

Original Research Article

Research on the transformation strategy of mining sustainable development under the dual carbon target

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Abstract: Against the backdrop of global climate change, China has proactively proposed dual carbon targets in response to the global call for greenhouse gas emission restrictions. Mining, as a fundamental industry of the national economy, belongs to a high energy consumption and high emission industry in its development process. The proposal of the dual carbon strategy brings new challenges to the sustainable development transformation of China's mining industry. This article analyzes the situation and challenges faced by mining development under the dual carbon target, proposes a transformation strategy system for sustainable mining development, and proposes implementation paths from three aspects: Technological innovation, policy guarantee, and financial support. Research has shown that achieving low-carbon transformation in the mining industry is not only an inevitable requirement for implementing the dual carbon goals, but also a fundamental way to enhance industry competitiveness and achieve sustainable development. It requires multi-party collaboration among the government, enterprises, and research institutions to promote the deep transformation of the mining industry towards green, low-carbon, and intelligent directions.

Keywords: dual carbon target; sustainable development of mining industry; green mines; low carbon transformation; circular economy

1. The situation and challenges faced by mining development under the dual carbon target

1.1. Carbon emission constraints are becoming increasingly rigid

China has included major carbon emitting industries in the industry's rigid constraint indicators, marked by carbon peak and carbon neutrality. As the world's largest producer of steel, China's energy structure dominated by coal in the medium to long term requires stricter standards for carbon emission control. At present, the country has implemented stricter carbon emission accounting for processes such as non-ferrous metals, steel industry, mining, and tailings treatment. Some regions have already started incorporating carbon emissions into the mining transfer process during mining operations. For major carbon emitting steel, coal, and iron ore mining and selection enterprises, under the premise of strict control of total carbon emissions, in order to ensure sustainable development, they must continuously reduce the carbon emission intensity per unit output. Only in this way can they reduce production capacity pressure, continuously reduce production costs, and obtain market access from developed countries.

1.2. The energy consumption structure urgently needs to be optimized

Mining requires a significant amount of energy to sustain its production during the mining process. Taking coal mining as an example, whether it is underground transportation or ventilation and drainage, in addition to electricity consumption, a large amount of fossil energy is also required. However, currently, green electricity accounts for a relatively low proportion of electricity consumption in the production, transportation, and processing stages of mining enterprises, and fuel equipment still dominates. In the transportation sector, diesel used by a large number of trucks accounts for more than half of the energy consumption in mines. Due to financial and technological limitations, existing mining enterprises are slow in their energy consumption transformation. Equipment updates, infrastructure upgrades, and restructuring of energy systems require continuous funding and technological support, which presents new challenges for mining enterprises.

1.3. There are bottlenecks in the technological path

Under the dual carbon target, China's mining industry has made significant progress in green transformation. However, compared to the requirements of the dual carbon target, China's mining industry still faces technological bottlenecks in green transformation. On the one hand, although carbon capture, utilization, and storage technology is gradually being applied in mining, its high cost makes it difficult to apply on a large scale, and companies find it difficult to accept its cost pressure. On the other hand, the mining environment of mining enterprises is harsh, and in deep mining and complex geological conditions, the application of green mining equipment is limited, making it difficult to fully replace traditional fossil energy driven mining and transportation equipment. Breakthrough progress has not yet been made in key technologies such as tailings resource utilization and mining ecological carbon sink enhancement.

2. The transformation strategy system for sustainable development of mining industry

2.1. Adhere to green mining and reduce carbon emissions at the source

The core activity of mining is mining, which involves green transformation from the source and reducing carbon emissions from mining design schemes to ensure sustainable development of the mining industry. In terms of mining methods, priority should be given to low energy consumption, changing from extensive mining to reduce disturbance to the surface. In underground mining, the filling mining method is preferred, which not only reduces surface disturbance and avoids low-fat disasters, but also reduces the ventilation energy consumption of the mine. For open-pit mining, optimize the stripping ratio and step parameters, and adopt processes such as steep slope mining and parallel mining to reduce the amount of stripping. In terms of energy selection in the mining process, we should reduce the direct use of fossil fuels and instead promote the electrification of mining equipment. Choose new energy mining cards and build charging stations to meet the requirements of green transportation in mines. For mines with a large land area and high spare space, solar and wind power generation equipment can also be installed to improve the self-sufficiency rate of green energy. For underground mining equipment, promoting the use of lithium battery power units instead of diesel engines can improve underground air quality while reducing carbon emissions.

2.2. Adhere to clean production and reduce carbon emissions during the process

In the production process, clean production and carbon emissions can be achieved by optimizing mineral processing technology, selecting green flotation reagents, and adopting green energy. Optimize the crushing and grinding process in the selection of mineral processing technology. Replacing traditional crushers with high-pressure roller mills to reduce equipment power consumption. For the problem of cyclic processing in conventional beneficiation processes, a combined beneficiation method of magnetic separation, flotation, and gravity separation can be used to improve beneficiation efficiency. For the use of mineral processing agents, priority should be given to selecting green flotation agents that can be efficiently degraded to reduce the amount of treatment for mining wastewater. With the development of biotechnology, it is also possible to explore the use of biological oxidation and other methods for mining and selection to achieve low-carbon emissions in the mining and selection process. The energy consumption in the production process is relatively high. In order to fully utilize energy, the main energy consuming equipment can be intelligently optimized. For energy-saving renovations of ventilation systems, mineral processing equipment, water pumps and other equipment, low-energy consuming equipment can be selected. In order to improve energy efficiency, it is necessary to include unit production energy consumption in employee performance evaluation, making clean production closely related to each employee.

2.3. Adhere to circular economy and reduce carbon emissions from resources

The sustainable development of mining requires adhering to a circular economy, fully utilizing resources, ensuring optimal economic benefits, and reducing carbon emissions throughout the entire mining industry chain. In China's mining industry, there are numerous associated resources. Following the traditional method of single resource extraction not only results in resource waste but also increases the cost of tailings treatment and carbon emissions. The mining process should be optimized by selecting multiple processes in the mining and selection process, fully extracting associated components such as gold, silver, cobalt, bismuth, molybdenum, etc. from the ore, and reducing the carbon emission intensity

of the mine. In terms of tailings utilization, a large amount of waste residue generated during mining can be used as building materials, made into aerated concrete, or utilized as cement raw materials. This can not only reduce the harm of tailings to the environment, but also reduce the exploitation of natural sand and gravel. In addition, developing tailings bonding filling technology and using slag based cementitious materials instead of cement can further reduce the carbon footprint of filling operations.

3. Implementation guarantee and path suggestions for transformation strategy

3.1. Construction of technological innovation system

The sustainable development of mining industry cannot be separated from technological innovation. We should leverage the advantages of enterprises, be market-oriented, and adopt an innovative system that integrates industry, academia, and research. For large mining enterprises, they have strong financial advantages and can form technology innovation centers with universities and research institutions, focusing on technical public relations in mining equipment updates, mining technology, tailings utilization, and mining processes. In the promotion and utilization of new energy-saving and emission reduction technologies, establish a catalog for promoting low-carbon mining technologies and provide subsidies for the promotion and application of mature and applicable technologies. Strengthen international cooperation in science and technology. Introduce, digest, and absorb advanced mining technologies such as CCUS and bio mining from abroad.

3.2. Improve policy guarantee mechanism

To leverage policy guidance and accelerate the transformation of green mining in the mining industry. In the construction and management of mines, carbon emissions are included in the assessment and management content. For enterprises with significant dual carbon emission reduction effects, support is provided in resource allocation and technological transformation funds. For high carbon emission enterprises, their production capacity should be limited, and they should be forced to save energy and reduce emissions through methods such as tiered electricity prices. Establish a special subsidy fund for carbon emissions reduction in the mining industry, providing investment subsidies or loan interest subsidies for energy-saving renovation and new energy substitution projects. Accelerate the inclusion of ecological carbon sinks from mines in the national voluntary emission reduction mechanism, and open up carbon trading channels for mine restoration.

3.3. Capital investment guarantee mechanism

The low-carbon transformation of mining enterprises requires continuous capital investment, and in the process of green transformation, diversified financing channels should be established. At the central level, special funds for energy conservation and emission reduction should be established to support a group of technologically advanced enterprises with significant energy conservation and emission reduction effects. Utilize market effects, encourage social capital to participate in mining ecological restoration work, and reduce the capital investment of mining enterprises. In terms of financing methods, we will leverage financial innovation to promote mining enterprises to issue carbon neutral bonds and transition bonds, and raise funds specifically for low-carbon transformation. For low-carbon mining projects that meet the conditions, priority will be given to inclusion in the national green bond support project directory.

Summary: Under the dual carbon goal, the sustainable development transformation of mining requires reducing carbon emissions from the mining source, fully utilizing clean energy in the production process, adopting a circular economy model combined with ecological restoration, in order to ensure the green transformation of mining. In the process of transformation, the mining industry needs to ensure the success of green transformation from the aspects of technological innovation, policy guarantee, and financial support. Looking ahead to the future, with the deepening of carbon peak and carbon neutrality work, sustainable development of mining will cooperate with new energy, while leveraging numerical technology and artificial intelligence to transform into green mines, thus achieving green mines.

About the author

Wencheng Xing (1986-), male, Han, from Qujing, Yunnan, holds a master's degree and is a lecturer. His research interests include mining safety and safety management.

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