

# Study on the Strategic Path Choice of Coal Industry in Shanxi Province under the Background of Double Carbon

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**Abstract:** Under the current situation that the energy structure cannot be adjusted in the short term, promoting the clean and efficient use of coal is the core of solving the energy and environmental problems in Shanxi Province. Efforts to provide efficient, safe, low-carbon and economic energy is of strategic importance to ensure national energy security and ease the pressure on resources, environment, ecology and carbon emissions in the province. For Shanxi Province one is to analyze the gaps in the development of the province's coal industry in terms of capacity layout, scientific and technological innovation, clean utilization, and low-carbon development according to the new requirements of the low-carbon economy for the coal industry. Second is to build a modern coal industry system by expanding the coal industry chain, support the implementation of mergers and acquisitions of key enterprises in the province in the key links and core technologies of the industry chain to accelerate resource integration and enhance the value chain of the cluster industry. Third, improve the level of industrial openness. Work on four aspects of financial credit, fiscal and taxation, cross-border trade, and property rights system to create a low-carbon economic development highlands. Fourth, focus on attention to focus on the effective interface between the coal industry and the dual carbon economy, co-development, comprehensive consideration of energy consumption, pollutant emissions, carbon emissions, resource output efficiency and other factors, the development of thermal power, smelting and casting, chemical, cement and other industries to reduce carbon dioxide emissions action plan.

**Keywords:** Cleaner production, Double carbon background, Extended industrial chain, Supporting policies, Technological innovation.

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## 1. Introduction

In recent years, the international community has continued to promote global environmental governance, resulting in major landmark documents such as the Kyoto Protocol and the Paris Agreement. The COP27 discussed topics such as decarbonization and energy and proposed solutions, noting that providing climate finance to developing countries "requires a new mindset, newer strategies and policies, especially in the context of the current financial crisis, debt challenges and rising interest rates. As the world's second largest economy, China is deeply involved in global ecological and environmental governance, and has been continuously promoting carbon peaking and carbon neutrality. Shanxi Province is an important energy province in China. Double control of energy consumption is an important support for Shanxi Province to deepen the comprehensive reform pilot of energy revolution and promote high-quality development in all aspects. Although the province has made some achievements in improving the efficiency of clean coal utilization and promoting the low-carbonization of coal industry, the development of low-carbon economy in the province has a long way to go due to the solidification of industrial structure, single energy consumption structure and the commissioning of new coal-consuming projects. The purpose of this paper is to analyze the development dilemma faced by coal industry development in Shanxi Province and put forward relevant suggestions, to put forward policy suggestions in terms of further improving the analysis of coal chemical technology, improving a series of industrial

structure policies, industrial technology policies and financial and taxation policies for coal industry development, and then to explore the low-carbon economic development mode of coal energy chemical base and low-carbon economic mode of coal enterprise production in our province. The development path of coal industry with characteristics of our province.

## 2. Literature Review

In recent years, the study of the strategic path of coal industry has become an important research topic in the fields of economics and management. K Gürtler, DL Beer, J Herberg (2021) pointed that climate change mitigation triggers both spatial and moral complexities, as demonstrated by the contentious issue of phasing out coal power [5]. Chen Che (2022) pointed out that in the short term, coal consumption will affect the development of low-carbon economy, and in the long term, coal consumption and low-carbon economy development are causally related to each other, and the degree of influence of low-carbon economy on coal consumption is more obvious. The process of low carbon economy construction should deepen the industrial structure adjustment, promote the development and utilization of clean energy, and improve energy utilization efficiency [2]. Luo Lijun (2022) pointed out that low-carbon economic development is an important trend in modern economic development. Low-carbon economy should be incorporated into the ecological development of coal economy to improve the process of coal economic development [8]. Brauers, H., Oei, P. Y., & Walk, P. (2020) investigates reasons for the different developments and aims to identify main hurdles and

drivers of coal phase-outs by using the Triple Embeddedness Framework [1]. Zhao Jianfeng (2011) pointed out that the analysis of the current situation of each stage of the life cycle of clean coal utilization shows that: the traditional utilization of coal in China is less efficient, the power industry has become the main source of CO<sub>2</sub> emissions, and the construction of a low-carbon power industry system can not be delayed [21]. The analysis of coal chemical technology shows that: China should develop coal-to-olefin technology scientifically and moderately; coal-to-oil can be subject to scientific research, but it should be strictly limited. The review of coal regulations and policies shows that: China's coal laws and regulations are lagging behind and need to be revised and improved; coal policies lack corresponding incentive and restraint mechanisms, and low-carbon provisions and regulations are missing. It is proposed to start the "10 a plan for clean and low-carbon utilization of coal", set up regional coal low-carbon economy department and low-carbon technology standard department, establish independent technology innovation system and mechanism in coal low-carbon field, establish low-carbon technology development fund, and conduct pilot research on coal carbon tax system, etc. to promote the clean utilization of coal in China under low-carbon economy policy recommendations. Tang (2022) pointed out that China's corporate income tax preferential system formed based on industrial development orientation, although there are a series of tax preferential policies in promoting environmental protection and circular economy development, etc., due to its insufficient embodiment of the concept of low-carbon development, resulting in insufficient tax preferences for China's corporate income tax to promote the development of low-carbon economy, and there are policy gaps in many fields, and some preferential policies and Some of the preferential policies are in conflict with the goal of low-carbon economy development. To promote the development of low-carbon economy and strengthen the low-carbon orientation of corporate income tax preferential policies, corporate income tax preferential policies should be improved [16]. Luo Tian (2022) pointed out that to explore a new model of low-carbon economic development in China from the perspective of industrial spatial structure, we should fully grasp the role of industrial synergistic agglomeration on low-carbon economy channels, and accelerate the realization of China's low-carbon development goals by optimizing industrial spatial structure [11]. Hu Yi and Jin Shuchang (2022) pointed out that achieving the goal of "double carbon" is an inherent requirement and the necessary path to high-quality development. In the context of flourishing digital technology and low-carbon economic transformation, it is of theoretical significance and practical value to explore the theoretical mechanism and practical path of digital technology to help "dual carbon" goals [6]. RY Cui, N Hultman, D Cui, H McJeon, S Yu, MR Edwards, A Sen, K Song, C Bowman(2021) think that structuring a high-ambition coal phaseout in China while balancing multiple national needs[3]. Joshua, U., & Bekun, F. V. (2020) pointed out the path to achieving environmental sustainability in South Africa[7]. Li and Wang (2021) pointed out that the strategic and positive externalities of future industries require the government to pay high attention and actively intervene, and the predictability of the general direction of development is a prerequisite for the success of industrial policy; however, the frontier nature of the driving technology, the long-term nature

of industrialization, and the uncertainty of development also require the transformation of industrial policy, i.e., from emphasizing industrial policy to competition policy, from selective support to development direction guidance, and from emphasizing applied technology to strengthening basic research. From emphasizing applied technology to strengthening basic research, from support for technology industrialization to market pull, from relying on specific enterprises to encouraging diversified trial and error. Cultivating and growing China's future industries requires government support in strategic guidance, supporting basic research, creating early markets, improving industrial ecology, and utilizing global resources [10].

## 2.1. Methodology

In this article, we first classify and summarize the literature in the development of coal industry. Secondly, Current situation of Shanxi coal industry is described and assumed, and then the limitations is derived. Then we construct an analysis. Finally, we draw conclusions and give recommendations, as shown in Figure 1.

## 3. Analysis

From the perspective of high-quality development, the coal industry in the Shanxi province still faces several shortcomings that need to be addressed. These problems are mainly related to the coal industry's clean and efficient technology support system, industrial concentration and added value, core technical issues in intelligent coal mine construction, and resource waste and environmental pollution. Problems are as follows:

3.1 Coal clean and efficient technology support system: Shanxi province lacks a sound innovation system for clean and efficient coal and low-carbon development, which hinders the transformation and application of clean coal development results. Key components and equipment for clean coal technologies, such as coal gasification furnaces, methanol reactors, and direct liquefaction reactors, still heavily rely on imports. Additionally, certain processes used in coking production, like wet coke quenching, result in significant energy waste and environmental pollution.

3.2 Industrial concentration and added value: Shanxi province's coal industry structure lacks rationality, with a heavy reliance on traditional industries and a small proportion of new industries. Particularly in the traditional coal chemical industry, the share of new coal chemical technologies is low. The deep processing, refining, and conversion rate of coal products remain insufficient, resulting in low added value and technological content. The extension of the coal industry chain is also limited, as most coal products are produced in the upstream of the industry chain, relying heavily on markets outside the province, which limits active control and increases vulnerability to market risks.

3.3 Core technical problems in intelligent coal mine construction: Shanxi province still faces challenges in breaking through core technical issues related to intelligent coal mine construction. There is a lack of personnel and insufficient funds for intelligent construction. For example, high-precision measurement of coal mining machine positions and automatic straightening technology for working faces are not fully developed. The accuracy of mining sensors is also inadequate. Moreover, the majority of coal mining enterprises in the province are small-scale, with many operating mines below 900,000 tons/year, and these

enterprises lack sufficient special funds for development.

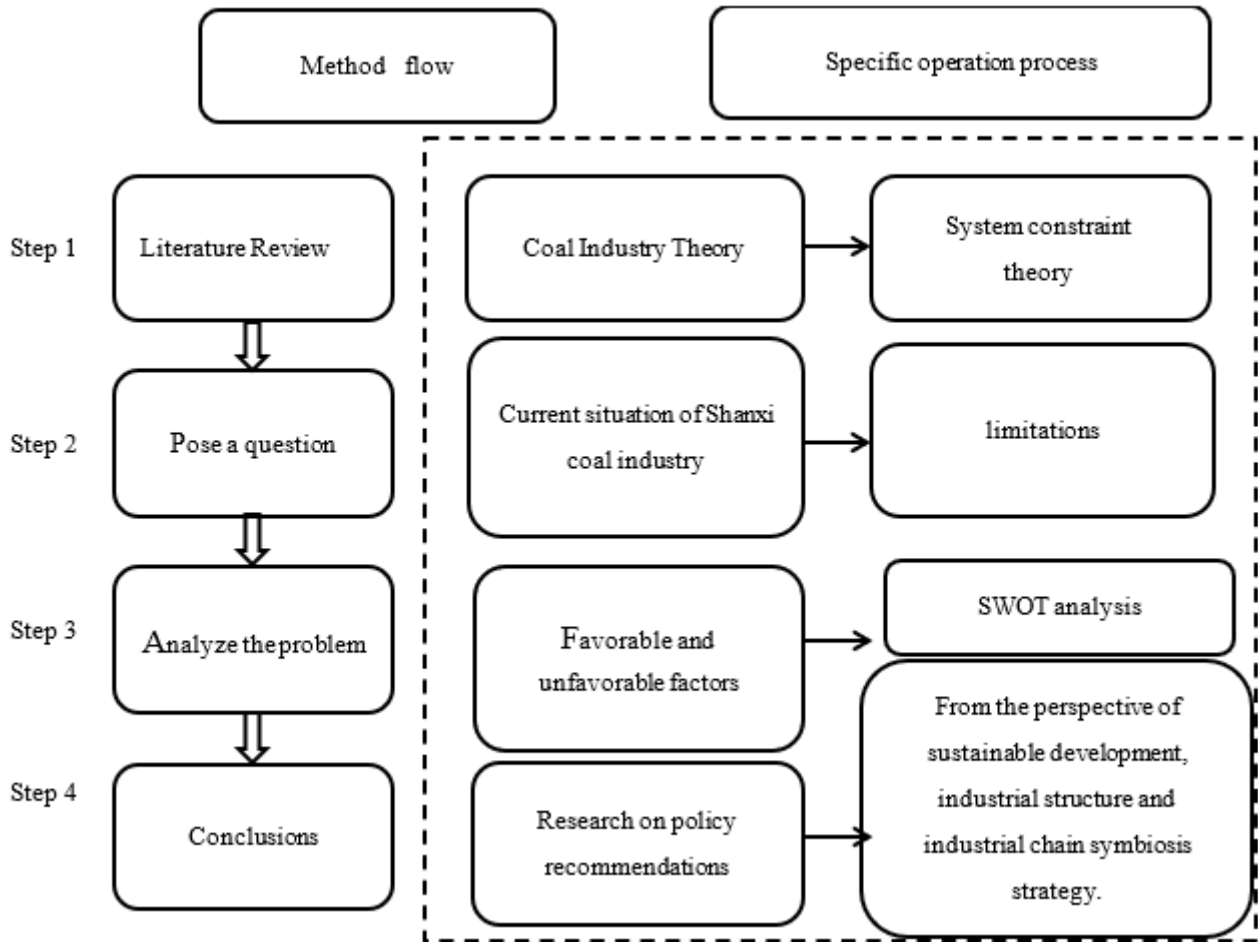


Figure 1. The research framework

## 4. Result

There are some issues such as the lack of a sound technology support system for clean and efficient coal, the need for industrial restructuring and increasing added value, challenges in intelligent coal mine construction, and the serious concerns of resource waste and environmental pollution. To address these issues, it would be important to consider practical solutions and strategies. Some potential measures could include:

### 4.1. Promote clean production and clean use of coal

In coal washing, coal-fired power generation, coal-fired boilers for heating, coal conversion and other areas to make articles. In coal production and development, promote intelligent mining and other technologies to improve coal mining efficiency; coal utilization, in-depth implementation of coal power unit transformation, research and development of clean power generation and other technologies to achieve energy saving and emission reduction; coal conversion, coal to oil, coal to natural gas, and other chemical technology breakthroughs. First, the development of coal washing and processing. Improve the washing rate of raw coal, the realization of the depth of coal quality and quality classification utilization, and gradually realize the large-scale coal washing and processing. Promote the quality of low-quality coal utilization, the construction of a number of coal

grading and utilization demonstration projects, promote the integration of coal, chemical, electricity, heat development, grading and grading, energy and chemical combination, integrated co-production, and actively explore and promote the application of coal pyrolysis combustion grading conversion technology to improve the efficiency of coal combustion. Second, the development of clean and efficient coal-fired power generation. Actively research and development, demonstration and promotion of advanced combustion and power generation technologies, accelerate the pace of energy-saving and emission reduction transformation of coal-fired power stations, and enhance the efficient and clean use of coal power. Promote the construction of modern large-scale coal power outbound base, accelerate the pace of construction of outbound power channels, to achieve the cleanliness of the terminal energy. Third, control the emission of pollutants in the process of coal utilization, and promote the realization of the integration of desulfurization and denitrification and the synergistic control of mercury emissions. 1,389,800 tons of desulfurization gypsum was generated in Taiyuan, the capital city of Shanxi Province in 2020, and the comprehensive utilization rate was only 17.6%. It is recommended to take advantage of the concentration of universities and talents in the provincial capital city, and rely on the R&D advantages of universities in chemical, materials and machinery to establish a research and development and industrialization center of industrial by-product gypsum comprehensive utilization technology and equipment in Taiyuan, so as to play a demonstration and

leading role for the comprehensive utilization of solid waste in our province and create a billion-level comprehensive utilization of high value-added solid waste industry. Preliminary estimates, such as more than 1 million tons of desulfurization gypsum and 1 million tons of fly ash produced annually in Taiyuan City are all converted into gypsum-based self-leveling mortar, which can be used for more than 20 million square meters of buildings, equivalent to only 6% of the new building area in Beijing, Tianjin, Jin and Hebei in 2016, with an annual output value of more than 1 billion, with broad prospects for industrialization. Fourth, the development of energy-saving technology in the process of coal utilization. Focus on the development of coal - hydrogen-rich gas (such as natural gas, coke oven gas, etc.) co-production of syngas, blast furnace high air temperature oxygen-rich coal injection, secondary energy recovery and utilization of coal and new energy coupling and other advanced coal utilization technology. The experience of dry coke quenching device of Shanxi Xinxin Technology Co., Ltd. is promoted, which can reduce environmental pollution, recover red coke heat and improve coke quality.

## **4.2. Vigorously extend the coal industry chain**

First, moderate development of modern coal chemical industry. Give full consideration to the market demand of coal chemical projects, environmental protection requirements, water resources to ensure supply, equipment matching and long-cycle operation capacity, etc., and promote the industrialization process in a prudent and orderly manner. Promote coal-to-oil and Fischer-Tropsch oil downstream deep processing, the development of coal-to-olefin, coal-to-ethylene glycol, steadily promote coal-to-gas, strengthen the development of coke oven gas, coal tar, crude benzene comprehensive utilization and deep processing and other characteristics of coal chemical industry, and promote the transformation of coal from fuel to fuel and raw materials and direction. Second, we should accelerate the quality and efficiency of the coal-bed methane industry. Vigorously promote the construction of two major coal-bed methane ground development industrialization bases in Qinshui and Hedong and coal mine gas extraction full coverage project, encourage base enterprises to rely on coal-bed methane ground development projects or provincial gas transmission pipeline network to transport coal-bed methane. Establish and improve the outreach and smooth internal gas network to serve the province's coal-bed methane development and gas market, and to serve the construction of Xiongan New Area, Beijing-Tianjin-Hebei cooperative development and the national strategy of Beijing-Tianjin-Hebei air pollution prevention and control. Third, accelerate the scientific planning of hydrogen energy industry and actively join the national fuel cell vehicle demonstration city group. In Tai Xin Economic Zone, we plan to build "one park, two roads and three centers". The "one park" is the hydrogen energy zero carbon core equipment industrial park, based on the hydrogen energy equipment industrial cluster laid out by Meijin in the country, introducing and cultivating leading enterprises in storage and transportation, refueling, hydrogen fuel cell vehicles, etc. to build a highland of hydrogen energy research and innovation with core competitive advantages. The "two roads" are the hydrogen logistics highway and the hydrogen passenger highway, and the "Tai Xin-Xiong'an hydrogen logistics corridor" will be built. It will be equipped with a comprehensive hydrogen refueling energy station to realize

zero-carbon logistics transportation between Tai Xin and Xiong'an and supply hydrogen to the demonstration cities of Beijing, Tianjin and Hebei for fuel cell vehicles. The "three centers" are the hydrogen fuel vehicle R&D and testing center, the hydrogen logistics transfer center, and the vehicle after-sales maintenance center. Further focus on advantageous enterprises, carry out fuel cell demonstration applications in logistics, heavy trucks and public service application scenarios, jointly explore economical and feasible models of vehicle demonstration and promotion, gradually form a scale effect, and promote the hydrogen energy industry chain to be better and stronger. Fourth, to promote the transformation of relevant enterprises in Shanxi coal industry chain in technology research and development, exploration and cultivation of new business models and growth points, etc., learn from the experience of Yang Coal Group, create a "production, learning, research, system, use" cooperative alliance in the field of coal energy and coal chemistry, innovate commercial marketing model, and extend to the whole industry chain of coal gasification.

## **4.3. Promote technical innovation of clean and efficient utilization of coal industry**

With the clean and efficient utilization of coal resources as the main line, we focus on the key technology research and development around coal efficient combustion and power generation technology, new generation coal oil technology, new coal chemical product structure control technology, clean coal combustion technology, carbon sequestration technology, etc., and implement major special projects for clean and efficient utilization of coal science and technology innovation. First, the deployment of technological innovation chain around the coal industry chain, around the innovation chain to improve the capital chain, encourage support for enterprises in coal mining methods, coal product development and industry chain extension and other key areas to achieve major technological breakthroughs. In the field of efficient coal mining, clean utilization, low-carbon utilization, ecological restoration technology in industrial and mining areas, research and development of bulk industrial solid waste resource utilization technology, etc. to carry out joint research and promote technology promotion and application. Actively promote the demonstration project of the construction of circular economy industrial park represented by Datong Tashan coal mine, and explore the industrialized development path that meets the clean and efficient utilization of coal through the construction of the demonstration project. Second, the formation of government, industry, academia and research collaborative innovation alliance. Play the role of government guidance, relying on the advantages of enterprises, joint provincial and foreign institutions of higher learning, scientific research institutes, the formation of coal clean and efficient use of industrial technology innovation strategy alliance to carry out government, industry, academia and research collaborative innovation. Integrate existing provincial science and technology projects, around the major common key technology bottlenecks to solve the constraints of clean and efficient use of coal, condensed into a major scientific and technological research projects, take public bidding or directed to select the best way to carry out integrated collaborative research units, to provide technical support and intellectual support for the clean development of coal in Shanxi. Around the major strategic needs of clean and efficient utilization of coal, combined with the actual situation

in our province, we plan the development strategy of clean and efficient coal science and technology innovation in Shanxi Province, realize the "three integrations" of science and technology resources, science and technology funds and science and technology projects, and strengthen the innovation capacity of basic research at the front end of the innovation chain.

#### **4.4. Improve supporting policies to promote clean and efficient use of coal**

First, increase financial support, relying on the Shanxi Coal Clean Utilization Investment Fund, effectively increase capital investment, focusing on supporting the integration of coal power, modern coal chemical industry, coal bed methane (gas) extraction and utilization, carbon emission reduction and other coal clean and efficient utilization of technology research, tilted to the implementation of the benchmark level transformation of enterprises, cultivate the clean and efficient utilization of coal leading enterprises, accelerate the transformation and upgrading of the coal industry structure in Shanxi. Second, the implementation of good coal clean and efficient use of special equipment, technological transformation, comprehensive utilization of resources and other tax incentives, research and introduction of special tax incentives specifically for clean coal technology. According to the different resource endowment conditions, mining ease of mine, explore the implementation of differentiated tax policies. Third, improve energy investment and industrial policy. Encourage banking and financial institutions to increase support for energy conservation and efficiency, comprehensive utilization of energy resources and clean energy projects. Actively develop green credit, green trusts, green funds, green insurance, etc., so that enterprises and projects that meet the requirements of energy conservation and emission reduction receive priority support for funding. Fourth, support the training of clean coal professionals. Drawing on the long-term cooperation mechanism between Taiyuan Boiler Group and Tsinghua University established by industry-university-research, with the advantages of research institutes and university platforms, the formation of mutual industry-university-research deep integration development mode, docking international innovation resources and the introduction of high-end talent, the formation of first-class R & D team, and constantly produce chemical reactions, incubation effect. It is suggested that the Department of Education organize the universities and research institutions where the relevant State Key Laboratories are located to open specialties related to clean coal industry, provide specialist, undergraduate and postgraduate education and professional training, and focus on training a group of leading talents in coal science and technology for the clean coal industry in our province in the future. Fifth, sound environmental protection and ecological compensation policies for mining areas. As soon as possible to introduce the "Shanxi mining area ecological restoration compensation regulations", the mineral resources, atmospheric environment, water basin and important mining areas and several other major ecosystems, respectively, to develop the implementation of ecological restoration in each area, clear compensation subjects, procedures, regulatory measures in each area, etc., to provide a standardized, market-oriented institutional guarantee for the ecological management of coal mining areas.

## **5. Discussion**

From the theoretical level, the coal industry has been an important promoter of green and low-carbon development. Although the province's coal industry has made some achievements from coal mining, washing and processing, ecological restoration of mining areas, energy conservation and emission reduction, clean conversion of coal to the construction of circular economy industrial parks, but from the perspective of high-quality development, there are still many shortcomings. Coal mining and washing still have imperfect policies and regulations, technology and equipment need to be upgraded, the lack of feasible coal and emission standards, coal combustion and power generation stage still exist in the use of high efficiency. All these problems need to be solved from the practical level. The problems are mainly manifested as follows.

5.1 Coal clean and efficient technology support system is not sound. At present, the province's clean and efficient coal, low-carbon development of the innovation system is not perfect, which restricts the transformation and application of the results of clean coal development. The province has built a large coal gasification furnace, methanol reactor, large coal direct liquefaction reactor, key pumps and valves and many other core components are still dependent on imports. The wet coke quenching process etc. used in coking production causes huge energy waste, and the production process produces a large amount of outgoing steam, which still contains a large amount of coke dust and harmful substances such as phenol, cyanide and sulfide, causing pollution to the environment.

5.2 Industrial concentration and added value still need to be improved. The province's coal clean transformation industry structure is not reasonable, mainly in the traditional industries, the proportion of new industries is small, especially in the traditional coal chemical industry, the proportion of new coal chemical industry is low. Coal products deep processing, finishing and conversion rate is not high enough, the added value of products and technology content is still low. The extension of the coal industry chain is not sufficient, the vast majority of coal products produced in the upper reaches of the industry chain, mainly relying on the market outside the province to pull, the space for active control is extremely limited, and the ability to withstand market risks is weak.

5.3 The core technical problems of intelligent coal mine construction still need to be broken in a new step, the lack of intelligent construction personnel, insufficient funds. For example, high-precision measurement of coal mining machine position and automatic straightening technology of working face are not perfect, and the accuracy of mining sensors is not enough, etc. Moreover, the overall scale of coal mining enterprises in our province is small, and there are more mines below 900,000 tons/year, and the special funds for intelligent construction of enterprises are not enough.

5.4 Resource waste and environmental pollution is serious. The province's coal resources recovery utilization rate is low, resulting in a large number of coal resources consumption, waste, abandoned in the underground amount of stagnant resources is very large. Coal mining and utilization in a sloppy manner, leading to increased environmental pollution and serious ecological damage.

## **6. Funding**

The scientific research project of social and economic s

tistics of Shanxi Province, "Research on the coordinated development of coal industry and dual carbon economy" No. KY(2022)105

## 7. Institutional Review Board Statement

Not applicable.

## 8. Informed Consent Statement

Not applicable.

## 9. Acknowledgments

We thank the anonymous referees for their constructive comments and suggestions that have led to an improved version of this paper.

## 10. Conflicts of Interest

The authors declare no conflict of interest.

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