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Article

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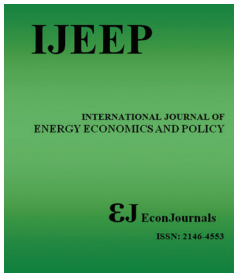

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2023, 13(2), 301-308.

Comparative Analysis of Innovative Development Strategies of Fuel and Energy Complex of Ukraine and the EU Countries: International Experience

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Received: 28 November 2022 **Accepted:** 25 February 2023 **DOI:** https://doi.org/10.32479/ijeep.14035

ABSTRACT

The European Union is pursuing an ambitious energy policy to reduce the emission of pollutants into the environment and achieve complete decarbonization by 2050. According to the approved Green Deal, each European state had to introduce its own energy strategy based on its own economic, social, climatic, and climatic conditions. In the process of European integration, Ukraine has developed its own strategies that meet the principles of European government policy. The analysis of the experience of implementation of energy strategies of different member states of the European Union will have a positive impact on the process of implementation of the new energy policy in Ukraine. According to this, a comparative analysis of strategies and the state of the fuel and energy complex of France, Austria, Poland, which have common features with the energy system of Ukraine. As a result of the study, it was found that the process of decarbonization should be gradual. Abrupt changes can lead to negative consequences in economic and social aspects. The information obtained can be useful for energy reforms in Ukraine.

Keywords: European Union, Ukraine, Fuel and Energy Complex, Energy Strategy, European Green Agreement
JEL Classifications: Q28, Q38, Q48, Q58

1. INTRODUCTION

The European Union (EU) is a world leader in combating climate change. European energy policy is aimed at the rational use of the fuel and energy complex (FEC), reducing resource dependence, reducing harmful emissions into the environment by expanding the use of efficient, energy-saving, and environmentally friendly technologies in the sectors of energy, transport, agriculture, construction, Over the past decades, the European Commission has approved a number of energy strategies based on the following goals: reducing greenhouse gas emissions, improving the environment, increasing the role of renewable energy sources in the fuel and energy complex, and improving the quality of life of EU citizens. This article examines the energy strategies of selected European countries under the Green Deal presented in 2019, the first part of the study. The European Green Deal is a set

of policy initiatives aimed at achieving a climate-neutral European continent by 2030%. The intermediate stage of the strategy by 2030 is to reduce greenhouse gas emissions by at least 55%, transport by 90% compared to 1990 levels, to produce 10 million tons of hydrogen, to renovate 35 million energy-intensive buildings (Tagliapietra et al., 2019).

Changes in the energy sector will primarily affect traditional energy sources. In achieving climate neutrality, European policy forces countries to abandon the generation of electricity from coal, gas, and nuclear power plants. Renewable energy sources must become the main source of energy production. In the metallurgical sector, the use of carbon in converters and blast furnaces in steelmaking must be phased out. In the transport sector, internal combustion engines are to be abandoned and replaced by electric motors, and hydrogen fuel is to be used. In the agricultural industry, it is planned to reduce the use of pesticides and antibiotics to grow organic food. By 2050 the recycling of waste should reach 100% (European Green Deal, 2022).

The implementation of this strategy for each EU member state depends on economic, social, territorial, climatic, and geographical features. The study of the experience of greening the economy of European states is of great importance in the process of European integration of Ukraine.

In recent years, the Ukrainian government has implemented its own energy strategies, consistent with the principles of EU policy. Since Ukraine has a powerful fuel and energy complex, it is necessary to carry out a large-scale reorganization of the energy, transport, agrarian, construction, and production spheres. Ukraine is strategically important because it is one of the most powerful transit countries for natural gas and oil and has substantial reserves of minerals, and the Ukrainian energy system is capable of exporting electricity to other countries. Covering this issue is the second part of the study. The purpose of the article is a comparative analysis of the strategies of innovative development of the fuel and energy complex of European countries and Ukraine in the world of the Green Deal. This will provide possible tasks to be solved, on the way of development of the Ukrainian energy sector, achieving decarbonization and independence from energy imports.

2. LITERATURE REVIEW

The EU's energy reforms are the subject of many contemporary publications. Claeys et al. (2019) provide a detailed description of the specifics of European countries' transition to the Green Economy. Sikora (2020) analyzes the possible consequences of the Green Deal in the legal and financial aspects. It is noted that the success of this reform largely depends on stable funding and citizens in the process. Rivas et al. (2021) consider the possibilities of increasing the production of renewable energy and have developed measures to reduce the high level of emissions in the transport sector. Identified the most rational solutions for local authorities in following the European Green Deal.

Furfari and Mund (2021) discuss the conditions under which the Green Deal will be successful. The authors question this strategy because radical modification of the energy system involves fundamental changes in the transportation sector, which is 94% dependent on petroleum products. The paper's results indicate that achieving carbon neutrality in the expected time frame could be unsuccessful and economically disadvantageous.

A study by Musiał et al. (2021) estimated the rate at which the goal of increasing the share of alternative energy sources in total gross energy consumption was achieved. Denmark, Ireland, and the United Kingdom achieved the best results. In the case of the listed countries, there was the greatest reduction of greenhouse gas emissions and optimized energy consumption. Germany, France, and Italy are leaders in the production of energy from alternative sources. The highest use of biofuels is observed in Lithuania, Latvia, Estonia, and Hungary. Electricity generation from hydroelectric power plants reaches the highest rates in Sweden, Austria, Romania, and Croatia. Wind power is widespread in Germany, Great Britain, Ireland, and Denmark. The author notes that those countries that joined the EU after 2004 face the greatest difficulties in implementing a green economy.

Haines and Scheelbeek (2020) see the Green Deal as improving the environment and reducing harmful emissions and will improve the health of European citizens. Ziabina and Pimonenko (2020) conducted a bibliometric analysis of publications to identify public awareness of future radical economic and energy changes.

Krykhtina et al. (2021) studied the process of Ukraine's accession to the European Green Deal and identified priority areas of this cooperation. They include the development and improvement of the efficiency of the economy, regenerative and hydrogen energy, agriculture, transformation of the coal industry, the introduction of a greenhouse gas emission tax system for enterprises, scientific cooperation, etc. Proposals were also provided to involve citizens in the implementation of the goals of the new energy strategy. Shevchenko et al. (2021) studied the specifics of Ukrainian-European cooperation and the transition of Ukraine to a climate-neutral economy. The researchers emphasize the country's readiness to implement the provisions of sustainable development according to the European Green Deal.

3. METHODOLOGY

The analysis and comparison of the energy strategies of the EU member states and Ukraine, which has recently received the status of a candidate for accession, is the leading research method. The work done is divided into two stages.

At the first stage, the energy strategies of France, Austria, and Poland were analyzed after briefly describing the main provisions of the European Green Deal. These countries were chosen based on similarities with certain features of the Ukrainian FEC. France, Poland and Ukraine have similarities in their mutual dependence on traditional energy sources (nuclear and coal). Among renewable energy sources, hydroelectric power plants are most common in Ukraine, as well as in Austria. The historical prerequisites of the formation of fuel and energy complex of the listed countries were considered. These countries differ in

economic power, territory, and reserves of natural resources. The strategy of Austria, which banned the use of nuclear power, and France, the main part of the production of electrical energy of which comes from nuclear power plants, are contrasted. The countries also have different views on the implementation of the hydrogen strategy. They have in common that despite the high share of renewable energy sources, the level of emissions in the countries remains high. In the case of Poland and France, there is pressure from the European government on the use of coal and nuclear industry, the abandonment of which can lead to negative economic and social consequences. The analysis of the first part of the study indicates that, despite the economic potential of the country, the abandonment of traditional energy is a serious challenge.

The second stage considers the energy strategies of Ukraine: low-carbon development, energy security, National Energy Efficiency Action Plan for the period up to 2030 (2021), the strategy of the Operator of the gas transportation system of Ukraine. Aspects of Ukraine's integration into the European energy system ENTSO-E are highlighted. As a candidate for accession to the EU, the Ukrainian government has approved a new energy policy, which must comply with the provisions of the European Commission. Like France, Ukraine has a strong nuclear industry. A high share of energy generation comes from the coal industry, which is similar to Poland's situation. Among renewable energy sources, hydropower is widespread in Ukraine and is an important part of the Austrian fuel and energy complex. The experience of European countries will help in the process of reforming the fuel and energy complex of Ukraine and achieving the set energy goals.

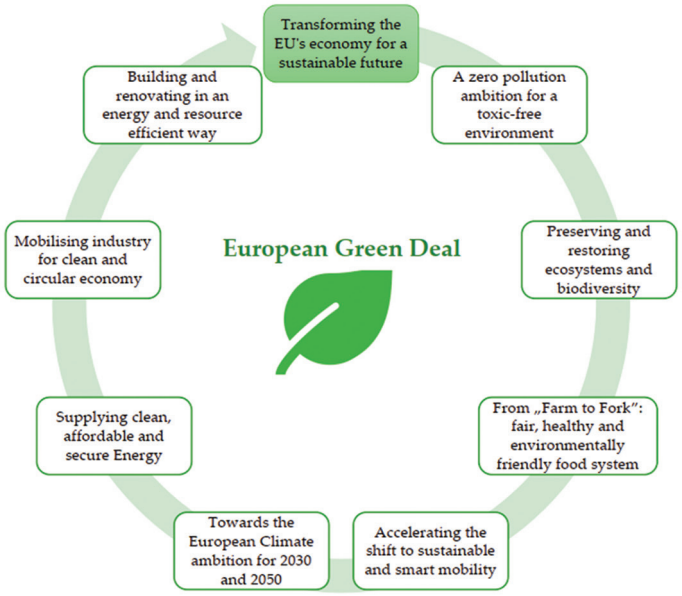
4. RESULTS

4.1. European Green Course

The current policy of the European Union is aimed at approving sustainable economic development encompassing social, economic, and environmental components. The energy field is of key importance for the assertion of this concept. The idea of environmental protection and climate preservation occupies a leading place in the European energy sector. Increasing the number of renewable energy sources, approving the safety of the energy system, minimizing the use of coal in power generation, and reducing harmful emissions are among the main measures of the process of sustainable energy development. This principle is of great importance for the economy and social well-being of EU member states (Tutak et al., 2020).

The combination of these principles is reflected in the European Green Deal. In December 2019, the European Commission introduced a roadmap of measures aimed at the transition to a climate-neutral economy. One of the main goals of this strategy is to achieve zero carbon emissions by 2050. The functioning of the fuel and energy complex must be optimized, and dependence on imported minerals must be reduced. In addition to the energy sector, changes should include the following sectors: transport, agriculture, construction, food, and chemicals (Wolf et al., 2021). The main points of this strategy are depicted in Figure 1.

Figure 1: The main objectives of the European Green Deal



Source: Smol et al., 2020

EU member states have been obliged to implement green policies. However, for some states, this strategy is a real challenge. Despite ambitious goals, the national energy strategies of EU member states have not been agreed upon. Most European countries do not possess natural resources and cannot overcome their dependence on energy imports in the short term. The level of economic development among European countries varies. In addition, the energy industry in some countries is focused on the use of their own minerals (e.g. coal), so the forced abandonment of these resources causes significant difficulties in the transition to green energy. Other obstacles include the deterioration of energy infrastructure, unstable power generation, and weather dependence on renewable sources. Achieving these goals is a challenge, even for countries with highly developed economies. According to the Treaty on the Functioning of the EU, the development and implementation of energy strategies is the competence of each state separately. In terms of the European integration of Ukraine it was decided to choose the following countries for analysis. France and Ukraine can be compared in terms of operating significant nuclear capacity. Coal is a major contributor to the electricity generation in Poland as well as in Ukraine. Increasing alternative energy production decreases dependence on traditional sources, which is crucial to achieving goals of Green Deal. Both in Ukraine and Austria hydropower is given a high role (Aszódi et al., 2021). The experience of mentioned countries will help to make right decisions when introducing reforms in Ukraine energy sector.

4.1.1. France's energy strategy

In 2020, the French government approved an energy strategy for decarbonized development. The main goals were to reduce emissions into the atmosphere by developing the electrolysis sector, to increase the number of hydrogen-heavy cargo vehicles (including airplanes and ships), and to encourage and support innovative research in the energy sector (Huybrechts, 2020). On the other hand, France has a strong nuclear industry, which contradicts the principles of the EU energy policy of phasing out nuclear power generation.

Resource shortages during both World Wars and the oil crisis of 1973 prompted the French government to become energy independent. Fifty-six nuclear power plants were built, now generating about 70% of France's electricity, the highest in the world. The state is heavily dependent on nuclear power but is fulfilling its obligation to make the industry greener and develop alternative energy sources. Since the building sector in France is the largest consumer of energy and a source of pollution, biomaterials-based insulation measures are being actively implemented to optimize the FEC and general decarbonization. Adherence to the concept of a circular economy involving the reuse of resources, the construction of energy-efficient buildings, and waste management will have a positive impact on the development of the country. Nevertheless, changes in the energy sector will inevitably cause negative political, social, and economic consequences. As an example, an increase in energy prices and a reduction in jobs (Engels, 2022).

Currently, France is actively developing alternative energy, especially hydropower. The share of energy generation by renewable resources in 2021 has reached a figure of 27%, but the volume of harmful emissions remains at a high level (Ma et al., 2021).

4.1.2. Austria's energy strategy

Austria's geographic features have favorably influenced the development of hydropower. At the same time, the state has limited fossil fuel reserves and is dependent on energy imports, since the use of nuclear energy was banned by the Constitution in 1999 and coal mining was finally stopped in 2006. Since the late twentieth century, Austria has adopted a number of energy strategies with resource dependence, reduction of harmful emissions, increasing the role of renewable sources in the electricity system, especially increasing the number of hydroelectric power plants. In 2018, the Energy and Climate Strategy 2030 was adopted, which aims to reduce greenhouse gas emissions by 36% by 2030, compared to the 2005 figure, and to achieve full decarbonization of the transport and construction sector by 2050. The new strategy aims to improve the efficiency of freight transport and to intensify rail transport (Wenz, 2020).

In 2022 Austria joined the energy strategy of hydrogen. By 2030 it is planned to reach a production level of about 10% of the country's electricity consumption as of 2021. Some features of this are that the use of hydrogen transport, unlike in France, and space heating with this resource will not be introduced, as the Austrian government has recognized this as inefficient. Hydrogen will be used as a chemical raw material in the steel industry (Trattner, 2021).

Despite the balanced dynamics of energy sector reform and technological readiness to achieve carbon neutrality, the country's emissions remain high. There is also a dependence on imported natural resources, although the Austrian government intends to ban the use of fossil fuels for heating systems and replace them with renewable sources in 2023 (Kurmayer, 2022).

4.1.3. Poland's energy strategy

Poland is Europe's largest producer of hard coal and the second-largest producer of lignite. Approximately 80% of the country's electricity is generated by coal-fired power plants. The main reason for resistance to the European Green Deal is that a large share of the population is employed in the coal industry. Abandonment of this resource would lead to the loss of jobs, lead to higher energy prices and threaten the energy security of the state. Nevertheless, the pollution of the environment due to harmful emissions is causing public dissatisfaction (Brauers and Oei, 2020). The need to introduce reforms and pressure from the EU led to the approval in 2021 of the Polish Energy Policy until 2040. It aims to achieve zero emissions, optimize the FEC, diversify the oil and gas supply, modernize and expand energy infrastructure, increase electricity generation, introduce co-generation plants, increase overall energy efficiency According to Tomaszewski (2020), Poland is able to effectively implement the European Green Deal if it reduces the use of coal cheese (Tomaszewski, 2020). An intermediate step to abandon coal resources can be the use of clean coal technologies. This will solve the problem of reducing harmful emissions from coal-fired power plants, avoiding a sharp increase in energy costs and job losses in this type of energy industry. Currently, the development of alternative energy sources in Poland among the EU member states is one of the lowest (Rybak and Włodarczyk, 2020).

4.2. Ukraine's Energy Strategies

Since independence, the government of Ukraine has approved two energy strategies: until 2030 and 2035. The first strategy was canceled because it did not meet modern requirements and lacked the necessary financial support. When developing the Energy Strategy-2035, approved in 2017, the main directions were chosen to ensure the safety, energy efficiency, and competitiveness of the Ukrainian energy industry (About approval, 2017). The main goals were to build a conscious and energy-efficient society, achieve the independence of the fuel and energy complex, integrate gas and electricity networks into the European energy space, ensure the stable development of the energy market, introduce investments, modern management system, and energy security. The purpose of this strategy was to increase the volume of alternative sources, to gradually abandon the generation of electricity by coal fuel while maintaining nuclear power generation at a high level. It was supposed to decrease the transit of Russian gas and there was a scenario of achieving full independence from energy imports from the Russian Federation. Integration of Ukraine into the European Network of Transmission System Operators for Electricity (ENTSO-E) was a priority. In February 2020, it was proposed to revise the Energy Strategy-2035 (Bilozerova, 2021).

In 2021 National Energy Efficiency Action Plan for the period up to 2030 was implemented. It is aimed at achieving the national energy efficiency goal: Primary and final energy consumption in Ukraine in 2030 should not exceed 91,468 thousand and 50,446 thousand tons of oil equivalent respectively (About National Energy Efficiency Action Plan, 2021).

The new strategy of the low-carbon development of Ukraine by 2050, approved in 2021, takes into account the principles of the EU Green Deal, namely the need to develop "green" energy,

the production and introduction of hydrogen fuel, technology modernization, increasing the level of energy conservation. It is supposed to expand the production of electricity from alternative sources and providing renewable energy for companies, the introduction of biogas, efficiency and modernization of thermal power plants and combined heat and power plants, intellectualization of electric networks, development of nuclear energy, cogeneration, energy storage technologies.

Decarbonization of Ukraine is the main task, since the volume of greenhouse gas emissions in the energy sector is 65%, and together with the industrial sector −82%. Modernization and introduction of innovative technologies in the traditional energy sector will reduce greenhouse gas emissions to 1064 million tons. There are several scenarios for changing the level of emissions: "Basic" and "Energy Efficiency, Renewable Energy, Modernization and Innovation, Transformation."

Under the Baseline scenario, the technological characteristics of the energy sector and resource consumption will remain unchanged at 2012 levels. The forecast of changes in greenhouse gas emissions is shown in Table 1.

The strategy "Energy Efficiency, Renewable Energy, Modernization and Innovation, Market and Institutional Transformation" of Ukraine until 2050 provides for improving the energy efficiency of buildings through thermal modernization of the housing stock, monitoring the energy performance of buildings and energy audits, compiling energy certificates, cold and hot water supply, and lighting. It is planned to introduce a national system of technical regulation of "green" construction, i.e. to regulate the design and construction according to environmental standards. Conditions will be created for the use of cogeneration in energy production enterprises (utilization of waste heat in the production of electricity for the needs of consumers), the use of natural gas in boiler plants, reducing the consumption of carbon-intensive resources. Changes will also affect the agro-industrial complex. For example, agricultural equipment running on diesel will be transferred to biofuel.

Power plants will be retrofitted to achieve low or zero greenhouse gas emissions, and Integrated Gasification Combined Cycle (IGCC) technologies will be enforced, Carbon Capture and Storage or Reuse Ready technologies. Inefficient thermal power plants will be decommissioned.

Nuclear power is a low-carbon source of energy, and its role in the future energy development of the country is important. Re-licensing and improving the efficiency of nuclear power plants will be implemented, and the development of innovative technologies, such as small modular reactors, will be encouraged. It is planned to intellectualize the electric grid to reduce transmission losses.

The transportation branch implies a significant reorganization. Vehicles must be converted to use motor fuel with biofuel additives. Stimulate the use of electric or hydrogen cars, public electric transport. The share of obsolete cars must be reduced by creating advantages to their disposal (provision of rewards, the introduction of car vouchers, etc.). Railway infrastructure and inland waterway infrastructure shall be improved to increase the use of freight transport. For passenger transportation, the train fleet and routes will be optimized.

Enterprises will be obliged to disclose information on the level of emissions and absorption of greenhouse gases. Public procurement will be based on energy efficiency criteria. Society will be involved in activities related to low-carbon development. Special educational programs will be created to improve the skills of specialists. To reduce the movement of workers by vehicles, conditions will be created to organize remote work in those organizations where it is possible. The Ukrainian government intends to increase funding for energy efficiency measures and attract investment in this area (Low-carbon development strategy of Ukraine until 2050, 2018).

4.2.1. Ukraine's energy security strategy

At present, the fuel and energy complex of Ukraine is in critical condition. This is caused by a number of factors, chief among which is cooperation with the energy system of the aggressor state-the Russian Federation. The Republic of Belarus is also not a reliable strategic partner for a long period, the policy of this sector of Ukraine blocked the development of energy markets, which led to their monopolization and reduction of transparent competition, deterioration of technological equipment of most funds and an increase in the cost of energy.

Due to the deterioration of Ukraine's energy sector infrastructure, there are high losses of energy during its production, transportation, and consumption. Consumers are not supplied with affordable and reliable electricity. Most of the fleet of thermal power plants and power plants have exhausted their operating resources.

50% of the electric networks are worn out, about 15 thousand km of the 309 thousand km of gas distribution networks are in

Table 1: Forecast of greenhouse gas emissions under the baseline and alternative scenarios

Scenario	Unit	2012	2015	2020	2025	2030	2035	2040	2045	2050
"Basic"	mln t CO_2 eq	367	265	347	408	455	500	540	570	592
	Percentage from the level 1990	44	31	41	48	54	59	64	68	70
"Energy efficiency, renewable energy, modernization and innovation, market and institutional transformation"	mln t CO_2 eq	367	265	265	259	242	236	264	265	261
	Percentage from the level of 1990	44	31	31	31	29	28	31	31	31

Source: (Low-carbon development strategy of Ukraine until 2050, 2018)

an emergency condition. When transporting energy from the producer to the end consumer, the percentage of losses is 44%. For comparison, in the EU countries, this figure is 32%. (Energy efficiency system in Ukraine, 2018).

The fuel and energy complex of Ukraine depends on energy imports, primarily Russian raw materials. As of 2020, the total percentage of imported natural gas was 30% and oil products exceeded 85%. Lack of sufficient diversification, stocks of petroleum products, and reliable supply networks can strike the Ukrainian energy system if the supply of resources is interrupted. A similar situation is observed with imports of Russian coal and nuclear fuel. Resource dependence, continued Russian aggression, lack of innovative technologies and energy reserves, low efficiency and worn-out technical equipment, shortage of qualified specialists, debts on energy markets, inflexible regulation of renewable energy production, environmental pollution from mining, threats of cyber-attacks on automated control systems negatively affect the fuel and energy complex of Ukraine. To address these challenges, an energy security strategy was approved in 2021. Three scenarios were formulated for further changes in the energy sector and FEC development. The first is the "no change" scenario or the preservation of current trends. The second was the "unfriendly influence" scenario, whereby additionally we were to observe an increase in the influence of the Russian Federation on the energy policy of Ukraine. The third is the "positive transformation" scenario, which envisages the implementation of the European on the Euro-Atlantic course of Ukraine. The strategic objectives of this scenario are to ensure the availability of all types of energy resources for consumers, increasing the sustainability of economic, environmental, and energy efficiency of the sector of European integration of the independence of the formation and implementation of the energy policy of national interests (About approval of the Energy Security Strategy, 2021).

4.2.2. Ukraine's gas transmission system operator strategy "decarbonization and clean development"

On June 23, 2022, Ukraine acquired EU candidate status. Preparations for integration into the European energy market encompassed the following events. In 2020, the Limited Liability Company (LLC) Operator of the Gas Transmission System (OGTSU) of Ukraine was granted observer member status in the European Network of Transmission System Operators for Gas (ENTSO-G). The reforms in this sector had an impact on natural gas accounting. According to the Law of Ukraine from 02.11.2021 № 1850-IX, the cost of gas will be determined in accordance with its energy value, and physical parameters should be brought to the values in the domestic European market. About amendments to some laws of Ukraine, 2022) Instead of metering in cubic meters, the unit of measurement for natural gas has become kilowatt hours. Thus, consumers will pay not for the used volume of gas (which can be of poor quality), but for the thermal energy received. This also simplifies import and export operations in the energy market (Gas Transmission System Operator of Ukraine became a member of the European Alliance for Clean Hydrogen, 2020).

Under the EU Green Agreement, Ukraine's GTS Operator has created its own strategy aimed at decarbonizing the gas industry. On August 13, 2020, OGTSU joined the European Alliance for Clean Hydrogen. Thus, Ukraine is involved in the implementation of the Hydrogen Strategy for a climate-neutral Europe. When the contract between Naftogaz and Gazprom expires, the volume of transported natural gas will significantly decrease by 2025. This allows Ukraine's pipeline system to be used in the future for the transit of reducing gases: Hydrogen, biomethane, and synthetic methane.

OSHSU is currently implementing a carbon-free European policy by replacing coal as the main fuel for power plants with natural gas, which will reduce harmful emissions into the atmosphere. In addition, the operation of automobile gas-filling compressor stations, some of which are located on the main gas pipelines to the operator of the GTS of Ukraine, can provide more than 160 thousand vehicles with natural gas (Decarbonization and the GTS of the future, 2020). The use of gas to fuel municipal vehicles will reduce emissions in cities and reduce dependence on diesel imports.

4.2.3. Integration of Ukraine into the European energy system ENTSO-E

Synchronization of the Ukrainian power system took place on March 16, 2022. Since the Ukrainian power system had been connected to the power systems of the Republic of Belarus and the Russian Federation since Soviet times, its operation went into isolated mode, shortly before the start of a full-scale invasion by Russia on February 24, 2022, and the seizure of power infrastructure did not prevent planned integration with ENTSO-E, the first export of Ukrainian electrical energy took place from June 30, 2022. Prior to the massive shelling of energy facilities in mid-October 2022, Ukraine exported 125 MW of electricity each to Romania and Slovakia, 210 MW to Poland, and 200 MW to Moldova. Technically Ukraine can export up to 1,690 MW, after modernization this figure can reach 6 GW (Integration into the European Power Grid ENTSO-E, 2022). Temporarily, electricity exports have been halted since October 11, 2022; at present, the power system operates solely to cover the needs of Ukrainian consumers.

5. DISCUSSION AND CONCLUSION

Compliance with the Green Deal introduced by the European government is personal in each individual case. Four cases of implementation of energy strategies are contrasted, using France, Austria, Poland, and Ukraine as examples. These countries differ in their economic power, geographic features, and natural resources. Although the Green Agreement calls for a total ban on nuclear power and coal, the cases of France and Poland show that the states do not intend to completely abandon these energy resources. Since the ultimate goal of the Green Agreement is zero greenhouse gas emissions, in the case of Ukraine we can recommend the implementation of efficiency, energy saving, and environmental measures in the production of conventional energy as an intermediate step between the complete phase-out of non-renewable sources. For example, to use clean coal technology or use exergy analysis to reduce energy losses at enterprises. For a sample, see Volianska and Pikul's (2019) study on the possibility

of improving the efficiency of a Ukrainian combined heat and power plant or Kapitanchuk et al.'s (2022) work on improving the energy efficiency of gas pipelines under the new natural gas calculation standards. The metallurgical industry consumes significant amounts of electricity and emits carbon dioxide into the atmosphere. Nakhodov et al. (2022) implemented a strategy to reduce carbon emissions and improve the efficiency in steel mills. Since a large share of energy is generated by hydroelectric power plants, Ukraine should learn from Austria's successful experience by adopting the latest technologies, such as increasing energy production through a combination of buffer reservoirs, hydroelectric diversion plants, and reservoirs (Reindl et al., 2022).

The innovative development of the country is inextricably linked to the intellectualization of the economy. Scientific and technological progress plays a huge role in shaping the energy of the future. Bushman (2021) conducted research on the intensification of scientific and technological work and the increase in the number of scientific resources and identified the main trends in the development of the intellectual economy in some countries. Ovcharova (2022) analyzed the relationship between digitalization and the national smart economy model to achieve innovation process strategies. The paper noted that further intellectualization will have an impact on the competitiveness of countries' economies, but it requires significant investment.

The paper does not consider the positive impact of renewable energy expansion on the number of jobs, as it was investigated in Dell'Anna (2021). This is an important social aspect, as the introduction of the latest energy technologies requires increasing the qualifications of specialists (Britchenko and Saienko, 2017). This article explores to a greater extent the strategies of the Ukrainian FEC and does not cover the peculiarities of energy reforms of European countries. A more detailed analysis of the development of approved policies in the EU member states was conducted by Skjærseth (2021). On the other hand, the study highlights the real state of the energy sector of Ukraine, reflects the peculiarities of energy sector reforms in accordance with the provisions of the European Commission and the possibilities of achieving the goals under the Green Agreement and considers different scenarios of this process. The necessity of development of the energy sector is explained, as it directly affects the welfare of the population and the development of the economy.

Ukraine has a large energy potential that can provide both its own consumers and export energy resources. The energy strategy meets the goals of the Green Deal but differs from other strategies of European states in the scale of changes. Ukraine's fuel and energy complex covers mining, processing, and transportation of minerals, coal, and oil and gas industry, electricity is produced at nuclear, thermal, wind, solar, and hydroelectric power plants. As can be seen from the analysis, an abrupt transition to exclusively renewable energy sources is not possible. This is a gradual process characterized by the gradual reduction of conventional energy. Due to its great potential, Ukraine is able to achieve all the goals set by the European Green Agreement. In future studies, attention should be paid to the specifics of cooperation between Ukraine and the European Union in energy activities.

REFERENCES

About Amendments to Some Laws of Ukraine Regarding the Introduction of Metering and Settlement of Gas Volume in Energy Units on the Natural Gas Market. (2022), Official Web Portal of the Parliament of Ukraine. Available from: https://www.zakon.rada.gov.ua/laws/show/1850-20#text [Last accessed on 2022 Nov 25].

About Approval of the Energy Security Strategy. (2021), Official Web Portal of the Parliament of Ukraine. Available from: https://www.zakon.rada.gov.ua/laws/show/907-2021-%d1%80#tex [Last accessed on 2022 Nov 25].

About Approval of the Energy Strategy of Ukraine for the Period up to 2035 "Security, Energy Efficiency, Competitiveness." (2017), Official Web Portal of the Parliament of Ukraine. Available from: https://www.zakon.rada.gov.ua/laws/show/605-2017-%d1%80#text [Last accessed on 2022 Nov 25].

About National Energy Efficiency Action Plan for the Period up to 2030. (2021), Unified Web Portal of Executive Authorities of Ukraine. Available from: https://www.kmu.gov.ua/npas/pro-nacionalnij-plan-dij-z-energoefektivnosti-na-period-do-2030-t291221 [Last accessed on 2022 Nov 25].

Aszódi, A., Biró, B., Adorján, L., Dobos, Á.C., Illés, G., Tóth, N.K., Zagyi, D., Zsiborás, Z.T. (2021), Comparative analysis of national energy strategies of 19 European countries in light of the Green Deal's objectives. Energy Conversion and Management: X, 12, 100136.

Bilozerova, L. (2021), Third in 20 Years: What Does Ukrainian Energy Strategy Lack? Ukrainian Energy. Available from: https://www.ua-energy.org/uk/posts/tretia-na-pidkhodi-choho-ne-vystachaie-ukrainskym-enerhostratehiiam [Last accessed on 2022 Nov 25].

Brauers, H., Oei, P.Y. (2020), The political economy of coal in Poland: Drivers and barriers for a shift away from fossil fuels. Energy Policy, 144, 111621.

Britchenko, I., Saienko, V. (2017), The perception movement economy of Ukraine to business. Economic Studies Journal, 26(4), 163-181.

Bushman, I. (2021), The development of the intellectual economy of the future: trends, challenges of the future. Futurity Economics & Law, 1(3), 33-42.

Claeys, G., Tagliapietra, S., Zachmann, G. (2019), How to Make the European Green Deal Work. Vol. 5. Brussels, Belgium: Bruegel.

Decarbonization and the GTS of the Future. (2020), Gas Transmission System Operator of Ukraine. Available from: https://www.tsoua.com/pro-nas/upravlinnya-kompanieu/dekarbonizatcia-ta-gts-maibutniogo [Last accessed on 2022 Nov 25].

Dell'Anna, F. (2021), Green jobs and energy efficiency as strategies for economic growth and the reduction of environmental impacts. Energy Policy, 149, 112031.

Energy Efficiency System in Ukraine. (2018), Ministry of Communities and Territories Development of Ukraine. Available from: https://www.minregion.gov.ua/wp-content/uploads/2018/09/GIZ-brochure.pdf [Last accessed on 2022 Nov 25].

Engels, F. (2022), The French (non-)compliance with the European energy policy. Zeitschrift Für Politikwissenschaft, 1, 1-22.

European Green Deal. (2021), Green Deal. Available from: https://www.greendeal.org.ua/ru/european-green-deal [Last accessed on 2022 Nov 25].

Furfari, S., Mund, E. (2021), Is the European green deal achievable? The European Physical Journal Plus, 136(11), 1101.

Gas Transmission System Operator of Ukraine Became a Member of the European Alliance for Clean Hydrogen. (2020), Gas Transmission System Operator of Ukraine. Available from: https://www.tsoua.com/news/operator-gts-ukrayiny-stav-chlenom-yevropejskogo-alyansu-z-chystogo-vodnyu [Last accessed on 2022 Nov 25].

Haines, A., Scheelbeek, P. (2020), European green deal: A major opportunity for health improvement. The Lancet, 395, 1327-1329.

Huybrechts, E. (2020), France national urban policies: Towards sustainable, inclusive and innovative cities. In: Developing National Urban Policies. Germany: Springer Singapore. p357-375.

Integration into the European power grid ENTSO-E. (2022), Ministry of Energy of Ukraine. Available from: https://www.mev.gov.ua/reforma/intehratsiya-u-yevropeysku-elektromerezhu-entso-e [Last accessed on 2022 Nov 25].

Kapitanchuk, K., Andriyishyn, M., Pikul, M., Otroshchenko, V. (2022), A Study of the Energy Balance of Main Gas Pipeline Operating Modes on its Efficiency. Engines and Power Installations: Safety in Aviation and Space Technologies: The Seventh World Congress. p1.

Krykhtina, Y.O., Leonenko, N.A., Khmyrov, I.M., Stankevych, S.V. (2021), Role of European Green Deal as a transformation mechanism of the state policies for the European integration of Ukraine. Ukrainian Journal of Ecology, 11(5), 97-101.

Kurmayer, N.J (2022). Austrian government wants to ban fossil heating from 2023. Euractiv. Available from: https://www.euractiv.com/section/energy-environment/news/austrian-government-wants-to-ban-fossil-heating-from-2023 [Last accessed on 2022 Nov 25]; [Last accessed on 2022 Nov 03].

Low-carbon Development Strategy of Ukraine Until 2050. (2018), Ministry of Environmental Protection and Natural Resources of Ukraine. Available from: https://www.mepr.gov.ua/files/docs/proekt/LEDS_ua_last.pdf [Last accessed on 2022 Nov 25].

Ma, X., Ahmad, N., Oei, P.Y. (2021), Environmental Kuznets curve in France and Germany: Role of renewable and nonrenewable energy. Renewable Energy, 172, 88-99.

Musiał, W., Zioło, M., Luty, L., Musiał, K. (2021), Energy policy of European union member states in the context of renewable energy sources development. Energies, 14(10), 2864.

Nakhodov, V., Borychenko, O., Cherniavskyi, A. (2022), Formation of a strategy for increasing the energy efficiency of metallurgical enterprises as guarantee of decarbonization of the Ukrainian economy. Power Engineering Economics, Technique, Ecology, 2, 48-56.

Reindl, R., Neuner, J., Schletterer, M. (2022), Increased hydropower production and hydropeaking mitigation along the Upper Inn River (Tyrol, Austria) with a combination of buffer reservoirs, diversion hydropower plants and retention basins. River Research and Applications, 1-8.

Rivas, S., Urraca, R., Bertoldi, P., Thiel, C. (2021), Towards the EU Green Deal: Local key factors to achieve ambitious 2030 climate targets. Journal of Cleaner Production, 320, 128878.

Rybak, A., Włodarczyk, E. (2020), Energy policy until 2040 and the future of hard coal in Poland. IOP Conference Series Earth and Environmental Science, 609, 012009.

Shevchenko, H., Petrushenko, M., Burkynskyi, B., Khumarova, N. (2021), SDGs and the ability to manage change within the European green deal: The case of Ukraine. Problems and Perspectives in Management, 19(1), 53-67.

Sikora, A. (2020), European Green Deal-legal and financial challenges of the climate change. ERA Forum, 21, 681-697.

Skjærseth, J.B. (2021), Towards a European Green Deal: The evolution of EU climate and energy policy mixes. International Environmental Agreements Politics, Law and Economics, 21(1), 25-41.

Smol, M., Marcinek, P., Duda, J., Szołdrowska, D. (2020), Importance of sustainable mineral resource management in implementing the circular economy (CE) model and the European Green Deal strategy. Resources, 9(5), 55-60.

Tagliapietra, S., Zachmann, G., Edenhofer, O., Glachant, J.M., Linares, P., Loeschel, A. (2019), The European union energy transition: Key priorities for the next five years. Energy Policy, 132, 950-954.

Tomaszewski, K. (2020), The polish road to the new European Green Deal-challenges and threats to the national energy policy. Energy Policy Journal, 23(2), 5-18.

Trattner, A., Klell, M., Radner, F. (2021), Sustainable hydrogen society-vision, findings and development of a hydrogen economy using the example of Austria. International Journal of Hydrogen Energy, 47, 2059-2079.

Tutak, M., Brodny, J., Siwiec, D., Ulewicz, R., Bindzár, P. (2020), Studying the level of sustainable energy development of the European union countries and their similarity based on the economic and demographic potential. Energies, 13(24), 6643.

Volianska, L.G., Pikul, M. (2019), Energy and exergy efficiency analysis of combined heat and power plant. Science Based Technologies, 44(4), 468-475.

Wenz, N. (2020), Energy governance in Austria. In: Handbook of Energy Governance in Europe. New York: Springer International Publishing. p1-29.

Wolf, S., Teitge, J., Mielke, J., Schütze, F., Jaeger, C. (2021), The European Green Deal-more than climate neutrality. Intereconomics, 56(2), 99-107.

Ziabina, Y., Pimonenko, T. (2020), The Green Deal policy for renewable energy: A bibliometric analysis. Virtual Economics, 3(4), 147-168.