

Analysis of Greenhouse Gas and Pollutant Emission Reduction in Ukraine and European Union Countries

Stepan Mysak, Stepan Shapoval, Marta Martynyak-Andrushko *

Lviv Polytechnic National University, 12 S. Bandery St., Lviv, 79013, Ukraine

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Abstract

Following the European Green Deal, which aims to develop a closed-loop economy and reduce emissions of pollutants, Ukraine is also implementing it in its plans. Therefore, this paper analyzes and compares the reduction of CO₂, NO_x and SO₂ emissions by the European Community countries and Ukraine. Actual data on achievements in reducing emissions of the specified substances and the plans of the countries under study have been analyzed and compared. Based on the elaboration of the energy and climate plans of the countries of the European Union and Ukraine, graph-analytical dependencies have been built, based on which the actual achievements since 1990 by the countries in reducing emissions of greenhouse gases and pollutants have been analyzed. Also the plans for these data represented by the countries by 2050 have been compared.

Keywords: decarbonization; greenhouse gases; climate change; energy and climate plan.

1. Definition of the scientific problem

Because of the global climate changes associated with the 1°C temperature rise from pre-industrial levels, which have become strongly manifested recently, and the disappointing forecasts of the United Nations (UN) regarding the threats to a safe life in the near future, the countries of the world are faced with the need to implement sustainable development to meet the needs of modern life without harming future generations. Therefore, in 2016, the Paris Agreement (hereinafter referred to as the Paris Climate Agreement) was approved, signed, and later ratified by the participating countries as part of the UN Framework Convention on Climate Change (UNFCCC) to replace the Kyoto Protocol – a document on the regulation of measures to reduce the CO₂ content in the atmosphere from 2020 to keep the increase in the average global temperature at a level well below 2°C from pre-industrial level and direct efforts to limit the growth in this temperature to 1.5°C, because this will reduce the negative impact on ecosystems, health and well-being of people, which will facilitate the achievement of the UN Sustainable Development Goals. Each country determines its participation in the achievement of the global goal individually with the help of a "nationally determined contribution" to the reduction of greenhouse gas (GHG) emissions, reporting on the progress of implementation and increasing the nationally determined goal every five years.

In connection with the fulfillment of international obligations on climate change, the Government of Ukraine approved and sent to the Secretariat of the UN Framework Convention on Climate Change the Updated Nationally Determined Contribution of Ukraine to the Paris Climate Agreement, according to which [4] the country undertook that the volume of emissions GHG in CO₂ equivalent will not exceed 34.8% of the 1990 level. And the National Economic Strategy of Ukraine for the period until 2030 has determined the main goal of the economy decarbonization, its development as a circular economy, and synchronization with The European Green Deal.

* Corresponding author. Email address: marta.a.martyniak@lpnu.ua

In 2021, as part of the Treaty on the Establishment of the Energy Community, Ukraine undertook to implement the fourth energy package The Clean Energy for all Europeans (CEP) (includes EU legislation in the field of energy efficiency, RES, safety rules of electric energy supply, etc.).

The European Green Deal aims to develop a closed cycle economy (circular economy), reduce emissions of pollutants, preserve biodiversity, and economic growth separated from the use of resources.

2. Analysis of recent publications and studies related to the research problem

According to the decision of the 21st session of the UNFCCC Conference about Paris Climate Agreement in 2018, the Intergovernmental Panel on Climate Change prepared a Special Report on Global Warming of 1.5°C compared to pre-industrial levels. This report, based on the research into the causes and effects of global warming, projected that the world would warm by 1.5°C between 2030 and 2052 at current emission level, and proposed measures to combat climate change (in the energy sector – increasing energy efficiency, reducing energy consumption, reducing fossil fuel consumption, increasing the share of renewable energy sources (RES)), stressing that limiting the average global temperature requires huge changes in all areas of people lives. This called for a 45% reduction in GHG emissions by 2030 compared to 2010 and to "net zero" (residual emissions to be balanced by removing CO₂ from the air) by 2050.

In 2022, before the 27th session of the UNFCCC Conference of the Parties, the Intergovernmental Panel on Climate Change published new relevant scientific data [8]. According to this report, the current commitments of the parties to the Paris Climate Agreement will increase GHG emissions by 10.6% by 2030 compared to 2010 levels, and further increases in emissions will increase global temperatures by 2.5°C by the end of the current century. That is why the report calls for urgent action to reduce global GHGs by 43% by 2030 compared to 2019. According to the results of the conference, to achieve the Paris Climate Agreement, the governments of the countries need to update their climate plans (Nationally Determined Contributions) to take into account more ambitious goals, in particular accelerate efforts to phase out the use of coal and abandon the inefficient fossil fuel subsidy system, accelerate a clean and fair transition to the RES.

At the end of 2019, the European Commission, to fulfill the obligations of the Paris Climate Agreement, reviewed the energy policy of the European Union (EU), aimed at building an energy union that provides consumers – households and businesses – with safe, sustainable, competitive and affordable energy, and presented a large-scale program of the European of the green course (European Green Deal) – a roadmap for achieving sustainable development of the Union economy with the transformation to a carbon-neutral continent by 2050. To achieve climate neutrality, it is proposed to implement a large number of measures in all sectors of the economy, such as supporting innovations in the industry, investing in environmentally friendly technologies, expanding the use of cleaner, cheaper, and less harmful emissions from private and public transport, decarbonizing the energy sector, improving energy efficiency buildings, cooperation with international partners to raise global environmental standards. Therefore, effective use of heat-generating units [1] and effective use of alternative energy sources [2], [3] is necessary.

3. Formulation of the goal of the article

Today, Ukraine is very dependent on fossil fuels, a large part of which comes from abroad. This makes our economy very vulnerable to fluctuations in the quantity and cost of traditional energy sources. That is why one of the most important areas of energy policy is a significant increase in the use of RES. This will not only improve energy security and independence by diversifying sources of energy, but also save traditional fuel and energy resources, improve the state of the natural environment, and significantly contribute to the decarbonization of the economy to fulfill international obligations on climate change. Therefore, it is important to scientifically analyze achievements in reducing emissions of greenhouse gases and pollutants in the context of Ukrainian European realities and compare real data and plans.

4. Theoretical prerequisites

Reductions in emissions of greenhouse gases and pollutants, %, compared to 1990, were determined as the difference between the level of emissions in 1990, taken as 100%, and the level of emissions, %, in subsequent years using the equation:

$$P = \frac{C}{C_{1990}} \cdot 100, \%$$

where P is the level of emissions of greenhouse gases and pollutants, %; C is emissions of greenhouse gases and pollutants after 1990, thousands of tons; C_{1990} is emissions of greenhouse gases and pollutants in 1990, thousands of tons.

The actual values are the values of the quantities recorded by the state monitoring services in the past years, which are represented by solid lines on the graphs, predicted values are present and future values of quantities based on the adopted model of development of the state energy policy, which is depicted by dotted lines on the graphs.

The national energy strategy of each country contains several development scenarios that take into account the plan of measures to achieve the goals depending on the existing domestic and international economic situation, one of which is considered the main one. The baseline is the baseline scenario, which reflects the current situation and makes predictions with existing policies and measures, without taking into account new, more ambitious goals. The energy strategy of the Netherlands is built on the national climate and energy policy, which, according to the Climate Act, is published annually in the Climate and Energy Report (KEV) [9] and provides that the climate and energy plan should be drawn up every five years and contain the main priorities of the climate policy for the next ten years. The energy strategy of Germany adopted a development model – Climate Action Plan – a scenario of an action plan on climate change [10], [11], in France – Avec Mesures Supplémentaires (AMS) – a scenario with additional measures [12], in Poland – Balanced increase of CO₂ emission allowance prices – a scenario of a balanced increase in prices for CO₂ emissions [13], in Ukraine – according to [4], a scenario that takes into account the planned growth rates of the economy specified in the National Economic Strategy for the period until 2030 and other sectoral strategic documents, and in terms of reducing GHG emissions, it is close to the optimistic prognostic scenario.

5. The main text of the article

Following the Energy Strategy of Ukraine for the period until 2035 "Security, Energy Efficiency, Competitiveness", in Ukraine the problem of decarbonization and reduction of pollutant emissions is planned to be solved by reducing the energy intensity of the country's GDP, the general reduction of the volume of PPE, the partial decommissioning of thermal power plants, the introduction of a trading system quotas for greenhouse gas emissions, the introduction of restrictions for the largest sources of greenhouse gas emissions, legislative provision of financing mechanisms for investment projects in the construction of gas cleaning equipment.

Emissions of GHG and polluting substances were determined without taking into account the sector of land use, changes in land use, and forestry.

The Integrated National Energy and Climate Plans for 2021–2030, which each EU country submits to the European Commission for review and control reporting on progress every two years and, according to the European Climate Law, updating every five years, set out how each country intends to solve five main issues: diversifying European energy sources and ensuring energy security, building an integrated internal energy market, improving energy efficiency, implementing the Paris climate agreement, prioritizing research and innovation to stimulate the energy transition and increase competitiveness.

At the end of 2020, the European Commission, based on a comprehensive assessment of the impact of social, economic, and environmental consequences, guided by the realism of implementation, on the eve of the 26th session of the Conference of the Parties to the UNFCCC, amended the proposed European Climate Law and presented a plan to reduce GHG emissions, as a new EU Nationally Determined Contribution of at least 55% by 2030 compared to 1990 levels. This level of ambition will ensure a balanced path to climate neutrality by 2050.

First, the realized and planned reduction of GHG emissions compared to 1990 was analyzed (Fig.1).

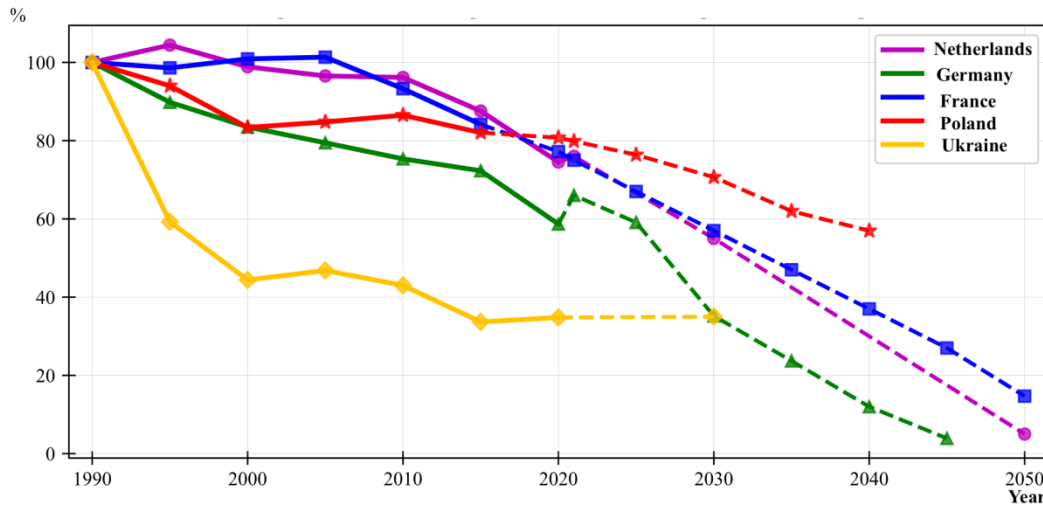


Fig. 1. Relative reduction of greenhouse gas emissions, %, in Ukraine and EU countries from the 1990 level.

For the Netherlands, Germany, France, and Poland, the actual values of GHG emissions were obtained from [14], and the predicted values from [9], [11], [12], and [13], respectively. For Ukraine, actual data for 1990–2015 were obtained from [5], for 2020 – from [6], and projected data – from [4].

Fig. 1 shows that from 1990 to 2020, the largest reduction in GHG emissions was recorded in Ukraine. The reasons for this were the decline of the industry after the collapse of the USSR, deep economic crises, and military operations in Donbas. According to [4], in 2030, the national goal for reducing greenhouse gas emissions is 34.8% from the volume of 1990. At the same time, the level of GHG emissions will remain constant from 2020 with a projected slight increase in energy consumption in the economy. Because of this, the nationally determined goal is assessed by international researchers as insufficient and therefore contradicts the Paris climate agreement. If, in addition to the implementation of changes to the current legislation, there are no structural changes in energy and the economy, the end of hostilities, no significant further reduction will occur.

The best indicators of GHG reduction in the long term are predicted in Germany, which, according to [11], thanks to decisive energy measures, plans to reduce emissions by 65% in 2030, by 88% in 2040, and become climate neutral by 2045 keeping greenhouse gas emissions at 3.9% compared to 1990. France plans to cut 43% by 2030, 63% by 2040, and reach climate neutrality by 2050, projecting greenhouse gas emissions at equal to 14.7% compared to 1990.

GHG emissions reduction in the Netherlands is similar to the French climate plan. Currently, the government, under the Paris Climate Agreement, only declares that the country will become climate neutral by 2050, with a final emission level of 5% compared to 1990, but neither [15] nor [9], the strategies developed under the Climate Action Act adopted in 2019, predicted it in detail. It is expected that GHG emissions in the Netherlands will be reduced by 39-50% in 2030 compared to 1990. This means that the government's 55% reduction target, which is also proposed by the Fit for 55 packages of legislative initiatives, is currently not expected to be met, as this requires faster implementation and tougher policy, which has not yet been developed in detail in [9].

Until the 2000s, Poland was also one of the leaders in reducing GHG emissions and achieved a reduction of 16.6%, which, like in Ukraine, is associated with a significant reduction in industry after the collapse of the USSR. But after joining the EU, with significant economic growth and the resulting increase in industrial production and energy consumption, emission reductions slowed down and even started to increase slightly, reaching a reduction of 13.5% in 2010.

Today and in the future, according to forecasts [13], Poland will remain the leader in terms of GHG emissions, with plans to reduce emissions by 29.3% in 2030 and 43% in 2040, reaching a final emission level of 57% compared to 1990, which is mainly related to the significant use of coal and natural gas in the energy sector.

Next, the realized and planned reduction of CO₂ emissions compared to 1990 was analyzed (Fig.2)

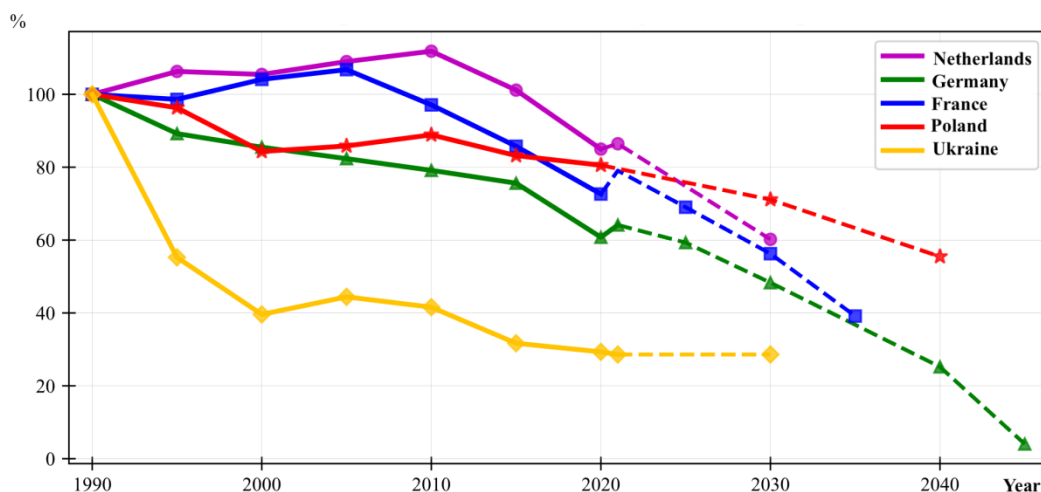


Fig. 2. Relative reduction of CO₂ emissions, %, in Ukraine and EU countries from the 1990 level.

For the Netherlands, Germany, France, and Poland, the actual values of CO₂ emissions were obtained from [14]. Projected data for the Netherlands, France, and Poland – from [9], [12], and [13], respectively, and for Germany, due to the absence of such data, but almost the same share of CO₂ among greenhouse gas emissions throughout the observation period from 1990 – by multiplying by 0.85 (the coefficient defined as the arithmetic mean of the ratio of CO₂ emissions to GHG emissions for the last relevant years) of the projected data of GHG emissions from [11]. For Ukraine, actual data for 1990-2015 were obtained from [5], for 2020 – from [6], and projected data – from [4].

From Fig.2, it is noticeable that the reduction of CO₂ emissions is similar to the graphs in Fig.1, with a slight decrease in emission reductions by the Netherlands, which plans to reduce emissions by 39.8% compared to 1990.

In the absence of projected data for Germany, these data were determined as corresponding data of greenhouse gas emissions with [11] multiplication by 0.85 – the average share of CO₂ in greenhouse gases in recent years. Germany plans to achieve a reduction of 51.7% by 2030, 74.8% by 2040, and 96% by 2050 compared to 1990.

France projects to cut CO₂ emissions by 43.7% by 2030 and 61.8% by 2035 compared to 1990. Poland, since its economy is not as powerful as in developed European countries, cannot afford decisive measures to modernize industry, and energy facilities and build new clean energy production facilities and is forced to declare emissions reductions of 29.9% by 2030 and 35.5% by 2040 compared to 1990 values.

For Ukraine, the reduction of CO₂ is similar to the reduction of GHG emissions in Fig.1. It is projected to reduce carbon dioxide emissions by 71.4% by 2030 compared to 1990 emissions.

Then an analysis of NO_x emissions' actual and planned reduction compared to 1990 was performed (Fig.3).

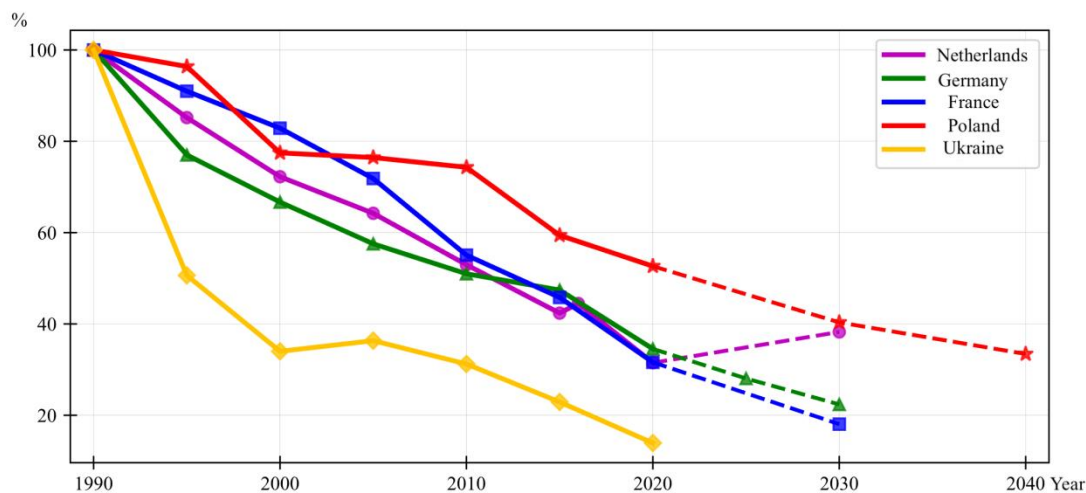


Fig. 3. Relative reduction of NO_x emissions, %, in Ukraine and EU countries from the 1990 level.

For the Netherlands, Germany, France, and Poland, the actual values of NO_x emissions were obtained from [16], and the predicted data – from [15], [10], [12], and [13], respectively. For Ukraine, the actual data for 1990–2015 were obtained from [5], for 2020 – from [7], and forecasted data that would cover all sectors of the economy, except for non-commercial enterprises, are not available.

Fig.3 shows that the reduction of NO_x emissions for Ukraine is the largest, which is associated with a significant reduction in the economy (a decrease in industrial production and energy consumption) during a deep economic crisis, and in 2020 it reduced emissions by 86.1% compared to 1990. The German and French economies plan to achieve similar reductions of 77.6% and 82%, respectively, by 2030 compared to 1990. Due to its heavy use of fossil resources, Poland plans to reduce them by 59.7% in 2030 and 66.6% in 2040. The Netherlands plans to reduce them by 61.8%.

Projected NO_x emissions for the Netherlands are in the Integrated National Energy and Climate Plan 2021-2030, in which according to [14, table. 5.2], and, excluding emissions from GHG, in 2016 amounted to 297.7 thousand tons, and in 2030 will amount to 256 thousand tons, which is more than the actual data in Eurostat, which, according to [16], in 2015 were 283.6 thousand tons, and in 2020 - 210.8 thousand tons. That is why there is a jump-like change in NO_x emissions, which from 2015 to 2020 will decrease by 10.9%, and in the next ten years emissions increase by 6.7%.

To correct the situation in Ukraine, the Climate Law of Ukraine is being finalized, which will cover all directions in the sphere of formation and implementation of Ukraine's climate policy. Also, with the support of international partners, new documents are being developed:

- Comprehensive National Energy and Climate Change Plan for 2021-2030 – a document that includes reporting on current plans and strategies, analyzes their impact according to the five dimensions of the Energy Union, covers the period until 2030, and contains a forecast until 2050.
- Ukraine's low-carbon development strategy for the period until 2050 is a long-term strategy for 2050, which will include new government goals for fulfilling the obligations of the Paris Climate Agreement.

In Ukraine, the assessment of projected GHG emissions and pollution is considered in the “Report on the determination of the second national determined contribution of Ukraine to the Paris Climate Agreement” [4], and the projected use of renewable energy sources is a project dated September 21, 2022, “On the National Action Plan for the Development of Renewable Energy for the Period until 2030”, which does not yet take into account the intention to achieve 50446 thousand tons by 2030 (17.1% reduction) in total final energy consumption, as stated in the National Energy Efficiency Action Plan to 2030 approved by the government in late 2021.

Finally, the implemented and planned reduction of SO₂ emissions compared to 1990 was analyzed (Fig.4).

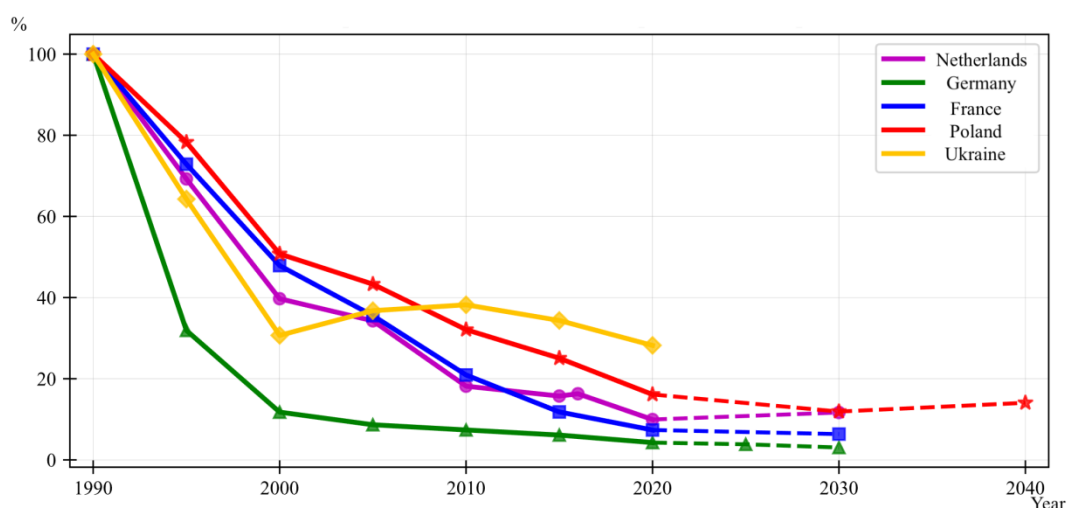


Fig.4. Relative reduction of CO₂ emissions, %, in Ukraine and EU countries from the 1990 level.

For the Netherlands, Germany, France, and Poland, the actual values of SO₂ emissions were obtained from [16], and the predicted data – from [15], [10], [12], and [13], respectively. For Ukraine, the actual data for 1990–2015 were obtained from [5], for 2020 – from [7], and forecasted data that would cover all sectors of the economy, except for non-residential enterprises, are not available.

Fig.4 shows that EU countries have taken strong measures to reduce SO₂ emissions by 2020, achieving significant reductions compared to 1990 by 95.7% in Germany, 92.6% in France, 90.1% in the Netherlands, and 83.9% in Poland. Germany plans to cut emissions by 97% by 2030, France by 93.6%, the Netherlands by 88.3%, Poland by 88.1% and 88.3% by 2040.

6. Conclusion

Unlike Ukraine, the EU imposes strict rules on reducing greenhouse gas emissions, introducing high carbon taxes, and reforming its Emissions Trading Scheme (EU ETS) to give industry an incentive to modernize. Moreover, member countries' support of the European Green Deal initiative and a flexible credit system (grants to compensate part of the funds for the purchase of energy-efficient equipment or optimization of technological processes) allows for attracting financing on favorable terms.

Ukraine is a leader in reducing CO₂ compared to 1990 emissions due to a shrinking economy in times of deep crisis, so it projects a 71.4% reduction in emissions by 2030. In Ukraine, despite the reduction in industrial production and energy consumption, the level of SO₂ emissions remains the highest and in 2020 is 28.2% of the level of emissions in 1990.

According to the Energy Strategy of Ukraine for the Period until 2035 "Security, Energy Efficiency, Competitiveness" the current level of emissions of pollutants (NO_x, SO₂, dust) exceeds the European Union standards by an average of 7-80 times depending on their type, which is planned to be reduced to the European level for SO₂ and dust by 2028, and for NO_x by 2033.

References

- [1] Pistun Y., Mysak S., Kovalenko T., Lys S. (2017) Development of the analytical method for determining the armor wear of the drum ball mill. *Eastern-European Journal of Enterprise Technologies*, **5(1-89)**, 45-50. doi: 10.15587/1729-4061.2017.109629.
- [2] Mysak, Y., Pona, O., Shapoval, S., Kuznetsova, M., Kovalenko, T. (2017) Evaluation of energy efficiency of solar roofing using mathematical and experimental research. *Eastern-European Journal of Enterprise Technologies*, **3(8-87)**, 26-32. doi: 10.15587/1729-4061.2017.103853.
- [3] Venhryn, I., Shapoval, S., Voznyak, O., Datsko, O., Gulai, B. (2021) Modelling of optical characteristics of the Thermal Photovoltaic Hybrid Solar Collector. *International Scientific and Technical Conference on Computer Sciences and Information Technologies*, **1**, 255-258.
- [4] Ukraine Ecology and Natural Resources Ministry. Ukraine 2050 Low Emission Development Strategy 2018. Report on the determination of the second national determined contribution of Ukraine to the Paris Climate Agreement. Center for Economic Recovery (UBTA). Kyiv, June 2021(in Ukrainian); https://ubta.com.ua/files/20210713/Annex_1.pdf (accessed on: 2023-03-15)
- [5] Ukraine's Greenhouse Gas Inventory 1990-2016. Ministry of Ecology and Natural Resources of Ukraine. Kyiv – 2018.
- [6] H.Ritchie, M. Roser (2020) Our World in Data. Ukraine: CO₂ Country Profile. <https://ourworldindata.org/co2/country/ukraine> (accessed on: 2023-03-15)
- [7] Ukrstat. Emissions of pollutants into the atmospheric air of Ukraine. (in Ukrainian)https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fukrstat.gov.ua%2Foperativ%2Foperativ2020%2Fns%2Fns_rik%2Fvzr_apU_90_20_ue.xlsx&wdOrigin=BROWSELINK (accessed on: 2023-03-15)
- [8] Climate Change 2022: Mitigation of Climate Change. Technical Summary. IPCC, 2022. https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_TechnicalSummary.pdf (accessed on: 2023-03-15)
- [9] Climate and Energy Outlook 2022. PBL Netherlands Environmental Assessment Agency. The Hague, 2022. PBL publication number: 4838. (in Dutch)
- [10] Integrated National Energy and Climate Plan. Germany , https://www.bmwi.de/Redaktion/DE/Downloads/I/integrierter-nationaler-energie-klimaplan.pdf?__blob=publicationFile&v=1 , (accessed on 2023-03-23)
- [11] Update to the long-term strategy for climate action of the Federal Republic of Germany. https://unfccc.int/sites/default/files/resource/Anlage_2_Update_to_the_long-term_strategy_for_climate_action_of_the_Federal_Republic_of_Germany_02Nov2022_0.pdf, (accessed on 2023-04-21)
- [12] Integrated National Energy and Climate Plan for France. March 2020, https://www.ecologie.gouv.fr/sites/default/files/PNIEC_France_mars_2020.pdf , (accessed on 2023-03-17)
- [13] Eurostat. Energy Policy of Poland until 2040. Appendix 2. Conclusions from forecast analyses for the energy sector. Ministry of Climate and Environment, <https://www.gov.pl/web/climate/energy-policy-of-poland-until-2040-epp2040> , last accessed 2023-03-26

- [14] Greenhouse gas emissions by source sector (source: EEA).
https://ec.europa.eu/eurostat/databrowser/view/ENV_AIR_GGE_custom_4885837/default/table?lang=en (accessed on: 2023-03-15)
- [15] Integrated National Energy and Climate Plan 2021-2030 The Netherlands. Colophon. November 2019, Version 0.4 final version. Ministry of Economic Affairs and Climate Policy.
- [16] Eurostat. Air pollutants by source sector (source: EEA).
https://ec.europa.eu/eurostat/databrowser/view/ENV_AIR_EMIS_custom_4885966/default/table?lang=en (accessed on: 2023-03-15)

Аналіз скорочення викидів парникових газів і забруднюючих речовин в Україні та країнах Європейського Союзу

Степан Мисак, Степан Шаповал, Марта Мартиняк-Андрушко

Національний університет "Львівська політехніка", вул. Степана Бандери, 12, м. Львів, 79013, Україна

Анотація

Відповідно до Європейського зеленого курсу, який ставить за мету розвиток економіки замкненого циклу та зменшення викидів забруднюючих речовин, Україна також імплементує це в свої плани. Тому в даній роботі було проаналізовано та співставлено скорочення викидів CO₂, NO_x, SO₂ країнами Європейської Спільноти та Україною. Проаналізовано фактичні дані, щодо досягнення по зниженню викидів зазначених речовин, а також співставлено плани досліджуваних країн. На основі опрацювання енергетичних та кліматичних планів країн Європейського Союзу та України було побудовано графічні залежності, на основі яких було проаналізовано фактичні досягнення з 1990 року країнами по зменшенню викидів парникових газів та забруднюючих речовин, а також співставлено плани, щодо цих даних представленими країнами до 2050 року.

Ключові слова: декарбонізація; парникові гази; зміни клімату; енергетичний та кліматичний план.