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ANALYSIS OF RENEWABLE ENERGY'S IMPACT ON ENERGY IMPORT DEPENDENCY IN LITHUANIA

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The aim of this paper is to analyse the security of energy supply of Lithuania, taking into account the use of renewable energy sources in the country. Using cluster analysis, the study categorizes Lithuania as a nation with above-average energy import dependence and an average utilization of renewable energy sources. In 2011, Lithuania's energy import dependency stood at 77.5%, with renewable energy accounting for 19.9% of the country's gross final energy consumption. Over the subsequent decade, as the proportion of renewable energy sources in gross final consumption rose to 28.2%, Lithuania's energy import dependence decreased to 73.3%. Should the present trajectory of energy import dependence persist, Lithuania's import reliance is projected to decrease by a mere 1% by 2025. Conversely, if the current trend in renewable energy adoption continues, the share of renewable energy sources in Lithuania's energy mix could potentially reach 31% by the same year. To substantially reduce future energy import dependence, it is imperative to introduce additional incentives and policies that promote a more rapid shift towards renewable energy sources.

Keywords: *renewable energy; imports; energy resources; prognosis; level*

INTRODUCTION

The economic, political, and energy instability of society necessitates the introduction of balanced sustainable development. The transition of European countries to sustainable economic growth is one of the strategies of the European Union (European Energy Security Strategy, 2014). Sustainable development necessitates the systematic fostering of economic growth, the promotion of social justice, and the safeguarding of natural resources for the benefit of future generations (Bórawski et al., 2019). Balanced sustainable development is a complex and long-term process. Such development requires comprehensive cooperation between all sectors of the country's economy and society (Torchio et al., 2020).

The European Energy Security Strategy proposes a balanced transition to renewable energy sources (RES) and a reduction of dependence on unsustainable conventional energy sources (European Energy Security Strategy, 2014). In the early 2000s, energy production from renewable sources accounted for 15% of the total final energy consumption in the EU. According to the Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (2009/28/EC), this figure was to increase to 20% by 2020 (Directive 2009/28/EC, 2009). The European Commission has recommended increasing the share of renewable energy to 27% of total final energy consumption by 2030 (European Energy Security Strategy, 2014). However, in 2018, the previous directive (2009/28/EC) was revised and a target of 32% of renewable energy in EU gross national energy consumption was recommended (Directive (EU), 2018). In 2021, the European Commission proposed to raise the share of renewables in EU countries from 32% to 40% by 2030. Taking into account the political events of 2022 and the possibility of an energy crisis, it is proposed to raise the share of renewables to 45% for European countries (Renewable Electricity, 2022). To achieve the above goals, the EU countries are focusing on improving economic and environmental sustainability, protection against external risks (reducing energy import dependence).

In recent years, the import dependence of energy resources in the EU has averaged 53% and has been on the rise (De Rosa et al., 2022). To ensure the EU's energy supply and gradually eliminate dependence on imported energy sources, the EU Energy Platform was launched in 2022 (Strategy for an EU external energy engagement, 2022). EU countries can

use the renewable energy financing mechanism as a tool for implementing recovery and resilience plans (EU renewable energy financing mechanism, 2020). However, EU national renewable energy plans differ from country to country, taking into account the unique conditions and capacities of each country (Renewable energy – national targets, 2019).

Recently, a significant number of researchers have been paying attention to the policy of diversification of energy sources (Strielkowski at al., 2021; Lu at al, 2020). In particular, the analyses of the research results (De Rosa et al., 2022) indicate a decrease in energy security with a higher dependence on imports of energy sources from European countries. The study found a tendency to raise the share of power generation from renewable sources over the last decade. (Sipa and Gorzeń-Mitka, 2014) identifies the correlation between the use of energy sources and certain indicators of innovation in the European Union. The authors note that not all EU countries have made progress in managing energy consumption, especially for renewable energy sources. And, the overall impact of the level of renewable energy consumption on energy security has not been studied. The article (Halkos and Gkampoura, 2023) examines the relationship between energy poverty and the use of fossil fuels and renewable energy sources, taking into account gross domestic product per capita (GDPpC). The results of the analysis confirm the positive effect of the share of renewable energy in the overall energy system of countries on the overall energy security of countries. However, the study (Musiał et al., 2021) notes that the proportion of renewable energy in the total final energy demand of the analysed EU Member States is very different. The results of the study confirm that the development of the RES market is influenced by a country's development level, innovation and openness to change. The aim of this paper is to analyse the security of energy supply of Lithuania, taking into account the use of renewable energy sources in the country.

RESEARCH METHODS

The energy import dependency (EID) indicates the share of a country's total energy demand covered by imports from other countries (Energy import dependency by products, 2023) and is considered as the dependent variable in the study. In this study, also the renewable energy indicator is considered as the proportion of renewable energy consumption in total final energy consumption (Share of renewable energy, 2023).

For cluster analysis, we used Statistica (v.11.0, StatSoft) software, namely the Cluster Analysis module (State et al., 2019). The analysis was carried out using two variables E - energy import dependency and R - renewable energy sources by building a cluster tree. The tree was constructed according to the Complete-linkage rule (Canizes at al., 2023), the distance was calculated using the Euclidean distances method (Fotia and Ferrara, 2023). Cluster analysis is a technique used in machine learning and statistics to group similar data points into clusters. Complete linkage is a method of hierarchical clustering, and Euclidean distance is a commonly used measure of dissimilarity between data points. In Statistica, cluster analysis methods are implemented in the Cluster Analysis module, which is located in the Multivariate Exploratory Techniques block.

RESEARCH RESULTS AND DISCUSSION

During the period under study, changes in the indicators of Energy import dependence and RES in the European Union are very diverse. Therefore, a cluster analysis of the European Union countries in terms of the above indicators was conducted. The cluster analysis is based on average data for the period from 2012 to 2021. Six clusters were identified based on the similarity of indicators: I - with a high level of EID and a low level of RES (Cyprus, Luxembourg, Malta); II - with an above-average level of EID and a below-average level of RES; III - with an above-average level of EID and an average level of RES; IV - with an average level for EID and an above-average level for RES; V - with a below-average level for EID and a below-average level for RES; VI - with a low level for EID and a fairly high level for RES (Sweden, Denmark, Romania, Estonia). The majority of EU countries are in the clusters with an average value for both energy import dependence and renewable energy sources (Fig. 1).

The EU countries belonging to clusters II-V are striving to achieve the RES target set by the European Commission Directive and reduce energy import dependence. Lithuania is in the cluster with an above-average level of EID and an average level of RES. Therefore, in accordance with the National Energy Plan of the Republic of Lithuania for 2021-2030 (National, 2021), it is advisable to analyse the impact of RES on EID. From 2011 to 2022, Lithuania's EID decreased by 5.5% (Energy import dependency by products, 2023), while the share of renewable energy consumption increased by 31.7% (Share of renewable energy, 2023). The regression analysis revealed a linear relationship (1).

$$E = -14.68 \ln R + 122.04 \quad (1)$$

where E – energy import dependency (EID), %;
R – renewable energy sources (RES), %.

The resulting equation is adequate according to Fisher's criterion with a reliability level of 0.95 and has a determination coefficient of R^2=0.6802. In 2012. Energy import dependence was 77.5% with a share of renewable energy in Lithuania's gross final consumption of 19.9%, while over 10 years, with the share of renewable energy in gross final consumption increasing to 28.2, the Energy import dependence decreased to 73.3% (Fig. 2).

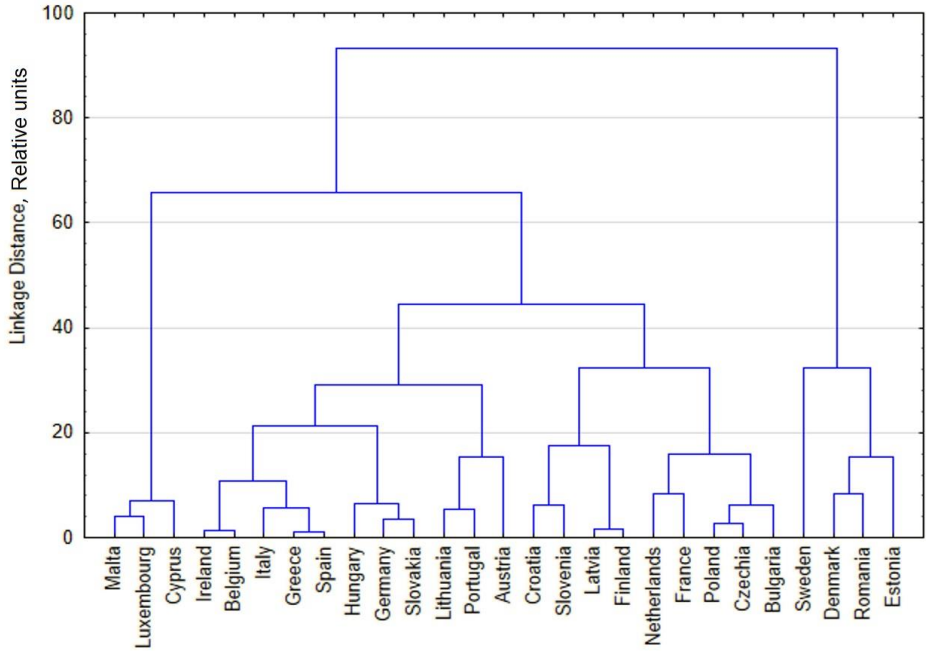

Figure 1. Graphical visualization of clusters.

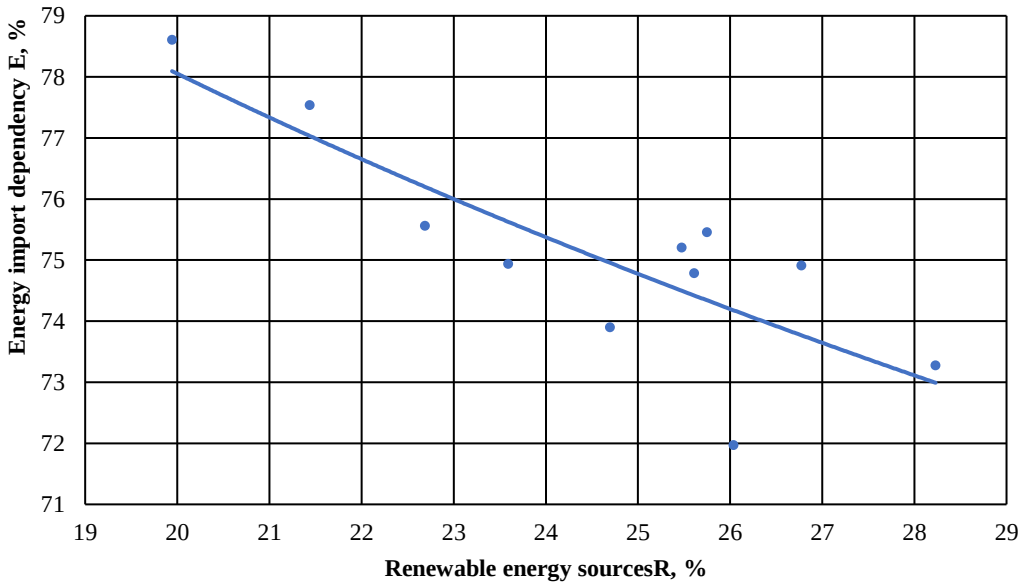

Figure 2. Impact of RES on EID.

For the EID indicator, the trend line is described by the logarithmic equation (2) with the coefficient of determination R^2=0.68

$$E = -2.028 \ln Y + 78.327 \quad (2)$$

where E – energy import dependency (EID), %;
Y – year number (for example, for 2011 Y=1, and for 2025 Y=15).

If the established trend in EID continues, this indicator may decrease by only 1% in Lithuania by 2025 (Fig. 3).

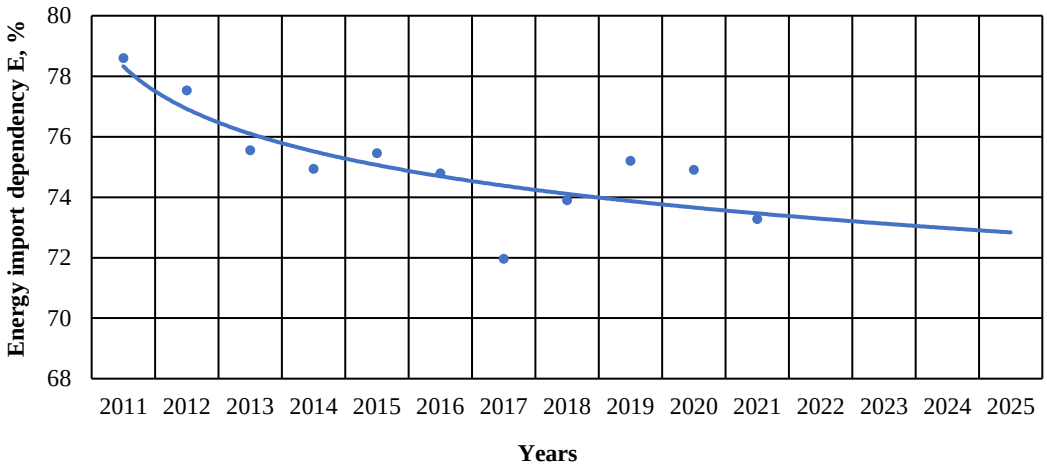

Figure 3. Trends in energy import dependence.

For the RES indicator, the trend line is described by linear equation (3) with a determination coefficient of R^2=0.83.

$$R = 0{,}6694Y + 20{,}55 \quad (3)$$

where R – renewable energy sources (RES), %;
Y – year number (for example, for 2011 Y=1, and for 2025 Y=15).

If the established trend in the change of RES continues, this figure may increase to 31% by 2025 in Lithuania (Fig. 4).

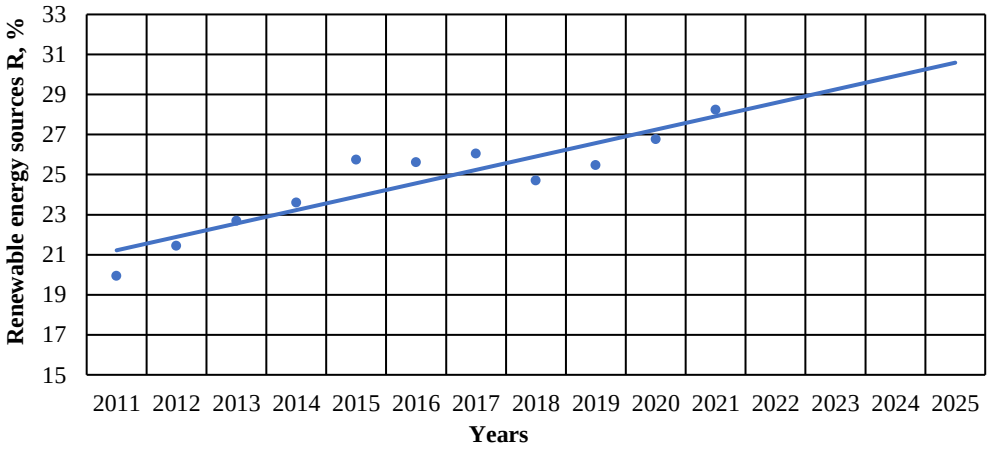

Figure 4. Trends in renewable energy sources (10 years).

If we look at the trend of changes in renewable energy sources over the past 4 years, as described by equation (4), in Lithuania, this figure may increase to 34% (R^2=0.98) by 2025 (Fig. 5).

$$R = 23.459e^{0.0451Y} \quad (4)$$

where R – renewable energy sources (RES), %;
Y – year number (for example, for 2011 Y=1, and for 2025 Y=15).

Thus, these trends and the forecast of further growth in the share of RES suggest that the goals of the national energy development strategy can be achieved. However, it will be difficult to achieve the goal of reducing energy import dependence. Therefore, it is necessary to introduce additional incentives to change this indicator.

From the information provided, it is clear that Lithuania has made some progress in reducing its dependence on energy imports and raising the proportion of renewable energy in its gross final consumption over the last 11 years. However, the rate of change has been relatively slow, with energy import dependence decreasing by only 4.2% and the share of renewable energy increasing by 8.3% over that period. If the current trend continues, it is projected that by 2025, Lithuania's energy import dependence may decrease by only 1% (from the 2011 value of 77.5%) and the share of renewable energy may increase to 31% (from the 2011 value of 19.9%). While these projections indicate some progress, they may not be sufficient to significantly reduce energy import dependence in the future.

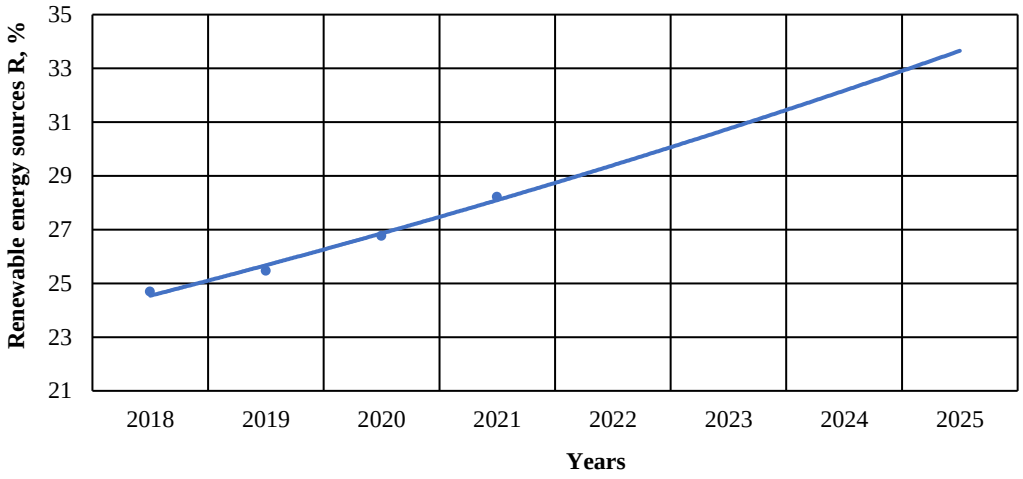

Figure 5. Trends in renewable energy sources (4 years).

To accelerate the reduction of EID and increase the share of RES, additional incentives and measures should be considered. Here are a few potential strategies:

Policy support: Implementing policies and regulations that promote the development and adoption of RES can provide a favorable environment for growth. This includes providing financial incentives, tax breaks, feed-in tariffs, and simplified administrative procedures for renewable energy projects.

Research and development: Invest in research and development efforts to enhance the efficiency, reliability, and affordability of renewable energy technologies. This can help accelerate their deployment and reduce dependence on imported energy sources.

Infrastructure development: Invest in the necessary infrastructure to support renewable energy generation, such as building transmission lines, expanding grid capacity, and establishing charging networks for electric vehicles. This would enable the integration of RES into the existing energy system.

Energy efficiency measures: Promote energy efficiency initiatives in various sectors, including buildings, transport and industry. Energy saving measures can help to reduce total energy demand, thereby reducing dependence on energy imports.

Public awareness and education: Raise awareness among the general public about the benefits of renewable energy and the importance of reducing energy import dependence. Educating consumers about energy conservation and promoting behavioral changes can contribute to a more sustainable energy future.

By combining these strategies and implementing additional incentives, Lithuania can make significant progress in reducing EID and increasing the share of RES. It's important to note that the effectiveness of these measures may vary, and a comprehensive approach tailored to the specific needs and characteristics of the country is essential.

CONCLUSIONS

Six clusters were identified of countries: I - with a high level of energy import dependence (EID) and a low level of renewable energy sources (RES); II - with an above-average level of EID and a below-average level of RES; III - with an above-average level of EID and an average level of RE; IV - with an average level for EID and an above-average level for RES; V - with a below-average level for EID and a below-average level for RES; VI - with a low level for EID and a fairly high level for RES. The majority of EU countries are classified in clusters with an average value for both EID and RES. Lithuania is in Cluster III with an above-average level for EID e and an average level for RES.

In 2011, energy import dependence was 77.5% with a share of renewable energy in Lithuania's gross national consumption of 19.9%, while in 11 years, as the share of renewable energy in gross national consumption increased to 28.2%, energy import dependence decreased to 73.3%. If the current trend in energy import dependency continues, Lithuania's energy import dependency could decrease by only 1% by 2025. If the current trend of changes in renewable energy sources continues, the proportion of renewable energy sources in Lithuania could increase to 31% by 2025.

In order to significantly reduce energy import dependence in the future, additional incentives should be introduced to change this indicator.

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