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Review

Exploring the Interplay Between Energy Policies and Sustainable Development Goals Within Lithuania's Energy Sector: A Critical Review

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Abstract: This paper presents a critical review of Lithuania's climate change mitigation policies within the energy sector, focusing on their alignment with Sustainable Development Goals (SDGs). This study highlights the significance of energy efficiency, renewable energy, and energy security in Lithuania's efforts to reduce greenhouse gas emissions and transition to a sustainable energy system. The review analyzes the selected research literature that studies Lithuania's efforts to adapt and fulfill EU energy directives and national goals, emphasizing the impacts of these policies on various sectors, including residential, transport, and industry. The methodology includes a comprehensive analysis of the existing literature and semi-structured interviews with stakeholders regarding their perceptions of the current state and future directions of Lithuania's energy policies. Findings indicate substantial progress in renewable energy adoption and energy efficiency improvements, contributing to SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action). However, challenges such as high costs, underdeveloped financing mechanisms, and limited public awareness hinder further advancements. This paper suggests that future policies should focus on overcoming these barriers, enhancing public engagement, and integrating technological innovations to achieve more significant energy savings and GHG reductions. Recommendations for policy improvements and further research directions are also discussed.

Keywords: energy policies; energy efficiency; renewable energy; energy security; Sustainable Development Goals (SDGs)

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Citation: Alonso Soto, A.; Stasiškienė, Ž. Exploring the Interplay Between Energy Policies and Sustainable Development Goals Within Lithuania's Energy Sector: A Critical Review. *Sustainability* **2024**, *16*, 10018. https://doi.org/10.3390/su162210018

Academic Editors: Konstantinos S. Ioannou, Evangelia Karasmanaki and Georgios Tsantopoulos

Received: 9 August 2024
Revised: 4 November 2024
Accepted: 6 November 2024
Published: 17 November 2024

1. Introduction

The effects of climate change on the global stage demand urgent and collaborative actions across all sectors of human activity. The world is seeing more frequent and severe consequences of rising greenhouse gas (GHG) emissions, such as record-breaking heat waves over both land and ocean, severe floods, major hurricanes, and extreme wildfires [1]. Among all economic sectors, the energy sector stands as a major contributor to climate change, but it also stands as a pivotal player in the mitigation and adaptation strategies set to reach the ambitious climate targets of the Paris Agreement [2]. Overall, the energy sector has a fundamental role in economic and social development, and the global reliance on it accelerates global warming as it exacerbates environmental degradation, posing a direct threat not only to ecosystems but also to human well-being.

Daily human activities heavily depend on the use of fossil fuels, which has resulted in an excessive rise in carbon dioxide levels and other energy-related GHG emissions. Despite previous efforts and targets set during global climate panels, the prediction for energy demand trends indicates an increase, attributed to economic growth and the rising population. Starting at 30 gigatons (Gt) of carbon dioxide (CO_2) emissions annually in 2010, forecasts suggest that without measures to limit emissions, the carbon dioxide emissions linked to fossil fuel utilization from the energy supply sector as well as energy consumption in transportation, industry, and buildings could reach 55–70 $GtCO_2$ per year by 2050 [3,4]. Only in Europe, considering the countries that constitute the European Union (EU-27), the total emissions of GHGs in 2021 were 3.5 billion metric tons of carbon dioxide equivalent ($MTCO_2e$), to which the energy supply sector was the lead contributor, having emitted a total of 902 $MTCO_2e$ [5]. With the aim of combating the rising GHG emissions by at least 55% by 2030 in comparison to 1990 levels, the EU adopted a set of commission proposals to their climate, transport, taxation, and energy policies. This implementation, better known as the European Climate Law, can lead to a spur of sustainable economic growth and an accelerated clean energy transition, as well to the improved well-being of EU citizens [6].

Lithuania became a Member State of the EU in 2004, and it is committed to reaching the 2030 European Union climate and energy targets. To ensure the implementation of EU and international agreements to achieve climate change mitigation and adaptation goals and objectives, in 2021, Lithuania approved the National Climate Change Management Agenda (NCCMA). The agenda contemplates targets for GHG emission reductions in the short term (30% until 2030 compared to 2005), mid-term (85% until 2040 compared to 1990), and long term (net-zero until 2050) [7,8]. These goals are ambitious to achieve for the Baltic State as its energy mix remains highly dependent on fossil fuels and electricity imports (about 70% of gross electricity consumption [9]); they are also ambitious due to the increased consumption of energy that the country has seen since 2015, which corresponds to a 2% increment yearly [10]. By 2022, Lithuania's total energy consumption per capita was 2.4 tons of oil equivalent (toe) and the overall energy consumption was 6.8 Mtoe, which accounted for approximately 19.3 $MtCO_2e$ of GHG emissions [11,12]. Recognizing the obligation to tackle climate change and reduce GHG emissions, the country is committed to improving their energy infrastructure and practices addressed in national energy laws and regulations, emphasizing the importance of sustainable practices, innovation, and international collaboration [13].

Addressing climate change in the energy sector is fundamental for shaping a sustainable and resilient future [14]. Transitioning to cleaner, renewable energy sources is not merely an environmental necessity but a strategic act for curbing the increasing threats posed by climate change. The Sustainable Development Goals (SDGs), adopted by United Nations Member States in 2015, are a set of 17 goals "aiming to end poverty, protect the environment, and ensure prosperity and peace for all by 2030" [15]. "Affordable and clean energy", the 7th Sustainable Development Goal (SDG7) adopted by the United Nations in 2015, "aims at ensuring access to affordable, reliable, sustainable, and modern energy for all" [16], and is intricately linked to poverty reduction, health improvements, and economic development. Additionally, SDG 13, "Climate Action", highlights the urgency of addressing climate change, emphasizing the importance of integrating sustainable practices in all sectors [17]. Considering that Lithuania's main energy policy goal is "to ensure energy security at competitive prices with the lowest possible environmental impact" [8], SDG 7 and 13 align with the country's energy strategies, such as achieving energy independence that can be fulfilled by the transition to renewable energy sources, for example, wind and solar power. Furthermore, Lithuania's energy transition is supported by policies that support investment in green technologies [18] and energy efficiency that aligns with broader environmental objectives under the SDGs, including building sustainable cities and communities (SDG 11) [19], and "building resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" (SDG 9) [20].

Based on this inherent interconnection, this study aims to examine how Lithuania's energy policies facilitate the achievement of the SDGs by conducting a critical review of available literature that focuses on any of the three policy areas of interest to this study: energy efficiency, renewable energy, and energy security. The selected literature covers development of the specific fields including, but not limited to, frameworks, reviews, case studies at local level, and comparative assessments, from 2010 to 2024. The article discusses relevant aspects such as policy implementation challenges, the role of technological innovations, policy adaptability and flexibility, and public perceptions. To have a deeper understanding of the perceptions of the country's energy policies, the researchers conducted a qualitative survey directed at stakeholders from the private energy sector, private industry, and local governments. Insights from the participants contributed to having closer and more sensible feedback about policy implementation challenges in the country, complementing the focus of this research.

The paper is structured in the following way: in Section 2, an overview of Lithuania's climate change, energy sector, and energy policy status is presented, followed by the methodology implemented to perform this study in Section 3. Section 4 presents the results of the critical review, and the analysis of these studies with relevant SDGs. Section 5 presents the Discussion Section, including the main takeaways from the survey conducted and recommendations for future research.

2. Climate Change, Energy Sector, and Energy Policy in Lithuania: Some Background

2.1. Climate Change and the Energy Sector in Lithuania

Lithuania is situated along the eastern shore of the Baltic Sea. The country's climate is influenced by the Atlantic Ocean and westerly airflow due to its geographical location and flat topography. The country experiences an average annual temperature of 6.9 °C, and relatively high precipitation levels, with higher levels presented in the western part of the territory. The Baltic Sea coast region of Lithuania is especially vulnerable to climate change, with concerns including rising sea levels, storms, hurricane winds, warming of the sea and Curonian Lagoon waters, and changes in salinity [21–23].

Over the past decades, Lithuania has experienced noticeable changes in its climate, indicated by rising temperatures and alterations in precipitation trends. Winters have become milder, with a decrease in the duration of snow cover, while summers have witnessed more frequent heat waves [24]. Figure 1 shows a historical trend of mean annual temperatures recorded in Lithuania's capital city, Vilnius, from the year 1778 to 2021.

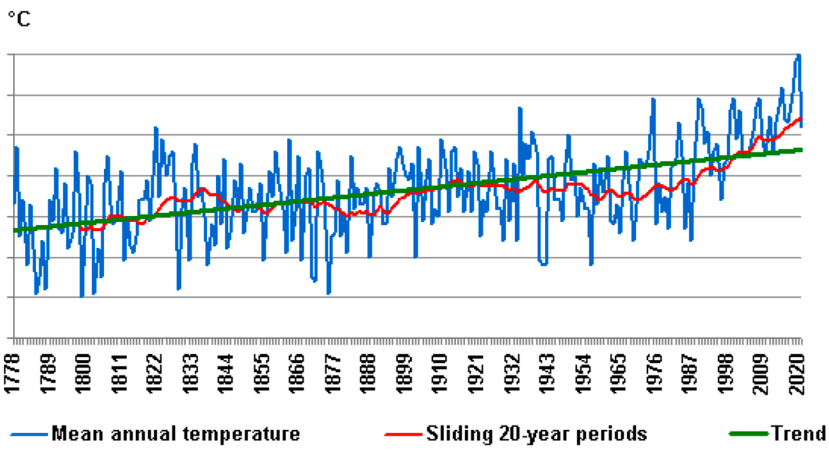

Figure 1. Average annual temperature in Vilnius, 1778–2021. Source [25].

The long-term trend represented with the green light depicts a clear increase in mean annual temperatures, indicative of warming over time. The red line, representing the sliding 20-year periods, highlights periods where the mean temperature deviated from the average. From the blue trend line representing the mean annual temperature for each year, it is notable that in the last 30 years the sharp rise in the mean temperature in Lithuania aligns with the global patterns of climate change. According to Lithuania's Ministry of Environment prediction models, the highest changes in average minimal and maximum temperatures should occur during the cold season, with values as high as 4 °C above the current levels by the year 2100. With these changes, it is expected that the country will experience more heatwaves (days when the temperature rises above 30 °C) during the hot season while cold spells will become less frequent (days when minimal temperature falls beneath −15 °C). These shifts in climate patterns have direct implications for various sectors, including agriculture, water resources, and energy [23,25].

Lithuania's energy sector has historically been a significant contributor to the country's climate change due to its reliance on fossil fuels for electricity generation and heating [26]. The country has been heavily dependent on imported oil, natural gas, and coal, leading to substantial greenhouse gas emissions [9]. In 2020, the energy sector contributed as a source of GHG emissions in Lithuania with a share of 58.5% of the total emissions, excluding Land Use, Land Use Change, and Forestry (LULUCF), as represented in the left pie chart of Figure 2. Focusing on the Energy sector depicted in the right pie chart of Figure 2, the largest share of emissions comes from the "Transport" sector, followed by the "Energy Industries" sector, at 13.1%. Combined, the "Manufacturing Industries and Construction", "Fugitive emissions from Fuels", and "Other sectors" contribute 14.8% to the emissions pie. Emissions from the energy sector include CO_2, CH_4, and N_2O GHG. The most significant GHG during the same year was CO_2, which contributed 67.6% of the total national emissions of CO_2eq. In 2020, CO_2 emissions stemming from the energy sector represented 82.1% of the nation's total CO_2 emissions. Within this, transportation and energy industries were the primary contributors, accounting for 45.0% and 19.4% of the nation's total CO_2 emissions, respectively [25]. Lithuania's GHG emissions increased by 8.8% per inhabitant between 2005 and 2019, while during the same period, EU levels decreased by 22% [27]. Several factors contributed to the rise in emissions levels in the country during that period, including the Ignalina Nuclear Power Plant shutting down in 2010, which incurred larger oil product imports, with a share of 36.2%, surpassing the percentage of the previous decade which fluctuated around 32.6% [25,28].

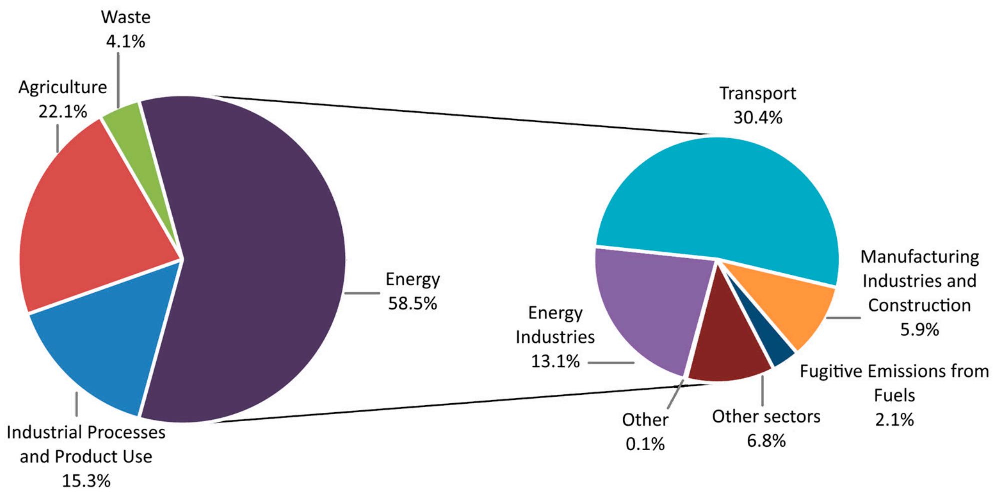

Figure 2. Lithuanian GHG emissions (CO_2eq.) by sector (excl. LULUCF) in 2020. Source [25].

One of the key factors driving Lithuania's emissions in the energy sector is its aging infrastructure and inefficient energy systems. Outdated power plants and heating facilities, coupled with inefficient energy usage in residential, commercial, and industrial sectors, have led to higher emissions per unit of energy produced or consumed. Additionally, the dominance of conventional energy sources has limited the incorporation of renewable energy alternatives, further exacerbating the carbon footprint of the energy sector [13,29]. Despite the active challenges, Lithuania has been focusing on diversifying its energy sources, increasing energy efficiency, and integrating renewable energy into its grid, aiming for sustainability and energy independence. This approach not only contributes to reducing greenhouse gas emissions but also strengthens Lithuania's energy security, reducing its reliance on imported fossil fuels [13].

2.2. Climate and Energy Policy in Lithuania

Lithuania's climate policy aligns with the EU's Climate and Energy Framework (2014) that set the goal of reducing EU-wide GHG emissions by 40% by 2030 in comparison with 1990 levels. The framework required all member states to present National Energy and Climate Plans (NECPs) that set a ten-year plan detailing each member's contribution to the EU's 2030 climate targets. Lithuania adopted the NECP from 2021 to 2030, which details a series of steps aimed at achieving various policy goals such as decarbonization of the energy sector, enhancing energy efficiency and increasing the use of renewable energy in public and residential buildings, reducing the population's energy poverty, and becoming a leader in energy technology innovation to ensure energy security. The NECP was developed in parallel with the 2021–2030 National Progress Plan, the objective of which is to assess the country's long term development goals and priorities to ensure progress in social, economic, environmental, and security areas. For long-term action in the period of 2030–2050, Lithuania adopted the National Energy Independence Strategy (NEIS) in 2012. The NEIS's main strategic goals are "to increase the share of electricity production from RES (renewable energy systems) in the final electricity consumption up to 45% in 2030 and 80% in 2050" [8,29,30]. Table 1 summarizes the energy and climate targets of Lithuania that are contained in the NEIS and the NECP. For the mid-term period, Lithuania's goals are to reduce non-ETS (Emissions Trading System) sector emissions by 9% compared to 2005. For the long-term period, the country must increase the total share of renewable energy systems (RESs) in the total gross energy consumption by up to 80%. For medium- and long-term objectives, Lithuania aims to cut GHG emissions by at least 40% by 2030 and to become carbon neutral by 2050 from 1990 levels, with 20% of reductions coming from land use and forestry sectors [7,13,29].

Lithuania's general energy policy objective is to guarantee sustainable energy security provided at competitive prices [31] that aligns with the international climate agreements and the SDGs. As the purpose of the study is to analyze the interplay between energy policies and sustainable development, Table 1 presents the targets contained within the NEIS and the NECP for the years 2030 and 2050, along with the SDGs relevant to the National Progress Plan main energy-focused objectives [13]:

1. To enhance environmental quality and resource sustainability, reduce Lithuania's contribution to climate change, and raise its climate resilience;
2. To improve the energy sector's competitiveness;
3. To merge Lithuania's natural gas market with the single EU gas market;
4. To connect Lithuania's power grid with the continental European grid to enable synchronized operation;
5. To maintain and improve the reliability and local contribution of the Lithuanian electricity market and power system;
6. To reduce energy poverty among the population;
7. To expand the use of renewable and alternative fuels in the transportation sector and support sustainable intermodal mobility;
8. To raise the proportion of renewable energy used in national energy production and gross energy consumption and implement measures to cut down pollution in the energy sector;
9. To enhance energy efficiency and the utilization of renewable energy in residential and public buildings.

Table 1. Interplay between NEIS/NECP targets and SDGs. Adapted from [29], Table 2.1; adapted from [13], Table 1.1.1.

NEIS/NECP Targets	2030	2050	NPP ** Objectives	SDGs
GHG reduction under the Doha amendment to the Kyoto protocol and Paris Agreement, compared to 1990 level	At least −40%	Net zero	1, 6, 8	7.1, 9.1, 11.b ***, 13.2

Table 1. *Cont.*

NEIS/NECP Targets	2030	2050	NPP ** Objectives	SDGs
GHG reduction in the EU ETS sectors compared to 2005 level	−43%	--	1, 8	13.2
GHG reduction in the EU non-ETS sectors compared to 2005 level	−9%	−95% (energy and transport)	1, 6, 8	13.2
Share of RESs in gross final energy consumption	45%	80%	8, 9	7.2, 8.2
Use RESs in transport	15%	50%	5, 6, 7	7.2, 11.2
Electricity interconnection	15%	--	4	7.a ***, 7.b
National contribution for energy efficiency (in Mtoe) - Primary energy consumption - Final energy consumption	PEC—5.4 FEC—4.5	Reduce primary and final energy intensity * by 2.4 times (from 2017 levels)	6, 8, 9	1.2, 7.3

* Energy intensity is often used to measure energy efficiency, and it is calculated as units of energy per unit of GDP [32]. ** National Progress Plan. *** targets a and/or b of the SDG.

3. Methodology

This section outlines the systematic approach used to conduct the critical review, which explores the interplay between energy policies and Sustainable Development Goals (SDGs) within Lithuania's energy sector. The critical review aims to analyze the existing body of knowledge related to Lithuania's energy policies and their alignment with SDG7 (Affordable and Clean Energy) and other relevant SDGs. The review method follows a qualitative approach, where data from various sources are compared and critically assessed.

The review process involved collecting data from academic journals, reports, case studies, and policy documents. The first step of the process was to collect the data from the chosen databases, "Elsevier's Science Direct" and "Google Scholar", using the following keywords defined for the search: "energy efficiency", "renewable energy", "energy security", "Lithuania", and "energy policies". Boolean operators (AND, OR) were used to combine different terms, and filters were applied to limit results to publications between 2010 and 2024 and English language articles. The period from 2010 to 2024 was selected with the purpose of covering an important energy transition period in the country marked by the shutting of the Ignalina Nuclear Plant in 2009. Many results came back from the strings: Science Direct (n = 113) and Google Scholar (n = 13,140). All results from Science Direct were scoped to determine if a further analysis was pertinent. Only the first 150 search results from Google Scholar were scoped to determine if further analysis was pertinent.

The literature was selected based on three main inclusion criteria: (1) publications related to the energy sector in Lithuania, and covering policy implementation and/or impacts in the context of any of the three main focus areas, that is, EE, RE, and ES; (2) studies which indicate a relationship between energy policies and one or more SDGs, especially SDG 7 and SDG 9; (3) articles that provide quantitative or qualitative data regarding EE, RE, or ES outcomes or case studies relevant to the Lithuanian context. The exclusion criteria were the following: (1) literature not directly related to Lithuania's energy sector and to at least one of the focus areas defined; (2) publications in languages other than English. Once the initial pool of literature was selected, the next step was to conduct a screening of their titles and abstracts. Articles and documents that did not cover the inclusion criteria were no longer considered. The following step was to read the articles in full to assess their depth of analysis, methodological rigor, and relevance to the Lithuanian energy sector. After completing the reading, the documents were classified in the three focus areas to facilitate the critical analysis by comparing their results regarding the success of policy implementation, as well as shortcomings and potential alignment with SDGs. The critical review and the analysis of synergies between energy policies and SDGs are presented separately in Section 4. The implemented methodology is presented in Figure 3.

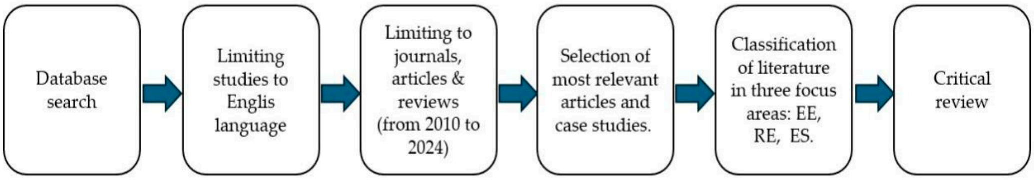

Figure 3. Methodology.

To broaden the scope of the review, four semi-structured interviews were conducted on stakeholder perceptions of energy policies in Lithuania. These surveys included both the positive aspects of policy implementation and the perceived drawbacks, as well as possible ways for improvement. The interviews with the participants were conducted via email and via video call, with those who agreed to meet with the interviewer. The questions addressed in the survey are available in Appendix A of this document, while Table 2 summarizes the arrangement of the survey, maintaining the anonymity of the participants based on their request. The answers to the questions were obtain in both the English language and Lithuanian language, and the results of the interviews are analyzed in the Discussion Section of this article.

Table 2. General description of interview design. Adapted from [33].

Participant Function/Entity	Method of Contact	Date of Survey
Sustainability partner, energy industry	Video call interview	27 September 2024
Legal counsel, private production company	E-mail interview	7 October 2024
Member of National Network of Green Municipalities	E-mail interview	27 September 2024
Director of smart energy consulting company	E-mail interview	3 October 2024

4. Critical Review and SDGs Analysis

4.1. Critical Review of the Literature

4.1.1. Energy Efficiency

Until the year 2010, the Lithuanian energy sector was characterized by energy generation capacities that exceeded the national demand. The turning point at the end of 2009, caused by the closing of Ignalina Nuclear Power Plant, directed the country to become dependent on energy imports of both electricity and natural gas [34]. Because of the plant closure, the main energy policy of Lithuania, the Law on Energy Efficiency, was reviewed, carrying with it the strengthening of energy structure development, like a high-voltage grid interconnection with other member states that launched later in 2017 [35]. Shortly after, in 2012, the Energy Efficiency Directive 2012/27/EU was proposed with the main goal of achieving a reduction of 20% in primary energy consumption by 2020 [36]. Currently, the NEIS is the country's leading energy policy document that, in the area of energy efficiency, aims to achieve a primary and final energy intensity that is 1.5 times lower than the 2017 level by 2030, and approximately 2.4 times lower by 2050, as specified in Table 1.

In the study conducted in [37], the authors focused on the evaluation of energy efficiency policies in Lithuania within the context of EU directives and national goals. The document emphasizes the need for a clear distinction between energy intensity reduction due to efficiency improvements and the downscaling of energy-intensive activities. The research highlights specific programs and measures, such as the modernization of apartment complexes, renovation of public buildings, voluntary agreements with industry, and infrastructure improvements in the transport sector. To evaluate the success of energy efficiency policies, the authors established three main categories: effectiveness (achieved energy savings, in GWh), efficacy (achieved savings compared with targets, %), and cost efficiency (achieved energy savings compared with costs, KWh/LTL). The most significant energy savings found were reported in the service sector, while the energy production sector ranked second. However, they noticed that the potential for energy savings in the household sector, particularly through behavioral changes, was underutilized. They also found that the economic efficiency of implemented energy efficiency policies was low, indicating the need for more cost-effective policies and measures, especially in the transport sector. Their comparative assessment indicates that while some sectors have successfully met or exceeded their energy-saving targets, others, like the household and energy sectors, have fallen short, pointing to the need for revised or additional measures to meet national and EU energy efficiency goals. Additionally, for this sector, the authors identified significant energy-saving potential through behavioral changes, such as information campaigns and home energy audits. These measures are practical and can be implemented at relatively low costs.

The research conducted in [37] set a broad and inclusive approach to the Lithuanian energy policies. By the time of the study, the author was able to identify a lack of harmonization between policies addressing energy efficiency and climate change mitigation. Similar studies carried out in [38,39] also point out that the primary focus of energy efficiency and climate change mitigation policies in the EU and Lithuania had been on the supply side of energy and industrial users, highlighting that household efficiency has a significant potential of study for policies implementation. The focus on residential infrastructure is especially important in Lithuania because buildings make up a large share of the country's energy consumption. By 2021, there were 1.4 million dwellings in Lithuania, of which only 167,000 were built after 1995, which translates into old infrastructure with poor insulation materials, outdated heating equipment, and poor or non-existent bioclimatic design [29,40].

In [38], researchers turned their study to the critical role of households in energy savings and sustainable use. They continued the analysis presented in [37], showing how behavioral changes and the adoption of energy-efficient appliances are two ways in which households can contribute to energy-saving and reduction in GHG emissions. The research uses an interesting approach to evaluate energy policies: SWOT (Strengths, Weaknesses, Opportunities, Threats) and PEST (Political, Economic, Social, Technological) analyses. This approach is beneficial, because it serves to assess the effectiveness of Lithuania's climate change mitigation policies across various sectors, including housing, transport, energy, and education. Through the SWOT analysis, the paper identifies the strengths of Lithuania's policies in promoting energy efficiency in apartment buildings and transport, as well as in raising public awareness through various media and educational programs. The use of correlation analysis to identify the impact of various drivers on energy consumption across different countries (Lithuania, The Netherlands, the United Kingdom, Germany) is a robust methodological choice, offering comparative insights. The research detected weaknesses in policies, for instance, the excessive costs of technology, underdeveloped financing mechanisms, and a general lack of knowledge within the population, which slow down the implementation of energy-saving measures. The PEST analysis complements this by looking at the macro-policy environment and strategic planning tools that can select new policies. It emphasizes the influence of political stability, tax rates, social values, technological advancements, and innovation on energy consumption and savings behavior. The researchers concluded by suggesting that Lithuania's GHG emission reduction efforts should primarily be directed towards improving energy efficiency, parallelly highlighting that this goal can only be achieved when the gap between the legislative framework and implementation of concrete measures is closed.

Another interesting case study that assesses potential energy savings in the Lithuanian building sector is presented in [39]. The study provides a comprehensive analysis aimed at evaluating feasible energy savings in space heating and hot water by 2030, emphasizing energy efficiency solutions for a total of 30 building types. The research employs various cost curves to represent both investor and overall economic perspectives on energy savings potential. The methodology includes analyzing the Lithuanian building inventory, calculating energy demand, evaluating the cost-effectiveness of investments, and deriving cost curves based on a comprehensive data set that includes the decomposition of supplied energy for buildings: biomass, coal, district heat, gas, and oil. The study concludes that a 56% reduction in final energy demand is achievable by 2030 if least-cost energy efficiency solutions are selected for each building type. Specifically, implementing energy performance class A measures in pre-1990 apartment buildings supplied by district heating emerges as the most cost-effective technological strategy. In line with the findings of [37–39], the study underscores the need for policies that encourage building renovation, particularly focusing on structures with low energy performance, and promote deep renovation to prevent lock-in effects and facilitate the transition to nearly zero-energy buildings. The robust methodology presented in [39], which combines the Fisher Ideal Index and Logarithmic Mean Divisia Index, provides a solid foundation for analyzing energy intensity and GHG emissions.

Up to now, we have analyzed how national energy plans, energy efficiency programs, and related planning documents typically include goals and strategies aimed at reducing energy intensity [35]. Energy intensity is known as the most common indicator to measure changes in energy efficiency [32]. The possibility of energy intensity reduction differs among countries and is conditioned by factors inherent to their characteristics, but it is possible to compare trends and drivers, especially if similar or the same policies are adopted. The study performed by Ref. [41] explores the strategic importance of enhancing energy efficiency in the Baltic countries—Estonia, Latvia, and Lithuania—as a vital component of transitioning to a low-carbon economy. The paper inspects the trends in energy intensity from the years 2000 to 2018 within the context of the EU's energy and climate framework and analyzes variations in the energy intensity of these countries in three principal areas: primary and final energy intensity, and sectoral energy intensity. The study employs the Fisher Ideal Index to discern contributions from increased energy efficiency and structural changes within these economies. Three main strengths can be listed for the research conducted in [41]: (1) the analysis spans nearly two decades, providing a broad view of energy efficiency trends and their implications for sustainable energy sector development; (2) utilizing the Fisher Ideal Index adds a layer of depth to the analysis, allowing for a better understanding of how energy efficiency improvements and economic structural changes have contributed to trends in energy intensity; (3) the paper goes beyond aggregate measures, investigating sector-specific energy intensity trends, which is crucial for targeted policy interventions. Although the progress made by the Baltic States in reducing energy intensity is significant, the sector-specific analysis suggests that targeted interventions in sectors like transportation and industry could produce substantial energy savings.

The research of Ref. [42] examined energy intensity and GHG emissions in the three countries—Lithuania, Latvia and Estonia—focusing specifically on the manufacturing sector during the period of 2010 to 2020. The researchers carried out a study of how improvements in energy efficiency and shifts in the structure of manufacturing activities within those countries impacted their energy consumption rate, achieved overall energy savings, and reduced GHG emissions. The research methodology starts by analyzing time series data for energy consumption within the manufacturing industry of each country and calculating their energy intensity. By doing so, the authors identified how the influences of various factors such as labor productivity and improvements in the consumption of fossil fuels contribute significantly to the sector's progress in mitigating climate change. The decomposition analysis of GHG emissions indicated that lower energy intensity and reduced fossil fuel use played a key role in cutting GHG emissions across the three Baltic countries. However, these efforts seemed to be somewhat offset by the rise in the production rate during the examined timeframe which led to an increase in personnel and emissions intensity. The authors conclude by stressing the importance of incorporating RESs in all sub-sectors of the manufacturing industry to further enhance the decrease in GHG emissions. This study offers valuable insights into the specific contributions of different drivers to changes in energy intensity and GHG emissions, which can inform targeted policy interventions. However, while the paper points out the necessity for updated policies, it could benefit from a more detailed exploration of specific policy recommendations and strategies to address the identified challenges. Further studies could explore the impact of emerging technologies and innovations in the manufacturing sector to achieve national and EU emissions targets.

4.1.2. Renewable Energy

The correlation between energy efficiency and renewable energies is a keystone of the global transition towards sustainable energy systems. While both are critical for reducing GHG emissions and mitigating climate change, they function in complementary ways that together enhance the overall sustainability of energy systems [43]. By 2030, Lithuania aims to have a minimum of 45% of its energy consumption sourced from renewable energy. By 2050, the government is aiming to achieve 80% of the overall energy demand from renewable sources and to reach 100% renewable energy usage in electricity generation, as shown in Table 1.

The study of Ref. [44] is a thorough analysis examining the GHG emission trends and the efficacy of climate change mitigation policies in Lithuania and Bulgaria's fuel combustion sectors. The study emphasizes that, despite having comparable economic statuses and historical backgrounds, the two countries have adopted key EU energy and climate policies, yet have experienced different degrees of success in reducing GHG emissions. The document begins by asserting the cruciality of climate policies in the EU's energy sector, noting that fossil fuel combustion remains the leading human-caused contributor to GHG emissions. Later, it presents a comparative analysis by examining reports to the United Nations Framework Convention on Climate Change, delineating the key areas and potential for GHG emission reduction, as well as the driving forces behind these changes. An observation from the study is the difference in the effectiveness of the mitigation policies between the two countries. Bulgaria's policies, which prioritize switching from coal to natural gas, are less efficient than Lithuania's, which focus on improving energy efficiency and integrating renewable energy sources. The analysis delivered by Ref. [44] helps in understanding the complexity of implementing climate change mitigation policies in transitioning economies, and it serves as a reference to demonstrate the efficacy RESs can achieve over conventional energy sources.

The research of Ref. [45], different from Ref. [44], adopted an economic perspective. Their primary aim was to assess whether and how the use of RES impacts Lithuania's real GDP, with a particular focus on calculating the elasticity coefficients of real GDP to RES use. The study employs unit root tests, co-integration tests, and Granger causality tests to analyze the relationship between the two variables. These methods help determine the stationarity of the time series, the long-term equilibrium between the variables, and the directionality of any causal relationships. The analysis reveals a unidirectional causality running from RES use to real GDP in the short term, suggesting that increased employment of RESs could positively impact Lithuania's economic growth in the short term. However, a long-term effect of RES development on real GDP was not found. Because the study of Ref. [45] centers on a specific country and period, it allows a detailed insight into Lithuania's national context. This narrow analysis facilitates national policymakers to use the study as a reference to explore the interrelationship between RES and economic growth.

Ref. [46] presented results through the implementation of the NEIS targets and EU Directive 2009/28/EC on the encouragement of RES adoption. The authors examined the changes in Lithuania's total inland fuel and energy consumption from 2012 to 2017, revealing an increase in the proportion of renewable and domestic energy sources from 19.4% to 24.6%, and a rise in electricity's contribution from 7.7% to 9.7%. Their research shows that during this period, the share of renewable energy sources in total final fuel and energy consumption grew from 21.4% to 25.6%. Additionally, the percentage of RESs in gross final electricity consumption rose from 10.9% to 16.8%, and in total heating and cooling usage, it increased from 34.6% to 46.5%. Although the largest quota of RESs in the country came from biofuels, like wood and agricultural waste, wind energy performed second as a source of alternative fuels with a change from 2000 to about 5000 TJ of produced energy for the period of the study. At the same time, the authors analyzed the change on GPD in Lithuania, which increased 1.3 times from 2012 to 2017, as a measure to assess economic development and as a way towards energy security and independence. These results can help corroborate the research of Refs. [44,45] by demonstrating how implementing assertive RES policies in transitioning economies can boost GHG emission reduction while having a positive impact in economic growth.

While it is important to focus on the evolution of RES implementation in a specific country, it is worth comparing results obtained in geopolitically similar nations and assessing the differences in EU policies across its Member States. The studies conducted on [47,48] focus on the results that energy policies have in the Baltic States—Lithuania, Latvia, and Estonia—from an RES perspective. On one hand, Ref. [47] provides a systematic examination of RES deployment trends in the three member states from 2010 to 2019, effectively contextualizing these trends within EU energy policies, particularly the Renewables Directive 2009/28/EC. By 2019, the share of RESs in the gross final energy consumption within the Baltic States surpassed the minimum targets set in the directive. All countries' results were positive with different percentages of the achieved share of RESs. Lithuania surpassed the mandatory target by 10.7%. The study also demonstrates that the proportion of RESs in the final energy consumption for cooling and heating in Lithuania was higher than planned in Lithuania by 20.1%.

On the other hand, Ref. [48] offers a comprehensive analysis of the achievements of the Baltic States in meeting the EU's 20-20-20 climate and energy targets, which included a 20% cut in GHG emissions from 1990 levels, ensuring 20% of energy consumption from RESs, and achieving a 20% improvement in energy efficiency by 2020. The research of Ref. [48] developed an indicator framework consisting of three areas: energy efficiency, renewable energy, and GHG emissions reduction. The indicators' description and relevance were summarized in a table to facilitate differentiation and tracking. The results in [47,48] highlight that while the Baltic States have met the 20-20-20 targets, the levels of achievement vary among the countries, with Lithuania showing the second overall performance, after Latvia. Nevertheless, all three member states compared poorly in comparison with general EU levels, with the energy intensity as high as double the EU-27 average. The variation in energy intensity is attributed to differing national policies, economic structures, and resource availability. Both Refs. [47,48] stress the achievement of the Baltic States in increasing their share of renewables in their energy mix, attributing part of the success to the transition from Soviet-era outdated and inefficient systems.

An applied study conducted by Ref. [49] assessed the contribution of local-level initiatives in Lithuania towards sustainable energy development and climate change mitigation. It specifically examines the role of renewable energy in this context by analyzing Sustainable Energy Action Plans (SEAPs) from various Lithuanian municipalities. The research employs a mixed-method approach, combining SWOT analysis with expert surveys to evaluate the effectiveness of SEAPs. This approach enables a comprehensive understanding of the strategic position and the practical implications of local renewable energy initiatives. The SWOT analysis conducted on the SEAPs indicates a range of strengths, including existing legal frameworks and infrastructures that support renewable energy development. However, weaknesses such as insufficient funding, lack of coherent policies at the municipal level, and inadequate public awareness about renewable energy benefits are notable obstacles. The expert survey emphasizes the prioritization of building renovations and the modernization of energy infrastructure to enhance energy efficiency. One of the main takeaways from this paper is the identification of contradictions between state and municipal legal acts and energy security objectives. Another important finding is the impossibility of fully developing renewable energy projects at the rural level for economic and legislative issues, which are controlled by the government or municipal councils. Even when Lithuania has adopted legal acts that aim at implementing renewable energy technologies, the researchers maintain that there is no allocation of funds to secluded or small cities, forcing the citizens to continue using fossil fuels for their daily activities.

4.1.3. Energy Security

Russia's illegal invasion of Ukraine ratifies the necessity for energy security for all Member States of the EU [50]. This pressing event locates energy security at the same level of importance as energy efficiency and renewable energies. Considering the long and distressing history between the Baltic States and Russia, it is pertinent to underscore the urgent need to reinforce measures and policies that help speed up Lithuania's energy transition and terminate energy imports from the Russian Federation.

In the research conducted by Ref. [51], scholars explored Lithuania's transition from high dependency on imported electricity to renewable energy sources as part of its national energy strategy. The study scrutinizes the Copenhagen Securitization Theory to examine how perceptions of energy security have influenced Lithuania's shift in energy policy. According to the Copenhagen theory, energy politics and policies are directly determined by the socially constructed perception of energy security. The research states that about 70% of Lithuania's electricity consumption had been generated abroad by a single provider, Russia, until 2015. Despite Lithuania's initial pro-nuclear stance, the country transitioned to a renewable-focused national energy strategy within a decade. The research suggests that this shift was driven by concerns over potential energy security risks. The document traces the political processes that led to two distinct national energy strategies between 2009–2012 and 2013–2018. The findings indicate that the adoption of renewable energy policies was not directly due to energy security concerns related to dependency but rather followed the de-securitization of energy supply. The researchers present an insightful geopolitical analysis, suggesting that the war-related crisis in Eastern Europe could affect the landscape of renewable energy adoption, potentially deterring the transition due to amplified energy security concerns.

It is worth highlighting how Ref. [51] challenges the notion that direct energy security concerns drive renewable energy adoption. Instead, it suggests that a level of perceived energy security must first be established before renewables become a central part of energy strategy. Going deeper into the Lithuanian case, it is a good suggestion from the study that the transition towards renewable energy in the country appears to be influenced by a combination of internal policy shifts and by external geopolitical factors. This perception provides valuable insights for other countries and regions facing similar energy security challenges, suggesting that the path to renewable energy adoption might first require addressing and mitigating immediate security concerns.

Before the geopolitical conflicts that escalated in 2022 between Ukraine and Russia, and consequently the EU, studies conducted in the Baltic States were already assessing the influence that energy efficiency, renewable energies, and energy import dependence had in achieving energy security. The research by Ref. [52] provides an analysis of energy security trends across Estonia, Latvia, and Lithuania during the period from 2008 to 2012. The study employs multi-criteria decision-making techniques to develop aggregate measures of energy security, using a range of indicators—economic, social, and environmental—aligned with the priorities of European Union energy policy. This approach, which incorporates both Data Envelopment Analysis-linked and modified Simple Additive Weighting methods for weight calculation, is tough and innovative because they increase the objectivity and reliability of the analysis. The simultaneous comparison between the three countries' energy security status shows that Lithuania performed very poorly in terms of energy dependency indicators, despite having a decent performance of renewable energy and carbon intensity indicators, in comparison with Latvia and Estonia. Considering that previous similar studies on energy security in the Baltics had only focused on energy storage and security of supply [53,54], this research broadened the perspective on how social, environmental, and economic indicators can be implemented. The comparison among the Baltic States positioned Latvia as the best-performing country in terms of energy security, while previously Estonia had taken the higher rank. This is an insightful takeaway from the study because it provides evidence that limiting or modifying the selection of indicators provides different perspectives, so this result could encourage other researchers to create different frameworks for assessing policy implementation in terms of the specific case of each country or study group.

For the Baltic Sea region (BSR), and particularly for countries that are heavily reliant on imported energy, ensuring energy security involves diversifying supply sources, reducing dependency on single suppliers, and increasing the resilience of energy infrastructure [55]. The paper by Ref. [56] addresses these concerns through the development and expansion of Liquified Natural Gas (LNG) infrastructure through the lens of the Network of Adjacent Action Situations framework, presenting LNG as a strategic solution to enhance energy security in the BSR. The document emphasizes the polycentric nature of energy governance and highlights how interconnected policy areas influence infrastructural decisions and outcomes. The author highlights the transition from state-controlled to privatized energy infrastructure and the resulting complexities in governance with the use of the Network of Adjacent Action Situations framework, which links multiple policy areas and demonstrates how decisions in one area impact others. According to the author, the LNG infrastructure in the BSR offers a critical alternative to the Russian pipeline gas, enabling countries to diversify their energy sources and enhance energy security by mitigating supply disruptions and geopolitical risks. The development of LNG terminals in Lithuania, Poland, Finland, and Sweden, symbolized by Lithuania's "Independence" terminal, illustrates a strategic push towards greater energy independence and increased bargaining power in the energy market.

Europe's energy dependence on Russia is not limited to Eastern Europe, but also extends to Central Europe and some Western European countries, such as Germany. In the analysis of Ref. [57], the authors examine the impact of Russia's cut of gas supply to EU after the aggression against Ukraine, which accounted for 45% of the block natural gas imports. Germany's response to the supply cut was shifting to piped gas from Norway and LNG via Belgium and the Netherlands. While some countries from the Visegrád Group—like Poland—saw the decrease and eventual ceasing of Russian supply as an opportunity for energy independence, Hungary continued to maintain business with the aggressor country and even increased its imports. With the expansion of LNG capacity, the authors explain how Member States like Germany, Lithuania, Croatia, and Poland could increase their needs from 200 TWh/year to 500 TWh/year. The shift towards RESs came along stronger after the war started, with some easing of regulations to support the initiative so that ambitious plans like Germany's goal to triple wind and solar capacity by 2030, that is, from 440 GWh/day to 1200 GWh/day, might be achieved. Other EU countries, like France, the Czech Republic, Hungary, Slovakia, and Poland plan to expand their nuclear power capacities, which can help in reducing the consumption of fossil fuels, yet these projections are set for the long-term and some of the plants in central European countries still depend on Russian fuel for their operation, perpetuating concerns about energy security through energy weaponization.

In the research of Ref. [58], the authors conducted a broader analysis of energy security goals' effectiveness across all the EU-27 countries between 2010 and 20120, from two different angles: a traditional energy-economical approach and a sustainable energy-security perspective that incorporates environmental and social factors on top of traditional ones. The study starts by setting a list of indicators that characterize energy security from energy, economic, social, and environmental factors. The authors used a Multi-Criteria Decision-Making method to weigh the selected indicators with the combination of Criteria Importance Through Intercriteria Correlation and Standard Deviation methods. A second Multi-Criteria Decision-Making method was implemented to determine an index for assessing the EU-27 in terms of energy security: Gray Relational Analysis and the Technique for Order of Preference by Similarity to Ideal Solution methods. The results show that Scandinavian countries have the highest level of energy security along with France, attributed to the use of nuclear energy. The countries with the lowest performance were Cyprus and Malta due to their practically non-existent self-supplied source of energy. From a sustainable energy-security perspective, countries like Sweden, Finland, Belgium, and the Netherlands performed well. From the BSR countries, only Latvia figured in the list. During all years evaluated in this research, Lithuania showed a poor performance from both perspectives, and even when there have been improvements in the share of RESs, the study positions the Baltic country in the warning level for energy security.

4.2. Linking Studies to SDGs

Tables 3–5 provide an overview of how the analyzed research studies align with specific SDG targets. They highlight the interconnected nature of energy policies, renewable energy adoption, and energy security with global sustainability goals. The studies collectively support the interplay between SDGs and energy policies: the expansion of renewable energy and improvements in energy efficiency (SDG 7) directly contribute to the reduction of carbon emissions, a primary driver of climate change (SDG 13) by transitioning away from fossil fuels to renewable energy sources and paving the way to achieve energy independence. Implementing SDG 7 can lead to significant co-benefits for climate action, such as reduced air pollution, which in turn has positive effects on public health and productivity (SDG 11). Equally, pursuing SDG 13 by focusing on lowering carbon emissions will often involve strategies that are also favorable to achieving SDG 7, such as promoting the adoption of green technologies and enhancing energy efficiency.

Referring to the literature that analyzes the EE and RE spheres, it can be observed that targets 7.2 and 7.3 are properly covered, which can be linked to the significant efforts of Lithuania to increase the share of RESs by the expansion of alternative energy sources infrastructure such as wind power, and to increase to 80% the total share of renewable energy systems in total gross energy consumption. From the selected literature, it can also be noticed that the efforts to address the inefficiency of old building infrastructure in the country are significant and that simple suggestions like changes in population behavior could result in significant changes for this sector. Then, as previously stated, the progresses of policies addressing energy efficiency are directly linked to innovations of RESs and they need to be constantly reviewed and reconsidered in order to have a proper alignment with technological upgrades.

Table 3. The interplay of the analyzed literature with the SDGs targets—EE.

Research	SDG Targets Addressed
[37]	• Comprehensive overview of Lithuania's energy efficiency policies across multiple sectors—energy production, household, service, and transport. Good performance of sectors to support 7.2, 9.1 in the service sector, and need to improve 11.2 for the transport sector. • The analysis of specific programs and measures, like the modernization of buildings and the promotion of cogeneration, supports targets 11.1 and 11.6, and subsequently contributes to target 13.2.
[38]	• The emphasis on public education and behavioral changes in energy consumption analyzed in this research supports targets 12.8 and 13.2 by promoting sustainable practices and reducing emissions, while directing impacting 7.3, 9.1, and 11.1.
[39]	• The paper emphasizes the need to rush the renovation of pre-1990 apartment buildings in the country and to push for nZEBs, supporting targets 7.3 and 11.3. • The decrease in energy use in buildings leads to lower GHG emissions, which is crucial for mitigating climate change (13.2).
[41]	• The analysis of primary and final energy intensity trends, along with the implementation of cost-effective energy efficiency measures, supports the goal of providing sustainable and modern energy (target 7.1). • By examining the factors that drive energy efficiency, the paper highlights the importance of responsible energy use (12.2).
[42]	• The authors discuss the increasing consumption of RESs in manufacturing, aiming to enhance the share of clean energy in the energy mix (7.2) and emphasize the improvement of EE in the sector, which aligns with the goal of doubling the global rate of improvement in EE (7.3). • The study highlights the structural changes in activities and the deployment of RESs as key drivers in reducing energy intensity and GHG emissions in manufacturing (9.4).

Table 4. The interplay of the analyzed literature with the SDGs targets—RE.

Research	SDG Targets Addressed
[44]	• The article emphasizes energy efficiency measures, like the upgrading of power plants and the promotion of combined heat and power systems, supporting the goal of doubling the global rate of improvement in energy efficiency (7.3). • The paper highlights improvements in EE and the development of low-carbon technologies in the energy sector through the modernization of infrastructure, including district heating systems and smart grids (9.4), and by addressing the reduction in GHG emissions with increased use of RESs (12.2); the article indirectly supports the goal of reducing the adverse per capita environmental impact of cities, and of creating more sustainable environments (11.6). • The study enhances understanding of the drivers and impacts of GHG emissions and the effectiveness of different mitigation policies, contributing to adaptation, impact reduction, and early warning (13.3).
[45]	• The study directly addresses economic growth by examining how renewable energy consumption (7.2) influences Lithuania's real GDP (8.1) and improves global resource efficiency in consumption and production (8.4). • The article supports the modernization and sustainable development of infrastructure (9.4) for the use of RES over fossil fuels (12.2). • The article enhances the understanding of the role of renewable energy in economic growth, contributing to improved education, awareness, and capacity on climate change mitigation (13.2, 13.3).
[46]	• The authors discuss the increase in the proportion of RESs in Lithuania's total inland fuel and energy consumption (7.2) by the development of new infrastructure (9.4, 9.B) like wind power plants, which is projected to produce over 50% of electricity by 2050. • By highlighting the growth in renewable energy production, such as wind and biogas, the article supports the target of doubling the global rate of improvement in energy efficiency (7.3), outlining Lithuania's targets for increasing RESs in final energy consumption for 2030, 2040, and 2050 (13.2), and simultaneously supporting rationalizing inefficient fossil-fuel subsidies that encourage wasteful consumption (12.C).
[47,48]	• The articles discuss the increase in the share of RESs (7.2) in final energy consumption in the Baltic Countries across various sectors. By analyzing the progress towards achieving 20% of renewables in final energy consumption, they promote access to more affordable and modern energy services through a more solid and realistic integration of climate change policies and strategies in the region (7.1, 12.2, 13.2).

Table 5. The interplay of the analyzed literature with the SDGs targets—ES.

Research	SDG Targets Addressed
[51]	• The article discusses Lithuania's transition from high energy dependency on Russia to increased use of RESs (7.2) and the integration of the energy system with the European grid (9.1, 9.4). • The article points out Lithuania's collaboration with other European countries and its integration into the broader European energy market (17.7), essential for achieving the national energy independence strategy.
[52]	• The authors present energy security in the context of the availability and affordability of energy by analyzing energy prices for medium-sized industrial users (7.1), while improving energy intensity and efficiency in the BSR, touching target 7.3 and 13.2.
[56,57]	• The articles explore the role of LNG as a transition from fossil fuels and the long-term goal of increasing the share of renewables in the energy mix and characterizes this infrastructure as a way of enhancing energy security for the BSR and all EU-27 (7.1, 7.2, 9.b). • The articles stress the importance of international cooperation and partnerships in achieving energy security and sustainability (17.7).
[58]	• By assessing energy security from both traditional and sustainable perspectives, the study underscores the need for consistent, secure, and increased energy supplies at reasonable prices (7.1, 7.3)

When it comes to ES, it is noticeable that long-due Russian energy dependency concerns obliged not only Lithuania, but the entirety of Europe, to commit even more to the development of alternative energy sources for gas and other fossil fuels, and to increase the global rate of improvement in EE. The analyzed literature shows a positive response in international cooperations and partnerships within Member States, which expands the interconnection of EE, RE, and ES beyond an environmental and economic perspective.

5. Discussion

This review of Lithuania's energy policies and their alignment with the Sustainable Development Goals showcases the progress of the RES sector and its impact on the country's energy efficiency goals. The findings indicate strong adherence to SDGs 7, 9, 11, 13, and 17, emphasizing the nation's commitment to fulfill the local and international energy and climate change targets contained in the NEIS, NECP and NPP. While the reviewed studies provide comprehensive data on the increase in renewable energy consumption and improvements in energy efficiency, many of the studies lack implementation barrier analysis, which could offer deeper insights into long-term impacts, and they could benefit from a more detailed exploration of specific policy recommendations and strategies to address the identified challenges. It can also be noticed from the studies that provide insights into the potential for energy savings in Lithuanian residential buildings and the effectiveness of current policies, that the measures and policies in this area could be enhanced by incorporating a more detailed analysis of the barriers to the adoption of energy-saving measures by households, including financial constraints, lack of information, and behavioral factors. They could also benefit from more conclusive evidence through the inclusion of surveys that measure citizens' knowledge of energy-efficient technologies. A weakness encountered is that the reliance on existing data sources may limit the ability to capture real-time changes in building stocks and energy efficiency measures, potentially affecting the accuracy of projections. Future research could expand on the integration of renewable energy sources with energy efficiency measures to provide a more rounded approach to achieving SDG 7 and an analysis of accessibility for the population regarding economic incentives and subsidies for citizens to upgrade their households' energy class to A, A+, or A++.

Although the progress made in Lithuania in reducing energy intensity in the building sector is significant, the sector-specific analysis found in the literature suggests that targeted interventions in other sectors like transportation and industry could produce further substantial energy savings. The studied literature reveals that it would be beneficial for future studies addressing energy policies implementation to turn their attention to the impact of emerging technologies and innovation, for example, in the manufacturing and production sectors, for energy efficiency and energy intensity improvement and subsequent GHG emissions reduction. For instance, the studied case of Lithuania–Bulgaria climate change mitigation policies revealed that the implementation of RESs to achieve emission reductions translated into better results on improving EE than focusing on switching from coal to natural gas. Yet, it is important to consider that results at the country level vary significantly depending on specific national policies and their implementation approaches. According to the perceptions obtained from stakeholders interviewed during the surveys, results in the national energy policies progress could be more accurate if there were more monitoring strategies, like real-time measurement of energy use. Some of the feedback from the experts pointed out that many regulations are measured from an ISO standards perspective that does not really consider changes in energy intensity, and that companies can change their consumption behaviors, possibly leading to almost instantaneous changes in consumption patterns, for example, reduced energy waste on the user's side.

Bearing in mind that the practical implications for policymakers include the necessity of supporting renewable energy initiatives and integrating climate change measures into national strategies, while allowing flexibility to adapt to regulations and technological changes, and promoting collaboration between all stakeholders, further perceptions and recommendations obtained from the survey are listed below:

- While Lithuanian energy policies are effective in promoting sustainable energy development thanks to their strong promotion of full speed RES development, there is a lack of communication with society and businesses. In both public and private sectors, there is a need for a more systematic approach for policy implementation that includes educational programs and transparent communication.
- Energy policies affect operations and strategic planning in all sectors, especially the energy generation and supply sector. Perceptions from these stakeholders include the challenges associated with planning and operating while legislation changes continuously, and with informing their clients and users about those changes while trying to fulfill their needs. They highlight the necessity of obtaining feedback from the end users regarding changes, and once again consider relevant stronger educational and information campaigns carried out by relevant ministries and local governments.
- Examining the energy sector and the development of RESs, interviewees consider that another main barrier is the acceptance of land and infrastructure documentation, as bureaucratic procedures can be exhausting and difficult to interpret.
- Moreover, they noted that other energy sectors, such as transport and industry, are very sensitive to prices. There appears to be a lack of incentives in these sectors for reducing their GHG emissions, aside from monetary incentives for purchasing electric vehicles (EVs) and installing charging stations. Hence, policies must be more flexible and adaptable to avoid business bankruptcies.
- From the public sector perspective, there are concerns from municipalities regarding financial limitations. An example provided by one respondent is that municipalities are forced to use more RESs and reduce GHG emissions, but at the same time the offered loans are not enough to cover the implementation of green projects. The approach to financial capital should be easier and more focused on direct GHG emission savings' results.
- At the EU level, referring to energy efficiency directives, respondents from the private sector consider policymakers to lack flexibility in interpreting the regulations or directive aims designed to achieve the best results in each country. The suggestion of promoting the collaboration between ministries and energy supply businesses, along with academic researchers, should help a lot to show the real effects or impacts of political measures. This will help to create flexibility and to provide feedback for the EC.

In conclusion, Lithuania's energy policies significantly contribute to achieving the SDGs, promoting global sustainability and climate action. The positive correlation between renewable energy adoption and enhanced energy security underscores the importance of continuing these efforts and achieving energy independence. Future research should focus on the socio-economic impacts of energy transitions, ensuring that all societal sectors benefit from these policies, for which it is fundamental to strengthen communication and educational campaigns and develop more approachable RES infrastructure.

6. Conclusions

Lithuania has made significant advances in achieving its targets under the National Energy Independence Strategy and National Energy and Climate Plan, described in Table 1. By 2022, the country's net GHG emissions were reported to be reduced by 69.3%, compared to 1990 levels, while the GHG emissions in the EU ETS sectors decreased by 55.1% compared to the baseline year of 2005. Referring to the non-ETS sectors—namely transport, agriculture, waste, small industry, and buildings—GHG emissions were approximately 14.2 $MtCO_2eq$, of which the transport sector was the biggest contributor with emissions reaching 6 $MtCO_2eq$. Projections indicate that emissions reduction in the non-ETS sectors can reach up to 15% versus 2005 levels by 2030 if existing measures are adhered to [12,29,59].

One of the most notable achievements is Lithuania's substantial increase in renewable energy capacity, particularly from wind and solar sources, helping the country move closer to its 45% renewable energy target by 2030. According to the country's official statistics portal, the consumption of wind energy, hydro-energy, ambient heat (renewable), and solar energy by 2022 was 5445 Terajoules (TJ), 1672 TJ, 2649 TJ, and 1232 TJ, respectively [60]. By the same year, the share of RESs in gross final energy consumption was reported to be 32.7% and the use of RESs in transport accounted for 6.7% (6.5% from biofuels and 0.2% from electricity) [61]. While the achievements for the share of RESs in final energy consumption are promising and in line with the target, the share of RESs in the transport sector seems to be falling behind the expected results, which were set to be 10% by 2022 and at least 15% by 2030 [62]. Reports indicate that the primary and final energy consumption in Lithuania for the year 2022, in Mtoe, was 6.43 and 5.33, respectively [13,59]. To achieve a PEC of 5.4 Mtoe and FEC of 4.5 Mtoe by 2030, Lithuania relies on efforts to promote the renovation of residential and public buildings and to develop industries that are both low in energy intensity and highly efficient, as well as to improve the transport sector energy consumption by upgrading to an efficient public system and overall fleet of vehicles, optimizing the road infrastructure and increasing taxes on diesel, gasoline, and liquefied petroleum gas [10,29].

Lithuania's efforts to fulfill the NEIS and NECP targets are also in line with the European Union's climate objectives and Sustainable Development Goals (SDGs), particularly SDG 7 and SDG 13. However, several challenges remain. Here are some issues identified by the authors in the studied literature, along with their insights into what needs to be carried out to achieve the goals in a timely manner:

- High Dependence on Biomass and Fossil Fuels (SDG 7, SDG 13). Although Lithuania has increased its renewable energy share, a significant portion comes from biomass, which can contribute to air pollution and carbon emissions [63]. Additionally, Lithuania still provides subsidies for fossil fuels and has not implemented a carbon tax [7,10], which could slow its progress towards a low-carbon economy; hence, implementing carbon taxes is a strong recommendation for policymakers. Furthermore, transport sector emissions continue to be significantly high, wherefore it is fundamental to develop an affordable and efficient transport system [64]. Some measures to facilitate the latter could include lower taxes for EV vehicles and limiting the mobility in congested areas of vehicles that run on fossil fuels.
- Energy Efficiency Gaps (SDG 7, SDG 9). Despite advances in energy efficiency, there is still potential for improvement, especially in older building infrastructure and industrial processes. Limited funding for energy efficiency retrofits and high upfront costs for sustainable technology adoption create barriers to further progress in this area, so it is necessary to speed up the modernization of the building stock as well as improve educational campaigns for citizens to understand the importance of this measure.
- Limited Investment in Green R&D (SDG 9, SDG 13). While Lithuania has made some investments in sustainable technologies, the funding for research and development (R&D) in green innovation remains relatively low, as it was also stated in the discussion section from the survey participants insights. Increased investment in environmental R&D could drive innovation in renewable energy, energy efficiency, and energy independence.
- Public Awareness and Engagement (SDG 13, SDG 12). Although environmental awareness is growing, there is still a need for greater public understanding of climate change and sustainable practices. As stated in the discussion section, engaging citizens in sustainable actions and increasing environmental education can be vital for achieving behavioral shifts toward more sustainable consumption patterns.
- Insufficient CO_2 Pricing Mechanisms (SDG 13). Without a carbon tax or stronger emissions trading mechanisms, Lithuania lacks a key economic tool to effectively price carbon emissions and encourage emission reductions across sectors [7]. Introducing

CO_2 pricing could help align sectoral emissions reductions with national and EU climate targets.

Author Contributions: Conceptualization, A.A.S.; writing—review and editing, A.A.S.; supervision, Ž.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Survey Questions:

1. How effective do you think current energy policies are in promoting sustainable energy development in Lithuania?
2. How do current energy policies affect your business operations and strategic planning in the energy sector?
3. What role do you think government policies play in encouraging innovation and investment in renewable energy technologies?
4. How can collaboration between the public and private sectors be improved to achieve better energy outcomes?
5. Are there any areas or issues you believe do not adequately address current energy policies? If so, what are they?
6. What are the primary challenges your company faces in the energy market, and how can policy changes help mitigate these challenges?
7. What changes or new policies do you think are necessary to improve Lithuania's RES sector in the next decade?

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