Renewable Energy Development in View of Energy Security

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The issue of energy security has been the subject of many studies, debates, and discussions. Undoubtedly, geopolitical crises in Eastern Europe and the actions of the EU as part of the continuous development of the EU's climate and energy policy have contributed to the advancement of discussions in this area. Due to the growing role and importance of energy in the economic systems of individual countries, the need to guarantee energy security is commencing to be regarded as an element of the economic security of the state and therefore, national security.

sustainable energy transformation | energy and climate change | clean energy

1. Introduction

Energy is the essence of any production process and it is among the most valuable strategic resources necessary for the independent and efficient functioning of countries and societies [1][2]. Global energy consumption has increased nearly every year for more than half a century, with the exception of the early 1980s and 2009 following the financial crisis [3]. Just in recent decades, the worldwide use of energy has risen exponentially, ranging from 8532 million tons (Mtoe) in 1990 to 14,585 Mtoe in 2022 [4]. Therefore, the continuity of energy supply is undoubtedly one of the most important economic challenges today, and various government institutions, such as the World Energy Council, the Organization of Petroleum Exporting Countries, and world mega-oil organizations have conducted numerous future global energy forecasting studies [5]. According to International Energy Agency [6], global energy demand is predicted to trend towards stability until 2030, after which energy demand should grow in pace with GDP. This is essentially due to the growth of the emerging markets and developing countries, led by China, India, and other Asian regions [7][8][9].

It is therefore clear that modern states prioritize energy security [10]. It is a crucial global issue and a core element of both energy management and global economy environment [11], which is due to the increasing concerns over energy supply security. Recent events like the COVID-19 pandemic and the geopolitical crisis in Eastern Europe have impacted global energy markets, causing energy price shocks and disrupting energy supplies. Environmental issues like climate change can be discussed in the same context. Extreme weather events such as floods, hurricanes, droughts, and low water levels are forcing the search for new sources of energy and transformation in energy management and governance models. Not surprisingly, the aforementioned problems are becoming increasingly relevant to the contemporary energy policies in various countries, and have become major concerns for political decision-makers [12]. Policymakers need to find a new energy mix to provide stable but also publicly acceptable energy supply in the future [13].

Measures to improve energy security include an increased use of renewable energy sources (RESs), which would allow for at least partial independence from external supplies of resources. With the support of effective policy and innovative business models, the use renewable energy can experience a considerable growth and shape energy security in many countries in the near future [14][15]. According to IEA [6], by 2030 we will notice a stronger push for renewables, faster electrification of industrial processes, vehicles, and heating. Thus, the current global energy crisis may prove to be a historic turning point towards a cleaner future, which would accelerate the transition to a more sustainable and secure energy system. It would also have some economic benefits. According to IRENA [16], by 2025, energy transformation would boost GDP by 2.5% and total employment by 0.2% globally. Every dollar spent in transforming the global energy system provides a payoff ranging from USD 3 to more than USD 7, depending on the study [16].

The IEA predicts the world is set to add as much renewable power in the next 5 years as it has in the past 20 [17]. This is in line with commitments made by most countries aimed at achieving a net zero carbon footprint in the coming years. It is also anticipated that total worldwide growth of renewable power capacity is set to almost double, overtaking coal as the largest source of electricity by early 2025 globally [17]. Low-carbon sources are expected to cover nearly 90% of the total projected boost in the global electricity demand between 2023 and 2025, whereas China is forecast to be responsible for more than 45% of the growth in renewable energy production. The European Union, on the other hand, is expected to account for 15% of the increase in total production [18]. It would be a big challenge for the EU Member States which have also adopted ambitious targets for the deployment of renewable energy systems. They have chosen to rely on wind and photovoltaics. However, in the past 10 years, the majority of Member States have deployed renewable energy technology sporadically rather than continuously, which has caused several markets to perform below their potential [19].

In 2020, the EU was a net importer of energy with a level of energy dependence reaching almost 55.5% in 2021 [20]. This explains the European Commission's growing concern to increase the energy security of the EU. Many studies show that this security varies throughout the EU [21][22]. For example, countries in the western European region (e.g., Germany and France) have higher energy security than southern Europe (e.g., Italy and Spain), primarily due to the more developed infrastructure and a richer energy mix.

To compensate for these disparities, a number of plans and institutional solutions have emerged (i.e., Renewable Energy Directive, Clean energy for all Europeans package). In reaction to the difficulties and disruptions in the global energy market that occurred in 2022, another plan was adopted, namely, REPowerEU [23]. It is aimed at accelerating the transition to clean energy and gradually reducing EU countries' dependence on Russian fossil fuels. The European Commission has proposed installing heat pumps, increasing the capacity of photovoltaic systems, phasing in the mandatory installation of solar panels on new buildings, and importing renewable hydrogen and biomethane to raise the 2030 renewable energy target to 45%.

The above-mentioned regulations apply to all Member States, including Poland which has high potential in the use of RES, although the share of coal in gross electricity production is high. In 2022, it amounted to 70.7%, which was 1.7 p.p. less than in 2021. However, it is worth noting that in 2022, for the first time, the production from RES in

Poland exceeded 20% of the mix. It amounted to 20.6%, thanks to the record production of 36.8 TWh and a 1.9% reduction in electricity demand. Photovoltaics is the largest contributor to the energy transition, as up to 53.4% of the renewable electricity generated in Poland comes from solar power. Next in line is wind energy (36.4%). In contrast, water (4.8%) and biomass and biogas (5.4%) are smaller contributors to green energy in Poland [24]. The potential for electricity production from photovoltaic panels in Poland is not significantly different from that of the neighboring countries situated at a similar latitude and is about 1000–1100 kWh/kWp3. However, it is significantly lower than the production achieved by South European countries. Recent years have shown a clear increase in the production of energy from photovoltaic panels in Poland, which is mainly due to the popularization of photovoltaic panels installed by prosumers.

2. Energy Security

Energy security is an issue historically associated with the depletion of fossil fuels, in the result of which the security of supply has become a particularly important concern [25]. It is defined in a variety of ways in the research literature with no clear consensus. Those definitions do, however, contain certain dominant aspects [26][27][28][29][30]. They include: energy availability, infrastructure, energy prices, societal effects, environment, governance, and energy efficiency [29]. In general, energy security is connected to risk management and energy management [11]. In the short term, this relates to the ability of the energy system to quickly respond to sudden changes in the supply–demand balance. However, in the long term, energy security concerns are associated with timely investment in energy supply in line with economic development and ecological issues. In the context of state, energy security is one of the key elements of economic security [31][32][33][34], where an important aspect is energy price [35]. Contemporary definitions of energy security exceed the aspect of protecting the supply of main energy sources to include environmental, social, and economic concerns, as well as the operational reliability of energy systems [36].

The IEA defines energy security as “the uninterrupted availability of energy sources at an affordable price” [37]. The EU also emphasizes the critical importance of ‘a stable and abundant supply of energy’ for European prosperity and security. This approach is supported by a number of studies which find that energy security plays a significant role in both national economic growth [38][39][40][41] and human life [42][43].

The concept of energy security is important primarily for the energy consumer who should be guaranteed energy in the form and quantity needed, at the required time and at an available price. The state’s task with regard to the energy sector should be to ensure a high level of energy security, understood as a supply, economic (certainty that energy prices will not create a barrier to economic development and will not lead to energy poverty), or environmental security (energy production will not cause excessive environmental pollution).

The European Union has established energy security as one of the cornerstones of its energy policy [44]. Throughout the years, it has taken a number of measures to ensure energy security, such as the creation of the Energy Union in 2015 to ensure free flow of energy between EU countries and reduce dependence on imports. It has, nevertheless, failed to make the economies of its Member States immune to disruptions, such as the COVID-19 pandemic or the 2022 cut-off of gas supplies from Russia. Therefore, it would be more reasonable to place

more emphasis on diversification of energy sources and, as raised with increased intensity in public discourse, greater use of alternative energy sources. In the document of 18 May 2022, the European Commission also emphasizes that internal energy security requires “diversifying the EU energy supply, increasing energy savings and efficiency and accelerating the green energy transition” [45].

3. The Role of Renewable Energy Sources

In consequence, fast development of renewable energy sources seems to be a matter of time, especially as many studies point to their contribution to economic growth, the promotion of local socio-economic development, better environmental protection and, above all, worldwide cooperation to reduce global warming [15][46][47][48][49]. Setting ambitious goals such as, among others, cutting greenhouse gas emissions by at least 55% (compared with 1990) by 2030, and becoming a climate-neutral continent by 2050 would speed up the transition to sustainable energy. These initiatives have begun to bear fruit, with an increasing proportion of Europe’s energy needs being met through renewable energy sources. In 2021, more than 22% of gross final energy consumed in the EU came from renewable sources [50]. However, their share in the energy mix varies considerably from one EU country to another: in Sweden, it is around 60%, in Denmark, Estonia, Finland, and Latvia, it is over 40%, and in Belgium, Hungary, Ireland, Luxembourg, Malta, and the Netherlands, it is between 10% and 15% [50]. Between 2005 and 2021 the renewable energy share in the EU grew by an average 0.8% per year.

There are also significant differences in the speed and motivation with which Member States are pursuing the transition towards clean energy. Some EU countries are strongly promoting renewables (e.g., Germany, Denmark), while others are actively resisting it (i.e., Poland) [51]. Observations in recent years have shown that in Western European countries, renewable energy is regarded as a means to bring these countries closer to energy independence and security, providing opportunities for further industrial development. In Eastern European countries, on the other hand, there is a concern about fossil fuel industry workforce and electricity prices. It appears that renewable energy is perceived as a win-win in the West and a win-lose in the East [51].

The transition to renewable energy sources is a major challenge. In order to promote their use, ensure uninterrupted energy supply and lower transmission costs, Europeans are being encouraged to become prosumers who generate electricity with, e.g., solar panels, consume it and feed it into the transmission grid. The benefits of doing so are numerous: from savings thanks to lower energy costs, to accelerating Europe’s energy transition and reducing greenhouse gas emissions [52][53][54][55]. Other benefits worth noting are the creation of local jobs, circumventing land use, escaping transmission costs and increasing grid flexibility [56]. According to data provided by the International Renewable Energy Agency (IRENA), the RES industry already employed more than 7.3 million people worldwide at the end of 2012, but in 2021 this number grew to about 12.7 million (of which the largest group of people, 4.29 million, were associated with the solar photovoltaic industry, while the smallest one, 0.77 million, were related to solar heating/cooling) [57]. Close to two-thirds of all jobs were in Asia (China alone accounts for 42% of the global total), followed by the European Union and Brazil with 10% each, and the United States and India with 7% each [57].

Individual EU countries use a variety of financial incentives to develop the prosumer market, such as low-interest and long-term loans, environmental tax exemptions, feed-in tariffs, or premiums with specific measures tailored to prosumers. Incentives should also aim to encourage the development and implementation of new technologies designed to protect the environment [58].

4. Renewable Energy in Poland

The dynamic development of renewable energy in Poland began after it joined the EU. Poland's installed capacity of renewable energy sources increased from 11.6 GW in 2005 to 23.4 MW in April 2023. According to the Ministry of Climate and Environment's statement, this growth is expected to be exponential in the coming years. According to the assumptions of the update to Poland's Energy Policy until 2040, by the end of the decade, the installed capacity of RES will reach 50, and 88 GW by 2040 [59].

In recent years, there has been a significant increase in the total domestic consumption of renewable energy, i.e., between 2017 and 2021, the increase was 44.38% [60]. Renewable energy generated in Poland includes energy from solar radiation, water, wind, geothermal resources, energy generated from solid biofuels, biogas and liquid biofuels, as well as ambient energy from heat pumps. As far as domestic acquisition (and use) of energy from renewable sources, solid biofuels occupied a dominant position. Compared with 2017, their share in obtaining energy from renewable sources in 2021 amounted to 69.35% and increased by 2.59 percentage points. Between 2017 and 2021, the share of wind energy decreased from 13.89% to 10.90%, biogas: from 3.04% to 2.49% and water energy: from 2.38% to 1.57%. At the same time, the share of solar energy increased from 0.74% to 3.31%. In 2021, solar energy (516%) achieved a relatively high position in obtaining energy from renewable sources by carrier, followed by heat pumps (102%), and then biogas, water energy, municipal waste energy, and geothermal energy, respectively [60].

A similar trend can be observed worldwide. Among renewable technologies, solar photovoltaic installations grew the fastest, with a twenty-six-fold increase in the 13-year period from 2010 to 2022. This was due to significant cost savings generated by technological advancements, high learning rates, policy support and innovative financing models [61]. In the EU, the REPowerEU plan introduced a strategy to double solar photovoltaic capacity to 320 GW by 2025 and install 600 GW by 2030. The plan also included a phased-in legal obligation to install solar panels on new public, commercial, and residential buildings [62]. This will certainly be reflected in employment in the sector as well. IRENA's estimates for upcoming years make Poland home to the largest solar PV workforce on the continent [61]. Among top ten countries where solar PV employment will grow, Poland ranks 6th (behind China, United States, India, Japan, Bangladesh, Brazil), ahead of Germany (8th), Vietnam (9th), and Australia (10th) [61]. Therefore, it seems that the popularity of solar photovoltaic energy resources will grow in the near future, especially since technologies are developing rapidly, including the market for so-called organic photovoltaic cells [63], the total cost of installing photovoltaic projects is projected to continue to decline over the next three decades [16], existing integration strategies and those under development will allow large penetration of solar PV not only in the power grid but in the entire energy system [64].

The complementarity of solar PV with, for example, wind energy is already being noted [16][65]. Although wind power will probably remain one of the major electricity generation sources, supplying more than one third of total electricity demand, solar PV power should follow, supplying 25% of total electricity demand. According to IRENA [16], it would represent over a tenfold rise in the solar PV share of the generation mix by 2050, in comparison with 2016 levels.

The role of photovoltaics in the energy transition is gaining recognition in Poland [66][67][68][69]. There are a number of factors contributing to the expansion of the photovoltaic user pool: ease of installation, simplicity of construction, relatively low costs, low labor intensity, no need to purchase fuel, and the ability to scale the installation depending on the capital [68]. Traditional centralized power systems, dominated by large conventional units controlled by few players, are being replaced by systems based on distributed generation capacity. Thus, a large part of energy can be generated by a group of producers including households and companies for which power generation is not the main business. The most important goals that can be achieved through such activities include [70]:

- Increased competition in the energy market which will consequently lead to a decrease in prices;
- The possibility of implementing a number of small investments, characterized by a relatively large total installed capacity;
- Stimulation of the development of innovative technological solutions, especially smart grids;
- The involvement of private capital in the development of a low-carbon economy;
- Technological diversification in the electricity system;
- A broadly understood improvement in the environment, both locally (improving air quality) and globally (combating climate change);
- Increased public awareness of energy transition and security.

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