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REVIEW OF THE EUROPEAN EXPERIENCE OF AIC DEVELOPMENT AND THE ROLE OF GREEN TECHNOLOGIES IN THE MODERNISATION OF THIS PROCESS

Inna Honcharuk[1], Dina Tokarchuk[2]

Abstract. The relevance of the study is due to the need to adapt the agro-industrial complex (AIC) to modern challenges, in particular environmental and economic, to ensure its sustainable development. Studying the European experience of AIC development and the introduction of green technologies opens up opportunities for modernising the industry and increasing its efficiency in the face of global change. *The purpose* of the study is to examine the experience of European countries in the development of the AIC, to identify the main trends and to determine the place of green technologies in the modernisation of production. The object of the study is the agro-industrial complex of European countries, as well as the processes of modernisation of this sector, which are taking place through the introduction of modern green technologies, innovative practices, as well as the adaptation of European approaches to ensuring sustainable and efficient development of the agricultural sector in the face of global challenges and environmental constraints. *The research methodology* is based on systemic, comparative and analytical approaches that provide a comprehensive analysis of the agro-industrial complex in the context of its modernisation. The theoretical framework includes: a systemic approach that considers the agro-industrial complex as an integral interconnected system operating in an economic, social and environmental environment; a comparative method that provides an analysis of the European experience in implementing green technologies, with an emphasis on adapting these approaches to other conditions, identifying best practices and assessing the possibilities of their application for the modernisation of the industry; an environmental approach that studies the impact of implementing green technologies to reduce the negative impact of agricultural activities on the environment. The analysis of the main characteristics of EU agriculture in 2019-2023 showed that labour productivity in the sector is growing annually, while real factor income varies by year. The growth of agricultural production along with a decrease in CO_2 emissions indicates the application of environmental measures, however, the share of the industry in the total European emissions is growing, which confirms the need for its modernisation on a green basis. The authors systematise the main areas of green technologies in the AIC. The study showed that EU countries are actively implementing various effective models of green business in the agricultural sector, with the mainstream being the creation of green clusters, the development of green energy and the production of organic products. The study of the development of green energy in the European AIC has identified biogas and biomethane production as the fastest growing sectors; countries such as Denmark and Sweden have already replaced more than 25% of natural gas consumption in 2022. The analysis of the development of organic production showed an increase in the area under organic production (by 5.7% annually in 2012-2020) and an increase in the volume of organic production. Based on the study of EU programmes and initiatives related to the use of green technologies in the agricultural sector, the article summarises that they are aimed at reducing greenhouse gas emissions, developing organic production, increasing the efficiency of natural resources use, expanding the production and use of renewable energy sources in the agricultural sector, preserving biodiversity and introducing innovations for sustainable agricultural development. The analysis of the CAP 2023-2027 showed an intensification of the environmental direction of the industry's development

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to comply with the European Green Deal. Thus, green technologies are becoming an integral part of the development of the AIC in European countries and their use is being stimulated through financial instruments and regulatory frameworks.

Keywords: AIC, CAP, green technologies, greenhouse gases, organic production, green energy, biogas, biomethane.

JEL Classification: O13, *Q57*

1. Introduction

Agriculture is a key industry for the survival of humanity, providing food and raw materials for various industries. Agricultural production ensures a steady supply of food that sustains billions of people around the world. Over the years, technological advances in agriculture have led to significant increases in productivity, allowing for more crops to be harvested from less land through intensified production.

Agriculture has a huge impact on the environment, as food production is associated with high levels of greenhouse gas emissions. This applies not only to the agricultural activity itself, but also to all stages – from growing crops and animals to transporting the products to consumers. The intensive use of chemical fertilisers, pesticides and herbicides, as well as irrigation and other methods of land cultivation, can degrade the quality of soil and water resources and lead to the loss of biodiversity. Transporting food over long distances further increases CO_2 emissions, as it uses large amounts of fuel. All of these factors contribute to global warming and climate change, which has long-term consequences for the planet, including rising temperatures, changes in weather patterns, deteriorating soil fertility and threats to food security.

European countries are actively developing the agricultural sector, but they are not ignoring environmental concerns by implementing sustainable development strategies and green technologies, including reducing greenhouse gas emissions, moving to organic farming, developing precision agriculture, preserving biodiversity and increasing the efficiency of resource use, including water and soil. These initiatives help reduce the negative environmental impacts of agricultural activities while supporting food security and economic growth in the region.

Researchers are focusing on green technologies as a component of the green economy, as they help reduce the negative impact on the environment, use resources more efficiently, and contribute to the transition to sustainable development. Such technologies help reduce greenhouse gas emissions, improve air, water and soil quality, as well as create new jobs and stimulate the development of environmentally responsible production and services.

Scientists agree that the green economy is a change in the way people think about development and growth that can improve people's lives and the environment, and contribute to environmental and economic sustainability (Zhang et al., 2022; Tucci & Battisti, 2020; Guo et al, 2021).

The green economy is seen as a source of economic growth and a way to improve people's lives and well-being, and to promote environmental and social well-being, and one of the important components of the green economy concept is the promotion of sustainable technologies (Söderholm, 2020).

The green economy is based on the use of renewable energy and fuel sources, environmentally friendly production technologies, environmentally friendly agricultural practices, green construction, as well as programmes that improve air, water and soil quality through pollution reduction, waste recycling and disposal, and so forth (Bondarenko et al, 2023).

The analysis (Kovalchuk, Kravchuk, 2019) identifies the essence of green transformations of the agricultural sector on the example of Eastern European countries, which indicates the regularity of the inclusion of the environmental factor in the system of key socio-economic indicators of development.

The researchers (Okhota, Chikov, Bilokinna, 2024) studied the innovative potential of agricultural production and substantiated the achievement of a cumulative effect from the effective use of innovative and energy potentials. Thus, green technologies are justifiably becoming part of the innovative development of agricultural enterprises.

Scientists have considered various aspects of the development of green technologies in the agricultural sector: growing bioenergy crops (Mazur et al., 2023), using the bioenergy potential of agricultural waste (Honcharuk et al., 2024a; Honcharuk et al., 2024b), developing organic production (Klimczuk, Klimczuk-Kochańska, 2020), and green cooperatives (Shpykuliak, Bilokinna, 2019).

However, most studies on the development of green technologies are narrowly focused. There is a need to summarise the experience of AIC development on the example of European countries and identify which green technologies are the mainstream in the agricultural sector.

2. Results and Discussions

In terms of trade balance, the EU is the world's first exporter and third importer of agri-food products. Over the past 5 years, the EU's agricultural trade surplus has increased by 9.4 billion EUR. The EU mainly imports raw materials, such as corn or soybeans, while the bulk of its exports are high value-added products. Increased costs and changes in demand for agricultural products were driven by the COVID-19 pandemic and Russia's unprovoked invasion of Ukraine, which negatively affected the trade balance in 2022.

In 2019-2023, the real value of agricultural products increased by 38 billion EUR; the gap between farmers' income and the average wage in the EU economy decreased by 10%; the share of the area under organic farming increased to 10%; and more than 500 agricultural research projects were supported.

After analysing the volume of greenhouse gas emissions associated with agriculture against the value of agricultural production, it was concluded that despite the fact that agricultural production increased, emissions decreased. This shows that the increase in production was not realised at the expense of increased emissions (Table 1).

Greenhouse gas emissions contribute to global warming. The European Green Deal's goal of reducing emissions by 55% by 2030 also affects the agricultural sector, as it accounts for around 13% of total emissions. Emissions in absolute terms decreased by about 32% between 1990 and 2022, while the share of agriculture in total emissions remained roughly the same (Figure 1).

Since the share of agriculture in total emissions remained almost unchanged between 1990 and 2022, this indicates that agriculture, compared to other sectors of the economy, is working at an insufficient pace to reduce greenhouse gas emissions and has an untapped reserve. In the EU as a whole, the agricultural sector accounts for about 13% of total emissions, but in some EU countries this share is lower – Belgium, the Czech Republic, Germany, Croatia, Italy, Cyprus, Luxembourg and others. Moreover, in some EU countries, the share of emissions from agriculture is almost twice the European level – Denmark, Latvia, Lithuania, Romania, and others. These are the countries that should primarily increase the pace of reducing emissions from agriculture (Figure 2).

To overcome environmental challenges, such as greenhouse gas emissions, soil degradation, water pollution, which threaten sustainable development and environmental safety in the context of increased regulatory control and growing demand for environmentally friendly products, the agricultural sector in European countries has begun to apply green technologies.

Green technologies are defined as a set of innovative technologies aimed at reducing the negative anthropogenic impact on the environment. The main goal of green technologies is to conserve natural resources, reduce pollution, increase energy efficiency and promote sustainable development. These include environmentally friendly energy sources (bioenergy, solar, wind, and hydropower), waste management technologies, biotechnology, greenhouse gas emission reduction solutions, and other methods that contribute to environmental safety and preservation of the planet for future generations.

Green technologies in the agricultural sector are environmentally friendly methods and innovations used to increase the efficiency of agricultural production with minimal impact on the environment. Their goal is to ensure sustainable agricultural development by preserving natural resources, improving soil quality, and reducing waste and emissions.

The main areas of green technologies in the AIC include: organic farming, precision farming systems, biotechnology, alternative energy sources and

Table 1
Key characteristics of EU agriculture in 2019-2023

Indicator	Year				
	2019	2020	2021	2022	2023
Trade balance of agri-food products, billion EUR	60,06	62,90	67,97	57,31	70,01
Labour productivity in agriculture, EUR/AWU	20695,85	22441,32	23788,19	28808,59	29461,20
Agricultural factor income (real), million EUR	161332	154317	158481	175312	159737
Area under organic farming, 1000 ha	13799	14724	-	-	-
Energy use in agriculture and forestry, 1000 tonnes of oil equailent, kToe	28083,9	28391,5	28651,1	26836,6	-
Production of renewable energy from agriculture and forestry, 1000 tonnes of oil equailent	27329	27064	27265	-	-
Emissions from agriculture, 1000 tonnes of CO_2 equailent	405111	402920	401945	394930	-
GHG emissions per Euro produced (emissions/€), kg CO_2 equailent /EUR	1,06	1,08	1,01	0,89	-

Source: Agri-food Data Portal, 2024

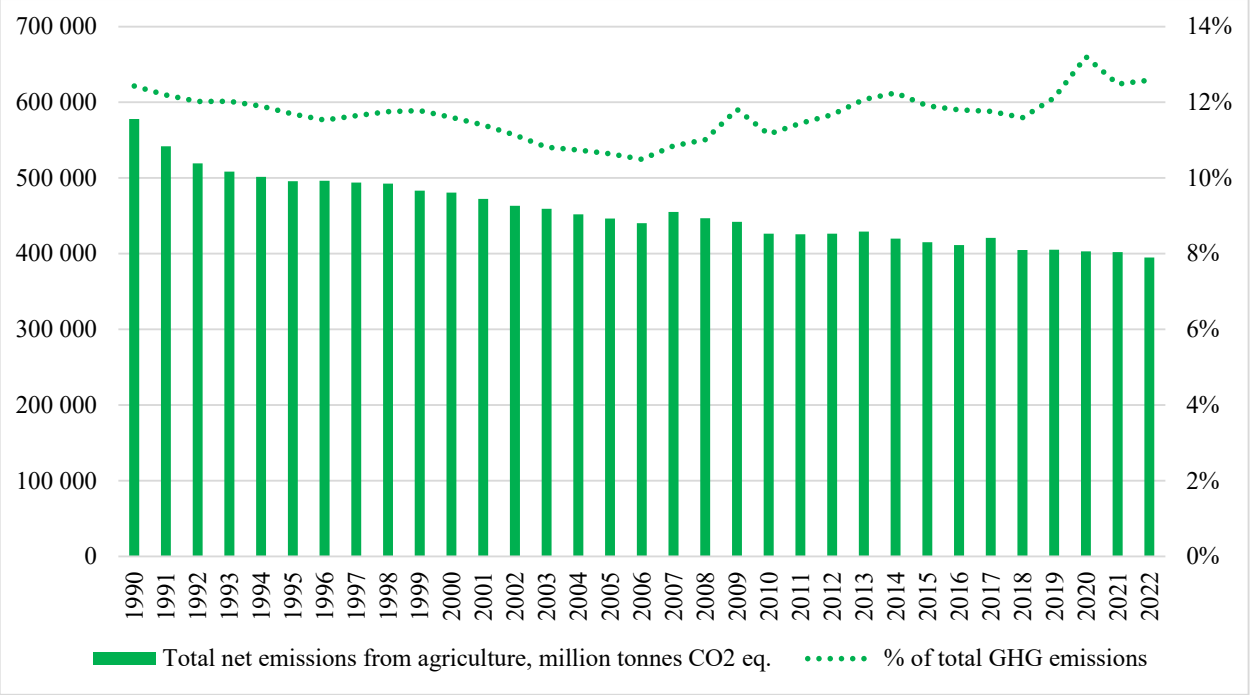

Figure 1. Greenhouse gas emissions in the AIC in 1990-2022, million tonnes of CO_2 equivalent

Source: Agri-food Data Portal, 2024

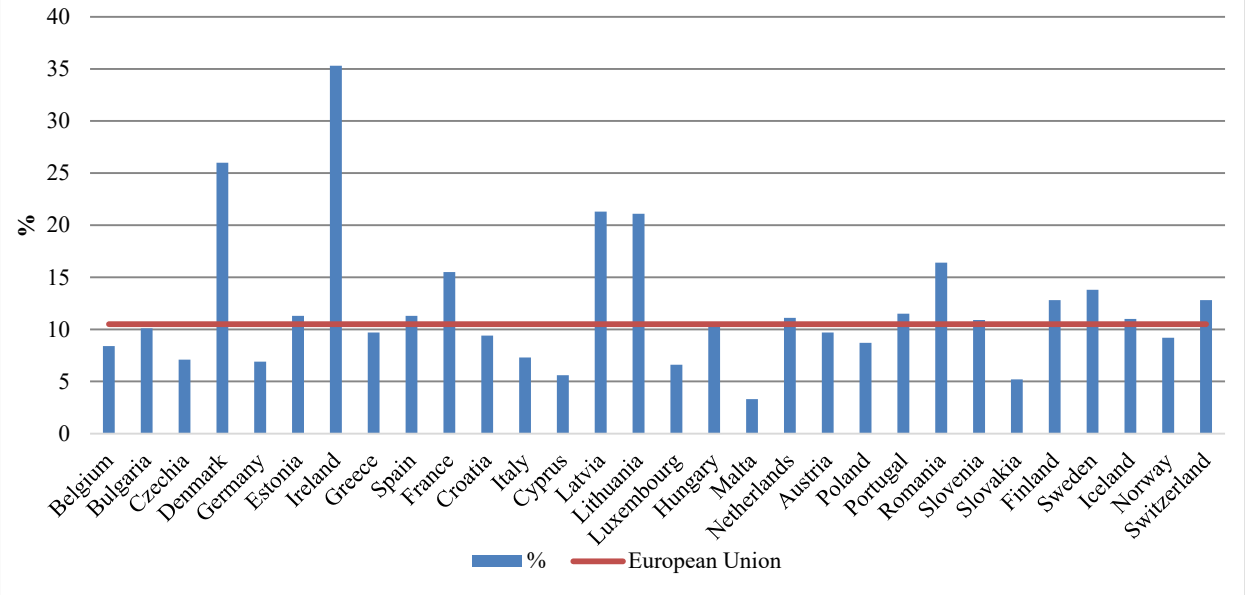

Figure 2. Share of greenhouse gas emissions from the AIC in the structure of emissions in the EU countries in 2022, %

Source: Eurostat, 2024

production and use, waste disposal and recycling, agroforestry and protective forest belts, and water-saving technologies (Figure 3).

The use of green technologies in the AIC not only contributes to environmental sustainability, but also helps farmers cut costs, improve product quality and preserve land fertility in the long term.

Green practices that farmers can apply depending on the EU Member State include, for example, green technologies, soil conservation, biodiversity protection, organic farming, and so on (European Council, 2024).

The EU countries currently practice various forms of green business in the agricultural sector: the formation of green clusters; the development of green energy

(including the production and use of biofuels); organic agricultural production, etc.

A common option for green business development in the EU is the creation of green clusters. Clusters often operate on the principle of an open innovation ecosystem approach, which means that all participants can share knowledge and technology to accelerate sustainable solutions. Such networks also work on international cooperation to support global initiatives related to climate change, CO_2 emissions reduction and the transition to a circular economy.

Examples of such clusters include the Green Tech Valley in Austria, the Green Tech Hub in Germany, or the Energy Cluster Denmark in Denmark, which bring together companies that develop technologies to conserve resources and reduce negative environmental impact (Table 2).

In the EU, green energy is an important component of ensuring environmental sustainability and the introduction of green technologies. In the context of the agricultural sector, bioenergy is a key area of green energy development, as agricultural enterprises can be both suppliers of raw materials and producers of various types of biofuels.

Biogas production occupies a special position in green technologies, as it allows for the efficient processing of organic waste, reduces methane emissions, produces clean energy and reduces dependence on fossil fuels. Biogas technologies contribute to the development of a circular economy, as waste is turned into a resource, and the residues from biogas production can be used as fertiliser, improving soil fertility.

The analysis of the raw materials for biogas production used by European countries showed that agricultural raw materials are the main ones (Figure 4).

In particular, in 2022, agricultural raw materials accounted for 67% of the structure of raw materials for biogas production, followed by raw materials from solid waste landfills – 13%.

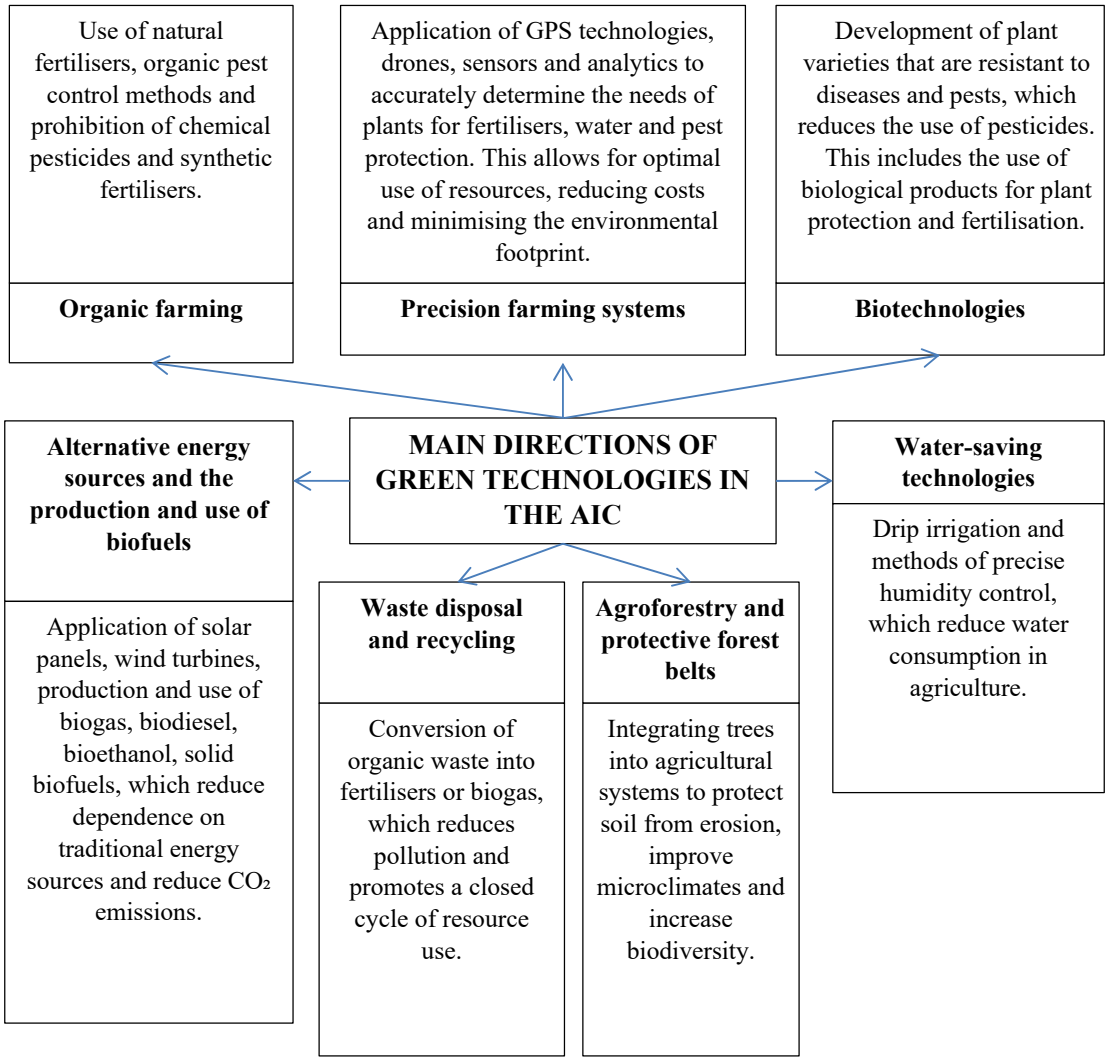

Figure 3. Main directions of green technologies in the AIC
Source: compiled by the authors

Table 2
Characteristics of selected green clusters in EU countries

Cluster	Members and participants	Projects and innovations
Green Tech Valley (Austria)	It brings together more than 200 participants, including more than 150 companies, as well as universities, research institutes, start-ups and local governments.	Numerous national and international projects are being implemented within the cluster, including EU programmes such as Horizon Europe. One of its main goals is to integrate green technologies into everyday life and production, involving both innovative start-ups and large corporations.
Energy Cluster Denmark (Denmark)	It brings together more than 350 organisations, including companies, start-ups, research institutes and government agencies.	The cluster is actively involved in international and national projects funded through Horizon Europe, national investment programmes, and private investment. One important initiative is the Power-to-X programme, which focuses on converting excess electricity into other forms of energy, such as hydrogen or synthetic fuels, for use in various sectors of the economy.
Green Net Finland (Finland)	It unites more than 100 members, including more than 70 green technology companies and start-ups, as well as research institutes and local governments.	The cluster is actively involved in numerous projects, such as Interreg, EIT Climate-KIC and Horizon Europe, and organises cooperation between businesses and research organisations to create new technological solutions. The projects often involve research, pilot programmes, technology testing, and the development of standards for sustainable development.

Source: summarised by the authors on the basis of (Smerichevska, 2020)

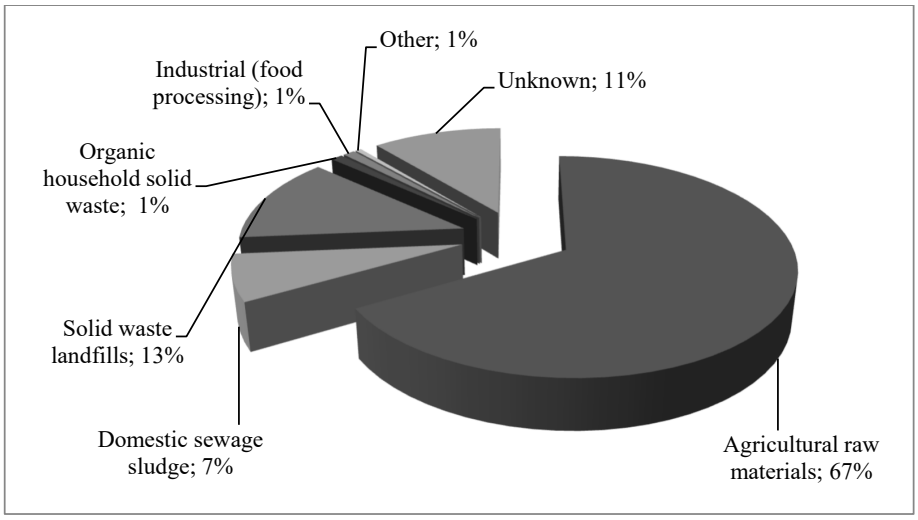

Figure 4. Share of biogas production in Europe from different types of raw materials, 2022

Source: EBA Statistical Report, 2023

Biogas and biomethane production in Europe shows a steady upward trend. In particular, in 2022, 16.8 bcm of biogas was produced, which is 1.3 bcm more than in 2018 and 10.0 bcm more than in 2011 (Figure 5).

Another trend in European countries is the increase in the production of bomethane, a purified biogas. After being purified from impurities, biomethane has a chemical composition almost identical to natural gas, which allows it to be used in the existing gas infrastructure without additional modifications. This reduces transportation and storage costs and makes biomethane compatible with existing supply systems. In contrast to biogas, biomethane can be effectively used not only for electricity and heat production, but also as an environmentally friendly transport fuel, significantly reducing carbon dioxide emissions. Due to its high degree of purification, biomethane has stable combustion characteristics, making it suitable for a wide range of applications.

While European countries produced only 0.5 billion cubic metres of biomethane in 2011, this figure increased to 2.1 billion cubic metres in 2018 and 4.2 billion cubic metres in 2022.

Biogas and biomethane are already partially replacing traditional energy sources in energy consumption. The analysis of the share of natural gas replacement by these types of biofuels in 2022 in European countries is shown in Figure. The leaders in the use of biogas technologies are Denmark, which replaced 29% of the natural gas base with biogas/biomethane, and Sweden – 26%, respectively (Figure 6).

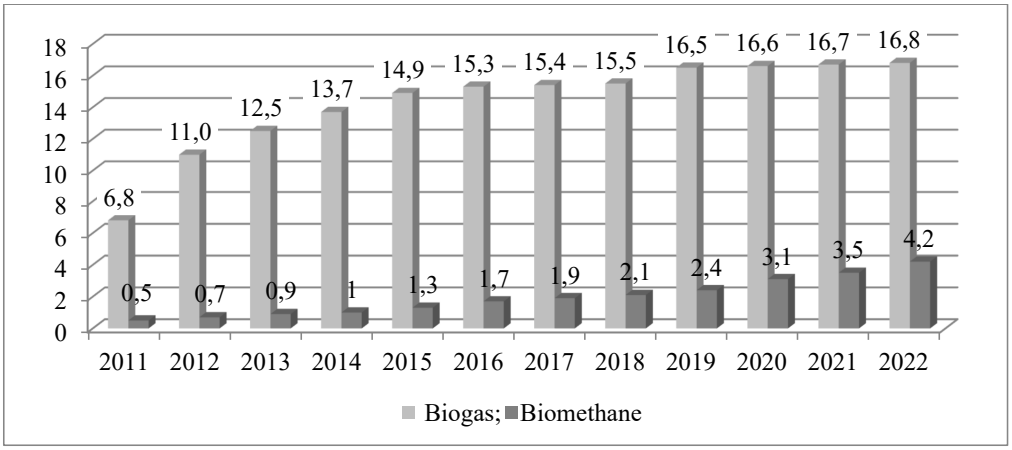

Figure 5. Biogas and biomethane production in Europe, 2011-2022, bcm/year

Source: EBA Statistical Report, 2023

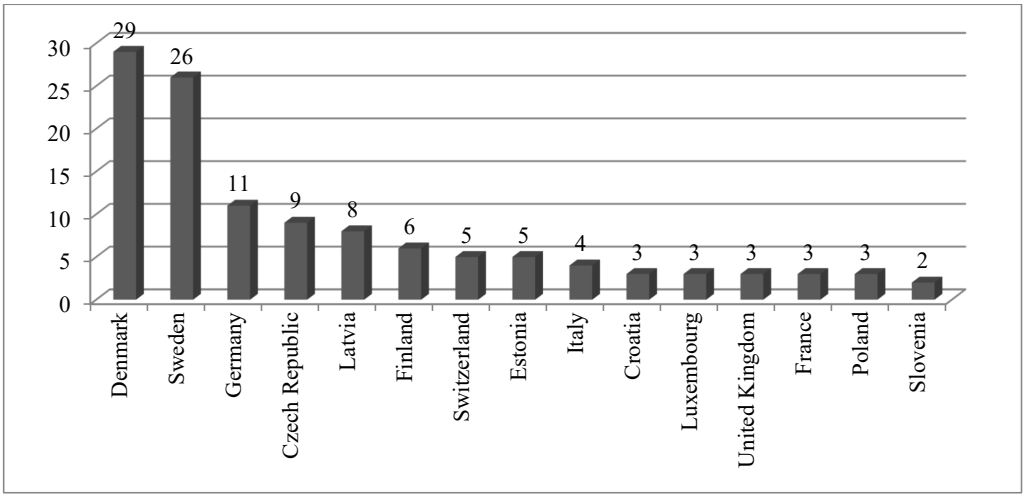

Figure 6. Percentage of biomethane utilisation relative to total gas consumption in 2022, in 15 European countries, %

Source: EBA Statistical Report, 2023

Organic production is another important component of the green technologies being introduced in the agricultural sector by European countries.

Sustainable agricultural development is ensured through organic farming methods aimed at producing food and feed from natural substances. The Common Agricultural Policy provides for support for the production and consumption of organic products to increase the sustainability of the agricultural sector of the economy, and a corresponding action plan for the development of organic production was developed and approved in 2021.

Organic agriculture, unlike traditional (non-organic) agriculture, has a positive impact on the environment, climate change and soil quality and fertility through the use of renewable energy sources, reduction of greenhouse gas emissions, biodiversity conservation and less nutrient loss per hectare of agricultural land, etc.

From 2012 to 2020, the area of land under organic farming in the EU increased by 5.7% annually and in 2020 amounted to 14.8 million hectares (9.1% of the total EU agricultural land and 20% of the total agricultural land under organic farming in the world). In the structure of agricultural land used for organic farming in the EU, the largest share is occupied by perennial pastures (42%), areas for growing green fodder (17%), cereals (16%) and perennial crops (fruits, grapes and olives) (11%).

Analysing the data in Figure 7, which shows the share of agricultural land under organic farming by EU Member State, it is possible to identify 4 leading countries – France, Spain, Italy and Germany. In 2020, the total area of agricultural land under organic farming

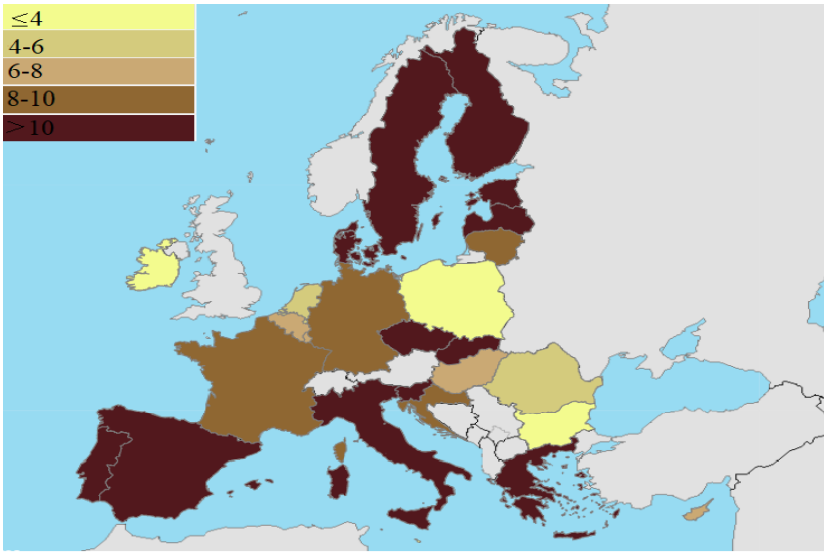

Figure 7. Share of organic farming area in total UAA by MS in 2020, %

Source: Agri-food Data Portal, 2024

in these countries was 59% of the total area of organic farmland in the EU.

Despite the fact that organic production volumes have been growing in recent years, the share of livestock products is still insignificant (1-7%). In 2020, 6% of cattle in the EU were organic, but in some countries these figures were higher: Austria – 22%, Sweden – 24%, Denmark – 15%, Latvia – 26%. A similar trend can be observed with the number of sheep and goats: in the EU as a whole, their share was 7.2%, in Austria – 35%, Sweden – 32%, and Latvia – 36%. Poultry in the EU accounted for 3.6% and pigs for 1%.

In organic farming, crop yields are 5-30% lower than in conventional farming. According to research, organic farms are larger, have 34% more species diversity than conventional farms, and their management staff is younger.

Enterprises engaged in organic crop production are characterised by lower production costs per hectare due to savings of 45-90% on fertiliser application and 75-100% on the purchase and use of plant protection products. However, despite lower crop yields and lower gross yields of crop products, organic farms earn higher income per employee than non-organic farms. The higher profitability of such farms is due to the higher selling price for organic products and financial support under the EU's Common Agricultural Policy through eco-schemes, interventions in rural development under the Horizon Europe, Horizon 2020, and EIP-AGRI programmes, etc. In 2020, 61.6% of the land under organic farming in the EU received special payments - an average of 144 EUR/ha under the Common Agricultural Policy and 79 EUR/ha under national funding programmes. The Common Agricultural Policy stipulates that the amount of such payments will increase from 2023 (Organic farming in the EU, 2023).

To summarise the study, it should be emphasised that the European Union is implementing a number of important programmes and initiatives aimed at ensuring sustainable development of agriculture and reducing its negative impact on the environment, covering various areas of green development of the agricultural sector (Table 3). These programmes, together with other initiatives, allow the European Union to actively combine agricultural development with the need to protect the environment, ensuring the sustainable development of the agricultural sector in the long term.

The CAP 2023-27 plays a special role in the implementation of green technologies in the EU's AIC, which is focused on achieving greater efficiency and environmental friendliness in the agricultural sector.

The EU's agricultural policy for 2023-2027 aims to:

– Support 7 million producers in EU countries;
– provide high quality food for 450 million Europeans;
– have a budget of 387 billion EUR, 1/3 of the total EU budget;
– contribute to climate action with approximately 40% of its budget.

CAP 2023-27 aims to increase the role of agriculture in achieving the goals of the European Green Deal. Key aspects include the following:

– Strengthening environmental ambitions. The strategic plans of the CAP in each EU country must meet the environmental and climate requirements of the legislation. Countries are required to demonstrate greater efforts to protect the climate and the environment compared to previous periods, and to update their plans in line with changes in legislation.

Table 3

EU programmes and initiatives related to the use of green technologies in the agricultural sector

Programme name	Green initiatives
European Green Deal	This strategy is the basis for achieving the EU's climate goals by 2050 and is focused on achieving carbon neutrality: - Reduction of greenhouse gas emissions by 50% by 2030; - expansion of organic farming: according to the plan, the area of organic land should increase to 25% by 2030; - support for environmentally friendly technologies, such as precision farming, to reduce the use of pesticides and chemical fertilisers; - improvement of water quality and biodiversity conservation by reducing water pollution from agrochemicals.
Common Agricultural Policy, CAP	The CAP is the main agricultural support programme in the EU and contains a number of environmental initiatives that contribute to the preservation of the environment: - Green Direct Payments – part of the support to agricultural producers depends on their compliance with environmental requirements, such as biodiversity conservation, reduction of chemicals use, and improved soil management; - Agri-environmental schemes are support programmes that encourage farmers to adopt sustainable practices, such as crop rotation, organic farming, conservation of natural landscapes, and soil erosion control; - Green architecture includes the creation of environmentally sustainable farms and improved livestock facilities with minimal environmental impact.
Horizon Europe	An EU research programme that funds innovative projects in various fields, including agriculture. Some initiatives under this programme are aimed at developing green technologies for agriculture: - Development of new methods to conserve water resources and reduce greenhouse gas emissions in the agricultural sector; - support for research in the field of biotechnology to create crops more resistant to climate change; - development of agroecological and bioeconomic solutions.
From Farm to Fork (F2F)	The EU strategy is part of the Green Deal and aims to ensure a sustainable food chain from production to consumption. Its main directions are: - Transitioning to organic farming and reducing the use of pesticides and chemical fertilisers; - encouragement to reduce food losses and fight against food waste; - improving food health and safety through more sustainable agricultural practices.
LIFE	It is a financing instrument aimed at supporting environmental and climate protection projects. It finances green initiatives in agriculture, including: - Projects to preserve biodiversity and landscapes; - initiatives to adapt agriculture to climate change; - support for environmentally friendly and sustainable technologies for agriculture.
EU Organic Action Plan	The plan was developed to support the development of organic agriculture in Europe. One of its main goals is to increase the area of organic land to 25% by 2030. The programme aims to: - Improve farmers' access to organic fertilisers and plant protection products; - raise consumer awareness of the benefits of organic products; - develop domestic and international markets for organic products.
REPowerEU	An EU programme to reduce dependence on fossil fuels and accelerate the green transition. Its key initiatives include: - Intensification of the use of alternative energy sources, support for the installation of solar panels and wind farms, and an increase in biomethane production to 35 billion m^3/year by 2030; - production of green hydrogen and development of infrastructure for hydrogen as a substitute for fossil fuels.

Source: compiled by the authors

– Contributing to the achievement of the objectives of the European Green Deal. The CAP National Strategic Plans are designed to provide a significant contribution to the implementation of Green Deal initiatives, based on established guidelines.

– Increased environmental requirements. Receiving CAP funding comes with stricter conditions. For example, farmers must ensure that at least 3% of arable land is used to maintain biodiversity and non-productive elements, with the possibility of increasing this share to 7% through participation in eco-schemes. Particular attention is paid to the preservation of bogs and peatlands.

– Development of eco-schemes. A minimum of 25% of the direct payment budget is allocated to eco-schemes that support environmentally friendly practices such as organic farming, carbon farming, agroecology and animal welfare measures in livestock.

– Sustainable development of rural areas. A minimum of 35% of funding is used for initiatives aimed at climate conservation, biodiversity, environmental protection and improving conditions for animals.

– Environmental focus in operational programmes. In the fruit and vegetable sector, at least 15% of the costs of operational programmes should be allocated to environmental measures.

– Climate and biodiversity priority. Over 40% of the CAP budget should be allocated to climate initiatives, as well as to support the EU's commitment to allocate 10% of the total budget to biodiversity conservation by the end of the EU's Multiannual Financial Framework (MFF) (The common agricultural policy: 2023-27, 2022).

The CAP 2023-27 reflects the EU's commitment to sustainable development and the integration of green approaches into agricultural policy.

3. Conclusions

European countries are actively developing agriculture, but at the same time, there is a growing awareness of the importance of environmental protection, which has become the basis for the transition to more sustainable and environmentally friendly production methods. The European Union, in particular, has initiated numerous policies and programmes to support the agricultural sector aimed at preserving nature and reducing the negative impact of agricultural activities on ecosystems. The use of green technologies in the AIC is becoming increasingly popular and is supported at the legislative level through a number of EU programmes and initiatives.

One of the key approaches is to promote organic farming, which uses minimal chemical fertilisers and pesticides to preserve biodiversity and improve soil health. In addition, many European countries are actively supporting the development of precision farming technologies, which reduce water, fertiliser and energy consumption, as well as greenhouse gas emissions.

The EU is also promoting initiatives to reduce greenhouse gas emissions from agricultural activities through the integration of methane and other gas emission control methods. The European Green Deal programme aims to reduce greenhouse gas emissions by 50% by 2030 and increase the area of organic land in Europe. The updated Common Agricultural Policy of the EU for 2023-2027 envisages a greater contribution of the agricultural sector to the achievement of the European Green Deal goals.

Another important step is the development of a circular economy, which involves reducing agricultural waste through biomass recycling, using waste to produce fertilisers or bioenergy, and moving towards more sustainable methods of land cultivation.

Thus, European countries are actively combining the expansion and modernisation of agricultural production with green initiatives, which allows them to conserve natural resources, reduce pollution and adapt agriculture to climate change.

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