

The Path Towards Green Transformation in Hainan's Manufacturing Sector

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Abstract: Under the inevitable choice of China's "dual carbon" strategy and ecological civilization construction, Hainan Province's free trade port adheres to green development. The green transformation of manufactory in Hainan Province is also active. Green transformation is influenced by multiple factors and involves the entire manufacturing cycle. Thus, this article first sorted out the 31 major categories of manufacturing in Hainan, calculated the average energy consumption of manufacturing enterprises above a certain scale, and obtained the basic situation of manufacturing enterprises in Hainan Province. This article also uses literature review to analyze the specific path of green transformation in Hainan Province's manufacturing industry from three aspects: government policies, industrial structure, and energy consumption. The research results found that there is a clear trend of green transformation in the manufacturing industry in Hainan Province. This article suggests that Hainan Province should expand the positive impact of policies such as free trade ports, promote digital and intelligent development, and continuously adjust industrial institutions.

1. Introduction

The urgency of global climate change and environmental degradation has prompted a global consensus on green transformation within the manufacturing industry. The United Nations Industrial Development Organization emphasizes using green digital transformation as an opportunity to promote sustainable development in the fourth wave of industrial revolution. This means that there is a global emphasis and promotion on the green transformation of the manufacturing industry. Chinese manufactory has consistently ranked first in the global total for many years, and its added value far exceeds that of other countries during the same period. Its products are distributed all over the world. To achieve sustainable development, China actively promotes the green transformation. One of the strategic tasks specified in "Made in China 2025" is to comprehensively promote green manufacturing. As an important special economic zone in China, the green transformation of manufactory in Hainan Province is a great significance for sustainable development. The Hainan Free Trade Port emphasizes the priority of ecological protection and should be supported by a green and modern industrial system. Hainan Province is actively promoting the construction of factories and supply chain management to achieve the green and low-carbon transformation of industries. Green industry would promote the construction of ecological civilization and green low-carbon development in Hainan Province,

support the construction goal of Hainan Free Trade Port, and achieve a win-win result between economic development and environment protection. Therefore, this study aims to explore the green transformation path of manufactory in Hainan.

2. Literature Review

The green transformation of manufactory is a model, which promotes the environmental friendliness of the entire product life cycle. It refers to the adoption of environmental protection technologies and management methods in production materials, production technology, product use, operation management, energy consumption, and waste discharge under the guidance of the concept of environmental sustainability [1-3]. The goals of this model are achieving resource conservation, improving energy efficiency, reducing pollution emissions and waste generation. Based on the wide geographical distribution and diversified characteristics in technology and application, researchers have also analyzed the green transformation of manufacturing industry from multiple aspects [4]. Firstly, government policies and environmental regulations are key factors in promoting the green transformation. Government policies guide the manufacturing industry towards green development by formulating development plans, providing financial support and tax incentives. Besides, moderate environmental regulations can stimulate technological innovation and industrial structure optimization, then

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promoting green transformation [5-6]. Secondly, the importance of industrial restructuring and technological innovation in promoting the green transformation has also received attention. Industrial structure would optimize industrial layout, reduce the proportion of high energy consuming and high polluting industries, while technological innovation provides methods to achieve green production [7]. Thirdly, the energy consumption structure is related to the energy efficiency and environmental impact of the manufacturing industry, which has a significant promoting effect on the upgrading of the manufacturing industry structure. The manufacturing industry is the main source of energy consumption and carbon emissions in China. Therefore, adjusting the energy consumption structure, reducing dependence on fossil fuels and carbon emissions, and increasing the use of renewable energy are important ways [8-9].

The future development plan of Hainan province clearly proposes to build an international tourism consumption center, create a modern service industry and high-tech industry highland. The achievement of these goals requires support of a high-quality and sustainable manufacturing system. There is relatively little research on the manufacturing industry in Hainan, mainly on the period from 2014 to 2017. Hainan Province has advantageous mineral resources and unique climate resources, which would provide sufficient raw materials and resources for the manufacturing industry.

In summary, the theoretical research model on green transformation in the manufactory in Hainan has presented. This article will analyze the green development path from three aspects: relevant policies, industries and technologies, and energy consumption structure, based on existing empirical research.

3. Analysis of Hainan's Manufacturing Industry Landscape

The manufactory in Hainan Province has developed rapidly. In 2023, the fixed assets investment in the manufacturing industry grew by 21.1%, accounting for 8.98% of the total proportion. The added value of traditional manufacturing industries has significantly increased and the pharmaceutical manufacturing industry also achieving a growth rate of 16.2%. The characteristics of Hainan's manufacturing industry are large quantity, diverse types, and average coverage. In 2023, the total number of manufacturing industry activity units in Hainan Province is 6588, covering 31 major categories in the National Economic Industry Classification (Figure 1). Among them, the proportion of various manufacturing units is relatively balanced.

According to the Hainan Provincial Statistical Yearbook, the average energy consumption of petroleum, coal and other fuel processing industries is highest, followed by Manufacturing of Raw Chemical Materials and Chemical Products, and next is Manufacturing of Non-metallic Mineral Products, with an average energy consumption of 72116.15 tce. The energy consumption of the three industries mentioned above accounts for 76.63% of the total energy consumption in Hainan Province. The energy consumption of emerging green manufacturing industries such as Manufacturing of Automobiles, Manufacturing of Computer, Communication and Other Electronic and Manufacturing of Articles for Culture, Education Arts and Crafts, Sport and Entertainment Activities is relatively low (Figure 2).

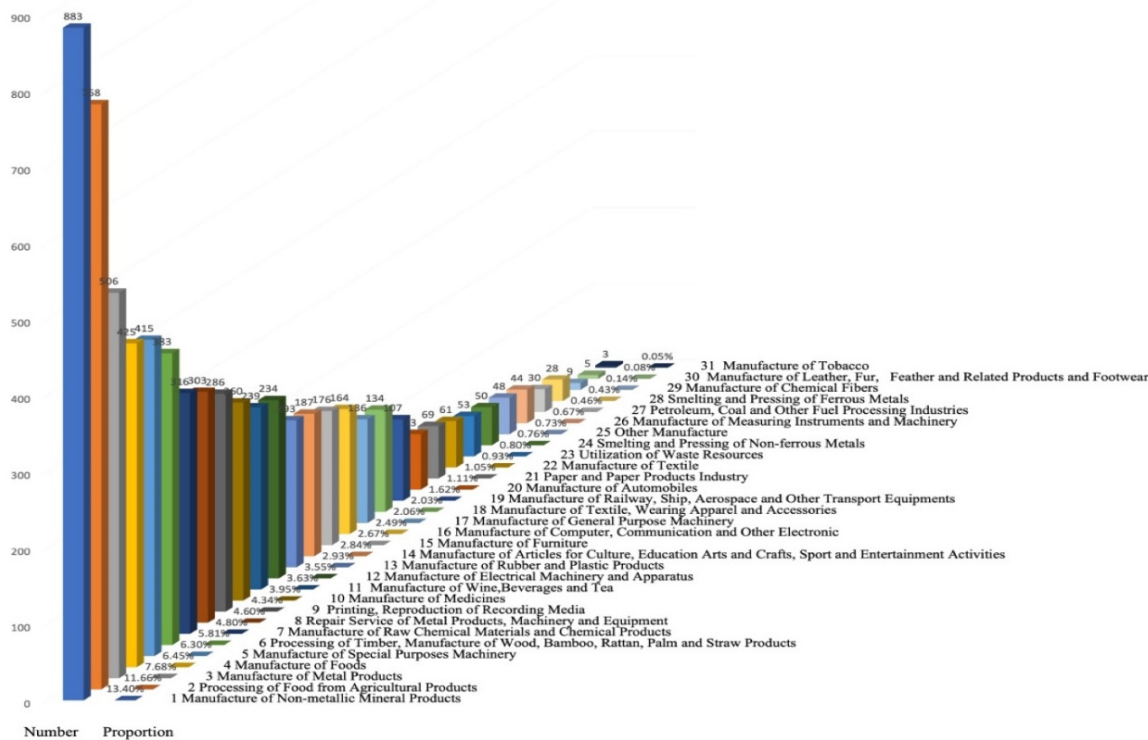


Figure 1. The Number of 31 Types of Manufacturing Industries in Hainan. (Drawn by the author, data source: Hainan Statistical Yearbook 2023)

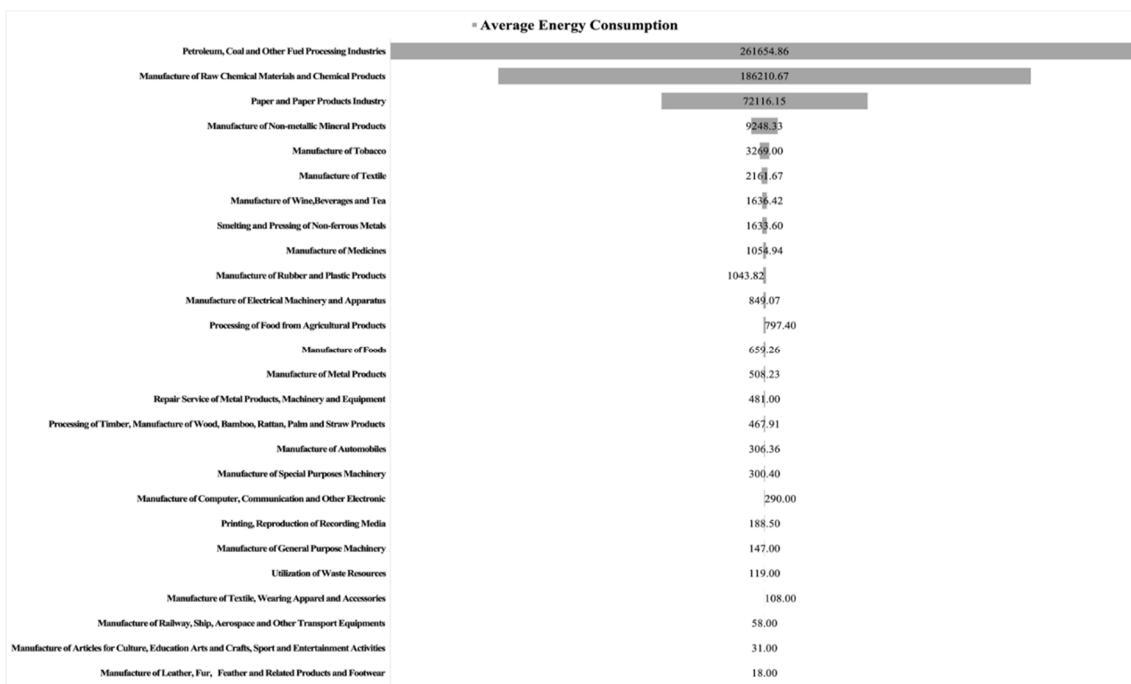


Figure 2. Average Energy Consumption of 31 Types of Manufacturing Industries in Hainan. (Drawn by the author, data source: Hainan Statistical Yearbook 2023)

4. The Green Transformation Path for Hainan Manufactory

4.1. Government Policies Supporting Green Development

Both the national and provincial governments have implemented a series of policies and measures to facilitate the green transformation. Firstly, at the national level, "Made in China 2025" establishes green development as a core principle, and one of the strategic tasks specified is to comprehensively promote green manufacturing. The Guiding Opinions on Accelerating the Green Development of Manufacturing Industry emphasizes the need to increase the proportion of green and low-carbon energy utilization, developing emerging green industries and green carpet industries, and promoting the green integration of new formats. China has also established unified evaluation standards and indicator requirements for green manufacturing industry. The guiding principles of the "General Principles for the Evaluation of Green Factories" (GB/T36132-2018) enable manufacturing enterprises to optimize the efficiency of energy and resource utilization, reduce waste emissions, strengthen environmental management mechanisms, and help achieve energy conservation. In addition, China has also formulated supporting systemic standards such as "Evaluation Indicators for Green Manufacturing" (GB/T43914-2024) and "Implementation Guidelines for Green Supply Chain Management of Green Manufacturing Enterprises" (GB/T43902-2024). Secondly, at the provincial level, Hainan Province has stated that the core goal of promoting the transition of the economic system in 14th Five Year Plan and 2035 Vision. It aims to achieve a harmonious

coexistence between economic prosperity and ecological environment quality. Besides, Hainan Province has issued multiple policies to promote the green transformation of the manufacturing industry from three aspects, including the aspects of green manufacturing, low-carbon emission reduction, and technological innovation. The 14th Five Year Plan for the Development of High-tech Industries in Hainan Province proposes to comprehensively promote green manufacturing, with plans to establish 10 green factories and 2 green parks. The Implementation Plan for Carbon Peak in Hainan Province sets clear emission reduction targets, encourages and requires the adoption of low-carbon technologies, and improves production processes. Finally, at the municipal level, cities such as Haikou, Danzhou, and Dongfang have all attracted cutting-edge high-tech manufacturing enterprises to settle down through institutional, service, and technological innovation, and provided sufficient financial support to jointly promote the green transformation of the manufacturing industry structure.

4.2. Green transformation of manufacturing industry structure

The development of high-tech industries is one of the ways to achieve green transformation in the global manufacturing industry. Hainan Province has continued to invest and develop in the high-tech field. In 2023, the added value of Hainan's high-tech manufacturing industry has increased by 8.3%. The real economy in Hainan has also been boosted and the added value of high-tech manufacturing and equipment manufacturing industries increased by 8.3% and 18.6% respectively. In addition, Hainan Province is vigorously promoting the development of new energy and cultural tourism manufacturing enterprises. By 2022, the number of related enterprises for

new energy vehicles in Hainan Province reached 20400, and there had been 11 Cultural Manufacturing enterprises. Hainan Province is committed to building a green manufacturing base, which would reduce the negative impact of industrial production on the environment by promoting clean production technologies, improving resource utilization efficiency, and reducing pollutant emissions. Hainan Province has designated 13 high-tech industry distributions throughout the province, forming a spatial form with Haikou City as the focus and surrounding Hainan Island. Different manufacturing industry development directions have been formulated for each industrial park. For example, the output value of Haikou's automobile manufacturing industry increased by 167.6% year-on-year, and the output value of the pharmaceutical manufacturing industry increased by 16.2% year-on-year. The National High-tech Zone focuses on developing the biopharmaceutical industry and has introduced companies such as Qilu Pharmaceutical (Hainan) Co., Ltd. and Huaxi Biotechnology (Hainan) Co., Ltd. Danzhou Yangpu Economic Development Zone focuses on building a new petrochemical and new material industry base, and has established 16 capital and technology intensive petrochemical and new material enterprises such as Hainan Refining and Yisheng Petrochemical (Figure 3).

4.3. Partial optimization of energy consumption

The manufacturing industry in Hainan Province accounts for a high proportion of overall energy consumption, gradually showing a trend towards greening. Not only has the average total energy consumption of individual enterprises decreased, but the number of high energy consuming and low energy consuming manufacturing enterprises has also increased, while energy consumption has remained stable or decreased. In 2023 alone, the comprehensive energy consumption of Hainan's large-scale manufacturing industry were 7987656 tons of standard coal, accounting for 63.2% of the total proportion, a decrease of 5.7% compared to the previous year. The electricity consumption in Hainan's manufacturing industry is relatively stable, Electricity Consumption was 847362 104kW·h, annual Growth was about 0.2% in 2023. Comparing the data of manufacturing enterprises above designated size in Hainan Province from 2014 to 2022, it is found that the number of manufacturing enterprises above designated size in Hainan Province has increased significantly, but the total energy consumption has remained relatively stable. In 2014, the average energy consumption of a single enterprise was 21931 tons of standard coal, and in 2022, the average energy consumption of a single enterprise was 14340 tons of standard coal, indicating a decrease in energy consumption in the manufacturing industry (Figure 4). Meanwhile, compared to the high energy consuming Petroleum from 2012 to 2022, Coal and Other Fuel Processing Industries is highest. The comprehensive energy consumption of large-scale manufacturing industries has slightly increased, but the energy consumption of emerging low-energy manufacturing enterprises has shown a clear downward trend.

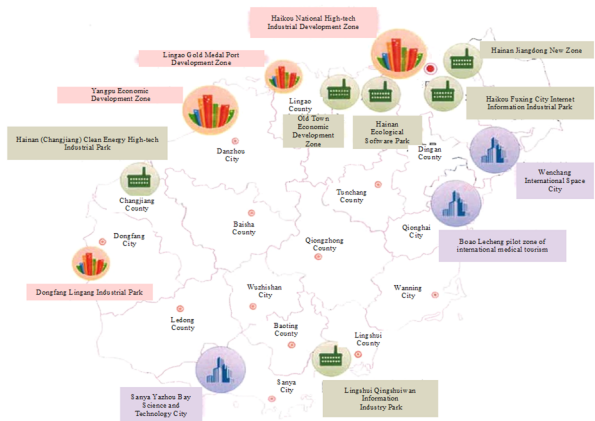


Figure 3. Spatial Layout of High tech Industries in Hainan Province (Source: The 14th-Five Year Plan for the Development of High-tech Industries in Hainan)

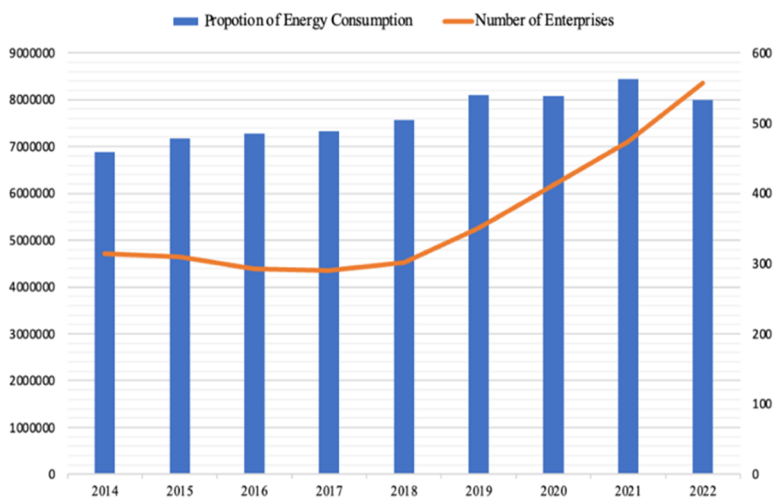


Figure 4. The Energy Consumption of Hainan manufacture in Industrial Enterprises above Designated Size (2014-2022) (Drawn by the author, data source: Hainan Statistical Yearbook)

5. Conclusions

With the continuous support of policies and the continuous improvement of market environment, the manufacturing industry in Hainan Province has shown a positive green trend in terms of scale, structure, and technological innovation. Therefore, this article also proposes three corresponding suggestions.

(1) Leverage the policy advantages of free trade ports to promote the green development of the manufacturing industry.

(2) Utilize digitization and intelligence to drive the green transformation of the manufacturing industry to a higher level of development.

(3) Actively adjust the energy consumption structure of the manufacturing industry.

In summary, the green transformation of Hainan's manufacturing industry is complex, involving the comprehensive application of various strategies. By adopting these strategies, Hainan can not only achieve green transformation of manufacturing industry and promote sustainable economic development, but also protect precious natural environment and leave a green landscape for future generations.

Acknowledgment

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