



Primary Sector Economics

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**DEVELOPMENT
OF THE ALTERNATIVE ENERGY MARKET:
CASE OF CENTRAL EUROPE**

Abstract

The paper presents an analysis of the development of the alternative energy market between 2010 and 2022 in seven Central European countries, namely Poland, the Czech Republic, Slovakia, Romania, Lithuania, Hungary, and Bulgaria. Analyzing changes in electricity generation from hydro, solar, wind and biore-sources makes it possible to comprehensively assess trends in the development of alternative energy. The countries of Central and Eastern Europe are economically and climatically similar to Ukraine, so studying the development of their renewable energy is of scientific value for the drafting of both Ukrainian and European energy strategies in the context of the transforming global energy system. Additionally, the article discusses the impact of renewable energy development on the labor market, outlining potential challenges and threats to regional labor markets. Research conclusions confirm the practical development and effective implementation of RES in the European energy system, even in countries that do not take the lead in generat-ing energy from renewable sources, i.e., in Central Europe.

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Problem Statement and Literature Review

Today, fossil fuels – coal, oil and natural gas – are unquestionably the main source of energy in most countries around the world. However, the climate change and energy security problems caused by the global crises and the instability of fossil fuel markets are forcing the European Union to expand its ambitions regarding alternative energy. Therefore, to stay ahead of the curve, Central European countries need to accelerate their transition from fossil fuels to renewable energy sources and take advantage of all potential economic benefits from the new energy system, while attracting significant funds from private foreign investors who understand the importance of energy security and stability in the global economic system.

Research of the global energy market has always been a key issue, but over the past two years, its comprehensiveness and urgency has grown evident. Among the foreign scholars who have studied the alternative energy market, it is worth noting B. Hodge (2017), who described the operation of the renewable energy system. Studies by Simon (2020) and Baretto (2018) not only described the economic benefits and identified the interdependence between economic growth and widespread use of renewable energy, but also highlighted the political and social implications of transforming the national and global energy systems. Ade-doyin et al. (2021) proved the importance of developing renewable energy to stimulate regional trade and the need for sustainable utilization of obsolete RES equipment.

Ukrainian scientists also pay considerable attention to renewable energy issues in their works. A. Dolinskyi (2006) scientifically substantiated the need to develop alternative energy in order to address such global issues as environmental protection and energy saving. Borovyk & Yelahin (2019) proved the importance of using renewable energy sources for Ukraine, and Derhachova and Bedyk (2014) presented a scientific position on the economic security of the country based on renewable energy in 2014. Bozhydarnik et al. (2017) argued that the development of Ukraine's energy strategy should include an analysis of the experience of the world leaders in the use of renewable energy, in particular some European countries. Doronina (2019) emphasized the importance of transforming the energy systems of the EU and Ukraine towards the use of RES, which is impossible without attracting and regulating the inflow of investments, as noted by Nabok and Kovtun (2019).

The paper aims to conduct an in-depth analysis of the renewable energy market in Central European countries from 2010 to 2022 based on statistical research and provide recommendations for boosting the development of renewable energy in Ukraine, which is economically and climatically similar to the countries under study, in the context of war and post-war reconstruction. To this end, the following main tasks have been formulated: (a) to determine the share of RES in total energy consumption in Central European countries; (b) to identify trends in the development of renewable energy in Central European countries and analyze which renewable energy sources are prevalent in each country; (c) to study the predicted changes in the labor market as a result of a potential increase in the share of energy generated by renewable sources in the countries under study; and (d) to develop recommendations, based on the research conducted in the article, on the development of alternative energy in Ukraine and increase its share in national energy consumption.

Methodology

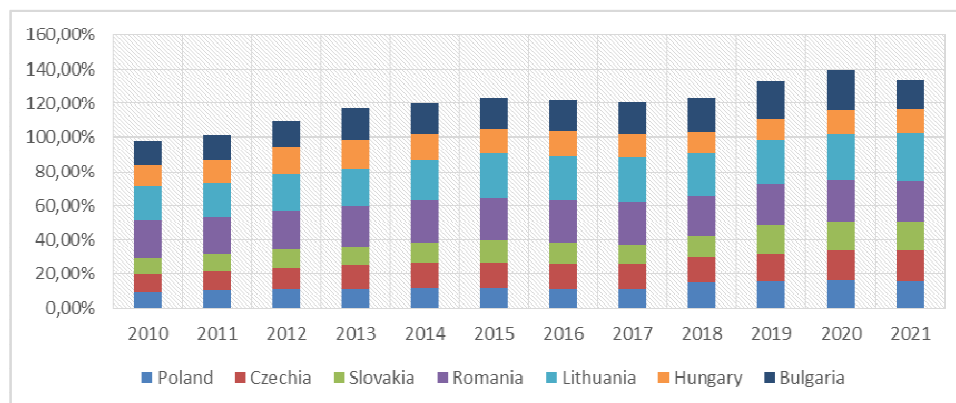
The article uses the methods of statistical and economic-mathematical analysis to study the dynamics of renewable energy development and the share of RES in energy consumption in the countries selected for the study. Comparative analysis is used to identify priority renewable energy sources for each country. Logical and generalization methods are applied to draw conclusions and develop recommendations for Ukraine on the development of renewable energy based on the experience of Central European countries.

Research Results

Central European countries are heavily dependent on fossil fuels and therefore need to increase their renewable energy production capacity to ensure their energy security, benefit from and implement EU plans to phase out traditional energy sources. As of the beginning of 2023, only Romania and Lithuania reached the average level of renewable energy use set out in the EU energy strategy; before a sharp drop in 2021, Bulgaria also met this target (see Figure 1) (EMBER, n.d.).

Figure 1

Share of renewable energy in Central European countries, 2010-2021
 (% of gross final energy consumption)



Source: designed by the author based on data from Eurostat Statistics Explained (2023).

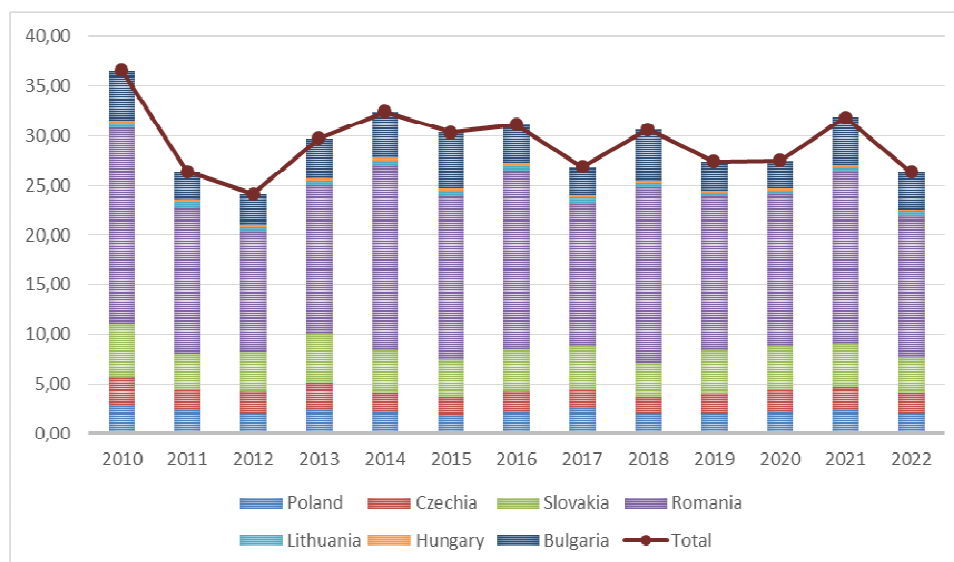
In Central Europe, the level of consumption and production of renewable energy is still lower than it is in Western Europe. Moreover, energy consumption continues to increase as a result of economic growth and a general improvement in living standards. At the same time, the countries of the region differ significantly from each other in terms of the structure of the energy supply, generating capacities, price levels, and prospects for transformation. The country with the highest demand for electricity is Poland, which accounts for more than one-third of the to-

tal demand of the countries studied; the Czech Republic and Romania are second and third, respectively (Central Europe Energy Partners, 2022).

The average rate of electricity generation by hydropower in 2010-2022 decreased from 36.61 to 26.33 TWh, which indicates insufficient support for the functionality of old and new plants. It is also worth noting that hydropower generated the most electricity in the countries studied until 2022, with Romania leading the way (see Figure 2).

Figure 2

Electricity generated by hydropower in Central European countries, 2010-2022 (in TWh)



Source: designed by the author based on data from EMBER (2022).

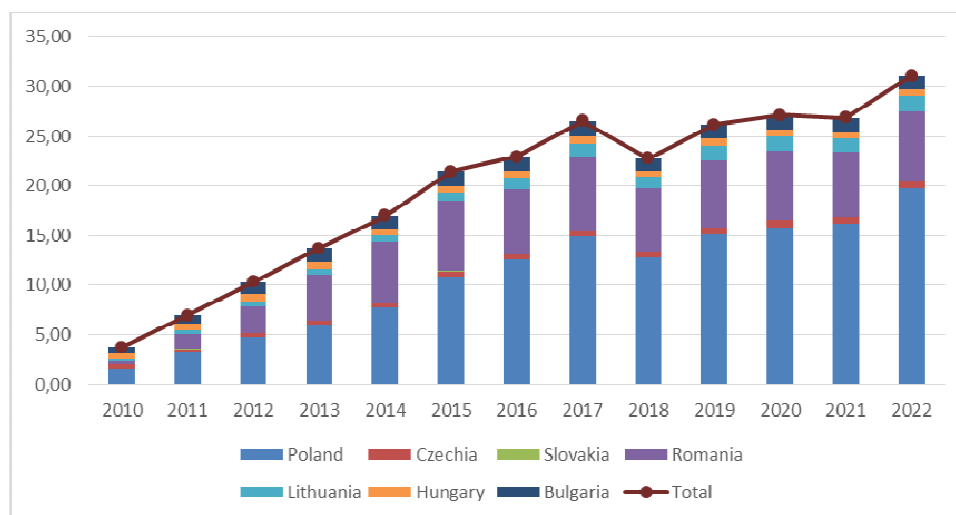
In Poland, the Czech Republic and Lithuania, the wind energy potential is significant and offers great investment opportunities. The northern regions of Poland and Lithuania are the best locations for both onshore and offshore wind farms. Mountainous areas in Romania and Bulgaria also have significant wind energy potential, which is still far from being fully utilized. However, in some regions, environmental regulations limit the development. Despite very favorable

conditions, most Central European countries lag behind Western Europe in terms of wind power capacity per capita (CISL, 2019).

Between 2010 and 2022, wind power generation increased eightfold from 3.75 to 31.12 TWh in the studied countries. Over the analyzed period, wind power was initially the third largest energy generator in the region, then in 2015 it became the second, and in 2022 it became the first, overtaking hydropower (see Figure 3). The leader in wind power generation is Poland, whose level of energy generation since 2015 has exceeded the combined level of the other six countries. Romania also demonstrates good generation levels.

Figure 3

Wind power generation in Central European countries, 2010-2022 (in TWh)



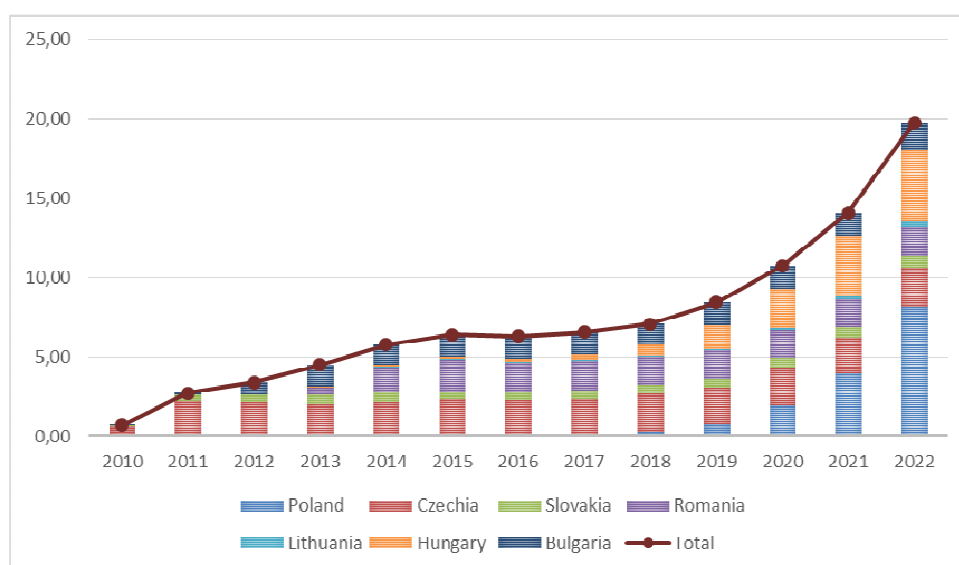
Source: designed by the author based on data from EMBER (2022).

The average annual potential of Central European countries to generate electricity from a 1 kW photovoltaic (PV) solar configuration is about 1.5 times higher than that of Germany or the UK. However, the use of solar energy is low or moderate compared to its huge potential. The capacity of photovoltaic solar panels per capita in the Central European region is significantly lower than the average Western European level. This untapped potential offers a great opportunity for solar investment, especially in southern Central Europe (CISL, 2019).

Over the analyzed period, solar power generation increased 29 times, even though solar energy has been growing rapidly only since 2019 and its growth rate was the lowest of all renewable energy sources in 2014-2019. Nevertheless, it has enormous potential in the future. Until 2020, the Czech Republic, Bulgaria, and Romania had the largest generation; after 2020, Hungary and Poland had the largest generation, which increased by 7 and 27 times, respectively (see Figure 4).

Figure 4

Solar power generation in Central European countries, 2010-2022 (in TWh)



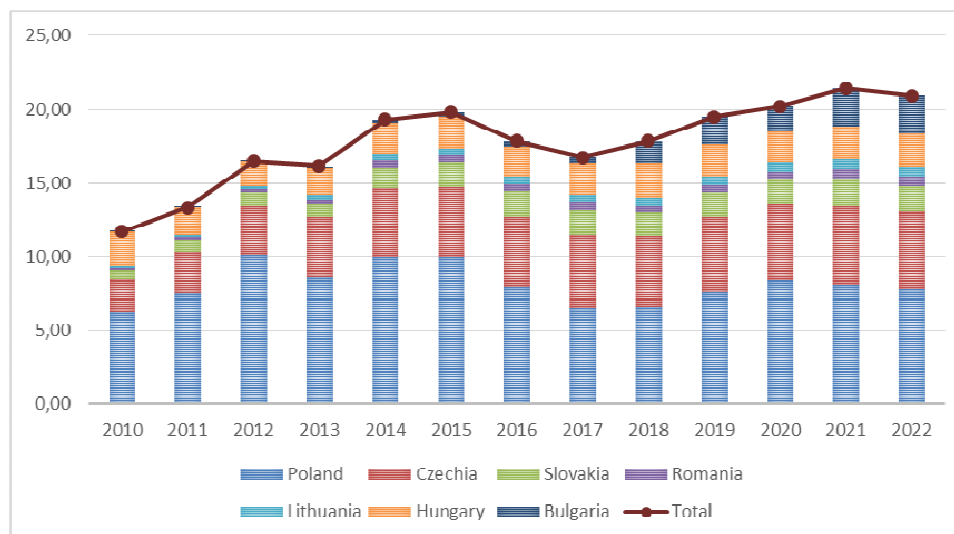
Source: designed by the author based on data from EMBER (2022).

Supporting the use of biomethane and biogas and preparing for the use of hydrogen in the coming years should be a priority. Domestically produced biogas and biomethane can reduce CO₂ emissions, increase market resilience, and significantly reduce dependence on fossil fuel imports. Biomethane and hydrogen can also be sold to a wider market using existing gas infrastructure and heating systems. Yet, countries in Central and Eastern Europe lack financial mechanisms and projects for low-emission biomethane or hydrogen production, despite their enormous potential (Beyer & Molnar, 2022).

Over the period under study, electricity generation from bioenergy increased from 11.69 to 20.92 TWh. Until 2015, bioenergy was the second largest generator after hydropower, but after 2015 it was overtaken by wind energy and since then bioenergy has been steadily ranked third (see Figure 5).

Figure 5

Power generated by bioenergy in Central European countries, 2010-2022 (in TWh)



Source: designed by the author based on data from EMBER (2022).

Poland, the Czech Republic, Romania, and Bulgaria are highly dependent on coal and employ many people in this sector. This poses a real problem, as a large share of coal power plants in the EU will be permanently closed in the next ten years. When this happens, there will be a need to provide retraining and support for employees who lose their jobs so that they can get new economic options. For example, the Oltenia region in Romania is likely to lose more than 10,000 jobs in the coal industry in the near future (on the other hand, this creates opportunities, as the region has some of the highest levels of solar radiation and wind energy potential among European coal regions). The Silesian (Śląskie) Voivodeship in Poland has approximately 80 thousand workers directly involved in the coal industry. If all the jobs at risk are lost (41 thousand), this could lead to an increase in the unemployment rate from 5.4% to 7.5%. In many cases, renewable energy sources already offer opportunities for cheaper, cleaner energy production than coal-fired power

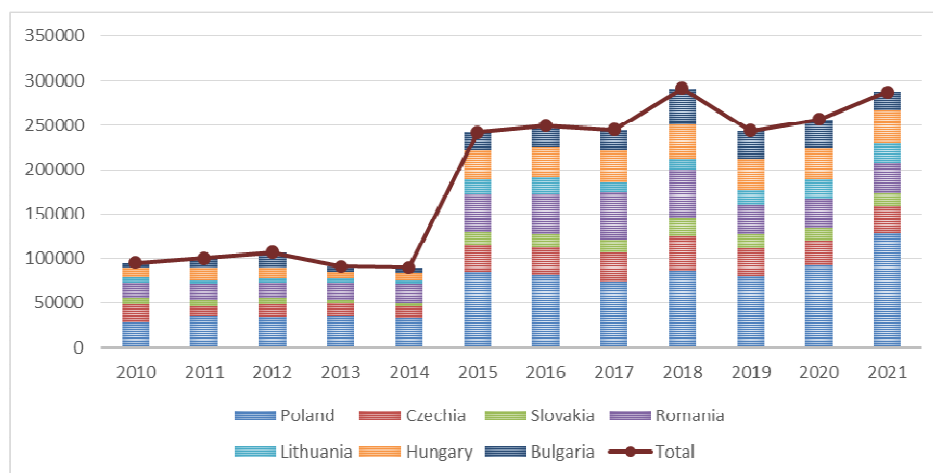
plants, but a large part of the population still works in the coal industry, meaning that coal can only be replaced gradually (CISL, 2019).

As of 2023, the majority of jobs in the EU energy sector were inextricably linked to traditional energy sources such as oil, gas, coal and nuclear power. However, alternative energy is gaining more investment and employment in RES is approaching the level of employment in the conventional energy sector. This growth in the renewable energy sector is leading to rapid job creation in related industries, including construction and manufacturing. Some sectors and regions of the EU need time to adapt to new renewable energy sources and learn how to use them efficiently. However, a transition is already underway in the EU's coal regions. The European Commission is actively implementing initiatives that promote a just transition for coal regions, both within the EU and in the Western Balkans and Ukraine, accelerating their path to decarbonization. Solar photovoltaics, wind power and bio-energy, which are already established industries, are becoming major job creators both globally and in the EU (Directorate-General for Energy, 2022).

In 2010-2021, the number of employees in the field of alternative energy grew in all countries except Slovakia (see Figure 6). The largest growth was observed in Poland, which was able to reach fifth place in the EU in 2020 by this indicator (EurObserv'ER consortium, 2023).

Figure 6

Direct and indirect employees in the renewable energy sector



Note: until 2015, only direct employment is taken into account; from 2015, both direct and indirect employment is taken into account.

Source: designed by the author based on data from EurObserv'ER consortium (2023).

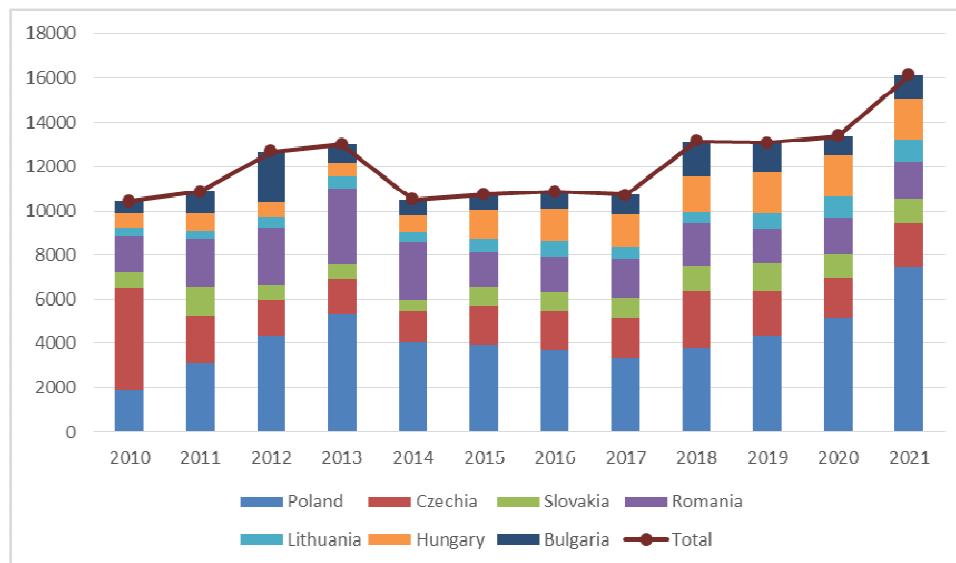
Driven by the European Union’s ambitious long-term goal of achieving full climate neutrality and its unwavering commitment to breaking its dependence on imported fuels, the EU’s renewable energy sector is growing steadily and rapidly, exceeding initial forecasts. Already in 2021, renewable energy-related industries reached an impressive turnover of around €184 billion in the EU27, representing a gross increase of €22 billion compared to 2020 (Directorate-General for Energy, 2022).

From 2010 to 2022, the turnover of the alternative energy sector increased by 5.7 billion euros. Poland showed the highest growth, while the situation in the Czech Republic was the worst, as it was the only country surveyed that saw its performance decline during this period, with financial turnover falling by 2.6 billion – more than by half (see Figure 7).

In terms of alternative energy development, northern countries have greater wind potential, while southern countries have solar potential (see Figures 8, 9). However, despite Romania, Hungary, and Bulgaria having higher solar energy potential than the other analyzed countries, together they generated less electricity from solar power plants in 2022 than Poland (see Figure 4), which indicates that the latter is following an effective state energy strategy and supports the development of the domestic energy sector’s potential.

Figure 7

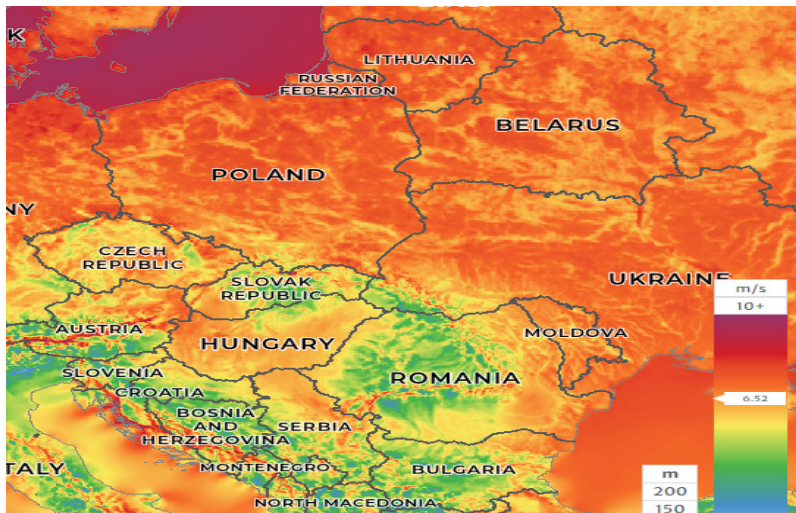
Renewable energy sector turnover (in millions of euros)



Source: designed by the author based on data from EurObserv’ER consortium (2023).

Figure 8

Wind energy potential in Central Europe



Source: Global Wind Atlas. (n.d.). *Global wind atlas v 3.3* [Interactive map]. <https://globalwindatlas.info/en>

Figure 9

Solar energy potential in Central European countries



Source: Global Solar Atlas. (n.d.). *Global solar atlas v 2*. [Interactive map]. <https://globalsolaratlas.info/map>

Conclusions

In summary, the study suggests that the upward trend in the share of energy generated by renewable sources in final consumption in all Central European countries is continuing. However, despite the active renewable energy market, most of the analyzed countries do not reach the EU average in terms of energy use from non-traditional sources. Among renewable energy sources, solar, wind, and bioenergy increased their production volumes, unlike hydropower, encumbered by outdated plants with declining productivity. The natural potential of alternative energy production in Central Europe is higher than that of Western Europe, but due to the lack of effective government programs to stimulate the development of renewable energy sources, it is not fully utilized. Poland is a leader in RES development and state support for increasing energy generation from renewable sources, with solar and wind generation at the forefront.

Transformation of the energy sector will significantly affect labor market dynamics. The inevitable reduction of workers involved in traditional energy, mainly in the coal industry, entails an increase in unemployment. However, these research findings confirm a positive trend in the number of workers in renewable energy, which, if there are programs for retraining energy sector workers, can slow the growth of unemployment or prevent it altogether.

The pro-European orientation of Ukraine's foreign policy and integration into the European Union poses new challenges for the country's energy system and national economy as a whole. From the study of practical experience of alternative energy development in Central European countries, it follows that ensuring a favorable political and legal environment for the development of renewable energy is key, and the development of solar and wind energy generation in Ukraine is crucial in terms of climate potential.

Post-war reconstruction is a very energy-intensive process and requires a significant increase in power generation, which is possible and sustainable through increased production of energy from renewable sources. Developing and implementing a state energy strategy based on a transparent and open energy market, attracting investments in the development of renewable energy and raising public awareness of the need for rational consumption and gradual abandonment of traditional energy sources will ensure stable and secure functioning of Ukraine's energy system. This, in turn, will boost the energy security of the European region, especially the Central European countries.

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