

## SUSTAINABLE USE OF METHANE IN THE EUROPEAN UNION. SELECTED SOCIAL AND ENVIRONMENTAL ASPECTS

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**Purpose:** the article focuses on the issue of sustainable use of methane in the European Union. In this area - and it should be particularly emphasized - the EU attaches great importance to the issue of reducing methane emissions, due to its significant role in climate change and the need to achieve greenhouse gas reduction goals. The importance and significance of these activities is emphasized by the fact that the strictest standards in the world regarding the release of greenhouse gases, including methane from the mining industry, are in force and planned in the EU. In the face of such environmental goals of the European Community countries, it is crucial, apart from the economic factors, to take into account the social aspects highlighted in the article, without which rational shaping of the new transformation policy cannot take place.

**Methodology:** the theses presented in the article verified using the following methods: literature review, critical analysis of literature, dogmatic and legal analysis, analysis and comparison of documents.

**Results:** it seems that implementing comprehensive strategies for the sustainable use of methane in the EU will require not only political will and investment, but also continuous monitoring, evaluation and adaptation of actions based on the latest scientific and technological achievements. Only through cooperation and joint efforts can the goals of reducing greenhouse gas emissions and protecting the environment be achieved.

**Originality:** the sustainable use of methane can not only contribute to achieving the EU's climate and energy goals, but also have a positive impact on human health, environmental quality and the economic stability of regions affected by mining activities. Therefore, it is not only a challenge, but also an opportunity to create a more fair, innovative and future-oriented economy that takes into account the needs of both current and future generations.

**Keywords:** transforming, coal, methane emission, protection atmosphere.

### 1. Introduction

The sustainable use of methane within the European Union is a key element of the strategy to combat climate change and achieve the goals of equitable development (Methane emissions..., 2024). Methane, one of the main greenhouse gases, has a significant impact on

global warming and its effective management is becoming increasingly urgent in the context of global climate and environmental challenges. The European Union, as one of the leading political and economic forces in the world, has adopted ambitious goals for reducing greenhouse gas emissions and increasing the share of energy from renewable sources in total energy production. In this context, the sustainable use of methane is crucial because this gas occurs both as a by-product in many industrial sectors and as an energy source. One of the key areas where the European Union is focusing on the sustainable use of methane is the energy sector (European Commission..., 2013). Promoting the energy use of methane, especially from renewable sources such as biogas or gas from geothermal sources, is becoming more and more important in the context of reducing greenhouse gas emissions and diversifying energy sources. Moreover, the European Union is taking action to reduce methane emissions in the industrial, agricultural and environmental sectors by introducing new regulations and promoting modern technologies aimed at improving energy efficiency and applying agricultural practices consistent with the principles of sustainable development (Questions and answers..., 2024). Improving the monitoring and reporting of methane emissions, as well as international cooperation in reducing emissions, are key elements of the European Union's policy in this area. Finally, the sustainable use of methane within the European Union also requires cooperation between various industrial sectors, research institutions, governments and local communities. These activities must be coordinated and integrated to achieve the intended goal, while supporting the development of technologies and practices consistent with the principles of a just transition. Implementing effective policies requires the involvement of all stakeholders and coordinated action at national, regional and international levels (A greener..., 2023).

## **2. EU policy goals towards methane emissions**

The European Union attaches great importance to the issue of methane management, in particular due to its important role in climate change and the need to achieve greenhouse gas emission reduction targets. The importance of activities related to the reduction of greenhouse gas emissions in the EU is emphasized by the new regulations announced by the European Parliament, which include some of the strictest environmental protection standards in the world. The EU and national governments have set clear goals to shape European climate policy in the 2050 perspective. The most important of these goals include (OJ 2004.90.864/2..., 2004):

- protecting, preserving and improving the EU's natural climate,
- transforming the EU economy into a resource-efficient, green and competitive low-carbon economy,
- protecting Europeans from environmental pressures and threats to health and well-being.

From the very beginning, EU environmental policy has been characterized by orderly and regulating legal acts, the most important of which over the past years have been:

- Articles 11 and 191-193 of the Treaty on the Functioning of the European Union (TFEU); the 1987 Single European Act introduced a new title "Environment", which was the first legal basis for the EU's common environmental policy (European Union consolidated versions ..., 2002),
- under the Maastricht Treaty (1993), the environment was recognized as an official EU policy area,
- The Treaty of Amsterdam (1999) introduced the obligation to include environmental protection in all sectoral EU policies (The Treaty of Lisbon..., 2009),
- in the Treaty of Lisbon (2009), "Combating climate change", like sustainable development, became specific objectives (Horizon Europe..., 2023).

A milestone in the transformation of EU countries towards reducing greenhouse gas emissions - which assumes the need to decarbonize the energy industry - is the Horizon Europe program (Methane emissions..., 2023). This program promotes excellence and provides valuable support to the best innovators, thereby driving the systemic changes needed to ensure a Europe that is green, healthy and resilient. The Horizon Europe initiative also stimulates scientific excellence through the European Research Council (hereinafter ERC European Research Council) to enable outstanding scientists to expand the frontiers of science and knowledge to help meet the economic and social challenges Europe faces. The program also supports collaborative research on European societal challenges and strengthens technological and industrial capacity through thematic policy groups addressing the full spectrum of global challenges. For example, the 'Climate, Energy and Mobility' and 'Digital Technologies, Industry and Space' clusters will increase research and innovation in climate-related fields and give European businesses access to the technologies and data they need. Horizon Europe introduces new initiatives, such as the European Innovation Council (hereinafter EIC European Innovation Council) and other missions. The EIC received over EUR 10 billion in the budget to support emerging and breakthrough innovations of start-up small and medium-sized enterprises. This activity will complement the work of the European Institute of Innovation and Technology (hereinafter referred to as EIT European Institute of Innovation and Technology). By establishing contacts with regional and national innovators, European innovation ecosystems will be strengthened. In turn, EU missions focus on issues that affect our everyday lives, from fighting cancer to adapting to climate change, living in greener cities, protecting water, and ensuring healthy soils for healthy food, human health and nature and climate.

The next document - the European Green Deal indicates the path and actions that Europe should take to achieve the so-called Climate neutrality. The European Green Deal agenda covers the following topics:

- a plan to build a sustainable economy bringing together all its sectors,
- resource efficiency and clean economy,
- the need for additional investment and a fair transition mechanism,
- citizens' voice and international cooperation,
- transition to a clean and circular economy,
- stopping climate change,
- counteracting the loss of biodiversity and reducing the level of emitted pollutants.

Climate change and environmental degradation pose a threat to Europe and the rest of the world. To meet these challenges, the European Green Deal agenda assumes transforming the EU into a modern, resource-efficient and competitive economy that (Communication from the Commission..., 2020):

- will achieve net zero greenhouse gas emissions in 2050,
- will separate economic growth from resource consumption,
- will shape the social order so that no person or region is left outside the transformation process.

The European Green Deal is financed by a third of the €1.8 trillion in investment under the Next recovery plan Generation EU and funds from the seven-year EU budget.

Thanks to these goals, actions and plans, the EU has developed and is currently implementing an ambitious methane strategy that covers several key areas of action. The first area focuses on regulations and standards regarding the emission of this gas. In this space, the EU is focusing on introducing strict regulations and standards on methane emissions in various economic sectors. These standards are intended to have a particular impact on the energy sector, industry, transport and waste management. These actions include reducing methane leaks from gas infrastructure, regulations on the storage of organic waste and emission standards in the transport sector. The indicated sources, i.e., the energy sector, industry, transport and waste management, were responsible for 74% of the EU's 64Mt CH<sub>4</sub> emissions in CO<sub>2</sub> in 2020 (Net Zero..., 2021). More specifically, as part of the EU methane strategy - the European Commission adopted a legislative proposal aimed at reducing CH<sub>4</sub> emissions in the energy sector, covering oil, gas and coal, including (Methane under control..., 2023):

- mandatory measurement, reporting and verification of all energy-related CH<sub>4</sub> emissions in the EU based on the United Nations Oil and Gas Methane Partnership (OGMP 2.0) methodology for the oil and gas sectors,
- mandatory periodic detection and repair of CH<sub>4</sub> leaks in all oil and gas companies in the EU (Korda-Burza, Figiel, Holewa-Rataj, 2022),
- a ban on venting and routine flaring, limiting it to unavoidable and precisely defined circumstances,

- for coal, a ban on the discharge of highly concentrated CH<sub>4</sub> from methane drainage stations, and for ventilation shafts, restrictions on discharge in coal mines, other than coking coal mines, from 2027 (Regulation of the European Parliament..., 2021),
- preparing an inventory of closed or abandoned assets (both shafts and mines), measuring emissions and adopting a plan to reduce these emissions,
- an obligation for importers of fossil fuel energy into the EU to provide information on monitoring, measurement and mitigation activities outside the EU in order to establish a CH<sub>4</sub> intensity profile for exporting countries and external entities; a review clause in 2025 will consider stricter measures on fossil energy imports,
- a transparency database that will include CH<sub>4</sub> intensity profiles of exporting countries as well as EU and external operators; they will be developed using information including importer responsibilities, EU reporting requirements and data from the Global CH<sub>4</sub> Emitter Monitoring Tool to document high CH<sub>4</sub> emissions worldwide,
- creation of a global CH<sub>4</sub> emitter monitoring tool that will provide information on the extent, repeatability and location of high-energy CH<sub>4</sub> sources; this tool should collect data from the Copernicus component of the EU space program and from the International Methane Emissions Observatory (IMEO) of the United Nations Environment Program (UNEP).

In the described area of issues, the EU's position as a region that:

- focuses on promoting renewable energy and reducing methane emissions in the energy sector,
- implements projects related to biogas, which is an alternative to conventional natural gas sources, contributing to the reduction of methane emissions, but also to the promotion of sustainable energy sources,
- invests in modern gas infrastructure that plays a key role in reducing methane leaks and focuses on improving technologies and practices in the gas sector to reduce methane losses and emissions in gas production, transportation and distribution processes,
- promotes agricultural practices aimed at reducing methane emissions, such as effective management and new technologies,
- works to promote global cooperation to reduce methane emissions. It supports international initiatives such as the Methane Partnership, which aims to improve the management of methane emissions on an international scale.

The EU's methane strategy is crucial in the global context of fighting climate change. By implementing strict regulations and investing in low-emission technologies, the EU can play a significant role in reducing methane emissions. At the same time, promoting sustainable energy sources and environmentally friendly agriculture helps create a more sustainable future. It is worth emphasizing that the EU methane strategy not only contributes to reducing greenhouse gas emissions, but can also create new economic opportunities and contribute to

the development of a green economy. Therefore, this is an important initiative both from the point of view of environmental protection and the economic development of the EU.

In this light, it is worth noting that sustainable methane emissions within the European Union represent both an economic challenge and a political decision. Reducing methane emissions is primarily a challenge for the economies of the Community countries. As mentioned earlier, there are numerous economic sectors in the EU that are sources of methane emissions, such as agriculture, energy, the chemical industry and mining. Controlling and reducing emissions in these sectors may require significant investments in new technologies, changes in production processes and other measures that may involve high costs (Fostering Effective Energy Transition..., 2022). Competitiveness is also an important aspect. Introducing stricter methane emissions standards could impact the competitiveness of EU businesses, especially if other regions of the world do not apply the same regulations. The need to adapt to these regulations may pose a challenge for European companies (The Global Methane..., 2023). The economic challenge mentioned above also plays a role in shaping changes in the labor market. The transition to a more sustainable economy could impact some jobs in sectors that are particularly linked to methane emissions. The need for restructuring may require employee training and support for those who may lose their jobs (Climate action..., 2023).

In the political space, regulations and goals related to planned changes come to the fore. This includes adopting climate strategies, setting emissions standards and promoting investment in sustainable technologies. At the same time, the EU is involved in international initiatives to reduce methane emissions, which has a political dimension. Cooperation with other countries and regions is important in the fight against climate change, and this requires negotiations and common decisions (Commission proposal of 15 December 2020...). In the light of these two activities, the area of social awareness and involvement is very important. In this area, EU institutions are taking action in response to the growing awareness and social pressure regarding climate protection. Political decisions often result from concern for the public interest and the health of society ("Fit for 55"..., 2023).

In order to present EU activities focusing on the need for compromise indicated above, it is worth analyzing the above-mentioned EU Strategy for reducing methane emissions. The EU strategy to reduce methane emissions was published in October 2020. The key determinant of its creation is methane, which is the second largest contributor to climate change after carbon dioxide (CO<sub>2</sub>). As noted in the strategy, reducing global emissions of this gas by 50% over the next 30 years, it could mitigate global temperature change by 0.18°C by 2050. It should be emphasized that this is an important element of the Paris Agreement. Methane is also a strong local air pollutant that causes serious health problems. Accelerating action on methane is essential to achieving climate neutrality by 2050 and reducing greenhouse gas emissions by at least 55%. By 2030, the strategy clearly emphasizes that agriculture, waste and energy are responsible for up to 95% of man-made methane emissions worldwide. In Europe this percentage is even higher. As noted, the dominant source of methane emissions is agriculture

(53%), followed by waste (26%) and energy (19%). The question is therefore what strategic actions need to be taken to reduce methane emissions in the EU and for the EU to become a global leader in reducing methane emissions in all relevant sectors and in cooperation with all partner countries. The most important activities include:

- proposing EU rules for mandatory measurement, reporting and verification of all energy-related methane emissions,
- improving measurement and reporting of methane emissions by enterprises, including through sector initiatives,
- detecting sources of disproportionately high emissions by satellite via the EU's Copernicus program,
- supporting the establishment of an international methane emissions observatory at the UN, including the development of a methane supply index to ensure international transparency,
- providing targeted support to accelerate the development of the sustainable biogas market, including pilot projects for rural and farming communities,
- promoting best practices and technologies, feed and breeding changes, and carbon-sequestering crops to reduce emissions from agriculture,
- an obligation to improve leak detection and repair practices on all natural gas infrastructure and in its production, transportation and use,
- possible future regulations on atmospheric releases, gas flaring and standards covering the entire supply chain, and support for the World Bank's Zero Flaring initiative,
- review of the Landfill of Waste Directive, the Urban Waste Water Treatment Directive and the Sewage Sludge Directive.

The strategy continuum can be found in the European Parliament's Resolution of 21 October 2021 on the EU strategy to reduce methane emissions, which reads: "The EU Commission calls for an end to EU support for the expansion of fossil fuel infrastructure; Recalls that, according to the International Energy Agency's latest report on achieving net zero greenhouse gas emissions by 2050, there is no need to invest in new supplies of fossil fuels on the path to carbon neutrality, a conclusion shared by the EU Commission in its proposal concerning a regulation amending the guidelines for trans-European energy infrastructure" (The European Green Deal..., 2023) entitled "Fit for 55 Package" (Social sustainability. Encyclopedia..., 2023) directly corresponds to the EU Strategy for reducing methane emissions described above. The Fit for 55 package was published in July 2021. To achieve the goal of carbon neutrality by 2050 under the European Green Deal, the EU must significantly reduce greenhouse gas emissions over the next decades. It has therefore increased its climate ambitions for 2030, aiming to reduce emissions by at least 55% by 2030 compared to 1990. To this end, the EU is reviewing its climate, energy and transport rules as part of the Fit package for 55" to align it with the 2030 and 2050 targets. The package supports the implementation of the

European Green Deal (Sustainable Development Goal 10..., 2019) and proposes revising existing or introducing new policies aimed at reducing net greenhouse gas emissions by at least 55% by 2030. Moreover, by maintaining and strengthening the innovation and competitiveness of EU industry, the package aims to ensure a level playing field for third-country economic operators and strengthen the EU's leading role in the global fight against climate change.

The Fit for 55 package includes the following legislative proposals and policy initiatives:

- revision of the EU emissions trading system EU ETS, including its extension to shipping,
- revision of aviation emissions rules and creation of a separate emissions trading system for road transport and buildings,
- revision of the Effort Sharing Regulation regarding Member States' reduction targets in sectors not covered by the EU Emissions Trading Scheme,
- review of the code on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry LULUCF (Land use, land use) change and forestry),
- revision of the Renewable Energy Directive,
- recasting the Energy Efficiency Directive,
- revision of the directive on the development of alternative fuels infrastructure,
- 2 emission standards for passenger cars and delivery vans,
- review of the Energy Tax Directive,
- carbon border adjustment mechanism,
- ReFuelEU regulation Aviation for sustainable aviation fuels,
- FuelEU regulations Maritime for a green European maritime space,
- Social Climate Fund.

In the Fit for 55 Package, the ETS is strengthened by increasing its targets for reducing emissions from specific economic sectors by 2030. To complement the significant climate spending in the EU budget - as stated in the Package - Member States will allocate all their revenues from emissions trading for emissions for climate and energy-related projects. It is proposed to create a new ETS for fuels used in road transport and construction, which can be combined with the existing ETS after 2030. Part of the revenues from this new ETS will be allocated to a new Social Climate Fund, the main aim of which will be to redistribute financial resources among EU Member States to address potentially adverse social impacts on vulnerable households, micro-enterprises and transport users.

In conclusion, sustainable methane emissions in the European Union are both an economic issue that requires taking into account complex economic and competitiveness aspects, and a political decision that aims to achieve climate goals, protect the environment and public health. The final actions and measures taken will be the result of a compromise between these two requirements.



### 3. Sustainable use of methane in the European Union - social aspect

As shown by previous analyses, one of the key objectives of the EU is the sustainable use of methane, due to its significant role in shaping the greenhouse gas balance. In this light, the methane management process must take into account not only environmental aspects, but also social aspects, such as jobs and the risk of job loss, public health, quality of life and equality. In this context, the EU uses a variety of instruments and strategies to achieve the goal of sustainable use of methane from a societal perspective.

To get closer to the issue of sustainable social development, it is worth citing the canons describing it. Social sustainability means focusing on the well-being of people and communities (Gillingham, 2023). In this definition, well-being is associated with the idea of promoting equality, human rights, access to education and health care, and decent work (Reducing greenhouse gas emissions..., 2023). Sustainable social development aims to create inclusive societies, reduce inequalities and ensure the long-term well-being of all people, while maintaining social cohesion and equity. To achieve sustainable development, efforts should be made to eliminate (Shayan, Mohabbati-Kalejahi, Alavi, Zahed, 2022):

- poverty and socio-economic inequality,
- discrimination, prejudice and social exclusion,
- lack of access to resources,
- insecurity and conflict at local, regional and global levels,
- poor governance, which includes phenomena such as corruption and institutional inefficiency.

In achieving sustainable social development, a particularly important role is played by striving to ensure equal access to opportunities and resources for all members of society on the basis of promoting systems and policies that can reduce social and economic inequalities. In addition to reducing inequalities, the key goals determining the achievement of sustainable social development are (Misiukiewicz, Gao, Filipiak et al., 2021):

- promoting policies that respect fundamental human rights, such as the right to health and education,
- adopting practices that value and include people of different backgrounds, genders, ethnicities, abilities and sexual orientations,
- creating a safer living environment with more effective administration of justice,
- improving people's health and mental and physical well-being through high-quality health services.

In this perspective, one of the key goals is the sustainable use of methane, due to its significant contribution to the increase in greenhouse gas emissions. The process of achieving the indicated goal must take into account the indicated social aspects - in particular public health, quality of life and equality. This is supported by actions aimed at reducing methane

emissions, which directly contribute to improving air quality. Reducing methane leaks from sectors such as industry, agriculture and transport reduces the level of atmospheric pollution, which has a positive impact on public health. Improving air quality significantly reduces the risk of respiratory and cardiovascular diseases, which clearly translates into the quality of society's health. In turn, the transition to more sustainable technologies and practices in methane-related sectors, such as biogas production, modernization of gas infrastructure and the development of renewable energy, contributes to the creation of new jobs. This, in turn, supports the decline in unemployment and improves the quality of life of society. In pursuing the goals of sustainable methane use, the EU pursues the goal of achieving social equality. This means that while striving to reduce methane emissions, the EU is also trying to minimize negative social effects, such as job losses in sectors that are undergoing restructuring. An equally important goal in this area is education and social awareness. The EU promotes education and public awareness of the importance of sustainable use of methane and the impact of methane emissions on climate change. This significantly supports understanding the reasons for reducing methane emissions, the importance and importance of this process, and creates impulses to change attitudes and social behaviors in everyday life (Transforming our world..., 2023).

To sum up, sustainable methane emissions not only contribute to reducing the impact of climate change, but also generate a number of important social benefits. Improving public health, protecting the environment and wildlife, creating jobs and stimulating technological innovation are just some of them. Therefore, taking action to reduce methane emissions should be a priority for societies around the world, as it can bring benefits not only to current but also to future generations. However, it should not be forgotten that the introduction of regulations on methane emissions is associated with various social risks that may affect various social groups and the economy as a whole. The most important of them include:

- costs for businesses. Regulations may impose additional costs on companies, especially those operating in the agricultural, energy and industrial sectors. The high costs of implementing new technologies and procedures may lead to employee layoffs and the closure of companies, especially smaller ones. To prevent this phenomenon, public policies should offer subsidies, subsidies and tax breaks for companies that invest in technologies that reduce methane emissions. It is equally important to create training and support programs for employees who may lose their jobs, which helps mitigate the negative effects.
- Impact on energy prices. In this area, regulations may lead to an increase in energy prices, which directly affects households, especially those with lower incomes. An instrument that can prevent this phenomenon is the introduction of support programs for the poorest households, such as energy subsidies or energy efficiency programs that help reduce energy bills.

- Counteracting social resistance. Society may be skeptical or resistant to new regulations, especially if they do not understand their benefits or are afraid of negative economic consequences. A method to prevent this phenomenon is to conduct educational and information campaigns about the benefits of reducing methane emissions, both for the environment and public health. In this case, it is necessary to dialogue with various stakeholder groups to take into account their concerns and needs.
- Passing costs on to consumers. Companies may pass on the additional costs of regulation to consumers, which can lead to higher prices for products and services. In this perspective, it is necessary to take into account regulations that may include mechanisms that prevent excessive costs from being passed on to consumers. Public institutions can also monitor prices and introduce interventions if price increases are disproportionate.
- Impact on international competitiveness. Regulations can impact companies' competitiveness in international markets, especially if other countries do not implement similar regulations. To counteract this, it is valuable to promote international agreements and cooperation on the regulation of methane emissions to ensure that competition on the international market is fair.
- Pollution transferred to other areas. Companies may move their production to countries with less stringent environmental regulations, which may lead to the so-called "carbon leakage". International cooperation and common regulatory standards are important here and can help reduce the transfer of emissions to other countries. Creating incentives for companies to stay and invest in clean technologies in their country.

With this in mind, the EU is investing in projects and technologies related to the sustainable use of methane by providing financial support and stimulating investment. In conclusion, the indicated goals, actions and instruments allow the EU to pursue the goal of sustainable use of methane, taking into account social aspects. Thanks to this, counteracting climate change becomes more holistic and favors a better development of the quality of life of society, while protecting the natural environment (EEA Signals 2023..., 2023).

#### **4. Sustainable use of methane in the European Union - environmental aspect**

The European Union has adopted ambitious targets for the sustainable use of methane, which focus on environmental aspects. In this area, the EU is introducing strict regulations and standards for methane emissions into the atmosphere in various economic sectors, as follows:

- in the energy sector, the EU has defined targets for reducing greenhouse gas emissions, including methane, as part of its climate neutrality strategy. Standards are being introduced for methane emissions in the processes of extraction, transport and processing of natural gas (Prussi, Julea, Lonza, Thiel, 2021),
- the agricultural sector is one of the main sources of methane emissions, mainly related to fermentation processes in the digestive tracts of farm animals. As part of the EU's common agricultural policy and the "Green to Clean" strategy, measures are being introduced to reduce these emissions, such as promoting more effective animal feeding technologies or developing animal excrement utilization and processing systems (Strategies to reduce emissions..., 2023).
- in the industrial sector, the EU is introducing emission standards, which also include methane emissions. These regulations apply to various industries, such as energy production, chemical processing, as well as the extraction and processing of raw materials (Assan, 2023),
- in the waste management sector, where methane is a by-product of organic waste decomposition processes, the EU is introducing regulations aimed at optimizing waste management in order to minimize methane emissions. This includes both segregation and recycling, as well as the development of technologies allowing energy recovery from organic waste (Case study Methane Recovery..., 2022),
- in the transport sector, including road and maritime transport, the EU is introducing regulations aimed at reducing greenhouse gas emissions, including methane. This includes vehicle emission standards, as well as initiatives supporting the development of alternative propulsion sources, such as electric vehicles or natural gas vehicles (Why is VAM Mitigation Important?, 2019).

Particularly important, in the light of the considerations undertaken on the sustainable methane emission policy, is the sector of extraction and processing of natural raw materials, such as coal, crude oil and natural gas. In the indicated policy, the EU introduces emission standards and regulations aimed at limiting methane emissions from these processes. It is worth noting here that coal seams naturally contain methane, which can be released during or after mining activities and is referred to as mine methane. Emission sources are mainly underground and open pit mines. Methane emissions are higher from underground mines than from open-pit mines because deeper coal seams usually contain more methane than shallower seams. The type of coal also affects the methane content: lignite tends to have the lowest methane content, followed by steam coal and coking coal. Despite the use of underground coal seam methane removal systems and the conversion of the resulting methane into energy, most of this gas ends up in the atmosphere along with ventilation air. Methane from ventilation air

(Ventilation Air Methane (VAM) is therefore the largest source of CMM<sup>1</sup> in underground coal mines. In turn, the main source of emissions in open-pit mines are drainage systems (Nawrat, 2006).

In this perspective, it is worth emphasizing that the European Environment Agency (EEA) indicates that over the last 30 years, CH<sub>4</sub> emissions in the EU have decreased by 36%. On a global scale, however, there is an increase in emissions. The problem may not only be higher emissions levels, but also their increased impact on climate change. According to the EEA, according to the European Union greenhouse gas inventory submitted to the UNFCCC secretariat, methane emissions in the EU amounted to approximately 379 million tons of CO<sub>2</sub> in 2020, representing 12% of total greenhouse gas emissions that year. More than half of total CH<sub>4</sub> emissions in the EU came from the agricultural sector. The agency further points out that in 2020, methane emissions in the EU decreased by 36% compared to 1990 levels, with the greatest emission reductions recorded in the energy supply sector, which includes the energy industry and fugitive emissions (-65%). waste (-37%) and agriculture (-21%) (Methane emissions..., 2023).

Taking into account the possibilities of methane reduction, in the environmental aspect it should be noted that despite the implemented technologies for reducing CMM emissions in mines, these actions are still insufficient. The reasons for this state are most often technical limitations of methane utilization, lack of potential users of energy from gas, economic barriers and legal and regulatory challenges regarding the properties of methane. It is assumed that thanks to developing technologies it will be possible to reduce global CMM emissions by more than half. Mitigation measures and their costs vary depending on the characteristics of the mine, including methane concentrations, emissions and the scale of the company's operations. Therefore, CMM concentrations can be very low and fluctuate significantly depending on the technologies used. For example, underground mine ventilation methane (VAM) generally contains less than 1% methane. The lower the methane concentration, the more difficult it is to reduce technically and economically. Sources of high concentrations of methane can be captured using methane removal systems, provided that methane emission reduction measures are planned before mining operations begin. These systems can also be used in active mines before mining begins in new areas or after cessation of operations in a given area. To sum up, based on the above analyses, diagnoses and assessments, a clear perspective emerges in which the reduction of methane from ventilation systems is the most important measure that the coal sector can take to reduce its emissions (Carbon Atlas..., 2015). Numerous studies indicate that this would reduce methane emissions at a global level by almost 30%. In this perspective,

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<sup>1</sup> CMM is methane released from coal seams and surrounding rocks as a result of mining activities, most often mine workings, but there are also known cases of it being released to the surface of the area, bypassing the workings. See <https://www.google.com/search?q=CMM+a+methane&oq=CMM+a+methane&gslcrp=EgZjaHJvbWUyBggAEEUYOTIHCAEQIRigATIHCAlQIRigATIHCAMQIRigAdIBCTEwNjxajBqN6gCALACA&sourceid=chrome&ie=UTF-8>, 10.04.2024.

it is assumed that the widespread use of CMM could provide approximately 40 TWh of electricity worldwide (Olczak, Piebalgs, Balcombe, 2023).

Taking into account the prospects for reducing methane emissions, it should be clearly emphasized that Germany has consistently emitted the most carbon dioxide in the European Union since the turn of the century. In 2022, Germany emitted almost 635 million metric tons of carbon dioxide. This is more than the total emissions generated by the next largest emitters in the EU – Italy and Poland (Carbon dioxide emissions..., 2024).

Another example of CMM emissions are countries where a few mines are responsible for excessive amounts of emissions. Reducing emissions in these locations is often most cost-effective due to the high concentration of methane and economies of scale in its use (<https://www.edfeurope.org/...>, 2024). Implementing greenhouse gas reduction technologies in these locations could also improve prospects for developing greenhouse gas reduction technologies elsewhere. They could help develop new infrastructure to use captured gas, including new network connections, gas processing equipment or pipelines, increase industry understanding of measures to reduce greenhouse gas emissions, and lower institutional barriers. It would also encourage new companies, including service providers, project developers and technical specialists, to develop, implement and maintain CMM technologies.

Policies, regulations and international cooperation appear to be key determinants of sustainable methane emissions and their reduction in the EU. The EU must have new digital technologies to monitor methane emissions on a direct basis, both within and beyond borders, in line with the Oil and Gas Methane Partnership 2.0 (OGMP 2.0) standards. New technologies, such as advanced methane emissions satellites, Methane SAT, will usher in a new era of reporting for climate accountability and clarification. The indicated plan corresponds to the need for international cooperation - for example through the Clean Development Mechanism (CDM) - which may significantly contribute to mitigating the effects of CMM. The CDM mechanism enables emission reduction projects in developing countries to obtain certified emission reduction credits. This mechanism stimulates sustainable development and emission reductions while giving industrialized countries some flexibility in achieving emission reduction targets (2024 Global Methane Forum..., 2024).

To sum up, from the perspective of environmental aspects, it should be emphasized that the EU continues to work on tightening current regulations and introducing new measures aimed at achieving ambitious goals related to the reduction of greenhouse gas emissions, including methane, by 2050. These regulations are part of a broader EU focus on climate change and achieving climate neutrality. The key premises determining the indicated actions are:

- commitments to achieve global climate goals,
- environmental and public health protection,
- energetic safety,
- development of technology and innovation,
- adaptation to climate change,
- obligations and social pressure.

Due to the above premises, work on tightening regulations and introducing new measures is considered necessary to effectively counteract climate change and its negative consequences from an environmental perspective. The implementation of these actions contributes to climate protection, air quality and sustainable development in general, which is crucial for the future state of the natural environment and human health. We find this context in particular in the document entitled "Investing in a climate-neutral future for the benefit of citizens", which states: "the current EU policy framework alone would not allow us to achieve our 2050 goals or meet our commitments under the Paris Agreement. Projections show that continued implementation of current legislation alone would lead to the EU achieving a 60% reduction in greenhouse gas emissions by 2050. The EU must raise its ambitions now for this decade and avoid leaving a greater workload to future generations. The less action the EU takes over the next ten years, the steeper and more difficult the reduction path will be after 2030 (Towards EU climate..., 2024).

## 5. Summary

In light of the increasingly urgent need for action to reduce greenhouse gas emissions and promote sustainable and efficient energy practices, the sustainable use of methane in the European Union is becoming a key element of the energy and environmental strategy. The socio-environmental analyzes presented in the article, in particular, show the regularity related to the extraction, processing and use of methane in coal mines, which brings both opportunities and challenges. In this perspective, EU actions, such as promoting innovative technologies, improving ventilation efficiency in mines and supporting alternative energy sources, constitute an important step towards sustainable methane management. However, to achieve full effectiveness in the process of sustainable methane emissions, it is necessary to engage all stakeholders, including industry, government institutions, civil society and scientists.

It seems that implementing comprehensive strategies for the sustainable use of methane will require not only political will and investment, but also continuous monitoring, evaluation and adjustment of actions based on the latest scientific and technological achievements. Only through cooperation and joint efforts can the goals of reducing greenhouse gas emissions and protecting the environment be achieved. Given these findings, the sustainable use of methane can not only contribute to achieving the EU's climate and energy goals, but also have a positive impact on human health, the quality of the natural environment and the economic stability of regions affected by mining activities. Therefore, it is not only a challenge, but also an opportunity to create a more sustainable, innovative and future-oriented economy that takes into account the needs of both current and future generations.

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