JOURNAL
OF EUROPEAN ECONOMY
Vol. 20. № 3 (78). July–September 2021
Publication of West Ukrainian National University

International Economics

Eckhard FREYER,
Ihor LISHCHYNSKYY,
Mariia LYZUN

DEVELOPMENT OF RENEWABLE ENERGY: THE EXPERIENCE OF EAST GERMANY FOR UKRAINE

Abstract

Renewable energy development has become a modern global priority. German regions are characterized by a very high degree of renewable energy development. In 2020, the volume of electricity generation from renewable sources exceeded the traditional ones. However, the use of renewable energy sources in the transport sector and in the heating / cooling industry remains relatively low in Germany. Regions in the East Germany had historically been dominated by coal energy. Staring with 2017, the EU has begun implementing a policy of developing so-called «Coal Regions in Transition», aimed at supporting economic diversification and technological transformation of coal and carbon-intensive regions. A total of 42 such regions were identified, including 4 in East Germany. The natural environment of the East Germany fits the development of

Freyer, Eckhard, Professor, Omnis Religio Stiftung Vorstand, Germany. Email: efreyer@t-online.de
Lishchynkyy, Ihor, Doctor of Economic Sciences, Professor of the Department of International Economics, West Ukrainian National University, Ternopil, Ukraine. ORCID: 0000-0003-1602-1677. Email: lischynigor@ukr.net
Lyzun, Mariia, Doctor of Economic Sciences, Professor of the Department of International Economics, West Ukrainian National University, Ternopil, Ukraine. ORCID: 0000-0003-3222-2962. Email: mlysun@ukr.net

wind energy better, though the solar system could be considered a substitute for the current coal plants. The green energy sector in Ukraine is only emerging. However, renewable energy is attracting more attention and investments. Its share in total supply has risen from 1.7 percent in 2007 to almost 5 percent in 2019. The energy of biofuels and waste is dominating among the renewable sources, comprising around 77 percent of their total supply. The paper aims to reveal the experience of East Germany to enhance the mechanism of green energy development in Ukraine. Among the new recommended tools for Ukrainian practice are export-credit agencies, EPC-contractors, green securities, and environmental investments.

Key words:

renewable energy; green energy; sustainable development; green bonds; photovoltaic; wind energy; nuclear energy.

JEL: F29, Q20, Q32, Q42, Q48.

8 figures, 2 tables, 24 references.

Introduction

Modern global economy is evolving under the influence of numerous challenges, including greenhouse gas emissions, climate change and energy security. Increased economic activity leads to an upsurge in energy consumption in developed countries by an average of 1.1% per year. According to the International Energy Outlook in developing countries such growth will average 3.2% by 2025. To meet the excessive demand for energy, currently there is a global trend to replace the use of conventional fuels with renewable energy sources. RES play an important role in addressing fossil fuel depletion and global warming, protection of the environment and energy recovery. Therefore, they are extremely effective in combating energy crises.

Humanity's growing energy needs have traditionally been met by nuclear energy, which provides electricity at stable prices and is a relatively environmentally friendly source. However, its use can have devastating consequences as a result of nuclear accidents, threats, development and proliferation of nuclear weapons, significant operating costs of nuclear power plants and improper handling of radioactive waste. On April 26, 1986, explosions occurred during an experiment at the No. 4 nuclear reactor of the Chornobyl Nuclear Power Plant. A cloud of radioactive dust was carried by the wind to the northwest across the territories Ukraine, Belarus to the Western Europe. The radioactive substances have been found in the ground in Austria, Belgium, Germany, Great Britain, Latvia, Lithuania, the Netherlands Norway, Poland, Russia, Finland, and Sweden. 203 people were hospitalized immediately, of whom 31 died (28 of them died from acute radiation exposure). Most of these were fire and rescue workers trying to bring the disaster under control, who were not fully aware of how dangerous the radiation exposure was. 135,000 people were evacuated from the area. Health officials have predicted that over the next 70 years there will be a 28% increase in cancer rates in much of the population which was exposed to the 5–12 EBq (depending on source) of radioactive contamination released from the reactor. However, the issue of real long-term effects of the Chernobyl disaster on civilians is very controversial. Currently, there is little evidence of increased mortality, cancers or birth defects caused by Chornobyl disaster's radiation after 3 decades (but WHO 2005 Report summarizes that up to 4000 people could eventually die of radiation exposure from the Chernobyl nuclear power plant).

Nevertheless, the threats of nuclear power became obvious for the global community after Chornobyl and later Fukushima Daiichi disasters. Many countries have changed their energy programmes by shrinking the share of nuclear energy. The focus is on the development of renewable energy, though the relative economic efficiency of nuclear power stations is still higher in most countries.

The paper aims to reveal the experience of East Germany to enhance the mechanism of green energy development in Ukraine.

Literature Review and Problem Statement

Current research in the field of economics points to the important role of renewable energy as a factor of sustainability and an element in achieving global development goals (Swain & Karimu, 2020). After all, new energy sources provide an opportunity for economic growth without harming the environment. In this regard, industrialized countries are actively involved in the development and implementation of a wide range of renewable energy sources, including biomass, solar, geothermal, hydropower and wind energy. As a result of empirical research, Saidia and Omrib (2020) found a fairly high efficiency of renewable en-

ergy sources in increasing economic growth and reducing carbon emissions. Renewable energy can meet two-thirds of global energy demand and contribute to the significant reduction in greenhouse gas emissions needed to limit global surface temperatures below 2℃ by 2050 (Gielena et al, 2019). A number of EU countries, including Germany, are considering the creation of a low-carbon energy system, but publications focus mainly on certain aspects and sectors of the economy. For example, Palzer and Henning (2014) present the transition to 100% renewable energy in the heating and electricity sectors, while keeping energy costs at a level similar to current costs. Pregger et al. (2013) found that fuel cost savings and reduced fuel imports are crucial to overall power system costs. Germany has set a rather ambitious goal of moving the energy system to 100% renewable energy by 2050. Hansen et al. (2019) propose a mechanism for the transition of the German energy system in the heating, industrial, transport and electricity sectors to renewable energy sources.

Green Energy Practice in East Germany

German regions are characterized by a very high degree of renewable energy development. If in 1990 the share of renewable sources in gross electricity consumption was 3.4%, in 2019 this figure reached 45.4%. Not surprisingly, some have begun calling Germany «the world's first major renewable energy economy» (Burgermeister, 2009). Among the defining sources of renewable energy in Germany are hydropower (the generation of which has not changed for the last three decades), wind, solar and biomass-based energy (their share is growing rapidly). Other types of sources (such as geothermal or biogenic waste incineration) account for a relatively smaller share. Fig. 1 illustrates the share of electricity production according to its type in 2020. As we can see, the volume of electricity generation from renewable sources gradually exceeded the traditional ones.

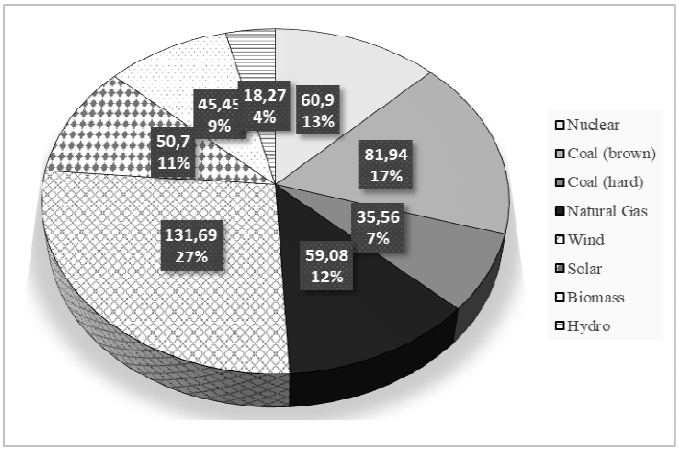
In Fig. 2, the fluctuating changes in electricity production based on renewable sources are illustrated for the timeline since the unification of Germany.

However, it should be noted that the use of renewable energy sources in the transport sector and in the heating / cooling industry remains relatively low in Germany. Though this situation is typical for most of the other advanced economies.

Such a significant increase in the share of onshore wind, photovoltaic and biogas energy is primarily due to Germany's legislation on renewable energy adopted 20 years ago. The regulatory environment guaranteed the priority of the network for renewable energy sources and provided them with generous tariff benefits. Renewable energy legislation (EEG) has undergone a number of transformations during implementation.

Figure 1

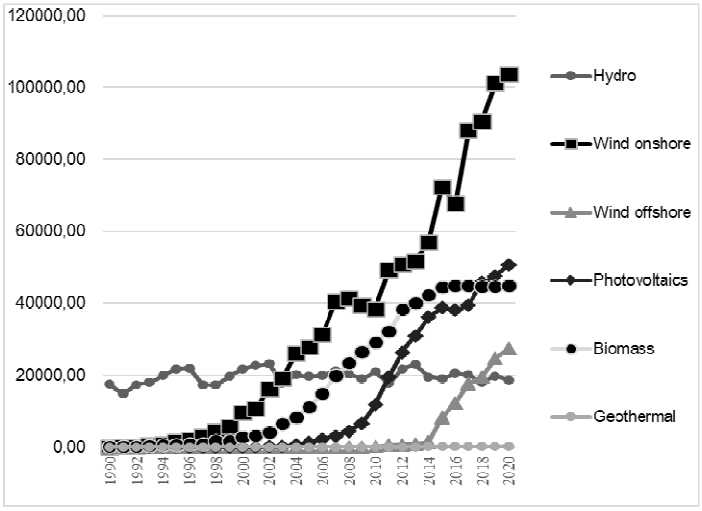
Electricity generation by type in Germany in 2020, TWh.



Source: (Energy Charts, n. d.)

Figure 2

Electricity production from renewable sources in Germany in 1990–2020, GWh.



Source: Informationsportal Erneuerbare Energien. (n.d.). Time series on the development of renewable energies in Germany [in German]. Bundesministerium für Wirtschaft und Energie. Retrieved August 31, 2021 from https://www.erneuerbare-energien.de/EE/ Navigation/DE/Service/Erneuerbare_Energien_in_Zahlen/Zeitreihen/zeitreihen.html

The latest changes took place in 2021 and were aimed primarily at adapting renewable energy producers to market conditions through a system of tenders, as well as new vectors such as the national hydrogen-based energy development strategy and the electricity pricing system for e-car charging. By 2027, the government plans to introduce a mechanism to stop public funding for renewable energy sources through EEG standards and ensure their competitiveness under fully market conditions.

EEG is aligned with ambitious 2030 EU climate targets. The new EEG plans to increase solar energy capacity to 100 GW (~52 GW today), onshore wind to 71 GW (55 GW today), biomass to 8.4 GW, and offshore wind to 20 GW by 2030 – targets that slightly exceed those from the Climate Action Programme 2030, which was decided in late 2019. The law sticks to annual deployment targets to make sure that capacity addition is compatible with the 65-percent-renewables target and allows for the adjustment of the power grid to incorporate the growing output from fluctuating renewables. An additional 500-850 MW per year will be tendered in so-called «innovation auctions» that are not technology-specific and where a combination of onshore wind, solar PV, biomass and/or power storage devices work together to stabilize the power system. Agri- and floating PV solutions can also participate in these auctions.

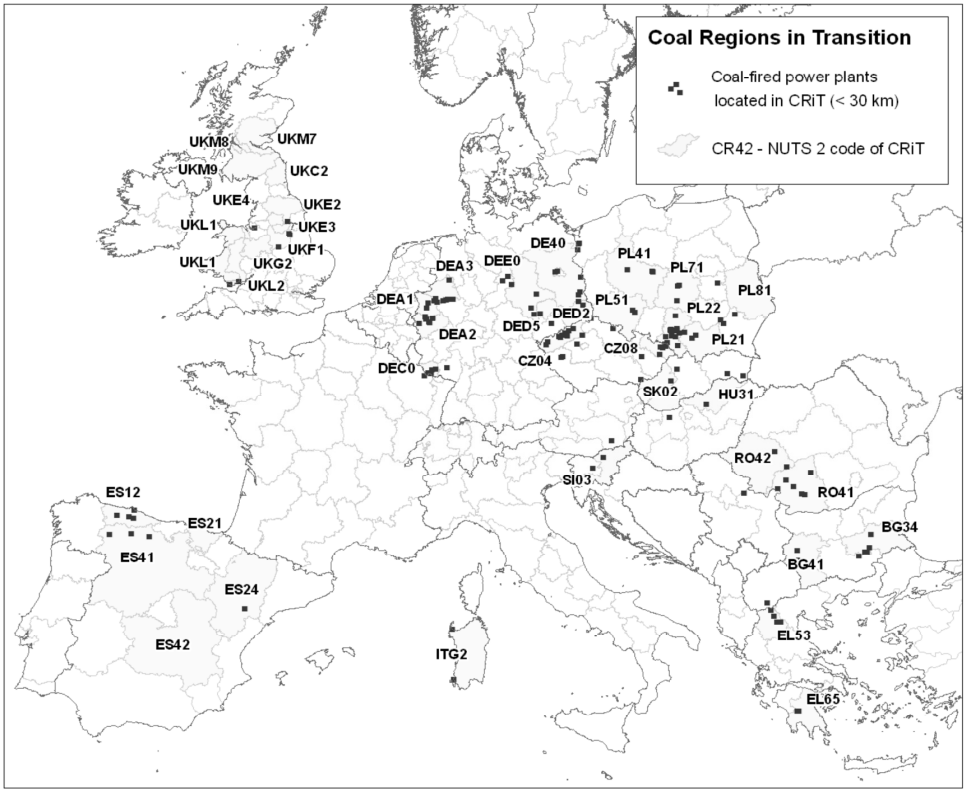
In three decades since reunification, East Germany has undergone tremendous changes, facilitated by large-scale transfers. However, differences in the level of socio-economic development between the new and old federal lands remain. There is a rather significant lag compared to West Germany in terms of GDP and employment, export quota and other indicators.

Historically, East Germany consisted of five lands: Mecklenburg-Vorpommern (DE8 – according to the NUTS classification), Brandenburg (DE4), Saxony (DED), Saxony-Anhalt (DEE) and Thuringia (DEG). In this paper, for the convenience of calculations, Berlin (DE3) is also included in the research area (despite the fact that only the eastern part of it was part of the GDR).

East Germany has historically been dominated by coal energy. Starting with 2017, the EU has begun implementing a policy of developing so-called «Coal Regions in Transition (CRiT)» (European Commission, 2017), aimed at supporting economic diversification and technological transformation of coal and carbon-intensive regions. A total of 42 such regions were identified in 12 EU Member States. Eight of them are located in Germany, including 4 in East Germany (Brandenburg, Dresden, Leipzig, Saxony-Anhalt). Economic activity in these regions is closely linked to existing mines and coal-fired power plants (Fig. 3).

Figure 3

Coal regions in transition of the EU and coal-fired power plants operating in their areas



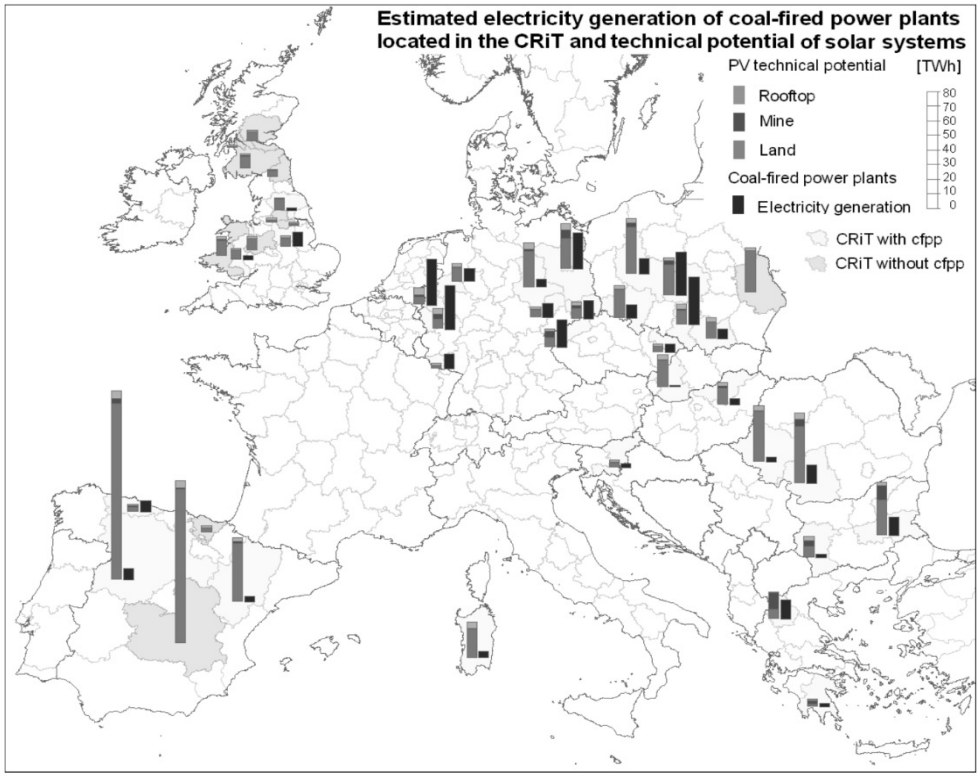
Source: Bódis, K., Kougias, I., Taylor, N., & Jäger-Waldau, A. (2019). Solar photovoltaic electricity generation: A lifeline for the European coal regions in transition. Sustainability, 11(13), 3703. https://doi.org/10.3390/su11133703

It should be noted that the use of coal for electricity generation is a major source of greenhouse gas emissions worldwide. According to the International Energy Agency, these emissions need to be reduced by more than 70% by 2040 to meet the 1.5-2 ℃ scenario proposed by the Paris Agreement. The paper of Bódis et al. (2019) developed a spatial methodology for estimating the solar photovoltaic potential in selected regions where existing coalmines are to be closed in the near future. Researchers have considered various types of solar photovoltaic systems,

including ground-based systems developed on or around minefields. In addition, the installation of solar photovoltaic systems on the roof of the existing construction stock has been analysed. The obtained results show that the available area of these zones in the transitional coal regions is large enough that solar photovoltaic systems can completely replace the current electricity production by coal-fired power plants (Fig. 4). This statement is also true for the regions of East Germany, although their photovoltaic potential only compensates for the current generation of coal-fired power plants. Whereas for the southern regions, the potential of solar energy far exceeds the traditional sources.

Figure 4

Comparison of electricity production by coal-fired power plants in transitional coal regions and the simulated potential of solar systems

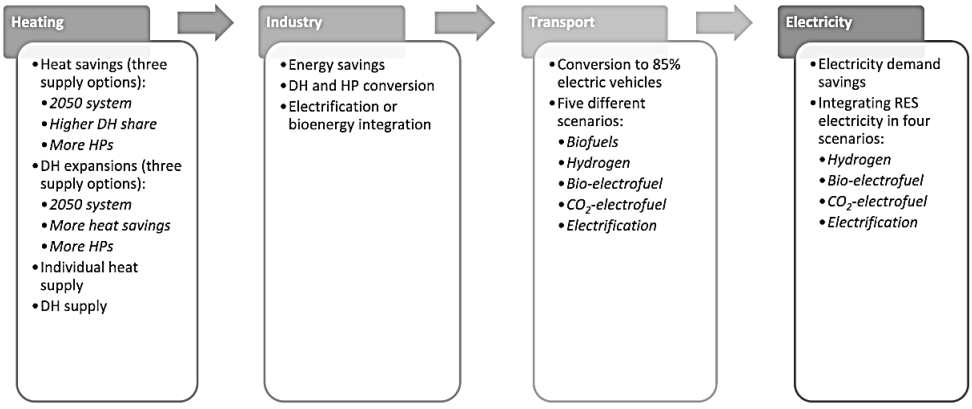


Source: Bódis, K., Kougias, I., Taylor, N., & Jäger-Waldau, A. (2019). Solar photovoltaic electricity generation: A lifeline for the European coal regions in transition. Sustainability, 11(13), 3703. https://doi.org/10.3390/su11133703

Researchers and practitioners propose different models of energy transition in Germany. Most of them have a rather precise ambitious target – 100% renewable German energy system in 2050. K. Hansen et al. (2019) propose four groups of measures to reach the above-mentioned goal. The first group is related to the heating market and in-heat savings and district heating expansions. Industrial development is considered from the perspectives of relying on bioenergy or electrification to the highest possible extent. The transport sector could be transformed by converting 85% of all cars and vans to electric vehicles within five different scenarios. Finally, the electricity sector may be converted through electricity savings and integration of renewable resources (Fig 5).

Figure 5

The measures for converting towards 100% renewable energy in Germany

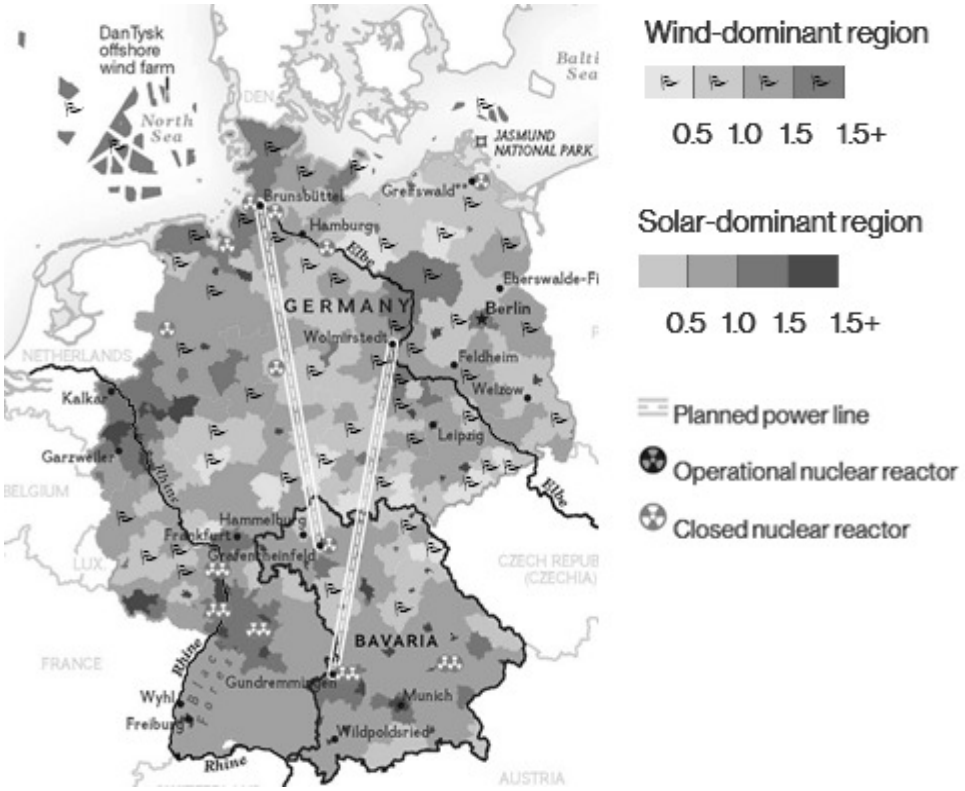


Note: (HP = heat pumps. DH = district heating)
Source: Hansen, K., Mathiesen, B. V., & Skov, I. R. (2019). Full energy system transition towards 100% renewable energy in Germany in 2050. Renewable and Sustainable Energy Reviews, 102, 1-13. https://doi.org/10.1016/j.rser.2018.11.038

Germany has Europe's second highest consumer electricity prices. However, the public support for an aggressive transition to renewable energy is at an impressive 92 percent. Considering the variety of tools implemented to reach the Green Germany, the target no longer seems so unrealistic. The natural environment of the East Germany fits the development of wind energy better, though the solar system could be considered a substitute for the current coal plants. The possible map of German energy system is shown in Fig. 6.

Figure 6

German energy scenario till 2050



Source: Kunzig, R. (2015). Germany could be a model for how we get energy in the future. *National Geographic Magazine*. https://www.nationalgeographic.com/magazine/ article/germany-renewable-energy-revolution

Renewable energy development in Ukraine

The green energy sector in Ukraine is only emerging. Ukraine consumes dozens of million tons of fossil energy resources, near half of which are imported (Table 1). Most of Ukrainian power plants (coal and nuclear) were built in the 1960-80s. By 2035, they all should be closed and replaced with new energy facilities.

Table 1

Energy Balance of Ukraine, 2019

(*Thousand tonnes of oil equivalent / TOE*)

	Coal & peat	Crude oil	Oil products	Natural Gas	Nuclear energy	Hydro energy	Geothermal, wind, solar etc.	Biofuels & waste	Heat energy	Total
Production	14089	2478	–	16318	21771	560	426	3786	667	60095
Import	13239	1341	10443	9506	–	–	–	47	–	34768
Export	–49	–54	–759	–	–	–	–	–429	–	–1830
International Bunkers	–	–	–121	–	–	–	–	–	–	–121
Stock changes	–1561	20	185	–2441	–	–	–	–43	–	–3840
Total delivery	25718	3786	9747	23383	21771	560	426	3362	667	89072

Source: compiled by the authors using the data of State Statistics Service of Ukraine.

However, renewable energy is attracting more attention and investments. Its share in total supply has risen from 1.7 percent in 2007 to almost 5 percent in 2019 (see Fig. 7).

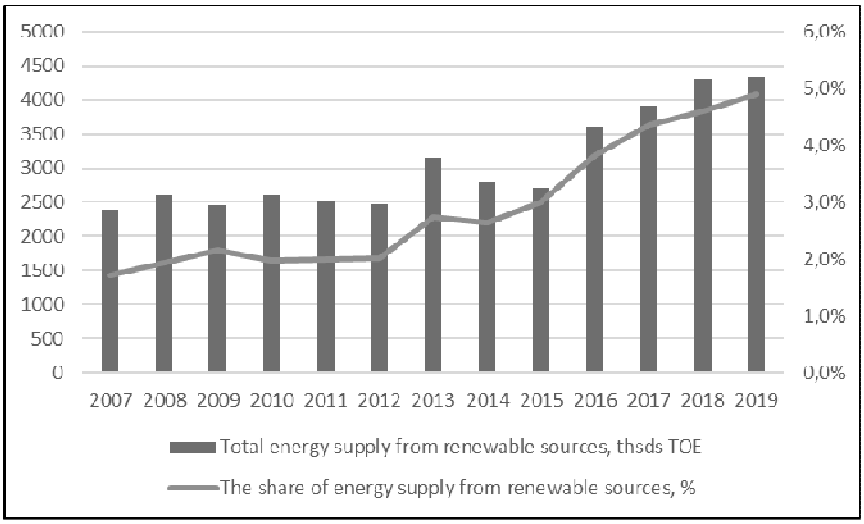
It should be noted that energy of biofuels and waste is dominating among the renewable sources, comprising around 77 percent of their total supply. The structure of energy supply from renewable sources is shown in Fig. 8.

Among the power generating plants, in 2020 the main share of electricity output was generated by nuclear power plants (52%), heat power plants (26%) and combined heat and power plants (9%). Renewable sources were responsible for about 12 percent: hydro power plants (including pumped hydro power plants) – 5,4%, solar – 4,1%, wind – 2,4% (Table 2).

Several successful projects in the field of green energy were aimed at Chernobyl recovery. The solar power plant in Chornobyl – at the site of the 1986 nuclear disaster – first began supplying electricity to Ukraine's power grid on July 1, 2018. The 3,800 panels, located on an area of more than 1.6 hectares, produce enough energy to power about two thousand apartments. A 1 megawatt (MW) solar power plant costs about one million euros. This is a joint project of the Ukrainian company Rodyna and the German company Enerparc AG.

Figure 7

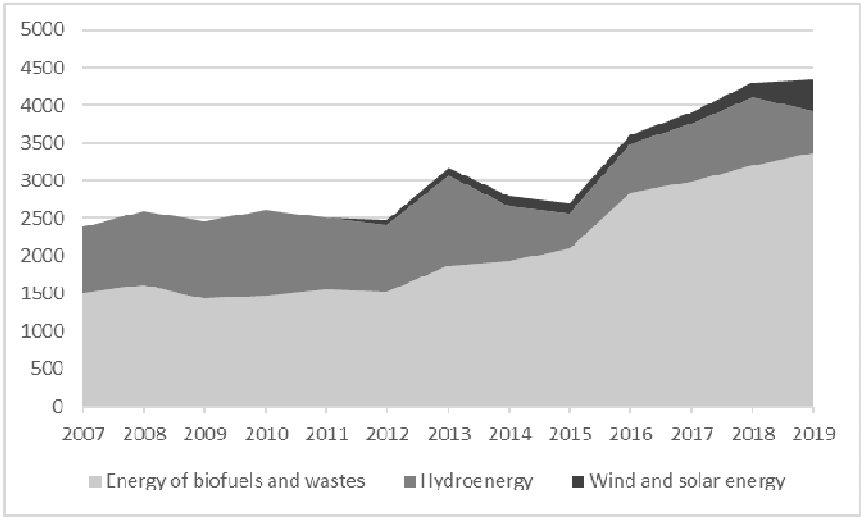
Energy supply from renewable sources in Ukraine in 2007-2019



Source: designed by the authors using the data of State Statistics Service of Ukraine.

Figure 8

Structure of energy supply from renewable sources in Ukraine



Source: designed by the authors using the data of State Statistics Service of Ukraine.

Table 2

Output of electricity and capacity of power plants, by type of power plant

	Power plants capacity by year-end, thou. kW		Electricity output, GWh	
	2019	2020	2019	2020
Total	141213	137197	51444	55138
heat power plants	40910	36300	22265	22311
combined heat and power plants	10738	12837	5855	5890
nuclear power plants	77948	71249	13835	13835
hydro power plant	7712	7415	6326	6335
wind power plants	1760	3271	795	1110
solar power plants	1883	5684	1953	5194

Source: compiled by the authors using the data of State Statistics Service of Ukraine.

The Ukrainian company DTEK – the largest private energy company in the country – is a key player in the field of renewable energy. It covers almost half of all investments.

In general, it can be concluded that the volume of wind and solar energy in the structure of Ukraine's energy balance has begun to grow rapidly since 2011. The main impetus was the introduction of green tariffs and the ability to become separate households independent of energy tariffs. Today, wind and solar energy are some of the most promising areas for energy independence in the country. Thus, an optimistic forecast of changes in the use of wind and solar energy is possible with the maximum involvement of environmental investments in the construction of solar and wind power plants and the improvement of their legal regulation.

It is worth noting that the use of energy from biofuels and waste by volume is in first place among renewable energy sources and is growing steadily. Today, the use of energy from biofuels and waste exceeds the use of energy from crude oil in the structure of Ukraine's energy balance, which is a positive indicator for the country in transition to a carbon-neutral model of national economy. According to the results of scenario forecasting, even by the pessimistic forecast, the volume of energy use from biofuels and waste will be about 6 million TOE by 2035, which is almost a third of the energy of fossil fuels in 2020. It should be noted that the use of energy from biofuels and waste is the least capital-intensive venture and does not depend on climatic conditions in contrast to hydro, solar and wind energy.

In August 2017, the Cabinet of Ministers of Ukraine approved the Energy Strategy of Ukraine for the period up to 2035 «Security, Energy Efficiency, Competitiveness», which today has lost its relevance and needs immediate revision and optimization, given Ukraine's ratification of the European Green Deal in 2020. The adoption of a new Green Deal in Ukraine is aimed at improving the energy efficiency of the national economy, optimizing the country's energy balance and increasing the amount of energy generated from renewable energy sources, which in turn will increase the competitiveness of the national economy and ensure energy independence.

In Ukraine, public funding is used mainly in the context of developing a system of hydropower plants, which largely reflect the potential for energy through the use of river resources. This creates the potential for decentralization of the national energy system and solutions to the problems associated with the lack of energy supply in remote rural areas. In turn, along with direct financing of hydroelectric power plants, a number of mechanisms are used at the state level in Ukraine to stimulate renewable energy in our country. In particular, currently, the practical mechanisms to stimulate energy production from renewable sources are: (1) «green» tariff; (2) tax benefits; and (3) preferential mode of connection to the electrical network (Klopov, 2016).

In order to increase the potential of alternative energy in the advanced nations at the government level, export-credit agencies (ECA) are often created. They aim to develop national production and increase employment. However, the potential of this mechanism is still not used in Ukraine, in particular for the needs of energy development and increasing its competitive position in international markets.

Currently, Ukraine is intensifying, to some extent, the funding for the development of alternative energy from the resources of domestic public and private banking institutions. In particular, Oshchadbank JSC in cooperation with international financial institutions implements the programme «Energy Efficiency in the Housing Sector of Ukraine». Since 2015, the bank has been launching soft loan programmes for condominiums to increase their energy efficiency. JSC «Ukreximbank» together with the EBRD has implemented a business support programme aimed at stimulating the implementation of investment projects in the energy sector, supporting the use of renewable energy and energy efficiency scenarios. Projects to increase energy efficiency and strengthen the potential of renewable energy were implemented by JSC «Raiffeisen Bank Aval», which allowed to expand the range of services for existing and potential customers of the bank and join international program UKEEP. At the end of 2020, Ukrgasbank and the United Nations Industrial Development Organization (UNIDO) within the Credit Guarantee Fund developed a programme of unsecured loans at a reduced rate, which will allow entrepreneurs to save up to 25%.

Effective interaction of banks with EPC-contractors is a rather popular tool for stimulating alternative energy. The EPC-contractors (Engineering, Procure-

ment and Construction) are represented by specialized companies implementing the full cycle of energy infrastructure construction, operating and commissioning. Such a mechanism minimizes the potential risks of banks, given the proven reputation and current history of EPC contractors. In addition, the EPC contractor has experience in conducting alternative energy development projects and relevant contacts, which allows them to manage the project effectively, gain access to specific facilities and progressive experience. However, currently this mechanism of EPC-contracts is not very effective and common in Ukraine. At the same time, we note that JSC «Ukrgasbank» has created conditions for the creation of the first in Ukraine open-access list of reliable contractors, who have passed the procedure of selection and objective evaluation.

Taking into account the harmonization of the national strategies with the European Green Deal, domestic business representatives face a number of new challenges related to the need to support energy saving, responsible and environmental activities. The demand arises for the so-called «environmental» or «ecological» investments. Thus, the review of investment strategies is currently in progress considering the resource attraction by means of sponsorship. Advertising, support for investment in alternative energy is the contemporary trend and indicator of sustainable development of modern society.

Promotion of the Green Deal in developed countries among other is related with the spread of environmental securities. Green bonds are the fixed-income debt securities designed to support specific climate-related or environmental (including energy efficient) projects. For example, in the last 10 years the global green bond market has grown from 860 million to 389 billion US dollars. Green securities primarily focus on energy saving and energy efficiency projects, combating climate change, preventing natural disasters, etc. In Ukraine, in recent years, attention to green securities has increased at the government level, though the financial mechanism still remains insufficiently mastered in practice (Pimonenko et al., 2021).

The resources of international financial institutions and grants from international donors are a promising source of funding for alternative energy development projects in Ukraine. The domestic government already has some experience of cooperation with the international financial institutions, business and financial institutions in the effort to increase energy efficiency. Thus, experts from the World Bank Group (IFC, EBRD, EIB, World Bank) and the US Overseas Private Investment Corporation (OPIC) are interested in alternative energy development projects in Ukraine. A number of Horizon Europe grant calls are aimed at developing the potential of alternative energy, which creates additional opportunities to attract funding in this area in the long run.

Conclusions

The development of the energy system directly affects the competitiveness of the national economy and living standards. Accordingly, economically sound and environmentally safe supply of energy resources to the country is a strategic task for each state. In summary of the systematization of scientific achievements and the results of East Germany experience we recommend:

- revising the Energy Strategy of Ukraine for the period up to 2035 «Security, energy efficiency, competitiveness» and setting new vectors of development, taking into account global trends towards carbon-neutral development of the national economy;
- considering communal property buildings (schools, colleges, universities, hospitals, kindergartens, etc.) as objects of energy independence, i.e. investing in their energy supply by installing renewable energy sources;
- promoting the principles of social and environmental responsibility in the field of energy saving and energy efficiency;
- optimizing and modifying the regulatory framework for effective control and supervision of energy service entities;
- developing municipal electric transport to improve the environment and reduce fuel dependence on other countries;
- applying sophisticated tools of financial support of green energy, including export-credit agencies, EPC-contractors, green securities, environmental investments.

The transition to renewable energy is achievable and necessary for Ukraine. Solar and wind energy have already reached the required technical and economic level for widespread implementation. At present, there is also a need to integrate domestic energy entities into international economic flows, where the role of the financial mechanisms should be decisive in terms of forming the necessary reserve of liquid financial resources for the development of Ukraine's energy sector.

Acknowledgements

This paper is prepared in the frames of project: «35th anniversary of Chornobyl disaster: preconditions for sustainable development» financed by the Omnis Religio fund. However, the support for the publication of this article does

not constitute an endorsement of the contents, which reflects the views of the authors only, and the Omnis Religio fund cannot be held responsible for any use, which may be made of the information contained therein.

References

Appunn, K. (2021). *What's new in Germany's Renewable Energy Act 2021*. Clean Energy Wire. https://www.cleanenergywire.org/factsheets/whats-new-germanys-renewable-energy-act-2021

Bódis, K., Kougias, I., Taylor, N., & Jäger-Waldau, A. (2019). Solar photovoltaic electricity generation: A lifeline for the European coal regions in transition. *Sustainability, 11*(13), 3703. https://doi.org/10.3390/su11133703

Bundesministerium für Wirtschaft und Energie. (2020). Law amending the Renewable Energy Sources Act and other energy regulations [in German]. *Bundesgesetzblatt,* Teil I, 65, 3138.

Burgermeister, J. (2009). *Germany: The world's first major renewable energy economy*. Renewable Energy World. https://www.renewableenergyworld.com/ baseload/germany-the-worlds-first-major-renewable-energy-economy/

Climate Bonds Initiative. (2019). *2018 Green Bond Market Highlights*. https://www.climatebonds.net/resources/reports/2018-green-bond-market-highlights

European Commission. (2017). Coal regions in transition platform. Platform on coal and carbon-intensive regions: Terms of reference. https://ec.europa.eu/ energy/sites/ener/files/crit_tor_fin.pdf

Gernego, Iu., & Liakhova, O. (2021). Financing the potential of alternative energy development in Ukraine [in Ukrainian]. *Efektyvna ekonomika*, *3*. https://doi.org/10.32702/2307-2105-2021.3.3

Gielena, D., Boshella, F., Sayginb, D., Bazilianc, M. D., Wagnera, N., & Gorini, R. (2019). The role of renewable energy in the global energy transformation. *Energy Strategy Reviews*, *24*, 38-50. https://doi.org/10.1016/j.esr.2019.01.006

Hansen, K., Mathiesen, B. V., & Skov, I. R. (2019). Full energy system transition towards 100% renewable energy in Germany in 2050. *Renewable and Sustainable Energy Reviews*, *102*, 1-13. https://doi.org/10.1016/j.rser.2018.11.038

Informationsportal Erneuerbare Energien. (n.d.). *Time series on the development of renewable energies in Germany* [in German]. Bundesministerium für Wirtschaft und Energie. Retrieved August 31, 2021 from https://www.erneuerbare-energien.de/EE/Navigation/DE/Service/Erneuerbare_Energien_in_Zahlen/ Zeitreihen/zeitreihen.html

Klopov, I. (2016). The mechanisms of state support for alternative energy sources [in Ukrainian]. *Problems and prospects of economics and management*, *1*, 117-124. http://ppeu.stu.cn.ua/article/view/76771

Knowledge for Policy. (n.d.). *International Renewable Energy Agency (IRENA)*. European Commission. https://ec.europa.eu/knowledge4policy/ organisation/irena-international-renewable-energy-agency_en.

Kunzig, R. (2015). Germany could be a model for how we get energy in the future. National Geographic Magazine. https://www.nationalgeographic.com/ magazine/article/germany-renewable-energy-revolution

Palzer, A, & Henning, H. (2014). A comprehensive model for the German electricity and heat sector in a future energy system with a dominant contribution from renewable energy technologies – Part II: Results. *Renewable and Sustainable Energy Reviews, 30*, 1019–34. https://doi.org/10.1016/ j.rser.2013.11.032

Pimonenko, T. V., Lyulyov, O. V., Ziabina, Ye. A., Makarenko, I. O., & Vasylyna, T. M. (2021). Forecasting of Ukrainian energy balance structure: Share of renewable energy [in Ukrainian]. *Scientific View: Economics and Management*, *4*(74), 21-27. https://doi.org/10.32836/2521-666X/2021-74-3

Pregger, T., Nitsch, J., & Naegler, T. (2013). Long-term scenarios and strategies for the deployment of renewable energies in Germany. *Energy Policy*, *59*, 350–60. https://doi.org/10.1016/J.ENPOL.2013.03.049

Saidia, K., & Omrib, A. (2020). The impact of renewable energy on carbon emissions and economic growth in 15 major renewable energy-consuming countries. *Environmental Research*, *186*, 109567. https://doi.org/10.1016/ j.envres.2020.109567

Savelyev, Ye., Kurylia, V., Lyzun, M., & Lishchynskyy, I. (2018). Analysis of Ukraine's transition to stimulating tariffs. *Journal of European Economy, 1*(17). 89-99. https://doi.org/10.35774/jee2018.01.089

Swain, R. B., & Karimu, A., (2020). Renewable electricity and sustainable development goals in the EU. *World Development*, *125*, 104693. https://doi.org/10.1016/j.worlddev.2019.104693

Ukrgasbank. (n.d.). European Green Deal [in Ukrainian]. Official Website of JSB «Ukrgasbank». Retrieved July 28, 2021 from https://www.ukrgasbank.com/ eco/epc_contr

Ukrgasbank. (n.d.). Open accreditation of EPC-contractors [in Ukrainian]. Official Website of JSB «Ukrgasbank». Retrieved August 28, 2021 from https://www.ukrgasbank.com/eco/epc_contr

Verkhovna Rada of Ukraine. (2017). Law of Ukraine on Alternative Energy Sources No. 2019-VIII of April 13, 2017 [in Ukrainian]. Vidomosti Verkhovnoii Rady Ukrainy, *27–28*, 312.

Verkhovna Rada of Ukraine. (2018). Law of Ukraine on the Electricity Market No. 2628-VIII of November 23, 2018 [in Ukrainian]. Vidomosti Verkhovnoii Rady Ukrainy, *49*, 399.

Vesolovski, T. (2019, Oct 22). *Renewable energy. Can it «recharge» Ukraine?* [in Ukrainian]. Radio Svoboda. https://www.radiosvoboda.org/a/30230756.html

Received: September 2, 2021.
Reviewed: September 7, 2021.
Accepted: September 9, 2021.