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Analysis of Energy Security Based on Level of Alignment with the Goals of Agenda 2030

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Abstract: In an era of a significant pace of economic, technological, and social development, an uninterrupted energy supply is one of the most important variables determining a country's economic sovereignty, position in international relations, and quality of life. The aim of this study was to develop a method of multifaceted comparative analysis of energy security of neighboring countries (Poland and Slovakia) based on the level of fulfillment of selected goals of Agenda 2030 and related tasks. The analysis of energy security, due to its multifaceted nature, requires an examination of Goal 7 (clean and accessible energy) and the corresponding tasks associated with Goals 8, 9, and 13 of Agenda 2030. The research objective involved the analysis of energy dependence, electricity, diversification of gas supply, terminals and gas storage facilities, and clean energy. The countries studied are in the midst of achieving the goals of Agenda 2030, and the current rate of growth and relevance of the energy measures taken are promising. Further actions are recommended in the areas of diversification of generation capacity, appropriate levels of investment, availability of infrastructure and expertise, increasing the share of renewable energy sources (RES) and natural gas, and increasing efficiency in electricity consumption.

Keywords: renewable energy; energy efficiency; fossil fuels; energy policy; modern technologies

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1. Introduction

Currently, global economic development is at a level where the energy sector influences each of its segments, often playing significant roles in them [1,2]. The issue of energy security is a foundation and an indicator of economic prosperity, being a key priority for any country. Energy security is one of the basic elements that determine the ability to guarantee security and the possibility of uninterrupted and sustainable development for each country [3,4]. Due to the growing demand for energy resources, fuels, and energy, energy security is gaining additional importance [5]. In the second decade of the twenty-first century, energy is one of the most important topics of political strategic considerations. In this view, energy security is equated with national security and economic security [6,7]. Individual governments set policy goals for energy security and determine the mechanisms for its implementation, taking into account the peculiarities of the functioning of society and the implemented model of public administration [8,9].

A trouble-free and affordable energy supply is crucial to the preferred quality of social life. Disruptions in energy supply can bring a significant number of projects to a complete halt [10,11]. Energy is a commodity, and the lack of availability of its sources (affordable), exaggerated dependence on imports, failure in its flows, and sudden price volatility are among the potential emergencies that have a critical impact on the economy [12]. As a consequence of the occurrence of the indicated events, the economic and social well-being of societies is also destabilized [13,14].

Although the consideration of energy security has been carried out for many years and is seen as important for economic development, there is no clear global definition of it [15]. Mostly, energy security is identified with the protection of the economy, the state, society, and citizens from the risk of energy shortages. Energy security is a term that encompasses the totality of issues that relate to ensuring the functioning of the state and independence (in terms of meeting national self-interests in an uncertain or risky energy environment), most often by addressing challenges, consuming opportunities, minimizing risks, and preventing systemic energy threats [16–18]. Energy security is a complex term with implications in a number of spheres: environmental, economic, political, social, and technical [19].

For many years now, the literature has attempted to conceptualize energy security in a universal and practical way [20]. The International Energy Agency defines energy security as unstoppable access to affordable energy sources. A similar approach is outlined in United Nations studies, according to which it is defined as access to clean, affordable, and reliable energy services for heating, cooking, communications, lighting, and other essential purposes [21,22]. Energy security is also the continued availability of energy in diverse forms, in sufficient quantities, and at affordable prices [23,24].

Currently, studies of energy security have seen a shift away from the classical view. Instead, the concept has become an interdisciplinary field [25]. Globalization, climate change, and the uncertain future of fossil fuels have influenced the formation of new dimensions, such as energy efficiency [26,27], energy poverty [28], reducing greenhouse gas emissions [29,30], and sustainable development [31]. As a result, the idea of energy security has been linked to other spheres, including social, political, environmental, and production spheres, as well as security problems and multifaceted areas with sustainable development [32,33].

From the point of view of scientific research, the idea that energy security should be based on the general concept of security is important and has been widely discussed in the literature, with energy security understood as a low vulnerability of the relevant energy systems [34]. This vulnerability is the result of resilience and exposure to natural and other social actors. The indicated vulnerability is considered in energy systems and infrastructure, energy services, and renewable energy sources [35,36]. The discussed approach helps to describe the concept of energy security in a universal way, but as emphasized, it is still very abstract and dependent on who uses it. This makes the term ‘energy security’ ambiguous [37]. Energy security is also defined as a state of confidence in the availability and stable receipt of fuel and energy of adequate quality in normal situations and at times of extraordinary circumstances [38]. The aforementioned type of security is the protection of the country, its economy, and its citizens from potential energy shortages, as well as from current and potential sources of threats coming from within or outside the country [39]. This security also refers to energy infrastructure: the implications of new technologies that minimize the level of dependence on imported energy resources through the development of alternative energy [40].

Based on the definitions of energy security presented in this study, it is assumed that energy security should be identified with the protection of the economy, the state, society, and citizens from the risk of losing access to clean, affordable, and reliable energy services, thus ensuring the functioning of the state and its independence.

Energy is an important component of sustainable development efforts [41,42]. The purpose of the EU energy policy and legal acts relating to the electric power sector is to implement this concept in accordance with the premises of sustainable development [43]. This is realized mainly through the development of technologies using RES and the development of cogeneration (combined production) of electricity and heat [44]. An example of such activities is the 2030 Agenda, which is a strategy for world development until 2030. The 2030 Agenda is a continuation of global efforts to improve the quality of life of people around the world. The document refers to and largely builds on the Millennium Development Goals, which were implemented between 2000 and 2015. With that said, the scope of Agenda 2030 is much broader than that of the Millennium Program. In addition to priorities for education, health, or nutrition and food security, the document addresses a significant number of economic, social, and environmental goals, as well as ensuring energy security. This leads to transforming economies to allow for long-term, sustainable growth that fosters job creation. New economic opportunities and jobs can ensure universal energy access, improved energy efficiency, and the spread of renewable energy. They will also contribute to creating more sustainable and inclusive societies and increasing resilience to the effects of climate change. Due to the materiality of the issue, these concepts are reflected in the content of the 2030 Agenda. The 2030 Agenda for Sustainable Development, adopted in 2015, established 17 Sustainable Development Goals (SGDs) [45]. Goal 7 refers to the creation of conditions for the steady and sustainable development of the energy sector, ensuring the energy security of countries, meeting the energy needs of businesses and households, and reducing the environmental impact of energy. Improving energy efficiency will remain a priority of energy policy. Within the framework of Goal 7, the following tasks have been adopted, to be completed by 2030 [46]:

- ensure universal access to affordable, reliable, and modern energy services;
- significantly increase the share of renewable energy sources in the global energy mix,
- double the growth rate of global energy consumption efficiency;
- increase international cooperation to facilitate access to clean energy research and technology in the areas of renewable energy, energy efficiency, and advanced and cleaner fossil fuel technologies, and promote investment in energy infrastructure and clean energy technologies;
- expand infrastructure and modernize technologies to enable access to modern and sustainable energy services for all residents of developing countries, particularly the least-developed countries, developing small island states, and developing landlocked countries, in accordance with their development programs.

The topic of sustainable energy security is also touched upon by Goals 8, 9, and 13. SDG 8 refers to economic growth and decent work, thus promoting stable, sustainable, and inclusive economic growth, full and productive employment, and decent work for all people [47].

SDG 9, or innovation, industry, and infrastructure, points to building stable infrastructure, promoting sustainable industrialization, and fostering innovation, which are linked to the broader energy security of countries. The long-term goal of SDG 9 is to put countries on a sustainable path to innovation. The key is to improve the legal and institutional environment that stimulates risky innovation activities. As a result, there will be an increase in the share of knowledge-intensive industries and services in the structure of the economy. The noticeable effects will be an increase in the degree of technological sophistication of products and stimulation of the emergence of new technological and organizational solutions, basing competitive advantages on the quality and innovation of products and services [48].

SDG 13 is climate action, specifically taking urgent action to address climate change and its impacts. The primary climate change actions remain those affecting emissions reductions. Programs related to saving energy, improving the efficiency of energy generation, and making greater use of renewable energy sources are essential [49].

The 2030 Agenda, through goals and targets, indicates the key areas to be improved, in line with the alignment of the essence of the three factors of development: respect for the environment, social progress, and economic growth. According to this message, the energy sector in each country should develop. The implementation of adequate goals of the 2030 Agenda and related tasks is essential to achieve a stable level of energy security for EU member states [45]. The specific tasks included in Agenda 2030 are based on the concept of sustainable development, i.e., intergenerational solidarity consisting of finding such solutions to guarantee further growth. These allow for active inclusion of all social groups in development processes while giving them the opportunity to benefit from economic growth. This idea of proceeding ensures even and responsible development of the energy sector [46]. Currently, the concept of sustainable development is increasingly entering the mainstream of ensuring the energy security of EU countries, becoming a horizontal principle reflected in all development policies of developed countries [50]. In addition, the very goals of Agenda 2030 and the related tasks are a commitment and an important motivation for taking action in the field of energy security growth, striving to ensure access to sources of stable, sustainable, and modern energy at an affordable price.

An important area of sustainable energy development is energy policy. Sustainable energy should be understood as the transformation of primary energy into electricity and heat, as well as its delivery to the final purchaser in such a way as to meet the needs of current and future generations, taking into account economic, environmental, and social development prospects [50,51]. Sustainable energy consumption issues should be considered as a component of energy policy, not energy itself [52]. There is an emerging belief that sustainable energy is still a theoretical term [53]. At the current level of civilization's flourishing, it should be seen as intentions related to the practice of the least environmentally degrading methods of energy conversion and distribution with the inclusion of the economic and social needs of current and future generations [54,55].

The term 'sustainability' is also found in the energy system. A sustainable energy system is a system based on the integration of renewable technologies for obtaining energy, renewable heat and fuel transport, utilization efficiency, demand reduction, and combined heat and power generation [56]. The features of such a system include increasing the use of renewable energy sources, building long-term economic and environmental goals, activity in competitive markets, constant analysis of new generation and management technologies, internationally oriented activity in markets characterized by equal competition rules, and consideration of external costs [57,58]. Today, sustainable energy is a separate term from renewable energy, and it has a broader scope. Sustainable energy includes all sources with a relatively long life cycle and negligible environmental impact [59].

Efforts to integrate the planes of energy, economics, and environmental protection with sustainable development have influenced, among other things, the formation of an interdisciplinary approach of scientific researchers [60], the diversification of sources of strategic raw materials [61], the progress of RES energy [62], the spread of SMART technologies [63], analyses in the field of increasing the energy efficiency of energy technologies [64], and increasing environmental care in the production space [65]. The sciences relating to politics, economics, and sociology, are also working on the analysis of the impact of sustainable development policies on social and economic change [66].

In the transition to a cleaner and more sustainable world, energy in terms of production and consumption and energy in terms of security is an integral and decisive factor for many countries. For this reason, in the literature, one can find studies relating to the analysis of the level of energy security. Methods are presented that relate to the study of the issues raised at the micro scale concerning cities and urban systems [67–69] or the security sector itself [2], as well as macro-scale issues relating to specific countries [70]. A significant number of publications refer to analyses of EU countries [71,72]. In terms of assessment, probabilistic models are created regarding the emergence of disruptions from threats and a model for the development of a disrupted energy system [67]. Adequate indicators are also used [70], which are sometimes integrated with functional regression models [69] to realize analysis of the dynamics of change or comparative analysis of energy security. In addition to the realization of assessments and dynamics or comparative analysis, research is also carried out on building development scenarios. Regression models of, for example, energy security risk index assessments are also used to determine energy market prospects [71]. Strategic analysis models for the energy security sector based on a scenario approach are being created [68]. Indicators themselves are also being studied [72], or proprietary ones are being created [73,74] and used for multidimensional energy security analysis. The characteristics of the mentioned methods are shown in Table 1.

Table 1. Characteristics of assessment methods and analyses of energy security.

	Activity	Characteristics	Author
Micro scale	Evaluation (probabilistic methods)	Methods of probabilistic assessment of energy security and energy security assessment of the development scenarios of the heating central system for strategic planning. A method of energy security assessment is introduced, including a model of disruption formation from threats and a model of development of a disrupted energy system, as well as an algorithm for calculating the energy security coefficient.	Augutis et al. [67]
	Strategic analysis (methodological aspects of the scenario approach)	Build a strategic analysis model for the energy security sector. It goes beyond scenario analysis, complementing it with sectoral, portfolio, and integrated analysis methods. The strategic analysis built in this way takes into account the achievements of many scientific disciplines, namely technology, security, strategic management, foresight, international relations, and military.	Daniluk, P. [68]
	Analysis of dynamics (ratio analysis and functional regression model)	The dynamics of the energy safety index are constructed and analyzed using comprehensive functional data analysis (FDA) techniques. Energy security indicators are taken into account. The impact of investments (in energy) on provincial energy security are also checked using functional regression models.	Bamisile et al. [69]
Macro scale	Comparative analysis of selected countries (indicator analysis)	A system of indicators was proposed that takes into account technical, economic, geopolitical, and socio-political aspects of energy security. Estonia, Latvia, and Lithuania are analyzed. A system of indicators using statistical data is used for each country.	Augutis et al. [70]
	Analysis and determination of energy market prospects (regression model for energy security risk index assessment)	Clustering of the analyzed countries into three groups according to the Energy Security Risk Index, then development of a regression model for assessing the Energy Security Risk Index, which takes into account the levels of economic, technical–technological, environmental, social, and resource components.	Chernyak et al. [71]
	Evaluation of methodological assumptions of the indicator (statistical methods)	Assessing the methodological assumptions of the Energy Trilemma Index (developed by the respected World Energy Council), which serves as a decision-support tool for energy policy and governance. To evaluate the methodological assumptions of the Index's reliability, a set of statistical methods was used, including a principal component analysis. The final assessment of reliability was made using a Cronbach's alpha test.	Sprajc et al. [72]
	Exploratory data analysis	A method of measuring energy security that, unlike previous energy stability indicators, takes into account political and social aspects in addition to economic and environmental indicators as part of a composite country risk index. The new Energy Security Index (ESI) is defined based on a principal component analysis (PCA).	Filipovic et al. [73]
	Comparative analysis of principal components (ratio analysis)	In addition to the core indicators, a country's credit rating was included as a measure of economic, financial, and political stability: one of the decisive factors determining global energy trade and the ability of national economies to maintain energy stability and security. The determination and study of the Geo-Economic Energy Security Index was carried out using a principal component analysis of the European Union and selected countries of the world.	Radovanovic et al. [74]

Currently, there is no single accepted methodology used to measure energy security, but the prevailing approach in the literature is that energy security should be defined and quantified to keep up with the dynamic development of the global geopolitical situation [75]. The indicators used in the analyses often refer to aspects of sustainable development [70,72,73,76], but there are a lack of analyses that analyze energy security by determining the level of fulfillment of the goals and specific tasks of sustainable development adopted in Agenda 2030.

The presented methods of assessment and analysis of energy security concern the micro scale (specific areas of a specific country) [67,68] or more often refer to the macro scale and include specific countries in the analysis by treating them separately [70,71,74]. With regard to the literature studies, the originality of the developed method is manifested in the fact that with its help, a comparative analysis of neighboring countries in the field of energy security is made. There is a research gap within the scope of analyses of the effectiveness of key modernizations, changes, and the establishment of new legislation in the context of increasing the level of security in neighboring countries. The originality of the method is manifested in the analysis of the neighboring country, which is seen as a potential for establishing agreements and joint ventures leading to mutual benefits in the energy, economic, and social spheres. Through the implementation of a comparative analysis of neighboring countries, it is possible to achieve a number of benefits, which include the identification of good practices in other countries, correction of one's own strategy, opportunity to support other countries with good practices, establishment of close cooperation with a neighboring country, and better use of resources. The method, unlike the described models of energy security analysis [68,69,72], allows researchers, on the basis of available data, to contribute in a relatively quick and uncomplicated way to the selection and implementation of adequate measures to strengthen energy security. Consequently, this will increase the likelihood of EU countries achieving the goals of the 2023 Agenda.

The available studies on the Sustainable Development Goals often include an analysis of one or more goals or aspects of energy security [67,68,74], but such an approach prevents analysis of multifaceted issues. Such an approach does not provide a comprehensive analysis of an issue that goes beyond the framework of the established goals. For a full diagnosis, an examination of the tasks included in the other SDGs of the 2030 Agenda is also required. In contrast to the available literature studies [67–74], the method developed allows for a broad analysis of a multifaceted issue such as energy security. The method makes it possible to diagnose progress in national energy sectors, taking into account the close correlation that occurs between energy and specific aspects of sustainable development. This approach distinguishes the method from the available literature on the subject, which in most cases in indicator analyses refers to the aspects of sustainable development itself [70,72,73,76], without examining their impact on other planes of state functioning. Against the backdrop of the review of the literature on energy security assessments and analyses, it is apparent that the issue of comparative analyses with Agenda 2030 goals and related tasks as a reference point is not being addressed. The analysis of the literature shows that it is worth developing such a method and applying it.

Another of the prerequisites for the realization of a multidimensional analysis of energy security is interdisciplinary and interstate research that allows articulating different perceptions of energy security and assessing the effectiveness of measures taken in this regard. In light of the above, the purpose of consideration was made to develop a method of multidimensional comparative analysis of energy security of neighboring countries based on the level of fulfillment of the selected goals of Agenda 2030 and related tasks. The analysis of energy security of the selected countries, due to its multifaceted nature, requires an examination of Goal 7 (clean and accessible energy) and the corresponding tasks associated with Goals 8, 9, and 13.

The achievement of the goals of Agenda 2030 is closely linked to the implementation of the tasks assigned to them. The achievement of the tasks is not always linear; hence, their evaluation should take place only after the completion of the adopted tasks. Selecting specific criteria will not contribute to reliable information on progress. Currently, EU countries are in the middle of the period provided for the implementation of the goals of Agenda 2030; hence, the degree of achievement of results should be approached with some reserve. Thus, the current opinions are only an indicative assessment of the degree of directional development, which is focused on indicating achievements and direction of development rather than indicating a rigid verdict.

Given that national economies are an integral part of a dynamic international economy, within which external shocks (political conflicts, wars, the global financial and economic crisis, among others) have an impact on energy security and prices, it is important to perform comparative studies of neighboring countries or those located in a specific region in the context of diagnosing and building energy security recommendations. On the basis of an analysis of neighboring countries, it will be possible to plan the conduct of integration policies at the appropriate levels or undertake joint ventures to strengthen energy security on a macro level.

2. Methods

The realization of the stated goal of this study required the implementation of unsystematized activities. The procedure allowing us to perform a multidimensional comparative analysis of the energy security of neighboring countries (Poland and Slovakia) based on the level of fulfillment of selected goals of Agenda 2030 consisted of 3 main phases: conceptualization and explication, proper research, and inference. Figure 1 shows the assumptions and phases of the analysis.

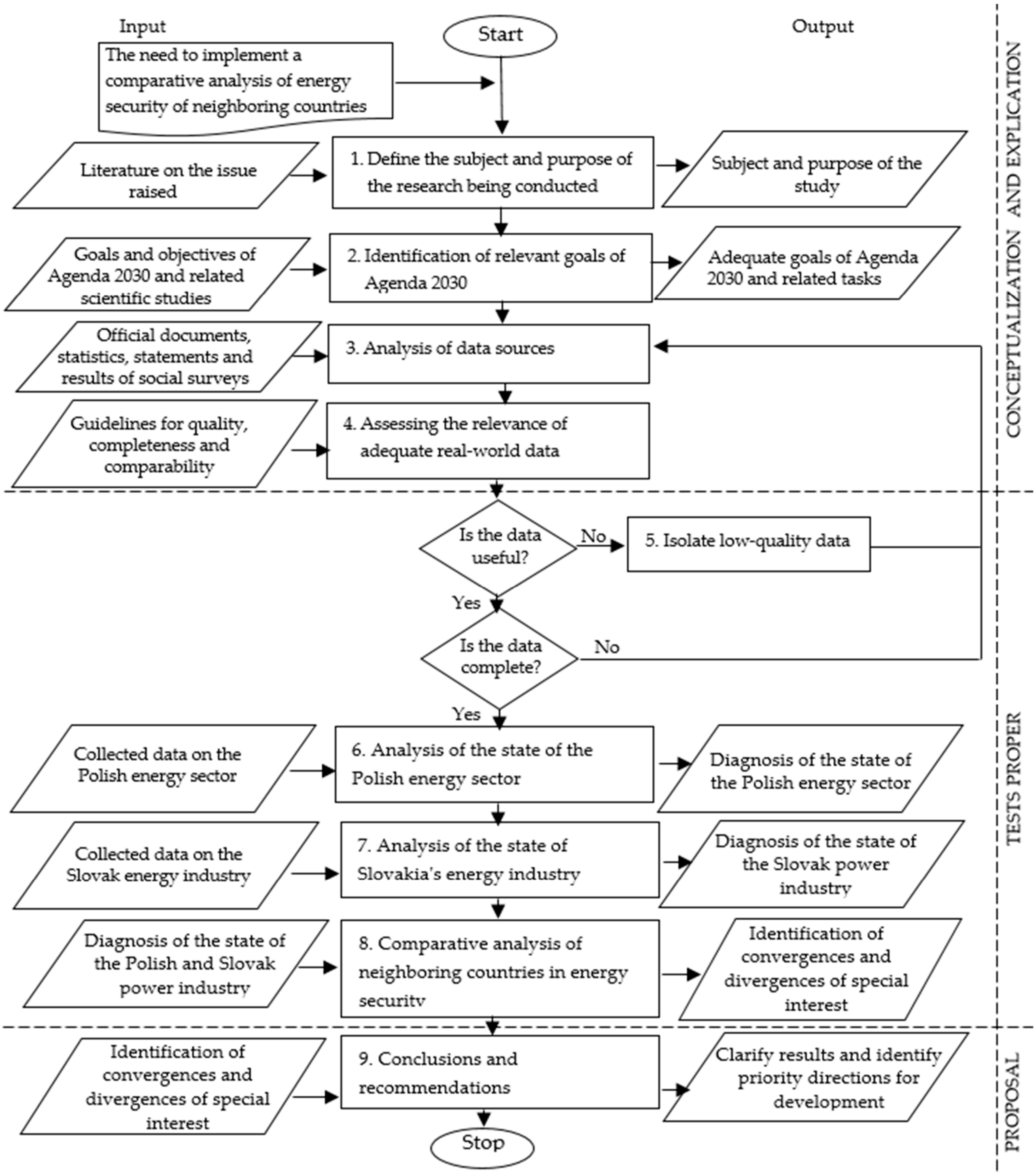

Figure 1. Concept of energy security analysis method based on the effectiveness of meeting the goals of Agenda 2030.

The developed sequence of the proceedings was divided into 9 integrally connected stages of research implementation.

2.1. Stage 1—Defining the Subject and Purpose of the Research

When defining the subject of the research, it is necessary to define the range of phenomena in relation to which something is to be judged, and then to state what—in connection with the thus defined purpose of the research—range of reality is to be covered by the research. The objects in relation to which the purpose of the research is articulated should be taken as the subject of the research. The purpose of the research is taken to be the type of result that the researchers expect to achieve as a result of conducting the research, taking into account the types of factors and variables with which the results obtained will be integrated.

2.2. Step 2—Identification of Relevant Goals of the 2030 Agenda

Identification of the goals of the 2030 Agenda for Sustainable Development related to the adopted research objective involves a detailed analysis of them. Given the complexity and interpenetration of the Sustainable Development Goals in this stage of analysis, it is necessary to identify the relationship between the adopted research objective and the SDGs and their specific sentences and facts related to the SDGs at the international and national levels.

2.3. Step 3—Analysis of Data Sources

The accumulation of knowledge is based on existing and available data that have been collected or generated by other (reliable and competent) entities. The use of found data involves sources that are the result of documenting particular areas of life, independent of their further use and interpretation or secondary analysis.

Due to the research topic undertaken, the following were considered as potential data sources: statistics and compilations (data from statistical offices and state institutions, public statistics), official documents (numerical summaries, reports, regulations, protocols, censuses and other materials created by offices, organizations and institutions related to the research topic), results of social research, as well as other information available online (expert statements, scientific studies).

2.4. Stage 4—Evaluate the Relevance of Adequate Real Data

The collected materials of a factual nature provide the material necessary to carry out the research objective and obtain original results. It was assumed that the information was considered as qualitative and useful for the implementation of the analysis, having the following characteristics:

- relativity—the information (data) meets the expectations of the recipient—meets his needs, has meaning for him;
- reliability—the information testifies to the authenticity of the data, contains elements indicating the reliability of the message;
- timeliness—information (data) is valuable, fresh;
- consistency—individual information, data, and elements form a logical whole;
- completeness—the information contains a sufficient amount of data so that the transformation of information into concrete knowledge can take place;
- repeatability—the information is repeatable in time and space;
- comparability—domestic and foreign information (data) relating to issues measured in an equivalent manner.

2.5. Step 5—Isolate Low-Quality Data

Low-quality data (superfluous data and data that make comparisons impossible) should be isolated so that they do not falsify the results of the study. Then, steps 3 and 4 of the method are again carried out. Deficiencies in the data should be filled in again by carrying out stages 3 and 4 of the method.

2.6. Stage 6—Analysis of the State of the Polish Energy Sector

The analysis of the state of the energy sector of a country should refer to a separate part of the economy covering the entirety of interrelated processes related to the acquisition and use of energy carriers as well as the study of the key features of the sector and the effectiveness of the development activities undertaken.

2.7. Stage 7—Analysis of the State of the Slovak Energy Sector

The analysis of the energy sector of the next country in question is done analogously to Section 2.6.

2.8. Step 8—Comparative Analysis of Neighboring Countries in Energy Security

The implementation of a comparative analysis in international research boils down to the selection of research samples, including various neighboring countries and the performance of an analysis of the studied entities and phenomena in accordance with the relevant criteria, in order to find the same, similar, or different degrees of intensity of the studied characteristics.

2.9. Stage 9—Conclusions and Recommendations

Establish conclusions and reflections on the completed analysis, as well as identify priority directions for development.

The indicated course of action for the analysis of the energy security of the selected entities includes objectivized, rational, and orderly activities that contribute to the achievement of the set research objective. Within the framework of the various stages, all activities aimed at developing science and knowledge, which makes it possible to obtain objective and orderly knowledge of a specific area of reality in order to formulate adequate directions for its development.

3. Research Results

In accordance with this study's assumptions, the analysis of energy security defined based on the level of fulfillment of the goals of Agenda 2030 is presented according to the listed stages.

3.1. Stage 1—Defining the Object and Purpose of the Research

In the implementation of this study, the object of the research was two neighboring countries, Poland and Slovakia, which were analyzed in the context of their energy security. The purpose of the research was to benchmark Poland and Slovakia in terms of the effectiveness of activities leading to energy security. At the same time, the level of this security was determined based on the degree of fulfillment/achievement of the goals of the Agenda for Sustainable Development 2030, as well as tasks and facts integrated within them. This study covered the years 2015–2022, with the period shortened where warranted. Due to limitations in terms of data availability (lack of comparative data) or lack of significant changes in the scope of the issue at hand, in select cases, the analysis covered the years 2019–2022.

3.2. Step 2—Identification of Relevant Goals of Agenda 2030

The provisions of Agenda 2030 establish 17 Sustainable Development Goals, among which one directly relates to sustainable energy development—SDG 7: Clean and Accessible Energy. This goal relates to ensuring access to sources of stable, sustainable, and modern energy at affordable prices for all. The theme of sustainable energy security is also addressed by Goals 8, 9, and 13. SDG 8 is about economic growth and decent work; that is, promoting stable, sustainable, and inclusive economic growth, full and productive employment, and decent work for all people. SDG 9, or innovation, industry, and infrastructure, points to building stable infrastructure, promoting sustainable industrialization, and fostering innovation. SDG 13, on the other hand, is climate action, specifically taking urgent action to combat climate change and its effects.

The implementation of the formulated research objective relating to comparing the level of energy security of two neighboring countries, Poland and Slovakia, which was defined by the achievement of selected goals established in the 2030 Agenda and related tasks, required analysis of the following issues:

- energy dependence, with particular reference to:
  - import dependency,
  - dependency on Russian fossil fuels,
- electricity, with particular reference to:
  - gross electricity production,
  - net imports of electricity,
  - electricity interconnection,
- diversification of gas supplies, with particular reference to:
  - gas consumption,
  - gas imports (by type and by main source supplier),
  - LNG terminals,
  - underground storage,
- clean energy, with particular reference to:
  - VC investments in climate tech start-ups and scale-ups,
  - research and innovation spending under the energy union's research and innovation priorities.

Analysis of the specified issues will contribute to the accurate examination of the key areas of energy security of Poland and Slovakia to which SDGs 7, 8, 9, and 13 refer. Thanks to the analysis of the indicated areas, it becomes possible to examine the accuracy of the actions taken and the adopted direction of development of the energy sector.

3.3. Stage 3—Analysis of Data Sources

Analysis of data sources (desk research) is a method that allows us to gain necessary knowledge based on existing information and data that have been generated or collected as a result of the activities of others. The essence of this stage is to perform a review and consolidation of information and data from various sources, often having different forms (for example, statistics, databases, published research reports). Due to the subject matter of the research, the following were considered binding sources of data: statistics and compilations from statistical offices (the European Statistical Office, the Polish Ministry of Climate, and the Slovak ÚRSO (Úrad pre reguláciu siet'ových odvetví), the equivalent of the Polish Energy Regulatory Office), the content of Agenda 2030 (with a particular focus on the goals and related tasks), the results of social research (project reports), as well as information and data available online (expert statements, scientific studies).

3.4. Step 4—Evaluation of the Relevance of Adequate Real Data

In accordance with the adopted sources of information and data, a collection of actual information and quantitative data related to the ongoing development activities within the energy sector of the analyzed countries (Poland and Slovakia) also related directly or indirectly to the relevant SDGs (SDGs 7, 8, 9, and 13) was compiled. In order to recognize the appropriate level of quality of the collected information and data, the level of fulfillment of the following characteristics was checked: relativity, reliability, timeliness, consistency, completeness, reproducibility, and comparability, which allows us to perform reliable comparative studies.

3.5. Step 5—Isolation of Low-Quality Data

The test of the developed method did not identify low-quality information and data. The collected information and data had all of the necessary characteristics; that is, relativity, reliability, timeliness, consistency, completeness, reproducibility, and comparability. The characteristics possessed allowed us to continue the implementation of the research.

3.6. Stage 6—Analysis of the State of the Polish Energy Sector

Poland's realized actions and efforts related to the diversification of natural gas supplies have helped mitigate the consequences of the suspension of transmission from Russia and have saved the country from serious disruptions. On 26 April 2022, Gazprom Export informed PGNiG and Bulgaraz that it had stopped gas supplies to Poland and Bulgaria as of 27 April. The reason for the decision was the failure of the designated importers to agree to pay for natural gas imports in rubles. The new settlement rules were contained in a special decree signed by Vladimir Putin on 31 March. The decree stipulated, among other things, that gas importers must set up currency and ruble accounts at Gazprombank and then make payments in a two-stage scheme: transfer of receivables in currency and conversion of funds into rubles.

Polaska has also taken steps to achieve the goals of REPowerEU, an instrument for the rapid decoupling of European countries from Russian fossil fuels by 2030, and to accelerate the energy transition in the EU. The REPowerEU chapter, added to the KPO (National Recovery Plan) as part of the revision process, includes seven new reforms and ten investments (including six in the grant part and four in the loan part). The new reforms are as follows:

- facilitating the development of renewable energy sources (RES),
- eliminating barriers to the development of RES,
- developing local energy communities,
- accelerating the integration of renewable sources into distribution networks,
- developing sustainable transportation,
- green skills,
- increasing energy efficiency.

The 10 investments included the following:

- in the subsidy part:
    - investments in the development of transmission networks (investment carried over from the original version of the NIP),
    - RES implemented by energy communities (investment carried over from the original version of the NIP),
    - zero-emission transport (buses) (investment carried over from the original version of the NIP),
    - energy storage facilities (BESS, i.e., large-scale battery energy storage facilities),
    - support of institutions implementing REPowerEU reforms and investments,
    - construction or modernization of distribution networks in rural areas.
- In the loan part:
    - energy storage facilities (pumped storage power plant),
    - energy support fund,
    - offshore wind energy fund,
    - construction of natural gas infrastructure (Gdansk-Gustorzyn).

The activities being carried out by Poland are expected to achieve the REPowerEU goal, thereby achieving improvements in energy security and affordability while accelerating the pace of the transition to clean energy and contributing to the EU's competitiveness in terms of clean energy.

Since 2014, Poland has significantly reduced its exposure to Russian gas through the implementation of strategic investments aimed at diversifying natural gas supply paths.

Over the past decade, Poland's dependence on Russian gas has decreased significantly, moving from about 76% (2014) to 55% (2021). Before 24 February 2022 (Russia's invasion of Ukraine), Poland received 10 billion cubic meters of natural gas per year from Gazprom, which accounted for about 45% of domestic demand. At the same time, it is worth noting that the Polish liquefied natural gas handling and regasification terminal in Swinoujscie (in operation since 2016) had a maximum regasification capacity of 5 billion cubic meters per year. Poland has plans to expand the terminal (expanded to 6.2 billion cubic meters in 2022) to 8.3 billion cubic meters. Priority infrastructure projects in Poland (the interconnector with Lithuania, Baltic Pipe, and the interconnector with Slovakia) have been completed and became operational in 2022. The completed investments, by providing an adequate level of import capacity, have made it possible to completely replace lost natural gas imports from Russia. In particular, the Baltic Pipe allows up to 10 billion cubic meters of LPG to be transported to Poland annually from the Norwegian shelf via Denmark and the Baltic Sea. Another international integration such as the interconnection with Lithuania gives Poland access to the liquefied natural gas trans-shipment and regasification facility in Klaipeda, Lithuania, and, through bilateral flows, facilitates the coordination of gas flows to the current level of regional demand and supply dynamics. Meanwhile, another of the interconnections, Slovakia–Poland, creates a transmission capacity of 5.7 billion cubic meters. In addition, Poland plans to launch a floating storage and regasification unit near Gdansk in 2026, which would have an expected annual capacity of up to 6 billion cubic meters of gas.

As of 25 February 2023, Russia stopped transporting and supplying oil through the Druzhba transmission system, at which point the country accounted for about 10% of all oil supplies. Poland is a country that is relatively well prepared to efficiently replace oil with alternative energy sources.

Poland is decrying the fulfillment of its gas storage obligation, which was adopted and specified in [77,78]. Last winter (heating season 2022/2023), Poland met its gas storage obligations. By 1 November 2022, a level of 98.91% was achieved, while on 15 April 2023, the heating season ended with a gas storage fill level of 50.15%. Note, however, that the storage capacity is relatively small (in terms of annual consumption, about 20 billion cubic meters per year), at 3.73 billion cubic meters. The operator of the gas storage facilities in Poland, Gas Storage Poland (GSP), which owns seven gas storage facilities located in Poland, is considering the implementation of further activities related to the expansion of the total storage capacity. These include VGS GIM Sanok (Brzeznica, Husów, Strachocina, Swarzów) and PMG Wierzchowice, VGS GIM Kawerna (Kosakowo, Mogilno).

Poland has undertaken a considerable amount of activity, with the main goal of reducing the level of energy consumption and popularizing energy efficiency. The "Clean Air Plus" subsidy program, administered by the National Fund for Environmental Protection and Water Management, was launched on 15 July 2022. In the program, households can obtain 90% subsidies for the replacement of old and inefficient heating boilers (and district heating connections) and thermal modernization. In addition, as of 3 January 2022, the Polish government has increased funding directed at home thermomodernization and the replacement of heat sources. Other financial measures from the Promoting Energy Savings group are related to the development of an energy savings register, a program to support energy efficiency for companies that use energy efficiency contracts, and the expansion of the white certificate system within the transport sector. The aforementioned activities and high prices accounted for the reduction in gas demand during August 2022–March 2023 by about 13%. It was 2% short of reaching the target level. The Polish government has imposed an obligation to reduce electricity consumption by 10% in public finance sector units.

Natural gas plays a relatively minor role in Poland's energy sector. Its share in 2021 was about 17%. It was noted that most gas is consumed by industry (35%), followed by energy (25.8%), households (25.8%), services and the public sector (9.1%), and transportation (1.7%). The remainder is consumed by agriculture, forestry, and fisheries. In 2021, the chemical and proctochemical (nearly 40%), non-metallic minerals (20%), and food, beverages, and tabacco (nearly 15%) sectors, respectively, accounted for the largest share of industrial gas consumption.

Poland still has a relatively small number of electricity connections with neighboring countries. The country's allocation constraints also cyclically limit cross-border capacity, which often reaches zero. This state of affairs adversely affects the pricing issue. Poland, in the role of a construction country, is participating in a project to synchronize the power grids of the three Baltic states (Estonia, Latvia, and Lithuania) with continental Europe. As part of the political declaration, three new power lines are being built, and another three in the northeastern area of the country are being upgraded. This will allow the Harmony Link, a new interconnection for electricity exchange between Lithuania and Poland, to be fully usable. The investments outlined will improve, to a significant degree, Poland's ability to integrate offshore energy into the national grid. In accordance with the provisions of Poland's Plan for Reconstruction and Increasing Resilience, the country has committed to investments in transmission networks, which mainly concerns the expansion of connections between the northern and southern parts of the country. These plans included the expansion of transmission lines and an adequate substation, the construction of a data network hub, and the conduct of power quality analysis in the electricity market.

In order to maintain the growth of renewable capacity in Poland's national energy sector, it is necessary to strengthen the internal distribution and transmission networks. The increase in variable power generation based on renewable energy sources (RES) combined with the projected increase in demand for electricity (the result of electrification of the national economy) will affect the infrastructure of the distribution and transmission network. Changes toward the creation of an efficient electricity generation portfolio should be accompanied by an increase in the use of resources and the implementation of additional investments in the power grid (with a particular focus on electricity grids). The Energy Regulatory Office reported that adapting the distribution grid to variable sources of distributed and renewable energy by 2030 will require (an estimated) PLN 100 billion. In addition, Poland plans to invest more than PLN 32 billion by 2032 in work in the following areas: modernizing transmission networks and enabling the transmission of electricity generated from offshore wind to regions in southern Poland where industries are concentrated.

In Poland, recent increases in the amount of electricity prices have encouraged energy conservation. In relation to the EU, the country was among those less affected by the increase in energy prices. This is a result, among other things, of the relatively small share of gas in the country's energy structure. In 2022, in the month of December, retail electricity prices reached 188 EUR/MWh. At the same time, the EU average was 318 EUR/MWh. The situation was similar for retail gas prices, which in Poland amounted to EUR 55/MWh, which was about a third of the EU average. Poland has set a cap on electricity prices (the upper limit) for public benefit organizations, local authorities, households, and small and medium-sized enterprises. Due to the anticipated increase in electricity prices, caused by the tripling of coal prices and the share of coal in the Polish power sector, prices were frozen at 2022 prices. Individuals will pay about 420 PLN/MWh + VAT (about EUR 90) for electricity consumption up to 2000 KWh. Households that consume above this level will pay 693 PLN/MWh (about EUR 150). The cap is 785 PLN/MWh (EUR 170) and applies to other entities/companies covered by the measures. Under the law, households and small and medium-sized enterprises that reduce their electricity consumption levels by 10% in 2023 with respect to the previous year will receive a 10% reduction in their electricity bills. On 1 October 2022, local and national governments were required to reduce electricity use by 10%. Under a law passed in December 2023, gas prices for Polish consumers (except businesses) were capped at EUR 43/MWh. The law provides for VAT refunds for the most vulnerable who use gas for heating purposes.

RES still plays a marginal role in Poland's energy structure. In the past few years, a number of positive developments could be seen, especially in the acquisition and management of solar energy. In 2021, the share of renewable energy in final energy consumption reached 15.62%. An almost fourfold increase in installed photovoltaic capacity was also observed between 2020 and 2022 (up from 3.9 GW to 11 GW). A subsidy program for photovoltaic panels located on rooftops contributed to the growth. Prosumers (individual or business) are responsible for about 70% of the total installed PV capacity. A number of programs have been launched in Poland to encourage the installation of photovoltaic panels and solar power generation. The country's onshore wind capacity is slowly growing. The growth of wind power capacity (amounting to about 8 GW in 2022) has been hampered by the distance law ("10 H"—the distance is ten times the height of the turbine), which leads to a reduction in the maximum installed capacity to the order of 10 GW. Poland has made a commitment to reform the distance rule in its Recovery and Resilience Plan (RRP). An amendment to the Distance Law was adopted (March 2023), according to which the permissible minimum distance between wind turbines and buildings was reduced to 700 m. This change will have a positive impact on the development of onshore wind energy, but it should be borne in mind that much of the potential on land will be untapped. The Polish Wind Energy Association (PWEA) points out that by 2030, with the 500 m distance rule, it would be possible to install new onshore wind capacity of 10 GW, but enacting the 700 m distance will reduce this capacity to 4 GW. In the case of offshore wind power, projects are being developed that will have a total capacity of about 8.4 GW (Phase I: 5.9 GW; Phase II: 2.5 GW). As for offshore wind farms, the first offshore wind farm in the Polish Exclusive Economic Zone in the Baltic Sea is scheduled to come online in 2026.

Pure hydrogen can play an important role in the decarbonization of the energy system, with a particular focus on those industries and transportation sectors where this process is difficult to implement. Poland has reached the third position in terms of hydrogen production volume among EU countries (production mainly of gray hydrogen produced by chemical plants and refineries). The government in November 2021 adopted the National Hydrogen Strategy Poland's Hydrogen Strategy to 2030 with an Outlook to 2040, which sets a target of 2 GW of installation capacity by 2030. The strategy's wording pays special attention to low-carbon hydrogen but does not specify the sources of additional electricity that are needed to generate hydrogen. The adopted strategy forecasts the final use of renewable hydrogen in sectors such as energy, transportation, and industry. The country has significant potential to generate and use biomethane from agriculture, sewage sludge, and organic waste. Poland has not undertaken activity related to this area. There is no developed strategy or pilot plants to support the use of biogas. Studies on the allocation of such enterprises have not been conducted.

Undertaking structural renovation projects could help improve the energy efficiency of building stock and reduce the level of energy poverty. This action would assist households and businesses in resource management in the context of rising energy prices. The last decade has seen a downward sentiment of energy demand within the construction sector. This trend is the result of improved energy efficiency and reduced energy intensity of heating systems. The construction sector continues to have significant savings potential. In Poland, the building stock can be mostly described as old—the age of about 65% of buildings is more than 30 years. About 66% of buildings still lack proper insulation, and about 20% of households suffer from energy poverty. In this country, coal covers about 50% of the heat demand of residential buildings. Given the above, renovations and especially thermal upgrades (moving away from fossil fuel-based energy sources) will play an important role in meeting the goals of the long-term renovation strategy adopted for 2030.

Another significant energy transition challenge is the transformation of the district heating sector. According to the definition of efficient heating and cooling systems established under the Energy Efficiency Directive, only about 20% of district heating systems in Poland were classified (in 2018) as energy-efficient systems. In the same year, 76% of district heating supply was based on coal. The increase in coal prices, which has been observed for several years, has influenced the increase in the number of heat pumps—the annual number of installations has quadrupled since 2017. Poland is now considered one of the most rapidly growing heat pump markets in the EU. In 2021, sales of heat pumps reached more than 93,000 units sold, an increase of 67% over the previous year. An upward trend was also observed in 2022—a year-over-year increase of more than 100%. In order to decarbonize the heating sector, which is still dependent on coal, the observed growth trend should be structural in nature.

The level of industrial energy efficiency has improved in recent years, as has the level of energy intensity of the Polish economy. In terms of undertaking market surveillance activities, relatively few inspections of energy-labeled and eco-coded products are carried out in the country. This state of affairs may cause concern about the degree of compliance of product data and may result in lost energy savings and CO_2 emissions. Mandatory adoption of recommendations that include energy audits (with a short payback period; for example, less than 5 years), could activate investment in energy efficiency issues in the industrial sector. This type of action would further develop energy supply companies and significantly improve energy efficiency in the industrial sector.

3.7. Stage 7—Analysis of the State of Slovakia's Energy Sector

Slovakia is still dependent on fossil fuels from Russia, and activities to reduce this relationship are being implemented slowly. Nuclear energy and fossil fuels constitute a significant component of the energy mix. This aspect makes the economy extremely vulnerable to changes in global prices, which implies increased activity in the sphere of energy transition. Slovakia is implementing a series of measures to achieve REPowerEU goals through the introduction of a resilience and reconstruction plan to improve affordability and energy security while at the same time accelerating the process of transition to clean energy. This will have a positive impact on increasing competitiveness among EU countries in the clean energy sector.

Slovakia is significantly vulnerable to rising import costs and possible disruption of Russian energy imports, which has a negative impact on the supply-side economy and economics. The country has found itself in a good position in terms of natural gas storage capacity located underground thanks to favorable geological conditions. The country has two underground storage facilities: the Láb (including Gajary baden), managed by Nafta, and PMG Lab IV—Pozagas, managed by Pozagas. The total capacity of the storage facilities reaches 3.98 billion cubic meters. Last winter, Slovakia met its gas storage obligation. On 1 November 2022, it reached 91.29%, which exceeded the EU's legal obligation of 80%. On 15 April 2023 (the end of the heating season), the gas storage level was 58.23%. Slovakia, like other EU countries, has adopted a diversification strategy since the start of the war in Ukraine. However, the country's most important gas importer (Slovenský plynárenský priemysel a.s.—SPP), signed larger and more favorable contracts with Norway and LNG distributors only in May 2022. As of this summer, only 50% of the gas available in Slovakia comes from Russia. Despite this, the country is considering implementing changes to its gas transmission system. The purpose of the considered changes is to be able to handle new gas supply routes. This includes gas imports via the route from Austria and the Czech Republic or the Slovak–Hungarian pipeline under consideration (scheduled for commissioning in 2027). In November 2022, the Slovakia–Poland connection was completed and commissioned, with an annual capacity of up to 4.7 billion cubic meters per year to Slovakia and 5.7 billion cubic meters to Poland. The implementation of other infrastructure projects in neighboring countries may assist Slovakia in securing gas supplies (the construction of a Floating Storage Regasification Unit (FSRU) in the Gdansk area, or the expansion of the LNG terminal on Krk Island under construction).

The security of supply of the gas and electricity systems is closely linked, and for this reason, Slovakia has put in place special contingency measures in case of emergencies. In the event of a disruption, Slovakia has implemented immediate preparedness measures related, for example, to the abandonment of gas storage facilities, diversification of supply sources, and voluntary reduction of consumption. It is also considering implementing measures related to fuel switching—switching from coal to gas and additional nuclear capacity. The country has measures at its disposal, such as improving energy efficiency, which will help reduce the demand for natural gas in the utilities and residential sectors. During the period of August 2022–March 2023, Slovakia saved 1% of gas consumption with respect to the average of the previous five years.

A nuclear fuel diversification strategy is currently being implemented. Discussions are taking place in Slovakia regarding the possibilities and efficiency of potential suppliers because currently, nuclear fuel for the country comes from Russia.

Gas consumption in Slovakia has been around 5 billion cubic meters per year for several years. Only less than 0.5% of the gas comes from its own production. It was noted that in 2021, the energy sector consumed the most gas (31.7%), followed by industry (27.2%), households (27.2%), services and the public sector (12.1%), and transportation (1.4%). The remainder was consumed by agriculture, forestry, and fisheries.

Slovakia is in the process of upgrading its physical grid infrastructure, but the implementation of further infrastructure projects would allow it to accept more renewable electricity. The investments underway mainly concern the modernization of distribution networks and the implementation of smart grid concepts to increase the level of integration of renewable energy sources. Electrically, the country is well connected to neighboring countries. Slovakia is a net importer of electricity.

In order to protect buyers from rising prices, the Slovak government has taken a number of measures. Some of the measures have concerned families (for example, child allowances or an increase in tax credits for families that have children). However, the key way to reduce the negative effects of fluctuating gas and electricity prices has been top-down regulation for households and small businesses. Prices for consumption entities such as households have been reduced to EUR 61/MWh for electricity, while for gas prices, it has been guaranteed that they cannot rise above 15% from 2022. Starting in 2023, the price of energy has also been set for companies and entrepreneurs. Energy prices were capped at EUR 99/MWh for natural gas and EUR 199/MWh for electricity. As a result of the measures taken, the consumption of electricity used by households and businesses has decreased. In addition, the still high prices contributed to the reduced level of consumption, which forced buyers to save energy.

Slovakia is still lagging behind in supporting local energy communities and creating comfortable conditions for consumers to take an active role in the long-term sustainable process of changing the economy, energy grids, energy sources, etc. to one less dependent on fossil fuels and more energy efficient, i.e., in the energy transition.

In Slovakia, under a national project implemented by the Innovation and Energy Agency called Zelená domácnostiam (Green for households), blocks of flats and single-family houses can apply for support in the form of a voucher for RES installations relying on natural and inexhaustible resources to generate electricity or heat. The support is aimed at small installations that generate electricity up to 10 kW and equipment that generates, processes, transmits, and consumes heat. This project is financed by the Operational Program—Environmental Quality, which is administered by the Ministry of the Environment.

Slovakia is a country with strong ambitions for energy transition, and continued government support would aid the process of decarbonization and ensure the energy security of the economy. The plan to increase resilience and recovery involves direct investments to increase installed RES capacity by 120 MW, which translates into an approximate 20% increase in current solar and wind power capacity. The plan envisages the implementation of a reform of the electricity market structure and assistance to RES in order to smoothly accelerate the implementation of clean energy. The updated legal framework will support the implementation of new activities and facilitate access to the energy market and energy services, as well as expand the capacity to connect new RES to the power grid. In key sectors, Slovakia has the potential to achieve RES penetration and decarbonization targets. In particular, this applies to the implementation of further projects to exploit geothermal potential.

3.8. Step 8—Comparative Analysis of Neighboring Countries in Terms of Energy Security

In the European Union, which has limited energy resources, energy imports are a necessity. It still covers more than half of the energy demand. Each of the 27 EU member states is a net importer of energy.

Indices of energy dependence on imports of energy raw materials (energy dependence) indicate the extent to which a particular economy relies on imports of raw materials to meet its energy needs. Energy dependence can take on a negative value for countries that are net exporters, while a value above 100% indicates the accumulation of energy stocks. Table 2 shows indicators relating to the energy dependence of Poland and Slovakia compared to the EU.

Table 2. Key energy indicators—energy dependency.

Key Indicators	Poland				Slovakia				UE			
	2018	2019	2020	2021	2018	2019	2020	2021	2018	2019	2020	2021
Import dependency [%]	44%	45%	43%	40%	64%	70%	56%	53%	58%	61%	57%	56%
of solid fossil fuels	8%	6%	0%	−4%	92%	92%	86%	88%	44%	44%	36%	37%
of oil and petroleum products	99%	97%	97%	96%	101%	101%	102%	98%	95%	97%	97%	92%
of natural gas	78%	82%	78%	84%	90%	137%	88%	69%	83%	90%	84%	83%
Dependency on Russian fossil fuels [%]												
of hard coal	68%	65%	74%	66%	39%	39%	35%	26%	40%	44%	49%	47%
of crude oil	77%	68%	72%	63%	100%	100%	100%	100%	30%	27%	26%	25%
of natural gas	62%	55%	55%	57%	100%	100%	85%	69%	40%	40%	38%	41%

Source: own compilation based on ref. [79]. Accessed 15 May 2024.

In 2018, the energy dependency rate in EU countries was 58%, indicating that more than half of the energy needs of EU countries were met by importing energy resources. Compared to 2021, this value decreased by 2 percentage points. In the surveyed years of 2018–2021, Poland achieved values of the import dependency indicator below the EU average. Imports of energy raw materials were reduced by 4 percentage points in this interval. Slovakia, on the other hand, achieved values of the import dependency index above the EU average in 2018 and 2019, while in the following two years, the value was below the EU average. The reduction of energy raw material imports in Slovakia reached a value of 17.2% during the period under review.

Dependence on external supplies most often concerns solid fossil fuels, oil, and natural gas. In the analyzed period (2018–2021), the sub-primary importer of the indicated fuels to EU countries was Russia. In 2019, Russia provided 46.7% of solid fuels, 26.9% of imported oil, and 41.1% of natural gas. The high level of dependence on imported raw materials threatens energy security and stability in the region, especially since the EU is dependent on imports of primary energy carriers and secondary manufactures that come from a single distributor. It is worth noting that Russia's energy independence rate is 100%. Poland imports oil and petroleum products to the greatest extent. The level of imports during the period under review ranged from 96–101%. Solid fossil fuels are imported to the smallest extent—in 2021 their level reached −4%. In Slovakia, the level of imports is much higher than in Poland. The country has had an accumulation of energy stocks, mainly oil and petroleum products, for several years.

Currently, electricity plays an important role. Every modern economy requires significant amounts of electricity. In addition, every person uses it in daily functioning. Equally important is thermal energy, which we also use on a daily basis (hot water in taps, space heating). Economic and technological development is inextricably linked with an increase in the demand for energy; for this reason, it is necessary to constantly think about its efficient use and consider new sources of energy. Electricity generation is understood as a process in which the primary energy contained in energy raw materials or manifested directly in the form of natural forces is transformed into the final form: electricity, the carrier of which is electric current. Table 3 shows the key energy indicators—electricity—for Poland and Slovakia.

Table 3. Electricity of Poland and Slovakia.

Key Indicators	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Poland								
Gross Electricity Production [GWh]	164.944	166.635	170.465	170.039	163.989	158.043	179.631	-
Combustible fuels	151.478	151.234	152.295	154.428	145.269	137.254	156.279	-
Nuclear	0	0	0	0	0	0	0	-
Hydro	2.435	2.622	3.034	2.387	2.665	2.937	3.101	-
Wind	10.858	12.588	14.909	12.799	15.107	15.800	15.234	-
Solar	57	124	165	300	711	1.958	3.934	-
Geothermal	0	0	0	0	0	0	0	-
Other sources	116	67	62	125	237	94	84	-
Net Imports of Electricity [GWh]	−334	1.999	2.287	5.695	10.623	13.267	888	-
As a % of electricity available for final consumption	0%	1%	2%	4%	7%	9%	1%	-
Electricity Interconnection [%]	-	-	4.00%	3.97%	4.00%	3.90%	7.00%	6.80%
Slovakia								
Gross Electricity Production [GWh]	26.903	27.064	27.738	26.971	28.434	28.383	30.016	-
Combustible fuels	7.008	7.015	7.367	7.542	7.953	7.897	8.999	-
Nuclear	15.146	14.774	15.081	14.843	15.282	15.444	15.730	-
Hydro	4.137	4.606	4.623	3.879	4.571	4.799	4.552	-
Wind	6	6	6	6	6	4	5	-
Solar	506	533	506	585	589	663	671	-
Geothermal	0	0	0	0	0	0	0	-
Other sources	100	130	155	116	33	31	59	-
Net Imports of Electricity [GWh]	2.388	2.651	3.028	3.682	1.700	319	774	-
As a % of electricity available for final consumption	9%	10%	11%	14%	7%	1%	3%	-
Electricity Interconnection [%]	-	-	43.30%	42.65%	45.30%	41.40%	40.20%	47.0%

Source: own compilation based on ref. [79]. Accessed 15 May 2024.

The National Electricity System (NPS) comprises all the infrastructure for the generation, transmission, distribution, storage, and use of electricity. The interconnection of the NPS with the system ensures the continuous supply of electricity in the country. Poland's NPS is well connected and integrated with the systems of other EU countries. As one of the larger (more extensive) systems in Central and Eastern Europe, it plays an important role. During the period under review, there was an increase in the value of the gross electricity production index of less than 9% (Table 3). However, the energy system in Poland is characterized by a relatively low level of diversification of the fuel base and the highest degree of dependence on combustible fuels (coal) in power generation in the EU. Between 2015 and 2021, gross electricity production from combustible fuels significantly ranged from 145,269 to 156,279. This distribution of energy production sources is largely the result of the historical conditions of the development of Poland's energy economy. The national economy was shaped according to the assumption of "national energy independence", within which the use of the domestic fuel base—mainly coal resources—was maximized. Poland's accession to the EU began the process of changes within the structure of fuels used in the country. As a first step, the Polish power industry was forced to increase the share of RES in electricity production. In terms of renewable energy sources, wind has the largest share as a source of electricity. From 2015 to 2021, an increase of 40.3% in wind energy generation, using wind turbines, was observed. It is worth noting that the country does not derive energy from nuclear power plants or geothermal sources.

The distribution of electricity generation sources is somewhat different in Slovakia. Gross electricity production in Slovakia during the period under review was on average five times less than in Poland. The key source of electricity generation in Slovakia is nuclear power plants. They produce an average of 53% of the electricity (Table 3). Nuclear power represents a stable source of electricity. In addition, the possibility of storing nuclear fuel has a positive impact on the country's energy independence. This makes the nuclear sector crucial in the country's energy policy via the responsibility of maintaining a constant and uninterrupted supply of electricity. The main inconvenience facing Slovak companies is dependence on nuclear reactor fuel supplies, which come from Russia. As part of becoming independent, measures are being taken to diversify nuclear fuel suppliers. The goal of the energy sector is to have at least two alternative suppliers. Given the ever-increasing requirements on the part of the EU for the safe operation of nuclear power plants, the sector requires constant modernization and transformation in terms of operation under changing political and legal conditions. An important developmental step for Slovakia is to expand its nuclear capacity, especially with small modular reactors (SMRs), which will contribute to the decarbonization of the economy. This will take years, not decades. As a result of coal plant closures, SMRs will supplement projected annual electricity consumption by an additional 2.6 TWh of electricity. There is a consensus among key Slovak political forces on this issue. Due to geological conditions, Slovakia does not have the possibility of replacing nuclear energy with another alternative carrier for electricity production. In the years under review, energy from combustible fuels accounts for about half of that from nuclear power plants. The country makes marginal use of hydropower and wind turbines.

The diversification of gas supplies is also an important issue in maintaining energy security and affordability. The level of diversification of the supply of this commodity is shown in Table 4.

Table 4. Key energy indicators—diversification of gas supply.

Key Indicators	2015	2016	2017	2018	2019	2020	2021	2022
Poland								
Gas consumption [in bcm]	18.2	19.1	20.4	20.8	21.3	22.0	23.4	19.5
Gas imports—by type [in bcm]	12.3	15.8	17.5	18.5	20.9	21.2	22.6	-
Gas imports—pipeline	12.1	14.7	15.7	15.8	17.5	17.4	18.5	-
Gas imports—LNG	0.2	1.1	1.8	2.7	3.5	3.8	4.1	-
Gas Imports—by main source supplier [in bcm]								
Russia	8.8	10.9	10.3	9.7	9.6	9.6	10.5	-
Qatar	0.3	2.0	3.1	4.6	4.6	4.6	4.7	-
Germany	3.2	2.7	3.6	3.0	3.9	3.7	3.3	-
United States	0.0	0.0	0.2	0.2	1.9	2.0	3.2	-
Others	0.0	0.2	0.3	1.0	0.9	1.4	0.8	-
Slovakia								
Gas consumption [in bcm]	4.6	4.7	4.7	4.6	4.7	4.9	5.5	5.3
Gas imports—by type [in bcm]	4.4	4.4	5.2	4.4	6.7	4.3	5.1	-
Gas imports—pipeline	4.4	4.4	5.2	4.4	6.7	4.3	5.1	-
Gas imports—LNG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
Gas Imports—by main source supplier [in bcm]								
Russia	4.4	4.3	4.4	4.4	6.7	3.7	3.5	-
Not specified	0.0	0.1	0.8	0.0	0.0	0.6	1.6	-

Source: own compilation based on ref. [79]. Accessed 15 May 2024.

Gas consumption has been steadily increasing over the past few years. This trend works in Poland and Slovakia. Between 2015 and 2021, Poland saw an increase of 28.59%, while in Slovakia, it was 16.60%. There was a decrease in gas consumption in both countries only in 2022 (Table 4).

Gas imports in Poland are carried out via pipelines and as LNG. Over the period under review, the share of imported gas in liquid form steadily increased, totaling an increase of less than 5% (in 2015, it accounted for 1.63% of imported gas, while in 2021, it accounted for 18.16%). In Poland, in accordance with market expectations, the so-called Diversification Ordinance of the Council of Ministers was amended. According to the new ordinance, by 2022, the level of single-source gas transmission will be allowed to reach a maximum of 70%, with the value being reduced to 33% from 2023. The changes force suppliers to ensure a balanced supply portfolio that is based on several sources. The regulation clearly defines natural gas supplies as subject to diversification. The obligation applies to all imported gas (from outside the EU or the European Free Trade Association (EFTA), including LNG and CNG). LNG imports through the Swinoujscie LNG terminal have been excluded from this obligation, as it is one of the most effective mechanisms for diversifying network supplies. Intra-community supplies do not need to be diversified, regardless of the method of entry into the country (i.e., on-load via virtual reverse). Given that Poland has depended on gas supplies from Russia for decades—as recently as 2015, imports were as high as 71.5%—the results of the work done toward diversification of natural gas supplies are impressive. In 2021, gas was imported from Russia (46.46%), Qatar (20.8%), Germany (14.6%), and the United States (14.6%). This state and forecasts allow us to look optimistically at the future of the gas market in Poland.

Slovakia is a country that is almost entirely dependent on external supplies of natural gas, which are imported by pipelines. In 2015, natural gas was imported entirely from Russia (Table 4). The situation in Slovakia's energy market with regard to independence from Russian gas supplies is difficult. In the period under review, practically 100% of the country's demand was met by raw material exported from the East (directly by supplies via Ukraine—85%, from the Czech Republic—15%, except that it was still largely Russian). For years, the transmission of gas from Russia flowing to the West has guaranteed Slovakia's security of supply. This makes it crucial for Slovak gas policy to maintain the country's transit role. The country's heavy dependence on gas supplies implies the need for a diversified import structure.

There are not many solutions for building a diversified gas supply structure. Currently, it is possible to import natural gas from the Czech Republic (a point in Lanžhot), and this possibility is being used. However, the source of the gas supply to the Czech Republic is largely Russia (Nord Stream pipeline). Gas can also be supplied from Hungary (a point in Vel'ké Zlievce) and Austria (a point in Baumgarten). An important project contributing to diversification is the Poland–Slovakia interconnector (Strachcina-Vel'ké Kapušany), which is a two-way high-pressure gas pipeline. The interconnector connects the Polish system's gas hub in Strachocina (Podkarpackie Voivodeship) with Slovakia's Velke Kapuszany hub located near the Ukrainian border.

The specifications of the terminals and gas storage facilities are shown in Table 5.

Table 5. Key energy indicators—terminals and gas storage facilities.

Key Indicators	**Poland**				**Slovakia**			
	2019	**2020**	**2021**	**2022**	**2019**	**2020**	**2021**	**2022**
LNG Terminals								
Number of LNG terminals	1	1	1	1	-	-	-	-
LNG storage capacity [m^3 LNG]	320.000	320.000	320.000	320.000	-	-	-	-
Underground Storage								
Number of storage facilities	10	10	10	10	2	2	2	2
Operational storage capacity [bcm]	3.5	3.5	3.5	3.5	4.4	4.4	4.0	4.0

Source: own compilation based on ref. [79]. Accessed 15 May 2024.

Poland has one terminal with a storage capacity of 320 cubic meters. Poland's LNG handling and regasification terminal opened in 2015. The construction of the liquefied natural gas terminal has made it possible to receive LNG by sea from virtually any direction in the world. This investment has contributed to Poland's energy security.

The country has ten underground LNG storage facilities. The largest underground installation of this type in Poland is the gas storage facility in Wierzchowice, located in Lower Silesia. After expansion (plans for late 2025 and early 2026), the capacity of the warehouse will increase by 60% to 2.1 billion cubic meters of gas, which will account for half of the country's storage capacity.

Slovakia does not have LNG terminals, but it has two storage facilities. Underground LNG storage in Slovakia plays an important role in offsetting seasonal demand for the commodity. However, it is important to increase storage capacity. Underground gas storage facilities are located in the southwestern part of Slovakia. Operators also provide natural gas storage services to foreign gas companies, while a storage facility located in the Czech Republic was used for domestic purposes. The Bojanovice reservoir fulfills the role of balancing the needs of the Slovak distribution network while ensuring the security of gas supply to households.

Since energy independence as a form of self-sufficiency is a measure of reliance on renewable energy, research work in the climate technology industry is recommended [80]. Spending on research and innovation under the energy union's research and innovation priorities seems to be authoritative—their structure in Poland and Slovakia is shown in Table 6.

Table 6. Key energy indicators—clean energy (research and innovation spending).

Key Indicators	**Poland**				**Slovakia**			
	2019	**2020**	**2021**	**2022**	**2019**	**2020**	**2021**	**2022**
VC investments in climate tech start-ups and scale-ups [EUR Mln]	n.a.	10.3	0.9	n.a.	n.a.	n.a.	n.a.	n.a.
as a % of total VC investments in country	0.0%	3.9%	0.2%	n.a.	n.a.	n.a.	n.a.	n.a.
Research and Innovation spending in Energy Union R&I priorites								
Public R&I (EUR mln)	59.7	76.9	70.5	n.a.	431.7%	922.5%	827.2%	n.a.
Public R&I (%GDP)	0.011%	0.015%	0.012%	n.a.	0.0%	0.0%	0.08%	n.a.
Private R&I (EUR mln)	92.2	n.a.	n.a.	n.a.	25.32	n.a.	n.a.	n.a.
Private R&I (%GDP)	0.02%	n.a.	n.a.	n.a.	0.00%	n.a.	n.a.	n.a.

Source: own compilation based on ref. [79]. Accessed 15 May 2024.

VC investments in start-ups and scale-ups in the climate technology industry were made in 2020 and 2021, with a value of EUR 10.3 million in 2020, accounting for 3.9% of the total investments in the country. In the following year, the value of investments was almost 11.5 times lower, amounting to EUR 0.9 million, which accounted for 0.2% of total investments in the country. With regard to the research and innovation expenditures incurred under the energy union's research and innovation priorities, publicly funded research is leading, but it falls within the range of 0.011–0.015% of the country's GDP. In 2022, they were not conducted.

In terms of fundamental transition technologies, there has been an increase in pumping capacity and photovoltaic heat. This is thanks to Northvolt's subsidiaries and LG Chem's battery factory located in Poland. The country is appropriately poised for the next stages of development of the battery market for electric vehicles and for stationary use (batteries for homes or industrial storage to store the energy they generate). Despite these favorable developments in recent years, the level of Poland's public spending on research and development activities (R&D sector) under the priorities of the energy union has fallen from 0.03% of the GDP in 2014 to 0.013% in 2020.

Slovakia is ranked among the countries with low levels of investment in energy research, development, and innovation. The level of undertaken public investments that are dominant among the goals of the energy union are worrisome. There has been a more than threefold decrease in the share of GDP in this regard (0.029% in 2014 to 0.08% in 2021). In contrast, private investment in research, development, and innovation saw a 28% increase between 2014 and 2019 (from EUR 7 million to EUR 25 million). The subject of public investment undertaken focuses most heavily on sustainable transportation (55%), followed by efficient systems (34%), while private investment is dominated by nuclear safety (92%). In 2019, the number of patent families related to clean technologies was equal to the value of 6, representing about 1.1 patent families per million residents.

At the EU level, in line with the energy solidarity intensively recommended since 2014, it has been pointed out that local conditions are important for the planning and subsequent implementation of energy policies of individual member states. Relative freedom has been provided to states to create energy mixes. At the same time, simultaneous and consistent pressure is being placed on moving away from sectors that cause excessive environmental degradation, in favor of RES. The indicated trends confirm the development directions of the analyzed countries.

3.9. Stage 9—Conclusions and Recommendations

A thorough, multifaceted analysis of the research objective defined in this study relating to the comparison of energy security of the neighboring countries, Poland and Slovakia, measured on the basis of the relevant components of the sustainable development goals, aimed to examine the following levels of energy management:

- energy dependence,
- electricity,
- diversification of gas supply,
- terminals and gas storage facilities,
- clean energy (research and innovation spending).

An analysis of the listed areas in this study allowed for conclusions to be drawn and recommendations to be made.

Increasing energy security requires the implementation of systemic activities. Key factors ensuring energy security in Poland and Slovakia include a diversified national fuel and energy balance that maintains energy security at a high yet stable level, access to adequate transmission, storage and distribution infrastructure, and diversification of supply sources and directions. The countries analyzed are aiming to achieve SDGs 7, 8, 9, and 13 and related specific provisions. The level of energy efficiency in the period under consideration has improved and increased stability through the implementation of productivity-oriented and sustainability-oriented projects, which creates opportunities for sustainable and uninterrupted development of countries. Nonetheless, in order to achieve the goals for 2030, the main priorities for Poland and Slovakia should be the following:

- increase in efficiency of electricity consumption,
- reduction of carbon dioxide emission intensity,
- significantly increase the share of renewable energy sources and natural gas in the energy mix,
- ensuring access to affordable energy to promote economic growth and protect vulnerable consumers,
- increase domestic and public spending on clean energy research and innovation,
- building new facilities for the direct production of electricity from wind and solar power,
- develop reliable, sustainable, and resilient quality infrastructure, including regional and cross-border infrastructure, supporting economic development and human well-being,
- increase the efficiency of the use of natural resources in global consumption and production and strive to break the link between economic growth and environmental degradation,
- strengthen adaptive capacity and resilience to climate risks and natural disasters.
- Poland's activity should concern in particular:
- introduction of nuclear energy,
- greater electrification of energy demand (especially in transportation).
- An unquestionable priority for Slovakia should be:

- promoting efficient and cost-effective diversification of gas supply sources and gas transportation routes, which requires supporting investments in infrastructure,
- introducing more underground LNG storage facilities.

Poland and Slovakia have achieved a significant number of their energy and climate goals adopted for 2020. An analysis of Poland's and Slovakia's efforts to ensure energy security may lead to the conclusion that they are effective; however, the long-term effects, if only with regard to possible changes in energy and raw material prices, are difficult to predict. Additional efforts are still needed to achieve a steady reduction in greenhouse gas emissions and a sustained increase in the share of RES, which are necessary to keep both countries on track to achieve their 2030 energy transition goals.

The implementation of a comparative analysis of energy security based on the level of fulfillment of selected goals of Agenda 2030 of neighboring countries, Poland and Slovakia, contributed to the recognition of the following significant difficulties directly related to the use of indicator analyses:

- lack of unification of the way of monitoring the progress of the energy economy,
- lack of unification of adequate data for supervision of Poland and Slovakia in the context of implementation of targets (and individual tasks) of SDGs 7, 8, 9, and 13,
- scarcity or limited availability of adequate data for oversight of Poland and Slovakia in the context of implementation of the goals (and individual tasks) of SDGs 7, 8, 9, and 13,
- lack of universal benchmarks for indicator values, as each field of economic activity has its own specifics,
- the need to collect a rich set of source information.

An indicator analysis does not reveal the causes of unfavorable phenomena, which is why it is advisable to precede it with an in-depth characterization of the analyzed entities. However, an indicator analysis is an effective method of gaining insight into the specifics of a country's development. Together with an analysis of the environment (e.g., a neighboring country with similar key characteristics), it can be used to forecast the appropriate directions of development in pursuit of specific goals.

4. Discussion

A steady supply of electricity is an indispensable condition for the functioning and stable development of modern societies. Equally important is the availability and ability to purchase energy at reasonable and acceptable prices. These issues are important for post-industrial countries, where electricity plays an important role in the processes of production [81,82], communication [18], and trading of goods [50].

There has been a steady increase in the level of global energy demand. Guaranteeing stable energy supplies is an increasingly important aspect in the long-term processes of the intensive transformation taking place in economies [43]. In order to maintain the current (or increased) level of production and provide favorable conditions for further economic development, it is necessary to guarantee readily available and relatively inexpensive energy with the provision of a system for its transmission that is highly resistant to disruptions (short- and long-term) [19]. Energy supply inefficiencies can cause chaos and result in significant financial losses. Interruptions in energy supply can also reduce the wealth level of a society and cause potential damage to health [25].

The projected growth in energy demand indicates that it would be necessary to supply energy from multiple sources, both currently and in the future. Diversifying the sources of energy generation in the mix contributes to the achievement of energy system security through flexibility in meeting a country's needs [7,61]. The importance of the raw material–energy base of national economies is the result of the special importance of natural resources in the modern world. This is related to the lack of possibility of diversifying their distribution and the phenomenon of depletion. In addition, exports, the objects of which are indigenous material raw materials, are an effective instrument of political pressure and an element of influence on regional and international policy [34].

The relevance and groundbreaking nature of the issues under consideration, especially in the Central and Eastern European region, as well as the EU treaty region, is evidenced by the plethora of publications on the issues of conducting an informed energy policy [1,2] and its measurement [4,5,13,14]. In the space of recent years, there have been many activities and efforts in the field of energy security; however, given the wide scope of this issue, there is a need to review the relevant activities and analyze the state of knowledge in the field of energy security measurement [6,16] and risks and solutions [8,24]. The increased importance of these issues is influenced by the results of changes in production and consumption patterns [14,42], tightening of regulations [15,38,58], climate guidelines and recommendations by the EU [22], low efficiency of RES participation [39,44,53,62], limited extraction capacity from domestic deposits, fluctuations in fossil fuel prices [35], the high energy intensity of the global economy [23], technological innovations [27,33,56,63], as well as the problem of making an accurate forecast of expected electricity demand.

In response to the indicated changes, energy security knowledge maps are being created to provide a comprehensive analysis of the issue. As a result, a consistent vocabulary map indicates that the most relevant dimensions of energy security relate to technology, trade, acceptability, productivity, diversity, equity, accessibility, governance, and efficiency [3]. The implementation of the knowledge maps is intended to improve the research environment as well as strengthen the debate based on data and information widely discussed and verified at the national and international levels [83,84]. However, the multi-level analyses presented lack a clear consideration of the aspects of sustainable development and the correlations between them.

The energy sector is burdened with a significant number of dependencies and factors affecting the achievement of certain thresholds for the implementation of energy policies and strategies. There are studies in the literature that use standardized indicators [70,71,76]. Authoritative indicator analyses are also being created [48,69,72]. These studies usually deal with the diagnosis of individual countries or include sets of countries, such as the EU [70,71]. However, the presented standardized indicator analyses only allow for monitoring of individual SDG targets. Their level of detail does not prevent the examination of individual tasks that are related to the goals of Agenda 2030.

It was noted that in the literature there are studies whose authors refer to the analysis of aspects of energy security of specific countries [70,73,74] without realizing a comparative analysis of neighboring countries in the field of energy security. There is a research gap within the effectiveness analysis of key modernizations, changes, and the establishment of new legislation in the context of increasing the level of security in neighboring countries. The originality of this study, which presents an analysis of energy security, is manifested in the analysis of the neighboring country seen as a potential for establishing cooperation leading to mutual benefits in the energy, economic, and social sectors. Through the implementation of a comparative analysis of neighboring countries, the following are identified: potential actions taken, changes in legislation, and strengths and weaknesses of the energy sectors. Such a collection of information makes it possible to establish beneficial agreements. The studies presented in the literature on progress in national energy sectors do not directly address the close correlation that exists between energy and specific aspects of sustainable development. The available studies in the field of diagnosing sustainability goals often refer to analyses of one or more goals or aspects of energy security [67,68,74], which prevents analyses of multi-pronged issues. Such an approach does not provide a comprehensive study of issues that go beyond the specific framework of established goals, and to fully analyze them also requires the study of tasks included in the other SDGs of Agenda 2030. A multifaceted issue such as energy security requires the researcher to carry out analyses with a broad multifaceted scope. The identified gap will be filled by the conducted research. The originality of the study also relates to the scope of the conducted analysis of energy security. Energy security is determined based on the level of achievement of the relevant goals of the 2030 Agenda and their tasks (often related to other, seemingly unrelated goals) by identifying key areas of the energy sector. There is a lack of studies that analyze the country's energy security issues by linking it to the 2030 Agenda goals and relevant tasks and confront the results achieved by specific countries. Available models of energy security analysis are not based on multifaceted comparative analyses capturing the energy, economic, and social issues of specific countries. The use of standardized indicators aimed at a specific agenda goal [69] prevents the realization of a complete analysis of energy security. In view of this, it was reasonable and expedient to perform a multifaceted analysis of energy security based on the level of fulfillment of the relevant goals of the 2030 Agenda and related tasks. The mode of proceeding presented in this study allows for the analysis of the relevant components of the sustainable development goals, which obliges the study of the following planes of the energy economy: energy dependence, electricity, diversification of gas supply, gas terminals and storage facilities, and clean energy (research and innovation spending). An analysis of the listed areas in this study made it possible to draw conclusions and develop recommendations that are adequate to the diagnosed national conditions.

Future research directions will concern the analysis of the effectiveness of activities leading to a high level of energy security of Poland's other neighboring countries, taking into account progress in achieving selected goals of the 2030 Agenda. The research proceedings will be extended to include an analysis of the EU, which will provide a benchmark for other countries.

5. Conclusions

In an era of buoyant economic, technological, and social development, an uninterrupted and stable energy supply is one of the most important components determining a country's position in international relations, its economic sovereignty, and the quality of life of its citizens. In light of the above, the purpose of consideration was made to develop a method of multidimensional comparative analysis of energy security of neighboring countries based on the level of fulfillment of selected goals of Agenda 2030 and related tasks.

As a result of the implementation of a multidimensional comparative analysis of Poland and Slovakia, it was noted that the in period from 2015 to 2022, the countries implemented effective measures, leading to an increase in the level of energy security.

EU countries had an energy dependency rate of 58% in 2018, indicating that more than half of the energy needs of EU countries were met by importing energy resources. Over the period under review, in the EU countries, as well as in Poland and Slovakia, the value of the indicator steadily decreased (the EU recorded a decrease of 2 percentage points). Poland imports oil and petroleum products to the greatest extent. The level of imports in the period under review ranged from 96 to 101%. Solid fossil fuels were imported to the smallest extent, with a level of −4% in 2021. In Slovakia, the level of imports was much higher than in Poland. The country has been experiencing an accumulation of energy stocks, mainly oil and petroleum products, for several years. The energy system in Poland is characterized by a relatively low level of diversification of the fuel base and the highest degree of dependence on combustible fuels (coal) for energy production in the EU. In terms of renewable energy sources, wind has the largest share as a source of electricity. From 2015 to 2021, an increase of 40.3% in wind energy generation, using wind turbines, was observed. It is worth noting that the country does not derive its energy from nuclear electric plants or geothermal sources. The distribution of electricity generation sources is somewhat different in Slovakia. The key source of electricity generation in Slovakia is nuclear power plants. They produce an average of 53% of the electricity. In addition, the possibility of storing nuclear fuel has a positive impact on the country's energy independence.

Gas consumption has been steadily increasing over the past few years. This trend works well in Poland and Slovakia. Over the period under review, the share of imported gas in liquid form in Poland has steadily increased. Considering that Poland has depended on gas supplies from Russia for decades—as recently as 2015, imports were as high as 71.5%—the results of the work done toward diversifying natural gas supplies are impressive. In 2021, gas was imported from Russia (46.46%), Qatar (20.8%), Germany (14.6%), and the United States (14.6%). This state and these forecasts allow us to look optimistically at the future of the gas market in Poland. Slovakia is a country that is almost entirely dependent on external supplies of natural gas, which are imported using pipelines. The situation in Slovakia's energy market with regard to independence from Russian gas supplies is difficult. During the period under review, practically 100% of the country's demand was met by raw materials exported from the East.

Energy independence treated as a manifestation of self-sufficiency is a measure of reliance on renewable energy, against which research work in the climate technology industry is recommended. The level of Poland's public spending on research and development activities (R&D sector) under the priorities of the energy union fell from 0.03% of the GDP in 2014 to 0.013% in 2020. Slovakia is ranked among the countries with low levels of investment in energy research, development, and innovation. Slovakia has seen a more than threefold decrease in the share of GDP in this area (0.029% in 2014 to 0.08% in 2021). In contrast, private investment in research, development, and innovation saw a 28% increase between 2014 and 2019 (from EUR 7 million to EUR 25 million).

The actions taken by both countries related to the energy sector are systematically bring them closer to achieving the selected goals of Agenda 2030 and related tasks. However, the current level of energy security of the analyzed entities was described as moderately satisfactory. However, given that the countries are currently in the middle of achieving the Agenda 2030 goals for the energy sector, and given the current rate of growth and relevance of the measures taken, both Poland and Slovakia are promising to achieve them. Still, both countries face a number of challenges in ensuring an affordable, reliable, and sustainable energy supply. A number of improvement measures are recommended in the areas of diversification of generation capacity, adequate levels of investment, availability of infrastructure and expertise, increasing the share of RES and natural gas, and increasing efficiency in electricity consumption.

The course of research presented in this study can be applied in decision-making processes as one of the supporting elements. The realization of the research has contributed to the identification of limitations and difficulties in conducting analyses of an international nature. These limitations mainly relate to the possibility of a lack of available information or data or their deficit, which may be associated with the lack of standardization of the way of monitoring the progress of the energy economy, the lack of standardization of adequate data monitoring the analyzed countries, and the lack of access to current information and data (outdated data). Other limitations of the model include the need to gather a rich set of source information.

The proposed course of action of the multifaceted analysis of energy security based on the level of fulfillment of the goals of the 2030 Agenda can support the creation of strategies and development plans of countries that want to ensure sustainable energy stability, responsible development, and meet the goals set by the EU. An effective course of action makes it possible to diagnose the progress towards meeting the goals and targets of the 2030 Agenda and determine their effectiveness, as well as future directions for adequate action and development. In addition, on the basis of an analysis of neighboring countries, it will be possible to plan the conduct of integration policies at appropriate levels or to undertake joint ventures to strengthen energy security at the macro level. The implementation of a responsible and effective energy policy on a national and international scale leads to stable energy supplies, the assurance of acceptable energy prices, and economic development.

The originality of this study, which presents an analysis of energy security, is manifested in the analysis of a neighboring country seen as a potential for establishing cooperation, leading to mutual benefits in the energy, economic, and social sectors. Through the implementation of a comparative analysis of neighboring countries, the following is identified: potential, actions taken, changes in legislation, and strengths and weaknesses of the energy sectors. Such a collection of information makes it possible to establish beneficial agreements. The originality of the study also concerns the scope of the analysis of energy security carried out. Energy security is determined based on the level of achievement of adequate goals of the 2030 Agenda and their tasks (often related to other, seemingly unrelated goals) by identifying key areas of the energy sector. There is a lack of studies that analyze the country's energy security issues by linking it to the 2030 Agenda goals and relevant tasks and confronting the results achieved by specific countries. Available models of energy security analysis are not based on multifaceted comparative analyses capturing the energy, economic, and social issues of specific countries.

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