都市生态工业园区循环经济发展研究

Research on Circular Economy Development of Urban Eco-industrial Parks

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摘 要

生态失调、环境污染和资源枯竭已成为困扰世界和中国的主要问题之一。据相关机构预测：全球每年损失大约 1300 万公顷的森林覆盖，每年有 600 万公顷土地沙漠化，煤、石油和天然气分别仅可供使用约 147、44 和 63 年。目前世界环境承载已不堪重负，而我国也面临环境与生态方面的巨大挑战。传统经济模式和末端治理模式已不适合经济社会发展的要求，创新发展理念，实现可持续发展已成为社会可持续发展的必然。而都市生态工业园区作为一种新型的工业生产方式，对其进行探索和研究对于实现经济、社会的可持续发展有着重大的理论及实践意义。

所谓都市工业，是指“适应城市发展要求，充分利用城市的生产要素，能满足城市消费需求和特定市场需求，低污染、低能耗，技术、信息、劳动密集型，与城市环境相协调的制造业”。与传统工业园区相比，都市工业的发展优势体现在：地理位置基本处于中心城区或相对密集的居民聚居区，可以充分利用都市的市场、信息等资源，辐射效应明显；经济效益明显，产值贡献率高。入驻都市工业园区的行业是能够与城市功能和生态环境相协调的工业；园区企业以中小型民营经济为主，自主经营，灵活性与竞争力都很强。

都市生态工业园区是在生态工业园的理论和实践基础上构建的，是针对都市的特定发展要求和定位而形成的一种新型工业园区。它的理论背景，也就是生态工业园的建立机制，是可持续发展理论，工业生态学理论和循环经济理论。

基于以上背景，本研究结合国际国内背景，指出都市生态工业园的基本特点、发展优势、国内外都市生态工业园区的具体实践，从而对都市生态工业园的循环经济发展做出规划，其主要规划内容和相关结论如下：

第一，本文在对生态工业园的相关理论梳理基础上，归纳总结出了国内外都市生态工业园区的特点。

第二，本文基于国内外生态工业园的发展现状，对都市生态工业园的循环经济发展做出产业规划。对都市工业园区所做的产业规划是整个研究的重点之所在。

第三，本文对都市生态工业园区的建设，支持系统和生态管理三个方面进行了整体规划，这是文章的重点之一和创新点所在。

最后，总结都市生态工业园区的发展并展望未来的发展前景。

关键词：都市工业;生态工业园；循环经济；产业规划

Abstract:

One of the key problems that perplex China and the whole world is ecological disturbance, environmental pollution and resources exhaustion. According to the prediction of related organizations, there are about 13million hectare forest coverage lost each year in the world, and 6 million hectare earth desertification each year, and the storage of coal, oil and gas will only be used for about 147 years, 44 years and 63 years respectively. At present, the capacity of the global environment can not bear the heavy burden, while China also is faced with great challenges in environment and ecology. Traditional economic mode and end-of-pipe control mode can not meet the demand of socio-economic development; therefore there is a necessity for the social sustainable development to innovate developmental mode in order to achieve sustainable development. Urban eco-industrial parks, as a new type industrial mode of production, will do great help to realize sustainable development in economy and society, and meanwhile, there will be great theoretical and practical significance of probing and researching on urban industrial parks.

The so-called urban industry refers to "meeting the demands of urban development, making full use of the city's factors of production, meeting the urban consumer demand and specific market demand, featured by low pollution, low energy consumption, intensified with technology, information and labor, the manufacturing industry in harmony with urban environment ". Compared with traditional industrial parks, the advantages of developing urban industry are: the location of it is mainly in the central city or relatively dense residential districts, which can make full use of the urban market and information resources, and the irradiation effects is strong; there is remarkable economic benefits, high rate of production value contribution. The industries entering the urban industrial parks can well coordinate with the urban function and ecological environment; the enterprises in the industrial parks are mainly middle and small-sized private economy, which has independent management, strong flexibility and competitive strength.

Urban eco-industrial Park is built on the basis of ecological industrial park theories and practices, which is a new type of industrial park formed by catering specific urban developing demand and urban position. The theoretical background, or the setting mechanisms of urban eco-industrial park, is sustainable development theory, industrial ecology theory and circular economy theory.

Based on the above background, this study is to point out the basic characteristics, the developing advantages, and practices at home and abroad of urban eco-industrial park, so as to make a master plan on circular economy development of the urban eco-industrial parks. The major planning contents and related conclusions are in the following:

Firstly, this paper comes to summarize the characteristics of circular economy development of the urban eco-industrial parks in China and foreign countries, based on reviewing the related theories about eco-industrial parks.

Secondly, this paper is to make an industrial planning of the circular economy development of the urban eco-industrial parks, based on the current development situation of the circular economy development of the urban eco-industrial parks in China and foreign countries. The industrial planning of the urban eco-industrial parks is the key part in the whole study.

Thirdly, the paper is to make a master plan on the construction, supporting system and ecological management of urban eco-industrial parks, which is also the innovative part and one of

the focuses of the study.

Lastly, this paper will give a summary of the development of urban eco-industrial parks and then look forward to the future prosperous development of it.

Key words: urban industry; eco-industrial parks; circular economy; industrial planning

CHAPTER 1 Introduction

On August 29, 2008, the Standing Committee of the National People's Congress (NPC) voted to pass the law on promotion of recycling economy, which took effect on Jan 1, 2009, marking that China has taken a key step in the road of sustainable development.

At present, China is in the deepening stage of developing industrialization. There is a need to innovate the industrial production model guided by scientific concept of development, to transform the pattern of economic growth and achieve sustainable development coordinated with economy and environment. As an ecological industrial mode, superior to the end-of-life control and clean production, eco-industrial park[1] can be regarded as the combination of preventing industrial pollution strategies and resources multi-purpose unitization strategies to some extent. While, urban eco-industrial parks, as an important component part of eco-industrial parks, can be regarded as the third stage after the previous stage of end-of-life control and clean production. The construction and development of urban eco-industrial parks is one key way to realize low-carbon economy.

1.1 International background

One of the key problems that perplex China and the whole world is ecological disturbance, environmental pollution and resources exhaustion. At present, there are about 13million hectare forest coverage lost each year in the world, and 6 million hectare earth desertification each year[1] . By the end of 2006, the total remaining explored reserves of coal was 909.1 billion tons. According to the current production level, the coal can only be available for 147 years. [2] At the same time, data shows that all kinds of metal resources in the world and some types of energy will be in depletion within a certain period of time in the future.

In the recent hundred years, the global emission of CO_2 has been increasing(see Figure:1-1), and the average temperature keeps rising(see Figure 1-2). The global warming has become a severe problem nowadays.

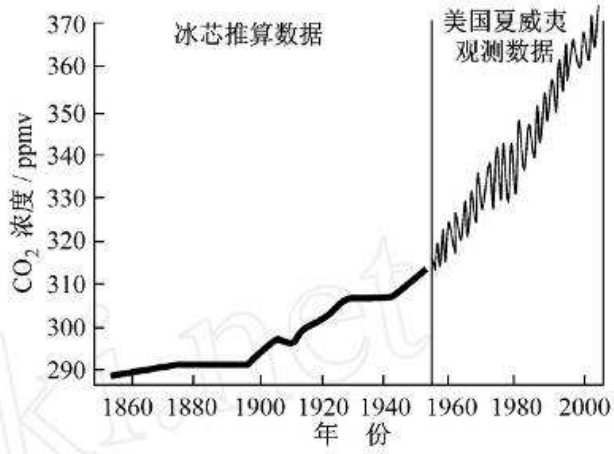

图 1-1 the changing CO_2 concentration in the atmosphere in the recent 150 years [2]

[1] Yang Yong, Commentary of eco-industrial park , economic geography, vol,20,no.4, July, 2000.
[2]联合国政府间气候变化专门委员会（IPCC）. 关于气候变化的第 4 次评估报告[R], 2007.

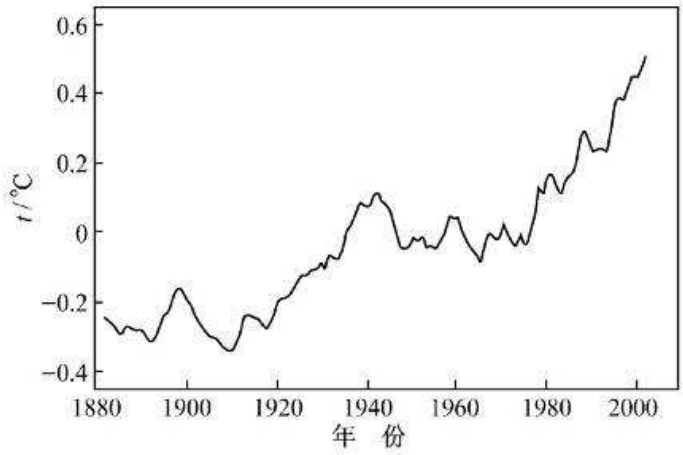

图 1-2 the changing of global average temperature in the recent 100years [3]

1.2 National background

To China, on one hand, the monumental achievements since open and reforming attracted the world's exclamation. On the other hand, extensive pattern of economic growth also makes China's environmental ecological problems worsening. In recent years, not only the amount of various kinds of pollutants emissions is huge, but also the emissions such as waste gas and waste water are in the trend of rapid growth, see Figure1-3 and Figure 1-4.

单位：万吨 (10000 tons)

指 标	Item	2001	2002	2003	2004	2005	2006
工业固体废弃物产生量	Industrial Solid Wastes Generated	88840	94509	100428	120030	134449	151541
#危险废物	Hazardous Wastes	952	1001	1170	995	1162	1084
工业固体废弃物排放量	Industrial Solid Wastes Discharged	2893.8	2635.2	1940.9	1762.0	1654.7	1302.1
#危险废物(吨)	Hazardous Wastes (ton)	20596	16972	2798	11470	5967	
工业固体废弃物综合利用量	Industrial Solid Wastes Utilized	47290	50061	56040	67796	76993	92601
#危险废物	Hazardous Wastes	442	391	427	403	496	566
工业固体废弃物贮存量	Stock of Industrial Solid Wastes	30183	30040	27667	26012	27876	22399
#危险废物	Hazardous Wastes	307.1	382.8	423.0	343.3	337.3	266.8
工业固体废弃物处置量	Industrial Solid Wastes Disposed	14491	16618	17751	26635	31259	42883

[3]Hansen J, Sato M, Ruedy R, et al. Global temperature Change[J]. PNAS, 2006, 103: 14288-14293.

#危险废物	Hazardous Wastes	229.0	242.2	375.4	275.2	339.0	289.3
工业固体废弃物综合利用率 (%)	Ratio of Utilized Industrial Solid Wastes (%)	52.1	52.0	54.8	55.7	56.1	60.2
“三废”综合利用产品产值 (亿元)	Output Value of Products Made from Waste Gas, Waste Water & Solid Wastes (100 million yuan)	344.6	385.6	441.0	573.3	755.5	1026.8

Figure:1-3 2001-2006 Industrial Solid Wastes generation and disposition （www.chinagate.com.cn）

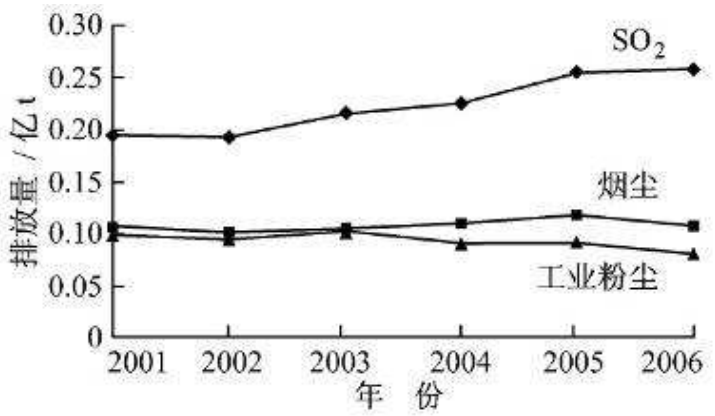

图 1-4 main waste gas disposition in China[4]

According to the 2008 Shanghai environmental bulletin published by Shanghai Environmental protection Bureau[5], the acid rain frequency in Shanghai is 75.6% in 2007, and the acid rain pollution is increasing year by year. The indicators of PM10 decreased slightly year on year. In recent years, the indicators of sulfur dioxide, nitrogen dioxide remain at the average standard, without great change; however, the integrated environmental quality is in the trend of declining.

Since Shanghai has put more and more emphasis on industrial environmental protection, part of the industrial pollutants has been successfully controlled or reduced. However, compared with the advanced international standard, the industrial environmental protection in Shanghai still has a great gap, no matter in the aspect of technology or in the supervision and social concern about it.

In the 1990s, the Shanghai industrial development was featured with strong characteristics of rapid industrialization period, high rapid of economic growth accompanied with high energy consumption and severe pollution. In comparison, although most European countries do not had rapid industrial growth, the connotation of their industrial growth has changed a lot, with most energy consumption and pollution declining, i.e., the industrial development of the European developed countries is in promoting environmental improvement, which has realized the competitive mutations in the 1990s. Shanghai’s industry development has created a miracle in ten years, but the pollutants and energy consumption is not out of control, indicating that Shanghai industrial environment protection level is improving. But it should be realized that Shanghai industrial development is, in a certain extent, at the expense of the environment, and there is still a certain distance from symbiotic relationship with environment harmoniously[6].

At present, Shanghai's industrial structure is undertaking strategic adjustment, with the

[4]中华人民共和国国家统计局. 中国统计年鉴(2001-2007) [M]. 北京: 中国统计出版社, 2001-2007.
[5] http://www.sepb.gov.cn/seicm/editor/filemanager/file/2008bulletin/cont.html

overall industrial structure in the transforming stage from "second industry, third industry and first industry" structure to "third industry, second industry and first industry" [7]structural , and now it has formed a new pattern promoted by second and third industry. With the successful host of 2010 EXPO, during the same time of industrial structure adjustment, Shanghai gave a positive response to the national policies, adopting the principle of clean production and energy conservation and reducing energy consumption, and vigorously implementing the development of circular economy, constructing eco-industrial parks and formulating many policies to offer a clear direction of Shanghai's industrial development in the future.

1.3 the research methods and significance

Nowadays, environmental capacity in Shanghai, China and even the whole world is overloaded. Traditional economic pattern and end-of-life control mode is not suitable for economic and social development. There is a necessity in innovating development mode and achieving sustainable development for the social sustainable development.

This research on urban eco-industrial parks adopts many methods. Combining the normal method of reviewing the theoretical background of urban industrial park with the unique way of comparing the practices of urban eco-industrial park in China and foreign countries, this research come to a conclusion of the characteristics and advantages in developing urban eco-industrial park in China urban area. This research also pays attention to doing specific case study, giving some examples of the concrete planning of typical urban industrial parks.

Eco-industrial Park is regarded as a new type of industrial production mode, and the study on it, especially on the urban eco-industrial park, has not only theoretical significance, but also very strong practical significance.

(1) Eco-industrial park and urban eco-industrial park is a necessity to achieve the harmonious development between human and nature. And also it is an important way to accomplish the objectives of building up a harmonious society guided by the scientific development concept.

(2) There is great theoretical significance of studying the urban eco-industrial park. In theory, urban eco-industrial park is rich in the connotation of eco-economy; therefore, doing research on the urban eco-industrial parks can promote the construction and development of ecological economic subjects. As an independent subject, ecological economics still need to be completed, compared with other subjects.

(3) Urban eco-industrial parks can be an important carrier to achieve circular economy. The study on it and the probing into its industrial planning have great realistic significance.

[6] http://www.gov.cn/test/2008-02/18/content_892073.htm
[7] http://news.xinhuanet.com/politics/2005-10/18/content_3640318.htm

CHAPTER 2 Theories and Practice of Eco-industrial Park

2.1 Main theories of Eco-industrial Park

2.1.1 Theory of Sustainable development

"Sustainable development"[8]， as a term, was firstly put forward on “Our Common Future” by the World Commission on Environment and Development in 1987, and has been widely used in all field of work. The current interpretation and understanding of the concept of sustainable development are rich in variety. The most popular interpretation was originally proposed in the Brundtland Report, namely, "Sustainable development is the development that not only meets the needs of contemporary people, but also doesn’t endanger the ability of future generations to meet their needs” [1]. This is a correct concept of development, which changed the long-exist view of the world in people's minds that resources and environment can serve timelessly. And this is a significant progress in human "environmental philosophy"[2] .

Sustainable development is formed and developed in recent 20 years with the serious ecological resource crisis and the development of environmental science. As to the notion of sustainable development, we can understand it from the following aspects [3]:

(l) economic development. Economic development is the foundation of sustainable development. The ultimate purpose of human development is to improve the spiritual and material life of mankind, and economy is one of the most fundamental factors. According to long-term development experience, absence of economic development can not be called development. What’s worse, it will also bring further destruction to the environment, and it is rather unfavorable for the progress of society.

(2) sustainability. Many natural resources are limited, but mankind has continued to live and have offspring in the earth. The core essence of sustainable development is to demand the human economic and social development not exceeding the capacity of environment and resources. Only if the natural system supporting the life on the earth is not destroyed, the development could be sustained permanently.

(3) compatibility. Sustainable development is to giant system evolution, also is

the economic support system, the social development system and natural interaction between the three systems based system should interact and develop coordinately, to come to the unification of economic efficiency, social benefits and ecological and environmental benefits (as shown in Figure 2-1).

[8] Our common future, 1987(4).

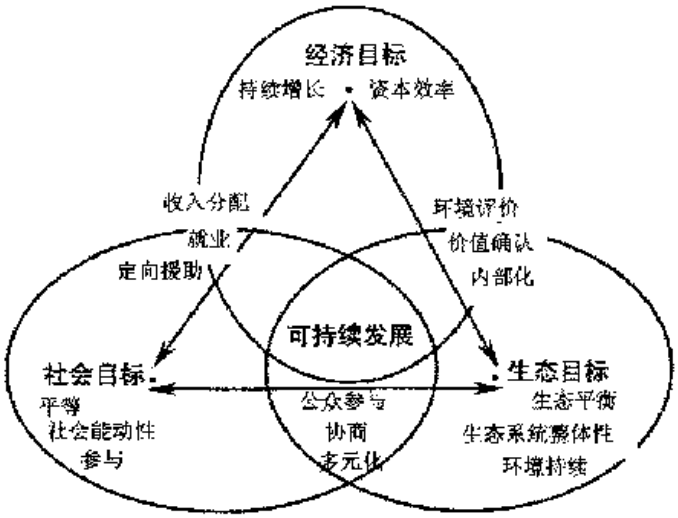

图 2-1 THREE GOALS OF SUSTAINABLE DEVELOPMENT AND ITS INTER RELATIONS [4]

After the careful analysis of the reality of human development and the overall understanding of the laws of human development, any country around the world，without exception，if it planed to implement sustainable development strategies, , must go through three basic steps to achieve three basic goals, which is theoretically called the three "non-symmetry of zero growth".[5] The consensus is extracted from the kernel of the sustainable development.

The first step: achieving the "zero growth" of the amount and size of population and size (natural growth rate), meanwhile greatly improving quality of the population in the corresponding direction;

Second step: achieving the "zero growth" of the consumption rate of material and energy, meanwhile greatly increasing social wealth in the corresponding direction;

Third step: achieving the "zero growth" of the deterioration rate of ecology and environment, meanwhile greatly enhancing the ecological quality and ecological security in the corresponding direction.

2.1.2 Theory of industrial ecology

The eco-industrial park construction is essentially to get the combination, links, and complement between industries, according to the resources advantages, industry advantages and industry structures in some certain areas, to make it form the interrelated and interactive industrial ecology chain or ecological net. And this must be achieved under the guidance of the theory of industrial ecology. [6]

In September 1989, Professor Robert Frosch and Nicolas Gallopoulos of Harvard University published an article in Scientific American magazine titled "the strategy of sustainable industrial development, and put forward the concept of" industrial ecology "[7] for the first time. In the article, the two authors pointed out we can set up the industrial ecological system imitating natural ecological system, by using an integrated mode of production to replace the traditional simplified mode of production, to reduce or eliminate the impact of industrial activities on environment. From this we can see that this industrial ecosystem is based on the theory of ecology, to study on the whole process of industrial production and do research on the relationship between

industrial activities and ecological environment in order to "work out the principles and methods of adjusting the current structure of the ecological chain, establish new substances closed-loop, and set up the ecological system combining natural ecological chain and artificial ecological chain[8]. The purpose is to alleviate the bad impact of human industrial activities on the natural environment, and to develop sustainable industry and economy.

In the theory of industrial ecology, ideal industrial ecological system should be in the following, see Figure 2-2.

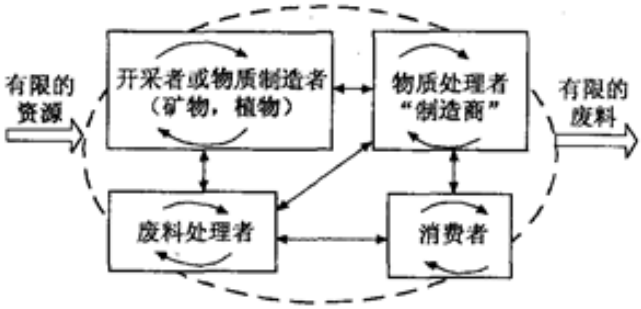

Figure 2-2 ideal industrial ecological system [8]

In the concept of industrial ecology, any industrial activity, any different industrial categories, various materials and energy are interact with each other to form a complete global industrial ecosystem. The ideal of industrial eco-system should be able to run in a full circle, "zero pollution", "zero emissions." In this state, there is no absolute waste， the waste in one department might be the resource to another department. Thus, industrial ecology is considered to be the most effective theoretical tool to coordinate the relationships between economic, social, environmental and other systems. The Eco-Industrial Park is the practical application of this theoretical tool.

2.1.3 Theory of circular economy

Compared with the ecology industry, circular economy brings environmental protection into economic operation mechanism from the width and height of national economy.

Circular economy [9] is a kind of economic form compared with the traditional economy, is to solve, and it is being put forth to solve the contradiction between economic development and environmental protection[10] ， which offers strategic theoretical paradigm to the transformation from traditional economy to sustainable development since the industrialization.

"The Circular Economy" is the abbreviation of Closing Materials Cycle economy and Resources Circulate economy, aimed at the high efficient use and recycling of resources, with the principle of "reduce, reuse and recycling”, and characterized by the closing materials cycle and energy use by echelon. And it is an economic mode according to the pattern of material cycling and energy flowing in the natural ecological system. Circular economy demands people voluntarily obeying and applying ecological laws in human society and economic life, to achieve low emission or even zero emission of pollutants and “win-win” of economic development and environmental protection by the means of high energy efficiency and cycling use [11].

Circular economy combines clean production with comprehensive utilization of waste [12]. It requires every industrial department coordinating well in the economic system, using the waste in a department to as the raw material in another department, to achieve "low exploration, high-use, low emissions" and thus form a society of "best production, the optimal consumption and minimum waste". In short, the logistics model of circular economy can be considered as the feedback processes of "resources - production - circulating - consumption - renewable resources", and the operating mode is "resources - products - renewable resources" (see Figure 2-3) [13] .。

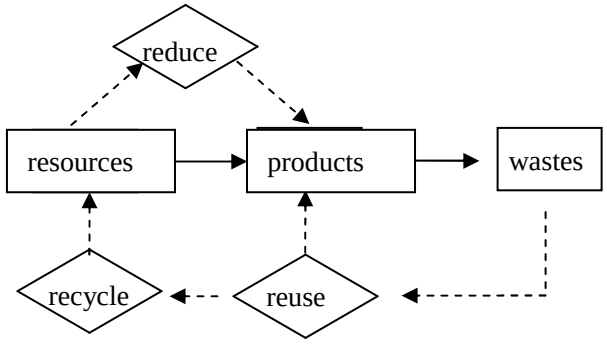

Figure 2-3 logistics model of circular economy

2.2 Practice of industrial park in China and foreign countries

Developed countries began to explore and implement the building of eco-industrial parks from 1990s. The first eco-industrial park was the Kalundborg symbiosis system in Denmark, which is still widely cited as an example. Since 1993, eco-industrial park blossom everywhere in the United States, U.S. President Commission on Sustainable Development also set up an "eco-industrial park special task force." By the end of the first half year of 2001, there are at least 40 communities build up eco-industrial park projects in the US. In addition to the U.S.A, other places, such as Asia, Europe, South America, Australia, South Africa and Namibia and so on have also established a number of eco-industrial parks, and there are at least 60 eco-industrial parks, according to preliminary statistics [14]. In these eco-industrial parks, a number of enterprises or the different sub-companies within one enterprise group gathered in a certain area, based on eco-industrial principles and imitating the structure of natural ecosystems. They take full advantage of different industries, projects or processes, and the relations of transverse coupling, longitudinal closing cycling, top-down convergence and collaborative symbiosis among resources, the main by-products or waste. Then they set up a industrial chain network structure with the multi-usage of materials and energy, fine recycling with high efficiency in transforming and win-win in both economic benefits and ecological benefits, by adopting the modern high industrial technology, information technology and economic measures horizontal coupling, vertical closed, the upper and lower convergence, collaboration symbiotic relationship, the use of modern technology, information, and economic measures to optimize configuration, so as to achieve the sustainable development. The typical mode is shown in figure 2-4 showing. [15]

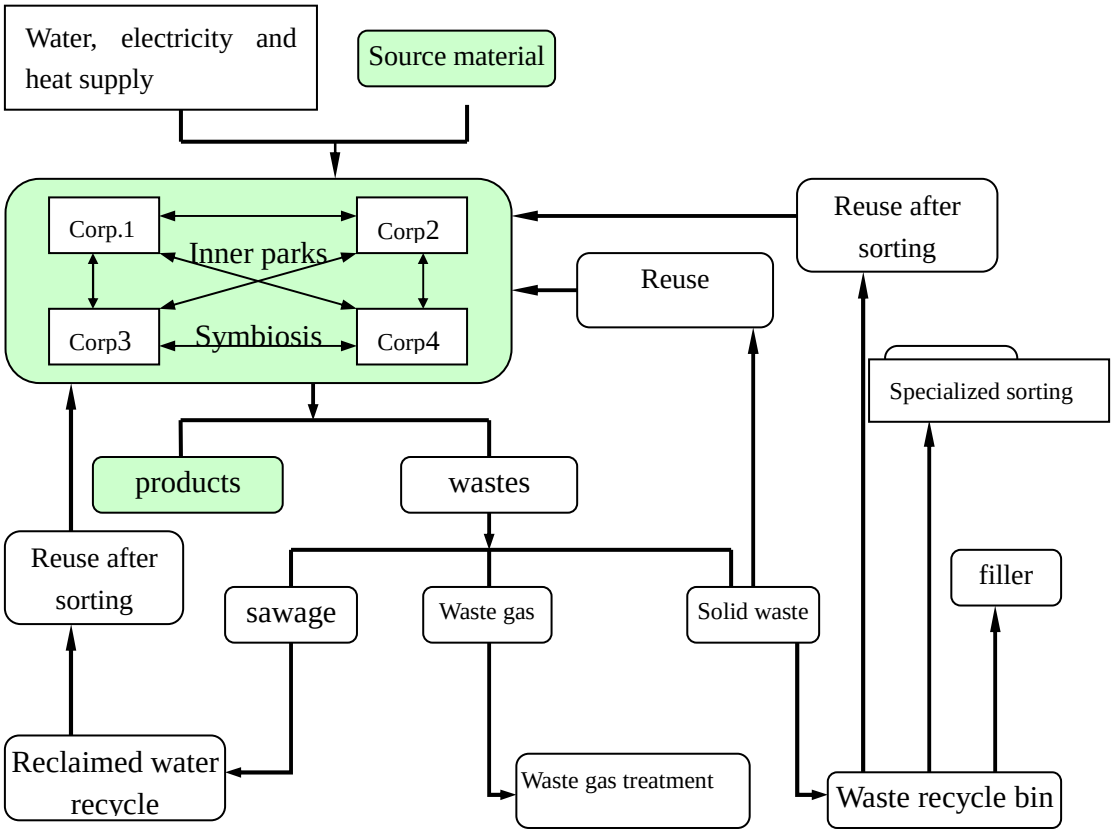

Figure 2-4: typical structure of eco-industrial parks

Eco- industrial park can be divided into three types [14] :

(1) the transformed-type park, which is formed by upgrading and reforming it through suitable technology, or by introducing new industries, projects, technological processes and so on, based on the principle of ecological industry theory. After some adaptation, this type of industrial parks can win in all the three parts, i.e., the economic, social and ecological environmental benefits.

(2) the new-type park, which is built entirely on the basis of land eco-industrial park planning and design, to make full use of resources, multilayer usage of main and by-products, waste recycling and emissions without pollution.

(3) virtual type park, which is built by using modern information technology and transportation technology, and form the exchanging relations between materials and energy among the members, then unit all the enterprises in the park together in reality through the contracts of supplying and requiring. And in this way, the symbiosis relationship can be formed between the industries closely related in economy, but scattered over in spatial. This type of parks can save large amount of money in buying the land and relocating the companies, therefore it is quite easy and flexible for them to find new partners according to the need of market and it will reduce the risk impacted by the market. This is the advantages of this kind of parks, while the shortcoming is that enterprises must pay a lot in transportation and other expenses.

Eco-industrial parks are generally consist of five systems, raw material manufacturing enterprises, manufacturing and processing enterprises, waste disposal companies, the park service-oriented businesses, the park management and coordinating department. [17] In China, we have begun to build eco-industrial parks by imitating the natural eco-system. The focus development of ecological industry in China includes three parts, first, large-scale comprehensive

enterprises; second, industrial parks, and third, towns concentrated with industries.[18] Since 2002, China a series of national eco-industrial demonstration parks have emerged, for example, the industrial parks of Guigang (sugar) in Guangxi province, South China Sea in Guangdong, Huang Xing, Baotou (aluminum), Shihezi (paper making), Lubei in Shandong province, and Tianjin.[19] These parks created the new mode of economic development with natural resources to products and supplies - renewable resources by the proper design of logistics and energy, and by sharing the resources and transverse coupling between different enterprises or technological processes. and resource sharing, the creation of natural resources - products and, a new economic development mode of thinking. Eco-Industrial Park has become the major development patterns of China's third generation of industrial parks [20].

Figure 2-5 shows the ecological chain of Guigang National Ecological Industrial Demonstration Park in Guangxi. [16] This ecological chain formed the transverse coupling relationship and to a certain extent, formed the network structure. There is no concept of waste in logistics, but only the concept of resource. Each link achieved fully sharing of resources, turning the negative pollution to positive resources benefits. In the "Ninth Five Year Plan" period, GuiTang enterprise’s comprehensive utilization value of "three wastes" reached 1.335 billion yuan, accounting for 53% of the total output value. And it created the tax for 1250million yuan, and the profit is 71.68 million yuan, achieving the win-win in environment and economy[21].

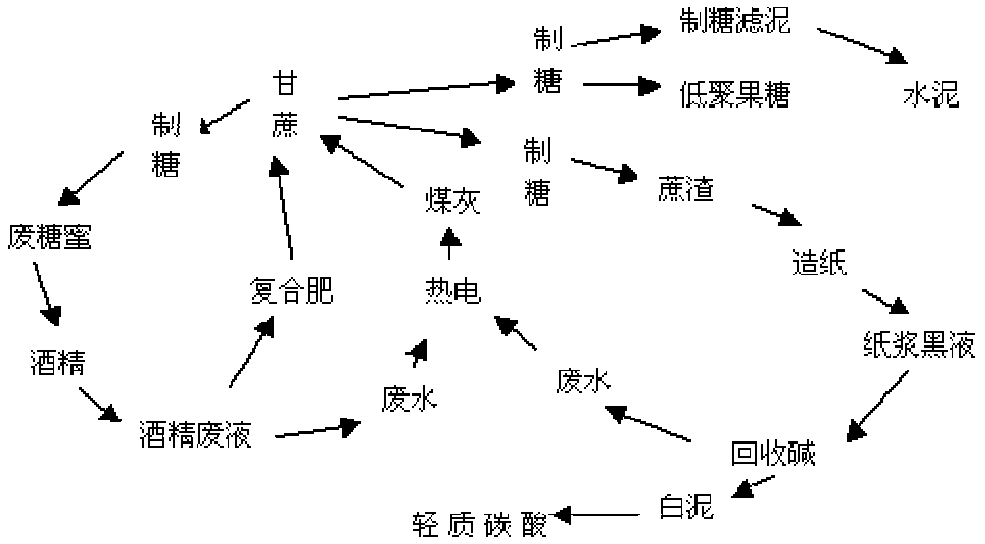

图 2-5 广西贵港生态工业园区循环经济生产模式示意图

Domestic and international eco-industrial park, its resources recycling models can be divided into two types, namely, supply chain recycling and waste interoperability [22]. The supply chain recycling is an important part of the green supply chain, which is the reverse process of inserting "recycling - Decomposition – classification - reusing - producing" into the original linear mode of "Production - Consumption - abandoned". The recycling mode, taking Xerox as the core, is one of the typical cases in this kind of recycling (See Figure 2-6). [23]

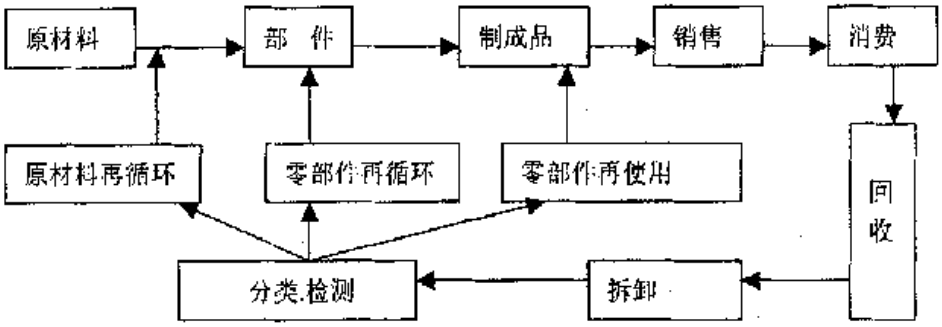

图 2-6 施乐公司的再循环管理模式

Waste interoperability mode focuses on solving the problem of reusing waste and by-products during the producing process, advocating the waste of one enterprise in the ecological industrial park can be directly used as the raw material for another enterprise after waste treatment. The Danish Kalundborg symbiosis system is the most successful international cases up to now. [24]

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CHAPTER 3 Urban Eco-industrial Park and its circular economy planning

3.1 Characteristics and advantages of urban eco-industrial park

Generally speaking, urban industry, as its name tells, refers to all the industries within the urban area, literally. While, in this paper, on contrary to the broad meaning as mentioned, the “urban industry” adopts its sense in the narrow meaning.

The so-called urban industry refers to "meeting the demands of urban development, making full use of the city's factors of production, meeting the urban consumer demand and specific market demand, featured by low pollution, low energy consumption, intensified with technology, information and labor, the manufacturing industry in harmony with urban environment "[1]. It is the industry specialized in product design, technology development, manufacturing, marketing management and other activities. In terms of content, it mainly contains food processing industry, food manufacturing, beverage manufacturing, tobacco processing industry, garment manufacturing, furniture manufacturing and other processing and manufacturing as well as other newly emerged industrial sectors catering to the characteristics of urban industries; in terms of organizational form, it has diverse production and workforce organizations, but the focus of urban industries is on small and medium-sized enterprises.

During the process of industrial structure readjustment of the industrial system, Shanghai put forward the idea that it will adhere to the "third, second, first industry" industrial development policy, and adhere to strategies that second and third industry unite to promote economic development, according to the target of building into the international metropolis city and the demand of its urban functional positioning of the city’s development. Guided by this strategy, Shanghai’s second industry has changed a lot in structure, layout and function. Following the strategy of focusing on the high-tech industry and modern equipment manufacturing industry, a series of middle and small-sized traditional industry seize the chance and readjust them quickly to meet the market demand, and thus urban-sized industry has been formed in this way, featured by marketable products, no pollution processing, friendly to the environment and suitable to develop within the city. These enterprises are typically urban industry, small sized, low pollution, low energy consumption, low material consumptions. With these advantages, they can bring more convenient to the citizens and play an important role in the process of urbanization.

Characteristics of urban eco-industrial park are [2]:

1.The location of it is mainly in the central city or relatively dense residential districts, which can make full use of the urban market and information resources, and the irradiation effects is strong;

2. There are remarkable economic benefits, high rate of production value contribution and friendly to the environment.

3. The products are in the leading position of the similar industry and can be ahead of the national markets, which will also benefit the customers and the surroundings.

4. The urban industry can be developed by using the old industry base, which can enlighten the old districts, bring the vigor to the city and offer more employment opportunities, and this will further the sustainable development of the city and urban area.

5. The industries entering the urban industrial parks can well coordinate with the urban function and environment, which are mainly the industries such as textile, clothing, advertising, software inventing, and medical equipment and make up products and other eco-industries.

6. The enterprises in the industrial parks are mainly middle and small-sized private economy, which has independent management, strong flexibility and competitive strength.

Urban eco-industrial park is developing in the city better and better, showing its advantages over traditional industrial park [3]:

1. Industries gathering together can promote its competitiveness.

2. Urban eco-industrial parks can promote to optimize and upgrade urban industrial structure.

3. The reuse of industrial heritage can do help to improve the efficiency in the use of urban land resources.

4. Developing urban eco-industrial park can do better in the environmental protection.

3.2 Industrial planning on the urban eco-industrial park circular economy

3..2.1 Industrial chain planning

3.2.1.1 circular industrial chain planning

The management of industrial chain is to view the business processes of enterprise as a chain structure of adding value and creating value. In the eco-industrial park, the management of industrial chain is to integrate the operational activities of producing, marketing, research and development and human resources in the enterprises, to integrate them into an organic entity, and to arrange all the processes according to the features of chains. All the loops should be related to each other and have the self organizing capacity of managing capital flow, information flow, logistics and technical flow. The systems of supplying, producing and marketing in the eco-industry form a value chain of circulation. [4]

The application of Chain Management in urban industrial park offers a way and reference to solve some problems in the urban eco-industrial parks at this stage, which can reduce the manufacturing costs and enhance the function of enterprises.

Circular industrial chain emphasizes that industrial raw materials and waste exists within the industry's own producing chain, thus constituting a reverse the process of "recycling - Decomposition – classification - reusing - producing", a green supplying chain circular.

1． industrial chain of refined steal recycling use

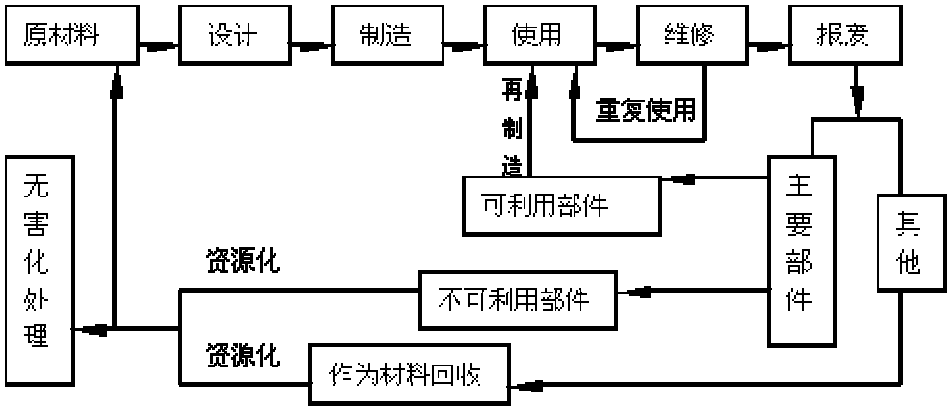

图 3-1 精品钢产品全生命周期回收利用流程图[5]

2． the industrial chain of auto parts and components manufacturing industry

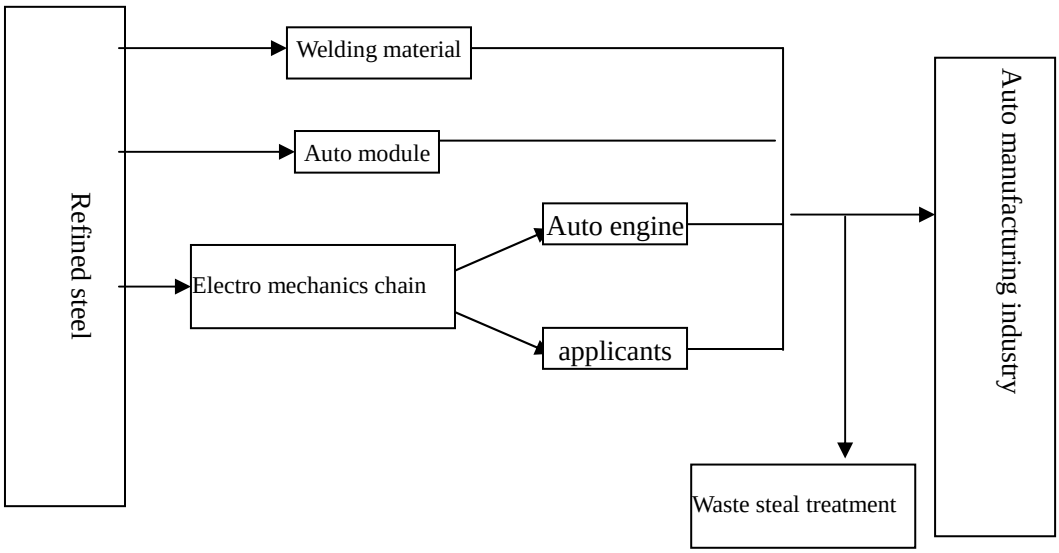

Figure 3-2 the industrial chain design of auto parts and components manufacturing industry[6]

3． the industrial chain of food storing, processing and exporting industry

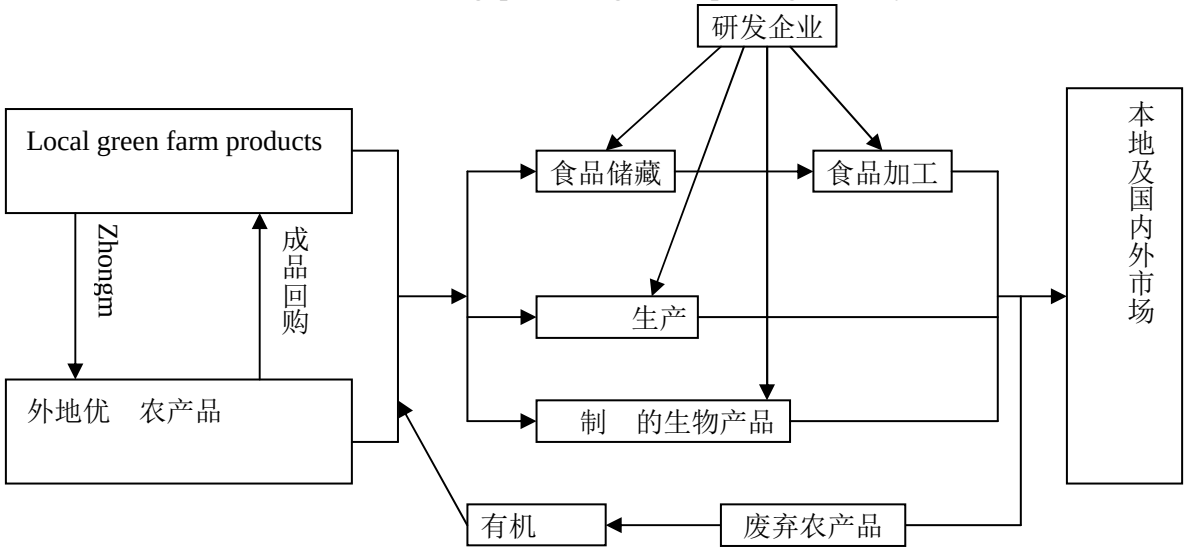

图 3-3 食品储藏、加工、出口产业链设计[7]

4． the industrial chain of textile and clothing industry

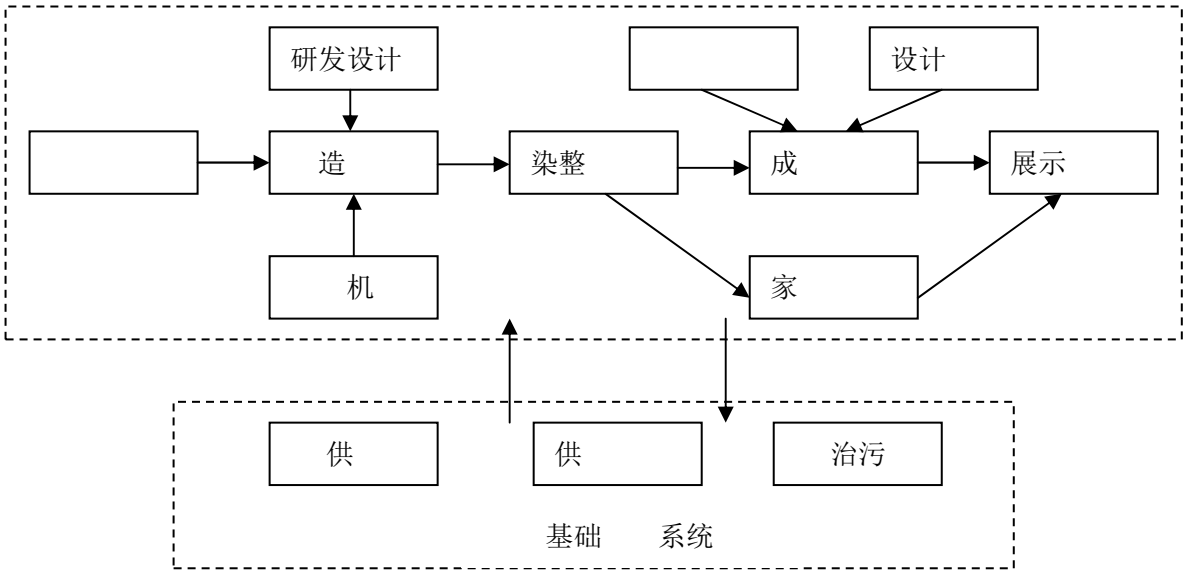

图 3-4 产业链[8]

5. the industrial chain of outdoor traveling products

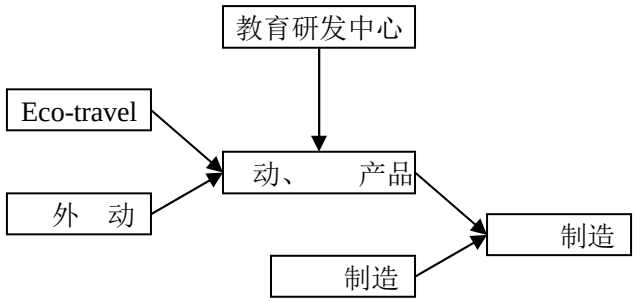

图 3-5 高 动产品产业链[9]

3. 2. 1. 2 industrial net planning for symbiosis industrial park

Some characteristics of the natural ecological system play a very important role in guiding human activity and practice; therefore there is great realistic significance of imitating natural ecological system and obeying laws of nature to plan the traditional industrial park. From the perspective of ecosystem, ecological industrial park, as a matter of fact, is a biological community, maybe the primary material processing factory, deep processing factory, manufacturing factory, or suppliers, waste materials processing factory to form an enterprises group, or maybe the fuel factory or even waste recycling plant forming a cluster of enterprises [10]. Within the system or group, there are various interrelated and interdependent relations between the enterprise, and environment resources. And according to their roles and functions in the park, the enterprises can also be divided into different types of enterprises, i.e., producers, consumers and decomposers enterprise [11]. In addition, in the enterprise community there are flow of capital, information, policy, talent and value, thus forming a kind of eco- industrial chain net similar to natural

ecosystem biological chain. Therefore, the symbiosis industrial chain refers to the enterprises in a certain region acting as the producers, consumers and decomposers imitating that in the natural ecosystem, and enterprise alliances linked by variety of resources (raw materials, byproducts, information, capital and talents), to achieve resources circulating inner the regional area. The structure model of symbiosis industrial chain net can be shown in figure 3-6.

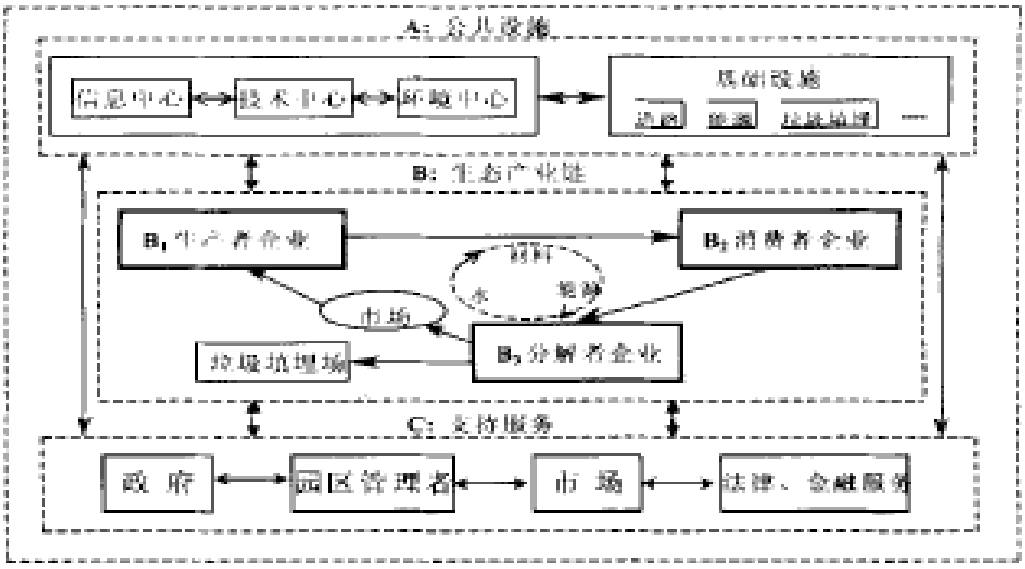

图 3-6 生态工业园生态产业链模型示意图[12]

1．精品钢制造产业 the industrial net of refined steel manufacturing industry

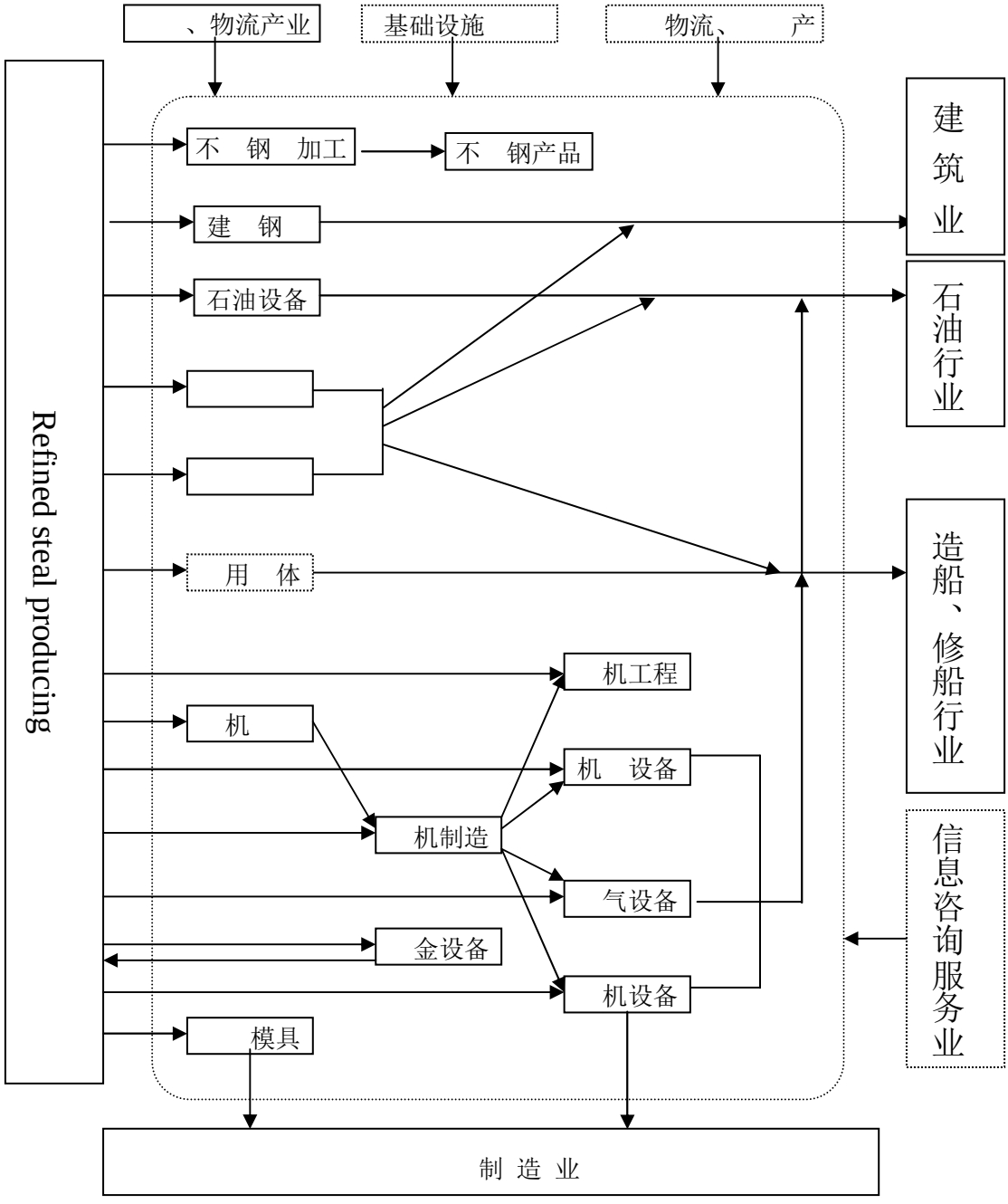

图 3-7 精品钢循环型产业 [13]

2． the industrial net of electronic industry

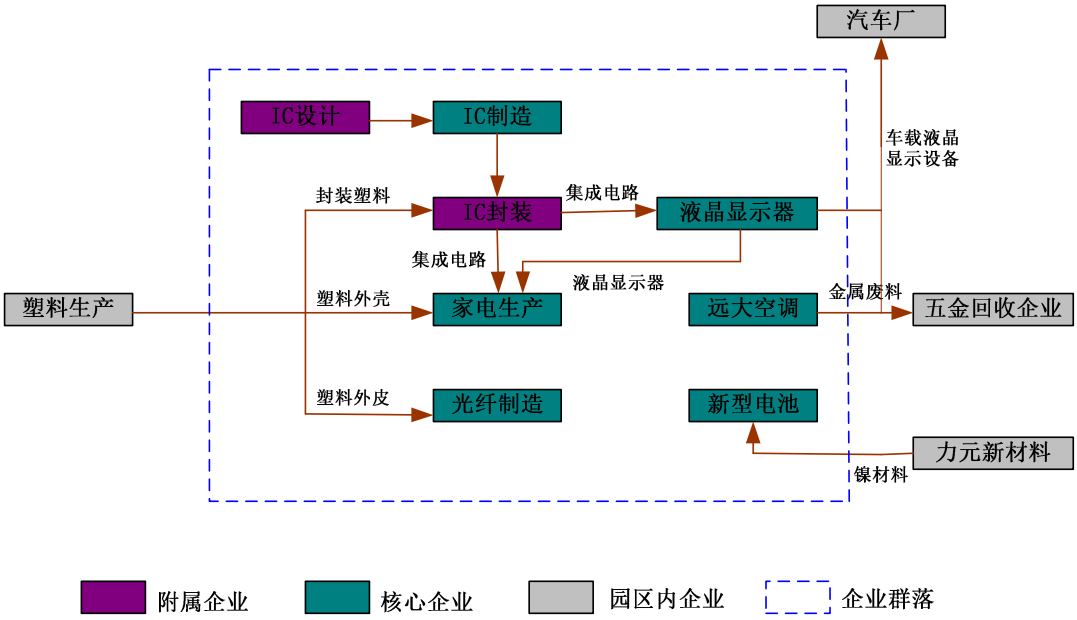

图 3-8 工业产业 [14]

3. the industrial net of new material producing industry

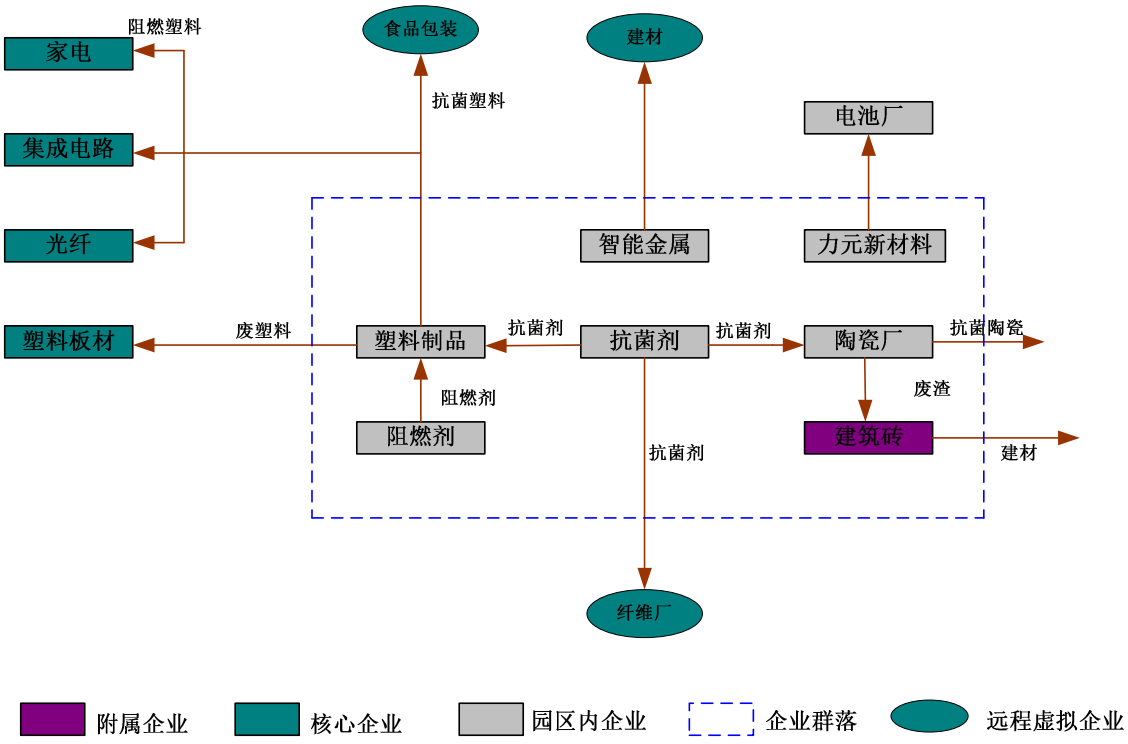

Figure 3-9 the industrial net of new material producing industry [15]

4. the virtual industrial net of information consulting service

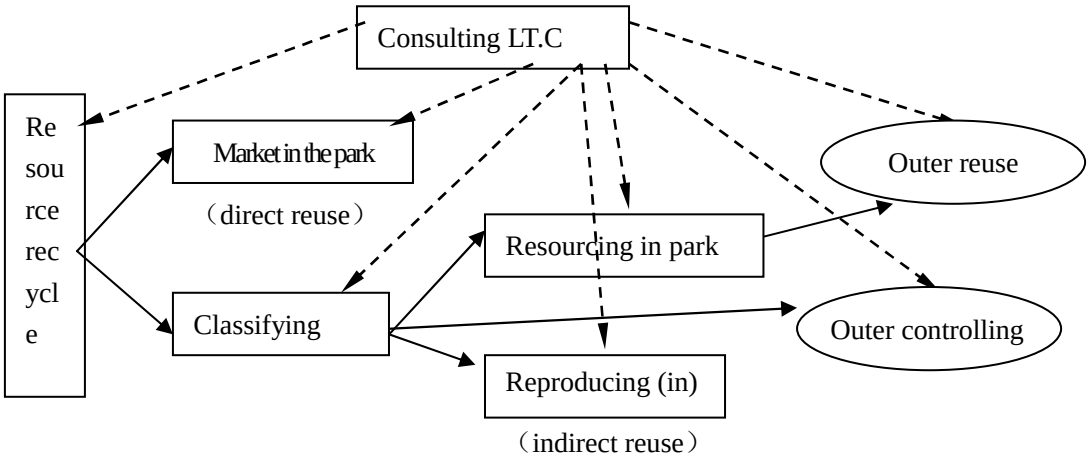

Figure 3-10 virtual industrial net design of information consulting service [16]

3.2.2 Spatial distribution planning for urban eco-industrial park

3. 2. 2. 1 Factors of choosing location

The location distribution of urban eco-industrial park must meet the demand of the modern industrial location theory, taking the factors influencing location selection into account. While, the modern industrial location theory is based on the classical location theory, integrated with the modern economic development theory. This theory is gradually developed focusing on the modern industrial organization, industrial structure and spatial change of technological structure, which mainly includes: growth pole theory, system theory and structure theory. The influencing factors of location selection include: 1) the proximity of urban markets; 2) technical supporting system; 3) information resources condition; 4) infrastructure condition; 5) labor force qualities; 6) surrounding environment [17]

Research in foreign countries shows the location selection of industrial eco-park being different from ordinary industrial parks, out of the consideration of environment and economy. Industrial eco-parks can be built up in the following places:

- the non-polluted open ground
- the existing industrial park
- the polluted open ground (brown land)

3. 2. 2. 2 Spatial distribution of eco-industrial park

1．The basic principles:
to give full play of its advantages in location
to clarify the functional position of industrial parks
to highlight its characteristics, having complementary functions
to pay attention to environmental protection, adapting to local conditions

to plan dynamically, leaving further space for development

2．Characteristics of spatial distribution:

In general, the development of circular economy in urban eco-industrial parks has 5 functions: production function, research and development, administration, resource recycling and reuse, and the park service (see Figure 3-11). In space, it can be divided into: production areas, research and development zone, recycling area, and central area.

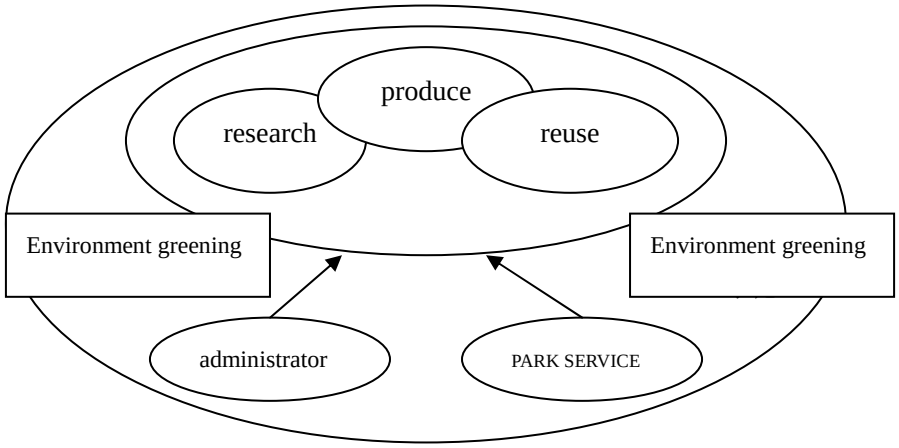

Figure 3-11 spatial function compositions of urban industrial park

The distribution features [18]are: 1) production area is mainly for industrial land, rich in storehouse and freight yard, functioning as manufacturing products for urban development; 2) research and development zone should be closely related to industrial land; 3) recycling area may be in the form of centralized recycling area or decentralized recycling area, according to the kinds of solid waste and the environment and ecosystem inner and outer industrial parks. One certain scale of solid waste processing venous industrial chain can be built in the industrial park, as illustrated in Figure 3-12.

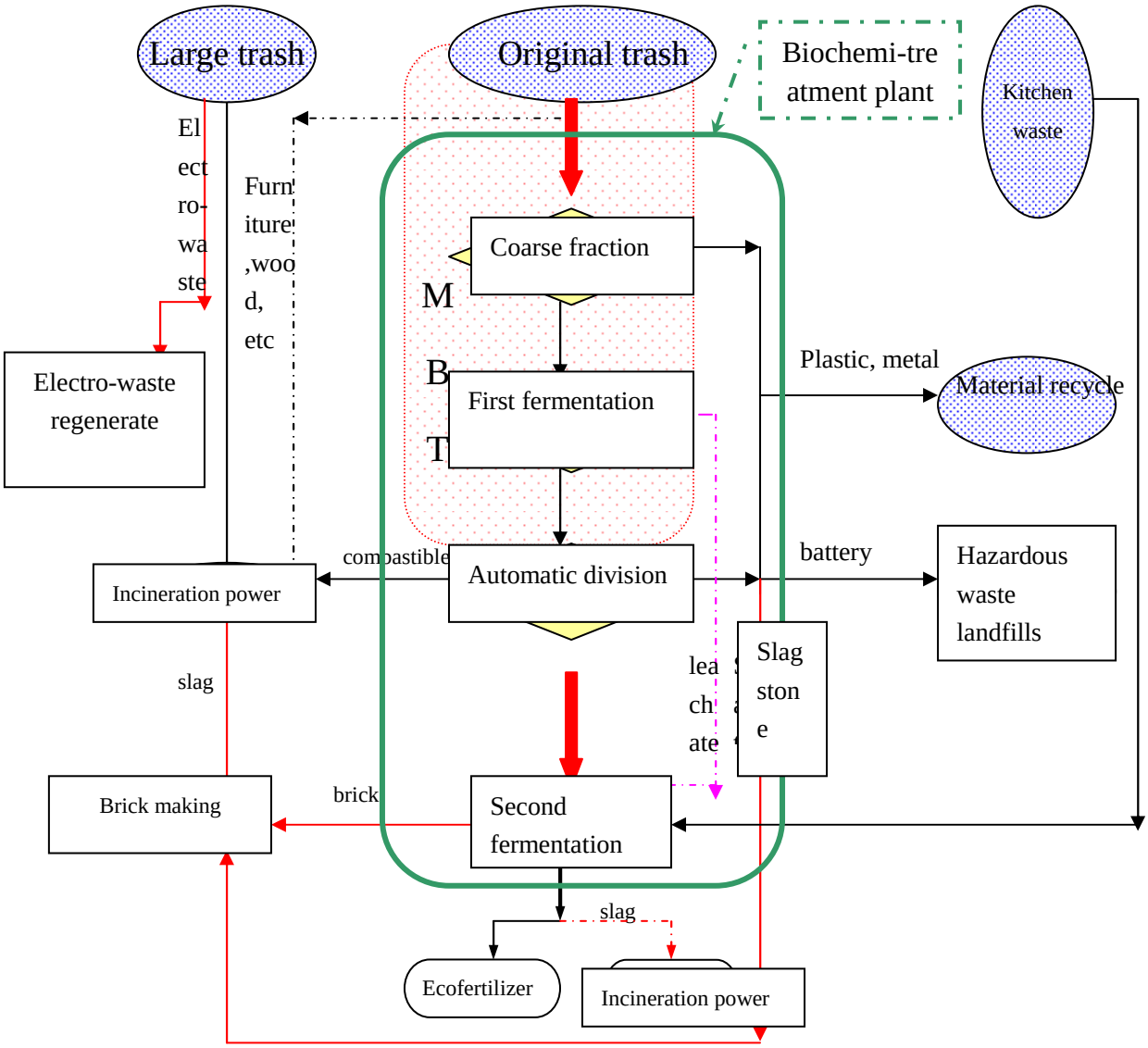

Figure 3-12 Solid waste processing venous industrial chain [17]

And 4) Central area is the center of the industrial park, the sign and core of the whole park, and also it is a social comprehensive center, the integrated support center of the whole park and the tie getting contacts with the outside. Therefore, the central area is designed to establish the park's management institution, financial center, information exchange center, the training center of circular economy theory and technology, commercial facilities, fitness and entertainment facilities, etc. Factors that should be considered in choosing the location of central area are as follows: (1) from the park management perspective, central area should be in the position for convenient communication; (2) considering the surrounding environmental conditions, central area should be chosen to make full use of the natural characteristics of the site, and can give prominence to the characteristics of industrial park; (3) central area should combine the situations for its present, middle and long-term development, the park near is beneficial to the development of the long-term development. Shanghai Baoshan industrial park is actively undertaking the circular economy construction, and its distribution planning can be shown in Figure 3-13.

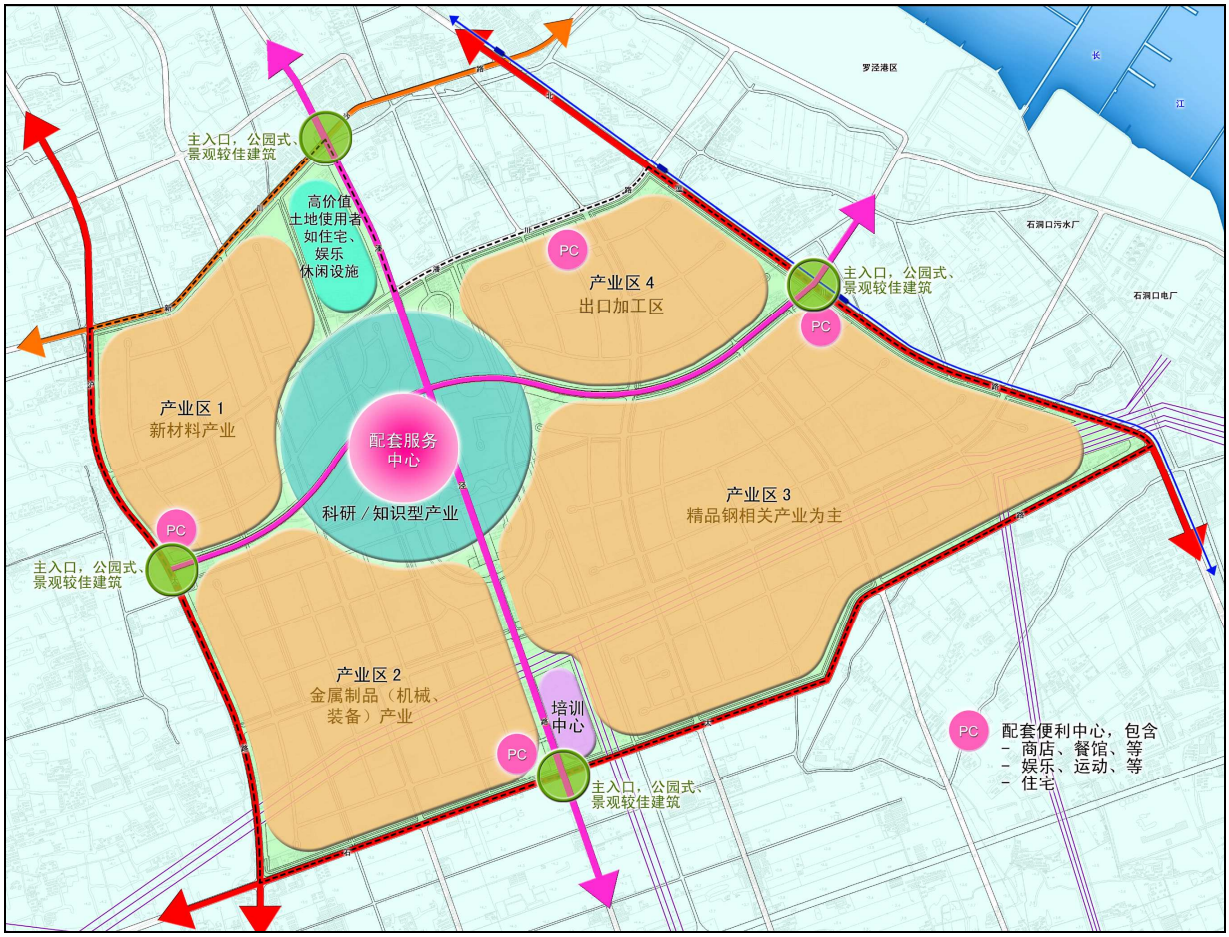

Figure 3-13 function division of Banshan industrial park, Shanghai [2]

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CHAPTER 4 Planning System and Specific operating measures of Urban Eco-industrial Park

4.1 introducing the industry and the construction

In developing urban eco-industrial park, first of all, we should fully understand the industry positioning and current enterprises of the urban industrial park. Only in this way can we introduce suitable industries to the eco-industrial parks.

The objective of introducing industries into the park is to do well with the following relations[1]: combing the promotion strategy of traditional industrial park with the unique developing advantages of urban eco-industrial park; coordinating the eco-industrial park economy and environmental objectives; attracting outer enterprises to join the park and maintaining the inner enterprises at the same time。

In constructing the eco-industrial park, there must be integration and share of the resources, information and so on. To be more specific, integration of the constructing includes material integration, water system integration, energy integration and technology integration. For share, there is share in information and infrastructure.

4.2 supporting system of developing circular economy

4.2.1 social service supporting system

Circular economy development of urban eco-industrial park is in the stage of exploring and design, and the notion of eco-industrial park and circular economy is still new to many people, therefore it is very important to strengthen the promotion and education on urban eco-industrial park and circular economy, to make managers, developers and designers that play a key role in the development of industrial parks aware of the necessity and feasibility of industrial ecology.

The key departments and individuals [2] are:

- managers of community development and financing department
- representatives of the main existing enterprises and potential enterprises within the industrial park
- decision makers of the local government and public departments
- representatives of local labor union
- local departments presiding environmental issues
- education department and scientific research institution
- architectural, engineering and other specific executive branch

4.2.2 technical supporting system

In the development of circular economy of urban industrial park, the technical support system

is important because it can do some help to solve the potential problems of community, park members, designers and managers. For example, by saving costs and taking full advantage of scale effect, advanced technology can contribute to improve the economic efficiency of the industrial park, to enhance the technical feasibility of symbiosis between enterprises within the industrial park, and to reduce the environmental burden of the whole park during the production and service process.

The technical supporting system mainly includes the transportation technology, recycling technology, environmental monitoring technology, information technology, energy efficiency technology, and water treatment technology. [3]

4.2.4 **preferential policy supporting system**

The construction of Circular economy in urban eco-industrial park has strong dependence on national or local policies, which is in need of the supporting preferential policies from the state or local.

Preferential policies of encouraging the development of industrial ecology mainly include [4]: 1) to formulate reasonable pollution controlling and pollution discharging policies based on the principle of “no pollution, no fine”, under the precondition of not affecting the construction of “ecological chain”.2) to develop trading on pollution and to impose or reduce or remit environmental taxes, according to their “ecological performance”, 3) to carry out preferential credit financial policies to the enterprises that contribute a lot to the ecological industry construction, namely, ①to provide eco-industrial projects with policy-based loan, according to a certain proportion of the gross value of national economy to release loans; ② to encourage domestic and foreign enterprises involved in the investment and operation of activities about the industrial park environmental governance, to ensure the interests of investors; ③ to formulate credit policies to encourage enterprises to develop eco-design; ④ to compete for science and technology loans for the construction of eco-industrial projects, especially the projects that do great contribution to the establishment of the industrial ecological chain.

4.3 eco-management of the industrial park

Selection of the management mode of eco-industrial parks directly affects the ecological industry features. An important prerequisite for the construction of industrial park circular economy is to manage the construction and operation of industrial parks according to the principles of circular economy and ecological industry, which is the eco-management of the industrial park [5]. This part mainly talks about the eco-management of the urban eco-industrial park in three layers, that is, industrial park, enterprise, and product.

4.3.1 Park eco-management

4.3.1.1 Park ISO14000 environmental management system

Establishing the park environmental management system, the management agency of the park

must base on the law and regulations and adopt the standards of ISO 14000 series as guidelines, taking the regional environmental management as the basis. The purpose is to achieve rapid economic growth, good environmental quality, better ecological circular, and clean circular economy industrial parks, and thus to accomplish sustainable development of environment, economy and the society.

The management agency should establish the environmental management system following up the steps below [6]:

1. System Planning;
2. Establishment of management agency for the environmental management system;
3. Environmental assessment on the region within the framework of management agency;
4. Implementing the environmental management system;
5. Environmental management system Documentation

4.3.1.2 green infrastructure construction

Green infrastructure construction in the industrial park [7] is one aspect embodying the park environmental management level. The green infrastructure of the eco-industrial park includes the production and supply of energy, transportation, water supply, waste water treatment, lighting, building and communication. In the construction of the industrial park, the entire infrastructure should be designed in accordance with the principle of environmental friendly, to reduce the water consumption and to recycle the industrial wastewater and solid wastes and to improve the energy efficiency.

Park green infrastructure construction mainly includes the following aspects: 1) strengthening natural ecosystem 2) environment friendly building 3) green transportation 4) energy-saving system 5) water-saving environmental system 6) sound insulation and noise lower sound environment system (less than 35 db on the daytime, and less than 30 decibel at night) 7) light environment system (nature light indoor, preventing light pollution in the residential area, advocating green lighting provided by new energy). 8) waste management and garbage classifying disposal system.

4.3.1.3 APELL plan

APELL means Awareness and Preparedness for Emergencies at Local Level[8], aimed at raising public knowledge and awareness of severe environmental pollution accidents, organizing to formulating contingency plans to deal with environmental emergencies caused by industrial accidents, to ensure that people's lives and health, to reduce property losses, and to protect the ecological environment.

APELL plan was targeted at environmental emergencies; it has diverse forms, sudden outbreak, dangerous results and long-term effect. The aims of establishing park APELL plan are: (1) to provide information to the public, making them understand the potential danger caused by the nearby enterprises producing process and the measures that should be taken to reduce these risks; (2), recalling, enriching, or compiling local emergency contingency plans; (3) to enable the

park businesses to participate in the process of raising community awareness and formulating emergency contingency plans; (4) to integrate the enterprises incidents emergency plans and emergency plans with the local communities contingency plans; (5) to enable more and more public to participate in the development, testing and implementation of comprehensive emergency contingency plans. [9]

4.3.1.4 park eco-bulletin plan

With the development of economy, the strengthening publication of information and the increasing of public's awareness of environmental protection, environmental information bulletin has become a new way of environmental management. Establishing park eco-bulletin plan is to promote the management of environment and improve its image of green enterprise and its market competition ability.

Park eco-bulletin plan can be divided into two levels: first, the ecological management bulletin of the entire industrial park, for example, quality of the atmospheric environment, quality of water environmental, soil pollution situation, and the bulletin of eco-management service in the eco-industrial park; second, the eco-performance bulletin or the environmental performance bulletin of the enterprises in the park, that is, to make announcement on the enterprises pollution discharging, ecological image of the enterprise, green products labels and so on. Park eco-bulletin plan focuses on the bulletin of eco-performance of the enterprises in the industrial park.

The basic procedure of the eco-performance bulletin of the park enterprises can be shown in figure 4-1. [10]

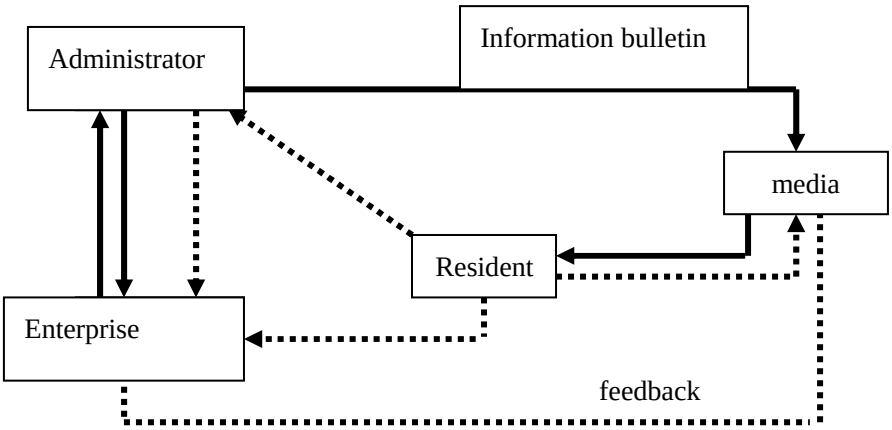
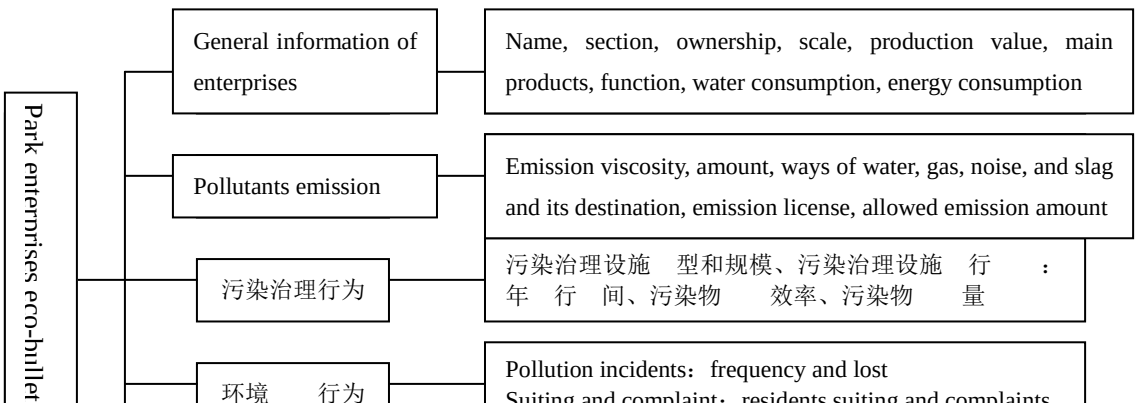


Figure 4-1 eco-performance of park enterprises procedure

The main contents of the eco-performance bulletin of park enterprises can be shown in figure 4-2. [11]



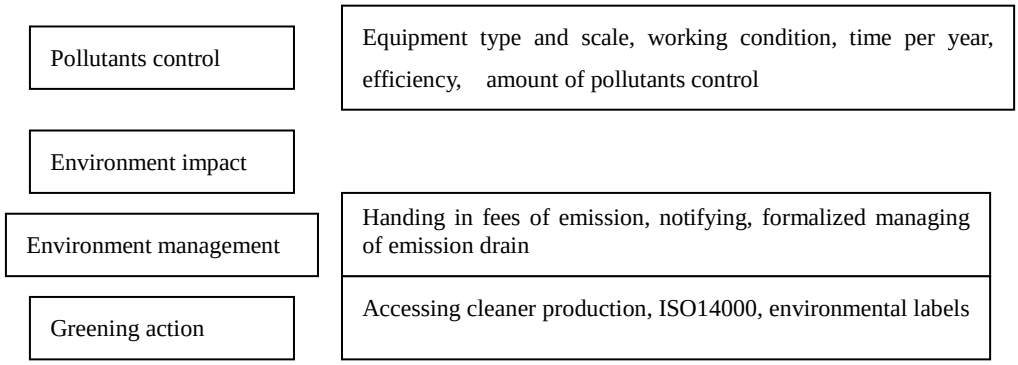


Figure 4-2 enterprises eco-bulletin index and information required

The essential purpose of eco-performance bulletin of park enterprises is to give an assessment and announcement of the enterprises' environmental credit grading. Taking this into account, we can design a color system of the enterprises ecological and environmental credit grading, that is, to use different color to stand for the difference of enterprises eco-or environmental credit grading. Green stands for the best environmental credit grading of one enterprise and second to it is blue, and then yellow, red and black. The classification and connotation of the eco-or environmental performance grading can be shown in table 4-1.

Table 4-1 evaluation grading standard of the park enterprises eco-performance [12]

Color	Meaning	Explanation
green	Excellent	enterprises pass the ISO14000 approving, clean production, meet the ecological production, get the environmental labels
blue	Good credit	Enterprises perform much better than the national and local standards, meet the requirement of environmental management
yellow	Normal	Enterprises come to the national and local standards, meet part of the requirement of environmental management
red	Warning	Enterprises can't meet the national and local standards, poor performance, not meet the requirement of environmental management
black	Reform within limited period	Enterprises seriously rebel the national and local standards, extremely poor performance, causing great damage to the environment

4.3.2 enterprise eco-management

Enterprise eco-management is the core of industrial park's environmental management system. The environmental management of the enterprises can be realized in many ways, such as ISO14000 environmental management system and cleaner production and so on. These ways play positive role in improving enterprises eco-management from different perspectives.

4.4.2.1 enterprise ISO14000 environmental management system

Establishing the enterprise environmental management system must base on the law and regulations and adopt the standards of ISO 14000 series as guidelines. The purpose is to reduce the pollution caused by various activities in producing and processing, to save resources to the utmost extent and to promote environmental quality, enhancing the enterprise's environmental management level, thus effectively strengthen the comprehensive competitiveness of the entire industrial park.

Enterprise ISO14000 environmental management system [13] can be mainly divided into five parts, accomplishing their corresponding function:

1. The managers of the enterprise determine the environmental policy of its environmental management system; and environmental policy is the objective and core of establishing environmental management system.

2. to do preparation work and planning on environmental management system

3. to set up t organizations of the environmental management system, specifying individual responsibility

4. to take inspection and corrective actions to ensure the system working effectively

5. to make assessment on the environmental management system, in order to get continual improvement.

4.3.2.2 cleaner production

Cleaner production[14] is the whole process of applying pollution prevention strategies for the production consistently, which can improve resources efficiency, reduce the generation and emission of pollutants and lower the damage to environment and humankind, through continuous improvement of management and processes and the adoption of advanced technology. The core of implementing cleaner production is to start from the source, taking measures to prevent pollution and controlling the entire process of production to achieve the uniformity of economic and environmental benefits.

Through the implementation of cleaner production, enterprises can reduce internal consumption of material and energy, the use of toxic and hazardous chemical materials and the generation of waste and pollutants, and then increase the resources recycling in order to achieve the park's environmental management objectives.

The idea of implementing cleaner production is at first to identify where the waste is, to analyze why the waste generates, and then to put forward proposals to reduce or eliminate waste. Mainly there are three steps:

Step one: to find out "Where is the waste produced?" by the way of on-site investigation and the material balance to find out the sites of waste generated and determine the amount of output.

Step Two: to analyze "Why does the waste generate?" by analyzing every part of the producing process (as shown in Figure 4-3) [15].

Step three: to study "How to eliminate these wastes?" focused on the corresponding causes of waste generation, to develop the appropriate cleaner production program, and to eliminate these waste by implementing the cleaner production program, and at last, to achieve the purpose of reducing waste emissions.

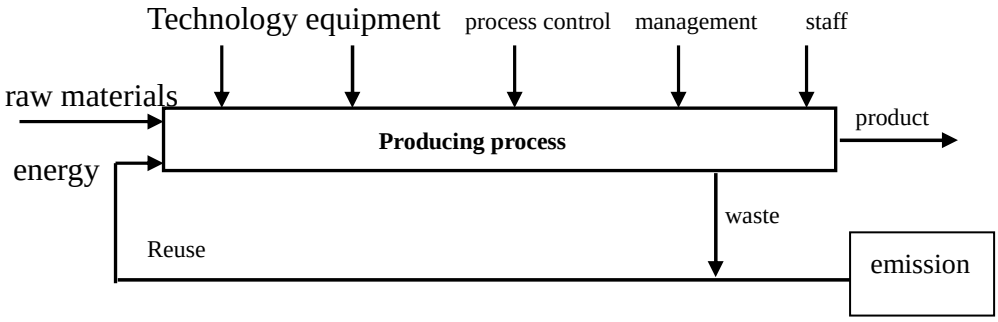


Figure 4-3 cleaner production process of the enterprises in the park

4.3.3 Products eco-management

Products eco-management can adopt many ways, for example, products life cycle, products eco-design and products environmental label.

4.3.3.1 products life cycle

Life cycle [16] refers to the assessment process of a product's effects on the environment throughout its whole life. The scope of product life cycle analysis is very wide, which can focus on the analysis of one phase of the product to another stage, or of one type of the product to another type, or of one place of the product to another place, so as to make a comprehensive assessment of the product's impact on the environment.

As an analysis tool, Life cycle assessment can be applied for the enterprises and public area. To the enterprises, it is used to compare and improve products. And to the government, it is adopted to make public policies, and the most application is to formulate environmental labels or ecological labels.

4.3.3.2 products eco-design

Green product innovation should firstly consider "Eco—design" or DfE [17], Design for Environment. DfE main consider: durability, respectively recycling, pollution prevention (e.g. waste reduction), efficient use of material, energy, and resources, easy maintenance, reusing, remanufacturing and reproducing. DfE must consider Life Cycle Assessment (LCA) at the same time.

Eco—design, sometimes called green design or life cycle design or environmental design, is to put environmental factors into designing to reduce impact on environment in the whole life cycle. Eco—design can reduce costs and risk, improve products quality and stimulate market demands.

4.3.3.3 products environmental labels

Environment labels[18], also called "the ecological labels", "environmental choice", is a sign and certificate issued by official agency designated by the state according to related environmental standard, index and regulations, indicating that the product confirms to the requirements of environmental protection and harmless to the ecological environment. The management of products environmental labels can guide consuming selection and promote the enterprises to save energy, reduce the consumption of raw material and recycle resources.

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Chapter 5 conclusion and prospecting

5.1 conclusion

No doubt, the Law on Promotion of Recycling Economy just voted by the Standing Committee of the National People's Congress (NPC) is the strong and powerful support to the construction of eco-industrial parks. However, China does not have a complete law system of circular economy at present. Meanwhile, there is a scarcity in the supporting system of encouraging the development of urban eco-industrial parks.

In China, it is not long to construct urban industrial park, and it is still in the stage of trying and learning. Almost all of the projects about urban eco-industrial park are dominated by the government, which can accelerate the development of our national eco-industrial park. However, depending on the government can not solve the essential problem of development urban industrial parks, and the healthy development of it relies on the cooperation of many different departments and many related industries.

The industrial chain planning, no matter it is circular industrial chain or symbiosis industrial net, should consider various factors that affect the producing process and environment. All the urban eco-industrial parks require a rational planning on the spatial distribution, and factors like energy supply, natural resources, human resources, and the situation in the industrial parks should be taken into account during the process of making a decision.

There must be effective supporting system in the eco-industrial park. Social service supporting system, technical system and preferential policy system are the three main supporting

systems in developing the circular economy of urban eco-industrial park. In addition, the management of industrial park is very important, which can be realized in three different levels, namely, the park itself, the enterprises in the park, and products output of the park.

Based on the above background, this study is to point out the basic characteristics, the developing advantages, and practices at home and abroad of urban eco-industrial park, so as to make a master plan on circular economy development of the urban eco-industrial parks. The major planning contents and related conclusions are in the following:

Firstly, this paper comes to summarize the characteristics of circular economy development of the urban eco-industrial parks in China and foreign countries, based on reviewing the related theories about eco-industrial parks.

Secondly, this paper is to make an industrial planning of the circular economy development of the urban eco-industrial parks, based on the current development situation of the circular economy development of the urban eco-industrial parks in China and foreign countries. As to the analysis and planning of China's eco-industrial parks, the main concern is that kind of eco-industrial parks in relatively large cities, for instance the typical eco-industrial parks in Shanghai and Suzhou. While, as to that in foreign countries, the main focus is Germany. The industrial planning of the urban eco-industrial parks is the key part in the whole study.

Thirdly, the paper is to make a master plan on the construction, supporting system and ecological management of urban eco-industrial parks, which is also the innovative part and one of the focuses of the study.

5.2 prospecting

The development of urban eco-industrial park is prosperous not only in china but also in other countries. To do further study and deep and intensive research is of great importance and of vital significance. While, the future of urban eco-industrial park relies on the successful practices in all of the world and learn from each other and do good cooperation in promoting the better development of urban industrial park, to achieve the utmost economic benefits and utmost environmental protection effect and utmost energy efficiency.