

Current Status of Methane Emissions in China and Its Impact on Climate Change: Policy and Countermeasure Analysis

Shuo Li^{1,a,*}

¹College of Liberal Arts and Science, University of Connecticut, Storrs, CT 06269, The USA

a. Shuo.li@uconn.edu

*corresponding author

Abstract: Sources of methane emissions include agriculture, such as rice fields and livestock farming, energy production, such as natural gas and oil extraction, and waste disposal, such as landfills. As a potent greenhouse gas, methane has a more substantial short-term warming effect than carbon dioxide, so controlling methane emissions has become an essential goal of global climate action. Countries are reducing methane emissions through policies, regulations, and technical means. Research has found that methane emissions have significantly impacted China's climate system, leading to frequent extreme weather events and posing threats to ecosystems. The Chinese government has adopted emission reduction policies but faces challenges in policy implementation and technology application. This article uses a literature review to analyze the current status of methane emissions in China, analyze its impact on climate change, evaluate the effectiveness of current policies, and propose improvements. The technological obstacles to reducing methane emissions and the challenges in implementing policies are examined in this essay, which combines policy analysis with technical application discussions. This provides a new perspective for climate policy research, enriches the research content in greenhouse gas emission reduction, and offers solid theoretical support for the comprehensive governance framework for climate change response.

Keywords: Methane Emissions, Climate Change, Policy Analysis, China.

1. Introduction

As one of the most potent greenhouse gases, methane's impact on climate change, is becoming increasingly apparent on a global scale. The global warming potential of methane is 25 times that of carbon dioxide, so the impact of its emissions on the climate system cannot be ignored [1]. In China, methane emissions mainly come from agriculture such as rice fields and animal husbandry, energy production such as natural gas and oil extraction, and waste disposal such as landfills [2]. These emission sources profoundly impact global climate change and have put significant pressure on China's environment and economy [3].

Recent research shows methane emissions are a growing concern for their role in global warming. According to research, methane emissions have increased extreme weather events, posing severe threats to ecosystems and human life [4]. The study pointed out that despite the implementation of

multiple policies by the Chinese government to reduce methane emissions, there are still numerous obstacles to be addressed in terms of policy effects and technology applications [5].

Technological innovation and policy improvements are essential to effectively reduce methane emissions and mitigate the adverse effects of climate change. Research shows that comprehensive solutions that incorporate both scientific advancements and governmental actions [6]. This paper aims to analyze China's methane emissions, evaluate the effectiveness of current policies, and provide recommendations for future improvements.

This study provides an in-depth analysis of methane emission sources, policies, and impacts, providing a valuable resource for Chinese policymakers and other global actors interested in climate change strategies. This research will not only enhance our understanding of methane emissions but also contribute to formulating climate change policies worldwide.

2. Literature Review

The global scientific community has identified methane as one of the leading greenhouse gases contributing to human-induced climate change. According to the Intergovernmental Panel on Climate Change, methane accounts for approximately 16% of global greenhouse gas emissions, with agriculture, energy production, and waste disposal being the primary sources [1]. However, due to its high warming potential, methane's contribution to global warming is much more significant than its percentage of total greenhouse gas emissions.

China's agricultural sector is a significant source of methane emissions. For example, growing rice creates anaerobic conditions that promote methane production by methanogenic bacteria [2]. China is the world's most significant contributor to agricultural methane emissions with its vast rice-growing areas. According to studies, rice fields account for nearly 20% of China's total methane emissions [3]. Animal husbandry is another important source, with enteric fermentation in ruminants such as cattle and sheep producing large amounts of methane. The decomposition of organic matter in animal manure also contributes to the country's total methane emissions [4].

China is one of the largest producers of coal and natural gas, and these energy sources generate significant amounts of methane emissions. Methane leaks occur throughout the natural gas supply chain, from extraction to transportation to emissions, and account for a large portion of total methane emissions [5]. Coal mining is another significant contributor to methane emissions, particularly in underground coal mines, where methane trapped in coal seams is released during mining activities. Although the Chinese government has introduced technologies such as coalbed methane capture, these systems are not widely implemented, especially in small-scale mining operations [6].

China's landfills are a significant source of methane emissions due to the anaerobic decomposition of organic waste. While developed countries have widely adopted landfill gas capture systems to reduce methane emissions, many areas in China still lack the infrastructure to implement these technologies effectively. As a result, landfills account for a large portion of China's methane emissions, particularly in rapidly urbanizing regions where waste production is increasing [5]. International efforts to reduce methane emissions are primarily governed by global frameworks such as the Paris Agreement, which emphasizes reducing greenhouse gas emissions to limit global warming to below 2°C. China has actively participated in these international efforts and has pledged to reduce methane emissions as part of its broader climate change mitigation strategy. China has set ambitious targets to peak carbon emissions by 2030 and achieve carbon neutrality by 2060, and reducing methane emissions is a key part of these goals. However, research shows that China's domestic methane emissions policy is still in its infancy compared to CO₂ policies. This difference is mainly due to the need for comprehensive data on methane sources and emissions, as well as the challenges of enforcing methane-specific regulations in different industries. The importance of research and data collection in addressing the issue is therefore paramount.

3. The Case for Controlling Methane Emissions

3.1. Agriculture: Policy Challenges and Technical Solutions

In the agricultural sector, methane emissions from rice paddies have been a focus of government reform. The Chinese government has promoted water-saving irrigation technologies, such as intermittent irrigation, which can significantly reduce methane emissions from rice paddies [2]. However, adoption of these technologies has been slow, especially in rural areas with deeply rooted traditional farming practices. In addition, the high cost of methane reduction technologies, such as biogas digesters for manure management, has limited their adoption by small-scale farmers [3]. According to one study, the lack of financial incentives and technical support for farmers has led to the widespread implementation of methane reduction technologies in China's agricultural sector [4]. The authors believe targeted subsidies and construction programs are essential to encourage farmers to adopt these technologies. In addition, public awareness campaigns are needed to educate farmers about the benefits of methane reduction on the environment and improve agricultural efficiency, as well as to make more farmers aware of the environmental degradation caused by methane.

3.2. Energy Sector: Coalbed Methane Capture and Regulation

The energy sector has made progress in reducing methane emissions through coalbed methane capture technologies, which not only reduce emissions but also utilize methane as a clean energy source [5]. However, the lack of capacity among smaller coal mining companies to implement these technologies and the inconsistent regulatory enforcement across regions remain significant challenges. A report from China's Ministry of Ecology and Environment has identified the need for stricter enforcement of methane capture regulations and, importantly, the development of financial mechanisms to support small mining companies in adopting these technologies [6]. In the oil and gas sector, methane leaks during extraction and transportation continue to pose a major challenge. While advanced leak detection and remediation technologies are available, their high costs have hindered widespread adoption, especially among smaller operators. The Chinese government has introduced new regulations requiring companies to monitor and report methane emissions, but enforcement remains a challenge due to the large scale of the industry and the cumbersome process.

3.3. Waste Management: The Role of Landfill Gas Capture

Methane emissions from landfills are a growing concern in China, particularly as urbanization leads to increased waste generation. While some large cities have successfully implemented landfill gas capture systems, many smaller towns need more infrastructure and financial resources to do so [5]. A study found that landfill gas capture could potentially reduce methane emissions by up to 50%, underscoring its significant impact on environmental protection [6]. China's waste management policies have traditionally focused on waste reduction and recycling, with less emphasis on methane capture. However, recent government initiatives have begun to address this gap by promoting the adoption of landfill gas capture technology in new waste management facilities. Additionally, policies aimed at reducing food waste and encouraging composting can help reduce the amount of organic waste sent to landfills, thereby further reducing methane emissions.

4. Discussion

4.1. Policy Implementation and Technology Promotion

Although China has made significant progress in addressing methane emissions and has formulated relevant policies and regulations, there are still some significant gaps in policy implementation and technology promotion.

First, there are significant regional differences in policy implementation. In some rural areas with high agricultural methane emissions, the lack of necessary technical means and financial support makes it difficult for these areas to implement methane emission reduction technologies effectively [3]. For example, rice cultivation and animal husbandry are the primary sources of methane emissions in rural areas. Still, due to the limited financial resources of local governments, these areas have yet to progress in technology upgrading and emission control. In contrast, due to relatively sufficient financial support in urban areas, emission reduction technologies in areas such as waste management have been more widely used [5]. For example, some large cities have installed methane capture systems at landfills to reduce greenhouse gas emissions generated during waste management. Second, the public lacks sufficient awareness of methane emissions and their impact on climate change, which also hinders the effective promotion of methane emission reduction. Compared with carbon dioxide, methane is often less prominent in public discussions, which has led to insufficient attention to methane emissions in national and local emission reduction strategies. According to research, the public's limited awareness of methane as a potent greenhouse gas has hampered the public and private sector's efforts to reduce methane emissions [6]. Therefore, it is particularly important to strengthen public education and raise awareness of the hazards of methane emissions in society. By increasing publicity efforts, the government can better mobilize all sectors of society to participate in methane emission reduction actions and promote more extensive technology application and policy implementation. This lack of awareness is a significant barrier that must be overcome to effectively reduce methane emissions.

4.2. Technical barriers and Potential Opportunities

Technological innovation plays a vital role in methane emission reduction, but in reality, the high cost and complexity of many advanced technologies hinder their promotion nationwide. Methane capture technologies, such as gas capture in coal mining and methane collection systems in landfills, have been proven effective in reducing emissions [5]. However, the high initial costs of these technologies are unaffordable for many small and medium-sized enterprises and individual farmers, resulting in an imbalance in technology application. In addition, promoting low-cost, scalable methane emission reduction technologies faces significant challenges in the agricultural sector, where methane emissions are most concentrated.

Take rice cultivation as an example. Traditional flooded cultivation methods produce a large amount of methane. Although alternative planting methods (such as dry rice cultivation) are considered to have the potential to reduce emissions, their cost and difficulty of promotion still need to be lowered under the existing technical framework [2]. Therefore, future research should focus on developing low-cost technologies suitable for small and medium-sized farmers, such as improving rice field management techniques and optimizing feed to reduce livestock methane emissions. In addition, promoting innovative technologies for methane emission reduction requires strengthening cooperation between the government, scientific research institutions, and enterprises to ensure that these technologies can be widely promoted and applied.

However, this challenge also brings great opportunities. The research and development, and promotion of methane emission reduction technologies not only help mitigate the impact of climate

change, but also promote the development of green industries. In recent years, the Chinese government has gradually realized that green technology innovation is not only a necessary means to address climate change, but also an important element to promote high-quality economic development. By increasing investment in the research and development of methane emission reduction technologies, China can cultivate a domestic green technology market. The country can encourage small and medium-sized enterprises and the agricultural sector to adopt new technologies by formulating incentive policies and providing subsidies. This will not only promote the achievement of emission reduction targets, but also provide impetus for the country's green economic transformation [6].

4.3. The necessity of international cooperation

As a major greenhouse gas emitter in the world, China should strengthen cooperation with other countries, share experiences and technologies, and promote methane emission reduction on a global scale. For example, in cooperation with developed countries, China can learn and introduce advanced methane capture technology and accelerate domestic technological development through international technology transfer. In addition, international cooperation can also promote coordination among countries in policy formulation and implementation by formulating more stringent global methane emission reduction standards [6]. This global collaboration is crucial in the fight against climate change and should be a priority for all nations.

The urgency of global climate change means that the efforts of any single country are unlikely to cope with the enormous challenges brought by methane emissions alone. Therefore, China should continue to actively participate in international climate negotiations and work with other major emitters to formulate and implement a global methane emission reduction strategy. At the same time, international platforms such as the United Nations Framework Convention on Climate Change also provide opportunities for countries to communicate and cooperate. China can use these platforms to showcase its achievements in methane emission reduction and obtain more technical and financial support through international cooperation.

4.4. Improvement plan

First, the research development, and promotion of emission reduction technologies are crucial. Although high-cost technologies have shown effectiveness in reducing methane emissions at this stage, they still face the problem of economic feasibility in popularizing these technologies nationwide. Therefore, future research and innovation should focus on developing low-cost, scalable emission reduction technologies to improve their operability and ease of promotion. For example, improving rice field management methods in the agricultural field and creating more adaptable methane capture equipment can provide more effective solutions to reduce methane emissions in the farm field. At the same time, coalbed methane capture technology in the energy sector and landfill gas capture systems in the waste management sector also need innovation and improvement to achieve larger-scale emission reduction targets.

Secondly, the need for more flexible policy frameworks to incorporate methane emission reduction into the overall climate change response strategy is crucial. Although China has introduced a number of policies related to methane emission reduction, the implementation of policies varies greatly between regions and industries. Some regions have implemented policies properly and achieved remarkable results, while other regions have faced technical and financial constraints and have failed to effectively implement emission reduction policies. In the future, policymakers should focus on narrowing this implementation gap and ensuring that emission reduction measures are more widely applied and implemented by providing more financial support and technical guidance, especially for

small and medium-sized enterprises with limited resources and rural areas. This will ensure that all industries and regions work in a coordinated manner to jointly promote the continued decline of methane emissions.

International cooperation is a key player in the field of methane emission reduction. As a global issue, methane emission reduction actions require not only the joint efforts of all countries, but also the strengthening of cooperative relations in technology, policies, and experience sharing. By participating in global climate action and international cooperation on methane emission reduction, China can draw valuable experience and resources from the successful experiences of other countries and regions. For example, some developed countries have made breakthroughs in methane emission reduction technology, and China can accelerate the introduction and promotion of relevant technologies in China by strengthening cooperation with these countries.

5. Conclusion

Methane emissions have become a significant challenge that cannot be ignored in China's climate change mitigation efforts. Although the Chinese government has implemented a number of technical and regulatory initiatives in the areas of waste management, energy generation, and agriculture, but much work remains until there are noticeable emission reductions. The primary obstacles impeding overall development are now uneven policy implementation, the high cost of solutions for reducing methane emissions and the lack of public awareness of methane emissions. However, suppose effective government intervention, policy reforms, and other means can be used to improve public awareness, including formulating targeted subsidy policies, implementing equipment construction projects, and generating a lot of media attention. China can still drastically cut methane emissions in that scenario. In future research, more attention must be paid to combining methane emission reduction with the overall low-carbon development goals. For example, more comprehensive and forward-looking guidance can be provided for China's climate policy by integrating methane emission reduction with renewable energy and carbon neutrality strategies. In addition, strengthening public awareness and education is also a critical link that must be addressed in reducing methane emissions. Government and society can work together to promote the in-depth implementation of methane emission reduction by raising public awareness of the hazards of methane emissions and encouraging individuals and businesses to actively participate in emission reduction. In summary, although China still faces many challenges in methane emission reduction, through efforts in technology innovation, policy improvement, international cooperation, and public participation, it will play a more active leading role in future climate change responses. These practical measures can reduce methane's negative impact on global climate change and support China's sustainable development.

References

- [1] IPCC. (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.
- [2] Li, X., & Zhang, H. (2020). *Methane Emissions in Agriculture: Challenges and Solutions for China*. *Journal of Agricultural Science*, 58(4), 23-45.
- [3] Xu, Y., & Li, J. (2021). *Landfill Gas Capture and Methane Emissions Reduction in China: A Policy Analysis*. *Waste Management and Research*, 39(3), 123-134.
- [4] Ministry of Ecology and Environment. (2021). *China's Methane Emission Control Strategy*. Beijing: Chinese Government Publishing House.
- [5] Zhang, W., Liu, F., & Zhou, P. (2020). *Coalbed Methane Capture Technologies in China: Progress and Challenges*. *Energy Policy*, 140, 111322.
- [6] United Nations Environment Programme (UNEP). (2020). *Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions*.