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The Influence of the Global Energy Crisis on Energy Efficiency: A Comprehensive Analysis

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Abstract: The global energy crisis, which began in 2021 due to the extraordinary economic recovery after the pandemic and intensified after Russia's invasion of Ukraine in February 2022, has changed the conditions of energy management, paying more attention to energy efficiency. Natural gas prices have reached record levels and, consequently, so have electricity prices in some markets. Oil prices have reached their highest level since 2008. Higher energy prices have contributed to sharply increased inflation. Households are again becoming interested in buying coal as a source of heat. High energy and gas prices have pushed many families into poverty and forced some factories to cut production or even close. They have also slowed economic growth to the point where some countries are heading for a serious recession. Paradoxically, the negative effects of the energy crisis may accelerate the introduction of cleaner, sustainable, renewable energy such as wind and solar energy. The energy crisis is comparable to the oil crisis of the 1970s, when it contributed to significant advances in energy efficiency. The current crisis has highlighted the importance of investments in renewable energy resources and initiated the process of integrating regional markets, developing energy efficiency and promoting renewable energies. The aim of this article is to comprehensively explore the complex relationship between energy awareness, consumption patterns, and energy efficiency, with a focus on both individual consumers and industries, during the global energy crisis. This paper is based on a literature review, overarching policy documents, energy reports, and other secondary documents. The primary research method was the systematic literature review method, based on which the impact of the global energy crisis on energy efficiency was evaluated. This study emphasizes the diverse influences on energy awareness, ranging from economic factors to consumer preferences and environmental consciousness. The findings of the paper underscore the significant responsibility of industries in contributing to energy-saving efforts and the active role of consumers in the energy market. The responsibility of industries in contributing to energy efficiency is highlighted, with a call for a comprehensive approach that integrates energy-saving criteria into product development and corporate social responsibility.

Keywords: trends; energy market; RES; energy crisis; energy efficiency; consumer awareness; climate policy

Citation: Gajdzik, B.; Wolniak, R.; Nagaj, R.; Žuromskaitė-Nagaj, B.; Grebski, W.W. The Influence of the Global Energy Crisis on Energy Efficiency: A Comprehensive Analysis. *Energies* **2024**, *17*, 947. https://doi.org/10.3390/en17040947

Academic Editors: Cornel Hatiegan, Marius Miloș, Laura Miloș and Mihaela Molnar

Received: 18 January 2024
Revised: 13 February 2024
Accepted: 14 February 2024
Published: 18 February 2024

1. Introduction

Energy efficiency (EE) was introduced in European Union (EU) public policy during the 1970s oil crisis [1]. The Energy Efficiency Directive (EED), introduced in 2012 and revised in 2018, is a key European policy to achieve energy savings targets for 2020 and

2030 [2]. At the time, the literature provided a broad overview of the definition from economic, social, and technical perspectives provided by Sorrell [3] and Batouta [4] in relation to the manufacturing industry. An analysis of the current literature (Figure 1) on EE indicated that interest in this topic is growing, which means that it is a topical issue that is becoming increasingly important from both the scientific side and practical application.

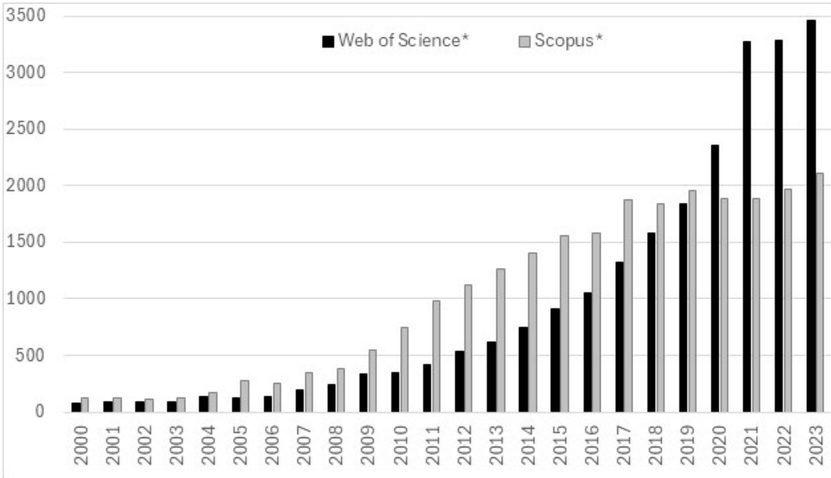

Figure 1. Number of publications* on energy efficiency. * Number of publications for the term "energy efficiency" for review articles and research articles in English in 2000–2023.

The subject matter regarding EE is also diverse. Figure 2 shows the Knowledge map of energy efficiency [5], i.e., the thematic coverage of the 100 most relevant documents on EE.

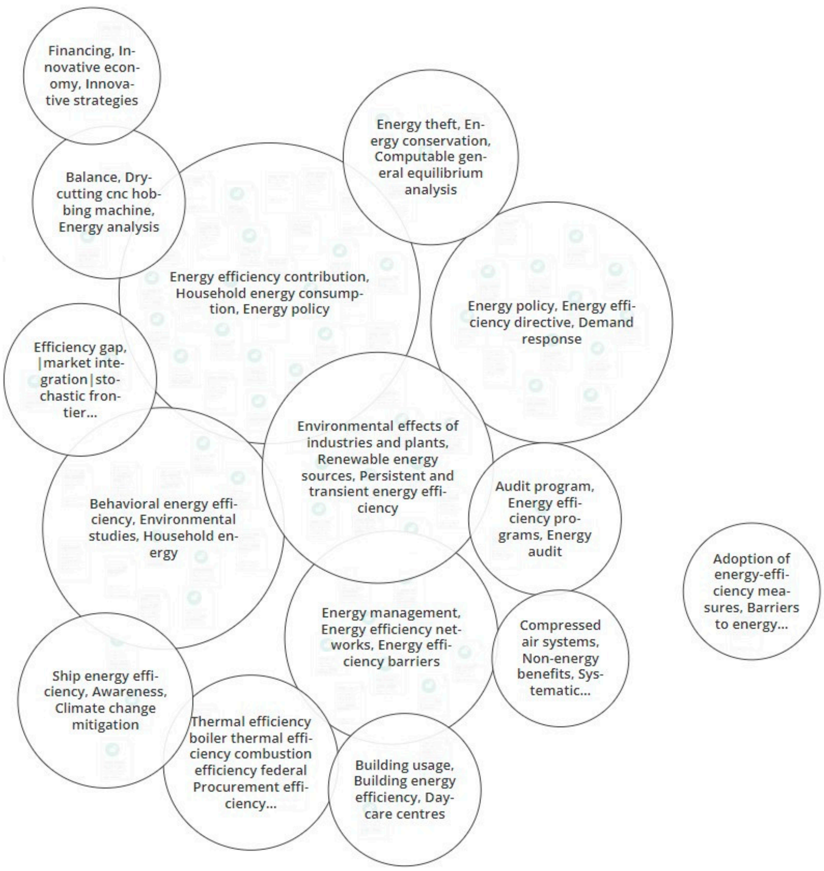

Figure 2. Topics taken up in the world literature on energy efficiency [5].

Due to the ongoing conflict in Ukraine, the European Commission has proposed to further reduce its energy dependence and increase its energy saving ambitions via the REpowerEUplan [6].

The contribution of this paper to the literature is twofold. Firstly, it reviews the literature after the onset of the energy crisis, i.e., also for the years 2022–2023. Literature reviews on EE have already been published; however, they related to an earlier period or did not relate to the subject matter discussed in this paper. An analysis of the issues addressed so far in the literature (Figure 2) shows that the issues addressed by the authors are new. Secondly, the literature [4] has already reviewed the EE concept framework. In this manuscript, the authors have undertaken an analysis of papers published since 2022. This paper stems from a critical need to comprehensively examine the intricate relationship between energy awareness, consumption patterns, and EE against the backdrop of contemporary global challenges. With the EU emphasis on reducing energy dependence and advancing energy-saving initiatives, this research seeks to contribute timely and relevant insights.

Previous literature reviews on EE [1–30] have undeniably made valuable contributions, yet they have predominantly focused on earlier periods or failed to align with the specific thematic concentration of this paper. Notably, Figures 1 and 2 illustrate the increasing interest in EE, emphasizing the topicality and growing importance of the subject from both scientific and practical perspectives. Despite existing studies delving into the EE concept framework, these reviews primarily cover the years 2016–2022. This paper seeks to extend the analysis beyond this timeframe, examining literature since 2022. The motivation lies in addressing the dynamic shifts in the energy landscape, including recent policy changes, global events, and the evolving context of the energy crisis. Furthermore, a comprehensive exploration of the interplay between various factors contributing to the energy crisis and their subsequent impact on EE is notably absent in the current body of knowledge. While prior studies have often focused on isolated aspects such as policy frameworks, technological advancements, or consumer behavior, a holistic understanding of the multifaceted dynamics shaping the energy crisis is lacking.

On the basis of an extensive analysis of the Scopus and Web of Science databases, we observed a lack of a comprehensive analysis of the various factors contributing to the energy crisis and their influence on EE. In this paper, we conducted an in-depth analysis on the basis of a broad literature analysis of papers researching various types of crises. The goal of this paper is to comprehensively explore the intricate relationship between energy awareness, consumption patterns, and EE, with a particular focus on both individual consumers and industries. This study delves into the multifaceted aspects of energy-saving practices, examining the influence of consumer behavior and technological innovations. While existing literature has extensively addressed the concept of EE, our examination of the Scopus and Web of Science databases revealed a notable research gap. Specifically, there is a lack of comprehensive analyses concerning the intricate interplay of the various factors contributing to the energy crisis and their subsequent influence on EE. Previous studies have often focused on isolated aspects, such as policy frameworks, technological advancements, or consumer behavior, but a holistic understanding of the multifaceted dynamics shaping the energy crisis and its direct correlation with EE is notably absent.

Although previous literature reviews on EE have been conducted, they predominantly pertain to earlier periods or do not align with the specific thematic focus undertaken in this paper. This gap in the current body of knowledge highlights the pressing need for an up-to-date exploration of the energy landscape, considering recent developments, policy changes, and global events that have reshaped the energy context. Our research aims to bridge this gap by offering a thorough and contemporary analysis encompassing the years 2022–2023 and delving into unexplored facets of the relationship between the energy crisis and EE. Through this approach, we aspire to contribute novel insights that advance our understanding of the complex dynamics surrounding energy conservation, propelling the discourse forward.

2. Methods and Materials

In this research, we analyzed publications from the Scopus and Web of Science databases. Both Scopus and Web of Science are renowned for their extensive coverage of scholarly literature, including journals, conference proceedings, and other academic publications. This ensures that this systematic literature review is based on a wide array of sources, increasing the likelihood of capturing relevant studies. These databases encompass a broad range of academic disciplines, allowing us to access literature from various fields related to EE, renewable energy, and decarbonization policies. This interdisciplinary approach is essential for a comprehensive understanding of the complex and multifaceted issues surrounding the global energy crisis. Scopus and Web of Science predominantly index peer-reviewed journals, ensuring a high standard of academic rigor in the sources. This is crucial for maintaining the quality and reliability of the information included in the systematic literature review. Scopus and Web of Science provide a global perspective by indexing publications from around the world. This is particularly important for a study that aims to analyze the impact of the global energy crisis. Accessing literature from diverse regions enhances the international relevance and applicability of the research findings.

In this analysis, we used the flowing inclusion criteria:

- Publications that directly address or contribute to the understanding of EE, renewable energy development, and decarbonization policies in the context of the global energy crisis.
- Peer-reviewed journal articles, conference proceedings, and reputable books to ensure the reliability and academic rigor of the sources.
- Publications in English to ensure comprehension and accessibility for the researchers involved in the study.

We used the following exclusion criteria:

- Publications that do not directly contribute to the understanding of EE, renewable energy development, or decarbonization policies in the context of the global energy crisis.
- Publications in languages other than English if language proficiency is a limitation for the research team.
- Duplicate studies or multiple publications reporting the same findings to avoid redundancy in the literature review.

We included review papers in the analysis because review papers provide a comprehensive overview of existing literature on a particular topic. Including them in our search may help in obtaining a broad understanding of the key concepts, theories, and findings related to EE, the global energy crisis, and associated themes. Review papers often cite and summarize key works in the field. This can assist in identifying seminal studies, theoretical frameworks, and foundational concepts that have shaped discussions on EE and the global energy crisis.

During the research process, the authors used the method of a systematic literature review, based on which the impact of the global energy crisis on EE, the development of renewable energy sources, and the policy of decarbonization of the economy were presented. Figure 3 shows the key steps taken in the research process.

The first step of the research process is to identify the research gap and the research problem that needs to be investigated. The authors attempted to examine the impact of the global energy crisis on EE and its perception. The main research method used to analyze this impact was a systematic literature review. A review of the current topic on EE undertaken in the literature indicated that the topic is not homogeneous, and that the thematic focus has changed over time. For this reason, the authors have identified thematic periods of EE studies based on the literature (Figure 4).

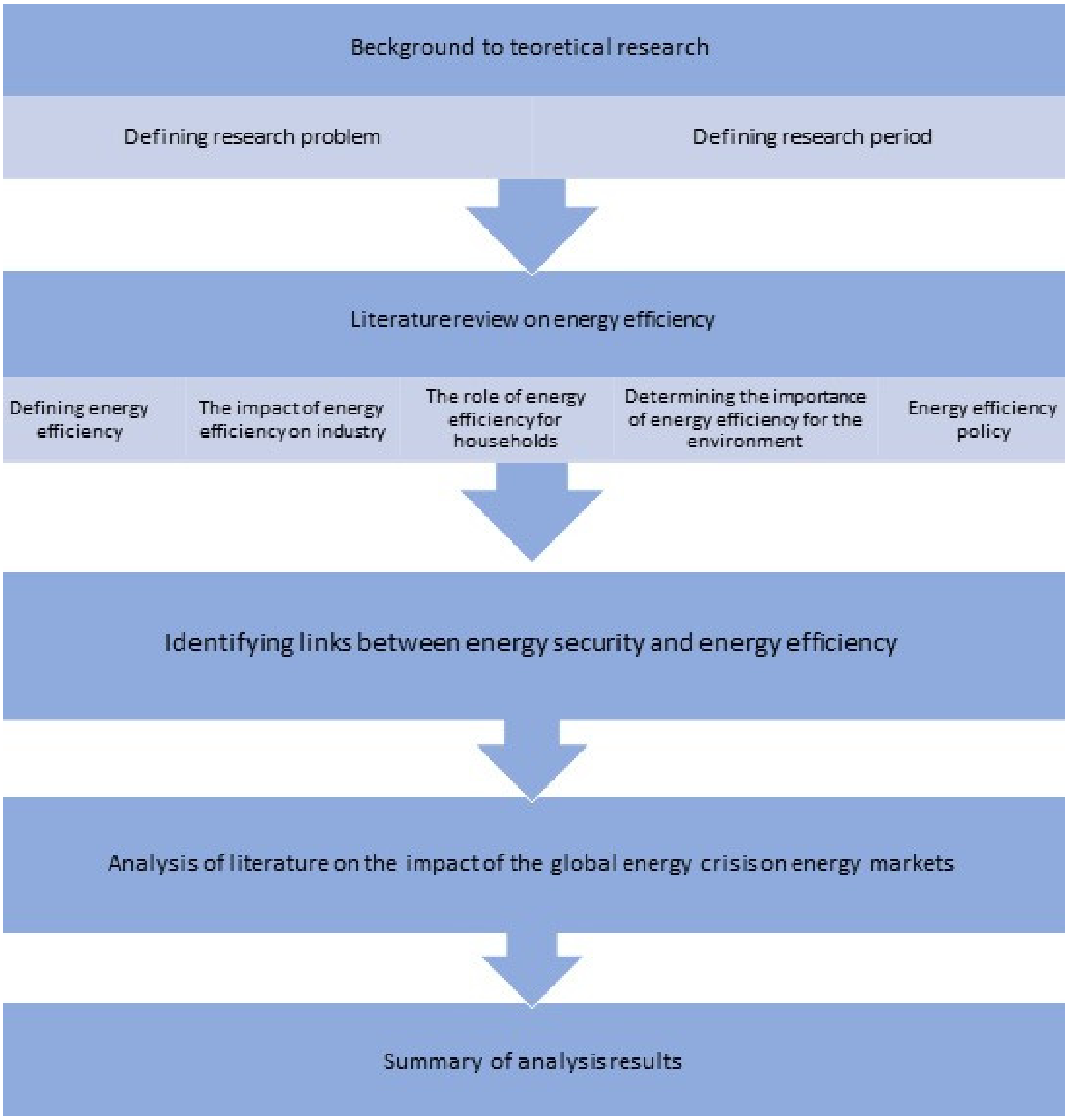

Figure 3. Stages of the research process.

The literature [7] has so far distinguished three periods related to EE analysis: the classical age (i.e., before the oil crisis in the 1970s), the modern age (the period after the oil crisis to the late 1990s), and the contemporary age (covering the period since the 2000s). While analyzing the literature on energy and EE, the authors identified five periods, four of which directly concern EE. The COVID-19 pandemic period was a transition period, when the world economy was almost closed for a year, and 2021 was a post-pandemic period when economies were coming out of restrictions. According to the authors, the period that clearly changed the attitude of the literature towards energy research, and especially the analysis of EE, is the period since the beginning of the war in Ukraine, which the authors call the high geopolitical risk and decarbonization age. And this period (with the addition of a transition period related to the COVID-19 pandemic in the research process) is a period of interest for the authors of this paper.

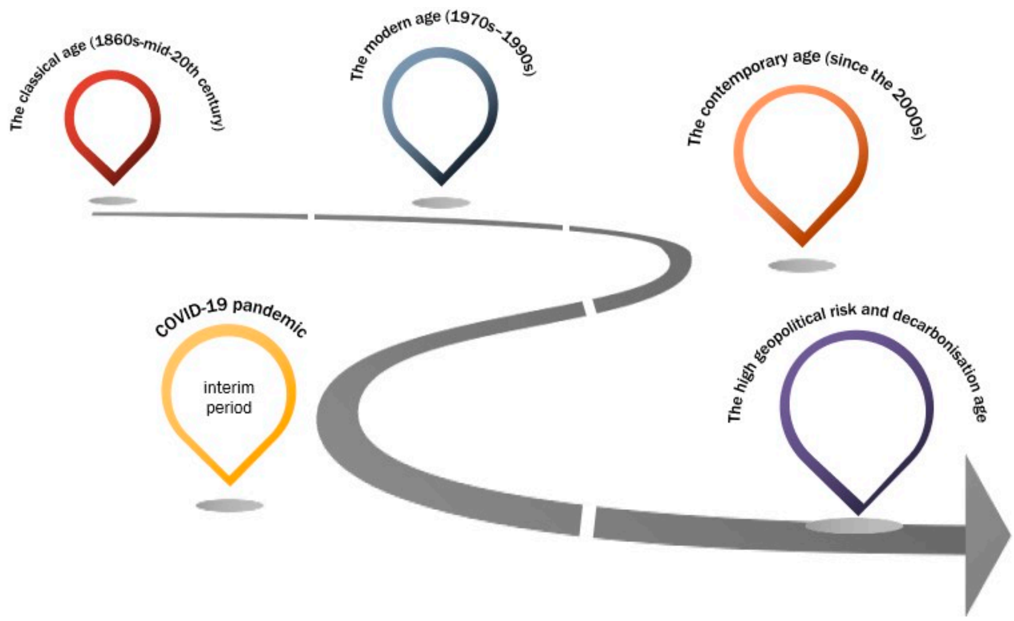

Figure 4. Timeline of energy efficiency research topics. Source: based on ref. [7].

Having identified the research period, the authors proceeded to the next stage of the research process, i.e., the review on EE literature. The aim of this phase was to examine how EE is defined and measured and to determine the impact of this phenomenon on the energy-intensive part of the economy, especially industry, how it affects households and in which areas of their lives, the environment and the process of decarbonization of the economy, and to identify which instruments are used in EE policy and what is the effectiveness of these measures. The next two stages of the research process are strictly related to the objective of this work, i.e., to examine the impact of the global energy crisis on EE. First, the impact on energy security and the links between EE and security will be examined, followed by the impact on energy markets.

3. Main Energy Efficiency Aspects

3.1. Energy Efficiency Concept

EE is not unequivocally defined in the literature [3,4,8–10]. EE is most commonly understood as energy intensity, i.e., the amount of energy consumed or required to produce or deliver a product [4,11], or the amount of energy needed to meet the necessary subsistence needs of households [9], or the costs incurred to meet current or basic consumer needs [9]. In the first case, EE is analyzed in manufacturing industry research, where EE is understood as the process through which a tangible product is produced through physical energy consumption. In this context, it is investigated how to improve the production process from a procedural, managerial, or technological point of view to reduce energy consumption or its physical flow [4,12]. In this understanding of EE, multi-criteria indicators are also used, such as the energy efficiency index (EEI), which consists of 12 different indicators and includes economic, technical, and environmental dimensions [13]. For the second way of understanding EE, the literature analyzes it under the term EE of households, which is understood as changing consumer behaviour or actions taken by consumers to achieve savings through energy-efficient services or products [8,10]. The third understanding of EE emphasizes the costs that must be incurred to cover the energy needs of society or the economy as a whole [14]. This understanding of EE includes analyses of the warming of homes and houses, the reduction of household energy bills through pro-efficiency measures [9], the amount of energy needed to produce gross domestic product, and the impact on public finances of measures taken by the government to reduce its energy intensity and to encourage society to adopt pro-efficiency measures.

Regardless of how EE is understood by the authors, the literature is unanimous in that EE can be regarded as one of the key resources in the economy. EE provides energy savings [15], allows economies to achieve savings in the production of gross domestic product [14], and provides various targets related to economic efficiency [16], economic competitiveness, and energy security [17,18]. Its main advantage lies in its potential to support environmental and climate protection [16,19–21] and the transition to low-carbon energy systems [18]. EE improves air quality and thus has a positive impact on the health of residents [18]. In this context, Dunlop and Volker define EE as a policy strategy to achieve energy savings, reduce energy consumption, and reduce greenhouse gas emissions in Europe [10] (p. 1).

EE is also defined as an improvement in the efficiency with which energy is used to provide services. In this sense, it brings a number of private and social benefits, but these are not always sufficient to motivate consumers to take advantage of these opportunities [22,23].

3.2. Energy Efficiency and Industry

As indicated in the above EE concept, the literature defines EE in a variety of ways, from which three leading approaches can be identified, i.e., industry, household relevance, and climate protection roles. In the first place, the authors will focus on the analysis of the literature on manufacturing EE. It is emphasized that in industry, EE means reducing the amount of energy required in production. As shown by Turkova et al. [24], the most effective way to reduce resource consumption is to develop and implement energy saving technologies and increase EE. EE in industry is achieved through the implementation of energy-saving technologies that reduce the consumption of the primary and final energy and materials required per unit of production or production of energy sources [24]. The process of saving energy can be implemented in two ways: either by implementing energy-saving technologies or by reducing the consumption of traditional energy carriers as fossil fuels by replacing them with alternative energy sources that increase the efficiency of their use [25]. EE in industry (large industrial enterprises and large industrial electricity consumers) is enhanced by energy management systems which also contribute to improved industrial competitiveness, carbon neutrality, and security of supply [26]. It is pointed out that EE is an important factor for the success of the energy transition, although, unfortunately, the potential for energy savings is not sufficiently exploited [27]. It is highlighted that energy efficiency has provided the largest contribution to historical greenhouse gas mitigation (mainly by replacing fossil fuel-based technologies with more efficient versions, financing these activities with public funds) [16,28]. Increasing EE is one of the key actions towards achieving the goals of the Paris Agreement [24,28–30]. It is pointed out that EE in industry not only involves the implementation of energy-saving technologies and reducing the use of fossil fuels, but also the issue of transport used in industry [31]. Tsemekidi Tzeiranaki et al. [31] show that increasing EE also contributes to reducing energy consumption and greenhouse gas emissions in road transport. This means that promoting EE has a stronger impact and supports the achievement of the EU's long-term decarbonization objectives. This is important, as the development of the tourism sector promotes an increase in energy consumption [32], and as the experience of the COVID-19 pandemic has shown, a decrease in energy consumption in this sector also has a beneficial effect on the reduction of greenhouse gas emissions.

3.3. Energy Efficiency and Households

Based on the literature, the authors of this paper note that EE is a key measure to reduce household energy consumption [33,34]. It is indicated that utilities and municipalities implement EE programs, thus encouraging households to improve the EE of their homes. As part of this, measures such as thermal insulation of homes, installing insulation, replacing inefficient appliances, and installing solar panels are undertaken [35]. It is also noted that untapped energy saving potential in the housing sector can lead to significant welfare losses [35,36]. Du Can et al. [9], when analyzing emerging economies, showed that the direct effects of promoting EE among households are to reduce their energy bills, increase energy availability, and increase household purchasing power. EE reduces household energy bills and thus frees up money in the economy, including for businesses, which can ultimately have a positive impact on economic growth.

Based on the literature, we indicate that one way to increase the EE of real estate is to use energy-efficient houses (greenhouses) [1,15,37–39]. Another is to renovate and warm old buildings [40]. Renovation costs may lead to a rent increase for energy retrofits, but energy cost reductions are assumed to offset the rent increase [41,42]. Unfortunately, as Mayer, Carter, and Feinberg [35] note, increasing household EE is often seen as too expensive, and unfortunately, financial factors are usually more important than the environmental benefits that are achieved. EE investments in residential and commercial buildings bring uncertain returns and long payback periods, making them vulnerable to a number of unforeseen situations [43]. According to studies by Solà, Escapa, and Galarraga [22], even if EE proves to be financially viable for consumers, they are not always able to invest as much as what may seem rational. This effect is referred to in the literature as the EE gap or the EE paradox, referring to situations where apparently advantageous investments are not made and/or seemingly unfavorable investments are made [6,22].

The EE gap is portrayed in the literature as a common paradox, as individuals and companies do not invest money or effort into seemingly highly profitable efficiency improvements [44]. There are several setbacks that may contribute to EE gaps. They can be grouped according to categories of market malfunction, behavioral malfunction, and other personal factors [22]. However, studies on the EE paradox' show that it can be difficult to achieve large savings because the measures taken towards EE are most often too small and do not reach the optimal level [30]. Giraudet [43] highlights that the EE gap typically relates to three categories of economic problems: market failures that actually hinder socially desirable EE investments, non-market failures that constrain investments without affecting social welfare, and behavioral anomalies that lead to individually irrational investments with unclear consequences for social welfare.

An additional barrier to EE investments for households which, according to Giraudet [43], is a major barrier, is information problems. The literature has explored the relationship between energy and financial literacy, appliance choice or energy consumption, and the socioeconomic factors of those with knowledge of energy-related investments [36,45,46]. Studies have shown that a household's level of energy, investment, or financial knowledge can positively influence its level of EE. This impact on EE levels can be achieved by supporting individual choices for more efficient electrical appliances and lighting [46]. One of the issues raised in the literature on EE among households is consumers' reading of energy labels on products.

The literature indicates that energy labels of equipment and devices should direct consumers' attention towards more energy-efficient devices, but the effectiveness of this instrument is not always certain. This is because consumers are not only guided by the information on the energy labels of devices. Therefore, the quality and quantity of information, as well as the way it is presented on energy labels, may influence consumer choices [46–51]. However, there are also opinions indicating the effectiveness of this instrument. As Ayala and Solà [52] point out, the EU EE label for appliances, adapted in March 2021 [53], is a key instrument to encourage consumers to make more energy-efficient purchases. Energy labels have been introduced in many countries to draw consumers' attention to energy consumption when making decisions about purchasing durable goods [50]. In most EU countries, minimum energy performance standards (MEPS) and energy labels are key policies to accelerate the spread of energy-saving appliances and help achieve EE and climate policy goals [54]. EE labels aim to influence consumer behavior at the point of sale by reducing misinformation regarding EE [55,56]. A similar situation applies to energy-saving lightbulbs, where the potential for EE the housing sector is untapped in this area due to a lack of knowledge and ability to read measurements [36]. As indicated by Filippini et al. [45], due to low levels of knowledge regarding energy, EE is low not only in

Europe but also in other parts of the world. Conducting such research in Nepal, the authors found that consumers with higher knowledge made more rational decisions regarding replacing appliances with energy-saving ones.

EE in households is not only about the benefits achieved by insulating houses or purchasing energy-saving devices. There are also social benefits resulting from lower bills paid by households. Therefore, many authors in their research analyze this topic in the context of energy sensitivity and focus on the ethical discussions conceptualizing the relationship between capabilities and energy vulnerability [57], energy poverty [58], energy justice [59], and operationalizing energy justice [60].

3.4. Energy Efficiency and Climate

EE is associated with benefits such as reducing CO_2 emissions and creating a clean environment [15]. This is a topic discussed in the field of EE, especially after the beginning of the energy crisis caused by the conflict in Ukraine in 2022. Until 2021, the literature pointed out that improving EE, especially in industry, reduces carbon dioxide emissions and increases supply security [26]. However, the EE analyses were mainly perceived in the context of EE investments or household behavior related to EE. An example is the research conducted by Chen et al. [20,21] for the UK in 2015–2021. It was found that the main problem for these companies is limited access to financing for pro-efficiency investments. Moreover, the authors indicate that companies that are EE and those that show energy-saving behaviors struggle less with financial difficulties, especially credit constraints. The literature also pointed out that human behavior influences changes in the level of EE and is also the main cause of global climate change [61,62]. However, since the onset of the energy crisis, EE has come to be seen as a way to ensure energy security and achieve climate goals. The concept of energy efficiency first (EE1st) has emerged, according to which EE is to become a priority in the energy and climate policy of the EU, filling the gap in the full implementation of two other guiding principles of EU energy and climate policy: cost efficiency and consumer conservation [63]. Currently, EE is seen as a way to mitigate climate change. As indicated in research by Chen et al. [20], improving EE, especially in industry and SMEs, is an important way to mitigate the climate impacts and cope with the increase in energy prices that have occurred as a result of the Russo-Ukrainian war.

Adu et al. [19] point out that EE may also have an indirect impact on the natural environment. Researchers examining entrepreneurial EE orientation in the UK among small- and medium-sized enterprises (SMEs) noticed that enterprises that are oriented towards improving EE better identify the green barriers existing in these companies and are willing to create green networks. This leads to improved initiatives that reduce SMEs' greenhouse gas emissions and ensure sustainable value creation. By promoting energy-efficient production methods, companies are more aware of how to save on energy consumption, which in turn has a positive effect on their profitability. It can therefore be concluded that the more EE initiatives undertaken by enterprises, the more aware they are of their needs related to climate change and green barriers, and the more willing they are to share opportunities to create green networks with other entities. This is a step towards achieving decarbonization of the economy. As the authors point out, green networks are such a valuable resource that regulatory authorities or the government should support the development of green enterprise network platforms. These are conclusions for the UK, but it can be concluded that such sharing of best ecological practices by companies will ultimately help reduce greenhouse gas emissions by the economy and will undoubtedly support the decarbonization goals set for 2050 in the EU.

3.5. Policy for Increasing Energy Efficiency and Its Barriers

Many authors (researchers) have extensively analyzed methods and instruments that can be used to improve EE (see Table 1).

Table 1. Assessment in the literature of the impacts of energy efficiency instruments.

Country	Author(s)	Factor	Impact
Portugal	Fuinhas et al. [64]	Income per capita, information and education policy, fiscal and financial incentives	Negative or positive impact Positive impact Positive impact—properties with high EE certificates.
The EU	Giampietro and Bukkens [65]	Information regarding the content of EE policy	Low impact; it is impossible to promote several objectives at the same time under a single policy.
The EU	Dunlop and Volker [10]	Indicators for measuring EE in the EU directives	Negative impact
The Netherlands	Kaufmann et al. [58]	Communicative policy instruments Financial policy instruments Regulatory policy instruments	Positive, although impact is negative when information is incomplete. Generally positive; however, negative when affecting citizens' debts. Exclusionary regulations may aggravate inequalities.
Turkey 12 European countries	Isik, Sarica, and Ari [66]; Georgatzi, Stamboulis, and Vetsikas [67]	Use of EE-efficient transport systems	Positive impact
India	Pani, Sahu, and Holguín-Veras [68]		
Israel	Steren, Rubin, and Rosenzweig [69]		
Hungary	Skobiej [70]		
The EU	Tsemekidi Tzeiranaki et al. [31]		
Turkey and Germany	Özkanli and Demir [15]	EE public transport	Positive impact
OECD Countries	Amendola et al. [14]	Supporting research laboratories, i.e., innovation and R&D institutions	Positive
Poland	Batóg and Pluskota [71]	EU regional funds	Positive
Switzerland	Bhadbhade and Patel [72]	Improvements to EE systems, equipment, and CHP	Positive
China	Dong et al. [73]	Artificial intelligence	Positive
UK	Calvillo [74]	"Best practices"	Differentiated

Source: based on references [10,14,15,31,58,64–74].

Fuinhas et al. [64] examined the impact of energy policies in Portugal on the energy performance of local properties. The authors found that residents' income had a negative impact on the EE of properties, i.e., those with high EE certificates, and a positive effect on those with low EE certificates. However, what has a positive impact in the context of the EE of real estate (regardless of the EE certificates held) is the information and educational policy. Additionally, the policy of fiscal and financial incentives also has a positive impact, but only in residential properties with high energy efficiency certificates.

In the context of using fiscal policy as a way to improve EE, Rodríguez et al. [75] indicated that it is better to tax only fossil fuels than all energy carriers (i.e., also renewable energy sources) and to strive to improve the efficiency of energy systems because reducing the consumption of primary energy is more effective than in relation to final energy.

Giampietro and Bukkens [65] examined the content of information policies in the EU regarding EE, and more specifically, the content of the information provided there. It was found that it is not possible to solve the various problems identified in the EU energy policy at the same time. The authors argue that it is impossible to effectively implement EE while promoting both decarbonization and EE within the same information policy. Meanwhile, Dunlop and Volker [10], analyzing changes to the EED in 2016–2018, found that the processes of formulating energy efficiency indicators themselves have a significant impact. The way they were formulated contributed to the reality of EE management by the European Parliament.

Kaufmann et al. [58] examined the impact of communicative, financial, and regulatory policy instruments applied to households on the tendency to undergo energy transformation aimed at saving energy at home. The study covered three types of policy instruments: communication and consulting, financial, and regulatory. It was found that by preventing citizens from accessing full information, citizens can be led to false expectations, which will discourage them from taking part in EE activities. Financial policy instruments, such as loans for home owners, subsidies for home energy saving, and VAT refunds for investing owners, may affect citizens' debt if, due to changes in eligibility criteria, the thresholds for citizens to implement energy-saving measures are raised. Meanwhile, if policymakers miscalculate the expected long-term consequences of regulatory instruments such as building regulations or permits, these policy instruments may (re)create energy sensitivity in an uneven way [58]. Another activity is government financing and the use of efficient transport systems (e.g., energy-efficient cars) [31,66–70] and the use of public transport [15]. All such activities contribute to increasing EE.

Meanwhile, Amendola et al. [14] note that most policies aimed at increasing EE are effective in reducing energy intensity, but that this is falling slower than required to achieve climate goals. They also point out that the most effective way is to support research laboratories, i.e., innovation and R&D institutions, because apart from promoting EE, state policy does not have a negative impact on the country's macroeconomic situation.

Batóg and Pluskota [71], examining regions in Poland, indicated that in the EU, it cannot be said that a higher level of economic development of the region guarantees an increase in funds allocated to EE and renewable energy. However, such a relationship does apply to EU regional funds. These authors point out that the way to increase financing for measures as EE and renewable energy is to increase regional funds, which are increasingly being allocated for this purpose.

A different approach is suggested by Bhadbhade and Patel [72] (p. 624). Their research results showed that in the Swiss manufacturing sector, the most cost-effective ways to improve EE are improvements to EE systems and equipment. Meanwhile, in the case of the electricity cluster, it was found that CHP is the most effective way to improve EE measured by energy savings. Unfortunately, this is not a cost-effective method. In the case of fuel-consuming clusters, EE measures include waste heat recovery measures, along with fuel substitution measures with varying degrees of profitability. Dong et al. [73] proposed the use of artificial intelligence for this purpose by using it in energy systems to manage it and optimize energy consumption and promote sustainability. Meanwhile, Calvillo [74] (p. 1) analyzed "best practices" regarding EE policies regarding the use of energy system models in the UK. The study shows that EE scenarios pursuing the same objective produce significantly different results in terms of technology mix, energy consumption, emissions, and costs. Furthermore, the results show that there is no overall best-case scenario for EE, as each scenario impacts different policy objectives that may conflict with each other.

Researchers have also indicated barriers to improving EE. Solà et al. [34] identified the limitations of these policies, such as difficulties in implementing codes and standards given the need to achieve a minimum level, differences in the effectiveness of rebate programs, and inconsistent results with respect to the monetary effectiveness of the EE label. Another barrier is when too many institutions and stakeholders are involved in shaping policies supporting EE [43]. Meanwhile, in emerging economies, the limiting factor is the fact that the effects of such policies are dispersed, which makes them hardly noticeable by consumers and government decision-makers [9]. Another limitation is a lack of legislative support. Ghazali et al. [76] conducted a study on EE prospects for Malaysia and the efforts undertaken by local authorities. They found that the authorities have little involvement in these activities and that efforts to strengthen EE management are ineffective without legal support, i.e., the establishment of specific legislation regarding the implementation of energy efficiency.

To summarize the literature review on EE, it should be stated that the emerging concept of EE1st is an important concept that, if implemented, will minimize the costs of energy and economy transformation and support activities aimed at decarbonizing economies. After the start of the military conflict between Russia and Ukraine in 2022, the world was shaken by rising energy prices, which continue to threaten households' access to affordable energy services, exposing them to fuel poverty [58]. A solution was proposed by Turkova et al. [24]: saving energy resources by replacing traditional energy carriers with renewable energy sources that support both.

3.6. Energy Awareness and Energy Efficiency

Increasing awareness of energy in societies and organizations is gaining significance, driven by the anticipated rise in global energy consumption and the escalating impacts of climate change resulting from fossil fuel combustion, such as tsunamis, floods, temperature fluctuations, and ecological shifts. In recent times, there has been a gradual shift from the earlier focus on energy conservation policies to embracing EE goals and concepts. The former aimed to reduce the energy required for optimal use, but the contemporary approach involves judiciously managing energy through enhancements in production systems, behavioral changes, innovation, adoption of energy-saving technologies, and utilization of renewable energy resources (RESs). The use of EE appliances not only saves on household energy expenditures but is also deemed essential in combatting climate change. The active promotion of EE plays a crucial role in achieving the United Nations Organization's (UNO) new norm of zero net carbon dioxide (CO_2) emissions. However, this journey toward the goal [77], especially for countries heavily reliant on coal, may pose significant challenges.

Awareness of the adverse effects of energy consumption, coupled with knowledge of energy-saving practices and engagement in activities vital to the RES market, is pivotal for the success of the energy transition. Residents and organizations can contribute to reducing greenhouse gas emissions through their energy consumption behavior and investments. The concept of energy consciousness has gained popularity, emphasizing the role of consciousness in shaping the responsible behavior of both energy producers and consumers. Since the 1980s, with the influential Brutland Report defining sustainable development, environmental awareness, including energy awareness, has become increasingly crucial for global economic development and, specifically, sustainable energy management.

The following concepts are used in this chapter: "energy awareness", "environmental awareness", and "ecological awareness". Each of these concepts has its own genesis and definition. The broadest of these three concepts is "ecological awareness". In general, the concept of ecological awareness is attributed to the totality of accepted ideas, values, and opinions about the environment as a place of human (society) life and development [78,79]. In general, the following environmental values are mentioned: life, health, responsibility, moderation (restraint), and community (solidarity). On the other hand, "environmental awareness" is either synonymous with "ecological awareness", or its strong focus on environmental protection is underlined. The conceptual model of environmental awareness (1999) was proposed by Partanen-Hertell et al. [80]. In this model, the authors list and explain the stages of environmental awareness developed among individuals in a given society to the point at which individuals become involved in environmental matters. Environmental awareness begins to develop when people notice unsuitable and life-threatening environmental conditions. The differences between "environmental awareness" and "ecological awareness" boil down to the different characteristics of the object of consciousness and its status and internal structure. The vast majority of authors underline the ambiguity of these concepts [78,79,81].

Sustainable development policy, which in many respects resembles a system of connected vessels, offers great opportunities for the development of “environmental awareness” [82]. The aim of this policy is to achieve economic development that is economically justified, socially desirable, and, most importantly, environmentally acceptable. It avoids the extinction of human civilization, contributes to the self-improvement of the individual in accordance with the ideals of civil society, and ensures a decent existence for all the inhabitants of the world (both present and future generations). One of the key areas of climate policy is RES-based energy policy. The concept of “energy awareness” is primarily about saving energy. Energy awareness is the understanding of energy consumption [83]. Along with radicalization of decarbonization policies, this includes the use of low-carbon and, in the future, zero-carbon technologies, as well as a transformation towards decarbonized electricity production, electrification of transport, battery technology, energy storage, smart grids, and overall improved EE [84]. “Energy awareness” as a concept will develop because many industries will undergo a technological revolution, especially with regard to high emissions (CO_2), e.g., the steel sector [85]. This will result in a radical transformation, as the consciousness of both industries and societies will change. The “net zero” strategy requires greater energy awareness than before [86]. In all these concepts, the link is consciousness. Partanen-Hertell et al. define awareness as a combination of motivation, knowledge, and skills [80].

Over time, as we engage in the pursuit of building sustainability, each person develops their own perspective on maintaining a balance between the current state and future possibilities to protect the environment for ourselves and future generations. Energy consciousness should be evident in the conduct of individuals or businesses that act as both energy producers and consumers. It is important not to overlook the category of prosumers, which includes individuals and companies functioning as both energy consumers and producers, particularly those relying on renewable sources. By generating their own energy, prosumers reduce their carbon footprint and contribute to the transition towards a low-carbon economy. Furthermore, prosumer-based systems can enhance energy security, decrease reliance on traditional energy sources, and foster local economic development [87,88]. Individual prosumers may or may not organize themselves into renewable energy communities, but their influence on the energy market is substantial when they are organized [89,90].

Since we posit that energy consciousness plays a pivotal role in introducing sustainable energy management and, consequently, energy efficiency, it is necessary to define it. Energy awareness has its roots in environmental awareness. Energy consciousness is a general inclination and, simultaneously, a capability to engage in behaviors related to energy consumption that are characterized by efficiency, thrift, and concern for the environment. This encompasses knowledge, internal motivational factors, and self-control.

To cultivate energy awareness, individuals need knowledge about the availability of RES, energy conservation programs, the latest technologies, etc. Attitudes and behavior are shaped based on this knowledge, forming the fundamental conditions for energy choices. The increasing awareness of energy saving among individuals drives changes in their consumption behaviors. Consumers are becoming more knowledgeable, environmentally conscious, and supportive of sustainability values. They are increasingly making informed decisions regarding their ecological footprint and demonstrating a growing tendency to influence others toward sustainable behaviors. Additionally, a high level of energy awareness can impact energy conservation and investment in RES [88,91].

There are two primary categories of energy awareness, with the first focusing on households or individual consumers, and the second centered around organizations such as firms and companies. Each category possesses its unique characteristics and facilities. The energy awareness of households or individuals is shaped by a multitude of factors, broadly classified into psychological, sociological, economic, and environmental aspects [92–97]. Various theories, including planned behavior and models like energy ladder and stacking, have been employed to elucidate energy awareness and the transition behaviors of households [98–104]. Individual energy-saving awareness is significantly influenced by factors such as age, size, income, education level, type of occupancy, and length of residency [105]. Environmental factors related to the physical attributes of buildings and immediate surroundings impact individuals' energy conservation behaviors [106,107]. Additionally, sociodemographic factors have been identified as influencers in energy conservation behavior [107–109]. In the theory of planned behavior, Alomari et al. [110] found that societal pressure and cultural influences play a significant role in an individual's intention to engage in energy-conscious behavior.

Energy awareness, or more specifically, household energy conservation awareness, encompasses a wide spectrum of activities, ranging from optimizing the efficiency of energy-using devices to minimizing their use through various means [111]. The incorporation of energy conservation principles into daily household activities is crucial for saving significant amounts of energy, as outlined in the International Energy Agency (IEA's) seven ways (refer to Table 2). Household energy awareness is shaped within the specific conditions of people's everyday lives. Guiding principles related to general attitudes toward daily energy-saving practices, social norms, ecological knowledge, and adopted values collectively influence what is termed as energy consciousness.

Table 2. Energy awareness versus energy efficiency: seven ways to save energy according to the IEA.

Form	Activity	Awareness
Heating: turn it down	Adjust your thermostat down by just 1 °C to conserve approximately 7% of your heating energy, resulting in a yearly savings of EUR 50–70 on your average bill.	Focus on efficiently heating only the rooms regularly in use to save energy. Similarly, in hot weather, conserve energy by turning off the air conditioning when the room is unoccupied and using it solely in the occupied areas.
Boiler: adjust the settings	Modify default boiler settings, usually set higher than necessary; reduce hot water temperature to save 8% of heating energy, leading to a reduction of EUR 100 on an average bill.	Opt for a shower instead of a bath to reduce energy consumption in water heating. Additionally, if you already use a shower, consider shorter shower durations. Ensure insulation for hot water tanks and pipes to prevent heat loss, and regularly clean heaters to maintain optimal efficiency.
Warm air: seal it in	Ensure windows and doors are closed, insulate pipes, and seal gaps around windows, chimneys, and other openings to retain warm air indoors.	Install curtains or shades on windows to retain heat, and close fireplace and chimney openings when not in use to prevent warm air from escaping. Seal unused chimneys to minimize heat loss and make efforts to seal the overall house.
Lightbulbs: swap them out	Upgrade old lightbulbs to energy-efficient LED ones and use only the necessary lights to promote savings.	Choose LED bulbs over incandescent and halogen lights for increased efficiency, longer lifespan, and annual savings of approximately EUR 10 per bulb. When purchasing bulbs, check the energy label and opt for A-rated (most efficient) rather than G-rated (least efficient) bulbs. Save energy by turning off lights when leaving a room.
Grab a bike	Opt for walking or cycling for short trips instead of driving, contributing to savings, emission reduction, and less traffic congestion.	Consider leaving your car at home for short journeys, especially if it is a larger vehicle. Share rides with neighbors, friends, or colleagues to save energy and money. Opting for biking can result in significant savings and health benefits, and many governments provide incentives for electric bikes.

Table 2. *Cont.*

Form	Activity	Awareness
Use public transport	Use public transport for longer distances where walking or cycling is not feasible, reducing energy consumption, congestion, and air pollution.	For longer trips, leave the car at home and take the train, potentially saving money with a season ticket. Check for incentives on travel passes offered by your workplace or local government. Plan your trip in advance to find cost-effective routes and save on tickets.
Drive smarter	Enhance driving efficiency by adopting a smoother driving style and lower speeds on motorways, closing windows at high speeds, and maintaining proper tire inflation to reduce fuel consumption.	Opt for routes with less traffic, and turn off the engine when stationary to conserve fuel. Driving 10 km/h slower on motorways can reduce fuel expenses by around EUR 60 per year. Maintain a steady speed between 50–90 km/h for fuel efficiency. When driving above 80 km/h, use A/C rather than opening windows, and service your engine regularly for optimal EE.

Source: seven ways to save energy IEA [112].

Environmental awareness is translated into pro-ecological behavior, operationalized through a positive attitude toward the environment and appropriate pro-environmental actions, such as energy-saving practices. Energy awareness, particularly within households, spans a broad spectrum of activities, from maximizing the efficiency of energy-using devices to minimizing their use through various strategies [109]. As per the IEA's seven ways (refer to Table 2), energy awareness, when practiced, leads to substantial energy savings.

Energy awareness holds significant importance within The European Green Deal, which serves as the novel growth strategy for a sustainable, cleaner, safer, and healthier EU economy. This strategic document outlines a roadmap for achieving net zero CO_2 emissions and reducing other greenhouse gases by 2050. Emphasis is placed on the efficient utilization of resources in a circular economy, restoration of biodiversity, and the reduction of pollution. The successful implementation of this strategy necessitates the collaboration of various stakeholders with specific relationships and dependencies, highlighting the growing importance of their environmental responsibility. One crucial aspect of this responsibility is energy consciousness, which is rooted in the collective need for energy-saving practices across individual and communal economies.

Various studies provide insights into energy-saving practices. For instance, Baidoo et al. [113] found that in Ghana, less than half of households owning TVs (29.80%), light bulbs (33.90%), fridges/freezers (40.60%), and fans (38.60%) consistently switch off their appliances when not in use. Gajdzik et al. [114] focused on active small consumers in the energy market in Poland, suggesting that consumers can enhance EE by adopting measures like using LED light bulbs, improving insulation, and employing energy-efficient appliances. Active consumers are also conscious of energy and heat efficiency, leading to reduced usage of non-renewable fuels. Jaciow et al. [92] conducted a study in 1407 households in Poland but could not confirm the impact of environmental awareness on curtailment behavior.

Another team of researchers, Gajdzik et al. [115], analyzed responsible consumption in four types of e-consumers, each with distinct preferences. Reisch [116] acknowledges criticisms of the sustainable consumption concept, labeling it a "fuzzy concept" due to unclear factors such as scale, scope, point of reference, and time horizon. Nonetheless, sustainable consumption, including energy consumption, is recognized as a vital component of the modern consumption model [117]. Consumers with heightened awareness exhibit consistent ecological behavior, such as turning off lights, purchasing energy-efficient products, and using appliances in a manner that minimizes electricity and water consumption.

Energy savings may not come directly from energy awareness but from high energy prices. Such a statement is found in publications [118,119]. The direct impact of high energy prices on energy conservation has intensified during the global energy crisis, but it is not always possible to turn off appliances that provide energy or heat because we need these resources to function on a daily basis. Therefore, one section of this publication points out the problem of energy poverty. In addition to consumers, industry is particularly responsible for energy saving. Enterprises are, on the one hand, responsible for EE to internal groups (owners, employees), and, on the other hand, to external groups (trading partners, customers) and to the authorities, local communities, and other social or ecological organizations. It is worth noting that among the important stakeholders of energy producers and industries are customers who are increasingly making sustainable choices [115]. Some consumers, although still small, have permanently included the energy saving criterion in their purchasing decisions, e.g., washing machines, refrigerators, stoves, boilers, water heaters, etc.

Consumer preferences influence the actions of producers and, conversely, product innovations influence consumer choices. More and more companies use instruments to help reduce the negative impact of their energy consumption. Programs of energy saving are a part of the Environmental Management System based on the requirements of the ISO 14001 standard [120] as part of the improvement of enterprises, as well as instruments of superior policies including European projects. Large enterprises (international companies) are the beneficiaries of many structural projects that are aimed at the innovativeness of industries. In addition, energy awareness and its corporate EE programs are part of social responsibility. Energy-saving activities can be undertaken by various organizations (enterprises, non-profit organizations, local governments, etc.) [121–123].

Innovativeness plays a key role in in pro-ecological attitudes [124]. Innovativeness is conditioned by trends in the energy market. For the past several years, the energy sector has been subject to the constant impacts of technological and business trends that are causing it to undergo an increasingly rapid and profound transformation. On the one hand, environmental and climatic conditions are playing an increasingly important role in shaping its future, while technological breakthroughs are changing the competitiveness of many industries and modifying the map of global dependence on raw materials. On the other hand, there is a rapid increase in the use of solutions based on information and communication technologies. The ongoing evolution in the areas of the internet, telecommunications, and digitization is putting tools in the hands of the end user to play new roles in energy production and optimization. The growing popularity of alternative fuels is challenging the leading role of hydrocarbons in the transportation sector. This is overlaid with political and social aspirations and regulatory models, changing the traditional system of how energy companies operate in commercial markets [125].

Studies on the impact of energy awareness on EE, which have been undertaken for more than two decades, have been carried out in industries, among others. An important area of research is industries with high energy intensities e.g., the steel industry, chemical industry, etc. The results of various studies are presented in publications [126–128]. There are publications in which the authors indicate, with regard to the segment studied, a low level of energy awareness, both in terms of theoretical knowledge and the consequences arising for the environment and society due to the use of energy [129–133]. In publication [134], the researchers indicate a high level of energy awareness among the surveyed segment. EE is a key strategic direction in the new concept of Industry 4.0. The authors of papers [135,136] compiled a number of enterprise-level decision-making problems in the Industry 4.0 concept.

A high level of environmental awareness influences the public's purchasing decisions. People committed to environmental issues are correcting their habits and increasingly choosing environmentally friendly products. This attitude influences manufacturers, who are forced to change their production methods to more environmentally friendly ones and to include green aspects in all product life cycles. Innovation in EE must include intelligence at each operational level of manufacturing companies [137] and in each link in the supply chain, facilitated by knowledge transfer [138].

Ecological awareness (including energy saving) is the first step to becoming a conscious prosumer. Conscious prosumers reduce their energy demand (they use less energy in their households, as they are sensitive to wasting energy in other places where they are, e.g., at work, in public places). Today, consumers see increasing availability and choice of energy sources and can choose their energy supplier in competitive markets. Given appropriate financial and spatial conditions, they can become prosumers and become independent from market prices, network fees, and additional fees and taxes. In a modern market with smart solutions, energy and heat should be strong and personalized [129]. Empowering consumers and giving them the tools to participate more in the market in a completely new way aim to make the electricity and heat market profitable for consumers. The market is and will continue to change due to increased consumer use of interactive tools to monitor and manage energy consumption. Consumers are encouraged to participate directly in the energy market through energy production and storage. These forms of activation turn the consumer into a prosumer, and prosumer behavior varies greatly depending on the development of economies [139]. The determinant of the development of EE is the availability of new technologies for energy production and consumption, including RES. In today's world, ecological innovations are a determinant of the development of many markets, including the energy market. The concept of innovation is understood very broadly because it applies to both technical and non-technical innovations. Both groups of innovations, in order to be considered energy innovations, must have a positive impact on the environment [140]. Energy innovations are in turn related to green business environments [141,142]. Lee and Min [143] associated the aspects of EE, green research and development, carbon emanation, and eco-innovation with firm performance. Sovacool et al. [144] deliberate that environmental innovation could play a crucial role in declining pollution and carbon footprints.

4. Renewable Energy Versus Energy Security and Energy Efficiency

The goals of the European climate policy, especially those set out in the European Green Deal, indicate that the role of all renewable energy sources will increase. It is also common knowledge that fossil fuels are energy carriers that ensure the stability of energy supplies and prices, but they are also a source of pollutant emissions. Renewable energy carriers, however, are unstable, so it is difficult to base security on them without finding a way to store them cheaply. However, the energy crisis and the resulting inflationary processes in related economies, especially the European Union, have resulted in a certain reorientation in the approach to green energy, fossil fuels, decarbonization, and energy security.

The war in Ukraine has led to a long-term increase in energy prices [145] and has highlighted the need for a more secure and diversified energy supply [146,147]. Thus, the literature has begun to analyze the relationships that occurred and recommend appropriate actions based on them. The one who feels the effects of this energy crisis the most is society. Chapetiev et al. [148] recommend that the effects of price increases should be compensated for sensitive customers in the short term. This should be the case because the implemented energy policy and changes in energy prices affect the level of energy poverty [149], and its level can be effectively eliminated through various types of subsidies and macroeconomic policy instruments [150]. As we know, society influences the decisions made by policymakers; hence, attitudes towards these geopolitical problems are important.

The war in Ukraine also highlighted the polarization of views in societies (especially highly developed economies) in relation to energy security, which decreased as a result of the war in Ukraine. Arndt [151] examined the preferences of societies in Western Europe. The results of this study indicated that people concerned about energy security prefer fossil fuels to renewable energy. Meanwhile, people concerned about climate change prefer renewable energy to fossil fuels. Therefore, policymakers must use trade-offs in decisions regarding the reorientation of economies towards renewable fuels. Banna et al. [152] additionally indicate that high-energy security risk reduces gross domestic product (GDP) growth rate. The risk of energy insecurity especially concerns poorer countries, and this negative impact on the level of development intensifies in years of high inflation, risk, and geopolitical activities, as we have seen since 2022 in Europe. Colgan et al. [153] indicate that “fossil fuel dependence creates national vulnerabilities”. Meanwhile, renewable energy sources, despite their instability, increase security in the event of geopolitical risk, because these fuels do not have to be imported. Additionally, they prevent the need for costly subsidies or sudden reductions in demand. These conclusions are confirmed by the findings of Igeland et al. [154], according to which the uncertainty of economic policy favors increased interest in renewable energy sources. The authors also point out that the process of switching to renewable energy must be properly managed, as it may result in an increase in share prices of ecological assets, which may have a negative impact on energy security. When managing the development of renewable energy in enterprises, it should be remembered that the development of renewable energy is associated with many barriers [155], which occur with different intensities depending on the region of Europe. Additionally, the same types of barriers are not the most troublesome everywhere.

Adedoyin et al. [146], examining the consequences of alternative solutions (investments in renewable energy or their cessation, or in coal) in the field of energy policy for Germany as a consequence of the COVID-19 pandemic and the energy and economic crisis of 2022, showed that in the long-term, there is a significant positive long-term relationship with coal production, air transport, real GDP per capita, and carbon dioxide emissions, and that renewable energy production reduces carbon emissions. Moreover, it was pointed out that investments in coal will distance us from the EU’s climate goals, while a 69% increase in renewable energy production will allow us to achieve Germany’s zero-emissions target by 2050. The authors, of course, do not glorify RES as problem-free carriers, as there are noticeable difficulties in the transition to RES, e.g., in aviation. Despite these limitations, however, for the development of renewable energy, it is necessary to strive to increase the share of renewable energy in industry. Aliabadi et al. [156], by examining the German transport sector, also proved that imported alternative fuels play a key role in reducing the consumption of fossil fuels. This is also confirmed by experience from the United States. The results of Husain et al. [157] showed that historical geopolitical risk has the most decisive positive impact on renewable energy production when the policies are driven by both energy security and environmental obligations. If the government only focuses on security, then it has a negative impact on the country’s renewable energy production. Therefore, taking advantage of the situation after the energy crisis, it is worth pursuing not only the goals of supporting renewable energy sources to increase energy security, but also decarbonization goals.

The literature also refuted the claim that fossil fuel prices are more stable than “green” sources. Research by Maneejuk et al. [145] indicated noticeable differences in the price cycles of renewable and fossil energy. The authors indicate that fossil fuels are characterized by greater price volatility in response to economic or political uncertainties. The renewable energy price cycle is more stable, while the fossil energy price cycle is more volatile.

As pointed out by Admad et al. [158], the development of renewable energy sources is related not only to climate protection and energy security, but also to the development of financial markets. By examining the role of geopolitical risk while examining the impact of financial development, natural resource rents, and eco-innovations on sustainable development in OECD countries, the authors indicated that financial development and eco-innovations are strongly positively related to sustainable development, which cannot be said about fossil sources. Admad et al. showed that natural resource rents have a detrimental impact on sustainable development. The geopolitical risks that arose, among others, after the start of the war in Ukraine also increased inequalities in greenhouse gas emissions, as well as the capital-to-labor ratio and per capita income [20]. As the authors point out, the solution here is not only the tax regulations applied in some countries, but also encouraging sustainable consumption and production patterns and promoting access to renewable energy.

The emerging geopolitical risk from 2022 has also caused the literature to become interested in the connections between EE and renewable energy [24,71,147,159,160]. Owjimehr et al. [147] show that the geopolitical risk resulting from the conflict in Ukraine has a positive impact on EE in European countries. Countries with high EEs are better prepared to face risks thanks to investments in infrastructure, especially renewable energy technology. Johannsen et al. [159] and Turkova et al. [24] indicate that promoting EE in industry through the use of renewable energy sources is one of the key actions to reduce the energy intensity of industries and is a way to achieve the goals of the Paris Agreement. This is also confirmed by the findings of Boonstra [160], who indicates that the way to increase the share of renewable energy in energy consumption is to increase EE. The end result of such actions will include low greenhouse gas emissions and predictable energy costs for consumers. Meanwhile, Batóg and Pluskota [71] note that financial instruments are becoming increasingly important in the transformation of the energy sector. The authors also confirmed the hypotheses that there is regional convergence of renewable energy production per capita and that the spatial accumulation of renewable energy production is decreasing. However, there is no correlation between the economic development of the region and the level of funds allocated to EE and renewable energy. This is consistent with the conclusions of Pifko et al. [161], according to which the availability of renewable energy sources on site is limited, and this is particularly problematic in densely built-up city centers and historical districts. This would mean that it is worth financing activities towards renewable energy sources and energy efficiency in less-populated regions.

There are two main conclusions from the literature review conducted above. Before the war, the main focus was on supporting energy efficiency, mainly to reduce energy consumption. Before the war, governments around the world undertook many programs aimed at reducing energy consumption in energy sectors. They were commonly called industrial energy efficiency programs (IEEPs) [162]. Since the energy crisis caused by the war in Ukraine, EE is more perceived as a way both to reduce energy consumption and also to reduce greenhouse gas emissions. The promotion of EE is worth supporting through wider use of renewable energy sources.

Mineral resources play an important role in the global pursuit of decarbonization and enhanced EE. The transition to renewable energy technologies heavily relies on critical minerals such as rare earth elements, lithium, cobalt, and nickel; essential components in solar panels, wind turbines, and batteries. These minerals contribute to the development of energy storage systems, a critical component for integrating renewable energy into the grid and improving overall EE. However, the reliance on specific countries for the supply of these critical minerals raises geopolitical concerns and underscores the importance of diversifying sources to enhance supply chain security. The extraction and processing of minerals also pose environmental challenges, necessitating a balance between meeting the demand for minerals and adopting sustainable and responsible mining practices.

To support renewable energy technologies, minerals are also integral to the manufacturing of energy-efficient devices and infrastructure components. LEDs, energy-efficient appliances, and components of decentralized energy systems all depend on various minerals to achieve optimal performance. The challenge lies in managing the environmental impact of mineral extraction while simultaneously advancing sustainable practices. As the global community works towards decarbonization and increased EE, ongoing research focuses on developing alternative materials and technologies to reduce dependence on critical minerals. Additionally, innovations in recycling processes aim to enhance the circular economy, promoting the reuse of minerals from used batteries and other devices. In conclusion, the path to EE is not easy, and there will be factors that are dependent and independent of the direction of climate policy [163,164].

5. Impact of the COVID-19 Pandemic on the Energy Market

On 7 November 2019, an outbreak of SARS-CoV-2 occurred in the Chinese city of Wuhan, Hubei Province, which has evolved into a global pandemic known as COVID-19.

The landmark date is 31 December 2019, when the Wuhan Health Commission reported cases of new viral pneumonia (Unilateral and Multilateral, 2021). The World Health Organization (WHO) officially recognized the pandemic on 11 March 2020 due to its rapid spread around the world, high number of cases, and more than 5.23 million deaths (as of 3 December 2021) [165]. The pandemic has led to many organizational changes in health security and economic restrictions. The pandemic paralyzed many sectors of the economy of all countries in the world. In order to protect the life and health of the population, many restrictions have been introduced in various spheres of economic activity. These restrictions, in particular those affecting industry and trade, were reflected in the sphere of macroeconomic indicators of economic growth (GDP), public finance deficit, and the closely correlated energy sector. However, beginning in 2021, we have been seeing a sudden, dynamic increase in the price of fuels, energy, and CO_2 emission allowances.

The rapid onset of the COVID-19 pandemic has swiftly disrupted both the global supply chain and the economy. The various phases of the pandemic have had detrimental effects on numerous markets, including the energy market ([166], they refer to Table 1 in that publication]. The changes during and after the pandemic period have resulted in a significant transformation in energy markets [167]. Global crude oil prices have experienced substantial fluctuations, plummeting by 50–80% in the first quarter of 2020. A mere 10% reduction in oil prices has led to an approximate 0.2% decline in the US GDP per year [168]. Notably, WTI and Brent oil futures in near-term curves have, for the first time in history, dropped by an average of 20%, posing an increased risk of insolvency for oil and gas companies [169].

Numerous recent studies have explored the intersection of COVID-19 and the energy market [170–179]. These publications delve into the impact of the pandemic on fuel prices. For instance, Narayan [170–172] scrutinized the effects of COVID-19 and oil price fluctuations on future oil prices, while Liu et al. [174] suggested that the pandemic has caused a prolonged and substantial decline in current oil prices. Gil-Alana and Monge [173] conducted an analysis of the pandemic's impact on oil prices. Wang et al. [176] presented comprehensive research on WTI crude oil and coal prices spanning from 1 January 2018 to 7 May 2021, capturing data from the pre-pandemic, pandemic, and post-pandemic periods. Their model revealed a rapid drop in market efficiency in the first quarter of 2020, culminating in the historic event of WTI crude oil futures turning negative on 20 April 2020 [180].

Further studies have examined the economic repercussions of the collapse of WTI oil prices during the pandemic on energy industry companies [181]. Additionally, there are studies focusing on individual countries or industry sectors, encompassing regional and local analyses as well as sectoral research [176,182,183]. For instance, research by Gajdzik et al. [183] observed a reduction in energy consumption in Italy due to the pandemic, and Wang et al. [176] analyzed WTI crude oil and coal prices within the context of the United States.

The initial manifestation of the pandemic's impact was a reduction in energy consumption, as analyzed by Iyke [184], Gillingham et al. [185], and Dutta et al. [186]. Iyke [184] investigated the response of US oil and gas firms to COVID-19, while Dutta et al. [186] analyzed the impact on oil prices and the US energy sector. In the US, the pandemic led to significant reductions in the demand for aviation fuel and gas, by 50% and 30%, respectively [185]. Similar decreases in energy demand were observed in China and India [187,188].

The IEA [189] expressed concerns about energy security, electricity security, and clean energy transitions in 2020 due to COVID-19. The IEA reported an unprecedented 57% decline in global oil demand and a 50–75% drop in road transport. However, Bocca [190], a World Economic Forum (WEF) member, discussed the shocks to the global economy and energy market caused by COVID-19, outlining a new, sustainable energy order. Szczygielski et al. [191], using bibliometric methods, found that COVID-19 introduced uncertainty into the energy markets of all countries. According to Ftiti et al. [192] and

Iyke [184], the impact on energy stock prices was a result of imposed restrictions. The energy sector faced challenges through restrictions on travel, production, and worker mobility, leading to reduced demand for oil, coal, and gas. This impact was exacerbated, as manufacturing and travel sectors contributed to almost 60% of the total energy demand [189]. The IEA [189] expressed concerns about energy security, electricity security, and clean energy transitions in 2020 due to COVID-19. The IEA reported an unprecedented 57% decline in global oil demand and a 50–75% drop in road transport. However, Bocca [190], a World Economic Forum (WEF) member, discussed the shocks to the global economy and energy market caused by COVID-19, outlining a new, sustainable energy order. Szczygielski et al. [191], using bibliometric methods, found that COVID-19 introduced uncertainty into the energy markets of all countries. According to Ftiti et al. [192] and Iyke [184], the impact on energy stock prices was a result of imposed restrictions. The energy sector faced challenges through restrictions on travel, production, and worker mobility, leading to reduced demand for oil, coal, and gas. This impact was exacerbated, as manufacturing and travel sectors contributed to almost 60% of the total energy demand [189].

In the long-term, we can say that the impact of the pandemic on the energy market was both positive and negative. During the pandemic period, gas and electricity consumption decreased, resulting in low carbon emissions. This situation can be considered positive because the air quality improved. Moreover, today, three years after the pandemic, the world, and Europe in particular, has a growing consumption of RES. According to the International Renewables Energy Agency (IRENA), in 2022, some 300 GW of renewables were added globally [193]. On the other hand, high energy prices were a negative result of the pandemic. The market for energy consumption accelerated rapidly after the lifting of the pandemic restrictions. Rapidly rising energy prices caused a rise in social problems inscribed in energy poverty. Thus, this section will present two areas of change: (1) energy market factors and (2) energy poverty.

The initial focus of examination pertains to the surge in energy prices following the relaxation of radical economic and social constraints post-COVID-19. Initially, during the pandemic, prices declined due to reduced energy consumption. However, in the post-pandemic phase, there was a rapid escalation in energy prices, particularly in oil, gas, and overall energy costs. The partial economic standstill induced by the pandemic prompted an upswing in energy demand as individuals reverted to their previous consumption patterns and lifestyles and businesses sought to recover their losses.

Post-pandemic, there has been a heightened demand for residences, automobiles, and laptops. The manufacturing of these goods heavily relies on energy, primarily sourced from fossil fuels. Additionally, the initiation of the conflict in Ukraine after the pandemic underscored Europe's prolonged dependence on fossil fuels and renewable gas supplies from Russia. Prior to the invasion, the EU was heavily reliant on Russia, accounting for approximately 50% of its oil exports and over 60% of gas exports. The invasion triggered disruptions in energy markets, prompting a swift and effective response from the IEA. In response to potential global supply shortages, the IEA facilitated the first of two emergency releases of oil from member countries' reserves, marking the largest releases in the Agency's nearly 50-year history.

Post-pandemic, Europe experienced intentional shortages of natural gas, attributed to disruptions in Russian gas supplies and elevated fuel prices. Consequently, there was a resurgence in electricity production from coal, with increased coal mining and some governments supporting consumers of this energy resource. Many countries accelerated efforts to diversify fossil fuel supplies to bolster energy security. Had this situation persisted, it could have led to higher CO_2 emissions from energy consumers compared to pre-pandemic levels. The restructuring of energy consumption ensued due to elevated energy prices, sparking renewed interest in coal among customers in countries with access to this raw material.

Europe responded to the challenge by seeking alternatives to Russian gas, such as investing in offshore liquefied natural gas (LNG) supplies from the United States, Qatar, and

Australia. This move resulted in heightened prices and redirected supplies from traditional LNG customers in Asia. By 2023, Russian pipeline flows to Europe had plummeted by 80% compared to pre-invasion levels. Revenue from Russia's oil and gas exports, which initially surged after the invasion, experienced a monthly decline of $12 billion in January 2023 compared to the previous year—a decrease of approximately 40% [194,195]. Regarding the energy market, high electricity prices were influenced by the situation on the oil market. Oil prices also initially rose sharply due to the reconfiguration of international trade routes after the United States, many European countries, and some of their Asian allies reduced their purchases of Russian oil. Some carriers refused to transport crude oil from Russia due to sanctions and insurance risks. Many major oil producers have been unable to increase supplies to meet rising demand—despite skyrocketing prices—due to a lack of investment in recent years [196]. Oil exports to world markets have fallen only marginally so far, but much of it is sold at high discounts to international reference prices, with fewer and fewer buyers in developed economies. Over the past two years, Russia's market power in oil and gas has declined. As far as oil is concerned, Russia's exports to the EU are almost completely exhausted, as an embargo on both petroleum and refined products came into effect [194].

The escalation in energy prices, which persisted in the post-pandemic years, was influenced by the dynamics in various fuel markets, including oil and natural gas. Detailed analyses addressing these changes can be found in energy reports and scientific publications [197–199]. The alterations in natural gas and electricity prices have played a role in the upsurge of inflation. In some EU countries, post-pandemic inflation reached double digits (according to Eurostat, inflation for the euro in the EU was 9.2% YoY in 2022, compared to 5.3% in 2021). This surge in inflation led to a rise in short-term interest rates in many countries, consequently impeding economic growth. The inflationary impact has also manifested challenges for electricity consumers, resulting in decreased expenditures on household appliances, a shift in spending from higher-level needs to energy purchases, and a push towards diversifying energy sources [200].

Kuik et al. [197] identified two primary factors influencing the changes in energy prices post-pandemic, the first being an increase in energy prices and the second being geopolitical factors, with both factors strongly interconnected. The surge in oil and gas prices in 2020 was predominantly driven by the recovery in economic activity and energy demand following the initial pandemic wave. Simultaneously, the acceleration in energy prices was propelled by supply constraints and geopolitical threats in the face of sustained high demands. The impact of geopolitical situations on the energy market has sustained high unpredictability in energy prices.

According to the IEA [199], the ongoing energy crisis shares similarities with the oil shocks of the 1970s but exhibits crucial differences. Unlike the 1970s, where price spikes were primarily limited to oil, the current crisis affects all fossil fuels. Moreover, the present global economy is more interconnected, exacerbating the repercussions of the crisis. The IEA labels the COVID-19 pandemic as the catalyst for a truly global energy crisis, highlighting its global and enduring effects [196]. The surge in wholesale energy prices worldwide began in 2021 in the aftermath of the pandemic and rising international demand.

In response to the crisis, countries are implementing energy diversification policies, promoting programs that introduce cleaner, sustainable renewable energy (RES) such as wind and solar power. Cleaner alternatives to Russian fossil fuels are gaining momentum as governments aim to fortify energy security amid the crisis. Globally, the capacity of renewable power added increased by approximately one quarter in 2022; electric car sales surged by close to 60%; investments in EE saw a notable increase; heat pump installations rose, particularly in Europe; and nuclear power witnessed a robust resurgence.

Research studies focusing on changes in the share of RES in total energy during and after the pandemic have been conducted by various authors [201,202]. Post-pandemic, statistics from global and European energy institutions validate the rise in the share of energy derived from solar and wind sources. Solar and wind energy collectively accounted for a record 12% of global electricity production in 2022, marking a 2-percentage point increase from 2021, as reported by the think-tank Ember in its fourth annual report "Global Electricity Review" [203].

The crisis has underscored the importance of investing in resilient gas and electricity network infrastructure to enhance the seamless integration of regional markets. Noteworthy initiatives to promote EE and renewable sources are embedded in the EU's RePowerEU program, unveiled in May 2022, and the US Inflation Reduction Act of August 2022 [196]. In recent years, there has been a significant upswing in momentum for climate and energy policy, exemplified by milestones such as the Paris Agreement (UN Climate Change Conference, COP21, held in Paris, France, on 12 December 2015) and the Net Zero Strategy 2050, a long-term strategy outlined in the EU Climate Action for the European Union. The EU's climate and energy policy set forth an ambitious objective of achieving climate neutrality (as indicated in COM(2019)0640). The scientific community acknowledges that climate change has emerged as a prominent concern, gaining increased attention across various disciplines, ranging from biological to economic and political perspectives [204–206].

Climate change means that extreme heatwaves, such as positive temperatures in the Arctic Circle, droughts in Central and Eastern Europe, or violent fires, hurricanes, cyclones (Gati), floods, and typhoons (Maria, Irma, Hagibis, and others) have been recorded all over the planet. The generation of greenhouse gases from the burning of fossil fuels is one of the main threats to global climate stability and requires decisive action. As the Intergovernmental Panel on Climate Change (IPCC) reports show, there are no reasonable alternatives to reducing the risks of global warming other than reducing human greenhouse gas emissions (IPCC 2001, 2007, 2013, 2020; USGCRP 2017). In order to achieve the climate goals and move away from coal, adequate energy levels must be provided. This is possible thanks to renewables, nuclear power, etc. All government actions are aimed at reducing the use of fossil fuels in favor of green energy.

The second area of analysis (impact), which is very closely linked to the situation in the energy market, is energy poverty. Energy poverty is understood as a situation where the cost of heating exceeds 10% of a person's income. Thus, energy poverty has been defined by the EPEE European Fuel Poverty and Energy Efficiency Project as "the lack of funds to maintain adequate heating at a fair price". Consumers' purchases of energy, which were (or still are) high during the crisis, have led to lower revenues and current expenditure. The immediate cause of energy poverty after the pandemic was the rapid rise in oil and gas prices, as well as high inflation in many countries (according to Eurostat, inflation in 2022/HICP, selected countries: Estonia, 19.1; Latvia, 18.9; Lithuania, 17.2; Hungary, 15.3; Czech Republic, 14.8; Poland, 13.2; Bulgaria, 13.0). In addition to high energy prices, the situation of energy poverty is influenced by measures taken within the framework of economic policies of countries and defined by economic growth indicators (e.g., GDP per capita). An important factor (determinant) of energy poverty is residential buildings, including the technical condition of the buildings in which people live (used building materials, energy intensity, ventilation, etc.). Buildings in poor conditions do not allow people to maintain adequate heat in their homes, so they buy more energy (heat) and spend more. However, a consistent climate policy is gradually having an impact on buildings. They are more environmentally friendly, and more and more buildings have energy codes [207].

Energy poverty is not a new phenomenon that was triggered by the pandemic, but after the pandemic, poverty increased. An analysis of energy poverty indicators shows that energy poverty in the EU as a whole increased by 1.3 p.ps in 2020 compared to the previous year [208]. The European Energy Poverty Observatory (EPOV) has estimated that about 50 million families in EU countries live in energy poverty conditions. Specifically, this means that these families cannot afford to heat their homes in winter or cool them properly in summer, or that they spend more than 10% of their income on energy services [208]. According to data published by the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA, https://www.enea.it/en, accessed on

13 September 2021), based on research by the Italian Energy Poverty Observatory (OIPE), more than 2.3 million Italian families will be living in energy poverty, or about 8.8 percent of the country's total. Governments have had to respond to this rise in poverty, and that is why electricity has been included in the European Pillar of Social Rights as one of the most important and essential services to which every European has the same right of access (EU Commission Recommendation 2020/1563, L 357/35).

In the coming years, energy poverty will continue to ripple under the influence of economic and industrial changes. Indeed, energy poverty is embedded in current policies and projects [209]–Table 3. Improving the fate of the energy poor vs. supporting the energy transition to RES are important strategy directions in the energy market. Economic and other instruments are needed to ease the burden on low-income, vulnerable, or energy-poor households [210].

Table 3. Impact of the pandemic on the energy market.

Indicator	During the Pandemic	After the Pandemic	Post-Pandemic
Global crude oil prices	Dropped 50–80% in Q1 2020, historic fall on 20 April 2020	Initial fall due to reduced consumption, followed by a rise	Continued rise influenced by geopolitical factors
Energy consumption	Initially reduced due to economic freeze	Increased after the pandemic, people returning to old habits	Growing demand for homes, cars, and goods after the pandemic; impact of war in Ukraine on fossil fuel dependence
Renewable energy share	Decrease in energy consumption initially led to low carbon emissions	Increased consumption of renewable energy post-pandemic	Growing consumption of renewables; 300 GW added globally in 2022
Energy prices (oil, gas, electricity)	Initially fell during the pandemic due to lower consumption	Started rising post-pandemic as demand increased	Continued rise, influenced by geopolitical factors and supply constraints
Global inflation	Contributed to rising inflation in some EU countries	Post-pandemic inflation, impacting short-term interest rates	High inflation causing problems among electricity consumers; impact on purchasing power
Energy security	Concerns about energy security during the pandemic	Continued focus on energy security, diversification of fossil fuel supplies	Dependence on Russian gas; efforts to replace it with LNG from the US, Qatar, and Australia
Renewable power capacity	Increased by approximately one quarter in 2022	Growing investments in cleaner, sustainable energy sources	Strong momentum in introducing cleaner alternatives amid the energy crisis

Based on references [193,194,196,203].

Regarding energy consumption in the future, nearly 50% growth in global energy consumption was projected for the period from 2018 to 2050. Household energy demand is increasing as incomes rise and more electrical appliances are owned. This contributes to an increase in total energy consumption despite improvements in EE [211] (p. 22). According to the World Energy Outlook (WEO) report in 2020, the energy demand will increase by 12% between 2019 and 2030 [212]. Global energy demand is on the rise [213]. It is projected to grow by 66% in 2050 from 2020 [214]. According to the WEO 2023, based on the Announced Pledges Scenario, total energy demand has flattened thanks to improved efficiency and the inherent efficiency advantages of technologies powered by electricity—such as electric vehicles and heat pumps—over fossil fuel-based alternatives [214].

6. Impact of the Russian Invasion of Ukraine on the Energy Market

The Russian invasion of Ukraine has had a profound impact on energy prices worldwide [206–215]. Russia is one of the world's largest producers of oil and natural gas, and the war has disrupted supply chains and fueled uncertainty, leading to a surge in prices. According to the IEA, the price of Brent crude oil rose from $92.77 per barrel on 24 February 2022, the day the invasion began, to $106.96 per barrel on 3 March 2022 [216]. This represents a 15.3% increase in just over a week. The price of natural gas has also risen sharply. The Dutch Title Transfer Facility (TTF) gas price, a benchmark for natural gas prices in Europe, reached an all-time high of €239 per megawatt-hour on 7 March 2022. This represents a 529% increase from the beginning of 2021 [217].

The surge in gas prices was driven by a combination of factors, including [215,218–220]:

- The disruption of Russian gas exports to Europe: The war disrupted the flow of Russian gas to Europe, raising concerns about the security of supply.
- The imposition of sanctions on Russia: The imposition of sanctions on Russia made it more difficult for European countries to import Russian gas.
- The global supply–demand imbalance: The global supply of natural gas was already tight before the war, and the conflict exacerbated the imbalance.

The sharp rise in gas prices had a profound impact on energy consumers across Europe. Households and businesses faced higher energy bills, putting a strain on their budgets. The impact was particularly severe for industries that rely heavily on natural gas, such as the chemical and fertilizer industries [218].

The impact of the war on energy prices has been felt most acutely in Europe, which is heavily reliant on Russian energy imports. The EU imports about 40% of its natural gas from Russia, and the war has raised concerns about the security of supply. In response to the war, the EU has taken steps to reduce its reliance on Russian energy [219]. The bloc has pledged to cut its gas imports from Russia by two-thirds by the end of 2022, and it is exploring ways to import more LNG from other countries. The war has also had a ripple effect on energy prices in other parts of the world [220].

In response to the energy crisis, governments around Europe took steps to mitigate the impact on consumers and businesses. These measures included [219–223]:

- Providing subsidies to energy consumers
- Lowering taxes on energy
- Promoting EE

The United States, which imports only a small amount of natural gas from Russia, has also seen prices rise as the global market has become more volatile. The price of gasoline in the United States rose by 42% in the months following the invasion, reaching a record high of $5.02 per gallon in June 2022 [220].

The impact of the war on energy prices is not limited to the immediate short-term. The war has also disrupted investments in new energy projects, and it could lead to a long-term increase in energy prices [221]. The war in Ukraine has highlighted the need for a more secure and diversified energy supply. Governments around the world are now looking for ways to reduce their reliance on fossil fuels and increase their use of renewable energy sources [222]. Table 4 shows the main impacts of the Russian invasion of Ukraine on energy prices.

Supply chain disruptions have further compounded the situation, as the war has disrupted the flow of EE equipment and materials. This has created delays in project implementation and increased project costs, making it even more difficult to advance energy efficiency initiatives [220]. As a result, EE investments have slowed down in the short-term, potentially hindering progress towards emissions reduction goals and energy security objectives. This presents a temporary setback for the global energy transition, highlighting the need for targeted measures to support EE efforts in the face of volatile market conditions [222].

The war in Ukraine has raised concerns about the future of global energy security. The conflict has highlighted the need for a more diversified energy supply and a transition to renewable energy sources [215]. However, these changes are likely to take time and will require significant investment. In the long-term, the war could accelerate the transition to a low-carbon economy. However, in the short-term, it is likely to lead to more expensive energy bills for consumers and businesses [223].

Table 4. Main impacts of the Russian invasion of Ukraine on energy prices.

Factor	Description
Disruption of Russian gas exports to Europe	The war disrupted the flow of Russian gas to Europe, raising concerns about supply security.
Imposition of sanctions on Russia	The imposition of sanctions on Russia made it more difficult for European countries to import Russian gas.
Global supply–demand imbalance	The global supply of natural gas was already tight before the war, and the conflict exacerbated the imbalance.
Speculation and risk aversion	Market participants are increasingly concerned about the potential for further disruptions to Russian energy supplies, and this has led to increased speculation and risk aversion in the energy markets.
Delayed investment in new energy projects	The war has caused some investors to delay or cancel investments in new energy projects, as they are concerned about the long-term viability of these projects in the current uncertain environment.
Reduced EE	In some cases, businesses and households may be reducing their energy consumption in response to higher prices, but this only provides a temporary solution to the problem.

Source: Authors' analysis based on references [215,218–225].

In the Table 5, we list the long-term implications of the impact of the Russia–Ukraine war on energy prices. The war has accelerated the global movement away from Russian energy. Countries are looking for alternative sources of energy, such as LNG from the United States and Qatar [11]. This shift will likely lead to higher prices for all energy consumers. This war has also renewed interest in renewable energy sources, such as solar and wind power. These sources of energy are not subject to the same geopolitical risks as fossil fuels. Higher energy prices can put a strain on household budgets and business operations. This will have a ripple effect throughout the economy, leading to higher inflation and slower economic growth [225].

Table 5. Long-term impacts of the Russia–Ukraine war on energy prices.

Implication	Description
Shift away from Russian energy	The global energy landscape is undergoing a significant shift, with countries seeking alternative sources of energy to reduce their reliance on Russian supplies. This transition will likely lead to higher prices for all energy consumers.
Renewed interest in renewable energy	The war in Ukraine has highlighted the vulnerabilities associated with fossil fuel dependencies and the need for a more diversified energy mix. Renewable energy sources, such as solar and wind power, offer a cleaner and more secure energy future but require significant investments to accelerate their adoption.
Higher energy costs for households and businesses	The increased demand for alternative energy sources and the lingering supply chain disruptions caused by the war are expected to keep energy prices elevated for an extended period. This will place a strain on household budgets and business operations, potentially impacting their financial stability and economic growth.

Table 5. *Cont.*

Implication	Description
Policy challenges in ensuring energy security and affordability	Policymakers face the daunting task of balancing energy security with affordability for consumers and businesses. This involves strategies to diversify energy sources, promote EE, invest in renewable energy infrastructure, and provide targeted support to vulnerable populations.
Addressing the economic impacts of high energy prices	Surging energy costs can have a ripple effect on the overall economy, contributing to inflation, slowing economic growth, and exacerbating social inequalities. Policy measures aimed at stabilizing prices, supporting businesses, and protecting vulnerable households will be crucial.
Accelerated transition to a low-carbon economy	The war has accelerated the global movement towards a low-carbon economy, with renewable energy gaining traction as a more sustainable and secure energy source. This transition, however, requires long-term planning, investments, and technological advancements to ensure a smooth transition and address the potential challenges associated with resource constraints and infrastructure needs.

Source: Authors' analysis based on references [223–231].

The Russia–Ukraine war has created a new reality for energy markets. Policymakers will need to work together to address the challenges that this new reality presents. With careful planning and investment, we can ensure that energy security and economic prosperity are not sacrificed in the pursuit of a low-carbon future [221].

Specific challenges that policymakers will need to address in the long-term are connected with finding ways to secure reliable energy supplies at affordable prices. This will require a mix of policies, including diversifying energy sources, investing in renewable energy, and improving EE. Higher energy prices will disproportionately affect low-income households [224]. Policymakers will need to find ways to support these households, such as providing subsidies or rebates [225]. Higher energy prices will inhibit economic growth. Policymakers will need to find ways to mitigate the impact of these higher prices, such as supporting innovation and investing in infrastructure [226].

The Russia–Ukraine war has underscored the critical role of EE in reducing reliance on fossil fuels, particularly from Russia, and strengthening energy security [227]. By improving EE, countries can conserve energy resources, reduce their energy consumption, and lower their overall energy bills. Energy efficiency measures can diversify energy sources, reducing dependence on any single supplier and enhancing resilience against geopolitical shocks like the current situation. This makes energy efficiency a cornerstone of a sustainable and secure energy future [228]. Recognizing these long-term benefits, governments and businesses are now accelerating their investments in energy efficiency initiatives. The EU, for instance, has pledged to double its investment in renewable energy by 2030, aiming for a 45% reduction in greenhouse gas emissions by that year [229]. Retrofitting buildings to enhance their energy performance is another key focus, with governments providing incentives and support for upgrades such as insulation, window replacements, and efficient heating and cooling systems. These measures can significantly reduce energy consumption in buildings, leading to substantial cost savings and environmental benefits [219,220]. The adoption of smart grid technologies is further accelerating, as these systems can optimize energy use, manage peak demand, and integrate renewable energy sources more effectively. Smart grids are playing a crucial role in modernizing energy infrastructure and enhancing EE [230,231].

The Russia–Ukraine war has undoubtedly presented challenges for the global energy efficiency agenda. However, it has also served as a wakeup call, highlighting the urgency of reducing reliance on fossil fuels, diversifying energy sources, and enhancing energy security [219,220]. As we move forward, EE stands as a critical enabler of a sustainable and secure energy future [231–233]. By investing in EE measures, we can reduce our reliance on fossil fuels, lower energy costs, and mitigate climate change while strengthening our energy resilience [234]. The war has accelerated the transition towards a more EE future, and it is imperative to capitalize on this momentum to build a more sustainable and secure energy system for the benefit of all [234]. In Table 6. we summarize the short-term and long-term impacts of the Russia–Ukraine war on EE.

Table 6. The short and long-term impacts of the Russia–Ukraine war on energy efficiency.

Factor	Short-Term Effects	Long-Term Effects
Rising energy prices	Made investments in EE measures less appealing	Heightened the urgency of EE measures and accelerated the shift towards a more sustainable energy future
Supply chain disruptions	Led to delays in project implementation and increased project costs	Disrupted the progress of the global energy transition, posing a challenge for achieving emission reduction targets and energy security goals
Short-term investment slowdown	Potentially hindered progress towards emissions reduction goals and energy security objectives	Underscored the critical importance of EE in achieving a sustainable and secure energy future
Long-term accelerated transition	Encouraged governments and businesses to invest more in EE initiatives	Accelerated investments in renewable energy projects, retrofitting buildings, and adopting smart grid technologies
Reducing reliance on fossil fuels	Conserved energy resources, lowered consumption, and reduced dependence on imported fossil fuels, particularly from Russia.	Diversified energy sources and reduced dependence on any single supplier, making energy systems more resilient to geopolitical shocks
Enhanced energy security	Made energy systems less vulnerable to geopolitical shocks and reduced vulnerability to price fluctuations.	Increased resilience is crucial for ensuring a stable and secure energy future
Investment in renewable energy	Shift towards renewables driven by the need to reduce reliance on fossil fuels, address climate change, and improve energy security	Further accelerated the trend, as countries sought to secure their energy supplies and reduce their dependence on Russian imports
Retrofitting buildings	Government provided incentives and support for upgrades such as insulation, window replacements, and efficient heating and cooling systems.	Reduced energy consumption in buildings and led to substantial cost savings and environmental benefits
Adoption of smart grid technologies	Gained traction as a means to optimize energy use, manage peak demand, and integrate renewable energy sources more effectively	Modernized energy infrastructure and enhanced EE

Source: Authors' analysis based on references [231–244].

Table 7 provides a description of the impact of the Russia–Ukraine war on particular types of RESs. The war has spurred a surge in investment in solar energy projects as countries seek to reduce their reliance on Russian fossil fuels and boost their energy independence [236]. Governments are offering incentives and subsidies to encourage the adoption of solar energy, and businesses are increasingly incorporating solar panels into their operations [237]. This trend is expected to continue in the years to come as solar energy becomes more affordable and efficient. Similarly, the war has heightened the demand for wind energy as countries look to diversify their energy portfolios and reduce their dependence on Russian gas. Wind energy is a reliable and scalable source of renewable energy that is not subject to supply disruptions from geopolitical events [238]. The war has accelerated the development of new wind energy projects, and it is expected to play an even more significant role in the global energy mix in the future [239].

Hydropower is an established renewable energy source that has been in use for centuries. While it has not been directly affected by the Russia–Ukraine war, the war's impact on the global economy could indirectly affect hydropower generation [240]. For instance, if the war leads to economic disruptions, it could reduce the demand for electricity and, consequently, the need for hydropower generation. Additionally, if the war leads to supply chain disruptions, it could make it more difficult to obtain the materials and equipment needed for hydropower projects [241]. Geothermal energy is another mature renewable energy source that harnesses the heat from the Earth's interior to generate electricity. It is not directly affected by the Russia–Ukraine war, but it could be indirectly impacted by the war's broader economic and geopolitical consequences. Similar to hydropower, economic disruptions could reduce the demand for geothermal energy, and supply chain disruptions could hinder its development and deployment [242].

Bioenergy is a renewable energy source that utilizes organic matter to produce heat, electricity, and transportation fuels. It is a versatile and abundant source of energy, but it is also susceptible to indirect impacts from the Russia–Ukraine war. Disruptions in the supply of agricultural inputs, such as fertilizers and pesticides, could affect bioenergy production, while disruptions in the supply of machinery and equipment could delay or hinder the development of new bioenergy technologies [243].

Ocean energy harnesses the power of the waves, tides, and currents to generate electricity. It is a promising renewable energy source with the potential to generate significant amounts of power, but it is still in its early stages of development. The Russia–Ukraine war could have a mixed impact on ocean energy. On the one hand, the war has increased the focus on developing new and innovative renewable energy sources, which could benefit ocean energy technologies. On the other hand, the war's economic and supply chain disruptions could hinder the development and deployment of ocean energy projects [244].

Carbon capture and storage (CCS) is a technology that captures carbon dioxide emissions from fossil fuel power plants and stores them underground. It is a crucial tool for mitigating climate change and reducing reliance on fossil fuels. The Russia–Ukraine war has increased demand for CCS as a way to address greenhouse gas emissions and improve energy security. Governments and businesses are investing more in CCS research and development, and there is a growing momentum to deploy CCS technologies at scale [245].

Energy storage is essential for integrating renewable energy sources into the grid. Renewable energy sources, such as solar and wind power, are intermittent, meaning they do not produce electricity consistently. Energy storage systems can store excess electricity generated during periods of high production and release it when demand is higher. The Russia–Ukraine war has accelerated the development of energy storage technologies as a way to address the intermittency of renewable energy sources and enhance the stability of the power grid [246].

Table 7. The impacts of the Russia–Ukraine war on particular types of renewable energy.

Type of Renewable Energy	Description of the Impacts of the Russia–Ukraine War
Solar energy	The Russia–Ukraine war has accelerated the development and deployment of solar energy technologies. Governments and businesses are investing more in solar energy projects as a way to reduce reliance on fossil fuels and improve energy security.
Wind energy	The war has also led to increased investment in wind energy projects. Wind energy is a reliable and scalable source of renewable energy that is not dependent on imported fossil fuels.
Hydropower	Hydropower is an established renewable energy source that is not directly affected by the Russia–Ukraine war. However, the war may have an indirect impact on hydropower generation if it leads to disruptions in the supply of machinery and equipment.

Table 7. *Cont.*

Type of Renewable Energy	Description of the Impacts of the Russia–Ukraine War
Geothermal energy	Geothermal energy is another established renewable energy source that is not directly affected by the war. However, the war may have an indirect impact on geothermal energy exploration and development if it leads to disruptions in the supply of machinery and equipment.
Bioenergy	Bioenergy is a renewable energy source that can be used to produce heat, electricity, and transportation fuels. The war may have an indirect impact on bioenergy production if it leads to disruptions in the supply of agricultural inputs or bioenergy technologies.
Ocean energy	Ocean energy is a promising renewable energy source that has the potential to generate large amounts of electricity. However, ocean energy technologies are still in development, and the war may result in a delay in the deployment of these technologies.
Carbon capture and storage (CCS)	CCS is a technology that can be used to capture carbon dioxide emissions from fossil fuel power plants and store them underground. The war has increased the demand for CCS as a way to reduce greenhouse gas emissions and improve energy security.
Energy storage	Energy storage technologies are essential for integrating renewable energy sources into the grid. The war has accelerated the development of energy storage technologies as a way to address the intermittency of renewable energy sources.

Source: Authors' analysis based on references [235–242,246–253].

7. Energy Policies in the European Union Energy Market

Energy policies are a set of government-led measures that aim to achieve specific energy-related goals, such as reducing greenhouse gas emissions, ensuring energy security, or improving EE. These policies can have a profound impact on the energy market, influencing the supply, demand, and price of energy [254].

Energy policies can have direct impacts on the energy market. Governments can set renewable energy targets, provide subsidies for renewable energy development, and establish feed-in tariffs that guarantee a minimum price for renewable energy. These measures can incentivize the growth of renewable energy production and reduce reliance on fossil fuels [255]. They can implement policies to improve EE in buildings, appliances, and vehicles. This can reduce energy consumption and lower energy costs for consumers and businesses. Those policies can support research and development of advanced energy storage technologies, such as batteries and pumped hydro storage, to address the intermittency of renewable energy sources and ensure a stable and reliable energy supply [256].

Energy policies can also have indirect impacts on the energy market. A stable and supportive energy policy environment can attract investments in the energy sector, leading to increased exploration, development, and deployment of energy resources. Stated policies can influence consumer choices by providing incentives for energy-efficient appliances, offering rebates for switching to renewable energy or implementing carbon pricing mechanisms. Also, policies can affect the European Union energy trade by imposing tariffs, quotas, or other restrictions on imports or exports of energy resources [257].

The EU has implemented a wide range of energy policies aimed at achieving its ambitious climate goals and ensuring a secure and sustainable energy supply for its citizens. These policies have had a significant impact on the EU energy market, influencing the supply, demand, and price of energy. Table 8 describes the main EU policies about energy [258–261].

The Renewable Energy Directive (RED II) sets binding targets for the EU to increase the share of renewable energy in its energy mix to at least 32% by 2030. It also provides support for the development of innovative renewable energy technologies and promotes the integration of renewable energy into the electricity grid [250–252]. The Renewable Energy Directive (RED III) is the third and most recent iteration of the EU's primary energy law regulating the use of renewable energy sources. It was adopted in November 2023 and entered into force on 20 November 2023. The directive aims to further accelerate the deployment of renewable energy in the EU, increasing the 2030 target from 32% to 40% of final energy consumption [262,263].

The Energy Efficiency Directive (EED) aims to reduce the EU's overall energy consumption by 32.5% by 2030. It sets minimum energy performance standards for buildings, appliances, and vehicles and provides incentives for energy-efficient renovations and investments in energy-efficient technologies [264,265].

The emission trading system (ETS) is a market-based mechanism that sets a cap on greenhouse gas emissions from large industrial installations. The cap is gradually reduced over time, forcing industries to either reduce their emissions or purchase allowances from other, more efficient emitters [266].

Table 8. The impacts of the main important EU policies on the energy market.

EU Policy	***Description of the Impacts on the Energy Market***
Renewable Energy Directive (RED) [259–263,267,268]	Encourages the use of renewable energy sources, leading to increased investments in renewable technologies and a shift away from fossil fuels. This can affect market dynamics, creating opportunities for renewable energy producers and impacting traditional energy sectors. RED II sets a binding target for the EU to reach a 32% share of renewable energy in its energy consumption by 2030, up from 22% in 2020. This has spurred the development of renewable energy sources such as wind, solar, and biomass. In 2021, renewables accounted for 26% of the EU's electricity generation, up from 16% in 2010. RED III's goal is to increase the share of renewable energy in the EU's energy mix to 40% by 2030. RED III sets more ambitious targets for the use of renewable energy in heating and cooling, recognizing the importance of these sectors in reducing greenhouse gas emissions. The directive introduces new measures to encourage the use of renewable fuels in transport, including an increased target of 14% for the share of renewable energy in the transport sector by 2030.
Energy efficiency directive (EED) [264,265,269–272]	Promotes energy efficiency measures across various sectors, encouraging the adoption of energy-efficient technologies and practices. This can impact the market by driving demand for energy-efficient products and services, affecting traditional energy consumption patterns. The EED aims to reduce the EU's primary energy consumption by 32.5% by 2030. To achieve this target, the directive sets minimum energy performance standards for buildings, appliances, and vehicles. It also provides incentives for energy-efficient renovations and investments in energy-efficient technologies. As a result, the EU has seen significant improvements in energy efficiency across its member states. Between 2005 and 2021, the EU's primary energy consumption per capita decreased by 20%.

Table 8. *Cont.*

EU Policy	*Description of the Impacts on the Energy Market*
Emission trading system (ETS) [266,273–282]	Establishes a cap on greenhouse gas emissions and allows for trading of emission allowances. This incentivizes companies to reduce emissions, influencing market behavior by promoting cleaner technologies and penalizing high-emission activities. The ETS is a market-based mechanism that sets a cap on greenhouse gas emissions from large industrial installations, such as power plants, refineries, and factories. The cap is gradually reduced over time, forcing companies to either reduce their emissions or purchase allowances from other, more efficient emitters. As a result, the ETS has helped to reduce emissions from these sectors. In 2020, emissions from the EU's power plants, refineries, and other heavy industries were 10% below 2019 levels.
Integrated energy market (IEM) [283]	The Integrated Energy Market (IEM) has played an important role in enhancing the seamless flow of energy resources across the European Union (EU), simplifying the process for member countries to import and export electricity, natural gas, and various other energy products. This has significantly heightened competition within the EU energy market, ultimately resulting in decreased energy costs for consumers. Furthermore, the IEM has bolstered the security of energy supply by promoting diversification in both energy sources and distribution routes.
Research and innovation initiatives (RII) [284–291]	The EU has invested heavily in research and innovation initiatives to support the development and deployment of new and innovative energy technologies. This has helped to accelerate progress towards a clean energy future. For example, the EU has funded the development of new renewable energy technologies, such as offshore wind power and marine energy. It has also supported the development of new energy storage technologies, such as batteries and pumped hydro storage.

Source: Authors' analysis based on references [259–291].

EU energy policies have had a significant impact on energy efficiency, both in the short-term and long-term. In the short-term, EU energy policies have helped to reduce energy consumption and improve energy efficiency in buildings, industries, and transport. This has led to lower energy bills for consumers and businesses, as well as reduced greenhouse gas emissions. In the long-term, EU energy policies are helping to promote the development of new energy-efficient technologies, such as smart meters and heat pumps [292]. This will help further reduce energy consumption and improve energy efficiency in the future. Table 9 provides an analysis of the short-term and long-term impacts of EU energy policies on energy efficiency.

In the long-term, EU energy efficiency policies contribute to the gradual transformation of the energy landscape. By incentivizing the development and implementation of energy-efficient solutions, these policies foster sustainable and resilient energy infrastructure. This shift towards energy efficiency not only aligns with environmental goals but also enhances energy security by mitigating dependence on scarce resources [255].

Table 9. The short- and long-term impacts of EU energy policies on energy efficiency.

EU Policy	Short-Term Effects	Long-Term Effects
Renewable Energy Directive (RED) [259–263,267,268]	Increased share of renewable energy in the EU's energy mix. Improved air quality—the increased deployment of renewable energy sources has also helped to improve air quality. Renewable energy sources produce significantly less air pollution than fossil fuels, which has led to a reduction in the levels of pollutants such as nitrogen oxides, sulfur dioxide, and particulate matter. This has had a positive impact on public health and the environment.	Accelerated development of renewable energy sources—the RED has provided financial incentives and other support for the development of renewable energy projects. This has led to an increase in the number of wind turbines, solar panels, and biomass power plants across the EU. Reduced reliance on fossil fuels and lower greenhouse gas emissions—RES are not only cleaner than fossil fuels but are also becoming increasingly cost-competitive. As a result, the EU is increasingly relying on renewable energy to meet its energy needs. This has led to a significant reduction in greenhouse gas emissions, which is critical to combating climate change.
Energy Efficiency Directive (EED) [259–263,269–272]	Reduced overall energy consumption in the EU—the EED aims to reduce the EU's primary energy consumption by 32.5% by 2030. To achieve this target, the directive sets minimum energy performance standards for buildings, appliances, and vehicles. It also provides incentives for EE renovations and investments in EE technologies. As a result, the EU has seen significant improvements in EE across its member states. Between 2005 and 2021, the EU's primary energy consumption per capita decreased by 20%. Reduced energy-related emissions—the EED has contributed to the reduction of greenhouse gas emissions from the EU's energy sector. By reducing energy demand, the EED has helped to lower the overall emissions of pollutants such as carbon dioxide, nitrogen oxides, and particulate matter. This has had a positive impact on air quality and public health.	Improved EE of buildings—the EED has helped to improve the EE of buildings by setting stricter requirements for insulation, windows, and heating systems. This has resulted in lower energy bills for homeowners and businesses.
Emission trading system (ETS) [266,273–286]	Reduced greenhouse gas emissions from large industrial installations—the ETS is a market-based mechanism that sets a cap on greenhouse gas emissions from large industrial installations, such as power plants, refineries, and factories. The cap is gradually reduced over time, forcing companies to either reduce their emissions or purchase allowances from other, more efficient emitters. As a result, the ETS has helped to reduce emissions from these sectors. In 2020, emissions from the EU's power plants, refineries, and other heavy industries were 10% below 2019 levels.	Encouraged industries to invest in cleaner technologies—the ETS has provided an incentive for industries to invest in cleaner technologies and processes to reduce their emissions. This has led to the development of new technologies, such as carbon capture and storage. Promoted a shift to renewable energy—the ETS has made it more expensive for companies to emit greenhouse gases, which has encouraged them to switch to cleaner energy sources, such as renewable energy. This has helped to reduce the EU's reliance on fossil fuels and promote a cleaner energy future.

Table 9. *Cont.*

EU Policy	Short-Term Effects	Long-Term Effects
Integrated energy market (IEM) [283]	Enhanced cross-border energy trade within the EU—the IEM has facilitated the movement of energy resources across the EU, making it easier for countries to import and export electricity, natural gas, and other energy products. This has increased competition within the EU energy market, leading to lower energy prices for consumers. It has also improved the security of supply by diversifying energy sources and routes.	Reduced energy costs for consumers—the IEM has helped to reduce energy costs for consumers by ensuring competition and efficient pricing. This is because consumers now have more options when it comes to purchasing energy, and they are more likely to switch suppliers if they can find better deals. IEM has made it easier for energy companies to operate across borders, which has also resulted in lower costs. Diversification of energy sources and routes, improving security of supply—the IEM has allowed the EU to diversify its energy sources and routes, reducing its reliance on any one supplier. This improves the security of the supply, as it means that the EU is less vulnerable to disruptions in energy supply from any one country or region.
Research and innovation initiatives (RII) [284–291]	Support for the development and deployment of new and innovative energy technologies—the EU has invested heavily in research and innovation initiatives to support the development and deployment of new and innovative energy technologies. This has helped to accelerate the progress towards a clean energy future. For example, the EU has funded the development of new renewable energy technologies, such as offshore wind power and marine energy. It has also supported the development of new energy storage technologies, such as batteries and pumped hydro storage.	Reduced reliance on fossil fuels and improved energy security—new and innovative energy technologies have the potential to reduce the EU's reliance on fossil fuels and improve its energy security. For example, renewable energy sources are less reliant on imported fossil fuels, and energy storage technologies can help to stabilize the grid and reduce reliance on fossil fuels for peak demand.

Source: Authors' analysis based on references [259–291].

EU energy policies have helped to reduce energy consumption in buildings, industry, and transport. The policies described in this chapter have helped to improve energy efficiency in buildings, industries, and transport. For example, the EED has encouraged the use of energy-efficient appliances and equipment, and the Energy Performance of Buildings Directive (EPBD) has set minimum energy performance standards for new buildings. As a result, the energy efficiency of buildings in the EU has improved by 2.2% per year on average since 2007 [264,265,269]. Also, it can be stated that energy policies have helped to lower energy bills for consumers and businesses. For example, the EED has provided financial incentives for energy efficiency measures, such as insulation and energy-efficient lighting. As a result, energy bills in the EU have decreased by 1.1% per year on average since 2007 [264,270].

In the long-term, perspective energy policies are helping to promote the development of new energy-efficient technologies such as smart meters and heat pumps. For example, the Innovation and Networks Executive Agency (INEA) has funded research and development of energy-efficient technologies. As a result, new energy-efficient technologies are becoming more affordable and accessible, which will help to further reduce energy consumption and improve energy efficiency in the future [255,256]. Also, they are helping to accelerate the deployment of renewable energy, which can help to reduce fossil fuel reliance and improve energy security. For example, RED III has set binding targets for the share of renewable energy in the EU's energy consumption. As a result, the share of renewable energy in the

EU's energy consumption has increased from 17% in 2007 to 21% in 2022 and is projected to reach 42.5% by 2030 [262,263,268].

The implementation of EU energy policies can lead to improvements in air quality by reducing emissions from power plants, industries, and vehicles. For example, the emissions trading system (ETS) has set a cap on greenhouse gas emissions from large installations, and the Clean Vehicles Directive (CVD) has set emissions standards for new cars and vans. As a result, air quality in the EU has improved and is projected to continue to improve in the future [256].

EU energy policies have played a significant role in promoting the development and deployment of renewable energy sources. These policies have set ambitious targets for increasing the share of renewable energy in the EU's energy mix, provided financial incentives for renewable energy investments, and encouraged innovation in renewable energy technologies [293,294]. Table 10 provides an extensive analysis of the impact of EU energy policies on the various types of renewable resources [293].

Table 10. The impact of EU energy policies on particular types of renewable energy.

Type of Renewable Energy	Description of Impact of EU Directives and Policies
Solar energy	EU directives encourage increased investment in solar technologies, fostering the development of solar infrastructure, incentivizing adoption, and driving down costs through economies of scale.
Wind energy	EU policies promote the growth of wind energy by setting targets, facilitating grid integration, and supporting research and innovation. This has led to the expansion of wind farms and increased competitiveness in the market.
Hydropower	EU directives focus on sustainable hydropower development, balancing environmental concerns. Policies aim to streamline licensing processes, encourage efficiency improvements, and address ecological impacts, fostering responsible hydropower projects. The EU Water Framework Directive and Floods Directive aim to protect water resources and reduce the environmental impact of hydropower projects. EU energy policies also encourage the development of pumped hydro storage, which can store excess renewable energy and provide backup power when renewable resources are intermittent.
Geothermal energy	EU energy policies support the development of geothermal resources by fostering research, exploration, and project implementation. This contributes to the growth of geothermal energy as a reliable and low-emission source. The EU Directive on the Geological Storage of Carbon Dioxide (CCS Directive) supports the development of geothermal energy as a potential storage site for CO_2 emissions from fossil fuel power plants. EU energy policies also promote the use of geothermal energy for heating and cooling applications.
Bioenergy	The EU encourages sustainable bioenergy production, emphasizing responsible sourcing and avoiding negative environmental impacts. Policies aim to ensure the efficient use of biomass for heating, electricity, and biofuels. RED sets binding targets for the share of bioenergy in EU renewable energy consumption, ensuring the sustainability of biomass production and minimizing the environmental impact of bioenergy use. RED also encourages the development of advanced biofuels, such as biogas and bio-based liquid fuels.

Table 10. *Cont.*

Type of Renewable Energy	Description of Impact of EU Directives and Policies
Ocean energy	EU directives focus on advancing ocean energy technologies such as wave and tidal power. Policies promote research, innovation, and pilot projects, fostering the growth of a sustainable and competitive ocean energy sector. The EU Directive on the Energy Performance of Buildings (EPBD) promotes the use of heat pumps powered by ocean energy for heating and cooling buildings. EU research and innovation funding supports the development of ocean energy technologies such as wave and tidal power.
Carbon capture and storage	EU policies encourage the deployment of CCS technologies to reduce emissions from industrial processes and power generation, contributing to the overall goal of decarbonizing the energy sector. The EU CCS Directive aims to promote the development and deployment of CCS technologies to capture and store CO_2 emissions from industrial processes and power plants. CCS could play a role in decarbonizing sectors that are difficult to electrify, such as heavy industries.
Energy storage	EU directives support the integration of energy storage solutions, such as batteries and pumped hydro, to enhance grid flexibility, stabilize renewable energy supplies, and improve overall system efficiency. RED recognizes the importance of energy storage for integrating renewable energy into the grid. RED encourages the deployment of various energy storage technologies, such as pumped hydro storage, batteries, and thermal storage.

Source: Authors' analysis based on references [259–291,295–297].

EU RED sets binding targets for the share of solar energy utilized in EU electricity consumption. These targets, coupled with support schemes such as feed-in tariffs and tax breaks, have driven investments in solar photovoltaic (PV) technologies and encouraged cost reductions [262,263]. RED also promotes the development of innovative solar applications, such as rooftop solar installations and floating solar PV plants. The EU has also set ambitious targets for the share of wind energy in EU electricity consumption [269].

While hydropower is a mature renewable energy source, the EU is also promoting its development through targeted policies. The EU Water Framework Directive and Floods Directive aim to protect water resources and reduce the environmental impact of hydropower projects. EU energy policies also encourage the development of pumped hydro storage, which can store excess renewable energy and provide backup power when renewable resources are intermittent. The EU is also recognizing the potential of geothermal energy as a clean and reliable source of renewable energy [295]. The EU Directive on the Geological Storage of Carbon Dioxide (CCS Directive) supports the development of geothermal energy as a potential storage site for CO_2 emissions from fossil fuel power plants. EU energy policies also promote the use of geothermal energy for heating and cooling applications [296].

The EU is promoting the use of bioenergy, but with an emphasis on sustainability and minimizing environmental impacts. The EU RED sets binding targets for the share of bioenergy in EU renewable energy consumption. RED ensures the sustainability of biomass production and encourages the development of advanced biofuels, such as biogas and bio-based liquid fuels. While still in its early stages of development, ocean energy has the potential to play a significant role in the EU's renewable energy mix. The EU Directive on the Energy Performance of Buildings (EPBD) promotes the use of heat pumps powered by ocean energy for heating and cooling buildings. EU research and innovation funding supports the development of ocean energy technologies such as wave and tidal power [297].

The EU recognizes that CCS could play a role in decarbonizing sectors that are difficult to electrify, such as heavy industries. The EU CCS Directive aims to promote the development and deployment of CCS technologies to capture and store CO_2 emissions from industrial processes and power plants [255–257]. Energy storage is crucial for integrating intermittent renewable energy sources into the grid. The EU RED recognizes the importance of energy storage and encourages the deployment of various energy storage technologies, such as pumped hydro storage, batteries, and thermal storage [292,293].

8. Discussion and Conclusions

This paper delves into the intricate dynamics of energy awareness, consumption practices, and efficiency considerations. This study emphasizes the diverse influences on energy awareness, ranging from economic factors to consumer preferences and environmental consciousness. Notably, it underscores the pivotal role of consumer behavior in steering demand for energy-efficient products and compelling industries to align with sustainable choices. The role of active consumers in the energy market, as analyzed in the EU, emerges as a crucial aspect. This study underscores the importance of energy-saving measures, emphasizing the adoption of technologies such as LED light bulbs and energy-efficient appliances. Additionally, the impact of high energy prices on energy conservation is acknowledged, pointing to the complex interplay between economic factors and sustainable behavior. Environmental awareness is explored as a potential driver for sustainable consumption, with varying degrees of influence observed across different segments of e-consumers. This paper highlights the intricate relationship between consumer preferences, industry actions, and the emergence of sustainable choices in the market. The concept of sustainable consumption, while acknowledged for its importance, is also critiqued for its vagueness, posing challenges related to scale, scope, and temporal considerations.

Moving beyond consumers, this paper underscores the significant responsibility of industries in contributing to energy-saving efforts. Large enterprises, particularly international companies, are noted as beneficiaries of structural projects aimed at fostering innovation in industries. Corporate EE programs are positioned within the broader context of social responsibility, aligning with the growing trend of consumers making sustainable choices. The theme of innovativeness in the energy sector is highlighted, with technological and business trends driving rapid transformations. The increasing role of information and communication technologies, coupled with the popularity of alternative fuels, challenges traditional energy paradigms. The discussion integrates considerations of environmental and climatic factors, technological breakthroughs, and the evolving landscape of global energy dependence.

This research extends its focus to high-energy-intensity industries, such as the steel and chemical sectors. Disparate findings regarding energy awareness in these industries are noted, emphasizing the need for targeted interventions based on sector-specific characteristics. This underscores the importance of tailoring energy-saving initiatives to the unique challenges and opportunities presented by different industries. The responsibility of industries in contributing to EE is highlighted, with a call for a comprehensive approach that integrates energy-saving criteria into product development and corporate social responsibility.

This paper holds significant scientific value by offering a comprehensive exploration of energy awareness, consumption patterns, and efficiency within the context of both households and industries. Through an extensive review of existing literature and empirical studies, the authors provide a nuanced understanding of the factors influencing energy-related behaviors. Also, this paper contributes to the scientific discourse by highlighting the intricate interplay between consumer behavior, industry practices, and technological innovations in shaping the energy landscape. The emphasis on the responsibility of industries in adopting energy-efficient measures, coupled with the discussion on the role of consumers in driving sustainable choices, underscores the interdisciplinary nature of this study.

This paper, while contributing valuable insights, has certain limitations that warrant consideration. This paper synthesizes findings from various studies with potentially diverse methodologies. Differences in research designs, sampling techniques, and measurement tools across these studies could introduce variations that might impact the coherence of the overall synthesis. While this paper touches on the responsibility of industries for energy efficiency, it does not deeply delve into sector-specific nuances. Different industries may face unique challenges and opportunities regarding energy consumption, and a more in-depth exploration of these dynamics could enhance this paper's depth.

Future research could be conducted, for example, cross-cultural comparative studies, to discern how cultural factors influence energy awareness and consumption patterns. Understanding cross-cultural variations would contribute to more nuanced and globally applicable insights. Given the brief mention of energy poverty, future research could dedicate focused attention to understanding the dynamics of energy poverty, its determinants, and the effectiveness of interventions. This could involve both quantitative and qualitative analyses to provide a comprehensive understanding of the issue.

Author Contributions: Conceptualization, B.G., R.W., R.N., B.Ž.-N. and W.W.G.; methodology, B.G., R.W., R.N., B.Ž.-N. and W.W.G.; software, B.G., R.W., R.N. and B.Ž.-N.; validation, B.G., R.W., R.N., B.Ž.-N. and W.W.G.; formal analysis, B.G., R.W., R.N. and B.Ž.-N.; investigation, B.G., R.W., R.N. and B.Ž.-N.; resources, B.G., R.W., R.N. and B.Ž.-N.; data curation, B.G., R.W., R.N. and B.Ž.-N.; writing—original draft preparation, B.G., R.W., R.N., B.Ž.-N. and W.W.G.; writing—review and editing, B.G., R.W., R.N., B.Ž.-N. and W.W.G.; visualization, B.G., R.W., R.N., B.Ž.-N. and W.W.G.; supervision, B.G., R.W., R.N., B.Ž.-N. and W.W.G.; funding acquisition, B.G. and R.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Silesian University of Technology: BK-264/ROZ1/2024 (13/010/BK_24/0081).

Data Availability Statement: The data presented in this study are available upon request.

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

Abbreviations

EE1st	Concept of energy efficiency first
CCS	Carbon capture and storage
CVD	Clean vehicles directive
EED	Energy efficiency directive
EE	Energy efficiency
EPBD	Energy performance of buildings directive
ETS	Emissions trading system
EEI	Energy efficiency index
EPOV	European Energy Poverty Observatory
EPBD	EU Directive on the energy performance of buildings
CCS Directive	EU directive on the geological storage of carbon dioxide
EU	European Union
GDP	Gross domestic product
IEA	International Energy Agency
ENEA	Italian National Agency for New Technologies, Energy, and Sustainable Economic Development
OIPE	Italian Energy Poverty Observatory
IRENA	International Renewable Energy Agency
IPCC	Intergovernmental panel on climate change
IEEPs	Industrial energy efficiency programs
INEA	Innovation and Networks Executive Agency
MEPS	Minimum energy performance standards

LNG	Offshore liquefied gas
RED	Renewable Energy Directive
RED II	Renewable Energy Directive II
RED III	Renewable Energy Directive III
RII	Research and innovation initiatives
RES	Renewable energy resources
SMEs	Small- and medium-sized enterprises
PV	Solar photovoltaic
TTF	Title transfer facility
UNO	United Nations Organization
WEF	World Economic Forum
WEO	World energy outlook
WHO	World Health Organization

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