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Research on the upgrading strategy and eco-oriented development of industrial clusters based on low-carbon economy

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ABSTRACT

Industry clusters are important carriers of China's rapid economic development. In recent years, there have been problems in areas highly concentrated with industrial clusters, such as the shortage of energy and environmental deterioration. To break through the bottleneck of resources and environment, industrial clusters must be restructured and upgraded in an eco-oriented way. This paper has formulated a matrix of carbon emission and competitiveness to analyze the upgrading strategies of different industrial cluster types. In line with the findings, the paper further explores the mechanism of eco-industrial clusters, which has shown that the recycling of resources is the core of the cluster ecology, and innovation system provides condition for the eco-oriented development of industrial cluster. Finally, the paper analyzes the institutional supply and policy option in the construction of eco-industrial clusters.

KEYWORDS

Industrial cluster; Upgrading strategy; Eco-oriented development; Institution.

INTRODUCTION

Clusters are geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition[1]. After the 1980s, industrial clusters have been developed rapidly in China; however, in recent years, there have been issues such as the shortage of energy and environmental deterioration in areas highly concentrated with industrial clusters. To break through the bottleneck of resources and the environment and achieve sustainable development, industrial clusters must be ecologically restructured and upgraded.

Those issues of eco-industrial clusters have been studied by many scholars. With the goal of ecological and environmental protection, Matthias Ruth and Paolo Dell 'anno have formulated the industrial circular model of American glass industry via the recycling of material and energy[2]. Wallner H.P emphasizes that the organizations with the characteristics of regional clusters should be concerned about their impact on the surrounding environment in the pursuit of economic development, and further points out one of the ways to achieve sustainable development of the industry is to build eco-industrial clusters[3]. Frank Boons discusses the eco-industrial park economics and ecological performance, and analyzes the subject and the role of industrial ecosystem[4]. Chunyou WU and Di WU have proposed the development model for eco-industrial clusters by exploring the ecological connotation of industrial clusters[5]. Some other scholars have studied the ecological innovation of industrial clusters from the low-carbon perspective[6].

Albeit the insightfulness of these researches, further exploration is need with respect to the complex nature of eco-industrial clusters. The research route and goal of this paper are specified as the following: (1) the paper classifies the industrial clusters from the low-carbon perspective and discusses their upgrading strategies; (2) since the ultimate goal of industrial cluster development is to achieve the ecologicalization of industrial cluster, the paper discusses the upgrading path and policies for eco-industrial clusters, aimed at deepening the relevant theory and providing a reference for policy makers. As for the research method, this paper integrates the low-carbon economics theory, the ecological economics theory and the circular economy theory, and formulates a model to analyze the upgrading strategy and ecological transformation of industrial clusters. This paper is innovative in establishing a matrix of low carbonization and competitiveness for industrial clusters, analyzing the small and large circulatory system of eco-industrial cluster, and offering policy recommendations concerned with the reality of China’s industrial cluster development.

THE CLASSIFICATION OF INDUSTRIAL CLUSTERS AND THEIR UPGRADING STRATEGY BASED ON LOW CARBONIZATION

In a background that low-carbon economy has become the major trend, the upgrading goal of Chinese industrial clusters is not just to create new competitive advantages, but also to pay more attention to low carbonization and ecologicalization. Therefore, the classification of industrial clusters needs to be conducted in line with this dual goal.

The matrix established for the classification of industrial clusters consists of two parameters in judging cluster types, namely carbon emissions and competitiveness. The parameter of carbon emission is divided into high and low levels, and the parameter of competitiveness into strong and weak levels. Accordingly, there are four industrial clusters types that have different characteristics and require different strategies. Industrial cluster types are shown in Figure 1.

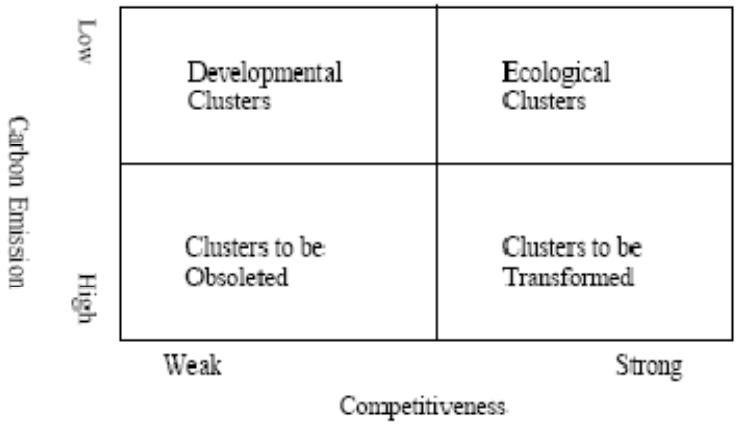

Figure 1 : Matrix of carbon emission and competitiveness for industrial clusters

Clusters to be obsoleted

The industrial clusters with high carbon emission and weak competitiveness are the targets to be obsoleted in the process of strategic transformation. The prospect of such clusters is dim, for they have to either withdraw from the current area to enter new industries, or to completely change the mode of production. The upgrading of industrial clusters is an ongoing process of eliminating backward production capacity and method that are typically of high energy consumption, heavy pollution, less productivity, and low efficiency. Apart from their low contribution to economic, the low-carbon transformation of these clusters is difficult and costly; therefore, they should be directly taken out of the way. In the process of industrial upgrading, this elimination approach produces an instant effect in curbing the growth rate of carbon emissions and pollutants; hence it is an indispensable step in industrial cluster upgrading and the strategic transformation of the relevant enterprises. Obviously, this approach of direct elimination will give rise to the formation of large sunk costs, but this is the necessary cost of economic adjustment. From the cluster level, the capital, labor and land resources slugged in backward production capacity can be re-configured to make room for the development of efficient industry; from the enterprise level, the strategic transformation and the elimination of backward production capacity can break the bonds that confine the production mode, which is helpful in propelling the early regeneration of the enterprises.

Clusters to be transformed

The industrial clusters with high carbon emission but weak competitiveness are the targets to be restructured in the process of strategic transformation, whose upgrading strategies are energy-saving oriented and aimed at reducing carbon emissions so as to finally transform into eco-clusters. One is to promote the utilization of energy-saving technologies to significantly reduce energy consumption, such as energy-efficient furnace technology, energy-saving technology in the buildings, large-scale integrated energy-saving technology, and energy-saving technology via monitoring, control, and diagnostics. The use of energy-saving technologies does not involve massive equipment upgrade; hence it is cost-efficient. The second one is to improve equipment and business process of the enterprise by replacing the inefficient equipment with energy-efficient type, replacing traditional equipment with advanced type, improving conversion rates and reducing energy consumption per unit of product, so as to achieve the energy efficiency and productivity gain on the basis of energy consumption reduction. The third one is to promote the use of clean energy and the recycling of emissions. Traditionally, the competitive advantages of industrial clusters in China come from the lower cost of products. Under the resource constraints, this kind of advantages is difficult to sustain in certain clusters. Therefore, the upgrading strategies of resource-dependent clusters need to take into account two aspects: one is the efficient use of energy and the minimized consumption of resources; the other is to raise the clusters into higher level of the value chain by upgrading product, technique and technology, or implementing strategic restructuring.

Developmental clusters

The industrial clusters with low carbon emission but weak competitiveness are classified as the developmental clusters whose upgrading strategy is to sharpen the competitive edge while maintaining low carbon emission. If they are in declining industries, however, it is necessary to implement the transformation strategy. There are a variety of upgrading routes to enhance the competitiveness. Firstly, the industrial chain and value chain need to extend to higher level with more value added, thereby enhancing competitiveness. Secondly, the innovative mechanisms to enhance the competitiveness of the cluster can be constructed through cooperation, including intra-enterprise cooperation, inter-enterprise cooperation and that with external partners or universities. Thirdly, we can optimize the organizational structure of the cluster by strengthening the division of labor, for instance, enterprises of different scales can achieve a reasonable division of labor in the production, so as to form a good collaborative relationship and improve the overall competitive advantage of the industrial clusters.

Ecological clusters

The industrial clusters with low carbon emission and strong competitiveness are classified as the ecological clusters. With both economic and ecological benefits, such a type is the developmental orientation of industrial clusters. With respect to this fact, the following section of the paper is devoted to illustrate their operating model.

THE OPERATING MODEL OF ECO-INDUSTRIAL CLUSTERS

Eco-industrial clusters are industrial clusters with low energy consumption, low emissions, but competitive advantages. Their development model is to achieve the recycling of resources and the establishment of eco-system within the clusters. The main goal of such a model is the pursuit of comprehensive benefits that integrates the economic, ecological and social benefits. Their core competitive advantages come from green products and services. Eco-industrial cluster is a complex system that can be subdivided into the circulatory system and innovation system, which is shown in Figure 2.

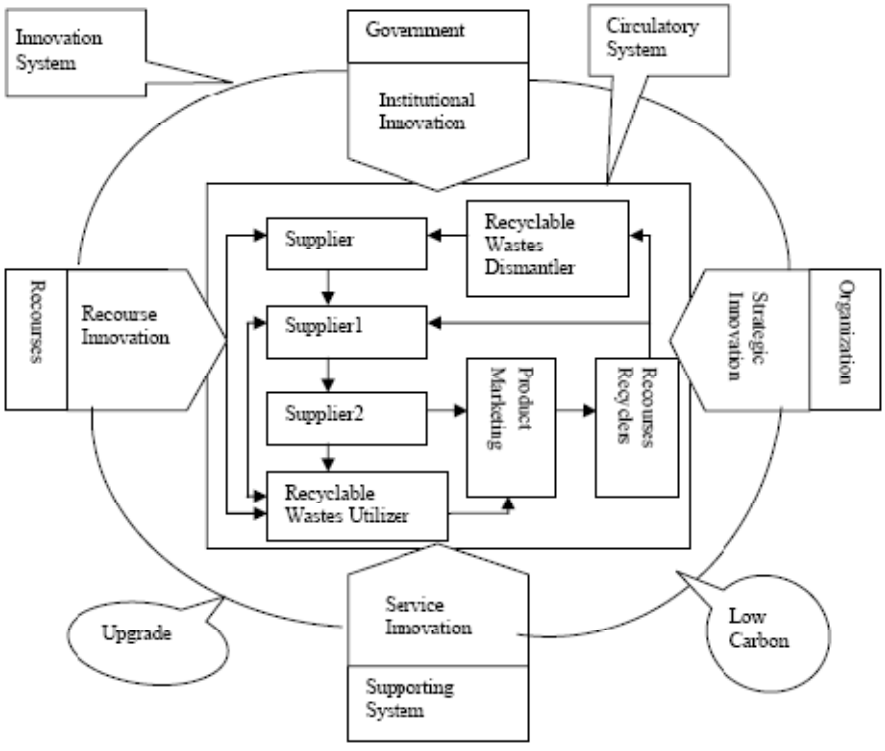

Figure 2 : The operating model of eco-industrial clusters

Circulatory system

Small circulatory system

The establishment of circular economy system is an important way to reduce emissions and pollution, whose operation is specifically realized in the circulatory industrial park. The resource utilization and material recycling are improved by combining the intra-enterprise cleaner production and inter-enterprise waste exchange within the industrial park, so that the wastes generated are minimized to maximize economic and environmental benefits[7]. Inside the park or cluster, the core value chain mainly consists of the supply of raw materials, intermediate products, final products, product sales, which is in linear order and fails to constitute a material recycling chain, resulting in wastes and exhaust emissions.

To achieve material recycling, the key is to establish or bring in companies and organizations that utilize wastes or exhaust gas in the park. These enterprises can be classified into two types. One consists of the companies that use wastes or emissions as raw material or power to produce new products. To illustrate this point, we can take coking enterprises as example. Their by-products mainly include tar, crude benzene, sulfur, ammonium sulfate, and gas, which can be produced by lengthening the chain of coking enterprises or by specialized production enterprises. Part of the by-products accesses to external markets in the form of final product, the rest of them are used in the park as the raw materials and intermediate goods. The other one consists of enterprises that make sewage and waste gas clean and utilizable via further processing so as to make them circulate in the park again and even access to external markets. Because the main products and some derivatives need to finally access to markets outside the cluster, this circulatory system is regarded as small or incomplete circulatory system.

Large circulatory system

The complete ecosystems are the much greater circulatory system. The products will finally become scrapped after bought and used by consumers, which then re-enter the clusters through recourses recyclers, recyclable wastes dismantlers and suppliers. Accordingly, a complete processing cycle is formed not only through one cluster, but a number of interdependent and convergent industrial clusters. The recycling of iron, steel, nonferrous metals, paper and other wastes has reached a considerable scale in China; meanwhile, some relevant sections of industry chain are relatively weak, such as scrapped product recycling, dismantling, reprocessing, which are the crucial nodes in the forming of large circulatory system. Therefore, to achieve the goal of build large circulatory system, those sections of industrial chain need to develop into a number of clusters themselves that are compatible with each other and operated interdependently. The small and large circulatory systems are inseparable, only in this way the material and energy can be recycled and utilized at multi-level. For example, there is a non-ferrous metal industrial cluster in Dazhou of Changge in Henan Province that reprocesses metallic scraps to make them reusable. The cluster has a yearly capacity of reprocessing metallic scraps about 2 million tons, and producing reusable metal 1.6 million tons; thus it constitute the key link in the large circulatory system of non-ferrous metals. This centralized processing has obvious economic advantages over decentralized processing, but the cluster itself still has ecological problems. In accordance with the goal of maximizing resource consumption while minimizing pollution, the local government has transformed the cluster into circular economy industrial park within which the new recycling model is constructed for the processing of waste gas, waste water, and industrial residue; hence a small circulatory system is built within the key node of the large one.

Innovation system

Innovative system is at the top of industrial ecology restructuring, which can either indirectly affect industrial system through innovation support system or directly act on the core of the industrial chain. Based on innovation system, the ecological restructuring of industrial clusters is a restructuring not only of the material production process, but also of the ways of creating and adding value[8].

Resource innovation

Industrial cluster resources include physical resources, human resources, financial resources and knowledge resources. In the construction of eco-industrial clusters, there are many activities of resources innovation and application innovation involved. Material resources are the basis for innovation, including the production and use of low-carbon materials, equipment, clean energy, and the improvement of low-carbon infrastructure. Human resources and knowledge resources are the core elements. Through R & D investment and human resource development, technological innovation can be achieved to reform the existing industries with low-carbon technology. In addition, the rational allocation of resources for innovation in different sectors can ensure continued innovation and the effectiveness of innovation activities.

Supporting system and service innovation

Industrial cluster support system or service system is an integrated system, which includes technical service platform, financing guarantee platform, information service platform, and marketing platform. The construction of eco-industrial clusters needs to solve two key problems. One is the construction of diversified information service system which plays an essential role to promote the comprehensive utilization of industrial cluster information whereby using technological innovation to speed up industrial upgrading and build industrial ecology cycle. Second is the innovation of financial instruments to accelerate the low-carbon transformation of clusters by strengthening credit support for energy-saving projects, implementing carbon credits, and establishing low-carbon fund system for carbon neutral, etc.

Organizational and strategic innovation

Most of traditional industry clusters are typically developed with heavy investments and at the cost of high consumptions and emissions, resulting in huge waste of resources and serious pollution to the environment. Consequently, their competitive advantages are of great difficulty to sustain. The organization of industrial cluster is in the process of evolvement; hence to achieve sustainable and eco-oriented development, the strategic innovation is necessary to achieve intensive mode of economic growth instead of extensive mode. The enterprises in the clusters must find their way to restructure at the level of strategic objectives, the mode of business operation, production, technology utilization, in order to lay the foundation for the construction of eco-industrial cluster.

Government and institutional innovation

Government plays a vital role in in the construction of eco-industrial cluster, with respect to institutional supply and the creation of favorable environment for innovation.

INSTITUTION AND GOVERNMENT

The construction of eco-industrial clusters needs the corresponding institutional insurance including legal system, economic incentives and compensation system in accordance with the management and coordination from the government. The institutional system of eco-industrial cluster is shown in Figure 3.

Law and policy

The construction of ecological industrial clusters needs to improve the relevant legal system, legally clarify the responsibilities and obligations of each enterprise, thus forming a strong constraint on their behavior. One is to integrate the constraint function of the legal system and the incentive function of the market mechanism. Except for optimizing the regulations for existing resources consumption, cleaner production, pollution control and ecological protection, we need to clarify the property rights regimes, implement carbon trading, improve property rights transfer system and technical property ownership system for low-carbon technologies. The second is to establish and strictly implement the

low-carbon standard over the whole range of industrial chain related to eco-industrial clusters, covering the sectors of research and design, raw materials supply and production, packaging, transportation, selling and after-sales service. The establishment of standards is an important part of the legal system construction. The third is to strengthen the legal constraint on the environmental behavior of the enterprises. Not infrequently, due to the external costs cannot be internalized, the innovation and application of low-carbon technology is lack of intrinsic motivation. Especially for the elimination of backward production capacity, which is not exactly an intra-enterprise problem, if there is no adequate government regulations and other external pressures, enterprises tend to be reluctant in taking actions. The severer the environmental pollution penalties for enterprises, the higher the probability they take measures to control pollution[9]. Therefore, the establishment of regulations should integrate the incentive measures and penalties. In addition, the government, especially at the local level, should make eco-industrial policy; the establishment of ecological environment supervision laws and regulations for local industrial clusters can accelerate the pace of their transformation into eco-industrial clusters.

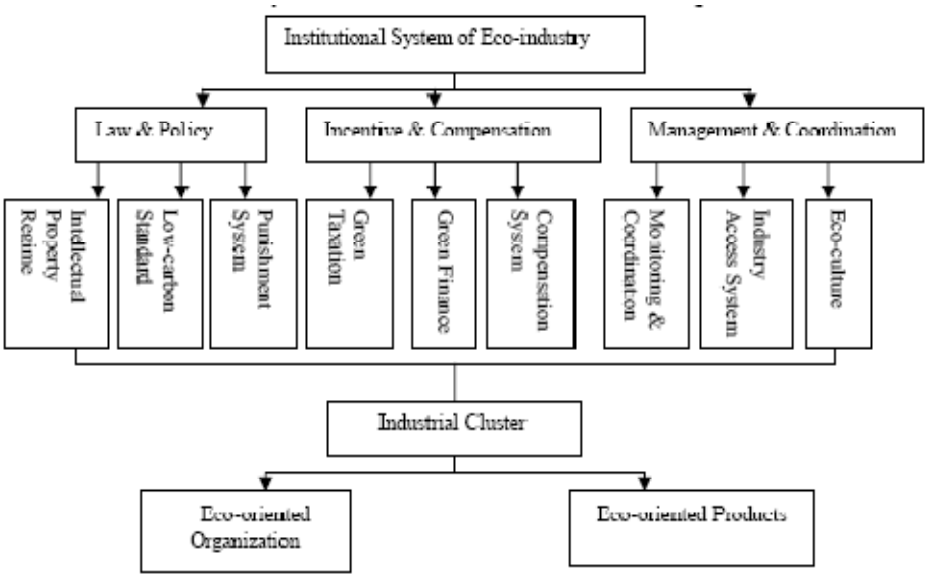

Figure 3 : Institutional system model of eco-industrial cluster

Incentives and compensations

Incentives constitute an important factor for both institutional improvement and regional innovation system. Firstly, the government should increase the supply of facilities for eco-supporting public service, especially the establishment of offline or online trading platforms for the utilization of waste material. The construction of ecological information network system is also of great importance to save enterprise cost, which includes environmental information database, technical information database, information database about enterprise wastes, wastes processing and exchanging platforms, consulting and service platform.

Secondly, green taxation policy has leverage effect for the eco-oriented development of industrial clusters through financial discount, pre-tax repayment, and technological innovation funding. Meanwhile, the rate and scope of resource tax should be increased, especially for resources such as water, land, forest, and mineral. New environmental taxes need to be introduced, such as taxes on atmospheric pollution, water pollution, pollution sources, noise, and eco-compensation[10].

Thirdly, we need to establish green credit policy and green financing policy to guide more credit funds and social capital flowing to energy saving enterprises and clusters.

Fourthly, we need to establish ecological compensation fund system and green procurement system. The enterprises or clusters that specialized in processing waste or scrapped products can receive ecological subsidies. The government shall give priority to purchase products with a green logo thus

encouraging clean production. For the implementation of these incentives and compensation mechanisms, an effective contract management system is required; therefore, the enterprises can obtain relevant profits and subsidies only under the condition that they highly cooperate with industry cluster management committee.

Management and coordination

Firstly, it is needed to improve the green management system and strengthen environmental supervision. Government can strengthen the monitoring and evaluation of circulatory system within the enterprises or clusters by using environmental management tools, such as cleaner production audit, environmental management system, the ecological design of the products, life cycle assessment. While strengthening the planning guidance function and management function of the government, we need to make more effort to improve government services, streamline planning and management system, simplify the administrative examination and approval system. The government should integrate resources, innovate supportive means, and organically combines eco-oriented industrial upgrading with the restructuring and reorganization of enterprises, so as to enhance the vitality and competitiveness of enterprises.

Secondly, it is needed to select low-carbon technologies scientifically. The key link between the current and future development of industrial cluster is the low-carbon technology selected under the guidance of government. In accordance with the principal of maximizing the co-development between low carbonization and enterprise benefits, those low-carbon technologies with higher maturity should be the primary options, with the leading enterprises as explorers in finding the way to maximally streamline the whole range of industry chain by virtue of using new technology, so as to form a network of plate-type industrial clusters[11].

Thirdly, the government needs to establish industry access system in the construction of eco-industrial cluster, which filters the forbidden projects and industries and gives priority to the waste recycling enterprises and those with high eco-industrial relevance, good growth prospect, low pollution, and low energy consumption.

Fourth, environmental management should combine the governance both from the government and non-government organizations to form a diversified but integrated network[12]. The cooperation between enterprises, universities, research institutes, financial intermediaries, and industry associations constitutes the vital link in achieving ecological technology innovation and organizational innovation. The difficulty, however, lies in coordinated action where the government is required to play the role of coordination and promotion.

Fifthly, it is needed to construct an ecological culture, which is an informal system and has a special role in the construction of eco-industrial clusters. The functions of ecological culture are speechified as the following. It helps to deepen the environmental protection awareness of enterprises and enhance their social responsibility, so as to meet the purpose of regulating their production and business activities. It can promote green consumption and increase public awareness of environmental protection, and enhance the public sense of participation in the construction of eco-industrial cluster thus playing a supervisory role in society. Ecological culture needs to be jointly promoted by the government, intermediary agencies and mass media.

CONCLUSIONS

In the context of low-carbon economy, industrial clusters can be divided into four categories: clusters to be obsoleted, clusters to be transformed, developmental clusters and ecological clusters. Eco-industrial clusters are industrial clusters with low energy consumption, pollution, and emissions; hence they have competitive advantages over the traditional industrial cluster. Their development model is the realization of resources recycling and the creation of ecosystem within industrial clusters. The construction of eco-industrial clusters needs the establishment of the circulatory system and innovation

system, and the institutional insurance of which the government plays an important role by virtue of the institutional supply.

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