UDC 338.49:330.15:504.05
DOI: 10.56318/eem2025.01.008

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# Analysis of the European renewable energy market in the context of the decarbonisation trend

**Abstract.** This study aimed to identify the development trends of the renewable energy market in the European Union, with particular emphasis on its role in the decarbonisation of the energy sector. The study explores energy consumption patterns in the EU from 2000 to 2022 and analyses the contribution of renewable energy sources (RES) to the achievement of Sustainable Development Goals. A comparative analysis of the development of the renewable energy market and the energy systems of the EU and Ukraine is provided, taking into account Ukraine's trajectory towards European integration. Special attention is given to the imperative of the circular economy as a leading economic model. The impact of the circular economy on global economic development is identified, particularly in terms of reducing waste and dependency on energy imports. A statistical analysis of the EU's dependence on natural gas imports is conducted, along with an assessment of greenhouse gas emission reductions and the increasing share of RES in electricity generation. The findings indicate that the EU is actively addressing energy security challenges, notably through the expansion of wind and solar power while maintaining its global leadership in the energy transition. It was established that between 2005 and 2022, the share of RES in electricity generation within the European Union increased from 10.18% to 23.06%. Iceland and Norway emerged as leaders in this area due to their well-developed hydropower sectors. In 2023, the share of RES reached a historic high of 24.1%, contributing significantly to strengthening the EU's energy independence. The main drivers of this growth were the implementation of legal frameworks, notably the Fit for 55 package and the REPowerEU plan. The structure of energy consumption in the EU is also examined, with RES accounting for 18.4%, highlighting the importance of improving energy efficiency. Key achievements in the development of the renewable energy market in Ukraine are outlined, along with the current challenges and prospects, particularly in the context of integration into the European energy system through ENTSO-E. The analysis underscores the positive impact of RES on environmental sustainability and the competitiveness

**Article's History:**
Received: 12.02.2025
Revised: 01.05.2025
Accepted: 05.06.2025

**Suggested Citation:**
Kuznietsova, K., Omelchenko, A., & Chenusha, O. (2025). Analysis of the European renewable energy market in the context of the decarbonisation trend. *Economics, Entrepreneurship, Management*, 12(1), 8-19. doi: 10.56318/eem2025.01.008.

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of both the EU and Ukrainian economies while also drawing attention to the need to overcome geographical and socio-economic barriers in the implementation of regulatory mechanisms and legal initiatives

**Keywords:** renewable energy; development trends; European energy space; energy system; circular economy; carbon neutrality; ESG principles

## INTRODUCTION

The International Energy Agency suggests that European countries should aim to decarbonise their energy industries by 2035. This would help meet the goals of the Paris Agreement to limit global warming to 1.5°C. Research by the organisation Beyond Fossil Fuels indicates that the top 10 EU countries (which together make up over 60% of the EU's energy sector) have committed to phasing out fossil fuels by 2035 or earlier. Specifically, Austria, Denmark, Lithuania, and Luxembourg have announced plans to switch from coal and natural gas to RES. Belgium, France, Germany, Greece, Italy, and the Netherlands also intend to decarbonise their energy systems by 2035. The main renewable energy sources in a decarbonised European energy system are expected to be groundbased and rooftop solar power, as well as onshore and offshore wind power (Green Transformation of Ukraine, 2024).

The relevance of research into the use of renewable energy by countries worldwide and the decarbonisation of economies is clear not only from the actual trends in national economies and energy markets between 2000 and 2022 but also from the significant interest shown by economic researchers in these topics. L. Rimšaitė (2024) examines how the European energy market has developed and the difficulties in balancing the dynamics of a competitive market with regulatory goals (such as ensuring reliability, fairness, and sustainability). The research also looks at the potential for creating regulations that will encourage fair competition and achieve long-term policy aims in the energy sector. Energy security has historically been a crucial issue for EU countries, evolving alongside shifts in the geopolitical situation, economic pressures, and technological advancements. Ensuring a stable and varied supply of energy sources is fundamental to the socioeconomic stability of the region, especially given today's global challenges, namely instability in the energy market, geopolitical tensions, and climate change (Kosowski, 2024; Pang *et al*., 2024).

M. Song *et al.* (2022) developed a theoretical model to explain how the integration of the energy market is linked to the growth of RES. Using data from 20 EU countries between 2007 and 2019, they empirically tested the relationship between how integrated the energy market is and the development of RES. Their findings showed a significant positive impact of energy market integration on the growth of renewable energy. C. Veghes *et al.* (2024) assess the connections between the production, consumption, and share of RES. They also look at EU consumers' attitudes towards renewables and their willingness to see them as a reliable alternative to traditional energy sources, considering the economic, social, and environmental aspects of sustainable development in EU member states. Given the EU's increasing demands for a higher share of renewables in the energy, industrial, construction, and transport sectors, research is being conducted on the state of the renewable energy market in specific countries, such as Poland (Jaworski *et al*., 2023).

K. Constant *et al.* (2024) are researching how macroeconomic factors, particularly financial crises, affect the EU's renewable energy market. S. Soeiro & M. Ferreira Dias (2020) look at the social impact of introducing renewable energy. They point out that while there are environmental benefits, renewable energy projects do affect local communities. Therefore, national and local authorities need to make sure that citizens are involved in these projects to gain their support. J. Pedraza Morales (2024) highlights the significant progress the EU has made in its energy transition strategy, positioning itself as a global leader. However, they believe the EU needs to build a balanced energy system with a diverse mix of energy sources to ensure stability during crises. A comprehensive model for the development of global energy in the context of decarbonisation is being developed, which includes innovative areas such as small modular reactors (SMRs), large nuclear power plants, wind and solar energy, and the use of biofuels (Kharin *et al*., 2024).

This article aimed to analyse the European renewable energy market and its development trends in the context of the new global push for decarbonisation and Ukraine's move towards European integration. The main objectives of the research were to identify the key development trends in the EU's renewable energy market, compare the Ukrainian market with the EU market, and analyse how the renewable energy market is regulated in the EU and Ukraine in the context of the decarbonisation trend.

## MATERIALS AND METHODS

In this research, a range of statistical information sources (Eurostat, n.d.; Sustainable Development Solutions Network, n.d.; European Environment Agency, 2025) and analytical articles by leading economic scholars, international organisations, and government bodies were analysed. The focus was on the European renewable energy market within the context of the trend towards economic decarbonisation. Methods of scientific inquiry, generalisation and systematisation, statistical analysis, and the identification of cause-and-effect relationships were employed.

A detailed analysis was conducted on the changes in energy consumption figures in the EU between 2000 and 2022. Key trends demonstrating the EU's path towards decarbonisation were identified. An analysis of the EU's

reliance on natural gas imports from Russia was presented, using data from May 2021 to August 2024. The energy self-sufficiency of EU countries as of 2022 was determined. The achievements of the UN's Sustainable Development Goals by EU countries and Ukraine were compared for 2018 and 2024 based on data from J.D. Sachs *et al.* (2018) and J.D. Sachs *et al.* (2024).

The proportion of RES in the total electricity production in the EU was analysed for the period 2005-2022. Additionally, the share of RES in the EU's gross final energy consumption in 2022 was analysed by electricity generation type. The energy efficiency indicator used to monitor progress towards achieving the energy efficiency targets set out in Directive (EU) No. 2023/1791 (2023), was also examined.

Emphasis was placed on the introduction of the circular economy approach in the EU as a key direction for achieving Sustainable Development Goals, improving resource efficiency, and reducing dependence on imported primary energy sources. The main aspects of implementing a circular economy in the EU were identified. For comparison, the state of renewable energy market development in Ukraine and the implementation of circular economy principles in Ukraine were presented. Furthermore, an analysis was conducted on the directions of renewable energy market regulation in the EU and the main measures within these directions in the context of the decarbonisation trend. The direction of renewable energy market regulation in Ukraine and the prospects for development, considering current realities, were also determined.

## RESULTS

Since 2022, the EU has successfully addressed key energy security challenges by regaining control over its energy market and prices and by accelerating its progress towards the climate neutrality set out in its Green Deal (Sustainable Development Solutions Network, n.d.). Renewable energy plays a crucial role in this process. The main trends demonstrating this path towards decarbonisation are as follows:

1) A record increase in the share of renewables – in the first half of 2024, half of the electricity generated in the EU came from renewable sources. The dynamics of energy consumption indicators in the EU from 2000 to 2022 are presented in Table 1.

2) A significant reduction in natural gas consumption – between August 2022 and May 2024, demand for natural gas fell by 138 billion $m^3$.

**Table 1.** Dynamics of energy consumption indicators in the EU, 2000-2022

| Indicators | 2000 | 2005 | 2010 | 2018 | 2022 |
|---|---|---|---|---|---|
| Total energy supply, GWh, including: | 17,091,252 | 18,289,837 | 17,765,554 | 16,643,604 | 15,346,580 |
| – natural gas, GWh | 3,588,988 | 4,183,440 | 4,219,855 | 3,777,913 | 3,421,444 |
| – RES, GWh | 1,120,695 | 1,394,672 | 2,023,648 | 2,625,174 | 2,898,030 |
| Share of natural gas in total energy supply, % | 21.00 | 22.87 | 23.75 | 22.70 | 22.29 |
| Share of RES in total energy supply, % | 6.56 | 11.06 | 11.39 | 15.77 | 18.88 |

**Source:** compiled by the authors based on the Eurostat (n.d.)

The total energy supply decreased by 10.21% from 2000 to 2022. Over the same period, natural gas consumption fell by 4.77%, although its share in overall consumption has remained relatively stable since 2005, accounting for 22.29% in 2022. Energy consumption from RES increased 2.59 times between 2000 and 2022, and the share of RES rose from 6.56% in 2000 to 18.88% in 2022. In 2024, RES provided 50% of electricity generation in the EU, while primary energy consumption has been declining since 2022 (down by 4.1%). Nevertheless, EU countries need to step up their efforts in energy efficiency to achieve the target of reducing energy consumption by 11.7% by 2030 (European Commission, 2024).

3) reduction in dependence on Russian natural gas – the share of imports decreased from 45% in 2021 to 18% in June 2024. The import of natural gas from the Russian Federation to the EU from May 2021 to August 2024 is shown in Figure 1.

Overall, regarding natural gas, the main countries exporting natural gas to the EU in 2022 were Russia – 22.7%, Norway – 17.1%, USA – 16.5%, Algeria – 11%, and Qatar – 5.3%. However, the energy self-sufficiency of EU countries varies. This indicator is calculated as the ratio of (primary production + renewable and processed products) to (primary production + renewable and processed products + imports + stock changes). In 2022, the most energy-self-sufficient countries were Estonia (62.11%), Romania (57.02%), and Sweden (52.60%). The least energy-self-sufficient countries were Malta (1.57%), Luxembourg (8.16%), and Cyprus (9.09%) (Eurostat, n.d.).

4) The gas storage capacity in August 2024 reached 90%, surpassing the target deadline for achieving this goal.

5) Stabilisation of energy prices – prices remain lower than the peak levels seen in 2022.

6) A 32.5% reduction in greenhouse gas emissions from 1990 to 2022, while the EU economy grew by 167%.

7) Achieving global leadership – the initiation of an international agreement to triple renewable energy capacity and improve energy efficiency, approved in Dubai.

8) Development of renewable energy, particularly wind energy, which has surpassed natural gas in the EU, becoming the second-largest source of electricity after nuclear power (European Commission, 2024).

According to reports on sustainable development and countries' progress towards UN goals in this context, since the adoption of Directive (EU) No. 2019/1 (2018), EU countries and Ukraine have shown the following changes in comparison, as illustrated in Figure 2.

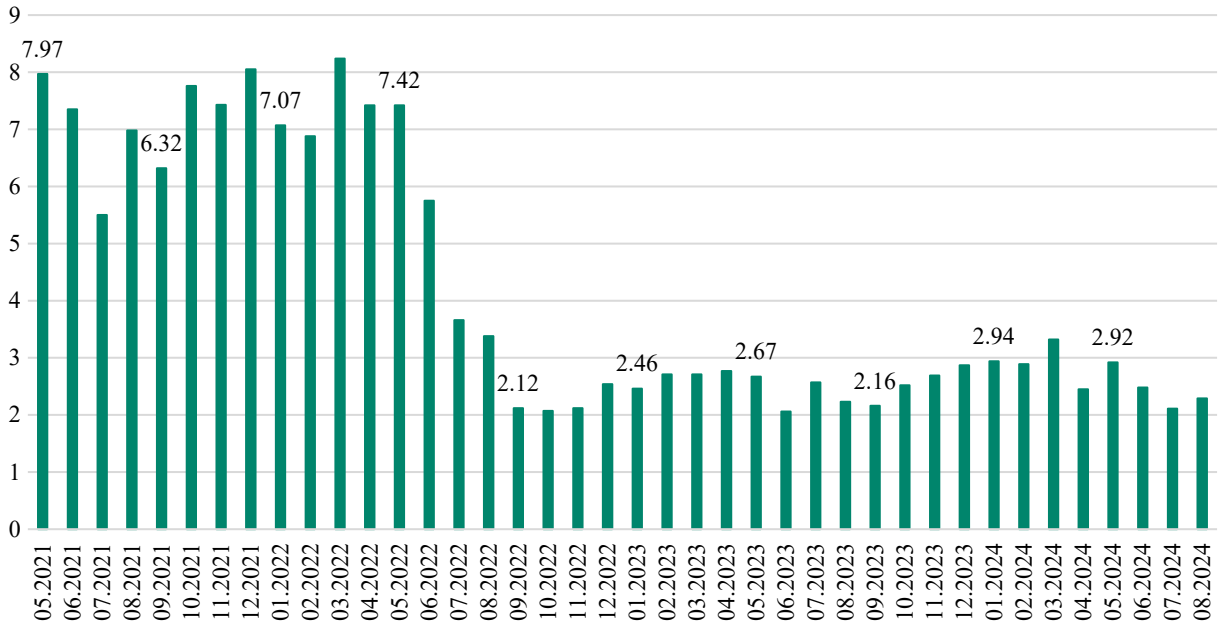


**Figure 1.** Monthly imports of natural gas from Russia to the EU from May 2021 to August 2024, in billions of $m^3$
**Notes:** values for natural gas imports from Russia to the EU in the figure are provided at 4-month intervals
**Source:** compiled by the authors based on the Eurostat (n.d.)

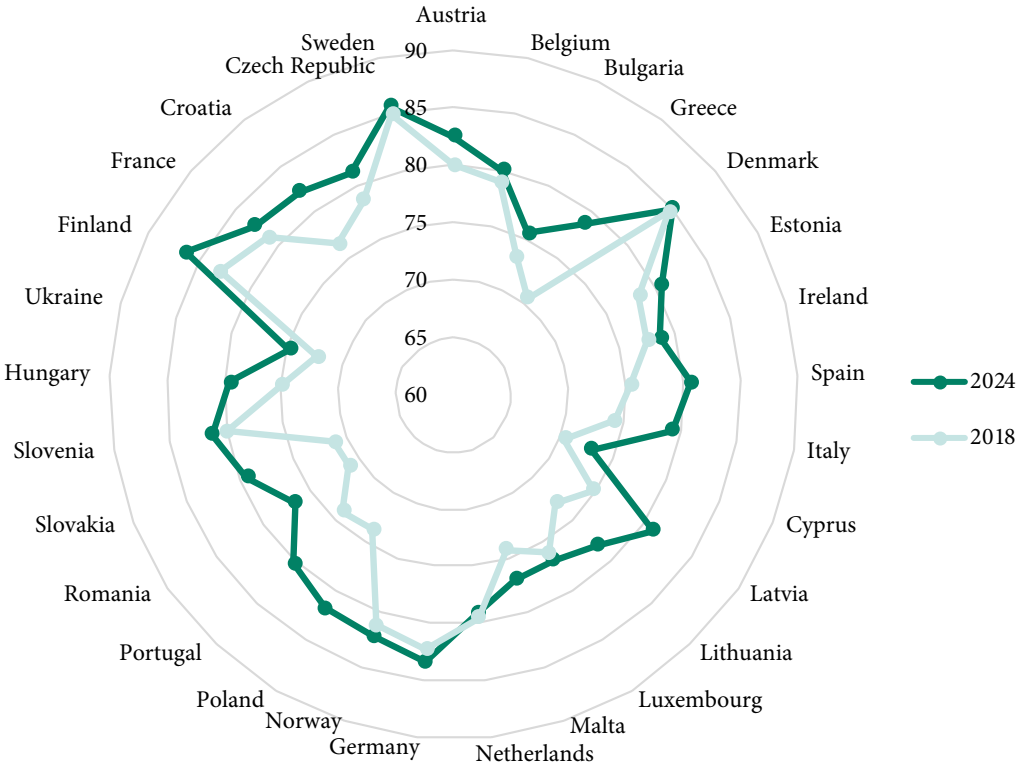


**Figure 2.** Achievement of Sustainable Development Goals by EU countries and Ukraine in 2018 and 2024
**Source:** compiled by the authors based on the J.D. Sachs *et al.* (2018), J.D. Sachs *et al.* (2024)

Among EU countries, Slovakia showed the greatest progress in achieving the 17 UN Sustainable Development Goals (an increase of 11.52% in the sustainable development index from 2018 to 2024), followed by Greece (11.47%), Latvia (8.43%), Portugal (8.38%), and Romania (8.03%). A decrease in the index was observed in only one EU country – the Netherlands (0.38%). Ukraine also improved its score in this ranking by 3.46%. The development of RES in the EU is characterised by the overall share of renewables in electricity production (Fig. 3).

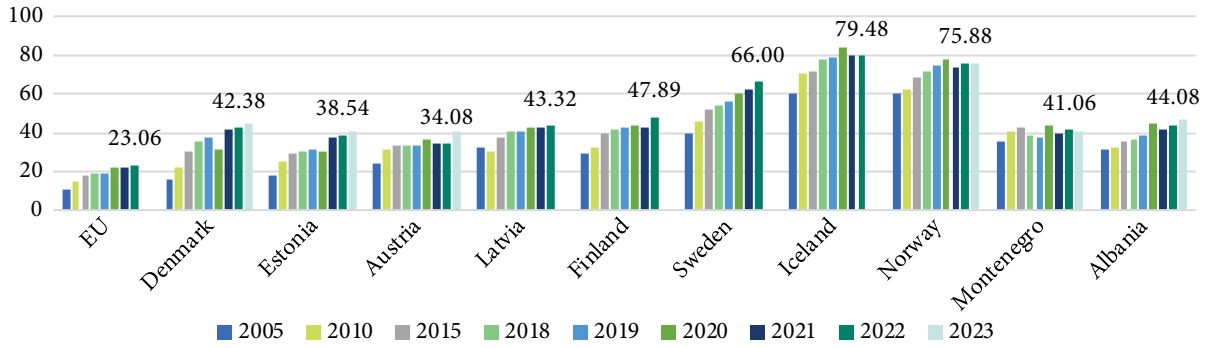


**Figure 3.** Share of renewable energy in total electricity production in the EU, 2005-2023
**Source:** compiled by the authors based on the Eurostat (n.d.)

Overall, across all EU countries, this indicator more than doubled (from 10.18% in 2005 to 23.06% in 2022). The leading countries in the EU for renewable energy development were Iceland (79.48% in 2022) and Norway (75.88% in 2022). Both countries had significant advantages at the start of the period studied (in 2005, the figures were 60.27% and 60.07%, respectively). Iceland and Norway are among the world's largest producers of hydroelectric power, making their energy sectors less reliant on fossil fuels. EU countries that have made significant progress in developing renewables include Denmark (from a share of 15.96% in 2005 to 44.92% in 2023) and Estonia (from 17.48% in 2005 to 40.95% in 2023). The EU countries with the lowest share of renewable energy in electricity production in 2022 were Ireland (13.07%), Belgium (13.76%), and the Netherlands (13.97%) (Eurostat, n.d.).

In 2023, the share of renewable energy in the EU increased by 1% compared to 2022, reaching 24.1%, which is a record high. This was helped by the adoption of several important legal measures aimed at transforming the EU's energy system, notably the Fit for 55 EU policy package and the RepowerEU plan, which was prompted by Russia's invasion of Ukraine. The target is to reach 42.5% by 2030 (European circular economy…, 2024). The RES are commonly divided into several types (solar, wind, hydro, geothermal, ambient heat, and biomass energy). For practical analysis and research purposes, renewables are often categorised into two groups: non-conventional renewables group 1 (NCR-1) – including solar, hydro, geothermal, wind, etc.; and non-conventional renewables group 2 (NCR-2), which includes energy derived from biomass, its processed products, household waste, etc. The share of renewable energy in the EU's gross final energy consumption in 2022 was 18.4%, ranking third. Oil and petroleum products held the largest share at 34.9%, followed by natural gas at 12.7%, and nuclear energy at 11.5%. The breakdown of gross final energy consumption among renewable sources in 2022 was: wind – 14.5%, hydro – 9.5%, solar – 7.7%, biofuels and renewable waste – 57.9%, and other – 10.4% (Eurostat, n.d.).

Another important indicator of the EU's renewable energy market development is energy efficiency, which is used to monitor progress towards energy-saving targets. Energy conservation can improve the security of the energy supply by reducing reliance on fuel imports. Increasing energy efficiency also boosts the competitiveness of European industry and services and helps to lower greenhouse gas emissions from burning fuel. Notably, Directive (EU) No. 2023/1791 (2023) was adopted in 2023. The main provisions of this updated Directive include a reduction of 11.7% in final energy consumption across the EU by 2030 (compared to the 2020 baseline scenario) and an increase in annual energy savings, averaging 1.49% annual savings for the period 2024-2030.

Annual primary energy consumption in the EU in 2022 was 1,257.08 Mtoe, compared to 1,235.72 Mtoe in 2020 and 1,353.36 Mtoe in 2015. Over these seven years, annual primary energy consumption in the EU countries collectively decreased by 7.11% or 96.28 Mtoe. The largest annual energy consumers among EU countries are the major economies: Germany (20.69%), France (16.30%), Italy (11.08%), Spain (9.01%), and Poland (7.83%). Since 2015, these countries have generally seen an annual reduction in primary energy consumption, except for Poland. Specifically, Germany experienced a decrease of 12.11%, France 16.14%, Italy 6.62%, and Spain 4.17%. In Poland, however, there was an increase of 9.36% over the seven years (Eurostat, n.d.).

The development of renewable energy is closely linked to the introduction of the circular economy approach (Gavkalova *et al.*, 2024). In the EU in 2024, the circular economy is a key focus for achieving sustainable development goals, improving resource efficiency, and reducing dependence on imported primary energy sources. The circular economy is a new economic and environmentally conscious development concept aimed at harmonising economic growth with ecological sustainability. The main aspects of implementing a circular economy in the EU are as follows (European circular economy…, 2024; Eionet Portal, 2024):

1) the introduction of an implementation strategy at various levels and across different sectors, particularly the European Green Deal, which directly relates to the development of the renewable energy market and the Circular Economy Action Plan as a general strategic direction. These documents focus on extending the lifespan of materials, minimising waste, and transitioning to business

models (Bochko *et al.*, 2024) that are service-oriented, eco-designed, and resourcereused, especially in critically important industries such as battery and electronics manufacturing;

2) rapid progress and interest in implementation among EU member states, with governments introducing programmes aimed at increasing recycling and material reuse rates, as well as updating legislation in waste management (Circular Economy Package). For example, there is a noticeable decoupling of resource consumption from economic growth, indicating a gradual shift towards a more circular economic model;

3) global leadership and cooperation, with the EU collaborating with international partners through initiatives such as the World Circular Economy Forum (WCEF), where particular attention is given to global supply chains and access to critical materials through the adoption of circular economy models. EU countries are at the forefront of implementing circular principles, the relevance of which continues to grow year by year.

The circular economy in Ukraine is gradually developing as an important part of its sustainable development strategy and its path towards European integration. The main directions for developing a strategy to implement the circular economy include introducing models for reusing resources, reducing waste, and increasing the use of renewable materials. In the current situation of war (2024) and its starting position regarding waste management and renewable energy development, Ukraine lags behind EU countries in this area. One of the key challenges is adapting businesses to the principles of circularity, especially during wartime, which affects economic stability and access to investment. Efforts are focused on analysing existing business models, considering the EU's experience, and developing legislative initiatives to support the transition to a new economic model.

The EU is supporting the implementation of the circular economy model in Ukraine by funding programmes to aid the transition, such as the European Structural and Investment Funds, Horizon 2020, and LIFE. Additionally, the European Investment Bank provides financing and advice for projects supporting the circular economy through the European Fund for Strategic Investments and the EU InnovFin programme. Notably, the EU-funded project "Circular Economy – Promoting Sustainable Production and Consumption Patterns in Ukraine" supports Ukraine in developing a Circular Economy Strategy in line with the Sustainable Development Goals and the European Green Deal to ensure the balanced use of resources. This project includes an analysis of economic, environmental, and social aspects, as well as the development of strategies for innovative technologies and business models (Ministry of Economy of Ukraine, 2024). Regulation of the renewable energy market in the EU aims to create favourable conditions for the integration of renewables into the European energy system, ensure the region's energy security, achieve climate targets, and decarbonise economies. The main directions in market regulation are presented in Table 2.

**Table 2.** Directions of renewable energy market regulation in the EU

| No. | Directions | Measures |
|---|---|---|
| 1. | Electricity market reform | In June 2024, amendments were made to EU Regulations (Regulation (EU) No. 2019/942, 2019; Regulation (EU) No. 2019/943, 2019) to improve the electricity market structure. The focus was on supporting the integration of RES, particularly solar and wind energy while ensuring stable prices for consumers even in crisis conditions. The reform includes the development of short-term markets that enhance system flexibility and adaptation to fluctuating renewable energy generation |
| 2. | Stimulating Investment in renewable energy | The EU promotes renewable energy development through financial mechanisms, including a green energy auction system. For example, EU member states are required to develop and implement national plans aimed at increasing the share of renewable energy to 42.5% of energy consumption by 2030 |
| 3. | Digitalisation and integration of the energy system | A priority for renewable energy market development is the creation of digital solutions for managing the electricity market, which will provide system flexibility, integrate distributed generation, and enable consumer participation in the market. The development of smart grids will allow for the efficient integration of intermittent energy sources (such as solar and wind), while investments in energy storage (batteries, hydrogen) will help stabilise the system |
| 4. | Supporting the energy transition | To reduce dependency on primary energy resources, the EU encourages the shift to renewable energy through legislative changes and the creation of new market mechanisms, including increasing market liquidity in real time for trading energy surpluses or shortages, which is crucial for variable sources such as solar and wind energy |
| 5. | Emission trading mechanisms | The European Union Emissions Trading System (EU ETS) provides an economic incentive for transitioning to renewable energy by limiting carbon dioxide emissions |

**Source:** compiled by the authors based on the EU provides legal framework for regulation and decarbonisation of the gas sector (2024); Directive (EU) No. 2024/1788 (2024)

The development of RES in Ukraine is a key aspect of the state's energy strategy, particularly in the context of integration into European energy markets and the transition to environmentally friendly energy sources. The development trends of the renewable energy market in Ukraine are characterised by the Order of the Cabinet of Ministers of Ukraine No. 761-r (2024):

- rapid growth in RES capacity. With significant volumes of solar and wind power plants commissioned between 2012 and 2022, they together account for more than 90% of RES capacity in Ukraine. As of 2024, the installed RES capacity in Ukraine stands at approximately 10.8 GW. However, due to the war with Russia, around 71% of wind power capacity is located in temporarily occupied territories (in the Kherson and Zaporizhzhia regions) and cannot be utilised. Additionally, about 14% of solar power plants are under occupation;
- increase in the share of RES in Ukraine's energy balance. In 2023, the share of electricity generated from RES accounted for approximately 14% of total generation. In 2010, this figure was very low compared to its current value, standing at around 1-2% of total generation. The majority of the generation was provided by large hydroelectric power stations (HPS), while solar, wind, and biomass energy played a minimal role;
- increase in legislative support for the sector. Since 2009, Ukraine has implemented the "green tariff", which provided fixed rates for RES producers and became a significant incentive for attracting investments into the sector. The concept of "green auctions" emerged in 2020 when amendments were made to renewable energy legislation. For solar stations commissioned from 2020 onwards with capacities over 1 MW, in addition to the "green" tariff, there was the opportunity to receive fair prices for the electricity generated. The auction system introduced aims to create a competitive environment, thereby reducing the cost of electricity generation;
- growth in investment activity. Notable foreign investments have been attracted, including significant contributions from the EBRD, IFC, NEFCO, and other financial institutions, which invested over 12 billion USD in the RES sector between 2019 and 2021;
- active international support. Ukraine receives substantial support from international partners for the development of RES, including technical assistance, grants, and project financing;
- obstacles to the development of RES. These include not only the ongoing military conflict on Ukrainian territory, which significantly complicates the functioning of the energy sector but also other challenges. Specifically, there are issues such as the financial debt of the state to RES producers under the "green tariff" and the need to modernise infrastructure for the integration of new RES capacities.

The prospects for the development of the renewable energy market are being shaped by the strong global interest in this as a trend towards economic decarbonisation. Despite the existing challenges, the National Renewable Energy Action Plan for the period up to 2030 in Ukraine, developed in 2024 (Order of the Cabinet of Ministers of Ukraine No. 761-r, 2024), is a strategic document that outlines the development of the sector between 2025 and 2030. According to this plan, Ukraine aims to achieve a 25% share of RES in total electricity production by 2030. Furthermore, it intends to ensure the active development of infrastructure for the generation, storage, and transmission of energy from RES and to integrate into the European electricity market through participation in ENTSO-E. Following the emergency integration in 2022, the next steps in reforming Ukraine's energy market should include decisions on creating conditions for the merging of spot markets, organising coordinated long-term auctions for the allocation of cross-border transmission capacity, joining platforms for the distribution of balancing energy and ancillary services, joint planning of energy system risks with European partners, and so on. The regulation of the renewable energy market in Ukraine is based on legislative and regulatory mechanisms aimed at developing the sector, attracting investment, and integrating into the European energy system. The institutional framework for the renewable energy market in Ukraine is focused on stimulating the growth of this sector (Table 3).

For the further development of the RES sector in Ukraine, systemic reforms are needed to support investors, create transparent conditions for competition, and encourage innovation. The main challenges in the current environment are high risks for investors due to the unstable economic situation and the war, the need to improve energy infrastructure, and to ensure integration with the European market. The prospects for the development of the renewable energy market in the EU remain strong due to ambitious climate targets, substantial financial support, and innovative technologies.

**Table 3.** Institutional support for the renewable energy market in Ukraine

| No. | Directions | Measures |
|---|---|---|
| 1. | Legislative framework | The Law of Ukraine No. 555-IV (2003) is the foundational document that outlines the legal framework for the functioning of the renewable energy market. The "green tariff", introduced by the Law of Ukraine No. 1164-VI (2009), is a stimulation mechanism that guarantees a fixed payment for electricity generated from RES. Since 2020, it has gradually been replaced by an auction system to determine competitive electricity prices (Law of Ukraine No. 2019-VIII, 2017). However, in 2024, the focus shifts to implementing incentive tariffs for the development of decentralised solutions (solar energy on rooftops, and small wind farms) and energy storage systems. Laws supporting energy storage systems and microgeneration, which introduce modern technologies into the sector, are part of Ukraine's overall strategy for modernising its energy system and achieving climate neutrality by 2050. These laws contribute to the integration of RES, reduction of $CO_2$ emissions, and attraction of investment in advanced technologies |

Table 3. Continued

| No. | Directions | Measures |
|---|---|---|
| 2. | Role of regulators | The National Commission for State Regulation of Energy and Public Utilities (NCREPU) is responsible for setting tariffs and monitoring the activities of market participants. The State Agency for Energy Efficiency and Energy Saving of Ukraine formulates policies in the areas of energy efficiency and renewable energy. Additionally, these agencies regulate market activities and oversee the implementation of decarbonisation strategies. Civil society organisations, such as the Ukrainian Wind Energy Association, contribute to the development of innovative solutions in RES and foster collaboration between investors, local authorities, and communities |
| 3. | Auction system | Since 2020, an auction system has been in operation, gradually replacing the "green tariff" for energy generated from RES. This ensures competition among producers and reduces the cost of produced energy |
| 4. | Investment prospects | Despite the ongoing war, investments in RES in Ukraine remain economically viable due to the long-term competitiveness of wind and solar energy. The sector is supported by international partners, including the EBRD, which finances projects aimed at modernising energy infrastructure |
| 5. | Integration into European markets | Ukraine is adapting its legislation to European standards, including directives on RES development and economic decarbonisation. After joining the ENTSO-E energy system, the country gained the ability to export and import energy within the unified European market |

**Source:** compiled by the authors based on the European business association (2024)

Decarbonisation in the EU is a key priority in the fight against climate change, part of the goal to achieve climate neutrality by 2050, as enshrined in the European Green Deal. To achieve this, the EU is implementing a wide range of measures across different sectors of the economy. Specifically, this includes: reducing greenhouse gas emissions – by 2030, the EU aims to cut emissions by at least 55% compared to 1990 levels, a legally binding target, with the goal of achieving net-zero $CO_2$ emissions by 2050; a complete transition to RES, phasing out coal and significantly reducing the use of natural gas, and promoting the development of a hydrogen economy as an alternative to fossil fuels; the introduction of the emissions trading system (EU ETS) – one of the largest systems in the world, covering over 40% of greenhouse gas emissions in the EU; the implementation of $CO_2$ emissions reduction requirements for cars, including a ban on the sale of new internal combustion engine vehicles from 2035, investment in the development of infrastructure for electric vehicles and railway transport; the creation of programmes for forest and soil conservation as natural carbon sinks, and the transition to sustainable farming, which includes reducing the use of chemical fertilisers and pesticides; the intensification of investments and funding – the Just Transition Fund supports regions dependent on fossil fuels, while the Climate Target Plan 2030 funds the transition to RES and energy efficiency; the carbon border adjustment mechanism (CBAM), which requires importers to pay for carbon emissions generated during the production of goods outside the EU, encourages other countries to also implement decarbonisation measures (Sustainable Development Solutions Network, n.d.). These ambitious goals create risks and obstacles in the implementation of measures. The high cost of transforming the region's economy, the need to coordinate measures between member states, and the search for socially just solutions to support populations potentially negatively affected by the decarbonisation trend (such as job losses in the fossil fuel sectors) must be considered in further implementation.

## DISCUSSION

Academic studies analysing RES in Europe and globally demonstrate the relevance and multifaceted nature of this topic. The findings of several researchers have been considered and presented separately for a clearer understanding of their approaches and perspectives in studying this area. Decarbonisation, as a new imperative for energy development and a global trend in economic growth, is highlighted in the research of many academics. In the research of E. Papadis & G. Tsatsaronis (2020), the challenges on the path to decarbonising the energy sector are central to scholarly inquiry and are defined in terms of environmental sustainability, security of energy supply, economic stability, and social aspects. P. Cheekatamarla *et al.* (2024) examine various pathways to achieving decarbonisation in the energy sector, including several scenarios that involve a transition to low-carbon electricity generation sources (RES and nuclear energy), as well as reducing carbon emissions from fuel consumption through electrification and the use of alternative fuels. The challenges and opportunities associated with each scenario are discussed, including technological advancements, policy frameworks, and public acceptance. Energy security is also impacted by military conflicts (Semenenko *et al.*, 2024). Such diverse approaches to studying the problem provide a comprehensive understanding of their potential application in the practice of other countries, particularly Ukraine, in reforming the energy sector and implementing European standards.

H. Kete (2023) notes in their research the increasing importance of RES in EU policy against a backdrop of declining fossil fuel and nuclear energy use and a rising share of natural gas, which contributed to higher energy prices following the start of the Russian-Ukrainian war in 2022. The European Green Deal and the REPowerEU Plan are key aspects of the European strategy for developing RES, which is relevant in the context of transitioning to climate neutrality, promoting global growth in clean energy investment, and reducing environmental problems. These

conclusions align with the findings of this study and confirm the ongoing process of examining the role of renewable energy in EU policy.

S. Wolf *et al.* (2021) delve deeper into the implementation of the European Green Deal, presenting goals for modernising the European building stock, updating the European innovation system, and additional measures in education and healthcare, thereby shaping an investment profile to achieve these objectives. Their proposals offer a new path for the region's development towards carbon neutrality and European unity, which is also relevant for Ukraine to adopt and implement such experiences.

P. Nowak & M. Dorota (2024) assessed the development of RES in Poland and the fulfilment of its commitments regarding the level of renewable energy consumption across different economic sectors. The results of analysing several countries provided a basis for grouping them according to their level of RES development, revealing regional differences and the achievement of consumption targets. The analysis methods and approaches to grouping by regional differences could be used in future research on Ukraine's energy sector. At the same time, A. Makurin *et al.* (2024), despite the state of war, are also conducting research on regulating decarbonisation processes at both national and local levels, which will contribute to economic stability, particularly during wartime. Their scientific contributions will provide an opportunity to accelerate the transition to carbon neutrality and convergence with European standards after the war ends.

M. Simionescu *et al.* (2024) assessed the impact of a country's energy poverty and the level of renewable energy consumption on carbon emissions in 10 Central and Eastern European countries (EU member states) between 2005 and 2022. The study's findings indicated that the promotion of renewable energy in 2009 through relevant regulations helped to lower $CO_2$ emissions in each of these countries compared to non-EU countries in the region (including Ukraine). Energy poverty in a country increases $CO_2$ emissions, while renewable energy consumption reduces them. This demonstrates a direct link between the need to implement renewable energy in Ukraine and its progress towards carbon neutrality, as well as the value of learning from the experiences of other nations to accelerate these transformations.

Alongside decarbonisation, the trend of the circular economy is inextricably linked, with both sharing the common goal of tackling carbon emissions. S.K. Ghosh & S.K. Ghosh (2023) point out that the circular economy acts as a catalyst for decarbonisation and helps to reduce the extraction of natural resources. Environmental concerns and decarbonisation are at the forefront of the political agenda in many countries. In particular, climate change and the increasing negative impact of this issue on humanity are prompting countries to take new measures and examine environmental performance. In this context, K.S. Mohammed *et al.* (2024) investigated environmental governance indicators, which play an important role at both country and company levels, and the practice of their implementation is being actively pursued in Ukraine, even despite the state of war.

A significant contribution to the research on economic decarbonisation, its impact on carbon emissions, and the role of renewable energy has been made by the group of scientists Y.A. Twumasi *et al.* (2024), who conducted a comparative analysis of some decarbonisation strategies adopted by the USA and the EU to reduce greenhouse gas emissions. The modelling results showed a decrease in average carbon emissions in the USA by 2030 and an increase in emissions in EU countries. The application of significantly different economic decarbonisation strategies by these two regions (the USA has historically relied on coal, oil, natural gas, nuclear energy, and renewables; the EU is showing decarbonisation strategies focused on electrification and carbon-neutral energy, as well as energy efficiency) demonstrates different modelling outcomes. While errors and the influence of various factors on the modelling results are possible in such a complex process, the conclusion about the need to address climate change and mitigate the consequences of rising emissions worldwide remains relevant.

## CONCLUSIONS

The European renewable energy market plays a crucial role in achieving climate neutrality targets by 2050 and has a positive impact on the development of national economies in the region. Through the implementation of key renewable energy sources (solar, wind, biomass), greenhouse gas emissions are being reduced, which is a primary priority of the EU's decarbonisation policy. The active involvement of private and public investment in the development of renewables, together with European initiatives, is driving large-scale funding for infrastructure, energy storage technologies, and "green" hydrogen. The integration of smart grids and energy storage systems allows for the balancing of energy production and consumption, increasing the reliability of the system and the efficiency of renewables. EU legislation provides effective regulatory support and ensures favourable conditions for the expansion of the renewable energy market, regulating its integration into various sectors (transport, construction, industry).

Despite the significant advantages and effectiveness of the reforms, there is a geographical unevenness in development, meaning that the renewable energy market in Europe shows considerable differences between countries. Regions with developed infrastructure and favourable climate conditions (for example, Northern Europe) are growing faster than regions with less funding or geographical limitations, which creates challenges for aligning implementation policies. Future research should focus on finding solutions to such challenges in the sector's development, such as: integrating intermittent energy sources (solar and wind generation) into the energy system with an economic justification of potential risks, developing ways to optimise and reduce the high cost of modernising energy systems, and exploring proposals to overcome the socio-economic consequences

of the widespread adoption of renewables for regions dependent on fossil fuels, and so on. Overall, the prospects for the development of the renewable energy market are optimistic, and it is expected that renewables will become the main source of energy in the EU by 2050, thanks to a comprehensive approach to decarbonisation and the promotion of innovation.

## ACKNOWLEDGEMENTS

This research was conducted as part of the initiative research project "Strategic Management of Ukraine's Economic Recovery" (State Registration No. 0123U101596), carried out at the Department of Enterprises' Management, Faculty of Management and Marketing, National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute".

## FUNDING

None.

## CONFLICT OF INTEREST

None.

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## Аналіз європейського ринку відновлюваних джерел енергії в контексті тренду декарбонізації

**Анотація.** Метою статті був аналіз тенденцій розвитку ринку відновлюваних джерел енергії (ВДЕ) в ЄС з акцентом уваги на їх ролі у декарбонізації енергетичного сектору. Досліджено динаміку енергоспоживання в ЄС у 2000-2022 рр., проаналізовано роль ВДЕ у досягненні цілей сталого розвитку, проведено порівняння розвитку ринку ВДЕ та енергетичної системи ЄС та України в контексті її вектору євроінтеграції. Особливу увагу приділено імперативу циркулярної економіки як провідної моделі економіки. Визначено вплив циркулярної економіки на розвиток світового господарства, що полягає у зменшенні обсягів відходів та залежності від імпорту енергоносіїв. Проведено статистичний аналіз залежності ЄС від імпорту природного газу, визначено скорочення викидів парникових газів та зростання частки ВДЕ у виробництві електроенергії. Встановлено, що ЄС активно долає виклики енергетичної безпеки, зокрема через розвиток вітроенергетики та сонячних станцій, та зберігає глобальне лідерство в енергетичній трансформації регіону. Встановлено, що за період 2005-2022 рр. частка ВДЕ у виробництві електроенергії в ЄС зросла з 10,18 % до 23,06 %. Лідерами в цьому стали Ісландія та Норвегія завдяки розвинутій гідроенергетиці. У 2023 р. частка ВДЕ досягла історичного максимуму – 24,1 %, що сприяло зміцненню енергетичної незалежності ЄС. Основними факторами зростання стала імплементація правових ініціатив, зокрема Fit-for-55 та RepowerEU. Розглянуто структуру споживання енергії в ЄС, де на ВДЕ припадає 18,4 %, і підкреслюється важливість підвищення енергоефективності. Наведено ключові досягнення у розвитку ринку ВДЕ в Україні, виклики та перспективи в сучасних реаліях, серед яких інтеграція в європейську енергосистему через ENTSO-E. Окреслено позитивний вплив ВДЕ на екологічну стійкість і конкурентоспроможність економік ЄС та України, водночас звертаючи увагу на необхідність усунення географічних і соціально-економічних бар'єрів при імплементації регуляторних механізмів та правових ініціатив

**Ключові слова:** відновлювальна енергетика; тенденції розвитку; європейський енергетичний простір; енергетична система; циркулярна економіка; вуглецева нейтральність; ESG-принципи