



Research on Green Transition Development of Energy Enterprises Taking Mining Industry as an Example

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ABSTRACT

To fully understand the development models of the green mining economy, this paper, based on the western externality theory, focused on a green mining construction case in China. Results have shown that the green mining concept has early emerged in the mining industry and currently has reached a relatively high target, indicating the application value of the concept of green mining development. It is then concluded that the green mining development model is valid and effectively verified by the green mining construction case.

INTRODUCTION

The coal mining industry is an important industry supporting China's social development, whose level of development is closely related to people's livelihood. Currently, development in all sectors demands more and more coal mines, posing great difficulty in coal mine supply. To alleviate this problem and achieve the purpose of energy conservation and emission reduction, the concept of green coal mining economic development has been proposed in China. The core philosophy is to realize the optimal mineral resources development and the minimum ecological environmental impact on the premise that the mine environmental disturbance is less than or equal to the regional environmental capacity. This model can maintain the ecological balance, advance the economic development of mining, and reduce the difficulty of coal supply, so as to promote the rational distribution of coal mine supply, attracting much attention of the community.

This paper, taking a mineral enterprise as an example, studied its actions for green coal mining development from the perspective of the system theory based on the Western mainstream economic theory, the resource industry economics and ecological economic theory. Additionally, a green mining economic development model and corresponding policy support system were put forward based on the analysis of the motivations for coal mining enterprises to develop green mining economy.

PAST STUDIES

Under the premise that the amount of environmental disturbance is not greater than the regional environmental capacity and its self-purification capability, the mineral development model with the optimal allocation of mineral resources and the minimization of regional eco-environmental impacts is implemented. Green mining is no longer taking the old road of extensive mineral resources development and utilization, but rather achieving sustainable development. For the relationship between mining development and economic development, many experts at home and abroad have conducted research (Dai et al. 2016, Usman et al. 2018, Hanafiah et al. 2017, Sultana et al. 2018). There is complete compatibility between mining activities, the environment, society and the economy. At present, the mining companies should be able to profitably provide the society with mineral products while also protecting the environment and social welfare. These environmental and social benefits are necessary for social and economic development. Mineral resource-based enterprises must handle several relationships in the course of their operations (Kusi-Sarpong et al. 2016, Babaranti et al. 2019). First of all, enterprises should listen to shareholders' opinions and provide enough investment returns and benefits. The second is to achieve the optimal allocation of resources. The last step is to govern, restore, and protect the ecological environment in the mining area and

compensate them in subsequent operations. This illustrates the basic connotations of green mining from another perspective. The miners are responsible for ensuring that the world economy supplies sufficient raw materials to support economic growth and continuously improve people's living standards. The development of mining must take into account the full use of resources, the protection of the environment, the training and development of staff, and the local economic and social development. Mineral resource companies must create a new business model. In this way, the sustainable development of the mining economy will be achieved through the joint efforts of the government, surrounding organizations and civil society groups (Musa & Chinniah 2016, Jamil et al. 2018, Khan et al. 2018). Therefore, the construction of green mines and the development of green mining are new models for the sustainable development of the mining economy.

As a large mining country, there are currently more than 10,000 state-owned large, medium, and small-sized mines, and mining cities such as Daqing and Panzhihua that are supported by mining and mineral processing industries. The development and utilization of mineral resources have become one of the pillar industries in China's socio-economic development (Ouoba 2017, Alsulaiman & Nizam 2018, Zada & Ali 2018). With the development and utilization of mineral resources, the topography and geomorphology of the earth's surface and the structure of subterranean rock formations have been greatly changed. This not only destroys the natural landscape of the surface, but also destroys the balance of the ground stress, water balance and ecological environment balance, resulting in the occurrence of ground subsidence, mountain cracking, landslides and mudslides and other geological disasters (Shen et al. 2015, Yew & Abd Rahim 2017, Ismail et al. 2017). The massive emission of by-products such as waste rock and tailings in mines not only wastes natural resources, but also destroys the structure of the soil, causing the loss of water and soil, the desertification of the land and the destruction of the ecological environment in the mining area. Tailings and their by-products are the wastes of mines in the process of exploiting and utilizing mineral resources (Sivakumar et al. 2015, Aslam 2017, Zarepourfard et al. 2017). Under different technical conditions, it is also a potential resource. Under the conditions of the development of green mining economy, it can be effectively developed and utilized through innovative technologies such as recycling and low carbon. In the field of green mining economy and sustainable development, domestic scholars have also conducted a lot of research. From the perspective of economic structure and regional economic development, the western region will certainly become the replacement of China's energy and mineral resources. Mineral resources are abundant, the degree of development and utilization is low,

and the potential is huge. Most of the eastern mines will be closed and mining cities will need to be transformed (Xu et al. 2016, Bakar et al. 2017, Kumar 2018). In formulating the grand plan for the development of the western region, the experience and lessons of industrial civilization and environmental and ecological imbalances should be summarized. The development of the western mining industry must be based on two basic points. First, starting from the overall perspective, two mineral resources must be developed. This is a national condition. Second, the ecologically fragile western region must be protected. This is a national policy. Based on the conceptual connotations of "resource depletion function", "intergenerational equity" and "social tolerance", sustainable development of the mining industry means not only meeting the needs of economic development, but also not damaging the human living environment, health and life. Through scientific and technological innovation, the consumption rate of coal resources is maintained at a relative level. When resources are depleted, humans have enough time and conditions to make an orderly shift to alternative resources. Based on game theory, the company's green mining and continuous innovation are systematically analysed (Zhang et al. 2017, OmaraShaestan et al. 2017, Sedaghatthoor & Shahrajil 2018). The corresponding policies and recommendations are put forward.

In summary, while providing clean fuel, raw materials, and electricity to the society, the coal industry should make full use of market mechanisms. Through scientific and technological innovation, it seeks alternative resources and regulates the optimal recovery rate and exhaustion rate of coal resources. Economic, social, environmental protection and resources are optimally configured. While satisfying the needs of the present generation, it does not pose a danger to future generations. Mining is the basis of economic development. In the process of economic development, on the one hand, a large amount of essential basic raw material is provided; on the other hand, mine pollution problems caused by irrational development and utilization of resources are gradually increasing, which destroys the inherent ecological environment. Typical diseases in mining areas are frequent, underground and surface water are polluted to varying degrees, and events such as landslides, mudslides, and soil depletion frequently occur. Therefore, it is of great significance to systematically deal with the relationship between the exploitation and utilization of mineral resources, the ecological environment, and regional economic development. The construction of green mines, the development of green mining and the green mining economy are the only way to coordinate sustainable development.

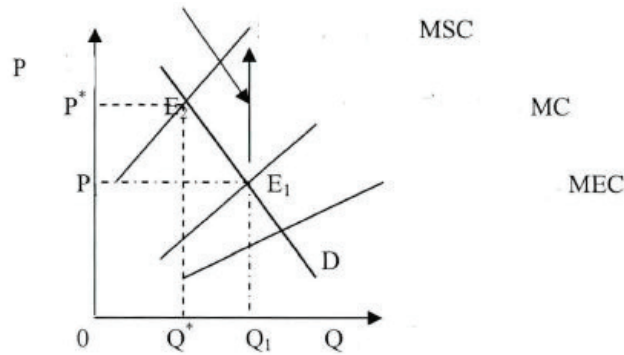


Fig. 1: Diagram of negative externality analysis of mining industry.

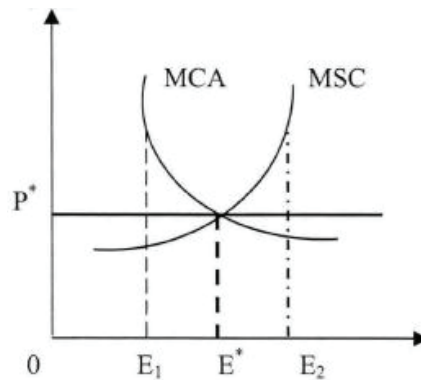


Fig. 2: Schematic diagram of optimal emission level in mining production process.

MATERIALS AND METHODS

Western Theoretical Basis: In this paper, the externality theory was used for the analysis. The externality theory was neglected in the initial stage. However, in the process of industrialization and urbanization with increasing environmental pollution and other problems, people gradually paid attention to the externality theory and tried to solve these problems by this theory. Western mainstream economics believes that the existence of externalities leads to market failures in the resources and the environment. Therefore, the externality theory is one of the important economic theoretical foundations for the development of green mining economy. Samuelson believes that external economic effects occur when producing or consuming incidental costs or benefits to other people. This effect is not reflected in currency or market transactions. This incidental cost is called externality (also known as external effects or spill over effects) that refers to the actions of people's economic activities that affect other people without taking into account the market transaction costs and prices.

Analysis of Mining Operating Target: The target of mining operations is mainly mineral resources. In the process of the exploitation and utilization of mineral resources, the discharged pollutants mainly include solid, liquid and gas wastes, which are referred to as "three wastes", such as coal gangue, wastewater, and coal bed methane. Companies are profit-making business units and determines production if the marginal cost equals the marginal revenue. At this time, the equilibrium of the company is the corresponding equilibrium output and the equilibrium price. Due to negative externalities, the equilibrium point is a market equilibrium that does not consider social pollution losses when it is efficient for the production of enterprises but inefficient for the society. If social pollution losses are considered, the optimal balance point for society should be the corresponding equilibrium output and equilibrium price. Therefore, the existence of externalities leads to social costs, producer costs, and pollution costs. Fig. 1 shows the negative externalities of the mining industry, and Fig. 2 displays the optimal emission levels during the mining production.

10, 10	3, 12
12, 3	5, 5

Fig. 3: Schematic diagram of game matrix between coal enterprises.

Analysis of Corporate Behaviours in Green Mining Development

Inter-enterprise game analysis: Coal is a non-renewable resource, and its recoverable reserves in China are relatively limited. To main the sustainability, both the time and space for development and utilization should be considered. In terms of space, it is to solve the problem of sustainable use within the generation, mainly referring to the exploitation of resources in one region doing no harm to the use of resources in other areas. Enterprises are profit-oriented business units. When considering the economic benefits, each market entity starts from its own, and does not pay attention to the impact of its own behaviour on other entities. The lack of the system concept leads to the “Tragedy of Public Land Use” in coal mining in China. In terms of time, it is to solve the issue of sustainable intergenerational use. It mainly refers to that the exploitation and utilization of coal resources by contemporary people does not harm the use of this resource by future generations. Therefore, the inter-enterprise game during the coal mining development and utilization can be based to analyse the root motivation for corporate green mining development. The inter-enterprise game matrix is shown in Fig. 3.

Enterprise-government game analysis: Another major content of developing green mining and building green mines is to reduce the environmental destruction and pollution reduction, which relies mainly on government policies. The treatment of environmental pollution and the implementation of green mining demands a large amount of capital and energy, which will cause rapid increase in the cost of business operations and losses for enterprises in the short term, and will not necessarily bring profits to the company in the long run. The shortage of funds, inexperience, and shortage of green technologies to minimize the remaining materials may all hinder the efforts of companies to build green mines, develop green mining, and achieve green mining economic growth plans. Therefore, only with the mandatory constraints of government policies, coal companies are forced to consider the development of green mining economy. Generally speaking, in the process of realizing the transformation from the traditional linear economy to the green economy, the

government bears the corresponding public responsibility and social obligations. In essence, the implementation process of environmental treatment policies is the process of transmitting or imposing government social responsibilities and value standards to enterprises. However, pursuing profit maximization is a rational behaviour of enterprises, which leads to the conflicts between companies and governments in the responsibility and value standards, also a conflict between individual rationality and collective rationality. From another perspective, this poses a test to the government in its governing ability and management level. When the policy design or implementation is weak, the best choice for companies may be to pay fines to further create environmental pollution and evade the responsibility for pollution control. From the perspective of government management, relevant administrative departments also have their own interest orientations in the process of law enforcement and management, which may lead to the distortion or failure of the original policy due to the pursuit of penalties. In order to systematically analyse the behaviour between companies and the government, the game between the two can be used. At present, in the economic policy system for environmental governance, China mainly implements a sewage charging system. During the policy implementation, there is a typical game process between enterprises and the government.

Enterprises and the government are participants of the game, and pursuing their own best benefits is the rational assumption and common point. The government promulgates relevant policies, implements inspections, and imposes fines on enterprises that have exceeded pollutant discharge levels to guide the companies’ pollution control activities.

There are two strategies for enterprises to choose, i.e. treatment or no treatment. The government can implement two strategies, i.e. inspection or no inspection.

Between the enterprises and the government, the matrix in the game process is shown in Fig. 4.

$R_e - C_e$	$R_g - C_g$	$R_e - C_e$	R_g
-F	$F - C_g$	0	0

Fig. 4: Game of sewage charges between enterprises and governments.

Table 1: Amount of coal mining, power consumption and coal output of the case mine.

RESULTS AND ANALYSIS

Green Industry Chain: Coal Mining-Gangue-Electricity -Building Materials: Mine production emits a large amount of coal gangue every year, which is a waste produced in the

Table 1: Amount of coal mining, power consumption and coal output of the case mine.

Time	Coal mining	Power consumption	The yield of coals
2005	281.69	6183.08	14.10
2006	280.00	6437.68	14.00
2007	305.24	6780.19	15.20
2008	320.37	7211.47	16.00

Table 2: Statistics of production and processing capacity of solid waste in the case mine.

Company	Raw coal producing star	Coal traitor emission	Fly ash thermal power plan Release
Example	343	17	-

coal mining, washing and adding, mainly composed of inorganic and organic matters. The piled-up gangue hill is susceptible to landslides, spontaneous combustion, and the release of toxic gases. Occupying a large land area, it will also pollute the surrounding soil and groundwater under the effect of leaching. Therefore, comprehensive development and utilization of coal gangue must be carried out.

Green Industry Chain: Coal Mining-Gangue-Electricity:

For a variety of reasons, the large amount of heat generated during the mining production process is lost in the form of residual heat, which is a great waste of energy. At the same time, the boiler room that was rebuilt or newly built to meet the needs of the ground production and life has consumed a lot of coal resources. Through the technical transformation of the production equipment of the coal gangue power plant, the capacity of the boiler has been increased and the heating pipelines have been laid, which enables centralized heating for the majority of the entire mining area and reduces waste heat emissions. At present, a wide range of the mining areas, office buildings, industrial squares and other places are receiving heating from the waste heat of the coal gangue power plant. Also, the waste heat can be used in water boiling, with the steam supply of more than 10,000 tons. At the same time, the coal mine has also cancelled the original coal-fired boilers to eliminate exhaust gas emissions from coal combustion, annually saving huge coal resources. If taken various costs such as utilities and labour costs into consideration, the implementation of the green industry chain can save up to 10,000 RMB. Next, the mine will make full use of the heat source of the power plant, and gradually expand the heating area. Table 1 is the amount of coal mining, power consumption and coal output of the case mine. And Table 2 is a statistical table of the amount of solid waste produced and processed in the case mine.

CONCLUSION

This paper, with a coal mine as an example, analysed its green coal mining construction based on the western externality

theory. The results show that the case mine has already started to build green mining in the early years, and has achieved two models, namely, the coal mining-gangue-electricity-building materials model and the coal mining-gangue-electricity model. In order to fully understand its development, the two green models were analysed respectively. It is concluded that the mine has great progress in the green mining construction, with good energy-saving performance in terms of electricity, labour costs, and waste heat discharge. It shows that the green mining project has always been successful along the way and is in line with the current concept of green mining construction. However, from the perspective of development, the green mining construction still have more improvement space.

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