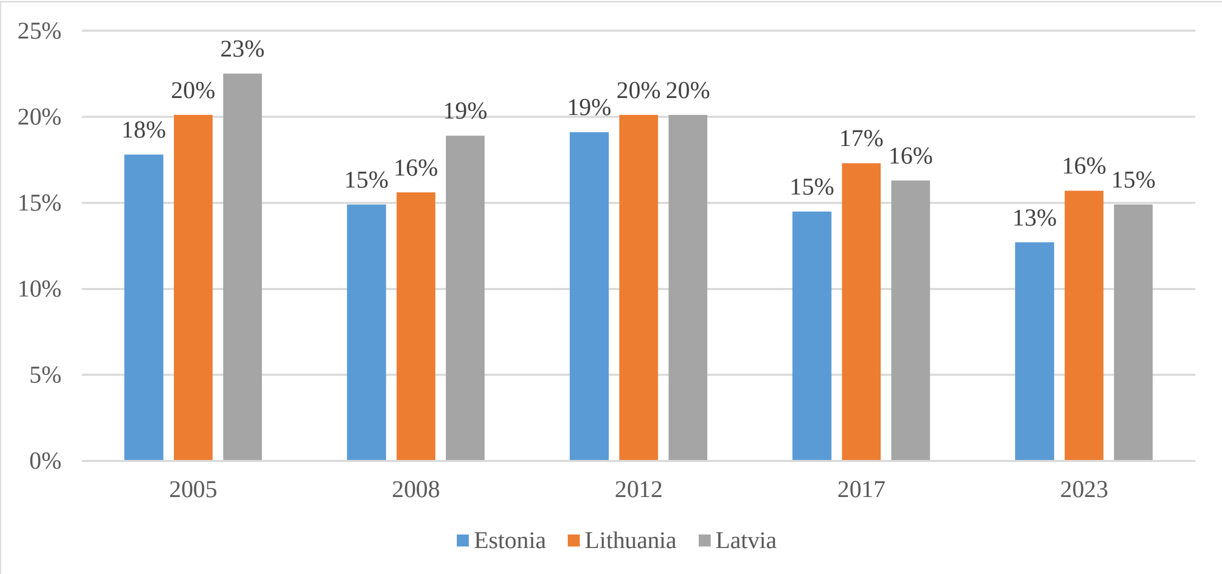

Figure 7. Share of disposable income for housing maintenance costs.
Source: compiled by the authors based on Measuring Energy Poverty (2017); Lithuanian Confederation of Trade Unions (2025)

All the Baltic countries have significantly reduced the share of their income spent on house maintenance in the first quarter of the 21st century. For example, while in 2005, Latvia, Lithuania and Estonia spent almost a fifth, a quarter and a sixth of their incomes on housing maintenance respectively, by 2023 the figures are 14.9% (Latvia), 15.7% (Lithuania) and 12.7% (Estonia). These results were better than the EU average of 21% (Lithuanian Confederation of Trade Unions, 2025).

A comparison of countries by the share of the population living in households that cannot afford to provide sufficient home heating due to lack of funds is shown in Figure 8.

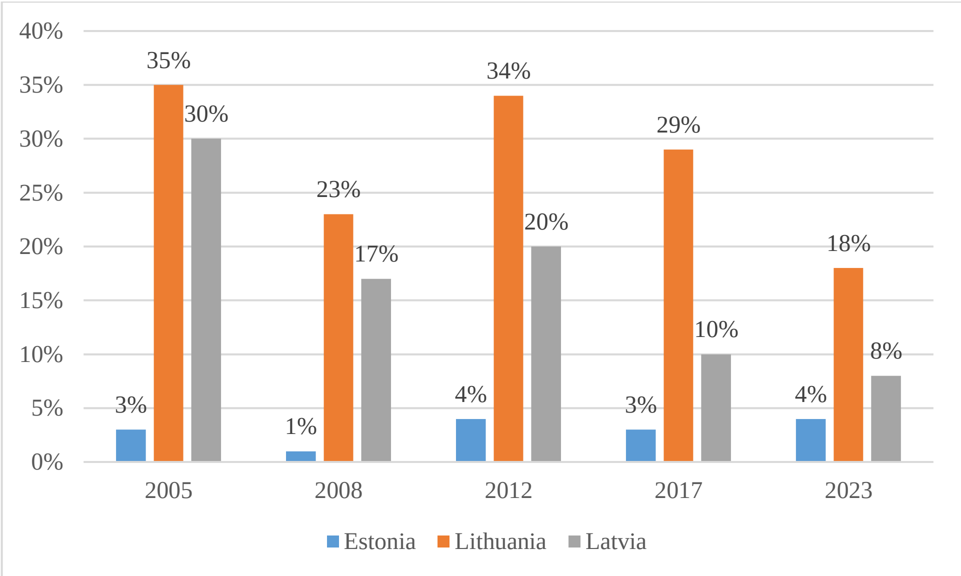

Figure 8. Proportion of people living in households that cannot afford sufficient heating due to lack of funds.
Source: compiled by the authors based on Measuring Energy Poverty (2017); Lithuanian Confederation of Trade Unions (2025)

The analysis of Figure 8 highlights Lithuania's *meta-problem* – the inability of a very significant part of the population to provide adequate heating for their homes. Despite the fact that Lithuania has managed to significantly mitigate this problem since 2005, when the share of the population that could not afford to heat their homes adequately due to lack of money reached 35%, it is still a pressing and worrying issue: by 2023, as many as 18% of the Lithuanian population will not be able to heat their homes adequately. Latvia and Estonia have made good progress in this respect. Particularly noteworthy is the experience of Latvia, which in 18 years has managed to reduce the proportion of the population that cannot afford to heat their homes adequately due to lack of money from 30% (2005) to 8% (2023), i.e. to the EU average (Lithuanian Confederation of Trade Unions, 2025). Estonia's score over the whole period was within 4% of the EU average.

Streimikienė (2020) underlines that Lithuania's inability to heat its households adequately reflects several problems. First, energy affordability is diminished, and energy poverty appears. Second, energy vulnerability remains threatening. The low insulation properties of the soviet period construction coupled with subdued renovation pace complicate the situation. The district heating systems are virtually impossible to disconnect from due to financial and legal obstacles. Therefore, relatively impoverished households remain trapped in low-efficiency multi-apartment buildings where the options for heat metering (and regulation) or suppliers do not exist (Streimikienė, 2020).

Streimikienė (2020; 2023) suggest that Latvia is the best performer in terms of energy poverty, while Lithuania is the worst. These studies have, among other things, identified some contradictory correlations at the level of individual countries and more generally in the context of the implementation of the 'energy trilemma'. For example, the example of Latvia shows that good performance in the low-carbon energy transition can be accompanied by good performance in reducing energy poverty. The example of Lithuania shows that relatively good performance in the low-carbon energy transition has not been accompanied by good performance in reducing energy poverty, nor has it been accompanied by good performance in the low-carbon energy transition alone (Streimikienė; 2023).

4.3. Environmental sustainability

Environmental sustainability element of the ETI relates to environmental pollution, decarbonisation, CO_2 emissions/per capita and other indicators (Kang, 2022; Alola, Adebayo & Olanipekun, 2023). All Baltic countries are rated A for this indicator in 2023, and the evolution of the corresponding indicator between 2000 and 2023 is shown in Figure 9.

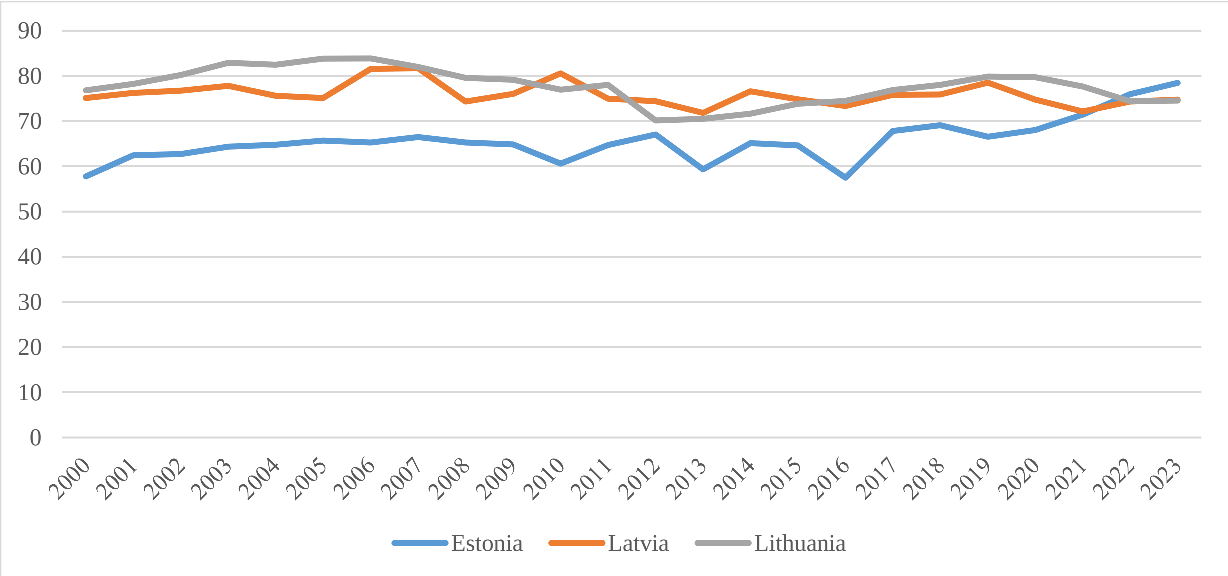

Figure 9. Comparison of ETI Environmental Sustainability indicators 2000-2023.
Source: compiled by the authors based on World Energy Council (2023).

At the beginning of the analysis period, Lithuania had the strongest position (83 in 2006) in environmental sustainability, while Estonia had the weakest. At the end of the period, Estonia had the best score (78), while Lithuania and Latvia were practically equal (74-75). Indeed, geopolitical shifts caused by the Russo-Ukrainian war have instigated changes in energy policy in the EU and Baltic States in particular. Specifically, the imports of energy sources from Russia have been halted or substantially reduced since 2022. Also, development of the green energy has gained momentum among expectations to increase energy security and sustainability (Kleinberga, 2024). One of the key factors determining the environmental sustainability ranking is the share of RES in the country's energy mix. The dynamics of this share in Lithuania, Latvia and Estonia between 2000 and 2023 is shown in Figure 10.

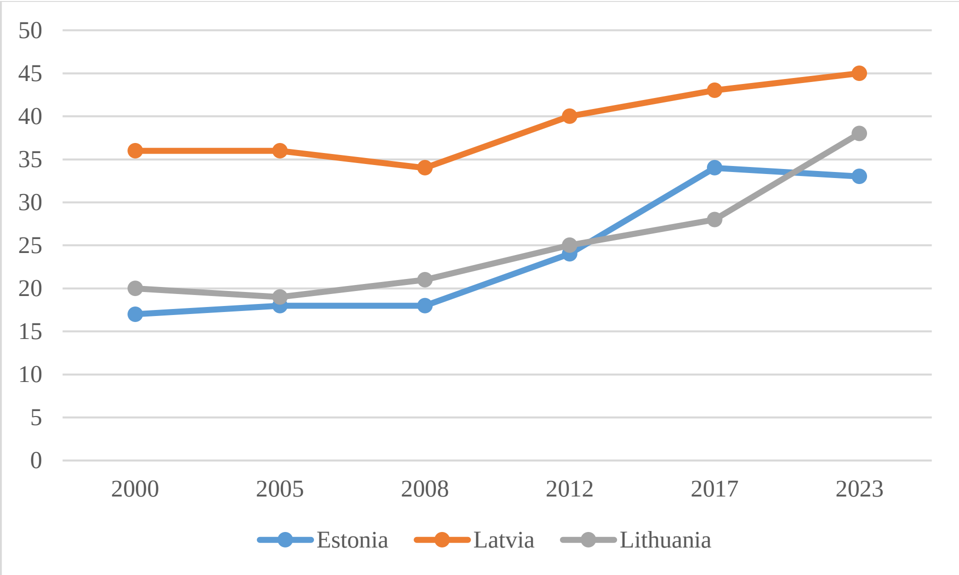

Figure 10. Renewable energy as a share of national energy mix (%).
Source: compiled by the authors based on IEA (2025a, 2025b, 2025c).

Thus, over the period 2000-2023, all the Baltic States have significantly increased the share of RES in their energy mix. Lithuania and Estonia have made the most progress over the period 2000-2023. Latvia, on the other hand, is ahead on this indicator, as a large part of its energy mix has traditionally consisted of RES and, in particular, hydropower (World Energy Council, Latvia, 2025). An equally important indicator in the context of environmental sustainability is CO_2 emissions/capita (Fig. 11.)

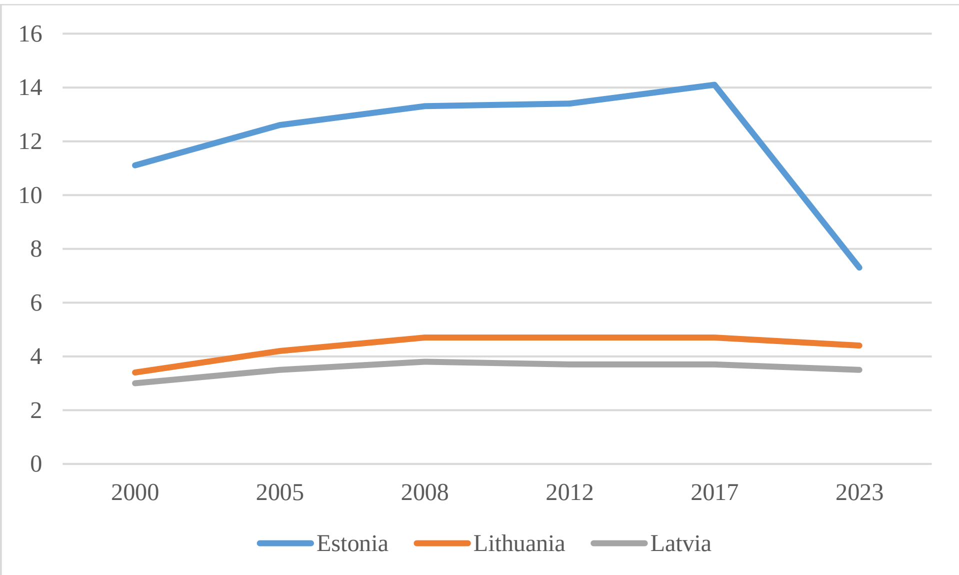

Figure 11. CO_2 emissions per capita (tonnes per capita).
Source: compiled by the authors based on IEA (2025a, 2025b, 2025c).

Between 2000 and 2023, Estonia remained the highest emitter of CO_2 per capita among the Baltic States. The indicator increased from around 11 t/person in 2000 to nearly 14 t/person by 2017, followed by a sharp decline to approximately 7 t/person in 2023. Increase was mainly driven by its dependence on oil shale for electricity production, while the decline after 2018 corresponds with declining oil shale output and energy transitions investments. In Lithuania, emissions rose from about 3.5 to 4.5 t/person, with a slight decrease by 2023. It can be linked to transport sector expansion, economic growth and delayed energy efficiency improvements. Latvia showed relatively stable emissions throughout the period, fluctuating around 3–3.5 t/person. It is associated with a higher share of renewables, especially hydropower, and a relatively lower industrial base. These figures represent annual point-in-time indicators, calculated as the total national CO_2 emissions in a given year divided by the average population of that year. This allows for an accurate assessment of the yearly emission intensity per capita. The analysis of the elements of the ETI is given in Table 4.

5. Conclusions

The Energy Trilemma Index is the most popular and currently most widely used measure of the implementation of the energy trilemma concept. The index shows how far a country has progressed in realising the three key elements of the energy trilemma - energy security, energy equity and environmental sustainability. There is still no consensus in the academic literature on the reliability of the ETI in assessing progress on the Energy Trilemma, but in comparison with other similar indices it seems to be the most appropriate at present.

An analysis of the experience of the Baltic States suggests that Estonia has made the most progress in the implementation of the energy trilemma between 2000 and 2023, and is now among the top ten countries in the ETI ranking. On the other hand, all three Baltic States are in the top 25 of the ranking and have managed to get rid of the EU’s ‘energy island’ stupor over the period 2000-2023 by diversifying their energy economies, synchronising their energy systems with continental Europe and significantly reducing the energy poverty of their populations.

On the other hand, the analysis shows that the energy security of all three Baltic States is currently vulnerable to ongoing geopolitical tensions and the ongoing transformation of energy systems, and that there are some energy trilemma challenges at the level of individual countries. Lithuania, for example, continues to experience high rates of energy (especially heat) poverty and is characterised by a very high dependence on energy imports. Latvia is characterised by energy irrationality and waste in the transport and buildings sectors, as well as a significant dependence on energy imports. Estonia has relatively high CO_2 emissions and oil shale remains the country’s main source of energy.

Table 4
Comparison of the Baltic countries in terms of realisation/solution of the energy trilemma in the period 2001-2023

Country	Aspects of progress	Challenges
Lithuania	• EU 'energy island' status revoked • Bioenergy leads the country's energy supply • Successful synchronisation with the continental European electricity system • Energy poverty reduced	• Possible price increases after disconnection from BRELL • Threat of war in Ukraine and other geopolitical challenges • Still high rates of energy (especially heat) poverty due to outdated housing infrastructure • Very high dependence on energy imports: 2/3 of energy
Latvia	• EU 'energy island' status revoked • Decreasing dependence on energy imports thanks to the development of the RES • Low energy poverty rates	• Possible price increases after disconnection from BRELL • The threat of war in Ukraine and other geopolitical challenges • One third of the energy sector depends on import • Transport and buildings consume large amounts of energy and are dependent on outdated infrastructure, which hinders further reductions in energy consumption and greenhouse gas emissions • Possible price increases after disconnection from the Russian and Belarusian electricity system (BRELL ring)
Estonia	• EU 'energy island' status revoked • Absolute independence from energy imports • Declining dependence on electricity generation from domestic oil shale • Reduced CO_2 emissions	• Possible price increases after disconnection from BRELL • Threat of war in Ukraine and other geopolitical challenges • Oil shale remains the main source of energy, while imported fossil fuels still play an important role, especially in the transport sector • Geopolitical risks from the war in Ukraine • CO_2 emissions still high

Source: compiled by the authors.

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