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SUSTAINABLE USE OF METHANE GLOBALLY. SELECTED SOCIAL AND ENVIRONMENTAL ASPECTS

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Human history is becoming more and more a race
between education and disaster[1].
H.G. Wells

Purpose: in the cognitive space, the article focuses on the issue of sustainable methane emissions, which can be seen as an approach aimed at controlling and reducing methane emissions into the atmosphere in a way that takes into account the balance between the emission and removal of this gas, in order to reduce its impact on climate change.
Methodology: the theses presented in the article were verified using the following methods: literature review, critical analysis of literature, analysis and comparison of documents and an example of good practices.
Result: in recent years, issues related to sustainable development and environmental protection have become central topics in the international arena. One of the key elements of this debate is the role of methane as a greenhouse gas and the question of whether its use can contribute to sustainable development or pose a potential threat to the environment.
Originality: the key task is to develop a strategy that will allow for the effective use of methane while minimizing negative effects on the environment. Innovative technologies, stringent regulations and international cooperation are the key to achieving this goal and turning the use of methane into an opportunity for sustainable global development.
Keywords: environment, methane, society, sustainable development.

[1] See: Wells, H.G. (1983). *World History*. Wrocław: Ossolineum National Library, Series II.

1. Introduction

As environmental concerns and the need to reduce greenhouse gas emissions become more pressing issues, methane, which is one of the most powerful of these gases, is becoming a subject of increasing concern. According to experts' estimates, the Environmental Protection Agency - the US federal agency working to protect human health and the natural environment EPA (Environmental Protection Agency) - China, the United States, Russia, India, Brazil, Indonesia, Nigeria and Mexico are responsible for almost half of all anthropogenic methane emissions. The main sources of methane emissions in these countries are very diverse. For example, a key source of methane emissions in China is coal production, while Russia emits most of its methane from its natural gas and oil systems. The largest sources of methane emissions from human activities in the United States are oil and gas systems, enteric fermentation of livestock, and landfills (https://www.epa.gov/gmi). Methane, which is both a by-product of natural processes and human waste, can also be a source of valuable renewable energy resources (Azar, García, Johansson, Sterner, 2023). In this light, the important question becomes how to use methane in a sustainable manner on a global scale to the benefit of society and the environment?

2. Definition and properties of methane

The history of the discovery of methane is associated with many researchers and discoverers who gradually learned about its existence and properties. As evidenced by numerous sources, one of the first to encounter methane was Antoine Lavoisier, known as the father of modern chemistry[2]. In 1783, Lavoisier noticed that the gas released by the decomposition of organic plant and animal materials was unusual and, in fact, different from other gases such as oxygen or hydrogen. This gas was called "flammable gas", but at the time of Lavoisier's work its exact composition was not understood. However, in the history of discoveries, the first person to successfully identify methane as the main component of "flammable gas" was Alessandro Volta, an Italian physicist and chemist - this took place in 1778. Then Alessandro Volta conducted thorough experiments that became the source of determining the chemical

[2] Antoine Lavoisier, in full version Antoine-Laurent Lavoisier (born August 26, 1743 in Paris, France - died May 8, 1794 in Paris), distinguished French chemist and leading figure of the 18th-century chemical revolution, who developed an experimentally based theory of chemical reactivity oxygen and co-author of a modern system for naming chemical substances. He also served as a leading financier and public administrator before the French Revolution, and was executed along with other financiers during the Terror. See: https://www. britannica.com/biography/Antoine-Lavoisier, October 25, 2023.

composition of this gas as a compound of carbon and hydrogen, i.e., methane[3]. Over the following years, researchers continued to study the properties and uses of methane, which led to an understanding of its role as an important fuel and chemical feedstock.

Semantically, the term "methane" comes from the Greek word methano, which means behind or beyond and rot or putrefaction (Favre, Powell, 2013). The name refers to the way methane is often created in nature, through the processes of bacterial decomposition of organic matter under anaerobic conditions, such as swamps, lakes and other areas with limited access to oxygen. In fact, methane is a by-product of the metabolism of anaerobic bacteria that break down organic substances such as plant residues, carbon, and organic material present in swamps and swamps. This process is a natural source of methane in nature. Water accompanied by methane in the process of decomposition of organic matter, is known as "mud water", and this process is called "mud fermentation." Methane is an organic chemical compound with the formula CH4, consisting of one carbon atom and four hydrogen atoms. It is one of the most important and simplest alkane hydrocarbons. As a gas, methane is not only one of the main components of natural gas, but is also important in both scientific and practical contexts (Hassa et al., 2004).

The history of the discovery of methane and the origin of the term "methane" illustrate the evolution of our knowledge of this important chemical compound. Methane, although simple in structure, has a significant impact on our everyday lives as an energy source and chemical raw material. Moreover, its role in ecological cycles highlights the importance of understanding and monitoring methane emissions in the context of climate change and the natural environment (Nosalewicz, Brzezińska, Pasztelan, Supryn, 2011, pp. 355-373). Methane has many practical applications in various fields. Some of the most important uses are methane as a fuel that can be used to produce heat and electricity in thermal and cogeneration plants. It is also used as a fuel for natural gas vehicles. In the chemical industry, methane is used as a raw material for the production of many chemical products, such as ammonia, methanol, and many other organic compounds. Methane is used in transport as a fuel in vehicles, especially in buses and trucks, in the form of compressed gas (CNG) or liquefied gas (LNG). Equally often, methane - which is present in crude oil and natural gas deposits - can be used as a raw material or fuel in the oil industry.

[3] Born into a noble family but in rather difficult financial circumstances, on February 18, 1745 in Como, Italy, Alessandro Volta would come to electrify the world with his intellect and achievements. His father would die in debt, leaving the family in poverty - which later led Volta to conclude: "I was actually poorer than poor". His intellectual abilities were initially suspect, and he was mute until the age of four, when he vigorously said "NO" to express his dissenting opinion on a planned family activity. His household quickly realized that they had a real intellectual gem among them. From this most inauspicious origin, Volta was already considered "one of the greatest leaders" during his lifetime. thinks not only in electricity, but in all branches of physics. From: Willis Hurst J., Bruce Fye, W., Volta, A. (2002). Atlanta, Georgia, USA: Emory University School of Medicine.

To sum up, methane is an important chemical compound that can be described in both theoretical and practical terms. As a simple hydrocarbon, it is of key importance in many areas, including - as has already been noted - as an energy source, a raw material in the chemical industry and as a fuel for vehicles. However, due to its properties as a greenhouse gas, its role in climate change and global warming is also important, which requires attention and actions to ensure its sustainable use in a social and environmental context - as a result, reducing its emissions into the atmosphere (Shivanna, 2022, pp. 160-171).

3. Methane and its sustainable use

In the space described above, sustainable methane emissions can be viewed as an approach that aims to control and reduce methane emissions into the atmosphere in a way that takes into account the balance between emission and removal of this gas, with the aim of reducing its impact on climate change (Mar, Unger, Walderdorff, Butler, Beyond, 2022, pp. 127-136). Methane (CH4) is a powerful greenhouse gas that has a much greater capacity to absorb heat than carbon dioxide (CO2), although it is present in the atmosphere in smaller quantities. So, a clear and explicit focus on sustainable methane emissions is very important, because methane, as already noted, has a major impact on global warming. Sustainable methane emissions include several key elements such as:

- monitoring and controlling methane emissions,
- methane removal and recovery,
- investments in renewable energy sources,
- education and social awareness,
- increasing economic efficiency and balance,
- protection of the environment and human health,
- resilience to climate change.

Achieving efficient and sustainable methane emissions based on the above actions will play an increasingly important role in global efforts to combat climate change. This requires international cooperation, investment in technologies and practices that reduce methane emissions, and the involvement of both the public and private economic sectors. This seems to be a key element of the transformation towards a more sustainable and fair economy that takes into account the protection of the environment and the lives of future generations.

In this perspective, it is worth noting that the sustainable use of methane is of great importance from an economic, social and environmental point of view. As noted by researchers dealing with the economic costs of methane emissions, traditionally climate change mitigation has focused mainly on reducing CO_2 emissions, because this gas is a key factor responsible for past and expected future global warming (Masson-Delmotte, 2021). However, some studies

indicate that rapid and sustained reductions in anthropogenic methane emissions are both cost-effective and necessary to limit global warming to 1.5 to 2°C above pre-industrial levels (Program Narodów Zjednoczonych…). Taking into account this undeniable fact, it should be emphasized that in social space, the emission and use of methane affect people's lives and the condition of ecosystems. Methane recovery and its use as an energy source can bring benefits to local communities. In areas where natural gas or coal mining occurs, controlling methane emissions is crucial to the safety of residents, both in terms of health and explosion risk. Methane recovery reduces these threats and can improve the quality of life in these regions. In the environmental context, controlling methane emissions is crucial to preventing climate change and preserving biodiversity. Methane emissions from mines, power plants and industrial installations affect air, soil and water quality. Reducing these emissions impacts ecosystem health, biodiversity and the quality of life of people, especially those living near these emission sources.

We cannot ignore the fact that the sustainable use of methane, especially in the production of renewable energy, contributes to the reduction of its emissions into the atmosphere, which is of key importance in the fight against climate change. Methane can be used to produce biogas, which is a valuable and ecological source of renewable energy. This in turn reduces dependence on fossil fuels and contributes to a more sustainable energy system. The sustainable use of methane creates new business opportunities, creating jobs and generating income from the production and sale of biogas. This contributes to the development of local communities and economies. Finally, the use of methane as a renewable energy source increases energy independence and security of energy supply, which is important in the context of changing conditions on the fossil fuel market (Sobczak, Chomać-Pierzecka, Kokiel, Rózycka, Stasiak, Soboń, 2022). An example to confirm the above thesis is the war in Ukraine, as a result of which gas prices on the stock exchange increased to over EUR 100 per megawatt hour (Wpływ wojny na Ukrainie…, 2023).

In conclusion, designing and implementing sustainable methane actions can improve public acceptance of these initiatives. The sustainable use of methane is a key aspect of combating climate change, ensuring sustainable development, creating jobs and improving the quality of life, which makes - as already noted - an important issue from an economic, social and environmental perspective. As estimated by Hoglund-Isaksson, global emissions could reach 414 Mt of methane in 2030. The technical mitigation potential is estimated at 195 Mt of methane in 2030, of which approximately 80% can be achieved at a marginal cost of less than 20euro t-1 CO_2 equivalent using a social planner's cost perspective. From a private investor's cost perspective, the relevant fraction is only 30 percent. In this light, methane emission and use constitute both an opportunity and a threat to social development (Hoglund-Isaksson, 2012). The key in this area is appropriate management and regulations that allow for the control of methane emissions while using it as an energy source. In the context of sustainable economic development, there is the potential to turn this challenge into an opportunity, improving people's

quality of life and protecting the natural environment (Pathway to a Cleaner Energy Future, 2021).

4. Methane and its sustainable use on a global scale

The issue of the use of methane in the global policies of the world's largest economies is extremely important in the perspective of climate change and the promotion of sustainable development. Methane (CH_4) is a powerful greenhouse gas that has much greater potential to trap heat in the atmosphere than carbon dioxide (CO_2). Therefore, focusing on reducing methane emissions is crucial to achieving greenhouse gas reduction goals. One of the key determinants of the indicated concentration is greenhouse gas emissions resulting mainly from the combustion of fossil fuels (coal, oil and natural gas) for automotive and industrial purposes, which causes carbon dioxide emissions during their extraction and consumption. The amount of CO_2 in the atmosphere before the industrial revolution was approximately 280 ppm, and has now increased to 412 ppm (as of 2019). An increase in atmospheric temperature also causes an increase in ocean temperature. Oceans play an important role in the global carbon cycle and remove approximately 25% of carbon dioxide emitted by human activities. In addition, some CO_2 dissolves in ocean water, releasing carbonic acid, which increases the acidity of seawater. Rising ocean temperatures and acidification not only reduce their capacity to act as carbon sinks, but also impact ecosystems (Global Methane Tracker, 2022). In this perspective - as emphasized in the introduction to the expert opinion - the world's largest economies, such as the United States, China, the European Union, India and others, play a significant role in the global use of methane (Table 1).

Table 1.
Methane emissions from coal mines by largest emissions and countries. Status at the end of 2023 and proposal for the future level of methane emissions.

Country	Operating Mines Methane (CH_4)			Proposed Projects Methane (CH_4)		
	Annual CH_4 Emisssions (MCM)	Annual CH_4 Emisssions (Mt CO_2e 20 years)	Annual CH_4 Emisssions (Mt CO_2e 100 years)	Annual CH_4 Emisssions (MCM)	Annual CH_4 Emisssions (Mt CO_2e 20 years)	Annual CH_4 Emisssions (Mt CO_2 100 years)
Australia	3,443	190	69	1,270	70	25
China	70,050	3,872	1,399	12,420	687	248
Czech Republic	105	6	2	5	0	0
Germany	352	19	7	0	0	0
India	1,528	84	31	1,320	73	26
Indonesia	1,306	72	26	85	5	2
Kazakhstan	587	32	12	45	2	1
Mongolia	162	9	3	64	4	1
North Korea	441	24	9	0	0	0

Cont. table 1.

Poland	1,213	67	24	60	3	1
Russia	3,788	209	76	1,397	77	28
South Africa	1,648	93	34	556	31	11
Thailand	119	7	2	0	0	0
Turkey	158	9	3	52	3	1
United States	4,286	237	86	56	3	1
Vietnam	409	23	8	0	0	0

Units of measurement: million cubic meters (MCM), million tonnes (Mt), CO_2 equivalent (CO_2e).

Source: Global Coal Mine Tracker.

An analysis of the role of each of these economies in the context of sustainable use of methane indicates the following regularities. The United States is one of the largest producers and consumers of energy in the world. Therefore, their role in reducing methane emissions is important. Recent years have seen increasing commitment by the federal government and many states to reduce methane emissions from the oil and gas industry, as well as the transportation sector. In this light, it is necessary to further increase efforts to regulate, monitor and modernize infrastructure to reduce methane leaks and its sustainable use. An example of such activities is the plan to reduce methane emissions through remediation in the space of closed coal mines, which are a significant source of methane emissions, the volume of which is estimated at 5.9 MMT CO2 on an annual basis. In this plan, President Biden proposed an aggressive program to remediate disused coal mines as a key part of his Build Back Better program (The Build Back Better Framework, 2021). The program was financed by the US Congress in the amount of $11.3 billion under the Infrastructure Investment and Jobs Act, of which a significant item was the Mine Land Abandoned (AML) grant, which allowed for the remediation of most of the currently known AML landfills in the area. USA, creating jobs and helping to reduce methane emissions from underclaimed, abandoned mines - stimulating economic development (https://www.epa.gov/superfund..., 2023). In turn, China is the world's largest producer and consumer of hydrocarbons, which makes it a key player in methane emissions. There is a need in this country to increase control over methane emissions, both in the energy sector and in agriculture. China is making efforts to modernize its industry by promoting low-emission technologies, such as technologies that reduce methane leaks in oil and gas extraction and production processes. As noted by the authors of the research published in the article entitled “Changes in methane emissions observed in China linked to factors influencing policy” increased control determines active reduction of methane emissions in China. A comprehensive assessment of the current situation can provide a benchmark for tracking the country's future progress. Using satellite and surface observations, methane emissions in China were quantified from 2010 to 2017. Incorporating newly available terrestrial grid data across China has significantly improved the ability to reduce emissions at sub-national and sectoral levels. Author's research shows that recent changes in methane emissions in China are related to energy, agricultural and environmental policies. In this light, contrasting trends in methane emissions across regions attributable to coal mining are found, reflecting region-

specific responses to China's energy policy of closure of small coal mines (decreases in the southwest) and consolidation of large coal mines (increases in the north). Coordinated methane production from coal and coal seams in southern Shanxi effectively reduces methane emissions despite increased coal production there. This perspective identifies the policy drivers of recent changes in methane emissions in China, providing inputs for formulating methane policies to achieve the climate goal (Zhang, Peng, 2022). Another large shareholder in methane emissions is the European Union. It is also taking an active role in promoting the sustainable use of methane as part of its strategy to combat climate change. To this end, it implements stringent methane emission standards in the energy sector and seeks to increase energy efficiency to reduce methane emissions. The European Union also supports environmentally friendly agriculture by promoting practices that reduce methane emissions. Authors of the work entitled "Reducing methane emissions - an important step in strengthening the sustainable development dimension in network activities" emphasize the importance of the following activities and goals (Olczak, Piebalgs, 2020):

- gas value chains should be more oriented towards sustainable development, and the network of methane emitting companies should mainly strive to reduce methane emissions,
- a regulation should be introduced limiting methane emissions from the gas sector at European level,
- solid and transparent monitoring of methane emissions should be created, encouraging the network of companies emitting methane to undertake and implement ambitious action plans in the area of establishing a European Methane Emissions Observatory, which could be an effective tool for significant methane reduction. The observatory would undertake data analysis based on grassroots reporting by a network of methane emitting companies, aerial surveys and satellite measurements, ensuring the necessary transparency of the results obtained,
- National Regulatory Authority (NRA) should recognize effectively incurred costs by regulated entities. A form of incentive-based regulation aimed at minimizing network losses based on the experience of the electricity sector could be a promising approach in the space of sustainable methane use.

As a result of their decision - and this should be particularly emphasized - the development of regulations on methane emissions in Europe will require the European Commission to make difficult choices; to strike the right balance between the stringency of the MRV (Monitoring Reporting and Verification) framework and the costs incurred by regulated entities, as well as creating a framework that takes into account technological developments while being sustainable.

The last economy discussed and a large emitter of methane is India. As a developing market with high potential for economic growth, this country is struggling with challenges related to controlling methane emissions. It addresses challenges related to methane emissions in the agricultural and coal mining sectors. In this perspective, India needs to invest in modern technologies and practices that will help reduce methane emissions and accelerate sustainable development. As noted in the report entitled A brief profile on coal. India (Country Profiles. The Carbon…, 2023). This is a particularly important process and challenge because India is the second largest consumer of coal in the world after China, overtaking the United States in 2015. Moreover, China's coal consumption has stabilized, meaning India can largely determine the fuel's global trajectory. Many analysts expect India's rapid growth to drive global demand growth over the next few years - although it is expected to remain below peak in 2014. Coal has fueled rapid growth in electricity consumption in India, and the size of the country's coal fleet has more than tripled since 2000. In 2017, coal generated 76% of India's electricity. As of January 2019, India has 221 gigawatts (GW) of coal-fired power plants in operation. According to Global Coal Plant Tracker, it is the third largest fleet in the world, with 11% of global capacity. Another 36 GW is under construction and another 58 GW is in earlier stages of development. As has already been noted, India is the second largest producer and importer of coal after China. Coal India, a national coal mining company and the world's largest coal producer, produces about 84% of the country's output. India has proven coal reserves of approximately 98 billion tones, or 9.5% of the world's reserves, again second only to China.

To conclude, a common challenge for the economies described above is the need to cooperate and coordinate activities for the sustainable use of methane. As indicated by numerous sources, there is a need to exchange technologies, experiences and knowledge in order to effectively reduce methane emissions on a global scale. Furthermore, international initiatives such as the Paris Agreement play a key role in achieving global harmonization. As the authors of the report note: Methane Abatement (Bredariol the Oliveira, McGlade'a, 2023). there is a huge opportunity to reduce methane emissions from the energy sector. We estimate that approximately 70% of methane emissions from fossil fuel activities can be reduced with existing technology. In the oil and gas sector, emissions can be reduced by more than 75% by implementing well-known measures such as leak detection and repair programs and retrofitting leaking equipment. In the coal sector, more than half of methane emissions can be reduced by maximizing the use of methane from mines or by flaring or oxidation technologies when energy recovery is not cost-effective.

In this space, it appears that the roles of economies such as the United States, China, the European Union and India are crucial in the global use of methane. Their actions and commitment to controlling methane emissions will have a significant impact on the future of our planet and the fight against climate change. However, achieving methane emission reduction goals requires international cooperation and long-term actions for its sustainable use.

The facts described above determine - as has already been emphasized - the need for joint action on a global scale in order to identify and reduce the sources of methane emissions and its sustainable use. The global methane commitment plays a huge role in this space, in particular the global declaration announced during COP26 in November 2021 to accelerate actions aimed at reducing methane emissions (The Global Methane Pledge).

Countries joining The Global Methane Pledge commit to a common goal of reducing global methane emissions by at least 30%. by 2030 relative to 2020 levels and striving to use the best available inventory methods to quantify methane emissions. By joining the commitment, the countries declare to take comprehensive actions to "achieve reductions in the energy and waste sectors and strive to reduce emissions from agriculture through technological innovations, as well as incentives and partnerships with farmers." This initiative, led by the United States and the European Union, currently brings together 111 participants from countries that together are responsible for 45% of global man-made methane emissions (https://www.ccacoalition.org/en/resources...). Among these activities, it is worth noting initiatives related to fossil fuels. The indicated sources are responsible for over one third of methane emissions caused by humans. These emissions represent one of the best short-term options for climate action because the ways to reduce them are known and understood (Rogelj, Geden, Cowie, Reisinger, 2021). The identified goals in the area of fossil fuels focus on precisely defined activities, which are:

- the need to build a broad coalition whose goal will be to bring methane emissions resulting from fossil fuel activities onto a net zero emissions path (Net Zero Strategy…, 2021),
- using proven technologies and principles to reduce methane emissions (Report ESG Respect Energy, 2022),
- thanks to well-known existing technologies, over 40% reduction in oil and gas emissions at no net cost (Wang, Li, Jon, Li, Liu, Zhang, 2023),
- widespread adoption of proven policies that would halve global emissions from oil and gas activities (Technologies and perspectives for achieving carbon (Wang, 2021),
- introducing institutional support that could lead to significant reductions in oil and gas traded internationally (Krueger, 2023),
- the construction of early warning systems to locate leaks could facilitate timely action and a significant reduction in methane emissions (Methane Report, 2022),
- creating conditions for shaping voluntary initiatives that can play a key role in ensuring timely methane reductions (A direct result of surveys detecting methane…, 2022),

In the area of the indicated activities - which should be particularly emphasized - avoiding methane emissions from coal is a serious challenge. Solving this problem, it is important to emphasize, is more challenging than in the case of oil and gas activities, but there are opportunities to mitigate these emissions. Existing technologies may play a significant role in

this process in the near term. In the IEA's (International Energy Agency) Net Zero Emissions by 2050 scenario, coal consumption will fall by 55% from 2020 to 2030 and by almost 90% by 2050. This decline would significantly reduce methane emissions from coal mines as well as CO2 and other air pollutants; emissions reductions would be even greater if the focus was on the worst-performing coal assets. For example, removing the worst-performing quartile would remove approximately 25 Mt of methane, while removing the best-performing quartile would only remove approximately 4 Mt (Zerowe emisje netto do 2050 r., 2022),

In the indicated perspective and indicated guidelines - numerous expert opinions emphasize - that policies and measures are still necessary to reduce methane leaks from coal plants on a global scale (Launay-Smirnov, 2023). Technology and innovation are a particularly important area in this field. In the light of the above thesis, it is worth emphasizing again that today is an era of dynamic technological development, and one of the key challenges we face is protecting our environment against harmful greenhouse gas emissions. Methane, a powerful greenhouse gas, plays a particularly important role in climate change processes. Therefore, contemporary development and implementation of new technologies are crucial to reducing methane leaks and protecting our planet. One of the measures to reduce methane leaks on a global scale is to monitor the sources of these emissions. Modern monitoring technologies, such as satellites, sensors, drones and telemetry systems, enable precise tracking of leak sources at various stages of the production process, from the extraction of natural raw materials to their processing and transport. This allows for quick identification of problems and more effective corrective actions. In practice, this means the possibility of minimizing methane emissions at the stage of extraction of natural resources, which is crucial for limiting the impact of this gas on climate change (Emran, Tannant, Najjaran, 2017). Along with monitoring, it is important to isolate methane sources and technological innovations enable the recovery and utilization of methane and its transformation into energy sources, instead of leaving it in the wind. This not only determines the reduction of emissions, but also creates additional energy sources. The above-mentioned goals are indeed found in hard coal mining, which has long been an important sector of the economy, providing the fuel necessary for energy production around the world. In recent years - and it should be particularly emphasized - in the global mining industry, experts have been focusing more and more attention on the need for technological innovations in the recovery, utilization and transformation of methane.

5. Summary

As has been noted several times in recent years, issues related to sustainable development and environmental protection have become central topics in the international arena. One of the key elements of this debate is the role of methane as a greenhouse gas and the

question of whether its use can contribute to sustainable development or pose a potential threat to the environment. In this perspective, methane, which is the main component of natural gas, plays a key role in the energy balance of the global economy. Its extraction and use are integral elements of modern society, providing energy for the production of electricity, heating homes and driving vehicles. However, methane is also a greenhouse gas, contributing to global warming. In view of the above regularities, it seems that the key global challenge is the need to construct an economic model that will allow for the sustainable use of methane (Brauers, 2022). One of the approaches to this goal is to develop technologies that allow for the effective capture and use of methane in energy processes. Equally important - and this should not be forgotten - are the potential threats related to the extraction and use of methane. Leaks in gas infrastructure, uncontrolled emissions and operational processes can lead to the release of methane into the atmosphere, which significantly accelerates the global warming process. Therefore, it is necessary to focus on improving technologies and industry practices to minimize the potential negative effects of methane emissions into the environment (Questions and answers…, 2020). From a global perspective, international cooperation is a key element in the effective management of methane emissions. Countries should strive to establish uniform standards for the extraction, transport and use of methane to avoid a situation where one country makes efforts towards sustainable use while others ignore the problem. Therefore, it seems correct to say that the sustainable use of methane in a global context is both a challenge and a threat. The key task is to develop a strategy that will allow for the effective use of this energy resource while minimizing negative effects on the environment. Innovative technologies, stringent regulations and international cooperation are the key to achieving this goal and turning the use of methane into an opportunity for sustainable global development.

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