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Energy Efficiency Policies in Poland and Slovakia in the Context of Individual Well-Being

Anna Barwińska Małajowicz [1,*], Miroslava Knapková [2], Krzysztof Szczotka [3], Miriam Martinkovičová [2] and Radosław Pyrek [1,*]

1 Department of Economics and International Economic Relations, Institute of Economics and Finance, University of Rzeszów, 35-601 Rzeszow, Poland
2 Department of Economics, Faculty of Economics, Matej Bel University, 974 01 Banská Bystrica, Slovakia
3 Department of Power Systems and Environmental Protection Facilities, Faculty of Mechanical Engineering and Robotics, AGH University of Science and Technology, 30-059 Kraków, Poland
* Correspondence: abarwinska@ur.edu.pl (A.B.M.); rpyrek@ur.edu.pl (R.P.)

Abstract: Improving energy efficiency includes a number of measures implemented as part of the greening of the energy industry, which in turn is a prerequisite for the creation of a sustainable energy industry to ensure energy and environmental security for the world. Despite the adoption of the EU directives on energy efficiency, there is still insufficient public awareness in this area in Poland and Slovakia. This is particularly surprising because improving energy efficiency not only brings national and global benefits, but also has a significant impact on the well-being of individuals and households. The main purpose of the paper is to analyze the national policies of Poland and Slovakia, which are based on the European Directive 2012/27/EU on energy efficiency, and which introduce new measures aimed not only at increasing energy efficiency, but also at increasing the well-being of households and individuals. Methods of desk research and content analysis were used. The current situation in both countries is illustrated by case studies that document the administrative process (Slovakia) and the calculation of energy savings (Poland) when using renewable energy sources in the case of family houses.

Keywords: energy efficiency; state policy; renewable energy sources; well-being; households; entrepreneurial opportunities; Poland; Slovakia

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1. Introduction

The issue of energy efficiency is a matter of concern where energy has multifaceted impact on each type of economic activity of human beings [1–3]. Unreasonable energy management simultaneously causes a lot of negative effects on many fields (economy, environment, society), and therefore activities aimed at improvement of the energy efficiency have great importance in the modern world. They can bring many potential benefits—not only in terms of energy saving and preventing climate change, but also in the broadly understood well-being, especially in respect of improving human health and life and creating new jobs. On the other hand, changes in society, not only due to rising energy prices as a result of scarcity, but also due to the impact of the COVID-19 pandemic (the shift of work from the workplace to the home and childcare from educational institutions to the home environment, and thus the increasing demand for energy consumption), place more and more emphasis on individual well-being, as experienced by each individual [4]. Therefore, energy efficiency should not only be in the interest of multinational groups and entire countries, but also of individuals and households.

Improving energy efficiency includes a number of measures implemented as part of the greening of the energy industry, which in turn is a prerequisite for the creation of a sustainable energy industry to ensure energy and environmental security for the world. The European Commission pays great attention to the growth of energy efficiency. Investments in energy efficiency result in not only reducing energy costs, improvement of air quality and decrease in energy losses, but also improving human health and well-being. The main purpose of the paper is to analyze the national policies of Poland and Slovakia, which are based on the European Directive 2012/27/EU [5] on energy efficiency, and which introduce new measures aimed not only at increasing energy efficiency, but also at increasing the well-being of households and individuals. The Polish government is implementing a number of solutions to contribute to increasing building energy efficiency in Poland. Public campaigns are being conducted to reduce the knowledge gap in this area among the public. Especially at this time when energy security is so important, every citizen of Poland is beginning to pay attention to the energy efficiency of the buildings they inhabit.

The article is divided into five parts, namely literature review, a methodological part, a review of national policies in Poland and Slovakia, case studies describing selected measures to increase energy efficiency and well-being of households and individuals in Poland and Slovakia and a discussion. The intention of the paper is to show that the national policies of the European Union countries represent an important intermediate step between the European Union's intentions and their implementation, thus creating room for the use of nationally specific instruments for achieving energy efficiency and related well-being of the population. On the one hand, this study contributes to enriching the theoretical basis of research on energy efficiency, national policies and well-being; on the other hand, through case studies, it provides an analysis of the practical challenges of implementing national policies to increase energy efficiency in the context of increasing well-being. Case studies provide complex insight into family house renovation, to meet the requirements of energy efficiency increase.

2. Literature Review

It is difficult to give a unified and universal definition of energy efficiency. Definition aspects which are considered depend on compounds and contexts in which this conceptual category is analyzed. Generally, we can define energy efficiency as a ratio between an output of performance, service or good, and an input of energy. In a little more detail, following a rule of rational management (they occur in two separable variants: (1) as a rule of greatest effect or (2) as a principle of least effort [6]), one can show that energy efficiency means delivering more results and services using the same energy effects, or delivering the same results with less energy effect. Moreover, energy efficiency can be determined as measure of energy efficiency in economic activity (Directive 2012/27/EU) [5].

In the literature of the subject, the term "energy efficiency" is assigned different meanings (more or less extensive interpretation) [7–10]. There are accessible definitions for various terms and meanings, for example: "power efficiency", "energy efficiency", "reduction of energy consumption", "sustainable use of energy resources", "effective use of resources", "energy services provided per unit of energy consumed", "reverse energy consumption", "ratio of useful results to physical energy inputs", etc. [2,11–13].

Regardless of the definition form, it is clear that energy efficiency is one of the main factors of development of entrepreneurship and innovations, it helps to reduce energy losses and it is not only widely accepted, but also a highly desirable tool used to achieve sustainable development [14]. It is worth adding here that economic development does not have to be identified with increased consumption of energy resources, which indicate chosen measures of energy efficiency [8,15–17].

Nevertheless, energy efficiency does not have only an economic dimension, and it does not only mean saving of energy and financial resources, but it is also very closely linked with an individual's well-being. An encyclopedic definition of well-being (Oxford English Dictionary) [18] refers to a general reflection on human well-being. The conceptual category of well-being is equivalent and multidimensional, which results in using ambiguous terminology (the terms used are, for example: "quality of life", "social well-being", "subjective well-being", "personal well-being", "happiness", "satisfaction"). Regarding welfare, it often approaches a subjective point of view (when individuals express their opinion about their own perception of welfare). Among the most frequently asked questions there are issues from the index based on questions referring to eight different aspects of life [19]. In this way, a range of data describing the impact of different dimensions of life on well-being can be collected. The issues of well-being need to be addressed in an objective approach which in turn means using different types of indicators. Data connected with these indicators depend on many variables (sex, age, nationality, origin, socio-economic status, belonging to vulnerable groups, etc.). Situations where quantitative indicators cannot be measured are supplemented with qualitative information.

In the economy, well-being is used to assess the quality of life from a quantitative perspective. However, it should be noted that quality of life cannot be confused with standard of living conditioned only by income. In contrast, typical quality of life indicators involve employment, education, physical and mental health, living environment, social belonging, social relationships, level of independence or environmental quality [20,21].

It is also worth emphasizing that the "quality of life" is studied by social sciences and medicine, while "welfare" is an original psychological construct. There are at least three different approaches to measure the well-being construct, which examine its different aspects: assessment of life (life satisfaction), hedonistic well-being and endemic well-being [22,23].

Studies of the literature show the evolution of theoretical considerations from neoclassical welfare economics (Marshall, Pigou), focusing mainly on individual usability (subjective individual well-being) through so-called new economy well-being (Pareto, Hicks, Kaldor) (value neutrality and normative economic theory) to economy of happiness (Easterlin, Frey, Stutzer, Kahneman, Veenhoven), which uses concepts of prosperity and quality of life [23], although economy of happiness is not intended to replace measures based on income, but rather they should be supplemented by wider measures of prosperity [24].

Meanwhile, it is assumed that economic activity, production of goods and services, has a value only then when it contributes to human happiness [23].

In the context of excessive CO2 emissions, activities aimed to improve energy efficiency may constitute significant support in the improvement of human well-being. They may, for example, help in preventing and relieving serious health problems including respiratory and cardiac diseases. Air pollution represents a major threat to human health and life. According to WHO data, it is the cause of approximately 3 million premature deaths a year [25].

Activities undertaken in order to improve energy efficiency may support not only physical but also mental health of humans. Among such activities is, for instance, creating a healthy living environment in both outdoor and indoor environments, in which the air temperature, level of humidity or noise level is appropriate or there is better air quality [26]. Under such conditions, the human mind and body work much more efficiently and effectively. On the other hand, energy poverty, lack of warmth and high energy bills have a negative impact on human health. They can cause different diseases, anxiety, stress or depression. Positive health effects of energy efficiency and better human well-being can be strengthened if activities aimed at increasing energy efficiency are included in financial support mechanisms [27] and supported by strong local community involvement [28].

The link between energy efficiency and well-being is not an entirely new topic. However, previous studies have rather addressed the issues of increasing energy intensity in order to increase individuals' well-being [29,30]. It is only in recent years that researchers' attention has been focused on the interrelationship between energy consumption, renewable resource use and well-being. Two contradictory findings are reported in the literature. Some studies show the absence of a relationship between energy intensity and well-being [31]; some studies, on the contrary, confirm that renewable energy sources can improve human well-being by improving environmental quality [32–34]. Some authors [35] also pointed, using the qualitative approach, to the nexus of health, well-being and energy consumption. In their conclusions, they pointed also to the necessity of targeted housing policies supporting energy efficiency solutions.

Although there are several studies and approaches focusing separately on the area of increasing energy efficiency through the use of RESs, as well as separately on the well-being of individuals, their interconnectedness and support by state policies are not sufficient and the interconnectedness is not sufficiently linked in the literature. For this reason, in this paper we focus specifically on those areas of energy efficiency policies in Poland and Slovakia that are closely linked to individuals, their housing and reducing the energy intensity of their housing. Reducing the energy intensity of housing represents not only savings on energy consumption (which is the expected effect), but also consequently higher housing comfort, higher satisfaction in terms of economic savings but also overall higher quality of life.

3. Materials and Methods

In this section, materials used for comparison of national policies of Poland and Slovakia, as well as methods of constructing case studies, are explained. Poland and Slovakia are both members of the European Union, entering the EU in within the "Eastern enlargement" in 2004. Both countries are also members of the Visegrád Four group, and they share a common history during which they have progressed from energy surpluses [36,37] to the current threat of energy shortages [38,39].

This article is based on the analysis of the strategic documents of Poland and Slovakia resulting from the EU Directive 2012/27/EU [5] (as the main legislative document for increasing energy efficiency in EU Member States). Table 1 summarizes legal acts and strategic documents involved in the analysis.

Table 1. Legal acts and strategic documents on increase in energy efficiency in Poland and Slovakia.

Poland	**Slovakia**
EU Directive 2012/27/EU [5]	
Dz.U. 2021 item 234 Act of 17 December 2020 on promoting electricity generation in offshore wind farms	Act no. 321/2014 Coll. on energy efficiency
National Energy and Climate Plant for the years 2021–2030	Integrated National Energy and Climate Plan for years 2021–2030
Poland's energy policy until 2040 (PEP2040)	Recovery and Resilience Plan
Strategy for Responsible Development until 2020	Act No. 368/2021 Coll. on the Recovery and Resilience Support Mechanism and on the amendment and supplementation of certain acts

The strategic documents and legislation themselves provide a framework for the application of real energy efficiency measures in the conditions of Polish and Slovak households. For this reason, the authors then focused on documenting the actual situation in Poland and Slovakia through case studies. Case studies describe ongoing (Poland) and planned (call for proposals) (Slovakia) instruments that aim to increase energy efficiency as well as to increase well-being of inhabitants and households.

The authors base their paper on two main assumptions, namely:

A1. Poland and Slovakia have adopted similar state policy and strategic documents on the basis of the EU Directive 2012/27/EU [5].

A2. Instruments for improving energy efficiency are different in the two countries.

The logic behind the research is displayed in Figure 1.

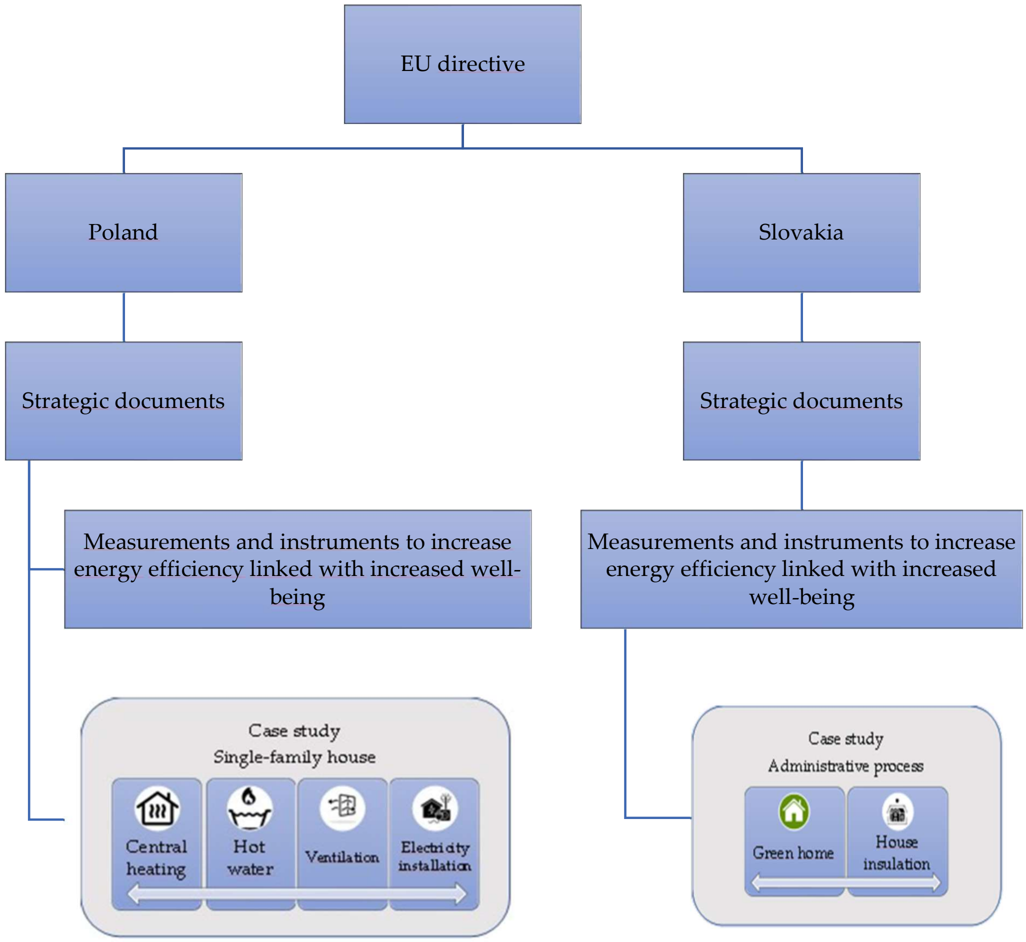

Figure 1. Research scheme.

Since the authors' intention is to illustrate that increasing energy efficiency is also linked to improving the well-being of individuals and households, they focus their analysis of the state policy and strategic documents only on those measures and instruments that are intended for households (i.e., the authors exclude those measures and instruments that are intended for the business sector and public administration from further examination).

4. Review of the State Policy in Poland and Slovakia

4.1. Review of the State Policy in Poland

Energy policy is a very wide issue and it is difficult to discuss changing trends, amendments and legal acts in a brief and accessible way. Poland as one of the European Union Member States has to adjust to several European Commission's directives regarding energy policy, reduction of CO_2 emissions and renewable energy sources. In accordance with the Regulations 2018/2019 [40], every EU Member State should take into account recommendations of the Commission concerning projects of integrated national energy and climate plans. The main goal of energy policy is energy safety while providing competitiveness of the economy, energy efficiency and reducing the influence of the energy sector on the environment with the optimal use of the country's own energy resources. Energy supply in Poland is still dominated by fossil fuels, of which the biggest part is coal, then petroleum and natural gas. Coal plays a key role in Poland's energy system and economy. A huge proportion of coal ranks Poland in second place among EU Member States in terms of the intensity of CO_2 emissions in the energy supply and in fourth place in terms of CO_2 intensity in GDP. Despite continued coal dominance, Poland has achieved significant success in the field of energy transformation. It has become one of the fastest developing PV markets in the EU due to small, distributed PV systems in residential buildings.

Moreover, Poland has a comprehensive and well-developed strategy for offshore wind energy [41] which resulted in contracts for the launch of 5.9 GW of capacity by 2030 and plans for at least 11 GW power up to 2040.

The first wind power system in Polish marine areas will start to be built in two years' time (and be finished in 2040). Polish energy policy is focused on decreasing emissions of carbon dioxide by increasing renewable energy source use and natural gas, introducing nuclear energy, greater energy demand and improvement of energy efficiency. Poland puts strong emphasis on safe energy and just transition. It will provide energy at an affordable cost in order to promote economic growth and to protect consumers. An important document determining Poland's energy and climate policy is the National Energy and Climate Plan (KPEiK) for the years 2021–2030, the Ministry of State Assets, version 4.1. from 18 December 2019 [42].

This document is required from all EU Member States and it was accepted in 2019. Another important document is Poland's Energy Policy until 2040 (PEP2040) [43], which was adopted in February 2021. In accordance with national regulations and EU directives, Poland has a various energy and climate targets. Greenhouse gas emissions from energy-intensive industrial plants and electricity production in Poland are governed by the EU Emissions Trading System.

The European Commission imposed on Poland an obligation to implement the National Energy and Climate Plan for the years 2021–2030, which was carried out by the Minister of State Assets in December 2019. This obligation is imposed on Poland by the provisions of the Regulations of the European Parliament and the Council 2018/1999 [40]. This act has been changed, the current consolidated version is: 29 July 2021 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 [44] and (EC) No 715/2009 [45] of the European Parliament and of the Council, Directives 94/22/EC [46], 98/70/EC [47], 2009/31/EC [48], 2009/73/EC [49], 2010/31/EU [50], 2012/27/EU [5] of the European Parliament and of the Council and repealing Regulation (EU) No 525/2013 [51] of the European Parliament and of the Council.

The Polish energy system is one of the largest within the European Union. It is one of the top ten main macro-energy indicators. This corresponds to the potential of the Polish economy, which has seventh place in the European Union in terms of GDP (in 2018— EUR 496.4 mld at current prices), and sixth in terms of population (37.9 mln). In the category of the amount of gross primary and final energy consumption in 2018, Poland takes 6th place in the EU National Energy and Climate Plan (KPEiK) [42].

In 2018, global energy consumption was 4490,7 PJ. National gross energy consumption per person was about 116 GJ, slightly deviating from the European average which was 137.1 GJ. In 2018, direct energy consumption was 3551.8 PJ. The sector of the economy which had the largest part in direct energy consumption was industry (34.5%). The second largest sector, in terms of consumption, was transport, the share of which has increased steadily in recent years and in 2018 was 27%. In 2018, households used 23% of energy, farmers used 4.6% and other recipients 9% [52]. The National Energy and Climate Plan presents aims and objectives, policies and actions to achieve the five dimensions of the energy union: energy safety, internal energy market, energy efficiency, decarbonization and scientific research, innovation and competitiveness. The document has been prepared on the basis of national development strategies approved at the government level such as the Strategy for the sustainable development of transport by 2030, Ecological policy of the State 2030 [53], Strategy for sustainable rural development, agriculture and fisheries 2030 and regarding Poland's draft energy policy until 2040.

The National Energy and Climate plan for the years 2021–2030 sets the following climate and energy goals by 2030:

- reduction of greenhouse gas emissions in the non-ETS sectors compared to 2005′s level by 7%;
- a contribution of 21–23% of RESs to gross final energy consumption considering:

- a 14% contribution of RESs in transport;
- annual increase in RES share in heating and cooling by 1.1% in an average year;
- a 23% increase in energy efficiency compared to the PRIMES forecast PRIME2007;
- reduction from 56–60% of coal's share in electricity production.

Two strategic framework documents are in the state's energy policy, consisting of: Poland's energy policy (known as PEP2040) [43] and the Strategy for Responsible Development until 2020 with prospects until 2030 (SOR) [52]. Poland's energy policy until 2040 (PEP2040) specifies how to transform energy in Poland. It includes strategic guidance on the choice of suitable technology to build a low-carbon energy system. PEP2040 contributes to implementation of the Paris Agreement signed in December 2015, taking into account the need to carry out transitions in a fair way and with solidarity. PEP2040 provides national contribution to the realization of the EU's climate and energy policy, whose dynamics have significantly increased in recent years. The policy considers the scales of the demands which are related to national economy adjustment to the EU regulatory environment related to the 2030 climate and energy goals, European Green Deal, the COVID-19 economy recovery plan and to achieve climate neutrality following national possibilities as a contribution to implementation of the Paris Agreement. A low-emission energy transformation provided for in PEP2040 will initiate wider modernization changes in the whole economy, guaranteeing the energy safety, ensuring fair sharing costs and protecting the most venerable groups in society. PEP2040 is one of the nine integrated sectoral strategies resulting from the Strategy for Responsible Development (SOR). PEP2040 is consistent with the National Energy and Climate Plan for the years 2021–2030 and it consists of a state description and terms of the energy sector. It points to three pillars [43] (just transition, zero-emission energy system and good air quality) on which eight specific objectives of PEP2040 are based, on the actions which are essential for their implementation and strategic projects.

PEP2040 foresees eight specific objectives which belong to: optimal use of own energy resources, development of manufacturing and network of electric energy, diversification of supplies and expansion of the network infrastructure of natural gas, petroleum and liquid fuels, energy market development, implementation of nuclear energy, renewable energy source development, heating and cogeneration expansion, improving the energy efficiency of the economy. The Strategy of Responsible Development (SOR) is more general in nature and it is the basis of the Polish energy policy 2040.

According to the strategy records, the main mission of the energy sector is to provide the economy, institutions and citizens constantly and optimally adapt to the needs of supplying the energy at an acceptable economic price. According to the SOR, it should be carried out using locally available materials in a rational and efficient way, having energy-efficient waste and renewable energy sources using the potential of innovation in energy generation, transmission and distribution.

At the operational level, it is planned to increase the share of stable renewable energy sources, including clusters, energy cooperatives, etc., and preserving the priority role of improving the energy efficiency of the economy including the elimination of environmentally harmful emissions. Furthermore, it is also important to develop energy storage technologies, the introduction of intelligent energy networks and develop electromobility, introducing energy-efficient and high-efficiency technologies. The strategy also covers projects to support implementation, including: power market, regional gas transport and trade center, electromobility development program, development and exploitation of geothermal potential in Poland, exploitation of the hydropower potential and also restructuring of the coal mining sector. Poland's Energy Policy is developed by the Minister for Energy on the basis of Article 12, 13–15 Act—Energy Law and in accordance with the Act of the principles of development policy and a number of entities and, in particular, the Minister for Climate and Energy and Council of Ministers are responsible for its realization.

With an ambitious funding program implemented with the support of the EU-funded project FinEERGo-Dom, buildings in Poland will become greener [54]. The PLN 100 million given to Polish citizens will finance projects that enable major renovations of buildings that will reduce greenhouse gas emissions and improve energy efficiency. In detail, matters of energy efficiency of buildings that are being designed or constructed, or reconstructed, are regulated by the Regulation on technical conditions of buildings and their location [55]. An amendment to the Regulation on the detailed scope and form of construction design expanded the obligation to conduct an analysis of the feasibility of using alternative systems in a rational way in all kinds of buildings and changed the range of it. The aim is to extend the usage of those alternatives (which include decentralized energy supply systems based on renewable energy, cogeneration, district or block heating or cooling, particularly when it is based entirely or partially on renewable energy, and heat pumps) where it makes economic, technical and environmental sense to do so. Minimum requirements include [56]:

- guarantees of the value of the EP index (kWh/(m^2rok)), which consider the annual calculated demand for non-renewable primary energy for heating, ventilation, cooling and hot water,
- partitions and technical equipment of the building should meet at least the requirements of thermal insulation.

Since January 2017, the values of permissible EP ratios for newly constructed buildings and certain U-values for the building envelope have changed, in accordance with the provisions of the ordinance amendment on the technical condition ordinance to be met by buildings and their location, which came into force on 1 January 2014 [57]

The gradual introduction of regulations is aimed at bringing all participants in the construction market into compliance with current legal requirements. The solution is that all new buildings should be near-zero energy buildings.

The Ministry of Climate and Environment and National Fund for Environmental Protection and Water Management are implementing a project to help households improve household energy efficiency. The Clean Air Program [57] was launched in Poland in 2018 and will last until 2030. The program is aimed at owners and co-owners of single-family houses, or separate residential units in single-family buildings with a separate land register. Subsidies for replacement of heat sources and thermal modernization of the house include up to PLN 30, 37 or 69 thousand, and up to PLN 47 or 79 thousand for subsidies with pre-financing. The subsidy can be used to replace outdated and inefficient solid fuel as a heat sources with modern heat sources which fulfill the highest standards and carry out the necessary thermomodernization work on the building [57].

4.2. Review of the State Policy in Slovakia

The legislation amendments in energy efficiency law and other minor issues in public ownership laws entered into force on 1st February 2019 in Slovakia. The most significant among them is Act no. 321/2014 Coll. on energy efficiency. It was adopted based on the Directive 2012/27/EU [5] (this directive replaced Directive 2006/32/EC) [58]. Besides that, Slovakia adopted an Integrated National Energy and Climate Plan for years 2021–2030 [59].

The Integrated National Energy and Climate Plan for the years 2021–2030 sets the following climate and energy goals by 2030:

- reduction of greenhouse gas emissions in the non-ETS sectors compared to 2005′s level by 12% (however, strategic document Envirostratégia 2030 [60] increased the plan to reducing greenhouse gas emissions up to 20% in 2030),
- to increase the contribution of RESs to gross final energy consumption to 19.2% in 2030 (an increase of 5.2% compared to 2020), considering:
- a 14% contribution of RESs in transport,
- a 19% contribution of RESs in the production of heating and cooling,
- a 27.3% contribution of RESs in electricity generation.

The war in Ukraine has intensified pressure on the energy self-sufficiency of Europe, including Slovakia. The shift away from Russian fossil fuels and the emphasis on renewable energy sources (RESs) is influencing various areas and economy sectors in Slovakia, and should be even more pronounced in the future. In 2020, the share of Russian gas in the

European Union was 38%. In Slovakia, it was significantly higher—up to 85% of Slovakia's gas came from Russia. Possible alternatives, including RESs, are therefore being considered as inevitable.

Unlike countries such as Sweden, Finland, Latvia or neighboring Austria, Slovakia is lagging far behind in the use of RESs. The share of energy that Slovakia obtained from RESs in 2020 was only 17.3%, with wood and wood chips contributing significantly. This was a relatively high share for Slovakia, as Slovakia's original target was only 14%. In comparison, Sweden, for example, had more than 60% of its energy come from renewable sources (with a target of 49%) [61].

According to data from the Statistical Office of the Slovak Republic, gross electricity production from renewable sources in Slovakia in 2020 amounted to 7279 GWh. The largest share, more than two-thirds (67.2%), was contributed by hydroelectric power plants. This was followed by wood (including wood waste and other solid waste) with a share of 15.4%. Solar photovoltaics accounted for 9.1% of the RESs in electricity generation, biogas accounted for exactly 7%. Gross heat production from RESs in 2020 was 6 518 TJ. Wood (including wood and other solid waste) accounted for the largest share, up to 82.8%. This was followed by biogas with a share of 11.1%. Energy recovery of industrial and municipal waste accounted for 3.1%, geothermal heaters for 2.8% [62].

The basic institutional and financial instrument for increasing Slovakia's energy self-sufficiency is the so-called Recovery and Resilience Plan. It is a time-bound mechanism to support recovery and resilience and it is a key instrument of the NextGenerationEU initiative [63]. It was developed and approved on the basis of the Regulation of the European Parliament and of the Council of 12 February 2021, when the Recovery and Resilience Facility 2021/241 was established. On 16 June 2021, the Government of the Slovak Republic approved Act No. 368/2021 Coll. on the Recovery and Resilience Support Mechanism and on the amendment and supplementation of certain acts.

The Recovery and Resilience Plan focuses on five key public policies in Slovakia:

- Green economy—allocation of EUR 2301 million.
- Education—allocation of EUR 892 million.
- Science, research and innovations—allocation of EUR 739 million.
- Health—allocation of EUR 1533 million.
- Efficient public administration and digitalization—allocation of EUR 1110 million.

The Slovak Republic has committed to allocate EUR 2.73 billion, 43% of the total allocation of the Recovery Plan, to the stated objectives of green transformation and climate change mitigation. The green economy area is divided into five components, namely:

- Component 1 Renewable Energy and Energy Infrastructure—allocation of EUR 232 million.
- Component 2 Renewal of Buildings—allocation of EUR 741 million.
- Component 3 Sustainable Transport—allocation of EUR 801 million.
- Component 4 Decarbonization of Industry—allocation of EUR 1368 million.
- Component 5 Adaptation to Climate Change—allocation of EUR 159 million [64].

The largest program from the Renewal of Buildings Plan will be the Single-Family Home Renewal. In total, it is planned to support the renovation of over 30,000 family houses. The subsidy per house will be a maximum of EUR 19,000 and at the same time a maximum of 60% of the total cost. It will only be possible to support projects that meet the requirements of a minimum of 30% primary energy savings. The announcement of the first call for renovation of family houses was published on 6.9.2022 and the call for project proposals was open until 17.10.2022 [65].

A restoration grant may be awarded if the project cumulatively meets the following conditions:

- the renovation must result in primary energy savings of at least 30% compared to the pre-renovation condition;

- the renovation of the house must include at least one measure from measures of group A. Group B measures are optional. Group A measures to improve the thermal performance of buildings include the following options:
    1. insulation of the building shell;
    2. insulation of the roof covering;
    3. replacement of window openings;
    4. insulation of the floor of an unheated attic (or any unheated space in the family house, under which there is a heated space);
    5. insulation of the ceiling of an unheated basement (or any unheated space in the family house above which the space is heated);
    6. insulation of the ground floor (of a heated room in the family house under which there is no other room).

Group B measures include five subgroups, namely: 1. installation of the energy source including putting it into operation (heat pump, photovoltaic panels, solar collectors, gas condensing boiler, heat recuperation, other heat source, e.g., electric boiler); 2. green roof (intensive or extensive); 3. rainwater storage tank (underground or aboveground); 4. installation of shading technology; 5. removal of asbestos.

5. Case Studies—Increasing Energy Efficiency Linked with Improvement of Well-Being

In the following, we offer a case study from Slovakia (replacement of heating equipment (measure group B) and insulation of the house (measure group A)), and a case study from Poland (impact of the use of RESs on the energy efficiency of a single-family building as well as energy savings and operating costs). Both case studies document the situation of family houses which are implementing possible measures to reduce energy costs or to increase energy efficiency. While the case study from Slovakia proposes to provide procedural aspects of the whole sustainability strategy, from the European Energy Self-Sufficiency Plan, through the National Renewal Plan, to the steps and actions that citizens have to use to put these intentions into practice in their houses, on the other hand, the case study from Poland is oriented more practically (it documents the calculation of the energy savings in the single-family house in using various kinds of RES). The basic assumption is that such changes will improve life quality (including well-being) of the population and their families, protect the environment, offer positive educational environmental role models for the younger generation and at the same time provide business and employment opportunities for companies that can be involved as contractors in the implementation of the projects.

The purpose of this section is to analyze the national policies of Poland and Slovakia, which are based on European Directive 2012/27/EU on energy efficiency and which introduce new measures aimed not only at increasing energy efficiency, but also at increasing the well-being of households and individuals. The two countries' policies are analyzed in the context indicated above. In the current phase of policy implementation in both countries, it would be expected that the results on energy savings from previously supported projects are known. However, the results of the analysis conducted show that there are information gaps in this area in both countries. They also indicated that the data refer to overall energy consumption, without being able to determine energy consumption for single-family houses (and thus being able to determine through the development trend the possible energy savings from projects supporting green households or home insulation). We consider this fact a significant shortcoming of the administrative procedure. The analysis showed that there is a lack of comprehensive information in the studied area, with which it would be possible to show how the energy-saving policies of Poland and Slovakia affect the individual well-being of the population. In both Poland and Slovakia at this moment (December 2022), there are no relevant statistical data on the actual use of RESs in family houses nor on the energy savings due to the implementation of government measures to promote the use of RESs in family houses and on the impacts of the implementation of RESs in households on the well-being of individuals.

For this reason, we decided to supplement the legislative side (national policies) with the procedure of applying for financial support for RES use in households (the currently ongoing call for RES use in households in Slovakia) and with a case study, in which we offer a technical calculation of energy savings and operating costs in the case of an exemplary house in Poland.

5.1. Slovakia—Case Study Documenting Administrative Procedure

Green households

National Green Households projects in Slovakia are prepared within the Operational Programme Environmental Quality, which has been managed by the Ministry of the Environment of the Slovak Republic since 2015. The project is part of Priority Axis 4 which is aimed at promoting an energy-efficient, low-carbon economy in all sectors. The purpose of the projects is to provide support for the installation of small-scale renewable energy sources (RESs), which will reduce the use of fossil fuels. The support is given for electricity generation installations, namely photovoltaic panels, and heat generation installations, which are solar collectors, biomass boilers and heat pumps. The goal of the project is to increase the involvement of RES use in households and the related reduction of greenhouse gas emissions.

The implementer of the national project is the Slovak Innovation and Energy Agency (SIEA). Thanks to the European and state support provided through the national Green Households project, since 2015, 18,502 devices for the use of renewable energy sources have been installed in Slovak households. Among them, there were 3673 photovoltaic panels, 6974 solar collectors, 2613 biomass boilers and 5242 heat pumps. In the pilot Green Households project, EUR 45 million was made available. Although the latest claims were received and paid in 2018, official data on the actual energy savings achieved for 2015–2018 are not yet known.

The continuation of the pilot project, which ended in 2018, is the national Green Households II project, under which households outside the Bratislava Self-Governing Region can benefit from European support for home renovation between 2019 and 2023. Green Households II is the second phase of support aimed at the use of so-called small-scale renewable energy sources in family and apartment buildings.

The rules for supporting the installation of small-scale RES installations are defined in the General Conditions for Supporting the Use of Renewable Energy Sources in Households. Support for the installation of small-scale RES installations shall be implemented through the issue of vouchers, in time-limited or otherwise limited rounds. Specific conditions are also defined for each round. The specific conditions specify, in particular, the type of small RES installations currently supported, the eligible territory or the number of individual subsidies. A small installation for electricity generation is an installation with a capacity of up to 10 kW. In the case of heat production, a small installation is an installation covering the energy needs of a building used by natural persons for residential purposes.

The support for the installation of small equipment for the use of RESs includes the provision of a financial contribution for the installation of small equipment to produce electricity or heat from RESs, which are:

1. small installations to produce electricity with an output of up to 10 kW:
    (a) photovoltaic panels (electricity production),
    (b) wind turbines (electricity production) (it is not yet possible to issue vouchers for these installations),
2. heat production installations that cover the energy needs of a family or apartment building:
    (a) solar collectors (heat production),
    (b) biomass boilers (heat production),
    (c) heat pumps (heat production).

The specific type of production facility for which a contribution may be granted must be listed in the approved list of eligible facilities maintained by the SIEA.

The following persons are entitled to install photovoltaic panels, wind turbines, solar collectors, biomass boilers and heat pumps in a family house:

1. a natural person who is the owner of the family house,
2. natural persons who are joint owners of the family house,
3. a natural person or natural persons who are co-owners of the family house and who are entitled to make decisions on the management of the common property according to the majority of their shares.

All categories of owners and co-owners are also subject to additional rules strictly regulating additional requirements concerning ownership, use or size of the heating area of the house.

In the second half of 2022, the Slovak Innovation and Energy Agency responded to an exceptional situation, as the interest of households in allowances for heat pumps, biomass boilers, solar collectors and photovoltaic panels is growing exponentially, but the delivery times of some technologies are becoming longer, and the installation capacity of contractors may also be limited. The current call for applications is therefore open from 13 June 2022. Thanks to an additional EUR 30 million increase in the project budget, households were able to benefit from support for all four installations—heat pumps, biomass boilers, solar collectors and photovoltaic panels—in the second half of 2022.

The vouchers are valid for 90 days, but when they are active and issued is now decided by households in agreement with contractors. This is based on when the equipment is ready to be installed. This is a fundamental change that responds to contractors' limited personnel, technological and time capacity.

The list of eligible contractors will be continuously updated by the Slovak Innovation and Energy Agency. Contractors can apply for the list at any time during the duration of the Green Households projects. All applicants who meet the conditions and commit to provide installations in accordance with the contract will be included in the list. SIEA publishes the list of contractors who have an effective voucher reimbursement contract.

For contractors who have agreed to provide their contact details to the public, telephone numbers and e-mail addresses are also published in the list. Additional contacts will be added upon receipt of consent at the next update of the list. As of 20 September 2022, there are 1386 eligible contractors on the list throughout the country.

House insulation

The development of interest in the contribution for insulation and reconstruction of older family houses shows that the Slovaks are more and more often engaged in the renovation of their homes. The contribution for the house insulation started to be granted in Slovakia in 2016; since then, a total of eight calls for projects and applications for support have been announced. In the first five calls from 2016–2019, the interest of the residents was so low that even within 30 days of the opening of the call, the reserved limit of 500 applications could not be met. In response, the Ministry of Transport and Construction of the Slovak Republic significantly reduced the number of applications accepted to 150 (in the 6th call, April 2020); in the last two calls (autumn 2020 and May 2021), the number of applications accepted was adjusted to 200. However, residents' interest in the insulation allowance has increased significantly since the start of the COVID-19 pandemic: in April 2020, the limit of 150 applications was reached within two days, in autumn 2020 it was reached in 24 hours, and in May 2021, the limit of 150 applications was reached within 17 minutes.

The year 2022 brought significant changes in the field of insulation of family houses. As of 8 March 2022, the contribution for the insulation of family houses has been suspended (eight calls since 2016), with the intention that contributions for the insulation of houses should be provided in the future from the SR Recovery and Resilience Plan project. Under the Recovery and Resilience Plan, the insulation of houses falls under the subprogram "Green Recovery". Owners of older family homes can therefore count on a significantly strengthened program to support home renovation and insulation. The Green Recovery Program should be one of the biggest measures to kick-start the economy after the COVID-19 pandemic. The funding in the program, which will flow to Slovakia under the Recovery and Resilience Plan, should be enough to renovate 30 thousand houses. The chances of receiving a grant for insulation and other home renovation should thus be significantly higher than before, when the state only granted a grant to 405 projects since 2016 (Table 2).

Table 2. Supported house insulation projects (2016–2021).

Round No.	Date of the Call for Proposals	No. of Applications	No. of Supported Projects
1.	16 March 2016–12 April 2016	230	39
2.	9 June 2016–6 July 2016	90	14
3.	1 August 2017–31 October 2017	246	34
4.	1 April 2018–31 August 2018	284	56
5.	17 June 2019–30 September 2019	317	63
6.	1 April 2020–30 June 2020	150	95
7.	2 September 2020–30 October 2020	150	80
8.	18 May 2021–30 June 2021	200	24 to date

According to the latest information [66], the call for applications from the Green Recovery Program opened in autumn 2022. The Ministry of the Environment has determined that the condition for obtaining the financial support will be the achievement of 30% savings of primary energy resources through a comprehensive renovation of the house. This will primarily involve insulating the façade and roof of the house, replacing windows and doors, upgrading heating and using renewable energy sources, as well as installing external shading and green roofs. Preliminarily, the maximum contribution per house is EUR 16,600. However, it is possible that the state may decide to support a larger number of houses, which will reduce the contribution somewhat. The Ministry of the Environment is considering contributing up to 50% of eligible costs.

Citizens can apply for support through the website of the Slovak Environmental Agency [67] based in the capital Bratislava. There are also ten regional offices (in 10 cities) where citizens can obtain help with their applications. The Ministry of the Environment announced that by the end of 2022 it would like to approve financial support for the first four thousand family houses.

The essential feature of the Green Recovery Program is that it will insist on the comprehensive renovation of houses. The two basic requirements for project funding are that any renovation must result in maximum energy savings for operation and reduce air emissions from heating. Grants for only partial works, such as replacing windows or roofs, would not achieve the necessary effect and it is positive that the state has ruled them out in advance.

Based on the call for proposals of 6 September 2022 [65], the eligible applicant must fulfill the following requirements:

- he/she is a citizen of an EU country,
- he/she resides permanently in a house (for the renovation of which he/she is requesting funding from the mechanism),
- he/she has a legal capacity,
- he/she is either the owner or the owner in common or the co-owner of the house,
- he/she has not been convicted of certain types of criminal offences,
- he/she has no tax debts for which the aggregate amount exceeds EUR 170, i.e., he/she is not on the list of tax debtors,
- he/she has no social security debts of more than EUR 100,
- he/she is not on the list of debtors for health insurance,
- he/she is not the subject of an execution under the Execution Code,
- he/she is the holder of the bank account mentioned in the application.

5.2. Polish Case Study of the Impact of the Use of Renewable Energy Sources on the Energy Efficiency of a Single-Family Building As Well As Energy Savings and Operating Costs

The requirements for energy consumption that must be met by new and modernized buildings are related to legal requirements and global trends. We strive for large energy savings through thermal modernization of buildings, greater use of renewable energy sources (RESs), electrification of heating and continuous improvement of the energy efficiency of the economy, including construction. Specific requirements are imposed on investors by the Act on RESs, energy performance and energy efficiency. These requirements are also included in the Regulation on technical conditions to be met by buildings and their location, which from 2021 set expectations for almost zero-energy buildings [68–71].

The obligation to produce energy performance certificates for buildings sold or rented, introduced in 2009 by the Act on the energy performance of buildings, is another contribution to improving the energy efficiency of buildings. This act also introduced the term "nearly zero-energy consumption building" (nZEB) and this is the standard applicable to all new buildings from 1 January 2021 [72,73].

Achieving the zero-emission building standard now, mandatory for all buildings erected after 2029, is not difficult and brings measurable operational benefits. The requirements and recommendations for new buildings included in the draft revision of the EPBD directive concern not only the lack of emissions at the location of the building, but also [68–70]:

- higher smart readiness indicator for buildings (SRI), i.e., the practical implementation of the idea of intelligent buildings ensuring high comfort, safety and controlled energy consumption,
- high share of renewable energy in the balance of energy consumed by the building,
- a higher level of self-consumption and autarky of energy from own (prosumer) photovoltaic systems with electricity storage,
- a healthy indoor climate thanks to effective and controlled ventilation,
- low energy costs for heating and hot water,
- the possibility of cooling rooms thanks to surface installations,
- better loans and higher creditworthiness thanks to low operating costs,
- higher value of the building on the market.

The draft revision of the EPBD directive on the energy performance of buildings from December 2021 provides that, by 2030 at the latest, new buildings will have to be erected as zero-emission buildings (ZEBs; this concept has replaced the nZEB standard, i.e., nearly zero-energy buildings), and in the public sector by 2027. Such buildings are to show low energy demand and use local renewable energy sources, they are to be devoid of fossil fuel combustion sources and they are also to have a low impact on global warming, related to CO_2-equivalent emissions throughout the life cycle. Additional conditions are: for residential buildings, EP < 65 kWh/(m^2year), no CO_2 emissions from heating devices used in the building and production of energy from renewable energy—e.g., a heat pump with the equivalent annual production of electricity from PV—realized in the building or as part of a local energy cooperative [71,74,75].

The analyzed single-family building

For the analysis of the impact of the use of RESs on the energy performance, a standard single-family building that meets the Technical Conditions WT2021, currently in force in Poland, was adopted. Taking into account the current trends in single-family housing, the selected construction project can be erected on a plot with minimum dimensions of 19.5 m × 17.5 m. The building has a simple and compact body, two stories with an attic, a gable roof and no basement.

The building contains a total of 15 rooms on the ground floor and attic with a total usable area of 154.89 m^2.

The building model was mapped in the SANKOM Audytor OZC 7.0 Pro software (Figure 2), which enables numerical simulation and energy performance calculations for a specific building model. Defining the model was a very important step during the construction of the model. The calculations were made on the basis of the PN-EN 12831: 2006 standard [75–80].

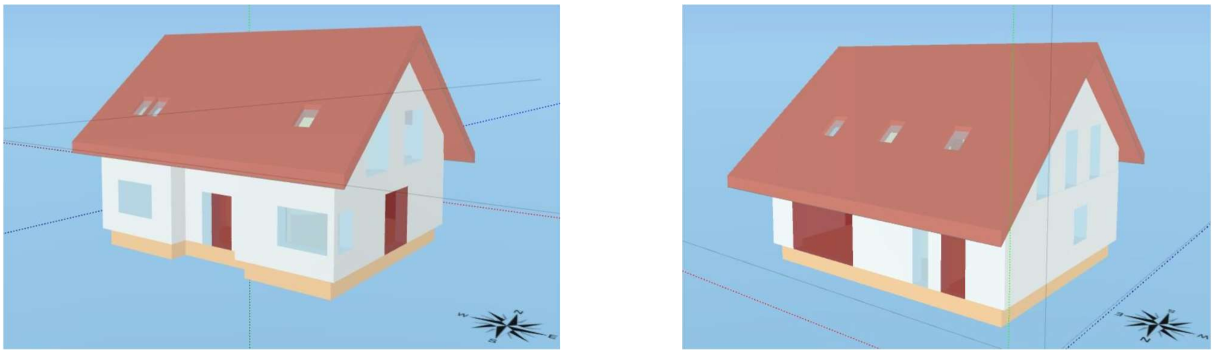

Figure 2. Analyzed building—view of the model of the analyzed building made in Audytor OZC (own elaboration).

A key element before evaluating the results and selecting the optimal solution for our building is to understand the meaning and method of determining the three key indicators in classifying the energy efficiency of a facility as a structure and the installations it contains. All buildings intended for human use, including public utility, industrial and residential, can be clearly characterized by calculating individual energy demand coefficients: primary EP, utility EU and final EK [72,73,81,82].

Moving on to a further analysis of the influence of the use of renewable energy sources on the energy performance of a building, several assumptions should be made that define the subsequent thinking. It is assumed that in terms of external partitions, such as external walls, floor on the ground, roof and ceilings with windows and external doors, the building meets all the requirements contained in the technical conditions of WT2021 [75,78,79,83,84]. In order to provide an overview spectrum and to show the differences and the impact of renewable energy sources on the energy performance of a building, several variants are set up (Table 3) that provide heating of the building surface and domestic hot water, the spectrum of which starts with energy from fossil fuels, through a partial share of renewable energy sources, up to the full share of RESs in the energy mix.

Table 3. List of variants of the analyzed models in central heating, hot water, ventilation and electricity installations for the analyzed building (own elaboration).

	Central Heating	Ventilation	Hot Water	Electricity
1.	Coal	Gravitational	Coal	Electrical grid
2.	Biomass	Gravitational	Biomass	Electrical grid
3.	Natural gas	Gravitational	Solar collectors	Electrical grid
4.	Electrical grid	Gravitational	Electrical grid	Electrical grid
5.	Heat pump powered by the electricity grid	Gravitational	Heat pump powered by the electricity grid	Electrical grid
6.	Heat pump powered by a photovoltaic installation	Gravitational	Heat pump powered by a photovoltaic installation	Electricity from a photovoltaic installation
7.	Electricity from a photovoltaic installation	Mechanical supply and exhaust	Electricity from a photovoltaic installation	Electricity from a photovoltaic installation
8.	Heat pump powered by a photovoltaic installation	Mechanical ventilation with recuperation	Heat pump powered by a photovoltaic installation	Electricity from a photovoltaic installation

When calculating the annual final energy demand, it is worth emphasizing the fact that it should be expressed as the ratio of the usable energy demand, which is determined by the heat balance of the building, to the average seasonal efficiency of the heating system.

The calculations are aimed at determining the demand for heating purposes and are given in the equation below [76,77]:

$$Q_{K,H} = \frac{Q_{H,nd}}{\eta_{H,\ tot}} \left[\frac{kWh}{year}\right] \tag{1}$$

where:

$Q_{H,nd}$—useful energy demand to heat a residential building (useful heat),

$\eta_{H,tot}$—average seasonal efficiency of the building's heating system.

An important element that is taken into account, apart from the energy intended to heat the building, is that used to prepare domestic hot water, and the energy demand for it is defined by the formula given below [76,77]:

$$Q_{K,W} = \frac{Q_{W,nd}}{\eta_{W,\ tot}} \left[\frac{kWh}{year}\right] \tag{2}$$

where:

$Q_{W,\ nd}$—demand for preparation of domestic hot water,

$\eta_{W,\ tot}$—average annual efficiency of devices preparing domestic hot water.

The above two equations allow us to determine the final energy factor (EK) of which they are components. It is important for both the auditor and the user that the EK, EU and EP coefficients are given as the number of necessary kilowatts used to heat a square meter of the building's surface throughout the year. The following equation shows us the method of calculating the required final energy EK to supply the building [76,77]:

$$EK = \frac{Q_{K,\ H} + Q_{K,\ W}}{A_f} \left[\frac{kWh}{year \times m^2}\right] \tag{3}$$

where:

A_f—heated or cooled space in the building with a specific temperature, expressed in m^2.

The primary energy demand factor is calculated on the basis of the annual energy needs for heating and domestic hot water preparation and, where applicable, cooling or ventilation of the premises and lighting in specific cases. The aforementioned EP coefficient is calculated from the following dependence:

$$EP = \frac{Q_P}{A_f} \left[\frac{kWh}{year \times m^2}\right] \tag{4}$$

where:

Q_p—annual demand for primary energy (kWh/year).

Of which the annual primary energy demand is calculated according to the formula:

$$Q_P = Q_{P,H} + Q_{P,W} + Q_{P,C} + Q_{P,L} \left[\frac{kWh}{year}\right] \tag{5}$$

where:

$Q_{P,H}$—annual primary energy demand through the heating and ventilation system for heating and ventilation,

$Q_{P,W}$—annual primary energy demand by the domestic hot water preparation system,

$Q_{P,C}$—annual primary energy demand for the space ventilation and cooling system,

$Q_{P,L}$—annual demand for a lighting system (calculated only for public buildings).

As can be seen from the above information, all indicators are directly related to each other. Having information about the height and proportions between individual indicators, we are able to relatively easily assess the overall quality of the building with the technologies used in the facility, looking through the prism of thermal modernization of partitions, the number and degree of elimination of thermal bridges, tightness of the structure as well as efficiency and efficiency of the heating installation rooms and domestic hot water.

After conducting an energy analysis of the building and carefully reading the results, the following conclusions can be reached. The main goal and criterion was to meet the requirements contained in the technical conditions of WT2021, which defined a number of requirements for the structure of the building, thermal transmittance of external partitions and energy coverage of the building's heating needs, along with meeting the needs of users related to domestic hot water. In fact, it turned out that the above-mentioned partitions not only meet the guidelines, but in most cases are of much higher quality in terms of insulation. The key element during the project implementation was to check which of the provided solutions are characterized by the best results in terms of energy demand, and above all, how renewable energy sources affect the final results of the building, together with an assessment of whether their use had a positive effect on the balance or vice versa. The seven analyzed variants could be divided into three characteristic subgroups in a simplified way. The first subgroup was characterized by the overall coverage of demand with non-renewable energy sources such as coal heating and electricity from the power grid, as well as fully electric heating from electricity from the power grid. The second subgroup was characterized by partial use of renewable energy sources. Among them, there were variants in which the object was heated by burning biomass and connecting household appliances to the power grid, burning natural gas for heating purposes and providing domestic hot water by means of solar collectors and electricity from the grid. The last variant in this subgroup was the use of an air source heat pump powered by the electricity grid. The third subgroup was characterized by the fact that both the heating of the building with the preparation of domestic hot water and electricity were fully generated by renewable energy sources.

In the case of the first variant in this subgroup, heating and domestic water were prepared by an air source heat pump powered by a photovoltaic installation. In the second case, in addition to fully electric heating, mechanical supply and exhaust ventilation were also used. The electricity of the second variant came entirely from the installation of photovoltaic cells.

When analyzing the results generated in the reports for each of the variants, it can be quickly noticed that only three out of seven proposed solutions met the guidelines, one option was close to meeting the guidelines, while the other three variants did not even come close to the stringent requirements of the WT2021 technical conditions (Figure 3). The worst solutions turned out to be those that obtained energy from the combustion of hard coal and obtained electricity from the power grid for heating purposes. The last three options managed to meet the primary energy requirements. The first variant obtained energy from the biomass combustion process, and more precisely from birch wood with very low humidity. The second solution that met the guidelines was electric heating of the building using energy from the installation of photovoltaic panels with the simultaneous use of mechanical supply and exhaust ventilation. The use of this variant made it possible to notice certain regularities. Firstly, the use of mechanical ventilation in the building generated profits thanks to the reduction of the EU's utility energy demand by 25%. Secondly, thanks to the application of the above-mentioned installation, it was also possible to reduce losses in terms of final energy (EK), which can be seen particularly easily when comparing the EK of variant VII with IV. Despite the many advantages that this installation brought, it cannot be called optimal, because the energy from the photovoltaic installation is closely related to weather conditions and, to heat the building with energy from PV panels, it would be necessary to use a fairly large number of panels. The last solution that met the guidelines was the variant which consisted of a photovoltaic installation supplying an efficient heat pump cooperating with gravity ventilation. The use of a variant containing such components obtained the best results compared to other solutions, looking through the prism of the obtained values of non-renewable primary energy (EP) and final energy (EK).

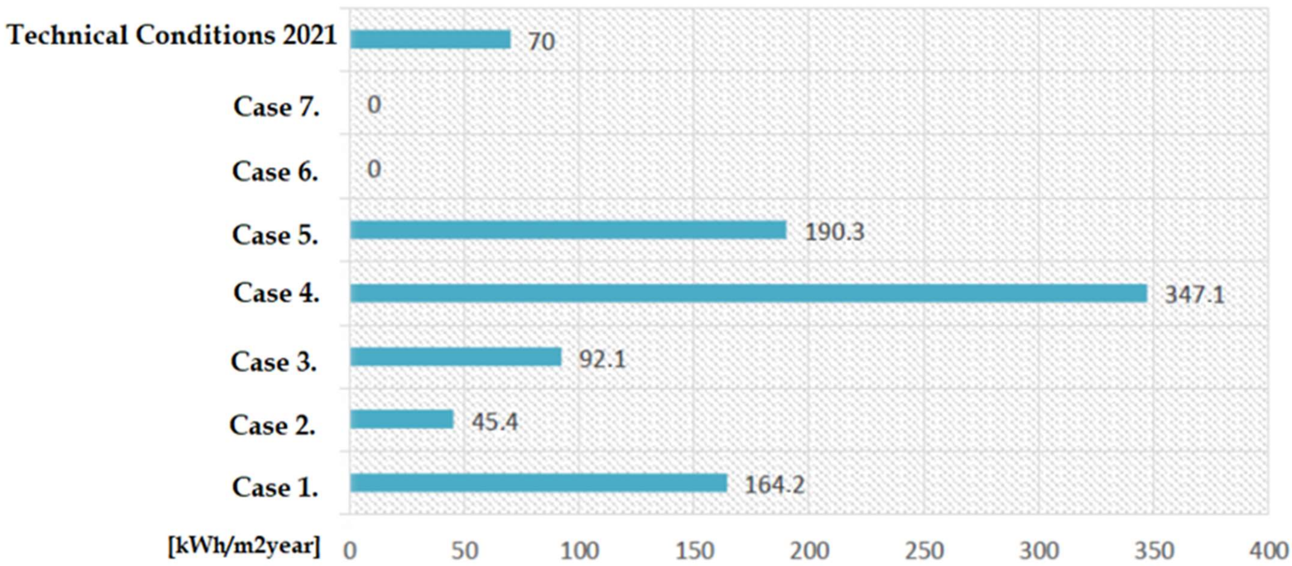

Figure 3. A collective summary of the results of the demand of the analyzed variants for EP in relation to the EP value established by the Technical Conditions for 2021 (own elaboration).

A solution that could drastically reduce EP, EK and EU coefficients would be variant VIII, which would include a compressed air source heat pump with a seasonal efficiency of 2.6, covering a total design heat load of the building of 7.5 kW in CO and DHW systems, inclusion of a mechanical ventilation installation with recuperation and powering all components and installations in the building from a 9 kW photovoltaic installation, covering the demand of the entire building at the level of 8400 kWh/year (Table 4).

Table 4. A collective summary of the results of the demand for individual energies for variant VIII (own elaboration).

Assessment of the Energy Characteristics of the Building		
Energy Performance Index	**Building Being Assessed**	**Requirements According to Technical and Construction Regulations 2021**
Annual useful energy demand indicator	EU = 58.3 kWh/m^{2}year	
Annual final energy demand indicator	EK = 39.6 kWh/m^{2}year	
Annual demand for non-renewable primary energy	EP = 0.0 kWh/m^{2}year	EP = 70.0 kWh/m^{2}year
Unit amount of CO_2 emissions	E_{CO2} = 0.0 MgCO_2/m^{2}year	
Share of renewable energy sources in the annual final energy demand	U_{OZE} = 100.0 %	

In the above solution (variant VIII), we can also note that due to the 100% share of renewable energy sources in the annual final energy demand, the analyzed building is zero-emission, powered only by its own energy sources—it is a zero-energy building (ZEB).

Taking into account the entire spectrum of possibilities and information provided by this analysis, it can be stated without any doubts that the use of renewable energy sources in building heating systems and domestic hot water brings many benefits, looking through the prism of sustainable energy consumption, economics and increased comfort of life. It is worth paying attention to the fact that the use of renewable energy sources gives tangible benefits in every case of use in buildings, however, the current requirements for primary energy pose new challenges for investors, which, as it is easy to see, can only be met by renewable energy sources.

6. Discussion

One of the strategic aims of the state's energy and ecological policy is to improve the energy efficiency of the economy [5,41,58–60]. Energy efficiency is related to the area of energy use and it is particularly crucial in the process of ensuring security of energy supply, ecological security, increasing the competitiveness of enterprises and many other elements. The issue of energy efficiency is a priority, as an advance in this area is vital for the implementation of all energy policies and most environmental and climate policy objectives. The primary purpose in the area of efficiency, in addition to the targets set out in the efficiency directives [5,46–50], is currently to achieve a reduction in energy consumption compared to the projections for 2030 as a result of energy efficiency improvements. The main objective of the article was to analyze of Polish and Slovakian national policies, which are based on the European Energy Efficiency Directive 2012/27/EU, and which present new measures focused on not only increasing energy efficiency, but also increasing the well-being of households and individuals. Many organizations and countries are working to make zero-energy and resource-free buildings a common practice in new constructions by 2030 or earlier. For example, the EU requires all Member States to establish building codes that required that by 2021 (public buildings from 2019) newly erected buildings would have energy consumption close to zero, and Canada is currently developing legislation on the gradual approach to zero energy buildings (ZEBs). A key step towards net-zero energy is energy efficiency, which can drastically reduce demand by up to 80% compared to typical new designs, thus allowing moderately small renewable energy systems to deliver the remaining energy at a lower cost. The same is true for waste and water, where the emphasis is first on minimizing consumption and then on finding alternatives to achieving the net-zero target.

In order for net-zero buildings to become a common practice, specific targets should also be set in Poland and Slovakia, such as building regulations which will make it mandatory to build new buildings with a net-zero balance by 2030 [42,53,59,60,85]. To achieve this, it is essential to have technical assistance for architects, engineers and builders and innovative packages for developers, as well as research and development on material efficiency strategies (low-carbon alternatives and demand reduction). Strategies should be developed for energy-intensive buildings, such as hospitals and shopping centers. Buildings are essential in the context of the EU's energy efficiency policy, with more than 40% of final energy consumption (and 36% of greenhouse gas emissions) occurring in homes, offices, shops and other buildings. In addition, the sector has the second largest, after the energy sector itself, untapped and cost-effective energy saving potential. There are also important cobenefits of increasing the energy efficiency of buildings, such as creating new jobs, reducing energy poverty, improving health and greater energy security and industrial competitiveness. The experience of the last few years shows that Member States are increasingly making use of cohesion policy funding for energy efficiency, especially for buildings, and that they are increasingly using financial instruments. However, there is a lack of comprehensive data on the impact of this financing on energy savings in the construction sector. For a comprehensive solution to the use of RESs and the reduction of energy consumption, it is not sufficient to focus only on public buildings and buildings that, due to their use, are directly linked to high energy consumption. Awareness of the use of RESs in households should also play an important role in European and national policies. This not only leads to an increase in energy efficiency, but also, as recent research confirms [32–35], to a positive impact on the well-being of individuals.

Desk research and content analysis methods were used. The current situation in both countries is illustrated by case studies documenting the administrative process (Slovakia) and the calculation of energy savings (Poland) using renewable energy sources in the case of single-family houses. Case studies describe ongoing (Poland) and planned (call for proposals) (Slovakia) instruments aimed at increasing energy efficiency and increasing the well-being of residents and households. Results show that governments of both countries are undertaking several actions to increase interest of individuals and family house owners to use RESs in family houses. This outcome is supported by [33–35], who stressed the importance of quality government policies supporting RESs to increase the well-being of individuals. An analysis of European legal documents [5,40,44–51], existing financial support measures for energy efficiency in buildings [57,59,64] and different market barriers shows that the situation differs considerably between Member States in terms of the building stock, financial support measures and significant market obstacles. Although investments in the energy efficiency of buildings are rising and there are many examples of good practice for instruments that bring cost-effective energy savings, there is only limited information on the effectiveness of the different financial support measures, both at the EU and national level; there are still significant barriers to the further implementation of investments in the energy efficiency of buildings, including a lack of awareness and expertise in the financing of energy efficiency measures by all factors, high upfront costs, relatively long payback periods and (perceived) credit risk associated with energy efficiency investments and the competing priorities of the final beneficiaries.

If the EU is to improve energy efficiency by 2030 and achieve the ambition of further savings by 2050, it is necessary to increase financial support for energy efficiency in buildings. To this end, it is essential to ensure the proper implementation of the regulatory framework, to increase the availability of financial resources and to remove the main barriers. The Commission is involved in a number of initiatives and actions to reach these goals. However, given the nature of the building stock and the building sector and the responsibility of Member States to implement relevant legislation and remove national market barriers, Member States play a decisive role in ensuring that further cost-effective investments are made.

In addition, the important role of a case-by-case approach in the context of energy efficiency financing measures means that close cooperation between public authorities, financiers and the construction sector is essential. Equally important, building owners will have to convince themselves of the benefits of improving the energy performance of buildings, not only because of lower energy bills, but also in terms of increasing comfort and increasing the value of real estate. This may be one of the most serious obstacles to overcome in the pursuit of improving the energy efficiency of European buildings. However, this is supported by macroeconomic arguments and targeted incentives and information measures will be needed to change attitudes. An essential tool in this context is the building renovation action plans that Member States must establish under the new Energy Efficiency Directive. Increasing the energy efficiency of energy generation, transmission and use processes is a base of a sustainable energy policy, which is reflected in national and EU legal regulations and actions taken by various national and EU institutions. Improving energy efficiency is of great meaning for the implementation of all energy policy goals and most environmental and climate policy targets, which is why it should be a priority in modernizing the country's economy. It can be accomplished by building high-efficiency generation units, increasing the degree of application of high-efficiency cogeneration, reducing the rate of network losses in energy transmission and distribution and increasing the efficiency of energy end use. Improving the energy intensity indicators of the economy, in addition to significant economic benefits, brings measurable ecological effects (reduction of consumption of natural resources, reduction of pollutant emissions) which are not able to match the effects of any other solutions reducing the environmental nuisance of the power sector (change in the structure of energy consumption, construction of protective devices and installations, etc.).

Taking into account the whole spectrum of possibilities and information provided by this analysis, it can be said without a doubt that the use of renewable energy sources in building heating systems and hot tap water brings many benefits, from the perspective of sustainable energy consumption, the economic aspect and increased comfort of life. It is worth noting that the use of renewable energy sources gives measurable benefits in every case of use in buildings, but the current demand for primary energy poses new challenges to investors, which, as it is easy to see, can only be met by renewable energy sources. In the above solution (variant VIII), we can also notice that due to the 100% share of renewable energy sources in the annual demand for final energy, the analyzed building is zero-emission, powered only from its own energy sources—it is a zero-energy building (ZEB). Thanks to the low costs of use, greater savings are generated, and this is directly due to the improvement of energy efficiency of our building, the implementation of RESs and independence from external energy supplies by providing electricity and heat with our own energy sources.

These cases show, among other things, how investments in energy efficiency in buildings affect the well-being of households. They are the basis for prosperity and health of citizens and are the starting point for the development of innovative branches of the economy, including broadly understood energy, including distributed energy, i.e., the use of renewable energy sources. It should be remembered that by improving the energy performance of buildings, we reduce energy consumption. As a consequence, by producing our own energy, we significantly reduce the operating costs of buildings. Minimal operating costs, together with simultaneous improvement of energy and environmental efficiency and independence from external energy supplies, directly improve the security of energy production and the sense of security of residents and users of such buildings and their well-being. The sense of security and energy neutrality combined with low operating costs directly improves the well-being and comfort of life of users of zero-energy buildings.

The growing public awareness of the beneficial impact of renewable energy systems on the environment and support in the form of various programs subsidizing the implementation of new installations make the production of energy from renewable sources more and more popular and widespread.

Actions aimed at improving energy efficiency and reducing final energy consumption are undertaken by many countries across the world and the European Union. In 2012, the European Parliament and the Council of Europe published Directive 2012/27/EU, which imposes an obligation on Member States to take action to reduce final energy consumption by 1.5% per year.

Despite the still low level of belief about the profitability of using renewable energy systems, RES installations are positively perceived and recognized as a new trend in both single- and multifamily construction. The growing share of renewable energy in the national energy system affects the reduced demand for energy produced from conventional sources. This obviously translates into reduced consumption of primary energy, for example, fossil fuels. As a consequence, this translates into a reduction in the exploitation of the resources of these raw materials, and thus contributes to the protection of the natural environment.

Findings related to CO_2 are in accordance with previous studies [25,33] that pointed to the negative impact of CO_2 emissions on human health and overall individual well-being. Improving energy efficiency, reducing the operating costs of buildings and implementing the assumptions resulting from EU directives are also extremely important in terms of utility, and translate into the comfort of using buildings, their cost-free operation and the increase in the well-being of users.

The analysis of energy efficiency of buildings with the use of renewable energy sources presented in the publication refers not only to the improvement of prosperity and well-being of single- and multifamily housing. Efficiency understood as the principles of rational energy management, either regarding efficiency, where the main goal is to maximize the effect (e.g., the use of RESs, energy savings, production volume), or regarding savings—as minimization of outlays, operating costs—where it is characterized by the widest range of content covered mainly due to the fact that it concerns the relationship between effects, goals, inputs and costs. In economic theory, it is associated with the concept of the Pareto optimum, i.e., a combination of goods at which the level of utility of all market participants is maximum. Broadly understood improvement of energy efficiency refers to many aspects, e.g., construction, professional energy industry, etc. This is an aspect within the meaning of international documents in this regard, which is very important and fits into the world's energy policy until 2050, i.e., aiming at full decarbonization in relation to the use of fossil fuels and related emissions of harmful greenhouse gases and increasing the share of renewable energy sources in the electricity and heat production sector. This is extremely important not so much in the local aspect by ensuring prosperity, but also through business aspects such as the competitiveness of buildings on the real estate market—those with very high energy performance using RESs with very low costs of use and operation. Thanks to these aspects, the sector of manufacturing enterprises can produce products more cheaply, which means that the demand for products will be greater due to the lower price, without losing the quality of the product in any way, but only reducing operating costs.

In the analyzed energy policies, there are several important relationships between the individual, security in terms of feeling as well as energy, achieving a specific energy efficiency. People are exposed to the influence of various factors that can threaten their lives, health and reduce the comfort of their functioning. The issue of achieving and maintaining the optimal state of security in given conditions and its sense is therefore one of the fundamental goals of human activity. Security is not a constant and unchanging value, one of the most important aspects of activities aimed at obtaining an appropriate level of security is the systematic identification, observation, diagnosis and modification of the conditions that create the secure environment.

In this publication, we have dealt with the energy efficiency policy in Poland and Slovakia in the context of the well-being of the individual, which is directly related to the individual housing sector. The reference and connection of these practices is cross-sectoral and has a very wide meaning, affecting all sectors, not only the one related to housing construction.

As we mentioned earlier, it is defined by the global energy policy, aimed at energy transformation at a very high and demanding level, which is to lead to improved security of societies in terms of well-being as well as improved energy efficiency, lowering the operating costs of buildings and increasing the use of RESs, and changes must take place in all sectors of life (e.g., housing, services, production) to make these forecasts a reality.

7. Conclusions

- The added value of this paper is 1. comparison of the state of the art in two countries, belonging not only to European Union, but also to the Visegrád Four (meaning sharing the mutual past influenced by energy surplus), 2. application of adopted state measures in Poland and Slovakia for usage of RESs and for improving energy efficiency in a case study (combination of administrative procedures and energy saving calculation), 3. linking the expected global savings and benefits of RES use to increasing individual well-being (or, conversely, pointing out that the use of RESs in family houses is important for increasing individual well-being, which in turn leads to savings and a positive effect on increasing energy efficiency). The cases shown directly show how we can achieve energy and economic well-being. Reducing energy consumption in buildings directly translates into a reduction in operating costs, which is a measure of the economic well-being of residents. The production of electricity and heat from one's own resources and renewable energy sources allows an increase in energy and ecological welfare, along with independence from external energy supplies. These two cases described with analytical examples show how to achieve energy independence through the use of RESs, which translates directly into the economic and energy well-being of residents.
- The low energy efficiency of single-family houses results in an increase in heating costs, and thus also in the deepening of so-called energy poverty. This is a phenomenon where homeowners cannot afford energy or energy services that provide the ability to maintain the right temperature while using good-quality fuel. The energy efficiency of buildings means saving energy, and reducing energy production means not only financial savings, but also less environmental pollution.
- The use of RESs has many benefits—one of the most frequently mentioned and shown is the reduction of monthly bills for the operation of the building, and one can gain

greater independence from energy suppliers. Thanks to the installation, as in the case of variant VIII—a heat pump and a photovoltaic installation—independence and a sense of security and self-satisfaction increase, which also increases the value of the property and its attractiveness for potential sale.

- The aim of the article is to show the possibility of achieving energy efficiency and the associated well-being of the population. Case studies show in what direction heating systems of single-family buildings should be modernized to meet the requirements of increasing energy efficiency with the use of renewable energy sources. Thus, from the perspective of national policies and strategies to increase energy efficiency and public awareness in this area, it may be crucial to focus attention on promoting the individual benefit of individuals and households in the form of increasing their individual well-being. The theoretical review of the literature on the subject and the results of empirical studies conducted by various entities in many countries show that investments in energy efficiency result not only in lowering energy costs and reducing energy take-off, but also improve air quality, living conditions and human health and well-being. In the context of strengthening the positive impact of energy efficiency on human health and well-being, it is extremely important to embed energy efficiency measures in financial support mechanisms and support them in local communities. The situation in Slovakia documents the European Union's efforts to increase the use of RESs, renovate buildings and thus reduce the energy intensity of individual housing. Due to the current subsidy call, both for the use of RESs [63] and home insulation [65], which are continuations of previous projects, it would be expected that the results on energy savings from previously supported projects would be known. Slovakia has gaps in this area as the latest data published by the Statistical Office of the Slovak Republic are for 2020. Moreover, these data refer to energy consumption in general, without the possibility to determine the energy consumption for single-family houses (and thus the possibility to identify through the trend of development the possible energy savings due to projects supporting green households or house insulation). Neither the Ministry of Economy nor the Ministry of the Environment provide information in this respect. We consider this fact to be a significant shortcoming of the administrative procedure. On the other hand, there is room for more comprehensive research on real energy savings due to state support (in this case, it would be advisable in the future either to conduct targeted interviews with beneficiaries of financial support or to carry out comprehensive data collection through a questionnaire survey).
- Taking into account the whole spectrum of possibilities and information offered by the case study and analysis of the energy efficiency of a single-family building, it can be concluded that the use of renewable energy sources in construction in heating and domestic hot water systems brings many benefits, looking through the prism of sustainable energy consumption, the economic aspect and increased living comfort.
- In this respect, however, it must be noted that in both Slovakia and Poland there is a lack of sufficient communication from the state (state policies) towards individuals and households to link increasing energy efficiency and well-being of individuals. Although we point out that the reduction of energy intensity through the use of RESs has a direct impact on the reduction of energy costs (case study Poland), it should be added that the reduction of energy intensity also represents an increase in the comfort of living, satisfaction with the quality of housing, quality of life and overall well-being. In the study, we did not investigate the perception of the owners of family houses regarding the increase in their well-being. Our intent was to show that state policies and state policy campaigns to increase energy efficiency should reflect the impact of RES use on increasing individual well-being in addition to savings on energy costs. Further research is also needed in this regard, especially through the collection of primary data from owners of those family houses in which energy efficiency improvements have already been made.

- It is worth noting that the use of renewable energy sources gives measurable benefits in every case of use in buildings, but the current demand for primary energy poses new challenges for investors, which, as can be easily seen, can only be met by renewable energy sources. A solution that could reduce EP, EK and EU coefficients could be variant VIII, which would include a compressed air source heat pump with a seasonal efficiency of 2.6, covering a total design heat load of the building of 7.5 kW in CO and DHW systems, inclusion of mechanical ventilation installation with recuperation and powering all components and installations in the building from a 9 kW photovoltaic installation, covering the demand of the entire building at the level of 8400 kWh/year (Table 4). Improving energy efficiency is clearly related to the improvement of the well-being of people using zero-energy buildings, among others, through implementation of the idea of intelligent buildings ensuring high comfort of use, safety and controlled energy consumption and high share of renewable energy in the energy balance consumed by the building, which in turn determines low operating costs of use.
- Thanks to the low costs of use, greater savings are generated, and this is directly due to the improvement of energy efficiency of our building, the implementation of RESs and independence from external energy supplies by providing electricity and heat with our own energy sources.
- In order to meet the requirements in force from 1 January 2021 for residential buildings specified in the current Regulation of the Minister competent for construction on the technical conditions to be met by buildings and their location, it is necessary to use RESs or connect them to an energy-efficient district heating network to which heat is supplied from high-efficiency cogeneration or RESs. When modernizing buildings, it is not always possible to take into account all the provisions of the above-mentioned regulation, so the use of RESs in them will be rather sporadic. To sum up, it can be clearly stated that in the next 10 years, most of the new and modernized buildings will use RESs to achieve appropriate energy efficiency indicators. The use of renewable energy sources also reduces the emission of combustion products as a result of reducing the consumption of chemical energy contained in primary fuels. The reduction of pollutant emissions (GHGs, dust, soot, BaP) released into the natural environment is proportional to the amount of non-renewable final energy replaced by RESs and the specific emissions of a given fuel consumed from a conventional source and the emissions of an alternative installation using RESs. This can be expressed by the difference between the emission of pollutants from a source and for a conventional installation (baseline state) and the emission of pollutants for an alternative installation based on RESs, which replaces this base state.
- Changes in the amount of pollutants emitted into the atmosphere when replacing conventional energy sources in the building with sources using renewable energy resources are shown in a single-family house example, consuming energy for central heating and domestic hot water preparation. Promoting and recommending the installations based on RESs in construction, in addition to improving the thermal insulation of building partitions, has not only a significant impact on increasing energy security but also achieving the required standards inside buildings with a lower operating cost. Doing so produces optimal and economically viable results in the lasting effects of non-renewable primary energy resources. Targeted and well-thought-out actions to rationalize final energy consumption for buildings should no longer be a challenge, but a necessary task in a sustainable low-carbon economy.
- Referring to the policies of both countries, it should be noted and emphasized that relevant laws and programs are being implemented to improve energy efficiency policies. The legal documents cited in the article are in response to the EU directives that are applicable in all EU countries. The referenced and cited documents such as PEP2040 and the NAPE (PL) became applicable in 2021. It is difficult to discuss their effects on the population at present, and therefore their impact on improving

social well-being. We noted a very large gap in the population's knowledge of energy efficiency in both countries. This is the added value of this paper, and it is not a fundamental purpose. A comprehensive impact of legal acts and public perception on energy efficiency in Poland and Slovakia will be possible in the near future, but not in this phase.

- The analyzed national policies to promote the use of RESs by private households have direct implications not only for individuals, households and individual well-being, but also for the business environment. The promotion of business opportunities is very significant in the context of the renewal schemes (focus on green households, house insulation, various systems of central heating, ventilation, hot water and electricity networks). The analyzed policies should help to revitalize the market for renewable energy equipment in households. At the same time, they have the potential to create a linkage between prospective production and technological capacities, subcontracting relationships, as well as the necessary service support for the installed equipment. All these steps also stimulate local employment growth, as the subsidies are allocated regionally. Last, but not least, the analyzed policies should contribute to improving the awareness and practice of RES installers and to increasing the interest in studying related fields. Thus, in this context, policies promoting the use of RESs in households not only have a positive impact on the well-being of individuals and entire households, but also on the development of business opportunities and therefore indirectly on the well-being of entrepreneurs. This area of linking energy intensity, household use of RESs and the development of entrepreneurial opportunities is not elaborated in the current literature, and represents a possible direction for future research.
- The EU has recently introduced ambitious new policies to persuade member states to take action to improve the energy efficiency of buildings. The new regulations take into account the fact that the main obstacle to building renovation is cost, including buildings in the productive sector. Currently, about 75% of buildings in the EU are energy inefficient. This means that we waste a significant portion of the electricity we use. It is possible to reduce energy waste by renovating existing buildings and using smart solutions and energy-efficient materials when constructing new buildings. Improving the energy efficiency of buildings therefore plays a key role in achieving the ambitious goal of carbon neutrality by 2050, according to the European Green Deal strategy [86].
- In summary, the analysis has shown that the study area lacks comprehensive information on the basis of which it would be possible to show in more detail how the energy saving policies of Poland and Slovakia affect the individual welfare of the population. Once the data contained in public statistics are completed, it will be possible to analyze the impact of the policies in question on the welfare of the population. However, the research gap discovered through the analysis requires further research projects to be undertaken.

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