绿色创新发展中心
Innovative Green Development Program

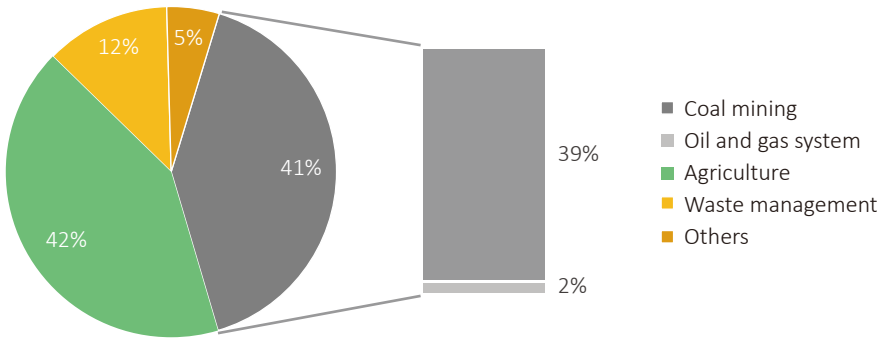
Methane Reduction in Coal Mines in China: Observations and Prospects

Status Quo

1. Coal mines account for the highest share of methane emissions in China

According to data from the *Second Biennial Update on Climate Change in the People's Republic of China* submitted in 2018, methane emissions reached 1.161 billion tons of carbon dioxide equivalent (CO_2e) in 2014, accounting for about 10.4% of the country's total GHG emissions the same year, with fugitive coalbed methane from coal mining and post-mining activities being taking up 39%, the largest source. As the total amount of coal mined in China declines, coal mining-related methane emissions will also decline, but research out of Tsinghua University shows that from 2015 to 2030, coal mining emissions will constitute between 39%- 44% of total methane emissions. This proportion will decrease by 2050, but will still be approximately 25.5% at that time. [1]Therefore, early action to reduce coalbed methane emissions is important to reducing China's long-term methane emissions.

Figure 1: Methane Emissions by Sector in China (2014)

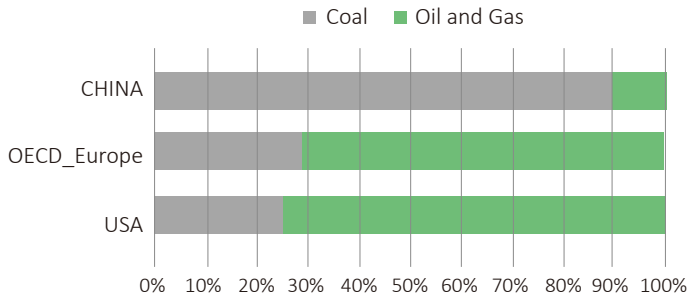


Data source: *Second Biennial Update on Climate Change in the People's Republic of China*

Compared to major countries and regions around the world, methane emissions from the energy sector in China come mainly from coal mine activities. in the U.S. and Europe, in contracst, methane emissions come mainly from oil and gas systems. Figure 2 shows the percentage of methane emissions from the energy sector in China, USA and Europe according to the EDGAR global database.

[1] Institute of Climate Change and Sustainable Development of Tsinghua University. (2021). *China's Long-Term Low-Carbon Development Strategies and Pthways*. China Environment Publishing Group.

Figure 2: Methane Emissions from Energy Supply by Sector in China, USA and Europe

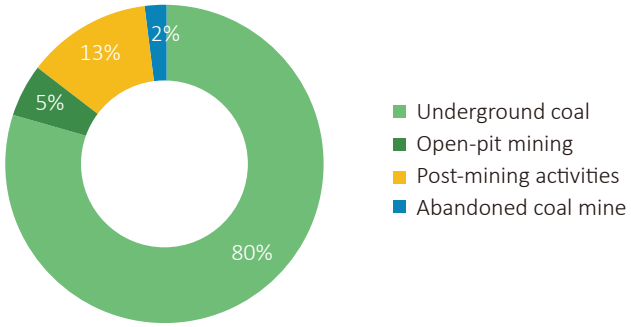


Data source: EDGAR

2. Ultra-low concentration coal mine gas dominates in coal mine methane emissions

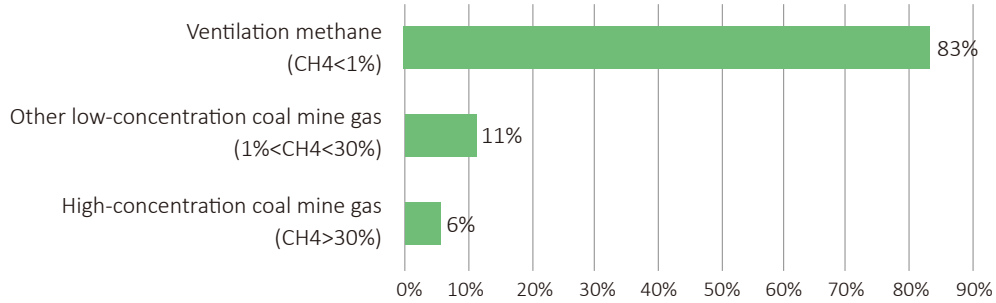
As shown in Figure 3, 80% of coal mine methane emissions in China currently comes from underground coal mining and 13% from post-mining activities. Ultra-low concentration ventilation gas accounts for more than 80% of the methane emissions from underground coal mining, while other concentrations take up roughly 11% (see Figure 4). Ventilation methane refers to the large amount of air introduced into the mine to ensure miner safety during underground mining, with methane concentration diluted to less than 0.75% (i.e., ventilation methane). The extremely low methane concentration makes it difficult for utilization and therefore most of it is vented directly, resulting in substantial emissions of ultra-low concentration gas from China's coal mines.

Figure 3: Distribution of methane emissions from coal mines in China



Data source: Liu et al, 2022[2]

Figure 4: Distribution of methane emission in underground coal mining



Data source: Zhou et al, 2016 [3]

[2] Liu, W., Xu, X., Han, J., Wang, B., Li, Z., & Yan, Y. (2022). Trend model and key technologies of coal mine methane emission reduction aiming for the carbon neutrality (in Chinese). Journal of China Coal Society, 47(1), 470–479.

[3] Zhou, F., Xia, T., Wang, X., Zhang, Y., Sun, Y., & Liu, J. (2016). Recent developments in coal mine methane extraction and utilization in China: a review. Journal of Natural Gas Science and Engineering, 31, 437–458.

Key Challenges

1. Insufficient standards for ultra-low concentration gas emission reduction

China's existing coal mine methane emission limitation standards **do not prohibit ultra-low concentration gas emissions**. *Coalbed Gas (Coal Mine Methane) Emission Standard (Interim)* launched in 2008 only prohibits emissions of high-concentration gas (methane volume fraction ≥ 30%). However, there is no prohibition on the emission of low-concentration gas (methane volume fraction < 30%) and ultra-low concentration exhaust from coal mine gas extraction systems[4].

Moreover, **the current standard restricts methane emissions only in terms of methane concentration, rather than total methane emissions**[5]. The current standard[6] requires coal mines to monitor methane concentration, flow rate, pressure, temperature and other parameters in the pipeline and to install automatic monitoring equipment for coalbed methane (coal mine gas) emissions, connected to the monitoring center of the local environmental protection department. However, the standard neither sets limits nor imposes monitoring requirements on the total quantity of methane emissions.

2. Lack of cost-effective technologies for ultra-low concentration coal mine methane

Low-concentration coal mine methane (5% to 30% concentration levels) is mainly used for power generation. However, due to the low efficiency of generating units, there is much room for improvement in cost-effectiveness. [7] For methane concentrations below 5%, especially ventilation air methane below 0.75% concentration, development and utilization presents a great challenge since the unfavorable economics of the technical process lead to unstable market demand. An additional problem is that ventilation air methane is further diluted by increasing ventilation for miners' safety, making it more difficult to utilize.

If the China Certified Emission Reduction (CCER) trading market is launched, methane emission reduction can generate CCER credits for trading, which would be expected to make this process more economically viable.

Case 1: CCER project on low-concentration coal mine gas

Zhongyuan Bozhi Energy Saving Technology Co., LTD cooperates with coal mining areas, applying the "reheat oxidation method". This method uses redox reactions to reduce methane emissions by producing carbon dioxide and water from the methane in the coal mine "ventilation air". The approved emission reductions generated through these CCER projects can be traded.

In the carbon emission reduction certification scheme, 25 tons of CCERs equals one ton of methane reduction, and the cost of capturing one ton of methane by the equipment is estimated to be less than $100. If sold as CCERs, capturing one ton of methane will make a profit of $1,250 assuming a CCER price of $50/ton. It is expected that after CCER initiates, the Zhongyuan Bozhi project will be able to generate 50 million tons of CCER in 2023.

The case is excerpted from: Qiu, X. 36kr, https://36kr.com/p/1863816681265026

[4] https://www.mee.gov.cn/ywgz/fgbz/bz/bzwb/dqhjbh/dqgdwrywrwpfbz/200804/t20080414_121137.htm

[5] Ma, C., Gao, M., & Chu, Z. (2021). Implementation of china's emission standards of coalbed methane/coal mines gas and related policy recommendations (in Chinese). World Environment, 47–49.

[6] https://www.mee.gov.cn/ywgz/fgbz/bz/bzwb/dqhjbh/dqgdwrywrwpfbz/200804/t20080414_121137.htm

[7] Yang, Y., Qu, D., Li, P., & Yu, J. (2018). Research and development on enrichment of low concentration coal mine methane by adsorption technology (in Chinese). CIESC Journal, 69(11), 4518–4529.

3. Abandoned coal mines call for immediate attention

China has not yet taken any measures to address methane emissions from abandoned coal mines, nor has it compiled an inventory. In the context of China's low-carbon energy transition, the number of abandoned mines is increasing as the energy sector gradually retreats from coal. Data show that the number of coal mines has been reduced from over 10,000 in 2015 to less than 4,700 by the end of 2020, with plans to limit the number to about 4,000 by the end of the 14th Five-Year Plan[8]. Research on and reduction of methane emissions from abandoned mines call for urgent attention.

Policy Suggestions

1. Methane Emission Reduction is a Key Area for U.S.- China Climate Cooperation

U.S.-China Joint Glasgow Declaration on Enhancing Climate Action in the 2020s, jointly issued by China and the U.S. during COP 26 in 2021, identifies methane emission reduction as a key area of cooperation. Coal mine methane is the largest source of methane emissions in China, making it the focus of China's methane reduction efforts. In the U.S., coal mine methane accounts for 13% of methane emissions from the energy sector. Reducing coal methane is a common challenge and opportunity for both sides. In addition, U.S.-China cooperation will send a positive signal to other countries to address methane emission reductions and encourage more emission reduction actions.

2. Compile an inventory of methane emissions from abandoned mines and strengthen statistics and management

After coal mine closure, methane continues to escape from poorly sealed vents or surface fracture zones in a continuous and unorganized manner. As the number of abandoned coal mines continues to rise, the resulting share of methane emissions from abandoned mines tends to increase [9]. The exact quantity of methane leakage from abandoned coal mines in China is unclear and no inventory has been compiled. It is estimated that from 1998 to 2020, China closed more than 70,000 coal mines which had exhausted resources or failed to meet safety production criteria, reducing the number of coal mines to about 4,700. The percentage of methane emissions from abandoned mines ranges from 1% to 2%, which has risen to 10-15% according to studies[10] . Therefore, attention must be given to research and development of methane emission monitoring and management technologies for abandoned mines. Also important is figuring out the number of abandoned mines and conducting relevant methodological studies as soon as possible.

3. Strengthen the management and control of methane emissions from post-mining activities

As mentioned above, post-mining activities account for about 13% of the total emissions from coal mining. The mining and later processing in China's underground coal mines are not well integrated, resulting in significant post-mining activity emissions, much higher than in Germany, the United States, and Australia. As

[8] China National Coal Association. (2021). Annual Report on Coal Industry Development in 2020. China National Coal Association.

[9] Liu, W., Xu, X., Han, J., Wang, B., Li, Z., & Yan, Y. (2022). Trend model and key technologies of coal mine methane emission reduction aiming for the carbon neutrality (in Chinese). Journal of China Coal Society, 47(1), 470–479.

[10] The U.S.-China methane emissions reduction diologue series in 21 July, 2022- Roundtable on methane emissions reduction in the coal industry. Hosted by Center on Global Energy Policy at Columbia University, Institute of Energy at Peking University, Energy Foundation.

coal densification proceeds (i.e. the volatile fraction decreases), the methane content from post-mining activities increases significantly. There is a lack of accurate statistics based on actual measurements for methane emissions from post-mining activities, and research is in urgent need.

4. Improve methane emission standards for coal mine and strengthen supervision and management

There is an urgent need to strictly control coal mine methane emission through a revision of standards. Existing methane emission standards exert little restriction on low-concentration gas (methane volume fraction<30%) in coal mine gas extraction systems or ventilation air methane in coal mine air return shafts. Based on key parameters such as relative methane emission and raw coal production in the mine gas rating identification, feasibility studies should be conducted on total methane emission amount limits and concentration limits. Meanwhile, standards supervision should be tightened, clarifying the specific authoritative regulatory body over coal mine methane emission standards and its method of supervision. This will ensure the effective exercise of authority by the relevant regulatory department.

5. Strengthen the methane MRV system in coal mines and promote capacity building among emission subjects and verification agencies

In terms of data monitoring, according to the requirements of *Coalbed Methane (Coal Mine Gas) Emission Standards (Provisional)*, enterprises are required to carry out methane emission monitoring of mine gas and install automatic emission monitoring equipment, networked with the monitoring center of the ecological environment department. However, enterprises have not strictly implemented this requirement. Therefore, it is necessary for the Ministry of Ecology and Environment to establish a sound system for reporting methane statistics and monitoring data from coal mines, to clarify the method, schedule and frequency of data reporting from enterprises, and to enhance data analysis and management. Meanwhile, it is recommended that *China's Greenhouse Gas Emission Accounting Methodology and Reporting Guide for Chinese Coal Producers* is to be further revised by Ministry of Ecology and Environment to refine the specific requirements on the monitoring objects, methods, technical parameters of monitoring equipment, installation locations, etc. for gas emissions from extraction systems and air ventilation systems.

Key emission units should be responsible for data quality. Emphasis should be placed on improving the emission unit's ability to manage the quality of emission data to eliminate systematic or unintentional error. The verification agency should ensure that the work is carried out in accordance with standardized verification requirements and methods. The national authorities should strengthen the management of verification agency qualification certification, while refining the specific requirements for agencies to verify emission reports.

6. Strengthen research on methane emission factors in coal mines in China

China currently uses IPCC GHG emission inventory guidelines to calculate methane emissions from coal mines, where methane emissions from different segments are obtained by multiplying raw coal production by emission factors[11] . Among the emission factors given by IPCC, T1 at the lowest level is the global average emission factor, T2 is the localized emission factor (that is, reflecting national characteristics), and T3, at the upper level, is the summation method of measured methane emissions from each mine. T3 is is the closest to the true value and has the least uncertainty.

[11] Liu, W., Xu, X., Han, J., Wang, B., Li, Z., & Yan, Y. (2022). Trend model and key technologies of coal mine methane emission reduction aiming for the carbon neutrality (in Chinese). Journal of China Coal Society, 47(1), 470–479.

The world's major coal-producing countries use the high-level T2 or T3 method for larger emissions, while the selection of methane emission factors for coal mines in China's national GHG emission inventory currently uses a combination of T1 and T2 methods. Since the stratigraphic structure and mining methods vary in each coal mine, the IPCC default values may deviate significantly from the actual emissions in China. A study on national characteristic factors should be conducted with the actual measured data from mines to support the preparation of a high-quality national GHG inventory and the formulation of targeted methane emission control measures.

7. Promote the efficient purification technology for low-concentration gas

Currently, gas with methane concentration less than 1%, despite intensive emission, is mainly evacuated, making it difficult to utilize due to its extremely low concentration. The existing utilization technology mainly converts it into carbon dioxide and water by heating and oxidation or catalytic oxidation, and the heat from the reaction is recovered for heating, coal processing and even power generation. *Benchmark Levels in Key Areas of Clean and Efficient Coal Utilization*, released by The National Development and Reform Commission (NDRC) in April, 2022 clearly proposes to include exploring the use of low-concentration coal mine gas into the CCER management system.

8. Improve incentive policies and establish investment and financing mechanisms for methane emission control

China's existing incentive policies include some methane emission reduction projects. Coalbed methane (coal mine gas) extraction and utilization has also been included in *Green Industry Guidance Catalogue (2019)* issued by NDRC. The *Catalogue of Green Bond Supported Projects (2021 Edition)* covers seven specific items in three areas related to methane emission reduction. However, more projects that promote methane reduction, such as disposal of abandoned mines, remain to be added. The above-mentioned projects are recommended to be reflected in the future updates of the catalogue and the development of a catalogue of support for climate investment and financing and transformational finance. The study of supporting policies on fiscal, tax, price, finance and land for methane recycling in the coal industry is simultaneously required to incentivize enterprises to perform emission reduction

9. Organize Voluntary Initiatives for Coal Mine Methane Emission Reduction

It is recommended that a voluntary initiative for coal mine methane emission reduction be launched to encourage key coal companies to set an example, laying the foundation for the transition to mandatory standards and emissions regulation. Just as many companies in the oil and gas sector have already put emission reduction actions into practice, the government and industry associations should strongly guide coal companies to take joint actions to set targets for methane emission intensity and promote methane emission control along the whole industry chain.

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About iGDP:

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