

# The green transformation and development in China under resource constraints

Xueyao Liu <sup>1\*</sup>

<sup>1</sup>Belarusian State University, Karl Marx street 31, Republic of Belarus

**Abstract.** Under energy constraints, green development becomes the main development direction in China now. The green transformation of the economic growth pattern and the green transformation of industry are feasible ways to pursue green development. For the green transformation of the economic growth pattern, various proposals related to environmental protection, resource utilisation, and ecological restoration of mining land are suggested and discussed. For the green transformation of industry, several suggestions are provided for resource-based industries, environmental industries, and other industries. These discussions can contribute to the formulation and development of economic, industrial, and energy policies in China.

## 1 Introduction

Energy is an important material basis for human existence and social development. It is related to the national economy and the people's livelihood. The rapid development of China's economy since the reform and opening up is inseparable from the stable supply of energy. However, along with the seriousness of resource and environmental constraints, the challenges of energy in the process of economic development in China would become more and more severe. The twin strains of economic development and environmental damage are also reflected in the enormous evolution of energy policy from inception to the present. In the early years of the country, China promoted energy policies focused on strengthening energy production and construction. During the "Great Leap Forward" period, energy production and construction policies based on the production of steel took the stage of history. In the "Cultural Revolution" period, energy policies focused on the miniaturization and decentralization of industrial organization and on the restructuring of the energy sector. After the reform and opening up, China's energy policies placed greater emphasis on energy conservation and the diversification of the energy structure with electricity as the mainstay, and an energy strategy in which the energy layout shifted from a balanced to a tilted one. At the turn of the century, China began to implement energy policies aimed at economic and environmental efficiency, while taking into account energy security. From the 21st century, energy policies focused on environmental efficiency, optimizing the energy structure and implementing dual control over total energy consumption and intensity have been intensively pursued. The energy policies of China show different emphases in different historical periods.

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\* Corresponding author: [18215686524@163.com](mailto:18215686524@163.com)

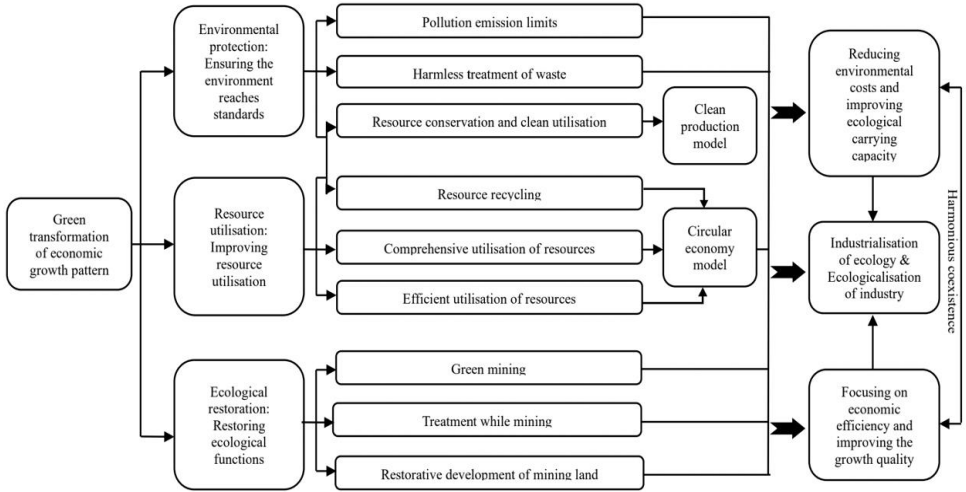
In general, it has evolved from a focus on energy supply to a focus on energy conservation, energy efficiency and optimization of the energy structure for sustainable development [1]

As the philosophy of green development develops in China in recent years, energy policy has gradually been incorporated into the scope of green development, which no longer considers the economic development as the priority, but begins to pay attention to the sustainability of energy, the possible pollution caused due to traditional energy sources, the positive significance of new energy sources for the future, and inter-regional energy cooperation, as well as a number of other issues. With the requirements of current development, the study on green transformation and development in China under resource constraints is of practical significance for achieving energy sustainability, solving the environmental crisis and realising high-quality economic development. Sun Yi believes that the two key components of green transformation are diversification of industrial structure and greening of economic growth pattern [2]. According to his idea, the main direction of green transformation lies in the green transformation of economic growth pattern and the green transformation of industry. Based on the purpose of green development, the green transformation of the economic growth pattern should involve environmental protection, resource conservation and ecological restoration. However, according to the existing literature, the green transformation of industry is considered to be a result of the cooperation of several industries. According to Che Liangliang and Wu Chunyou, the energy industry, or resource industry, is the major actor in the green transformation. The resource industry promotes the industrial development of a country by providing domestic markets and investment capital, thus making it easier for the developing countries to make the leap from underdevelopment to industrialization [3]. Juyang argues that the environmental industry is the key driver to green development, and that it has become an important part of the national economy of China as it emerges from pollution prevention and control [4].

## **2 Green transformation of economic growth pattern**

As far as the green transformation of economic growth is concerned, the green development concept requires attention to the intensive utilisation of resources and the protection and management of the ecological environment while ensuring economic growth. In three aspects, environmental protection, resource utilisation and ecological restoration, environmental capacity is ensured, resource utilisation is enhanced and ecological functions are restored. The direction and objectives of the green transformation of the economic growth pattern are shown in the Figure 1 [5].

The main methods of environmental protection are pollution emission limits, harmless treatment of waste, resource conservation and clean utilisation and resource recycling. Pollution emission limits are primarily concerned with clear and regulated emission standards for air and water pollutants released into the natural environment. Pollutants which do not meet emission standards are restricted. The harmless treatment of waste refers to the harmless treatment of waste that can be reused and the harmless storage of waste that cannot be reused. Resource conservation and clean utilisation is about reducing the resource inputs and pollution emissions by means of improved production technology. It falls within the category of clean production model. For example, desulphurisation and denitrification equipment can help enterprises to achieve clean production. Resource recycling is the recovery and treatment of waste discharged from production for reuse. An example is the treatment and reuse of mine water.



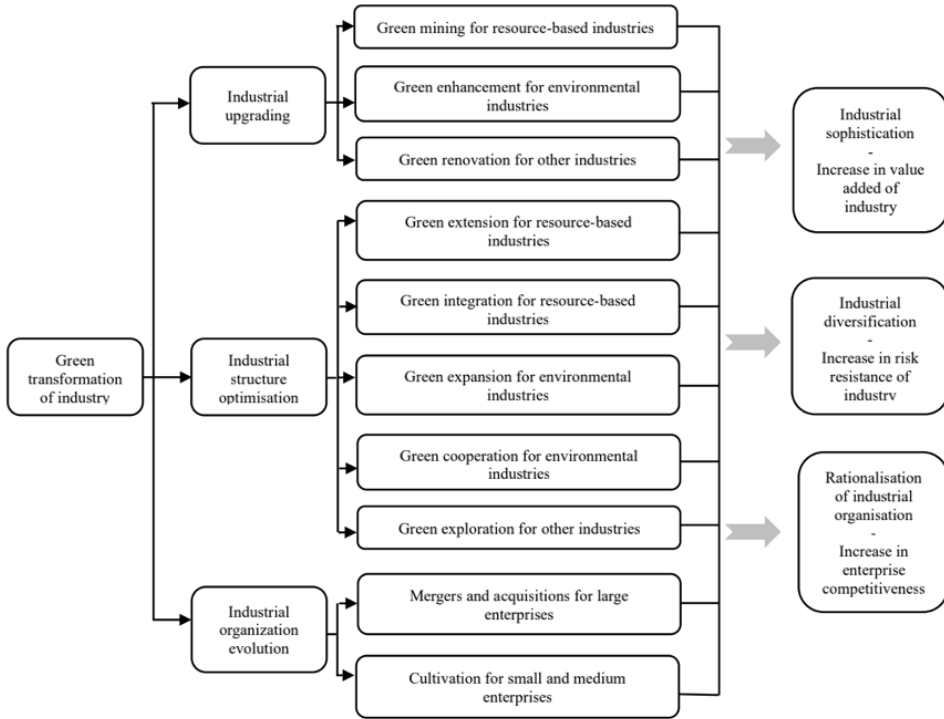
**Fig. 1.** Green transformation mechanism of economic growth pattern.

The green transformation of economic growth patterns in terms of resource utilisation mainly includes resource conservation and clean utilisation, resource recycling, comprehensive utilisation of resources and efficient utilisation of resources. Resource conservation and clean utilisation and resource recycling both fall within the category of environmental protection. However, from the perspective of resource utilisation, resource conservation and clean utilisation can essentially reduce resource inputs and allow for a more long-term integrated management of resource exploitation and utilisation. Resource recycling lies primarily in the gradient utilisation of resources. The gradient utilisation of energy can improve the energy utilisation efficiency in the overall system and reduce the possibility of energy wastage to a large extent. Comprehensive utilisation of resources is the rational utilisation of waste to replace energy inputs and the exploitation of concomitant or commensal resources. Practical examples of the former are the replacement of coal by the coal bed methane in aluminium trioxide production. Efficient utilisation of resources is to increase the added value of products through resource further processing or to substitute resource inputs with innovation and capital. The resource recycling, the comprehensive utilisation of resources and the efficient utilisation of resources are the concrete manifestation of the circular economy. They are important approaches to promote the green transformation of economic growth.

Ecological restoration aims to restore ecological functions before, during and after resource exploitation. The specific components are green mining, treatment while mining and restorative development of mining land. Green mining focuses on defensive measures before exploitation to ensure that resources are intensively exploited without ecological damage. Particular attention needs to be paid to the groundwater resources protection. Treatment while mining is to strengthen the treatment and restoration of the ecological environment during mining. For example, the coal gangue is backfilled while coal mining is in progress. It reduces the coal gangue pollution on the one hand and prevents the ground from collapsing on the other. The restorative development of mining land is a combination of ecological restoration and the utilisation of the natural environment by humans. For example, the rehabilitation of slag and gangue hills can make them become urban landscapes. The treatment and development of sewage rivers can have the same effect. This could make a real difference to the living conditions of residents [6].

### 3 Green transformation of industry

In terms of the transformation of industry, the priority is to integrate the green development concept into industrial development programmes and to promote industrial upgrading, industrial structure optimisation and industrial organization evolution. The direction and objectives of the green transformation of industry are shown in the Figure 2 [7, 8].



**Fig. 2.** Green transformation mechanism of industry.

The main directions of industrial upgrading include green mining for resource-based industries, green enhancement for environmental industries and green renovation for other industries. Among them, the green mining for resource-based industry is mainly concerned with the resource waste during resource exploitation and the sustainability of mineral resources. The application and optimisation of comprehensive resource exploitation, backfilling while mining, and the reuse of waste in mines are all important approaches for the resource-based industry to practice green mining. The green enhancement for the environmental industries focuses on inadequate pollution regulation and poor environmental protection enforcement. There is still a lack of reliable technical support for monitoring pollution generation and emissions. The high cost of environmental protection also makes some environmental initiatives or programmes unconvincing and unfeasible. Green technology innovation and reduced environmental protection costs are the priorities for the environmental industry in the green transformation. In addition, the green transformation for other industries is concerned with pollution emissions and resource wastage during the industrial operation. The gradient use of energy and the integrated use of waste can simultaneously reduce resource inputs and pollutants production and emissions.

The main directions of industrial structure optimisation include green extension and green integration for the resource-based industries, green expansion and green cooperation for the environmental industries, and green exploration for other industries. Among them, the green

extension for the resource-based industries is mainly based on technology and process innovation that extends the resource-based industries chain. In this way, the utilisation ratio of resources and the added value of industries can be increased. Green integration for the resource-based industries is the integration of resource industries with other industries or the incorporation of new ideas into existing industries so as to facilitate the flourishing of new industries. For example, coal tourism, coal finance, ecological logistics, ecological agriculture. Green cooperation for the environmental industries refers to the collaborative development of environmental industries and other industries. Due to the difficulty of defining rights and responsibilities, environmental protection lacks fundamental motivation and adequate financial support to a certain extent. Collaborative development of environmental industries and other industries can solve the dilemma in which environmental industries lack the motivation to develop, and it can also inject green concepts into the development and operation of other industries. Green exploration for other industries is the development of new industries with a comparative advantage in terms of energy efficiency and environmental protection by identifying regional advantages. The emergence and development of new resource and environment friendly industries can optimise the regional industrial structure and energy structure and reverse the pollution situation. It also facilitates the industrial restructuring while maintaining a stable and rapid economic development.

The industrial organization evolution, on the one hand, is aimed at large and medium-sized state-owned enterprises. Through mergers and acquisition of similar enterprises, affiliated enterprises, and upstream and downstream enterprises, the alliance of enterprises is strengthened. In particular, the dynamism and innovation capacity of enterprise groups could be further enhanced when non-resource-based projects with low resource consumption, high innovation capacity and abundant human resources are introduced. Another aspect of industrial organization evolution is to enhance the cultivation and development of small and medium-sized enterprises and to promote their competitiveness and employment absorption capacity [9, 10, 11].

## 4 Conclusion

As the theory of sustainable development evolved, the concept of green development was introduced. In the domain of economics, green development is concerned with the sustainability of energy and ecological damage due to production activities. As energy and environmental pressures continue to increase in China, green development has become the main direction of current development. The formulation and implementation of economic policies, industrial policies, and energy policies will all be based on the national strategy for green development [12].

In this context, this paper designs and discusses the mechanism of green transition under energy constraints. In terms of the green transformation of economic growth pattern, the measures from environmental protection, resource utilisation, and ecological restoration, are proposed and discussed in detail, such as pollution emission limits, harmless treatment of waste, resource conservation and clean utilisation, resource recycling, comprehensive utilisation of resources, effective utilisation of resources, green mining, treatment while mining, and restorative development of mining land. In terms of the green transformation of industry, the designed green transformation mechanism provides recommendations for resource-based industries, environmental industries and other industries in the three aspects of industrial upgrading, industrial structure optimisation and industrial organisation evolution, respectively. Our discussion of green transformation and the design of the mechanism can provide some suggestions for the formulation of energy policy, industrial policy and economic policy in the pursuit of green development in various countries.

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