Working Report
Task Force on Strategy and Mechanism Study for Promotion of Circular Economy and Cleaner Production in China

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At the turn of the 21st century, under the guidance of CPC, Chinese people are devoting all their efforts to building a well-off society in an all-round way. One of the most significant tasks is to quadruple GDP by the year 2020. At the same time of rapid economic growth, we should not ignore some drawbacks.

First, China’s cost for per GDP has been among the highest in the world, including energy consumptions and material consumptions for per GDP. If this situation continues, it will greatly discount our actual economic benefits. It will lead to a disadvantageous position in international market competition and will make the development unsustainable.

Second, it is not optimistic for our nation’s natural resources. The import of crude oil is growing rapidly while the water resource is in shortage. Many mines are being over exploited, and there are dozens of cities around the country facing natural resource depletion.

Third, the problem of unemployment is severe. With the process of reforms of enterprise ownership and political regime, many workers have been laid-off while many others facing potential unemployment. Population growth and urbanization demand for more work positions. The situation of weak group has raised concerns of the whole society.

Fourth, the environment is being overloaded. Though great efforts have been made, environmental pollution and eco-degeneration are only partially ameliorated while deteriorated as a whole. In recent years, Water pollution, cutoff of Huang River, sandstorms, floods and SARS have highlighted the severe situation of the environment, and have shocked the leaders and public as well. In addition to all these, the disadvantageous effects of global environmental problems have slowly appeared. We are facing an inevitable environmental challenge now.
The key points for maintaining the rapid economic growth while sustaining social stability is to change the traditional pattern of economic growth, and to truly implement the sustainable development strategy. Since 1980s, China has played an active role in the implementation of “cleaner production plan” established by UNEP, and gradually carried out cleaner production through out the country, which have a sound effect. In late 90th, China introduced the new idea of circular economy from abroad, and was thought highly of by the top leader. On the Global Environment Facility Meeting 2002, President Jiang Zemin gave the important speech of “Sustainable development can only be achieved through the way of circular economy based on utilizing the resource with maximum efficiency and environmental protection”. The speech was warmly received and thus circular economy became a popular trend throughout the country.

Our Task Force was founded on the basis of former Cleaner Production Working Group to conform to the trend of times aiming at illustrating the concept of circular economy, gathering and sorting the experiences on circular economy of foreign countries, and providing related policy recommendations to promote the healthy progress of China’s circular economy.

1. The Concept and principles of Circular Economy

1.1 The Concept of Circular Economy

1.1.1 Circular economy is a revolution on linear economy
Circular Economy is the abbreviation of closing materials cycle economy. From the angle of material flow patterns, traditional industrial economy is a one-way linear economy consisted of “resource-production - consumption – disposal”. In this kind of open-loop linear economy, people extensively drain all kinds of materials and energy from the planet, then release them as pollutions and wastes to air, water and soil, treating the earth as “sewer” or “garbage can”. Circular Economy, which is different, promotes an economy development pattern harmonious with the earth. The main purpose of it is to organize the economic activities to a close-loop process of “resource-production-consumption-secondary resource”. All materials and energy can be used rationally and continuously in sustained economy cycles, hence the harmful effect to natural environment can be reduced to a possibly minimized level.

Circular economy is an eco-economy in essence. It requires that all human activities be guided by ecology rule instead of mechanical rule. Circular economy is an imitation of the eco-system, so it is essentially an eco-economy. The basic difference between circular and linear economy is that the latter is merely a superposition of separate linear material flows, so the trans-system material flows are much greater than those within the system. Economic activities are characterized by “High exploitation, low utilization, and severe pollution”. However, the former
one require that materials and energy be exchanged in an intergraded way, recycle materials in every possible process, utilize the materials and energy at maximum to achieve the goal of “Low exploitation, high utilization, and low pollution”. An ideal circular economy usually consists of these four major roles: miners, processors(manufacturers), consumers and waste disposer. Because of the retroactive and network interactions within the system, material flows between different roles can be much greater than trans-system flows. Circular economy is the product of economy and ecology. Under the guidance of ecology, it can offer an overall thought to optimize the interactions between different parts of human economic activities. It can give a strategic theory for the transition from the traditional economy since industrialization period to a sustainable development economy; hence it will eventually harmonize the long conflict between environment and development.

1.1.2 “3R” is the working principles of circular economy
The principles of circular economy are “Reduce, Reuse and Recycle” (also called “3R” principles). Every principle is vital for the successful implementation of circular economy.

(1) Reduction is method concerning input, aiming at reducing the input material flows and energy flows into the production and consumption process, so it can also be called material reduction. In another word, we should learn more about how to produce the essential products with as little resource as possible. We should learn to prevent the waste from generation instead of dispose of them after production.

(2) Reuse is a method concerning processing. We should try to use natural resources and products in every possible ways. By reusing them, we can prevent them from becoming wastes, thus prolong the life span of products and services.

(3) Recycle is a method concerning output. By turning wastes to secondary resources, it reduces the wastes for final disposal in volume and decreases the consumption of natural resources. Producers should try to use secondary resources to displace natural resources. Consumers should buy the products containing the maximum raw materials made by secondary resources. These will help to close the economy loop.

The priorities of these 3R principles are not equal. Some may simply regard circular economy as the recycle of wastes. Actually, the fundamental goal of circular economy is to systematically prevent and reduce the wastes in economy process. The recycle of wastes is only one of the ways to reduce the wastes for final disposal. E.g. the “Circular Economy and Wastes Management Law” of Germany enacted in 1996, listed the priority concerning wastes problem as: Reduce-Recycle-Disposal. The principle of the law is to first reduce the generation and release of wastes from its beginning, then, wastes which cannot be reduced or the package and second-hand goods
used by consumers (These are called recyclable wastes) should be recycled. Only when both reduction and recycle can not be achieved, final wastes (These are called disposable wastes) are allowed to be environmental soundly disposed off. Take solid wastes as an example, this prevention-centered method of circular economy has a goal with different levels:

(A) Wasted should be reduced by prevention;
(B) All products should be used for maximum times;
(C) Try to recycle wastes. Some organic wastes can be composted;
(D) For those which can not be reduced, reused, recycled or composted, incineration is the choice;
(E) After all the four criteria are satisfied; remains should be sent to advanced landfills for disposal.

1.1.3 Circular economy is the economic pattern for sustainable development
When judging the rationality of economic development in 21st century, we should consider all the three dimensions of sustainable development, i.e. the integration of economic, social and environmental dimensions. According to the need of sustainable development pattern, first, we should try to make more values in economy aspects. It is the matter of effective distribution of resource, which can be regulated by price. Second, we should try to reduce bad influences in environment aspects. It concerns the maintenance of a healthy eco-system, of which the prevention of ecologic degeneration can be the major policy goal. Third, we should try to solve the problem of employment in social aspects. It is regarded as the problem of a fair distribution of social wealth, of which tax can be the major policy tools.

Traditionally, economic growth and environment protection are the two sides of a coin in the traditional industrialization pattern. They are separated instead of integrated in solving economic, social and environmental problems. Traditional economy solely pursues GDP growth. On one hand, it makes growth at the cost of natural capital consumption, thus lead to the antagonism between economy and environment; on the other hand, it reduces employment positions by increasing the level of automation, thus lead to the conflict between economy and society. Traditional environmental protection strategy lays great emphasis on terminal recovery, thus triggers violent contradiction between pollution recovery, economic growth, and social employment. For example, the “close, stop, merge, shift” policy towards pollution companies to solve environmental problems has brought with the problem of unemployment, and effected people’s livelihood and social stability.

Instead, circular economy is a “triple-win” economy; it combines economic growth, environmental protection and social employment all together, leading the three-dimensional separated development to an integrated one. In every aspect of development, circular economy means a revolutionary change. In the aspect of promoting economic growth, it brought the
revolution from material growth in volume to service growth in quality. In the aspect of solving environmental problems, it brought the revolution from open-loop terminal recovery to close-loop process control. In the aspect of promoting social employment, it brought the revolution from employment-downwards society to employment-upwards society.

We have long follow the linear growth pattern of the three-dimensional separated traditional linear economic growth. As the result, economic growth accelerated at the cost of ecological deterioration. So we must find a new economic pattern for China’s future development, i.e. the organic integration of economic growth, environment and resource protection, and social employment achieved by circular economy.

1.2 The significance of circular economy to China development

1.2.1 China should become a sustainable development economic power in 21st century
The modernization of China is not only to build an economic power of 19th-20th century, but a power facing 21st century. Following the thoughts of traditional industrialization can only leads to traditional linear economy and pursuing GDP growth from pure economic and technical views, etc. China’s environment and resources can not afford such kind of economic power, and such kind of development can not be sustained.

To change our way of thinking and research on the establishment of a new economic pattern-oriented economic power is our urgent task now. At present, there are two new economic patterns of revolutionary significance in the world. One is knowledge economy, the other is circular economy. The former emphasizes the replacement of intellectual resources of material resources and to achieve the intellectualization of economic activities. (So called “soften” trend); the latter aims at environmental sound utilization of natural resources and environment capacity and to achieve the ecological reform of economic activities. (So called “green” trend) Both eventually lead to dematerialization. Since the establishment of sustainable development strategy in 1990s, countries including Germany, Japan, and USA have all regarded the development of circular economy and the establishment of a circular society as an important way and the effectuation of sustainable development strategy. It is explicit that the development of knowledge economy and circular economy are two major trends in recent years. In China we have reached a consensus on the importance of knowledge economy, yet we should learn more of the significance of circular economy.

1.2.2 Circular economy and building a well-off society in an all-round way
We should have a comprehensive understanding of the goal of building a well-off society in an all-round way, instead of laying all emphasis on the increase of GDP. The goal of building a well-off society in an all-round way includes four aspects: the strengthen of economic development and national power, the perfection of democracy and legal system, the development
of science, education, culture and health sectors, and the improvement of eco-system and resources efficiency. Thus, the increase of GDP can not represent the establishment of a well-off society in an all-round way. We need some more comprehensive and scientific indicators.

Obviously, if we only pay attention to the quadruple of GPA in next 20 years and maintain the present economic pattern, the consumption of natural resources and environment pollution will quadruple as a result. It will run counter to our goal of a well-off society. The living standard may not be improved; on the contrary, it may deteriorate. Economic development will be constrained and can not be sustained.

The goal of building a well-off society in an all-round way requires that we develop economy in harmony between human and nature. The improvement of living standard means that we should improve our resource utilizing efficiency and reduce pollution. Because of China’s huge population and limited resources per people, circular economy is the only choice. We should limit the resources consumption increase to a very low level, thus we should improve our resource utilizing efficiency by 4-5 times. At the same time, we should control pollution to zero-increase or to decrease, leading China to the road of productivity development, wealthy life and healthy environment.

1.2.3 The implementation of circular economy needs the cooperation between government sectors.

The promotion of circular economy is a task with great comprehensiveness. The cooperation and coordination between different government sectors and industries is necessary. Without the participation of economic sectors, circular economy will be mired in the situation of “circular but not economy”. So we believe that the popularity of circular economy should spread from environmental sectors to economic and social sectors. The research on the integration of the three dimensions: economy, society and environment should be promoted. Peoples from different fields should be attracted to participate into following research and practices.

(1) In economic aspects, function-oriented economic revolution should be promoted in China. China economic growth has been greatly damaged by cheap disposable products. China in the future should dedicate to the development of durable and valuable products and services. “Made in China” should be brand production, instead of the workshop of mass production.

(2) In social aspects, we should take the way of circular economy to solve the unemployment problem. The huge population of China is a major obstacle in the way of modernization. Future China should convert from country with huge population to country with huge employment. Industrial chain will be extended and all kinds of services will be developed through circular economy. More employment will be offered by service sectors.
(3) In environmental aspect, we should perfect the resources utilization and pollution control based on prevention and process control. The safeguard of China’s modernization is the improvement of natural productivity. Future China should make more efforts on the entire proceeding of economic development from macroscopic view, and the life-cycle analysis of a product from microscopic view to ensure that China’s natural resources will fully serve the development of social economic development.

1.3 The three patterns of circular economy

Research has shown that an industrial system of circular economy should comprise at least following five characters:

(1) Production should not only focus on products development and quality, but also focus on the reduction of raw materials consumption and choice of recyclable materials and structures.
(2) We should resist the over-packaging of products for sales. When simplifying the package and containers, try to use recyclable materials and containers.
(3) When reducing the emission of industrial waste, try to recycle and reuse them. Hazardous wastes should be environmental soundly disposed of without delay.
(4) Foster the recycle industry of used products and reduce landfill and incineration of municipal wastes to minimum.
(5) Replace traditional energy resources by green energies like: solar energy, tidal energy and geothermal energy.

The industrial system of circular economy can be built in three different levels.

1.3.1 Minor cycles: Pattern of Dupont Chemical Co-Circular economy in an individual company

The material cycle within a company is the basic expression of circular economy in micro-levels. World Business Committee of Sustainable Development (WBCSD) members, who take eco-economy benefits as their principle, all attach importance to the inner-company material cycle. Dupont Chemical Co. is a typical example. In late 1980s, the researchers of Dupont creatively adapted the “3R” principle to “3R” manufacture code according to the reality of chemical engineering industry to reach the environmental protection goal of less emission or even zero emission. By abstain from using some hazardous chemical, reducing the usage of some chemicals and inventing new technologies to recycle company’s products, by 1994, the plastic wastes was reduced by 25% while air pollution was reduced by 70%. Meanwhile, they recycled chemicals from plastic wastes like discarded milk boxes and disposable plastic container, and developed some new durable productions using recycled polythene. The vice manager of Dupont Mr. Terb said: “The goal’s establishment (Zero emission) encourages our creativity. The more we consider this goal, the more we understand that wastes reduction is actually the development
of whole new technologies to use things usually discarded by us."

Generally speaking, the cycle within a company comprise following situations: (A) Retrieve the lost materials to former process as raw materials, for example: the recovery of paper pulp from wastewater in paper industry. (B) Through certain treatment, retrieve the waste of production to former process as raw materials or raw material alternatives, for example, copper can be extracted from waste electrolyte in electrolytic copper production through some treatment, and then reused as raw materials. (C) Through certain treatment, wastes of production can be reused as raw materials for other manufacture processes within the company.

1.3.2 Meta cycle: Pattern of Carlonberg ecological industrial park – circular economy facing symbiosis companies.
There is a limitation of cleaner production and circular economy within a company, for there will certainly be some wastes and by-products that can not be recycled within the company. Material cycle outside the company is necessary. The ecological industrial park is a manifestation of the circular economy principle in a wider range. It is an industry symbiosis of different companies linked to share resources and exchange by-products. The waste air, heat, water, materials of one company is another’s raw materials and energy. Carlonberg of Denmark is the most typical example of industrial ecological system in the world. The major companies of this industrial ecological park are a power plant, a refinery, a pharmaceutical factory and a plaster tablet factory. The exchange of wastes and by-products based on these four companies through trade relations not only reduces wastes in volume and costs for disposal, but also creates sound economic benefits, thus forms a benign cycle between economic development and environmental protection.

Circular economy in the form of ecological industrial park has raised two challenges to traditional business management. On one hand, Traditional business management lays all emphasis on the sales department, and throws the problems of wastes management and environment to secondary sectors. However, equal attention should be paid to wastes appreciation. The optimization of company’s material and energy exchange should be equally valued as the sales of products. On the other hand, with the background of fierce competition between companies, traditional business management has established the tenet of competitiveness. However, industrial ecological system requires the establishment of a management form beyond the limits of individual companies instead of pure opponent relationship to facilitate the optimized reciprocal utilization of resources.

1.3.3 Macro cycle: Pattern of Duals System Deutschland AG – Circular economy between production and consumption
Form the angle of general cycle in the whole society; it is a demand to develop second-hand regulation and resources recovery industries. (Called "vein industry" in Japan) Only by this can a circular economic loop of "resources-production-consumption-secondary resources" be
created in the whole society. Duals System Deutschland AG has played an exemplary role in this field. The Duals System Deutschland AG, a non-profit company, is in charge of organizing this system and recycling sales packaging. Commissioned by companies, it organizes collectors to collect and classify package wastes, and then sends them to relevant recovery factories to recycle. Package wastes which can be reused are directly sent back to producers. The establishment of DSD greatly improves the recycle of package wastes in Germany. For example, the recycle rate set by government for package like glass, plastic and paper box, etc. was 72%. It has reached 86% by the year 1997. In 1994, wastes recycled were 520,000 tons. It reached 3,590,000 tons in 1997. Package wastes falls from 13 million tons to 5 million tons per year.

1.4 Cleaner production is the cornerstone for circular economy.

With the enactment of “Law for Promotion of Cleaner Production”, under the plan and guidance of the department concerned, there will be a campaign for the promotion of cleaner production in all professions and trades around the country. Meanwhile, some provinces carried out drastic reforms on circular economy. What exactly is the relationship between circular economy and cleaner production? Without a clear idea of this question, it will lead to confusions in concept and misplacement in practice. It will interrupt the implementation of cleaner production, and be harmful to the healthy development of circular economy.

We believe that cleaner production is the cornerstone of circular economy, and circular economy is the extension of cleaner production. In concept, they share the same background and origin from the same theory; in practice, they have interlinked implementation ways, and should be integrated.

1.4.1 The raise of the two concept are both based on the demand of the day

We all know that industrial society exploited nature resources mercilessly with exponential growth, and has caused global environment deterioration, natural resources depletion and an overloaded earth. Traditional development pattern can not be sustained. Under the guidance of sustainable development theory, UNEP drafted “Cleaner Production Plan” in 1989, and promote cleaner production all around the world. In year 1996, German Closed Substance Cycle and Waste Management Act (CSCWMA) came into force. This waste management decree promotes economic development based on resources recycling, and thus a significant step towards building a circular economy. Both laws emerged in response to the conflict between economic development and natural resources.

China’s ecological fragility is well below the world’s average. With the population ascending to its peak, many experts predicted that the first 20~30 years of the 21st century will be a “narrow way” for China’s development. During that period, pressures caused by some unsustainable factors including the decrease of arable lands, water shortage, food insufficiency, energy shortage, aggravation of air pollution, and mineral insufficiency will be further increased. Some of these
factors will reach its limit. Facing the real danger to livelihood, cleaner production and circular economy will be the only choice to surmount the “bottleneck” in China’s sustainable development.

1.4.2 Both based on the theory of industrial ecology
Industrial ecology can also be translated into Chinese as trade ecology. As a branch of applied ecology, it uses the theory of ecology to study the interrelation between industrial activities and ecologic environment, to investigate the through process of substance cycle from the environment and to the environment, to probe the way of ecological industry. It regards the economic system containing human production & consumption activities as a special system in the whole biosphere. So economic system is not only subject to social rules, but is also subject to natural ecologic rules. To seek the harmony between society and environment and the compatibility between techno sphere and biosphere, the only solution is to fit the economic system into ecological system, to imitate nature macroscopically, and thus make economic activities resemble the ecosystem structure principles and operational rules to a certain level, achieving the ecological transformation of economy, also called “ecological economy”. Industrial ecology has offered thoughts and tools for the integration of economy and ecology. Circular economy and cleaner production are both important components under the industrial ecology’s framework.

1.4.3 Share the same targets and routes
Though designed mainly to prevent pollution, cleaner production has targets other than material recycling on different levels. Those include the reduction of hazardous raw material usage, wastes and pollution reduction in generation and emission, economizing on energy, and decarbonization of energy resources etc. Circular economy mainly aims at the recycling of natural resources, especially indispensable resources. Their targets are exactly the same. In recent years, some developed countries have set the goal of “zero emission, zero growth in material and energy consumption, and zero wastes landfill”. (3 Zero) Obviously, the “3 Zero” also represent the targets of cleaner production and circular economy.

There are also many similarities between circular economy and cleaner production in implementation. The practice of “cleaner production” can be divided into two categories, i.e. source reduction and recycling, including: reduction the consumption of resources and energy, reuse of the raw materials, intermediate products and products, recycle of substance and products, utilization of secondary resources and environmentally sound alternatives. The 3R principle of circular economy also derives from these.

1.4.4 The differences and relations between cleaner production and circular economy
The major difference between the two concepts is in the implementation level. Cleaner production on company level is the minor cycle of circular economy. Cleaner production can be implemented on a single product, single equipment or a single production line, using the
concepts of circular economy. However in ecological industrial park, cleaner production in individual companies is only the first step, cycles involving different companies are needed. In general circular economy, a great range and area is a necessity. For example, in Japan, it is called “the construction of a recycling-oriented society”. The implementation of circular economy covers a wide range, involves different sectors and factors, and will not show obvious effects in a short time. Not a simple department can undertake such a task of planning and organization.

In practice, when implementing circular economy, various technical problems should be solved. Cleaner production has provided an essential technical support. Especially, the premise of the implementation of circular economy is the ecological design of products. Without it, circular economy will remain as a slogan, and will never come true.

China has promoted cleaner production for over ten years, and has accumulated some precious experience in solving problems of state system, mechanism and legislation, and in the construction of methodology. The experience can be used as reference for the implementation of circular economy.

Present major task is to grasp the rare opportunity of the enactment of “Law for Promotion of Cleaner Production”, devote major efforts to implementing cleaner production, and lay the bases for circular economy. While practicing circular economy, it should be combined with cleaner production. The department concerned should include both circular economy and cleaner production, develop advanced industry guidelines, set unified plans, clarify the strategic task for dematerialization, and pursue for the reciprocal of environment, society and economy.

2. Case study on circular economy in home and abroad

2.1 Various approaches of circular economy practices with examples from Japan, Germany and the United States of America

It is necessary for China to learn from other countries, which have already had some experience with elements and practices characteristic of a circular economy. Hence, relevant policy developments as well as case studies from Japan, Germany and the U.S. have been selected and studied. In these countries some far-reaching and exemplary efforts have been realized to increase eco efficiency and implement elements of a circular economy. There are both similarities and differences in the approaches of these countries and China should evaluate them thoroughly. However, the lessons learned in the different countries during the implementation are highly valuable for China’s discussion on circular economy.
2.1.1 Efforts towards the construction of a recycling-oriented society in Japan

2.1.1.1 Brief history towards a recycling-oriented society

Since the late 1950s when Japan’s high economic growth started, industrial pollution began to draw attention. During the 1960s and 1970s, the government of Japan established environmental policies to address this kind of industrial pollution. During the so-called bubble economy of the late 1980’s, the volume of waste increased dramatically leading to an ever growing need for waste disposal sites and a strengthening of waste management policies. The Waste Management Law was revised and the Law for Promotion of Utilization of Recyclable Resources was passed in 1991. The Containers and Packaging Recycling Law and the Home Appliances Recycling Law were enacted in 1995 and in 1998, respectively.

By the end of 1990s, following the trend of these policies, rising awareness evolved of a need to shift away from the current socio-economic system, and to develop a new socio-economic system of the coming 21st Century that would enable Japan to overcome its environmental and resource restrictions.

The Industrial Structure Council of MITI\(^{1}\) prepared a report called “Vision of a Recycling-oriented Economy” in July 1999. This report concluded that, in order to achieve both environmental protection and sustainable economic growth, it would be necessary to create “a recycling-oriented economic system” by incorporating environmental protection measures and resource saving actions into every facet of economic activities.

The concept of a recycling-oriented economic system comprises four factors:

- To realize the maximization of resource and energy use efficiencies through input and output minimization in a way to harmonize environment and economy through making use of the market mechanism;
- To build a new economic system that is characterized by a cooperative partnership consisting of businesses, consumers, and national and local governments;
- To establish a new system for industrial technology development. To be specific, it is necessary to develop technologies to reduce environmental burdens throughout an economic system as a whole ranging from upstream to downstream of resource exploitation, raw material production, parts and components manufacturing, processing and assembly, distribution, consumption, and waste disposal and recycling;

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\(^{2}\) NOTE: Writers of this thesis owe a great deal to Mr. Yasuo Tanabe, former Director of Recycling Promotion Division of METI to write this.

To foster environment-related industries by the “environmentalization” of industries as well as the industrialization of the environment. As a party to facilitate a recycling-oriented economy, the industry sector has an extremely important role, and the environment-related industry is likely to create a market of about 37 trillion yen (about US$300 billion dollars) and the employment of about 1.4 million people in 2010.

The MITI’s initiatives and the following intensive debate within the government also stimulated active discussions in the general public. The year 2000 was named the “First Year of a Recycling-oriented Society”, and the Diet passed six recycling-related bills marked with an asterisk in the below figure (The Waste Management Law was revised and the Automobiles Recycling Law was enacted in 2002.).

![Diagram of Legislative Framework for Promoting the Creation of a Recycling-oriented Society]

2.1.1.2 Promoting the creation of a recycling-oriented society

The Basic Law for Promoting the Creation of a Recycling-oriented Society provides a basic legislative framework for such a society and rules over other recycling-related laws and regulations. This law defines the recycling-oriented society, determines the distribution of roles and responsibilities among the related parties, sets out basic principles for necessary measures, and requests the formulation of a national basic plan. The recycling-oriented society is a society
where the consumption of natural resources is well managed, and the environmental burden is reduced as much as possible. In addition to advocating the creation of such a society, it also strives for a “sound economic growth with less environmental burden.”

The emphasis is on the distribution of roles and obligations among the related parties, especially the “Extended Producer Responsibility” for businesses, and the “Emitter Responsibility” for consumers. The basic principle on priorities of necessary measures is as follows:

- “Reduction”, i.e. to require further reduction of waste;
- “Reuse,” i.e. to promote the reuse of “recyclable resources,” recovered from waste as products or parts;
- “Recycle”, i.e. to require further use of “recyclable resources” as raw materials;
- Recover heat from “recyclable resources”;
- Appropriate disposal of waste if unusable as “recyclable resources”.

The application of this basic principle to particular industries and products is to be stipulated by respective laws and regulations.

In accordance with this law, the Government of Japan decided the first basic plan for promoting the creation of a recycling-oriented society in March 2003.

2.1.1.3 Promotion of effective utilization of resources
The Law for Promotion of Effective Utilization of Resources requires the industry sector to implement waste reduction, reuse and recycling activities from upstream to downstream processes. It is an epoch-making and unprecedented legislation in the world, mainly aiming at creating an economic system with higher resource and environmental efficiencies. The law sets seven categories in which 3R (Reduce, Reuse, Recycle) efforts shall be made. A cabinet order was issued to designate 69 product categories in 10 industries effective from April 2001.

In addition, regulations in accordance with the characteristics of individual products are implemented through other five recycling laws and the Green Purchasing Law promotes the procurement of recycled products by the public sector.

2.1.1.4 Promotion of businesses and technological development
Since the mandatory regulation may not lead to actual practice of recycling, METI has introduced a supportive system for businesses.

The most effective one may be the Eco-Town businesses, which promote zero-emission towns in a region by offering subsidies to private entities that want to build sophisticated high-tech recycling facilities and to develop the recycling industry. Since its introduction in fiscal 1997,
METI co-approved 14 *Eco-Town* plans with the Ministry of Environment and granted subsidies to 24 facilities. Because technological innovation is a key for the creation of a recycling-oriented society, METI has a system to support such technological development in order to increase the potential for commercially feasible recycling businesses.

2.1.1.5 Lessons to be considered

Three lessons can be drawn from the past experiences of Japan. The first is the importance of public awareness. A recycling-oriented society deeply and inevitably involves the people living in that society. Therefore, to enhance the public awareness on the importance of realizing a recycling-oriented society is very vital. Information exchange and education play a critical role in this area.

The second is a need to take precautionary measures. Throughout its economic development, Japan tried to take the best measures available at each time. Unfortunately, taking precautionary measures would have reduced recovery costs in some cases. In the extreme case, pollution damage compensation and repairing cost is estimated to be 100 times more than that of taking the precautionary measures. It is important to realize that to ignore potential problems will increase the necessary future costs.

The third lesson is to utilize the market function as far as possible. This can be described as the internalization of the environment into the market economy. It is necessary to provide waste management and recycling services through proper cost sharing, whether they are managed by the public sector or the private sector. In Japan, the introduction of *Extended Producer Responsibility* is advancing the shift from public sector waste management to private sector economic activity.

As each country in the world has its own characteristics, it is impossible and also undesirable to transplant the experiences of one country to another country. The past experience of Japan may be a useful guide for China to build up its own recycling-oriented society.

2.1.2 Approaches to a circular economy in Germany

2.1.2.1 Brief review of legislative development

A major legal development in the area of waste management in Germany was the enactment of the *Waste Disposal Act* in 1972. Before, the only existing administrative measures were obligations of the communities to collect and eliminate the waste within their districts. Standards for treatment and disposal did not exist and, as a result, an immense number of contaminated

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4 Compiled by Rolf Dietmar, Director of the GTZ-Programme Environment-oriented Enterprise Consultancy Zhejiang, Hangzhou, China (The compilation is partly based on a study conducted in April 2003 by Ellen Gerdes).
areas generated. In 1986, the *Waste Avoidance and Waste Management Act* came into effect taking into consideration the basic elements of a progressive waste management system, consisting of waste avoidance in terms of volume and hazardousness, as well as material recycling, energy recovery and proper final disposal.

The *Packaging Ordinance* of 1991 applies to the packaging of all goods except hazardous substances aiming at the following goals:

- Significant reduction in the packaging materials by avoidance, reuse and recycling;
- Placing responsibility for product disposal on those who manufacture and market products;
- Relief of the local communities from the burden of disposal tasks;
- Clear promotion of material recycling.

Accordingly, end-of-use packaging has to be collected and recycled by commerce and manufacturers, who can be released from individual take-back obligations by joining a nationwide collection system. Industry has set up its own take-back and recycling system, financed by more than 19,000 licensees using the Green Dot as a label on their packaging and, in this way, financing the separate collection, sorting and recycling of plastic sales packaging. The Duales System Deutschland AG, a non-profit company, is in charge of organizing this system and recycling sales packaging.

The latest milestone in the development of German waste management legislation emerges with the Closed Substance Cycle and Waste Management Act (CSCWMA) that came into force in 1996. This waste management decree represents a real beginning of closed-loop recycling and thus a significant step towards building a circular economy. It represents a new dimension in German waste management policy with its central goals of avoidance and recycling.

There is an obligation to avoid waste in production processes with the CSCWMA requiring that whoever produces, markets and consumes goods is also responsible for avoidance, recycling, reuse and environmentally sound disposal of the waste. Thus, the CSCWMA clearly introduces the polluter-pays-principle.

Hence, waste minimisation is a key element of the German strategy to introduce a closed substance loop with the following hierarchy:

- Waste prevention/avoidance is first priority;
- Re-use has the same priority as recycling;
- Recycling on-site is prior to recycling off-site;
- Reduction of toxicity is as important as the reduction of waste quantity;
- Material recycling is as important as energy recovery;
- Priority of recycling over landfilling.
As a logical consequence, product responsibility is one of the centrepieces of the CSCWMA that aims at promoting the development of products, which on the one hand are of multiple use, have a long life, are repair-friendly, and, on the other hand, can be recycled and disposed of in the safest possible way.

In 2001, the *Ordinance on Environmentally Sound Disposal of Municipal Waste* was adopted specifying a regulation enacted in 1993 stipulating that by the year 2005 at the latest, the disposal of non-pretreated domestic waste would be prohibited. As a consequence, disposal of mixed waste with organic and soluble components will not be possible without prior thermal and/or mechanical-biological pre-treatment.

2.1.2.2 Effectiveness of closed cycle approaches
The effectiveness of the closed cycle approach may be measured by the avoided waste streams as well as the collection and recycling rates and the economic benefits through efficient use of resources and energy (eco efficiency).

The result of the efforts with regard to *Municipal Solid Waste* are shown in the below Table representing “average” rates extracted from different publications. They differ considerably, as collection systems and recycling facilities are not the same throughout the country.

<table>
<thead>
<tr>
<th>Type of waste/component</th>
<th>Collection rate</th>
<th>Recycling rate (of collected total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic fraction</td>
<td>50%</td>
<td>96%</td>
</tr>
<tr>
<td>Paper and cardboard</td>
<td>87%</td>
<td>100%</td>
</tr>
<tr>
<td>Glass</td>
<td>78%</td>
<td>100%</td>
</tr>
<tr>
<td>Tin and aluminium in cans and other metals</td>
<td>65%</td>
<td>approximately 100%</td>
</tr>
<tr>
<td>Plastic and paper packaging</td>
<td>75%</td>
<td>97%</td>
</tr>
<tr>
<td>Batteries</td>
<td>35%</td>
<td>100%</td>
</tr>
<tr>
<td>Automotive batteries</td>
<td>95%</td>
<td>100%</td>
</tr>
<tr>
<td>Waste tyres</td>
<td>94%</td>
<td>98%</td>
</tr>
<tr>
<td>Waste of Electrical and Electronic Equipment</td>
<td>no data available</td>
<td>estimated at 10%</td>
</tr>
<tr>
<td>Textiles</td>
<td>estimated at 70%–80%</td>
<td>estimated at 70%–80%</td>
</tr>
</tbody>
</table>

Source: Compiled by Ellen Gerdes, 2003

The *Packaging Ordinance* as a major regulation has demonstrated very good performance within a rather short period of time. As a result, waste generation from packaging decreased significantly, and packaging design changed towards lightweight, low-waste, single-compound packaging. The ordinance has proved successful in several fields:

- Manufacturers have changed their packaging habits. Environmentally friendly disposal
of packaging is taken into account during the production process and is increasingly used as an advertising argument;

- In the field of transport packaging a trend towards reusable packaging is obvious, for example packaging for furniture, food, and pharmaceutical products;
- Industry has set up a nation-wide collection system for throw-away packaging and has increased its recycling capacities;
- The large quantities of collected packaging have brought considerable relief to landfill sites.

Despite the increase in overall consumption, the total sale of primary packaging was reduced from 7.6 to 6.7 million tons per year between 1991 and 1997 and industry collected more than 74 million tons of packaging waste (40.6 million tons thereof were sales packaging) and conveyed them to recovery with 25 million tons being returned to the production loop.

2.1.2.3 Introducing elements of a circular economy - lessons learned

From Germany's experiences representing several decades of policy evolution and huge efforts by all involved stakeholders, the following major conclusions can be drawn:

- Tapping the potential of the general public can be highly effective. The majority of Germans have proven to be both very responsive and cooperative in any measures that are being taken to reduce or recycle waste. Both individual citizens as well as non-governmental organizations have become major supporting factors leading to the success of policies.

- Involving relevant stakeholders and appealing to their responsibility is crucial. Achieving active participation such as voluntary self-commitments has shown to be vital for waste policies. Proactive communication addressing pressure groups from industries and related associations is likely to generate substantial support. For instance, the German paper industry released a voluntary self-commitment in 1997 of increasing the waste paper recycling quota. After years of high investments, the utilization rate of recycled waste paper in paper production reached 65% in 2001.

- Making use of market mechanisms and market-based instruments increases efficiency. Relying on the polluter-pays-principle is instrumental in leading to reduction at the source of any waste cycle. For example, a deposit fee system, introduced in early 2003 for one-way drinking containers, has proven to be very effective in reducing littering and shifted consumption on a large scale to returnable containers.

- Adjusting counterproductive regulations at an early stage reduces hazards and long-term costs. The CSCWMA, for example, gives a preference to recovery before disposal, which has led to the use of hazardous waste to fill abandoned coalmines, a legally possible way of recovery. Reacting to this development, the German government issued the Ordinance on Underground Waste Stowage in 2002, regulating in detail types of waste, rock formations and documentation with regard to underground stowage of waste.
Applying principles of circular economy pays off economically in the long-term. Focusing on efficiency reveals potential for cost reduction both in companies and in the whole economy. Additionally, the search for eco-efficient solutions in production unleashes innovative forces and creates business opportunities resulting in enhanced competitiveness not only domestically but also internationally.

Looking at some of Germany’s experiences summarized above might be helpful for China in identifying its own most suitable policies. Above all, the outlined approaches must be carefully evaluated in view of an entirely different historical, societal and economic background.

2.1.3 Two case studies from the United States

2.1.3.1 U.S. Toxic Release Inventory - information disclosure policy for environmental improvement

In 1986, as part of the Emergency Planning and Community Right-to-Know Act, the U.S. Congress created the Toxic Release Inventory (TRI). Enacted in the wake of two major environmental accidents involving the release of toxic chemicals in Bhopal, India (1984) and Institute, West Virginia (1985), TRI was a response to growing public demands for information about toxic chemicals and the potential for deadly exposures in local communities.

Unlike many environmental regulations, TRI did not require corporations to treat or reduce pollution emissions but simply to estimate and report to the U.S. Environmental Protection Agency (EPA) “the quantity of chemicals emitted directly into the air, land, and water or sent to locations that treat, store, or dispose toxic waste.” EPA compiles all the reported data, issues annual public reports, and provides public access to information.

Prior to the implementation of TRI, estimates of the extent of toxic emissions were widely disputed, with industry representatives challenging the “exaggerated” figures suggested by environmentalists and members of Congress. When the first annual report was released containing data for 1988, it revealed that total emissions were far higher than either industry or the EPA had anticipated.

Although not initially designed to reduce toxic emissions, public disclosure and the widespread

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6 Compiled by Mr. J. Alan Brewster, Associate Dean, School of Forestry & Environmental Studies, Yale University.
7 This Case Study draws extensively from two papers by F&ES doctoral student Monica Araya: “From Washington to Brussels: The Influence of the Toxic Release Inventory in the European Union” (DRAFT), February 2003 and “Information as Environmental Regulation: A New Disclosure Rationale for International Business Activity” (Dissertation Prospectus), New Haven, CT, May 6, 2003
9 Ibid., p. 2.
public concern created by the release of this information caused private companies to take strong measures. As a result, over the course of the next twelve years direct emissions of the initial list of toxic chemicals to the air were reduced by almost 1.4 billion pounds (63.3%) and discharges to surface waters dropped by 65.1 percent (see Table above). In subsequent years, additional toxic substances were added to the list and a wider group of industrial facilities were required to report.

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>On-Site Releases</td>
</tr>
<tr>
<td>Pounds (in Millions)</td>
</tr>
<tr>
<td>Total Air Emissions</td>
</tr>
<tr>
<td>Surface Water Discharges</td>
</tr>
<tr>
<td>Underground Injection Discharges</td>
</tr>
<tr>
<td>On-site Land Releases</td>
</tr>
<tr>
<td>Total On-site Releases</td>
</tr>
<tr>
<td>Total Off-site Releases (Transfers Off-site to Disposal)</td>
</tr>
<tr>
<td>Total On- and Off-site Releases</td>
</tr>
</tbody>
</table>

Source: U.S. EPA

How and why has TRI worked?

The following analysis is a discussion of crucial factors that underline why information disclosure policies work:

- **Self-Monitoring**: Pollution inventories offer information that is valuable to corporate managers in its own right. Managers are not required to improve their performance, but the information might expose inefficiencies in their processes or unnoticed opportunities for improvement.

- **Peer Monitoring**: In the case of TRI, peer-pressure is possible because the information comes in a comparative format, which allows benchmarking of companies. As a result of the benchmark exercises, companies that are underperforming vis-à-vis comparable peers (or competitors) face an incentive to improve their relative positions in the rankings.

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10 Taken directly from the dissertation prospectus of F&ES doctoral candidate Monica Araya.
11 Karkkainen, "Information as Environmental Regulation: T.R.I. and Performance Benchmarking, Percursor of a New Paradigm?"
12 Organization for Economic Cooperation and Development, "Pollutant Release and Transfer Registers"
Communities as Monitors: When faced with information about environmental harms, communities can engage in self-help action, putting pressure on the polluter.\textsuperscript{13} TRI has created a system whereby maximum attention is placed upon minimum performers.\textsuperscript{14}

NGOs as Monitors: There is evidence that non-governmental organizations (NGOs) can help multiply the effects of information disclosure by communicating key aspects of the TRI reports to the general public.

Media as Monitors: Neither command-and-control regulation nor market-based mechanisms have made headlines in the way that TRI has.\textsuperscript{15} The media (especially local) covers the annual releases of the TRI and exposes the names of the worst performers.

Regulators as Monitors: The government has an incentive to monitor the data from the TRI as a way to assess whether the environmental regulation in place is effective and to identify new priorities.

Markets as Monitors: There is evidence that some banks, insurers, and real estate brokers in North America use the release and transfer data as a method to assess a company’s operations.\textsuperscript{16} Hence, poor performance may affect the availability and price of insurance and non-equity capital.

Potential for effective implementation in China

The experience in the U.S. indicated that prior to TRI many industrial enterprises did not know the extent of their own toxic emissions, and that the process of measuring and reporting on these emissions was an important step in understanding how to deal with them. Achieving widespread compliance with such a policy may not be easy. As in the U.S., it may be best to start with a limited number of industrial sectors and mandated reporting on a limited number of toxic substances.

Enterprises may need technical assistance to enable them to measure these releases and to adopt cleaner production methods leading to their reduction. Public education may be necessary to enable communities and the general public to understand the implications of the information on toxic emissions. Local and provincial authorities may also need to be given training and resources to enable them to monitor and assist enterprises in compliance with the information disclosure requirements.

\textsuperscript{13} Register results can also be used to plan for possible emergencies by providing insight into the kinds of releases that could occur under emergency circumstances. Ibid.

\textsuperscript{14} Fung, “Reinventing Environmental Regulation from the Grassroots Up: Explaining and Expanding the Success of the Toxics Release Inventory,” 120.

\textsuperscript{15} For an early example see “Air Pollution, It’s All Legal,” Newsweek, July 24, 1989.

With ongoing efforts to ensure compliance and to enhance the capacity of enterprises, communities, and local officials, an information disclosure policy such as TRI could become an effective tool to promote cleaner production and a circular economy in China.

2.1.3.2 Life-Cycle Analysis to Improve Environmental and Economic Performance

The paper industry is an important component of the U.S. economy, with annual output of $55-60 billion, (0.6 percent of GDP) but contributes significantly to environmental pollution. In the early 1990s a major study was carried out to recommend steps to be taken by large corporations with respect to their purchasing and use of paper products. The study included an extensive analysis of the environmental effects and compared the overall environmental impacts of production using virgin fibers versus recycled paper.

“For the recycled fiber-based system, the Task Force examined used paper collection, transport of the recovered paper to a material recovery facility (MRF), processing of the material at the MRF, transport of processed recovered material to the manufacturing site, manufacture of pulp and paper using recovered fiber, and disposal of residuals from MRF operations and paper manufacturing. For the virgin fiber-based system, the Task Force included harvesting of trees and transport of logs (or chips) to the mill, debarking and chipping, manufacture of pulp and paper using virgin fiber, collection of the paper after its use as part of Municipal Solid Waste (MSW), transport of the waste to MSW landfills and waste-to-energy incinerators, and disposal or processing of the waste at such facilities.”

The analysis compared both production systems for five types of paper and found “clear and substantial environmental advantages from recycling all of the grades of paper examined. For each of these grades, and for the majority of the parameters examined, a system based on recycled production plus recycling results in comparable or smaller energy use and environmental releases than does a system based on virgin paper production plus waste management.” For example, in the production of newsprint, recycling would reduce total energy use by 43 percent and solid wastes by 62 percent. While some water pollutants would increase, others would decrease, and all forms of air pollution would be reduced significantly.

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17 This case study is based largely on an article in the Journal of Industrial Ecology, Volume 1, Number 3: “A Life-Cycle Approach to Purchasing and Using Environmentally Preferable Paper: A Summary of the Paper Task Force Report” by Lauren Blum, Richard A. Denison, and John F. Ruston.
21 Ibid., p. 25
22 Ibid., p. 28
Potential for Effective Implementation in China

The life-cycle analysis described above is not directly applicable to China. The Chinese paper industry is very different from the U.S. industry, for instance in terms of scale of operations and cost structures.

However, the use of life-cycle analysis techniques to assess the environmental impacts of industrial systems and alternative inputs and technologies, has great potential for China as its industries expand and evolve. Industry associations or government departments could take the lead in sponsoring or conducting appropriate life-cycle analyses. These studies could help steer investments and technological choices in the direction of more efficient production systems and improved environmental performance.

2.2 Domestic case study

China initiated activities of cleaner production as early as the late 1970s. During more than ten years from the 1990s to the present, China witnessed rapid growth of its implementation of cleaner production and circular economy, with its scope being gradually expanded from inside the enterprises to the eco-industry parks and further to the cities and provinces. Hereinafter we'll give introduction and analysis on different levels as to some cases of the successful implementation of circular economy in China on the basis of our research and investigation.

2.2.1 Enterprise level

The enterprise is a basic unit composing the economical system. Accordingly, material cycling in enterprise level is the basic performance of circular economy in the microcosmic scale. On the one hand, the enterprise can, relative freely, organize the inner material cycling based on its own objective and desire, and consciously program constructing its own ecological industrial chain; on the other hand, as one section of the circular economy loop, the enterprise can consciously exert providing chain management to restrict other enterprises but can also be restricted in reverse. Some enterprises such as 3M and DuPont, which are well-known international corporations, have achieved excellent accomplishments and gained precious experience. For instance, DuPont Chemical Corporation initiatively developed the “3R Principles” into “3R manufacturing methods”, which are well combined with the actual chemical industry through totally abandoning using some environmental harmful chemical substances, reducing the using amount of some chemical substances and inventing new technologies to recycle its own products. As a result, until 1994, the amount of plastic waste produced in the manufacturing process had reduced by 25 percent, and that of air pollutants by 70 percent. Recently, some enterprises or enterprise groups, which aim at programming and constructing characteristic ecological industrial chain also start to come into being in China.
2.2.1.1 Ecological industry in Guigang’s sugar-making

Guitang (group) Company Limited is in Guangxi province that mainly produces sugar. The company is located in the national sugarcane planting base——Guigang city of Guangxi Chuang Municipality. Sufficient sugarcane resources are featured resources of Guigang city, and such an economic structure, in which sugarcane planting is the base, sugar making is the leader, and paper making development keeps abreast of wine making development, has formed in recent decades. The total amount of direct, indirect and radiation-driving production value of sugar making industry accounts for 33.8 percent of the total GDP in Guigang city, thus the sugar making industry becomes the support industry of Guigang’s economic development and the main power of resolving the unemployment problem and reinforcing the social stability and solidification. As the leading enterprise in Guigang, with the support of National Environment Protection Bureau, in 2001, Guitang(group) planned to construct the first ecological industrial chain of sugar making industry in China in 10 or 15 years. In this chain, sugar making is the main support industry, and ecological industrial theory is applied to instruct it. And based on this construction, a national demonstrational ecological industrial zone of sugar making industry, whose leading enterprise is Guitang(group), will be constructed. This ecological industrial zone will be the first national one in China.

The main contents programmed to construct in Guitang sugar making ecological industrial chain are as follows. Guitang (group) Company Limited will be the core company, and combined with the sugarcane planting, the utility of by-produced gooey and the recycle of waste alcohol, through many processes such as reacting, optimizing, advancing, expanding, there will establish sugarcane system, sugar making system, alcohol system, paper making system, combined heat and electricity producing system, environmental comprehensive treating system. And after that a multiple-industry integrated chain with a structure of “Sugarcane—sugar-making—alcohol—paper-making—heat and electricity—cement—compound manure” will be formed. To achieve this object, 12 key construction programs have been planned during “the tenth five-year” period: a) modern sugarcane zone construction project that can provide the zone with high-yield, high-sugar, safe and stable sugarcane to ensure sufficient materials; b) technological innovation engineering of alcohol as energy resources; c) the expansion project of paper used in daily life; d) biological engineering of low-polymerization fructose; e) biological engineering of yeast; f) CMC engineering that can fully utilize the by-produced bagasse, waste gooey and waste alcohol and thus achieve the efficient circular utility of resources; g) technological innovation engineering of organic sugar; h) technological innovation engineering of green paper pulp; i) new technology improvement of sugar-making that can greatly increase the technological contents of the products, improve the producing structure and enhance the competition ability of the enterprise; j) technological innovation engineering of the sugar-pith production using the combination of heat and electricity; k) water-saving engineering that can notably reduce the consumption of public resources such as a coal powder and fresh water; l) construction
engineering of ecological industrial ability that provide insurances from many aspects such as policy and training. Such programs mainly embody the characteristics of transverse coupling, lengthwise closing, and districts conforming:

(1) There are three ecological chains that form a transverse coupling relationship with each other and come into being a reticulation structure:
   - sugarcane → sugar-making → alcohol production from waste gooey → compound manure production from waste alcohol;
   - sugarcane → sugar-making → paper and pulp making from bagasse;
   - sugar-making → low-polymerization fructose production.

(2) The efficient operation of the sugar zone, which is both the origin and converge, and the above three ecological chains embodies the zone’s lengthwise closing that is from origin to converge.

(3) The reduction of waste released toward outside and the ability of collectively treating bagasses and waste gooey from Nanning and even the whole districts of Guangxi achieved districts conformity.

2.2.1.2 Ecological industry in Tuopai’s wine-making
Tuopai Company established a combined corporation ecological mode involved in vintage industry, ecological agriculture, stock raising, medicine industry etc. Its main characteristics are as follows:

(1) Form good recycle with natural ecosystem and achieve ecological balance: In Tuopai zone districts, animal egesta and other plant organic manure is used for ecological agriculture, wastewater is retreated to be virescence irrigation water when reaching standards. Ecological agriculture can produce unpolluted vintage raw material, this provides substance insurance for Tuopai’s ecological vintage; varieties of virescence trees make climate warm and wet which does good for plenty of microbe enrich and propagate, stable microbe system again makes plenty of crooked medicine and vault mud inoculate naturally. This creates conditions for ecological alcohol vintage and good living environment for stuff in the company.

(2) Industrial ecological chains are integrit and substances utilize sufficiently: Tuopai Company designs a full chain which use lees in breed aquatics- use animal egesta to produce methane- use methane to warm vintage- use creature production in pharmacy- use fertilization in ecological agriculture- provide unpolluted vintage raw material. Lees are used to produce mash and biological active organic manure; mash is used in breed aquatics of cattle, pigs and ducks; animal egesta and other plant material are used to be organic manure or produce methane; methane is used in vintage;
cattle, pigs, ducks productions and valuable Chinese traditional medicine material planted in the zone are used as biological pharmacy raw material; mash is used in ecological agriculture; plants provide unpolluted vintage raw material; Bricks which are made from char bits are used in zone construction; 90 percent of waste water is reused in secondary production.

(3) Tuopai Company collectivizes in management and has extruded characteristics Tuopai Group Company has 24 filiales which deal with items upward. These form a multilayer, multiple cell and high benefits intensively management striding districts and trades enterprise combination which majors in vintage also deals with domains such as medicine industry, packaging, feedstuff, construction, commodity and technology exploitation and melt with science industry and trade business.

2.2.1.3 Ecological industry in Lubei
Lubei ecological industrial mode is another form in ecological industrial practice in China. Its main characteristic is two ecological industry chains which majors in exploitation of material of industrial waste such as phosphor gesso and salt gesso and seawater through developing patch chain techniques, which contain high technology.

(1) Ecological industrial chain which use gesso to produce acid: Lubei Huagong builds the first phosphor ammonium, vitriol and cement combination production equipment in China from techniques before. The equipment uses waste residue phosphor gesso, which is left from phosphor ammonium production to produce vitriol and cement at the same time, vitriol can be returned to produce phosphor ammonium. It makes upstream production to be raw material for downstream processes. Resources are high efficiently recycled used in the whole production process owing to no waste letting off.

(2) Ecological industrial chain which use water in excessive ways: Lubei Huagong builds modern big salt field and an ecological industry chain which use salt water in excessive ways which realize theoretical qualify and good resources recycle and utilization of "salt water breeds aquatics, secondary water brings up bromine, saturation bittern water make salt, salt alkali electricity produces together, high level bittern water brings up kalium and magnesium, saltern waste residue salt gesso produce vitriol and cement at the same time" through reasonable distribution modulation in the process of salt evaporation and purification. This produces integrated efficiency.

Production costs reduce in evidence owing to low raw material expenses of Lubei's two production industry chains. For example, the same phosphor ammonium, vitriol and bromine element cost 30~50 percent lower than single manufacture factory, a ton of bromine element reduce 1200~1400 yuan. This greatly increase enterprise competition power, bring along
construction of items such as manure, chemical industry, construction material, salt industry etc. It promotes integrated economy increasing.

2.2.2 Industrial Zone level
Ecological industrial zone is a practice mode with circular economy principles between several corporations beyond enterprise level. It obtains scale benefits and ecological benefits in corporation management, attains high energy and resources utilization efficiency, improves social, economic and environmental reveals in whole zone districts by resources share, rundle utilization and waste exchange. Following ecological industrial zone mode in Denmark Carlonburgh, some countries such as U.S., Canada and France began ecological industrial zone programming and construction practices quite early and gained rich experience. China also develops fast with advocating and support of related country departments. Based on incomplete understanding, there have been dozens of ecological industrial zone of different types under programming and construction and many economy development districts in process of preparation for economic industrial districts practice.

2.2.2.1 National ecological industrial demonstrational zone in Nanhai
National ecological industrial demonstrational zone in Nanhai is entirely new programming and dummy districts. Nanhai city locates at Zhujiang delta. Nanhai’s economy develops fast, its environmental markets have large requirements, and possesses manpower, technology and industry needed in environmental industry development. Combined with district development programming, its leading industry is defined to be highly new technology “Large Environmental Industry”, including four leading industry groups-environmental science enquiry services, environmental material and equipments making, manufacture of green products and resources recycling.

Twelve core enterprises and seven dummy enterprises in existence are designed to be members of industrial ecosystem in Nanhai zone districts. Based on forward and backward position relations, technology and economic feasibility and environment innocuity requirements, five symbiotic industrial ecological communities are programmed in Nanhai zone districts. These form nine industrial ecological chains (three are close recycling chains), set up ecological administrative system of three levels such as products, corporations and zone. Its target in the near future is to build national environmental industrial basements with many functions adopted to 21st century such as environmental technology research, production, incubation, communion and innovation.

Characteristics in Nanhai zone districts programming:
(1) There are five industrial ecosystems such as green board materials, disposal plastic, environmental equipments, aluminum materials, green-frozen systems which each are
comparatively independent, together form symbiotic chain-net structure. This highly increases flexibility in industrial ecosystem.

(2) Environmental science and technology enquiry services play an important part in Nanhai zone. This makes great sense for ecological industrial construction, zone industry level improvement and promotion of traditional industry upgrade revolution.

(3) The industrial ecosystem of board material process systemically describe and explain five substance recycling levels such as origin recycling, material recycling, chemical recycling, waste recycling and heat energy reuse recycling.

(4) Nanhai eco-industrial zone programming improve resource utilization efficiency through highly new technology and also quite emphasize on resource recover and reuse.

2.2.2.2 Quzhou shenjia eco-industry Park
The Quzhou shenjia eco-industry Park in Zhejiang Province neighbors on the inorganic chemical raw materials base and the fluorine chemical base, with sufficient supply of chemical materials, which facilitates the development of fine chemical industry. Scores of chemical corporations have settled down into the Park, except that they are all small scale corporations, so the leading orientation of the Park becomes fine chemical industry, the one that is compositive and reconstructive.

The construction and programming of the Park features the following characteristics:

(1) Products programming of matter integration: Based on the system of the products in existence and the backward position, combined with the trend of development, a concourse of super products is developed, together considering the centralization, marketing risk, and the feasibility of technology and other factors, discriminate the concourse of preponderant products that boosts the development of Shenjia Park. Analyze the compatibility of the matter to the programming of the products, consider the matching characteristics of different products in the park enough, so that the system of the products can be established on the basis of compositive system of technologies.

Bring forward project of integration of matters in different levels as follows: substitution of matters, reduction of the fountainhead, improvement of the process, waste use, waste exchange and waste recycling and so on for the industrial ecosystem program, it has overcome the shortcoming that these eco-industry park are barely resting on the program of product chain now, it goes deep into the inside of the technologies and the core of the process, applies the technique of the process integration to realize the aim of the eco-industry.

(2) The construction of the eco-industry management information system: The characteristic of the system is that it provides expert supportive tools for administration: the analysis tools for
river polluted fountainhead and accident fountainhead, the evaluate tools for the coming corporation. The former could clustering analysis through the three points—time, spot, pollutant, then make certain the most possible polluted fountainhead, so that the park could take some steps in time; the latter could evaluate the program of the coming corporation in several aspects —technique, economy, environment, so that they can make certain whether the corporation is suitable to develop in the park, it is propitious to improve condition that the investment program depends on the experience and the main opinion of the manager.

2.2.2.3 Baotou eco-industry park (Inner Mongolia)

Baotou eco-industry park (Inner Mongolia) is located in the eastern part of DongHe District in Baotou, covering an area of 19.8 square kilometers from HeBei Village in the west to MaoQiLai Village in the east and from the yellow river dam in the south to State Route No.110 in the north. The park is centered on the joint ventures of aluminum industry and electricity industry, with the former as its leading industry and the latter as its basis. A chain/network of eco-industry will be formed through the material exchange between intermediate products, end products and wastes in various systems involved, thus make it possible for optimum allocation of resources, effective utilization of wastes, minimization of environment pollutions and promotion of economic benefit, all of which can finally boost local economy.

The eco-industry park is constructed under the following aim: within about eight years, to set up an ecological aluminum industry park with aluminum electricity joint ventures as its core industry and the electrolysis and intensive processing of aluminum as its main route. The construction of the park is guided by the theory of circular economy and ecological industry and is supported by Baotou Aluminium (Group) Co., Ltd.. Upon completion, the park will have such features as high energy transmission, state-of-the-art technology and low pollution in addition to its optimized structure, reasonable overall arrangement and complete necessary facilities. Furthermore, it will become the biggest aluminum alloy production base in Asia, which will lend solid support to the implementation of the strategy of DongHe District to convert part of its secondary industry into the tertiary industry, help Baotou to form its spanning economic development as the new spotlight and present a new pattern of development of aluminum industry and other industries of high energy and high pollution in China.

The eco-industry park is comprised of three functional zone. The core zone is based on the joint ventures of aluminum industry and electricity industry and focuses on the development of such related industry as electricity, aluminum electrolysis and intensive processing, aluminum alloy casting and new lanthanide series construction materials. The expanded zone is the expansion of the core zone, into which part of the foundry industry and other industries of high energy are introduced as what are removed from the original location due to the reconstruction of DongHe District as well as the implementation of the strategy of converting the secondary industry into
the tertiary industry. The emitting zone will bring its eco-industry function and emission effect into full play, taking advantage of the development of the park to promote the development of other industries and other districts so as to accelerate the adjustment and the evolution of the industry structure in Baotou and Inner Mongolia.

2.2.2.4 Shihezi eco-industry park (XinJiang)
Shihezi eco-industry park (XinJiang) is about 3 kilometers in width with an area of 1 million mu around the Shihezi reclamation zone (Xin Jiang), which is mainly used for achnatherum planting and municipal sewage treatment. It will make great efforts to develop the paper making industry under the support of such local leading enterprises as XinJiang Tianhong Paper Making Co.Ltd. and will gradually emit into the whole Shihezi reclamation zone so as to meet the ever increasing need for extension of the industry chain brought about by its development.

The eco-industry park is based on the eco-environment construction and can further accelerate the improvement of eco-environment and the adjustment of the industry structure. The town of Shihezi faces a marked problem of ecological environment and resources, in which increasing deterioration of the eco-environment, desertification and salination of ploughs are quite common. Industry sewage and municipal sewage lacks necessary treatment and the main water body is severely polluted. Therefore, the construction of the park takes advantage of local resources and is based on achnatherum planting and the beneficial utilization of municipal sewage and industry sewage. Three main eco-industry chains are developed as follows: ○ farming system → paper making system → sewage treatment system → farming system; ○ farming system → stockbreeding system → livestock product processing system → sewage treatment system → farming system; ○ farming system → ecotourism system. The park will focus on the adjustment of the industry structure, the development of state-of-the-art technolgy, and finally the construction of a green industry system which may act as an economy aircraft carrier.

The park is constructed under the following aim: During the 10th five years plan period, to treat the most part of the saline-alkaline land and part of the desert within Shihezi District so as to significantly improve the eco-environment of Shihezi; to reorganize and to improve the traditional industry structure and distribution, to optimize resources allocation and to form a series of first-stage industry groups and product groups that are widely recognized domestic and abroad; to establish one or two famous brand names that are characteristic of great economic benefit, high technology, marked emission effect and a long industry chain. Within another 10 to 20 years, to form a new eco-pattern of Shihezi with an optimized structure, to expedite the strategic shift of the stockbreeding in XinJiang and to restore and improve the beauty of the eco-environment of the vast Tianshan. To fulfill its construction aim of high-tech, premium quality, great economic benefit, low pollution, having complete necessary facilities and being ecological friendly, to stand as an eco-industry park of world fame, to create a ecological scene showing the
harmony of industry and nature and to realize the sustainable development of Shihezi in its social, ecological and economic aspect.

The park is divided into three main functional zone (core functional zone, expanded functional zone and supporting functional zone) and is comprised of six main systems(farming system, paper-making system, breeding system, livestock product processing system, eco-tourism system and sewage treatment system). The core functional zone consists of the farming system, the paper making system and the breeding system, which make up the most basic and indispensable units of the park. The expanded functional zone consists of the livestock product processing system and the eco-tourism system, which aims at promoting sustainable development of the park as well as increasing the value of its products. The supporting functional zone refers to the sewage treatment system, which, as the decomposer of the contaminants produced in the eco-industry chain, is an indispensable part of the eco-industry chain.

2.2.2.5 Practices of other eco-industry parks
In 2001, UNEP designated four demonstration industry zone in China on environment management, namely Dalian economic development zone, Tianjing economic development zone, Yantai economic development and Suzhou new zone, which are joint programs of UNEP DTIE and the SEPA. Each industry zone has its particular emphasis in the course of construction, that is, Dalian economic development zone emphasizes on the implementation of APELL program, Tianjing economic development zone on the development of cleaner production, Yantai economic development zone on the development of regional cleaner production and Suzhou new zone on the establishment of environment management system. Furthermore, on the basis of what's mentioned above, Yantai economic development zone has its clear goal of the development of regional circular economy and as well as the construction of eco-industry parks with ISO14001 environment management standard system as its safeguard mechanism and the implementation of cleaner production as its technological instrument. Plans of the construction of eco-industry parks are also under way in Tianjing economic development zone and Dalian economic development zone.

2.2.3 City level
Based on the above analysis, much more aiming at the natural and economic differences in China and imbalance in the development of cities, they are classified from the view points of the structure and layout of economic industries, energy resources and environmental conditions, the infrastructure system, security system for ecological circulation, actuality of ecological environment, etc.. And the main problems about the influence of the economy and administration in Chinese cities on their sustainable ability are explained, furthermore, specific problems influenced various classes of cities are analyzed.
2.2.3.1 Shanghai

Shanghai is a megalopolis in East China, and the LEADER of the Changjiang River Delta, one of the most active areas of Chinese economy. For several years, Shanghai has explored the way of sustainable development in developing countries, combining with the advantages of being a world megalopolis. Since 1995, Shanghai has early concerned on the various approaches of circular economy practice from Japan and German, and the circular economy practice in Shanghai has come through for three states. Firstly, the circular economy study was included by the Shanghai program of 21st Agenda of China in 1995. Secondly, from 1999 to 2001, Shanghai directed the circular economy into the “Tenth-Five Year Plan” of economic and social development. Finally, from 2002 to 2005, Shanghai will establish the special plans directed by circular economy, and implant the plans in different levels as inside the corporation, between the corporations, between the industries and integration, especially for the key projects of garbage, water town, city forest and exploit of Chongming Island.

One of the important specialties in the circular economy practice of Shanghai is the innovations in the city development, systems and techniques, which harmonized the circular economy and the development as possible. With the lead of Shanghai Plan Committee, several department were joint to bring the principles of circular economy into the economy structure modulate, reconstruction of the city zone, optimization of industry layout and ecology construction. As long as the rapid rise of the Third Industry, from 27% in 1990 to 51% in 2003, the environmental protection and ecology construction were enhanced, and the circular economy was combined with city development organically. For instance, railway traffic was developed and the structure of roadway was optimized to decrease the air pollution, the housebreaking for storied building was changed to housebreaking for road, and even to housebreaking for lawn. The natural resource protection and source control were emphasized, especially the protection of plantation, wet-land and natural protection areas. As the same time, Shanghai combined the construction of law and codes organically with the circular economy, which included environmental economy policies such as price of water, charges for disposing sulfur dioxide, and the state environmental laws were implement strictly.

The economy development and environmental protection are greatly improved and approbated all over the world. In 2002, Shanghai was awarded the “Sustainable Development Award” by the Summit Reference of Sustainable Development, which proved that the developing countries can coordinate the economical development and environmental protection, choosing the style of circular economy.

The practice of circular economy development in Shanghai has succeeded undoubtedly. However, Shanghai has more work to do with the non-economy macroscopic objectives and leading the development of the whole district. Some experts pointed that, viewing the
macroscopic objectives, the non-economic achievements in Shanghai had lag behind for 5 years compared with the economic ones, and Shanghai was lack of integration ideas and macroscopic design replying the challenge of resources in the future. For example, although Shanghai has recycled the garbage with classification, the source reduction still needs more great efforts. Furthermore, the government should do more jobs to guide styles of production and consumption, and implement the “leading by market, promoting by government” reliably.

2.2.3.2 Guiyang City
Guiyang is the first experimental city of circular economy established by the State Environmental Protection Agency. As one of the open cities inland, Guiyang grasped the opportunity of circular economy and decided to build a ecological city following the circular economy style. At the middle of April, 2002, Guiyang and Tsinghua University came to a full collaborate to achieve success in environmental projects, city construction in circular economy style as the core. Then, Chinese Environmental Academy was invited by Guiyang to study and workout the experimental blue print of ecological city construction with circular economy, and draft the Regulation of Construction Ecological City in Circular Economy Style in Guiyang. At May, Guiyang was confirmed by the State Environmental Protection Agency to be the first experimental ecological city in circular economy style in domestic.

Compared with German and Japan, which are advanced in circular economy construction, Guiyang has great contrast in economy and society. Although undeveloped economy, many inherited social problems, and great lack of basic installations for future development, were deposited as the initial obstacles, they brought advantages and opportunities of latter development, and made Guiyang modulate and concentrate novel industries and styles more easily. Since the Reformation, Guiyang had developed very quickly. From 1978 to 2002, the GDP(gross domestic product) of Guiyang increased 9.6 times, annual increasing with 10.4 percent (as the price of 1990). At the same time, however, the consumption of resources increased 3.3 times (included biomass, fossil fuel, metal mine, nonmetal mine, construction material), annual increasing with 6.3 percent, which is much higher than the average all over the country. The careless development style depending on the resources had resulted in large-scale and irreversible disaster on local environments and ecological conditions. It’s an important practical problem for Guiyang to deal with, and even a long-term strategy of future development, that how to find a new developing style to prevent the synchronizing increases of economy, resource consumption and pollutant discharge, to increase the economic benefit and improve the potential of the city development, and finally to implement ( Ô the Better Welfare Society) in the undeveloped inland cities of West China with weak ecological environment.

So, Guiyang has planed to Implement One Objective, Transform Two Styles, Construct Three Core Systems, and Promote the Formation of Seven Circular Systems. To Implement One
Objective is to build a good welfare society, and keep on improving the standard of people living, maintaining the beautiful ecological environments with the continuously rapid increase of economy. To Transform Two Styles is to change the styles of product and the consumption. Firstly, the traditional careless style of city development depending on resources consumption will be transformed to novel sustainable developing style based on resources benefits. While the gross of economy reach the certain amount, the economy increase will be disjoined from the resource consumption in the future ten year or even longer. At the same time, reasonable policies and regulations on Green Consume need to be issued to build the atmosphere of Green Consume, cultivate the service systems for circular economic industries and the environmental friendly commodities. To Construct Three Core Systems is to construct circular economic systems involved the three industries, to construct the basic installation especially the recycling system of water, energy and solid waste, to construct the system of ecological protection, including green architecture, dwelling environment and ecological protect. The first of the Seven Circular Systems is recycling industrial system of phosphor. And the second is the system of aluminum. The third is of Chinese herbal medicine. The fourth is of coke. The fifth is of agriculture. The sixth is architecture and basic installation. And the final is tourism and service for circular economy. The industries included in the seven circular systems will occupy 75% of GDP in 2005, and 78% in 2010, and 83% in 2020.

2.2.4 Province level

2.2.4.1 Liaoning province
Liaoning province is the first demonstration province of circular economy established by the State Environmental Protection Agency. Lead by the State Environmental Protection Agency and Liaoning province government, experts evaluated the Experimental Program of Developing Circular Economy in Liaoning Province in March, 2002. At June 5th, the CCP Committee and government of Liaoning province hold a meeting to mobilize and deploy the experimental program of circular economy, which initialized the experiments in whole province.

Liaoning province is an important base of raw material and accoutrement production in China. For decades of years, Liaoning province had contributed greatly for the industrialization and modernization of China. Especially during the Open and Reformation, the civil economy kept on increasing and became robust, and progresses were kept on making in the standards of people’s living. GDP of Liaoning province in 2002 is 466.83 billion yuan, and that of the first industry is 51 billion yuan, that of the second industry is 230.73 billion yuan, that of the third industry is 185.1 billion yuan, respectively occupying 10.9%, 49.4% and 39.7% of the total. As the industrialization and modernization were rapidly accelerated, Liaoning province intensified the environment protection and the ecological construction. The aggravating tendency of environmental pollution was held, and the ecological damage was alleviated, even the environmental qualities of some districts were greatly improved. However, because of the
industrial structure following the traditional development style with heavy industry as the core, the exasperate tendency of ecological environment all over the province haven’t been controlled yet, with high consume of resource and energy, heavy environmental pollutions, and obvious environmental problems of the cities. The economic development in Liaoning is confined by the lack of resources, the environmental pollutants, and ecologic damage. It’s inevitable to follow the way of novel industries and develop circular economy.

The objective of the experimental development of circular economy in Liaoning is to merge the ideas of circular economy into the reform of the economic structure and transition of the industries in Liaoning province, in order to coordinate the economy, society and environment according to the actuality of Liaoning. In near future, perhaps in five years, Liaoning will establish a set of circular economic enterprises and ecological industrial parks, and several cities with resource transitions. Industrial bases of territorial resource recycling will be constructed to cultivate new points of augments, and the mechanism and system for circular economic development will come into rudiments. In ten years or so, new developing style will be formed and the systems and frameworks of circular economic development will be perfect to lead Liaoning into the sustainable way of economic and living development with fine ecological conditions. The main job of the experiment is to build several enterprises with circular economy, some ecological industrial parks and recycling-orientated societies. The government adopted following steps. ① construct full regulation and law system for circular economic development. ② research advanced suitable techniques to build the technical support system for circular economy. ③ complete the social agencies to set up the platform to exchange information. ④ strengthen the propaganda and education, and promote the Green Consume. ⑤ cooperate and communicate with international organizations, foreign governments, financial and scientific institutions to study successful experiences of the circular economy in the developed countries, and to introduce finance and advanced technology. ⑥ reinforce the lead and confirm the division of work in departments to promote the development of circular economy.

After one year, Liaoning Province constructed the security system of the organization and issued the implement programs to promote the experiment all over the province, and harvested abundant fruits including:

(1) Promotion of clean production is effective. Since 2001, there have been 230 key enterprises that completed the evaluation of clean production, and 3933 clean production projects have been implemented, with total investigation of 1.086 billion yuan and financial benefits of 902 million yuan, and the annual abatement of 110 million tons industrial wastewater, 12 thousand tons Chemical Oxygen Demand and 12.2 thousand tons sulfur dioxide, respectively occupying 10%, 6% and 2% of total discharge. Wastewater of ten coal washery, steel rolling wastewater of Anshan steel corporation, Benxi steel corporation and Dalian steel plant, ore dressing wastewater
of Anshan steel corporation and Benxi steel corporation, and ash-sluicing wastewater of six coal-fired power plants have realized Zero Discharge, and saved 53.63 million m³ water. The recycling chain among the enterprises appeared. Jinxi Natural Gas Chemical Plant in Huludao utilized highly pure carbon dioxide discharged by hydrogen process in Jinxi Petrochemical sub-Company to produce urea, and increased 18 thousand tons urea annual with benefit of 11.4 million yuan. Gaoyang Company in this city used desulfurizing wastewater of twenty molybdenum smelting plant to produce sodium sulfite crystal, with benefit of 893 thousand yuan and abatement of four thousand tons sulfur dioxide.

(2) Ecological industrial parks were initialized. Fushun Mining Industrial Group began to construct the ecological industrial park emphasized on the project of “One Mine, Four Plants and One Gas” and concentrated the coal cutting, oil refinery, power generation, building materials and coal bed gas utilization. The project of sintering brick from coal gangue was put into production and produced 60 million pieces annual. The first term of the project supplying 1.25 million m³ per month to Shanyang city was accomplished. Anshan Corporation Group began to build the system for material recycling, energy converting and waste reusing, and constructed a reusing project of 180 thousand tons water to help the industrial water recycling rate to reach 91%. At 2002, there were 109 thousand tons boiler slag and 5.789 million tons metallurgic slag recycled, and project of recycling the blast furnace gas, reel oven gas and coke-oven gas was implemented, as well as the project of ecological remedy in mine area. The program of the ecological industrial park in Dalian Economical Development District, which was recently worked out, reused 7.5 thousand water per day, and realized Zero Discharge in electroplating industrial park. The integrated reuse of hazard disposal and waste household electrical appliances, recycling of industrial mediator, and reuse of fly ash was going on practice.

(3) The demonstration of recycling-oriented society was initialized. Combined with the construction of municipal wastewater treatment plants, the project reusing 1.2 million tons mid-water per day has been started, which occupied 62.3% of the total wastewater treatment capacity in the whole province. Dalian, Anshan, Shenyang, etc. have realized recycling 452 thousand tons mid water per day. In the aspect of solid waste recycling, Dalian established experimental districts of separate garbage collection in ten communities, schools and departments, and Jinzhou cultivate the capacity of utilizing garbage to produce soil ameliorant and organic fertilizer. Fushun was building solid water treatment plant with capacity of 800 tons separated collection garbage. Shenyang had produced a device with capacity of 30 thousand tons annual to extract protein feed from table waste. The integrated reuse of coal gangue and fly ash of Chaoyang Hualong Corporation Group and Tieling Xinxin Group was put into production, and utilized 330 thousand tons coal gangue and 700 thousand tons fly ash annual.
2.2.4.2 Jiangsu province
Jiangsu province is one of the areas where the industrial economy is developed. The industrial augments and amount of main industrial production in Jiangsu kept rapid increasing, and occupied much in those of Changjiang delta district and even those of whole country. Along with the improvement of industrial structure and technical level, the industries in Jiangsu developed into mid-final term of industrialization instead of mid term. But the continuous increase of industrial economy in Jiangsu cost high and durative inputs of natural resources such as water, energy, land, metal, nonmetal, lumber and etc.. From 1990 to 2001, the increase of wastewater, air pollution and solid disposal came to 2.53 times, 2.54 times and 1.62 times. Especially, the hazard metal pollutants as the total cadmium and total plumbean, which are easily accumulated in environment, have not decreased since 1990, and the discharge of total cadmium increased 5.6 times, much more than the increase of industrial output value at the same term. In 2001, the pollution load per territorial area in Jiangsu province was highly serious all over the country, which was worthy of concerning.

Jiangsu province made rapid progress in the industrialization process, but the material metabolic process supporting the run and development of industrial system was characterized with high consume and serous pollution, because of the traditional and one-way developing style of Resource - Production(Consume) - Waste. Take into account the lack of natural resources and energy in Jiangsu and the weak bearing capacity of ecological environment, if the careless development style was hold, the ecological environment would be seriously destroyed inevitably and the sustainable development of the economy and society in Jiangsu province would be confined. There are great challenges in the development of Jiangsu province. It’s very important for Jiangsu province to transformation the traditional development style, and construct the circular economic development style base on effective utilization of resources, continuous decrease of pollutant discharge, recycling and reuse of the waste, to achieve the Twice Double in economy, and construct the affluent society in Jiangsu with spanning over in the new industrial development.

In the tide of the circular economic development in domestic, at December 2002, the Environmental Protection Agency of the province government organized related departments, colleges and research institutions to study the program of the circular economic development in Jiangsu province. The plan contains for sub programs as circular agriculture, circular industry, circular three industries and circular society. The plan is demanded to promote the circular economy as the most optimized bonding point of environment and development, aiming at the general objective of constructing the affluent society in precedence, realizing the modernization in precedence and constructing the ecological province. Later, the province government selected eighty towns, enterprises, departments, schools and communities carefully to experiment with various circular economic styles. Now, the work of the plan comes to the end.
3. Main Conclusions and Policy Suggestions

Task Force on Circular Economy and Cleaner Production was established in responding to the call of the Chinese government to take the circular economy approach for new industrialization and sustainable development. Built on the policy studies and experiences from home and abroad, the Task Force defined the concept of circular economy, collected and reviewed experiences from home and abroad, and presented policy recommendations to the Chinese Government.

3.1 Main Conclusions

(1) The rapid progress towards establishing a comprehensive well-being society should take a sustainable approach

During the past 20 years, GDP growth rate reached 9.7% in China each year. In 2000, China's GDP reached 8.900 billions RMB, per capita GDP exceeded 800 US dollars for the first time. With the fast economic growth, the economic operation quality improved. However, some worrying signs emerge. The material and energy consumption per unit of GDP in China is far higher than that of the developed countries. This not only trades off greatly the growth rate but also puts China in competitive disadvantage. On the resource front, our outlook does not allow us to be optimistic. The oil import is at a steep increase during the past 10 years. Water resource is becoming much scarcer and many mineral resources are over exploited. On the environmental front, despite the tremendous efforts, improvements are only seen in local places and the overall situation is still worsening. Both top decisions making of the country and the people are increasingly disturbed by the water body pollution, drying up of Yellow River, sand storms, floods and SARS epidemic. Global environmental problems are also increasingly threatening China's ecosystem and people. It is reported that Mr. Klaus Topfer, the executive director of UNEP, once said that the target of China’s comprehensive well-being society can not be realized if the trends of resources depletion and environmental pollution continue. In all, to achieve the goal of developing well-off society and to solve these problems, China needs change the economic development approach.

(2) Circular economy is an important pathway towards economic growth transformation, newly industrialization and comprehensive well-being society

Comparing with the traditional one-way and linear material flow growth mode, circular economy is coined to present a new economic growth mode which operates in the way of “resource extraction — production — consumption — regenerated resources”. By organizing economic activities in a closed-loop of materials, circular economy promotes the harmony between economic system and the ecosystem. In an ideal circular economy system, all the
materials and energy are effectively utilized in the circulation and therefore reduces the impacts of development on the ecosystem to the minimum. Thus, the visions under circular economy correspond to the targets of new industrialization and comprehensive well-being society. However, it is proximately estimated that the environment deterioration in China will stop only when the resources utilization ratio increase 8-10 folds. Obviously, only circular economy can realize this ambitious target.

(3) Implementing Cleaner Production Promoting Law, deepening the promotion of cleaner production is a significant measure to develop circular economy

Currently, China has issued the *Cleaner Production Promoting Law*, and till now has more than 10 years’ experience of promoting cleaner production in a systematic way. However, comparing with the industrialized countries such as German and Japan, there is a deep gap in the aspects of utilization efficiency and benefit of energy and resources. For example, the produced GDP per kg energy (equivalent oil) for China is 0.7 US dollars, while USA is 3.4 US dollars, German 7 US dollars and Japan 10.5 US dollars. Another example, the energy consumption of main industrial products in China is also higher than that of industrialized countries. These facts show that China should pay more attention to cleaner production while facilitating wastes reuse and recycling, and put the reduction of resource use and wastes creation on the top of priority. Thus, China should reinforce the cleaner production promoting law at levels of industrial activities.

(4) The coordination and cooperation is crucial to promoting circular economy

Currently, some components of circular economy, such as waste minimization, cleaner production, wastes comprehensive use, industrial symbiosis and green consumption, have been implemented to some extents in China. Meanwhile, being a comprehensive and integrated framework, circular economy is also piloted at provincial, municipal, industrial parks and other levels. In this demonstration tide, Shanghai, Liaoning, Guiyang and Jiangsu took the lead and have gained some successful experience. However, the promotion of circular economy involves activities on all aspects of an economic system and requires coordination and cooperation of all agencies of government and participation of all stakeholders. The environmental agencies play a very important role in promoting circular economy, especially at initial stage. However, without active engagement and support of economic and development agencies, there will only be circulation and no economy. It is very important that economic development agencies and all the sectors in the society to take part in the development of circular economy.

3.2 Policy Suggestions

Based on the above conclusions and the overview of the relevant practices at home and abroad, the Task Force presents the following five recommendations:
(1) To formulate the master plan of promoting and implementing circular economy by the governments under the guidance of the State Committee of Development and Reform

The development of circular economy is crucial to the realization of the strategic target of comprehensive well-being society. Thus, the development goals and master plan should be formulated to promote and implement circular economy by the governments under the guidance of the State Committee of Development and Reform. According to the principles under circular economy, increasing the utilization efficiency of energy and resources, decreasing the resources depletion and pollutants creation should be incorporated into the controlling targets. In the master plan, from the national perspective, the overall development framework should be outlined, the implementation schemes and pathways should be formulated, the driving mechanism should be created, and finally, the national capacity of implementing circular economy should be built. Under the vision of the master plan, with the economy double increasing, the resources depletion will be well controlled at a reasonable lower level and even reaches zero-increase, the discharge rate of wastes and pollutants will be well controlled. Based on the master plan, some provinces, cities and industrial parks will be selected as demonstrations to carry out some pilot projects. With information and lessons sharing, the experience of implementing circular economy can be disseminated to the rest of the country.

(2) To promote the development of circular economy by enforcement of policy and legislation

According to the agency reforming of the State Council, the Task Force suggests that some modifications should be made on the Cleaner Production Promoting Law and the law enforcement agency should be decided as soon as possible. Based on the experience from home and abroad, the implementation rules of cleaner production should be formulated, and policy and legislation instruments, including forcing, economic and voluntary instruments, should be coined or modified to guide the capacity building, research and development, finance, taxation reform, government procurement, and others towards the development of circular economy and new industrialization. Meanwhile, some laws for special areas can be formulated immediately, such as for packaging, household electric appliance management and pollution emission inventory. Based on these lower laws or regulations, the basic law for circular economy promotion can be developed in future.

(3) To establish an integrated evaluation indicators’ system to monitor the progress of circular economy and sustainable development, and the corresponding databases and information systems on material and energy flows.

Due to the drawbacks of GDP (Gross Domestic Production) to evaluate the economic development and governance, an integrated evaluation indicators’ system should be established
to include the four pillars of the comprehensive well-being society: economic increase, resources depletion, environmental quality and peoples' well-being. To support this system, the state statistics agencies should build a systematic, comprehensive, and integrated database that contains data not only on economic performance but also on resources and its use-efficiency, environment quality, especially the utilisation efficiency of stressed and scarce resources. The agencies should also establish an information system in which information can be collected and map out the material and energy flows at different levels. The development of the information system should ensure the quality, completeness and up-to-date aspects of data. The information sharing should be integrated into the system development at early stage.

(4) To promote green consumption by implementing green procurement at governmental levels

Promoting green consumption should be enlisted in government agenda and work plans, specially the environmental protection plans. Encouraging green consumption not only reduces environmental impacts of consumption activities but also fosters market for cleaner production and eco-design practices. Green procurement is an effective means to create green market and promote green consumption. There exist already some practices in green procurement in different places of China. These efforts should be promoted, expanded, better organised and regularised through government policy.

(5) To promote the technological renovation and innovation by enforcing the support to R&D and policy studies

As an innovative new economic model, circular economy needs renovations and innovations on the aspects of theories, policies and technologies. The Task Force recommends that all studies concerning circular economy should be incorporated into the state long-term plan on the development of sciences and technology. Considering the current states and future needs of economy, society and environment, the main resources and environmental problems deferring or will defer the social and economic development should be identified, the key R&D regimes or areas should be decided, especially the key techniques to support the transformation of production mode and/or consumption mode should be put forward. More studies should be carried out on: ☐ key techniques to significantly increase the utilization efficiency of energy and resources; ☐ advanced, environmentally benign manufacturing technology; ☐ new industrial technology or system with wastes as raw materials or feedstock; ☐ economic and/or taxation policies to facilitate the material closing under the banner of market economy instruments; ☐ tracing mechanism and evaluation indicators to monitoring the development of circular economy.

In the perspective of the Task Force, circular economy is an effective approach to sustainable
development. It encompasses a wide range of issues, needs multi-stakeholder involvement, long-term efforts, and co-ordination and cooperation among difference agencies. With a clear vision, strategy, action plan and innovative practices, the People’s Republic of China will be able to reach its development goal through the development of circular economy.