

# UNDERSTANDING COAL MINE METHANE SOURCES AND MITIGATION OPPORTUNITIES IN SHANXI PROVINCE: TECHNICAL APPENDIX

## S1: Relative methane emissions estimate across cities

To estimate relative methane emissions across cities, we collected coal production methane emissions intensity data across all cities. Coal production data was collected from Provincial Yearbooks ([Shanxi Bureau of Statistics, 2023](#)). Absolute coal production values were plotted for all cities. For methane emissions intensity, we collected data on coal type and coal depth from [Peng et al., 2023](#). There are a number of other factors that could contribute to methane emissions intensity, but only these two factors were considered in this analysis.

Depth of mine data by city was originally from National Coal Mine Methane Level Identification for 2011, by the State Administration of Coal Mine Safety. Our team was not able to access the original source of the data. The data is the maximum mine depth in the city, and thus may not represent the majority of mining activities in the region. To evaluate the relationship between coal mining depth and emissions intensity, we used the slope of the analysis between coal mining depth and emission factors from [Kholod et al., 2020](#), which was extracted using plotdigitizer and is therefore an approximation. The relationship between coal type and depth was not considered in this analysis. Each city ranking was set relative to the city with the lowest coal mining depth.

Coal rank data by city was originally from [Liu et al., 2015](#). This paper provides a database by mine type that was aggregated to city-level using Baidu Mapping Platform in the [Peng et al., 2023](#) analysis. Only the major coal type was considered for each city. To estimate the relationship between coal type and methane emissions intensity, estimates for methane absorption by coal type were collected from [Wang et al., 2019](#), assuming the median value of temperature. Our analysis assumes methane intensity is similar to methane absorption level. Additionally, to match coal types available in city-level data, we assumed that lean coal is similar to the median methane absorption between meager and gas coal, and that weakly caking coal is similar to ligneous coal.

Values for depth and coal rank were multiplied to estimate methane emissions intensity.

Lines were added to Figure 4 to represent relatively equal CMM emissions. These were calculated using the equation:  $y=b/x$ , where b is equal to CMM emissions.

## Other conversions

Exchange rate from RMB to USD uses the State Administration of Foreign Exchange ([State Administration of Foreign Exchange, 2024](#)).

## Policy analysis

By February 2024, almost 350 policy documents from Shanxi province government websites and the government's official policy database were gathered containing “coal mine methane (CMM)”, “coal bed methane (CBM)”, “methane gas” and other synonyms as keywords (see appendix for additional details). This analysis then categorized them according to policy instrument type, CMM type, and policy focus areas using methodology developed previously (Yu et al., 2022). The policy instrument types considered in this analysis include strategies (e.g., action plans or development plans), laws and regulations, standards and procedures, economic instruments (e.g., carbon markets, tax exemptions, or subsidies), and voluntary programs (e.g., pilot projects and government-sponsored programs). In addition to national and provincial policies, this analysis also evaluated city-level policies from the PKU law and policy database (PKULaw, 2024). By February 2024, more than 1000 city-level policies were collected and a similar methodology was adopted. Please see tables below with examples of policies collected.

**Table S1. Shanxi Provincial Key Policies by Policy Focus.**

Policy focus	Policies
Energy	Shanxi Province Coal Industry Adjustment and Revitalization Plan (Government of Shanxi, 2009b) Opinions on Accelerating the Development of the Coalbed Methane Industry(Government of Shanxi, 2013) Shanxi Province’s “12th Five-Year Plan” for the Development of Emerging Energy Industries (Government of Shanxi, 2014c) Shanxi Province Low Carbon Innovation Action Plan (Government of Shanxi, 2014b) Shanxi Province Coal Mine Gas Drainage Full Coverage Project Implementation Plan (Government of Shanxi, 2015)

	<p>Shanxi Province’s “13th Five-Year Plan” Strategic Emerging Industry Development Plan (Government of Shanxi, 2016b)</p> <p>Dispute Resolution Methods for Overlapping Areas of Coalbed Methane and Coal Mining Rights in Shanxi Province (Trial) (Government of Shanxi, 2016a)</p> <p>Shanxi Province’s Implementation Plan for Deepening Coalbed Methane (Natural Gas) System Reform (Government of Shanxi, 2018)</p> <p>Notice on Matters Related to Carrying out Coalbed Methane Drainage Tests in Coal Goafs (Abandoned Mines) (Department of Natural Resources of Shanxi Province, 2019)</p> <p>Shanxi Province’s 2021-2025 Mineral Resources Overall Plan and Coalbed Methane Resource Exploration and Development Plan (Government of Shanxi, 2023c)</p> <p>Guiding Opinions on Promoting Comprehensive Utilization of Coal Mine Gas (Shanxi Provincial Energy Administration, 2022)</p> <p>Shanxi Province Carbon Peak Implementation Plan (Government of Shanxi, 2023b)</p> <p>Notice on Further Accelerating the Comprehensive Utilization of Low-concentration Gas in Coal Mines (Shanxi Development and Revolution Commission, 2024)</p>
<p><a href="#">Safety</a></p>	<p>Notice on Conscientiously Implementing the Spirit of the Provincial Emergency Telephone Meeting on Coal Mine Safety Production (Government of Shanxi, 2003)</p> <p>Implementation Opinions on Accelerating the Comprehensive Management and Utilization of Coal Mine Gas (Government of Shanxi, 2007)</p> <p>Notice on Strengthening Safety Management of Coal Mine Construction Projects (Government of Shanxi, 2009a)</p> <p>Notice on Several Provisions on Further Strengthening the Prevention and Control of Coal Mine Gas (Government of Shanxi, 2011b)</p> <p>Opinions on Further Strengthening Coal Mine Safety Production Work (Government of Shanxi, 2014a)</p> <p>Shanxi Province Coal Mine Gas Drainage Full Coverage Project Implementation Plan (Government of Shanxi, 2015)</p> <p>Three-year Action Plan for Special Campaign of Production Safety in Shanxi Province (Government of Shanxi, 2020)</p>
<p><a href="#">Climate</a></p>	<p>Implementation Opinions on Accelerating the Comprehensive Management and Utilization of Coal Mine Gas (Government of Shanxi, 2007)</p> <p>Shanxi Province’s Measures to Address Climate Change (Government of Shanxi, 2011a)</p> <p>Shanxi Province Low Carbon Innovation Action Plan (Government of Shanxi, 2014b)</p>

	<p>Opinions on Promoting Green Coal Mining in the Province (Government of Shanxi, 2023a)</p> <p>Guiding Opinions on Promoting Comprehensive Utilization of Coal Mine Gas (Shanxi Provincial Energy Administration, 2022)</p> <p>Shanxi Province Carbon Peak Implementation Plan (Government of Shanxi, 2023b)</p> <p>Shanxi Province’s Unconventional Natural Gas Industry Carbon Peak Implementation Plan (Shanxi Provincial Energy Administration, 2023)</p> <p>Notice on Further Accelerating the Comprehensive Utilization of Low-concentration Gas in Coal Mines (Shanxi Development and Revolution Commission, 2024)</p>
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**Table S2. Shanxi City-level Key Policies.**

City	Policies
Shuozhou	<p>Shuozhou Coal Industry Adjustment and Revitalization Planning Implementation Plan (Government of Shuozhou, 2009)</p> <p>Shuozhou Interim Measures for the Use and Management of Special Funds for Technological Transformation (Government of Shuozhou, 2019)</p> <p>Shuozhou Main Responsibilities Internal Organization and Staffing Regulations (Government of Shuozhou, 2015)</p> <p>Shuozhou 13th FYP for Climate Change Response (Government of Shuozhou, 2018)</p>
Changzhi	<p>Changzhi City Coalbed Methane (Natural Gas) Comprehensive Development and Utilization Management Measures (Government of Changzhi, 2008)</p>
Datong	<p>Datong Air Pollution Prevention and Control Action Plan (Government of Datong, 2014)</p>
Lvliang	<p>Implementation Opinions on Accelerating the Development and Utilization of Coalbed Methane (Government of Lvliang, 2013)</p> <p>Lvliang City Low Carbon Innovation Action Plan (Government of Lvliang, 2014)</p> <p>Lvliang Implementation Opinions of the Development Plan for the Utilization of Coalbed Methane (Natural Gas) (Government of Lvliang, 2015b)</p> <p>Implementation Plan for the Project Quality and Efficiency Improvement Year (Government of Lvliang, 2015a)</p> <p>Lvliang Mineral Resources Master Plan (2021-2025) (Government of Lvliang, 2023b)</p>

	Lvliang Carbon Peak Implementation Plan (Government of Lvliang, 2023a)
Jincheng	Opinions on Readjusting the Division of Responsibilities of the Coalbed Methane Management Leading Group Office and Various Coalbed Methane Management Departments (Government of Jincheng, 2013) Notice on Issuing the Jincheng City 2016 “1533” Industrial Action Plan (Government of Jincheng, 2016) Opinions of the General Office of the People’s Government of Jincheng City on the Implementation of the “Shanxi Province Coalbed Methane Resources Exploration and Development Plan (2016-2020)” (Government of Jincheng, 2017)
Xinzhou	Xinzhou City Coal Mine Gas Extraction Full Coverage Project Implementation Plan (Government of Xinzhou, 2015) Notice on the Establishment of a Supervision and Management Mechanism for Coalbed Methane Mining Rights (Government of Xinzhou, 2017) Xinzhou City's “13th Five-Year Plan” Comprehensive Energy Development Plan (Government of Xinzhou, n.d.)
Jinzhong	Implementation Opinions on the Development of Coalbed Methane Industry (Government of Jinzhong, 2011a) Take the Lead in Promoting the Implementation of Urban and Rural Ecology (Government of Jinzhong, 2011b) Implementation Plan for the Implementation of the Action Plan for the Prevention and Control of Air Pollution (2013-2017) (Government of Jinzhong, 2013) Jinzhong City Energy Development Strategy Implementation Plan (Government of Jinzhong, 2015)
Linfen	Linfen Low-Carbon Innovation Action Plan (Government of Linfen, 2014) Opinions on Further Accelerating the Work of Linfen City as a Comprehensive Demonstration City of National Energy Conservation and Emission Reduction Fiscal Policy (Government of Linfen, 2015b) Linfen City Coal Mine Gas Extraction Full Coverage Project Implementation Plan (Government of Linfen, 2015a)
Yangquan	The 13th Five-Year Development Plan for Industry and Information Technology of Yangquan City (Government of Yangquan, 2016) Yangquan City's “14th Five-Year Plan” for High-quality Industrial Development (Government of Yangquan, 2021) Yangquan City's 2021-2025 Mineral Resources Master Plan (Government of Yangquan, 2023)

Taiyuan	Implementation Plan of Taiyuan Coal Mine Gas Extraction Full Coverage Project (2015) (Government of Taiyuan, 2015)
Yuncheng	The Implementation Plan of the Energy-saving Society of the Construction of the City (Government of Yuncheng, 2008)

## References:

1. Department of Natural Resources of Shanxi Province. (2019). *Notice on Matters Related to Carrying out Coalbed Methane Drainage Tests in Coal Goafs (Abandoned Mines)*. [https://zrzyt.shanxi.gov.cn/zwgk/zwgkjbmll/zcfg/yqgll/xxgg/202109/t20210903\\_1845896.shtml](https://zrzyt.shanxi.gov.cn/zwgk/zwgkjbmll/zcfg/yqgll/xxgg/202109/t20210903_1845896.shtml)
2. Government of Changzhi. (2008). *Changzhi City Coalbed Methane (Natural Gas) Comprehensive Development and Utilization Management Measures*. [https://www.changzhi.gov.cn/xxgkml/czsrnzf/zfwj\\_3465/200807/t20080721\\_240335.shtml](https://www.changzhi.gov.cn/xxgkml/czsrnzf/zfwj_3465/200807/t20080721_240335.shtml)
3. Government of Datong. (2014). *Datong Air Pollution Prevention and Control Action Plan*. <https://www.pkulaw.com/lar/1e6f373c70a129e59647d2da347a9298bdfb.html?keyword=%E5%A4%A7%E5%90%8C%E5%B8%82%E4%BA%BA%E6%B0%91%E6%94%BF%E5%BA%9C%E5%8A%9E%E5%85%AC%E5%8E%85%E5%85%B3%E4%BA%8E%E5%8A%A0%E5%BC%BA%E5%A4%A7%E6%B0%94%E6%B1%A1%E6%9F%93%E8%81%94%E9%98%B2%E8%81%94%E6%8E%A7%E6%8E%A8%E8%BF%9B%E5%8C%BA%E5%9F%9F%E7%A9%BA%E6%B0%94%E8%B4%A8%E9%87%8F%E5%85%A8%E9%9D%A2%E6%94%B9%E5%96%84%E7%9A%84%E5%AE%9E%E6%96%BD%E6%84%8F%E8%A7%81&way=listView>
4. Government of Jincheng. (2013). *Opinions on Readjusting the Division of Responsibilities of the Coalbed Methane Management Leading Group Office and Various Coalbed Methane Management Departments*. [https://xxgk.jcgov.gov.cn/jcsrnmzf/zc/jszb/202101/t20210126\\_1346255.shtml](https://xxgk.jcgov.gov.cn/jcsrnmzf/zc/jszb/202101/t20210126_1346255.shtml)
5. Government of Jincheng. (2016). *Notice on Issuing the Jincheng City 2016 “1533” Industrial Action Plan*. [https://xxgk.jcgov.gov.cn/jcsrnmzf/zc/jszf/202101/t20210121\\_1344133.shtml](https://xxgk.jcgov.gov.cn/jcsrnmzf/zc/jszf/202101/t20210121_1344133.shtml)
6. Government of Jincheng. (2017). *Opinions of the General Office of the People’s Government of Jincheng City on the Implementation of the “Shanxi Province Coalbed Methane Resources Exploration and Development Plan (2016-2020).”* [https://xxgk.jcgov.gov.cn/jcsrnmzf/zc/jszb/202101/t20210125\\_1345549.shtml](https://xxgk.jcgov.gov.cn/jcsrnmzf/zc/jszb/202101/t20210125_1345549.shtml)
7. Government of Jinzhong. (2011a). *Implementation Opinions on the Development of Coalbed Methane Industry*. [https://www.sxjz.gov.cn/zwgk/fdzdgknr/zfwj/content\\_2904](https://www.sxjz.gov.cn/zwgk/fdzdgknr/zfwj/content_2904)
8. Government of Jinzhong. (2011b). *Take the Lead in Promoting the Implementation of Urban and Rural Ecology*. [https://www.sxjz.gov.cn/zwgk/fdzdgknr/zfwj/content\\_3088](https://www.sxjz.gov.cn/zwgk/fdzdgknr/zfwj/content_3088)
9. Government of Jinzhong. (2013). *Implementation Plan for the Implementation of the Action Plan for the Prevention and Control of Air Pollution (2013-2017)*. [https://www.sxjz.gov.cn/zwgk/fdzdgknr/zfwj/content\\_25827](https://www.sxjz.gov.cn/zwgk/fdzdgknr/zfwj/content_25827)
10. Government of Jinzhong. (2015). *Jinzhong City Energy Development Strategy Implementation Plan*.

- [https://www.sxjz.gov.cn/zwgk/fdzdgnr/zfwj/content\\_29314](https://www.sxjz.gov.cn/zwgk/fdzdgnr/zfwj/content_29314)
11. Government of Linfen. (2014). *Linfen Low-Carbon Innovation Action Plan*.  
[http://www.linfen.gov.cn/wj/szfwj\\_70775/202111/t20211129\\_2892.html](http://www.linfen.gov.cn/wj/szfwj_70775/202111/t20211129_2892.html)
  12. Government of Linfen. (2015a). *Linfen City Coal Mine Gas Extraction Full Coverage Project Implementation Plan*.  
<https://pkulaw.com/lar/0371e7cd0889db2ec5d49219257871f6bdfb.html?keyword=%E5%8D%B0%E5%8F%91%E4%B8%B4%E6%B1%BE%E5%B8%82%E7%85%A4%E7%9F%BF%E7%93%A6%E6%96%AF%E6%8A%BD%E9%87%87%E5%85%A8%E8%A6%86%E7%9B%96%E5%B7%A5%E7%A8%8B%E5%AE%9E%E6%96%BD%E6%96%B9%E6%A1%88%E7%9A%84%E9%80%9A%E7%9F%A5&way=listView>
  13. Government of Linfen. (2015b). *Opinions on Further Accelerating the Work of Linfen City as a Comprehensive Demonstration City of National Energy Conservation and Emission Reduction Fiscal Policy*.  
[http://www.linfen.gov.cn/wj/szfwj\\_70775/202111/t20211126\\_2745.html](http://www.linfen.gov.cn/wj/szfwj_70775/202111/t20211126_2745.html)
  14. Government of Lvliang. (2013). *Implementation Opinions on Accelerating the Development and Utilization of Coalbed Methane*.  
[http://www.lvliang.gov.cn/llxxgk/zfxxgk/xxgkml/szfwj/201312/t20131226\\_291432.html](http://www.lvliang.gov.cn/llxxgk/zfxxgk/xxgkml/szfwj/201312/t20131226_291432.html)
  15. Government of Lvliang. (2014). *Lvliang City Low Carbon Innovation Action Plan*.  
<https://www.pkulaw.com/lar/714754109451a62c885b7e887c374e80bdfb.html?keyword=%E5%90%95%E6%A2%81%E5%B8%82%E4%BA%BA%E6%B0%91%E6%94%BF%E5%BA%9C%E5%85%B3%E4%BA%8E%E5%8D%B0%E5%8F%91%E5%90%95%E6%A2%81%E5%B8%82%E4%BD%8E%E7%A2%B3%E5%88%9B%E6%96%B0%E8%A1%8C%E5%8A%A8%E8%AE%A1%E5%88%92%E7%9A%84%E9%80%9A%E7%9F%A5&way=listView>
  16. Government of Lvliang. (2015a). *Implementation Plan for the Project Quality and Efficiency Improvement Year*.  
[http://www.lvliang.gov.cn/llxxgk/zfxxgk/xxgkml/bgtwj/201503/t20150330\\_294821.html](http://www.lvliang.gov.cn/llxxgk/zfxxgk/xxgkml/bgtwj/201503/t20150330_294821.html)
  17. Government of Lvliang. (2015b). *Lvliang Implementation Opinions of the Development Plan for the Utilization of Coalbed Methane (Natural Gas)*. [http://www.lvliang.gov.cn/llxxgk/zfxxgk/xxgkml/bgtwj/201506/t20150624\\_294831.html](http://www.lvliang.gov.cn/llxxgk/zfxxgk/xxgkml/bgtwj/201506/t20150624_294831.html)
  18. Government of Lvliang. (2023a). *Lvliang Carbon Peak Implementation Plan*.  
[http://www.lvliang.gov.cn/llxxgk/zfxxgk/xxgkml/szfwj/202312/t20231220\\_1823514.html](http://www.lvliang.gov.cn/llxxgk/zfxxgk/xxgkml/szfwj/202312/t20231220_1823514.html)
  19. Government of Lvliang. (2023b). *Lvliang Mineral Resources Master Plan (2021-2025)*.  
[http://www.lvliang.gov.cn/llxxgk/zfxxgk/xxgkml/bgtwj/202309/t20230912\\_1792427.html](http://www.lvliang.gov.cn/llxxgk/zfxxgk/xxgkml/bgtwj/202309/t20230912_1792427.html)
  20. Government of Shanxi. (2003). *Notice on Conscientiously Implementing the Spirit of the Provincial Emergency Video and Telephone Conference on Coal Mine Safety Production*.  
[https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgnr/lzyj/szfbgtwj/202205/t20220513\\_5976861.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgnr/lzyj/szfbgtwj/202205/t20220513_5976861.shtml)
  21. Government of Shanxi. (2007). *Implementation Opinions on Accelerating the Comprehensive Management and Utilization of Coal Mine Gas*. [https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgnr/lzyj/szfbgtwj/202205/t20220513\\_5977015.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgnr/lzyj/szfbgtwj/202205/t20220513_5977015.shtml)
  22. Government of Shanxi. (2009a). *Notice on Strengthening Safety Management of Coal Mine Construction Projects*.  
[https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgnr/lzyj/szfbgtwj/202205/t20220513\\_5977181.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgnr/lzyj/szfbgtwj/202205/t20220513_5977181.shtml)
  23. Government of Shanxi. (2009b). *Shanxi Province Coal Industry Adjustment and Revitalization Plan*.  
[https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgnr/lzyj/szfwj/202205/t20220513\\_5975792.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgnr/lzyj/szfwj/202205/t20220513_5975792.shtml)
  24. Government of Shanxi. (2011a). *Notice on Issuing Shanxi Province's Measures to Address Climate Change*.  
[https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgnr/lzyj/szfwj/202205/t20220513\\_5975893.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgnr/lzyj/szfwj/202205/t20220513_5975893.shtml)
  25. Government of Shanxi. (2011b). *Notice on Several Provisions on Further Strengthening the Prevention and Control of Coal Mine*



- Gas. [https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202205/t20220513\\_5977308.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202205/t20220513_5977308.shtml)
26. Government of Shanxi. (2013). *Opinions on Accelerating the Development of the Coalbed Methane Industry*. [https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfwj/202205/t20220513\\_5975994.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfwj/202205/t20220513_5975994.shtml)
  27. Government of Shanxi. (2014a). *Opinions on Further Strengthening Coal Mine Safety Production Work*. [https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202205/t20220513\\_5977626.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202205/t20220513_5977626.shtml)
  28. Government of Shanxi. (2014b). *Shanxi Province Low Carbon Innovation Action Plan*. [https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfwj/202205/t20220513\\_5976011.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfwj/202205/t20220513_5976011.shtml)
  29. Government of Shanxi. (2014c). *Shanxi Province's "12th Five-Year Plan" for the Development of Emerging Energy Industries*. [https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202205/t20220513\\_5977528.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202205/t20220513_5977528.shtml)
  30. Government of Shanxi. (2015). *Shanxi Province Coal Mine Gas Drainage Full Coverage Project Implementation Plan*. [https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202205/t20220513\\_5977746.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202205/t20220513_5977746.shtml)
  31. Government of Shanxi. (2016a). *Dispute Resolution Methods for Overlapping Areas of Coalbed Methane and Coal Mining Rights in Shanxi Province (Trial)*. [https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202205/t20220513\\_5977924.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202205/t20220513_5977924.shtml)
  32. Government of Shanxi. (2016b). *Shanxi Province's "13th Five-Year Plan" Strategic Emerging Industry Development Plan*. [https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfwj/202205/t20220513\\_5976128.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfwj/202205/t20220513_5976128.shtml)
  33. Government of Shanxi. (2018). *Shanxi Province's Implementation Plan for Deepening Coalbed Methane (Natural Gas) System Reform*. [https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202205/t20220513\\_5978226.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202205/t20220513_5978226.shtml)
  34. Government of Shanxi. (2020). *Three-year Action Plan for Special Campaign of Production Safety in Shanxi Province*. [https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202205/t20220513\\_5978496.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202205/t20220513_5978496.shtml)
  35. Government of Shanxi. (2023a). *Opinions on Promoting Green Coal Mining in the Province*. [https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202207/t20220712\\_6683636.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202207/t20220712_6683636.shtml)
  36. Government of Shanxi. (2023b). *Shanxi Province Carbon Peak Implementation Plan*. [https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfwj/202301/t20230119\\_7825853.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfwj/202301/t20230119_7825853.shtml)
  37. Government of Shanxi. (2023c). *Shanxi Province's 2021-2025 Mineral Resources Overall Plan and Coalbed Methane Resource Exploration and Development Plan*. [https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202302/t20230209\\_7951197.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202302/t20230209_7951197.shtml)
  38. Government of Shuo Zhou. (2009). *Shuo Zhou Coal Industry Adjustment and Revitalization Planning Implementation Plan*. [http://www.shuo Zhou.gov.cn/xgk/zfwj/201502/t20150225\\_8701.shtml](http://www.shuo Zhou.gov.cn/xgk/zfwj/201502/t20150225_8701.shtml)
  39. Government of Shuo Zhou. (2015). *Shuo Zhou Main Responsibilities Internal Organization and Staffing Regulations*. [http://www.shuo Zhou.gov.cn/xgk/zbwj/201504/t20150428\\_39172.shtml](http://www.shuo Zhou.gov.cn/xgk/zbwj/201504/t20150428_39172.shtml)
  40. Government of Shuo Zhou. (2018). *Shuo Zhou 13th FYP for Climate Change Response*. [http://www.shuo Zhou.gov.cn/xgk/zbwj/201808/t20180828\\_211040.shtml](http://www.shuo Zhou.gov.cn/xgk/zbwj/201808/t20180828_211040.shtml)
  41. Government of Shuo Zhou. (2019). *Shuo Zhou Interim Measures for the Use and Management of Special Funds for Technological Transformation*. [http://www.shuo Zhou.gov.cn/xgk/zbwj/201909/t20190918\\_255453.shtml](http://www.shuo Zhou.gov.cn/xgk/zbwj/201909/t20190918_255453.shtml)
  42. Government of Taiyuan. (2015). *Implementation Plan of Taiyuan Coal Mine Gas Extraction Full Coverage Project*. [https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202205/t20220513\\_5977746\\_gfwj.shtml](https://www.shanxi.gov.cn/zfxxgk/zfxxgkzl/fdzdgknr/lzyj/szfbgtwj/202205/t20220513_5977746_gfwj.shtml)
  43. Government of Xinzhou. (n.d.). *Xinzhou City's "13th Five-Year Plan" Comprehensive Energy Development Plan*. Retrieved June 5,



- 2024, from [https://zwgk.sxxz.gov.cn/xzsrnzf/zdlyxxgk/ghjh/zxgh/201705/t20170523\\_109634.shtml](https://zwgk.sxxz.gov.cn/xzsrnzf/zdlyxxgk/ghjh/zxgh/201705/t20170523_109634.shtml)
44. Government of Xinzhou. (2015). *Xinzhou City Coal Mine Gas Extraction Full Coverage Project Implementation Plan*. [https://zwgk.sxxz.gov.cn/xzsrnzf/wj/zfwj/xzbf/201510/t20151026\\_109442.shtml](https://zwgk.sxxz.gov.cn/xzsrnzf/wj/zfwj/xzbf/201510/t20151026_109442.shtml)
45. Government of Xinzhou. (2017). *Notice on the Establishment of a Supervision and Management Mechanism for Coalbed Methane Mining Rights*. [https://zwgk.sxxz.gov.cn/xzsrnzf/wj/zfwj/xzbf/201701/t20170125\\_109730.shtml](https://zwgk.sxxz.gov.cn/xzsrnzf/wj/zfwj/xzbf/201701/t20170125_109730.shtml)
46. Government of Yangquan. (2016). *The 13th Five-Year Development Plan for Industry and Information Technology of Yangquan City*. <https://pkulaw.com/lar/cdabf4da16b140d6bb31e91791a86c9abdfb.html?keyword=%E9%98%B3%E6%B3%89%E5%B8%82%E4%BA%BA%E6%B0%91%E6%94%BF%E5%BA%9C%E5%8A%9E%E5%85%AC%E5%8E%85%E5%85%B3%E4%BA%8E%E5%8D%B0%E5%8F%91%E9%98%B3%E6%B3%89%E5%B8%82%E5%B7%A5%E4%B8%9A%E5%92%8C%E4%BF%A1%E6%81%AF%E5%8C%96%E5%8D%81%E4%B8%89%E4%BA%94%E5%8F%91%E5%B1%95%E8%A7%84%E5%88%92%E7%9A%84%E9%80%9A%E7%9F%A5&way=listView>
47. Government of Yangquan. (2021). *Yangquan City's "14th Five-Year Plan" for High-quality Industrial Development*. [http://www.yq.gov.cn/zthj/zyzt/sswgh/gwz/202112/t20211220\\_1261660.shtml](http://www.yq.gov.cn/zthj/zyzt/sswgh/gwz/202112/t20211220_1261660.shtml)
48. Government of Yangquan. (2023). *Yangquan City's 2021-2025 Mineral Resources Master Plan*. [http://xxgk.yq.gov.cn/yqsrnzf1/fdzdgnr\\_45346/lzyj/szfbgswj/202307/t20230714\\_1674439.shtml](http://xxgk.yq.gov.cn/yqsrnzf1/fdzdgnr_45346/lzyj/szfbgswj/202307/t20230714_1674439.shtml)
49. Government of Yuncheng. (2008). *The Implementation Plan of the Energy-saving Society of the Construction of the City*. <https://pkulaw.com/lar/6e92ffc23a7a0fb11f0611f6e6556fb5bdfb.html?keyword=%E8%BF%90%E5%9F%8E%E5%B8%82%E5%BB%BA%E8%AE%BE%E8%8A%82%E7%BA%A6%E5%9E%8B%E7%A4%BE%E4%BC%9A%E5%AE%9E%E6%96%BD%E6%96%B9%E6%A1%88&way=listView>
50. Kholod, N., Evans, M., Pilcher, R. C., Roshchanka, V., Ruiz, F., Coté, M., & Collings, R. (2020). Global Methane Emissions from Coal Mining to Continue Growing Even with Declining Coal Production. *Journal of Cleaner Production*, 256, 120489. <https://doi.org/10.1016/j.jclepro.2020.120489>
51. Liu, Z., Guan, D., Wei, W., Davis, S. J., Ciais, P., Bai, J., Peng, S., Zhang, Q., Hubacek, K., Marland, G., Andres, R. J., Crawford-Brown, D., Lin, J., Zhao, H., Hong, C., Boden, T. A., Feng, K., Peters, G. P., Xi, F., ... He, K. (2015). Reduced Carbon Emission Estimates from Fossil Fuel Combustion and Cement Production in China. *Nature*, 524(7565), 335–338. <https://doi.org/10.1038/nature14677>
52. Peng, S., Giron, C., Liu, G., d'Aspremont, A., Benoit, A., Lauvaux, T., Lin, X., de Almeida Rodrigues, H., Sauniois, M., & Ciais, P. (2023). High-Resolution Assessment of Coal Mining Methane Emissions by Satellite in Shanxi, China. *iScience*, 26(12), 108375. <https://doi.org/10.1016/j.isci.2023.108375>
53. PKULaw. (2024). *Laws and Regulations Database*. <https://www.pkulaw.com/>
54. Shanxi Bureau of Statistics. (2023). *Shanxi Statistical Yearbook (2015-2022)*. <https://tjj.shanxi.gov.cn/sxsj-show/yearData>
55. Shanxi Development and Revolution Commission. (2024). *Notice on Further Accelerating the Comprehensive Utilization of Low-concentration Gas in Coal Mines*. <https://www.cets.org.cn/dfkx/6252.jhtml>
56. Shanxi Provincial Energy Administration. (2022). *Guiding Opinions on Promoting Comprehensive Utilization of Coal Mine Gas*. <https://www.coalchina.org.cn/index.php?m=content&c=index&a=show&catid=39&id=142131>
57. Shanxi Provincial Energy Administration. (2023). *Shanxi Province's Unconventional Natural Gas Industry Carbon Peak Implementation Plan*. [https://nyj.shanxi.gov.cn/zfxgk/fdzdgnr/sjwj/202311/t20231130\\_9436420.shtml](https://nyj.shanxi.gov.cn/zfxgk/fdzdgnr/sjwj/202311/t20231130_9436420.shtml)

58. State Administration of Foreign Exchange. (2024). *Renminbi Central Parity Rate*. <http://m.safe.gov.cn/safe/rmbhlzjj/index.html#>
59. Wang, Z., Wang, X., Zuo, W., Ma, X., & Li, N. (2019). The influence of temperature on methane adsorption in coal: A review and statistical analysis. *Adsorption Science & Technology*, 37(9–10), 745–763. <https://doi.org/10.1177/0263617419890235>
60. Yu, S., Behrendt, J., Zhu, M., Cheng, X., Li, W., Liu, B., Williams, J., Zhang, H., Cui, R., Evans, M., Hultman, N., Mcjeon, H., Smith, S. J., Chai, Q., Chen, L., Chen, M., Fu, S., Guo, F., Isaksson, L. H., ... Yang, Z. (2022). *Roadmap for U.S.-China Methane Collaboration Methane Emissions, Mitigation Potential, and Policies*. <https://cgs.umd.edu/research-impact/publications/roadmap-us-china-methane-collaboration-methane-emissions-mitigation>