Discussion paper issued without formal editing

FOR PARTICIPANTS ONLY
26 December 2016
ENGLISH ONLY

UNITED NATIONS
CENTRE FOR REGIONAL DEVELOPMENT

In collaboration with

Australian Government,
Office of Green Industries SA on behalf of the Government of South Australia,
Commonwealth Scientific and Industrial Research Organisation, and
Ministry of the Environment, Government of Japan

SEVENTH REGIONAL 3R FORUM IN ASIA AND THE PACIFIC,
2-4 NOVEMBER, 2016, ADELAIDE, SA, AUSTRALIA

Role of Circular economy in achieving SDGs ~ Case of China

(Background Paper for Plenary Session 1 of the Programme)

Final Draft

SEVENTH REGIONAL 3R FORUM IN AISA AND THE PACIFIC,
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Role of circular economy in achieving Sustainable Development Goals (SDGs): A Case study of China

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1. Foreword

The 2030 Agenda for Sustainable Development and Sustainable Development Goals call for an equitable economic growth among countries. One of approaches to achieving equitable economic growth is circular economy, which requires 3R principles and its technology， policies, programs and infrastructures as basic instruments. The 7th Regional 3R Forum in Asia and the Pacific is hold under the theme of "Advancing 3R and Resource Efficiency for the 2030 Agenda for Sustainable Development" to gain policy and scientific solutions to promoting resource efficiency and 3R principles in achieving SDGs. A background paper on overview of circular economy implementation in China, including how circular economy concept developed, determination of development model and strategy, establishment of legislation and policies, and condition and outcomes of CE implementation, and the contribution of CE in achieving Sustainable development goals, is developed for The 7th Regional 3R Forum in Asia and the Pacific. This paper is expected to provide better guidance, understanding and support for effective implementation of circular economy and shared in the Seventh Regional 3R Forum in Asia and the Pacific in Adelaide, South Australia. The purpose of this paper is to address various roles of circular economy in align with the various sustainable development goals under the 2030 agenda for sustainable development in the Chinese perspective

Table of Content

Abbreviations and Acronyms

CCICED,	China Council for International Cooperation on Environment and Development
CE	Circular Economy
GDP	Gross Domestic Product
IMF	Millennium Development Goals
NBS	National Bureau of Statistics
NDRC	National Development and Reform Commission of PR China
NGO	Non- Government Organization
NPC	The National People's Congress of PR China
MDGs	Millennium Development Goals
MEP	Ministry of Environmental Protection of PR China
PPP	Public-private Partnership
SDGs	Sustainable Development Goals
SEPA	The State Environmental Protection Administration of PR China
SMEs	Small and Medium-sized enterprises
UNEA	The United Nations Environment Assembly
UNEP	The United Nations Environment Programme
WEEE	Waste Electrical and Electronic Equipment

2. Executive Summary

Sustainable development is a global unified goal since United Nations Conference on Environment and Development in 1992, and both developed countries and developing counties are committed to transforming our world into a sustainable world. China is one of those countries and have make effort to achieving 17 sustainable development goals by promoting Circular Economy (CE). Circular Economy was proposed as a national strategy that developed to address environmental issues and resource scarcity after a period of intensive economic development.

The method of promoting CE is launching a small number of CE demonstration enterprises, industrial parks, cities, and province, and then gradually increasing number of demonstration unit at each level to expand the range of CE implementation. This number increased from 74 units in 2005 to 140 units in 2007, and finally reached 1000 enterprise and industrial parks around China in 2013. The outcomes of 10-year CE implementation are remarkable and have made great contributions to achieving sustainable development goals. Higher level of resource efficiency, effective resource comprehensive utilization and better resource recycling have significantly reduced economic dependence on resource and environment, lowered carbon emission and decreased waste disposal. This helps to make the Chinese economic development model more sustainable, while generating direct economic benefits such as employment opportunities as industrial chains are lengthened by implementing circular economy initiatives. Sustainable economic development as well as better environmental and resource management make construct a safe, resilient and sustainable city possible.

Constrains and challenges that confined development of CE have also be also identified during the implementation of circular economy. Weak economic incentives and enforcement ability of legislation may weaken enterprises' engagement in circular economy. Advanced level of technology will also affect improvement of resource efficiency and resource recycling. Incomplete performance assessment system would result in poor assessment of circular economy performance. The complexity of government system made monitoring and management more difficult.

3. Background

Since the 20th century, significant environmental burdens related to population explosion, aggravation of global warming, environmental degradation, and resource scarcity have now been major concerns around the world. Under the demand of economy growth, balancing the relationship among economic development, environment and resource has become the greatest challenge and has caused many countries to seek innovative approaches to address these problems.

Since United Nations Conference on Environment and Development hold in 1992, sustainable development has been widely accepted as the key to meeting human development needs while protecting the earth's life support systems. Sustainable development is now an international consensus and an important objective of international and regional cooperation, and countries have made great progress in promoting sustainable development and achieving Millennium Development Goals (MDGs) so far (NDRC, 2012a). To promote and implement sustainable development further over the next fifteen years, the *2030 Agenda for Sustainable Development* had been adopted by world leaders at the UN Sustainable Development Summit in September 2015, and had established 17 sustainable development goals (SDGs) as core (UN, 2016). This agenda aims to mobilize effort to achieving sustainable development from local to global levels.

One proposed approach to achieving sustainable development is Circular Economy (CE), which aims to resolve the problem of dwindling economic resources by treat economic waste as a useful economic resource. A circular economy is an alternative to a traditional linear economy (make-use-dispose) in which we keep resources in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life. The traditional economic development strongly relies on environment and natural resource, causing environmental problems and resource scarcity, it is now realized that our planet should be regards as a closed economic system rather that open-ended system. The aim of Circular Economy is to convert the conventional linear

relationship of “Resource-Product-Waste & Emission” between into a circular relationship of “Resource-Product- Resource”, and encourages a closed-loop of material flows to weaken the dependence of economy on natural resource and environment (Sun, 2010). By promoting Circular Economy, an opportunity of reinvent economy is provided to make economy more sustainable and competitive, and benefits brought to businesses, industries, and citizens alike will be remarkable (EC, 2016).

Through embedding the 3R principles (Reduce, Reuse, and Recycling) into production and consumption process, the circular economy can be well implemented to minimize the raw material and primary energy input and reduce the load on natural sinks (Zhu, 2007, Heck, 2006). To date, increasing number of countries has taken measures to promote the circular economy, including Japan, Austria, Germany, and the Netherlands, and have already made strategies compatible with circular economy to some extent (Heck, 2006).they all give example of achieving sustainable development by implementing circular economy. Circular economy has also been accepted by some developing counties. However, every country has their own understanding and strategies of practicing circular economy due to different stages of economic development for different countries.

China as a developing country with huge population, facing the problem of environmental degradation and insufficient average resource per capita, its economic development is strongly confined by environment and resource. In addition, China is still under the pressure of improvement life qualities of citizens due to unbalanced regional development and partial poverty (56 million impoverished people by the end of 2015) (NBS, 2016). Therefore, the emergence of practicing sustainable development is instrumental for achieving stable economic growth and improving life qualities of citizens while protect over extraction from environment. In China, circular economy has been regards as a vital strategy for achieving sustainable development by the central government (George et al., 2015, Yuan et al., 2008, Geng et al., 2012), and has been widely accepted by scholars, scientist and policy maker that circular economy is the optimum development model to achieve sustainable development

(Xiong, 2004). This paper will evaluate the contribution of implementation of circular economy to sustainable development in mainland of China in detailed.

4. Development of circular economy in PR China

4.1 Current situation of Chinese economic development model

The Reform and Opening Policy was implemented in 1978, which was a signal of transformation from planned economy to market-oriented economy. Since then, the Chinese economic development has a great leap (Figure 4.1). However, its strategy has been focus on high savings and investment, strong export orientation and manufacturing and construction industries. The importance of environmental protection has been gradually realized in China, but economic growth is still first priority for China in the past three decades. The extensive economic development model indeed makes Chinese economy rapidly developed in a short period with an average annual GDP growth rate of 10%, approximately (Green and Stern, 2016). This progress is mainly contributed by energy intensive heavy industries in China. As a result of industrialization and urbanization, the proportion of GDP contributed by primary industry has gradually reduced, while the proportion of GDP contributed by tertiary industry has obviously increased since 1980 (Figure 4.2). However, the proportion of GDP contributed by secondary industry remains a high level (nearly 50%), which indicated the important position of heavy industry in supporting Chinese economy.

China Council for International Cooperation on Environment and Development (CCICED) and Garnaut et al characterized Chinese economic development as; a) a very high level of investment was put on heavy industries such as steel and cement production which is extremely energy consumption (both direct fossil fuels consumption and indirection consumption by coal-fired generated electricity consumption) ; b) the economy is strongly dependent on exports and external markets, thus the Chinese economy is quite vulnerable to external economic floating (CCICED, 2014, Garnaut and Ross, 2014, Garnaut et al., 2013). During the period of 2000-2013, the coal consumption grown at an average rate of 8% per year, thus China became a net coal importer from 2009 and its consumption took up nearly half of global coal

consumption (NBS, 2015). The GDP growth rate in 2008 and 2009 obviously decreased due to the impact of the global financial crisis of 2007-2008, which prove the dependence of Chinese economy on external markets (Figure 4.1) (Green and Stern, 2016).

Although this economic growth model have lifted hundreds of millions of Chinese out of poverty, there is an increasing agreement on that this model is not sustainable or desirable - for economic, financial, social and local environmental reasons (Pew Research Centre, 2013, Wike and Parker, 2015, World Bank& DRC, 2013, IMF, 2015). As the economic, financial, social and local environmental issues has been recognized by Chinese leaders, China's leaders began appealing to the need for fundamental structural change and policy reform in order to respond to steer China's development path onto a more sustainable and desirable course (Green and Stern, 2016). Data shows that economic growth rate started declining since 2010 and was expected to be stable at 5%.

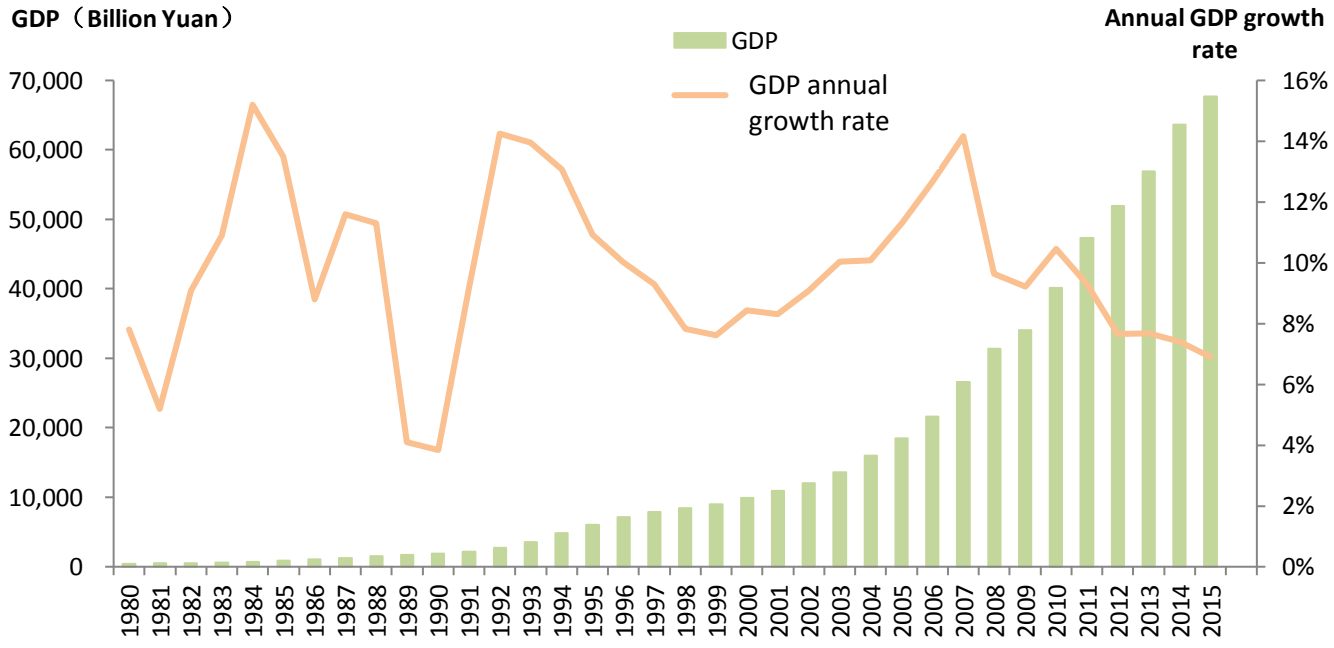

Figure 4.1 The GDP growths in China since 1980-2015 (NBS, 2015, NBS, 2014).

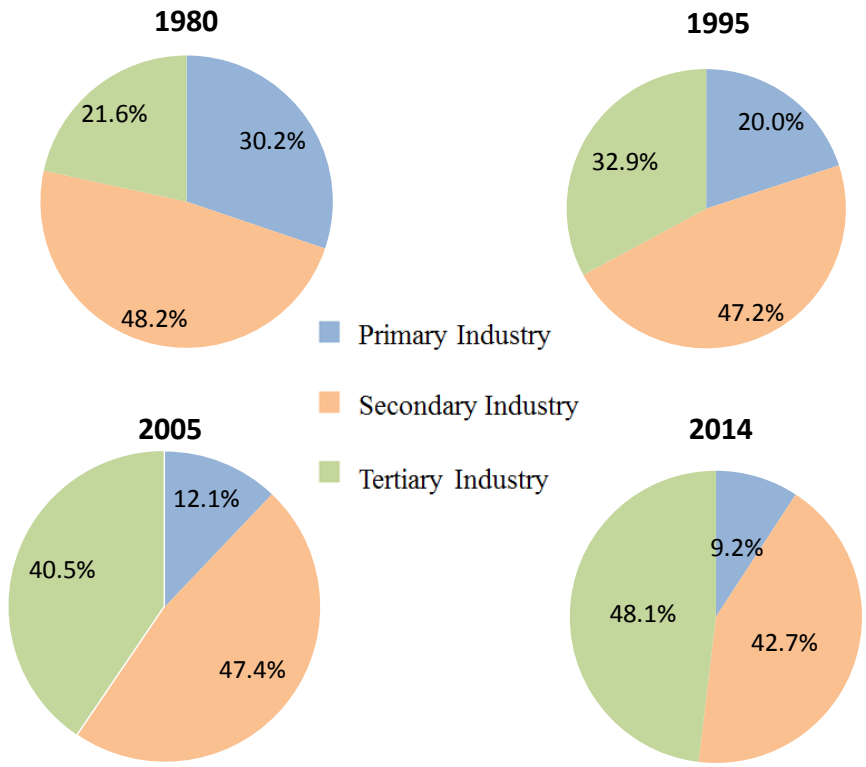

Figure 4.2 Economic structure transformation from 1980-2014 (NBS, 2015, NBS, 2014).

4.2 Transfer towards circular economy

4.2.1 Necessity of towards a circular economy

There is a huge success brought by extensive, heavy industry focused economy development model, while the problem of this model is non-negligible. Currently, the heavy construction and heavy industries already reach the saturation point, and continued political-economic incentives investment will diminish returns on capital and weaken productivity growth (CCICED, 2014, IMF, 2015). Thus, it will be difficult to keep economic growth.

The traditional economic growth model have caused numbers of negative impacts on environmental. Raw material exploration caused a large amount of waste generation and pollution emission. In 2010, the raw metal relative industry (include black metal, non-ferrous metal) generated 1.8 billion industry solid waste, and

discharge 2.73 million tons SO_2. Pollutions and Risk by the un-regular treatment of product waste was posed to environment and human health.

The reliance on coal-fired power and growing vehicle use in urban area has led to acute air pollution. 85% of SO_2, NO_x, CO_2 emissions and 70% of the dust come from coal In 2012, the primary consumption proportion of raw coal and crude in China was 86%, far higher than the world average proportion (63%). Total greenhouse gas emissions in China has surpassed the United States ranked first in the world since 2007 Rohde and Muller (2015) estimated that particulate matter pollution PM2.5 pollution is contributed to 1.6 million premature deaths per year. Water and soil pollution is also noticeable. It is reported by (MEP&DLR, 2014) that about 16% of land was polluted, which include about 20 million hectare of agricultural land (take up one fifth of total agricultural land). In terms of water condition, it was reported in January 2015 that 29% of total surface water was polluted to different extent, including 11% of surface water was heavily polluted (China, 2015). The economic loss caused by environmental pollution and ecological degradation is equivalent to 10% of annual GDP and huge amount of money was spent on environmental remediation (Sun, 2010).

In addition, resource and energy already became a huge constrain to Chinese economic development. China is the most populous country in the world and constitutes a quarter of world population. However, China only holds a low quantity of resource per capita, with 1/4 of world's average water resource per capita, 1/3 of world's land area per capita and 1/2 of world's mining resource per capita (Qian, 2009, Sun, 2010). China holds about 19% of world population, but only owns 17% of ferrous ore, 17% of copper ore, 11% of alumina, 11% of oil and 4.5% of natural gas. This data shows that water resource, land and major metal resource reserve per capita is lower than the average level in the world.

With such limited resource, the resource efficiency is also relatively low. Generation of US$1 of GDP requires 2.5 kg material in China compared with 0.54kg material per US dollar of GDP in OECD countries (in 2005 dollars) (Mathews and Tan, 2016). The energy and resource consumption industries also requires large

amount of fossil fuels and mineral input which already exceed the domestic supply. Therefore, Chinese economy growth strongly relies on the external resource supply, and the stability of Chinese economic growth increases (Sun, 2010).

It was widely agreed that the conventional economic growth model is unsustainable. Therefore, a sustainable, environmental friendly and resilient development strategy is required to address above problems and challenges while maintain a reasonable growth rate. The idea of circular economy is thus emerged and promoted in China to decouple the economic growth from environmental degradation and inefficient resource consumption.

4.2.2 Transfer towards circular economy

- **Development of concepts of Circular Economy**

The initial idea of Circular economy came from (Boulding, 1966), who stated that our planet is like a spaceship in the universe as closed system. This "spaceship" has limited resource on it without external input and output, and the resource will ultimately be used someday. Therefore, the resource on the planet must be recycled to maintain its essential functions. At late 1990s, facing the challenges of economic growth, environmental protection and carbon emissions mitigation, Chinese scholars inspired by the publication of The German Closed Substance Cycle and Waste Management Act in 1996 and first proposed the concept of Circular economy in China (Zhu, 1998, Zhu, 2008).

The Law of Circular Economy Promotion define circular economy as: The reduction, reuse and recycle activities during the processes of production, circulartion and consumption (NDRC, 2008). This simple definition is unable to well represent the function and connotation of circular economy, but it implies the core position of 3R principles. The "3R" principles—reduction, reuse, and recycling of materials and energy—are often described as three possible approaches to practice of circular economy (Feng, 2004). They have been embedded in production and consumption since the flow of materials and energy penetrates in both areas (Zhu and Qiu, 2007).

Reduction aims to minimize the input of energy and raw materials by the improvement of production efficiency, and also reduce the all kinds of waste production during the process of production, movement circulation and consumption, which is the most preferred option among three principles. Reuse refer to byproducts, recovered products, remanufactured products and wastes from one company or industry being used as resources/raw materials for itself or other industries. It requires using products to its maximum capability with frequent maintenance and reclamation to prolong its endurance. Recycle encourages processing the recyclable materials into new products so that the consumption of virgin materials can be reduced. These approaches are expected to achieve an efficient economy while discharging fewer pollutants.

Through 10 years' exploration and practice, China raises its own connotation and characteristics for circular economy. Yuan et al (2008) concluded that China's circular economy is an idea about the economic pattern and development strategy in respect of nature rather than environmental management policy (Zhu, 2008, Su et al., 2013, Geng et al., 2012). It is in line with Chinese scientific development strategy, and is very helpful in improving resource efficiency and environmental management, along with achieving sustainable development and win-win situation in both economy and environment. In addition, China's circular economy not simply aims at garbage economy or 3R economy for treating solid waste in respect of objects but at all scarce resources involved in China's economic development, including water, land, energy, materials and corresponding waste. Scholars and policy maker also realized increasing need to develop from low-level recycle of waste based on ecological efficiency (reduction on pollution and waste) to high-level recycle of products and services based on ecological effects (prevention of pollution and consumption)(Yuan et al., 2008).

- **Establishment of development paths, models, and strategies, and policies.**

After attendance of United Nations conference on environment and development

1992, sustainable development was put into schedule by Chinese central government. In 1994, China identified sustainable development as its national strategy by publishing *Population and development for 21st century in China White Paper*. Circular Economy as one of the effective approach to push sustainable development forward, actions were taken after the concept of circular economy proposed in 1996. The State Environmental Protection Administration (SEPA, former Ministry of Environmental Protection-MEP) started to promote the concept of CE by launching a series of trial projects across the country in 1998 (Yuan et al., 2008).

In 2002, Circular Economy is formerly accepted by Chinese central government as the main development strategy (Yuan et al., 2008). The "11th five-year (2005-2010)" national plan and "12th Five-year (2010-2015)" national plan has regards CE as the main task to build up resource-conserving and environmental-friendly society (NPC, 2006, 2011). In 2008, president Hu stated that promoting circular economy in large scale was a main request in building a moderately prosperous society in the report to the 17th National Congress of Communist Party of PR China (Hu, 2007). Than in 2012, Present Hu pointed out that Circular Development is a national strategy, and also one of the main approaches to achieve ecological civilization construction in the report to 18th National Congress of Communist Party of PR China (Hu, 2012).

The United Nations has also agreed that circular economy could be an approach to achieving sustainable development. In the 5th resolution about Chemicals and Waste, adopted by the United Nations Environment Assembly (UNEA) of the United Nations Environment Programme(UNEP) at its first session in 2014, it was emphasised that sound management of chemicals and waste, which is advocated by circular economy, contributes significantly to sustainable development (UNEP, 2014). Then at the second session of the United Nations Environment Assembly of UNEP in 2016, the 7th resolution and 9th resolution have further stated that all stakeholders were invited to engage in environmentally sound management of waste to prevent, reduce, reuse, recycling and recovery waste, including food waste. In 8th resolution, it was also declared that circular economy can be an approach to sustainable consumption and production (UNEP, 2016). Those contents have already shown in our Circular

Economy Promotion Law published in 2008.

In 2002, the Cleaner Production Promotion Law was established. This law does not directly mentioned about circular economy, but it came out environmental audit to improve resource efficiency and prevent and reduce the generation of waste, which is compliant with circular economy and is helpful in implementing circular economy in early time (NPC, 2002).

Then, Suggestions on Accelerating Development of Circular Economy by the State Council of PR China was published in 2005, which is the first document that supports promotion of circular economy implementation from a national level (the State Council, 2005). This document provided guidance on financial, taxation and investment measures on facilitating circular economy implementation, and clearly defined the responsibility of government and focus of circular economy promotion work.

National Medium and Long Term Development Outline for Science and Technology (2006-2020) has included circular economy as key technology in the document in 2006, and has provide technology supports to practice of circular economy (NDRC, 2006).

On August 29th, 2008, the Standing Committee of the Chinese 11th National People's Congress (NPC) passed the Circular Economy Promotion Law, which came into force in China on January 1, 2009 (NPC, 2008). This is third specialized legislation for circular economy after Germany and Japan in the worldwide.

The Cleaner Production Promotion Law was revised in 2012, which enhanced the intensity of punishment of deregulation (the State Council, 2012). The newest version of Environment Protection Law, which amended in 2014, have emphasis strengthening resource recycling and cleaner production (NPC 2014). The Prevention and Control Law on Environmental Pollution by Solid Waste revised in 2015 also declared to promote circular economy and cleaner production (NPC 2015). In addition, over 200 pieces of policies, regulations, guidance and standards related to circular economy have been published during 2005-2015 to facilitate the implementation of circular economy, and examples was given in table 4.1(the State Council, 2013).

By establishment of Circular Economy Development Strategy and Recent Action Plan, the state council published the plan during 2010-2015 for circular economy development. This document set the resource efficiency goals, goals of comprehensive utilization rate and recycling rate goals by 2015 for total 11 types of industries, which have been achieved by now.

A new plan for next five year for circular economy is being made by National Development and Reform Commission recently, and the draft of Guide Plan for Circular development is published. Main tasks for 13th five-year (2016-2020) are : to fully promoting circular production to construct a circular industry, agriculture, service industry and a circular society; to build up a circular development system and new resource strategy; to reduction consumption and emission, improve resource efficiency and promoting green life (including green consumption, waste classification, etc.) (NDRC, 2016). It is also announced that resource productivity should increase by 15% compare with 2015 level, and the Comprehensive utilization rate of industrial solid waste, Comprehensive utilization rate of straw should exceed 73% and 85%, respectively. Over 75% of national industrial park and 50 of provincial industrial park should implement circular economy. The expected output value of recycling industries is 3000 billion RMB (equivalent to 450 billion US dollars).

Table 4.1 Examples of policies, guidelines, regulations and plans for circular economy published during 2005-2015.

NO.	Name	Year of	Source
1	Recovery and Management measures on renewable resources	2007	The State Council
2	The Regulation for the Administration of collection and Treatment of Waste Electrical and Electronic Equipment(Chinese WEEE)	2008	The State Council
3	Notice on demonstration base construction of Urban mining	2010	National Development and Reform
4	12th five-year plan of Mineral resources saving and comprehensive utilization	2011	The Ministry of Land and Resources
5	12th five-year plan of Major industrial solid waste comprehensive utilization	2011	The Ministry of Industry and Information Technology
6	Implementation plan of comprehensive utilization of crop and straw during 12th five-year plan	2011	National Development and Reform Commission, the Ministry of Finance, the Ministry of Agriculture
7	The opinions on the promotion of circular-transformation of Industrial parks	2012	National Development and Reform Commission, the Ministry of Finance
8	Comprehensive utilization of resources guidance during 12th five-year plan	2012	National Development and Reform Commission
9	Circular economy development strategy, and the recent action plan	2013	The State Council
10	Action plan of Energy development strategy（2014-2020）	2014	The State Council
11	Opinions about accelerating the construction of ecological civilization	2015	The State Council
12	Guide Plan for Circular development (Draft open to public advice)	2016	National Development and Reform Commission

5. Achievement of circular economy and role of circular economy in achieving SDG

5.1 Implementation of Circular Economy in China

The Circular Economy strategy requires complete reform of the whole system of human activity, which includes both production processes and consumption activities. Thus, it is a long-term process of transformation in both individual level and national levels. Before circular economy is officially proposed, the State Environmental Protection Administration (SEPA) started to promote the concept of CE and launched a series of projects across the country. These projects mainly focused on waste recycling through the construction of waste based closed loops among different companies. Those practices provided guideline and experience for following promotion of CE，and a three-layer approach of promoting CE was proposed.

Since 2005, the three-layer approach was applied to implement Circular economy. At the micro or individual firm level, the implementation of CE is achieving by conducting Cleaner Production (CP) auditing, which is obligatory for heavily polluting enterprises. The environmentally-friendly enterprise evaluation mechanism was also launched. At the meso or second level, the main objective is to develop an eco-industrial network that will benefit both regional production systems and environmental protection by energy cascading utilization, sharing of local infrastructure, and exchanging by-products and recycling wastes. Development of eco-industrial parks (EIPs) is a typical practice at this level, More than 100 industrial parks throughout the country have claimed that they are developing or transforming towards EIPs (Yuan et al., 2008). At the macro or social level, the practice of CE is developing eco-cities, eco-municipalities, or eco-provinces. In China, the difference between an eco-city and an EIP is that eco-cities focus on both production and consumption activities, while EIP focuses on production activity, especially industrial production (Yuan et al., 2008). Efforts at all three levels include the development of resource recovery enterprises and building public facilities, were made to support

realization of the CE concept. The number of demonstration units at each level will gradually increase to expand the practice of circular economy to a wider ranger and to facilitate the transformation to circular economy. The CE implementation model shows in Figure 5.1.

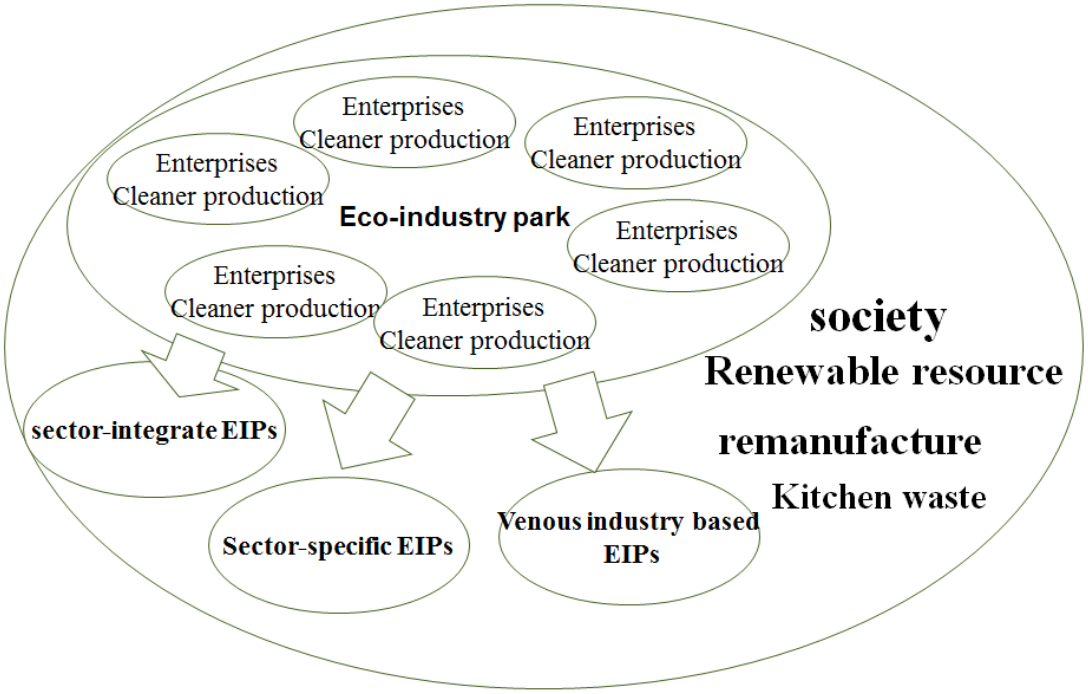

Figure 5.1 The Circular Economy implementation model in China.

In 2005, the first batch of circular economy demonstration unites was launched, which signified the start point of circular economy implementation. Total seven industries was and four recycling system was included, which mainly focus on transforming heavy industries to circular development. Total 67 enterprises, industrial parks from 19 provinces, have finished their transition and have been approved by in 2014 (NDRC et al., 2014) (Table 5.1).

The second batch of circular economy demonstration unites was launched in 2007. This project did not simply aim at heavy industries, but also included papermaking and textile industries, which have significantly negative effects on environment, as well as agricultural and forestry industrial. Extra 66 enterprises, industrial parks, cities and towns, and provinces have passed the national checking, in 2015 and the total

number of demonstration units increased to 150. Extra 9 provinces were added into implementation area. By the end of 2015, 29 provinces out of total 34 provinces have started their transformation to CE (table 5.1).

A huge project, called the circular economy “ten-hundred- thousand” project was carried out since 2013. This project aims to achieving technology throughout and management innovation, to promote circular economy to a considerable range. Firstly, ten circular economy demonstration projects were set up as list in Table 5.1. Each individual project will contain numbers of units (enterprises, industrial parks or cities) to complete its tasks. Those task including improve comprehensive utilization rate, founding innovative approaches to achieving comprehensive utilization, reducing emissions or even achieving zero emission, technology innovation, waste innocuous process. A hundred towns or cities and a thousand enterprises and industrial parks were chosen to participating one or more project. Guide Plan for Circular Development (NDRC, 2016) also stated that by 2020, 75% national level parks and 50% provincial level parks should implement the circulation reform.

Table 5.1 The List of national circular economy demonstration units. (Source: NDRC, 2014, NDRC, 2015, NDRC, 2016, NDRC, 2005, NDRC, 2007).

OBJECTS	1st batch	2nd batch	Ten, hundred and thousand project
	2005	2007	2013
Key industries	Iron and Steel nonferrous metals Coal Electricity Chemical industry construction material light industry	Iron and Steel nonferrous metals Coal Electricity Chemical industry construction material Papermaking Textile industry Machine manufacturing Agricultural processing Agriculture and forestry	**Ten demonstration Project includes:** Comprehensive utilization of resource Industrial park transformation to circular economy Renewable resource recycling system Urban mining Remanufacturing industrialization Food waste recycling and innocuous process Collaborative recycling of waste from production Agricultural circular economy Circular service 3R technologies industrialization
Key recycling fields	Renewable resources Metal scraps Waste electric and electrical products Remanufacturing	Renewable resources Metal scraps Waste electrics, waste tires, and waste batteries. Packing materials	
Enterprise	46	33	1000
Industrial Parks	21	20	
City and towns	14	9	100
Provinces	3	4	

In terms of social level, circular production and green consumption was promoted, and a complete recycling system should be build up for the entire city. Though years practice of CE, remarkable progress was made on promoting circular economy. Few examples were given below.

■ **Urban mining demonstration base construction.**

Chinese national development and reform commission and the ministry of finance has approved 6 batches of a total of 49 national "urban mining" demonstration bases by now. Urban mining demonstration bases located around China, but mainly concentrated at the eastern China. It was noticed that there is still 6 provinces have no demonstration bases, they are Jilin Province, Hainan Province, Yunnan Province, Qinghai Province and Xizang Province. There are four models of demonstration bases: market-led model, professional base model, leading enterprise model, and government-led model, and leading enterprise model is most preferred.

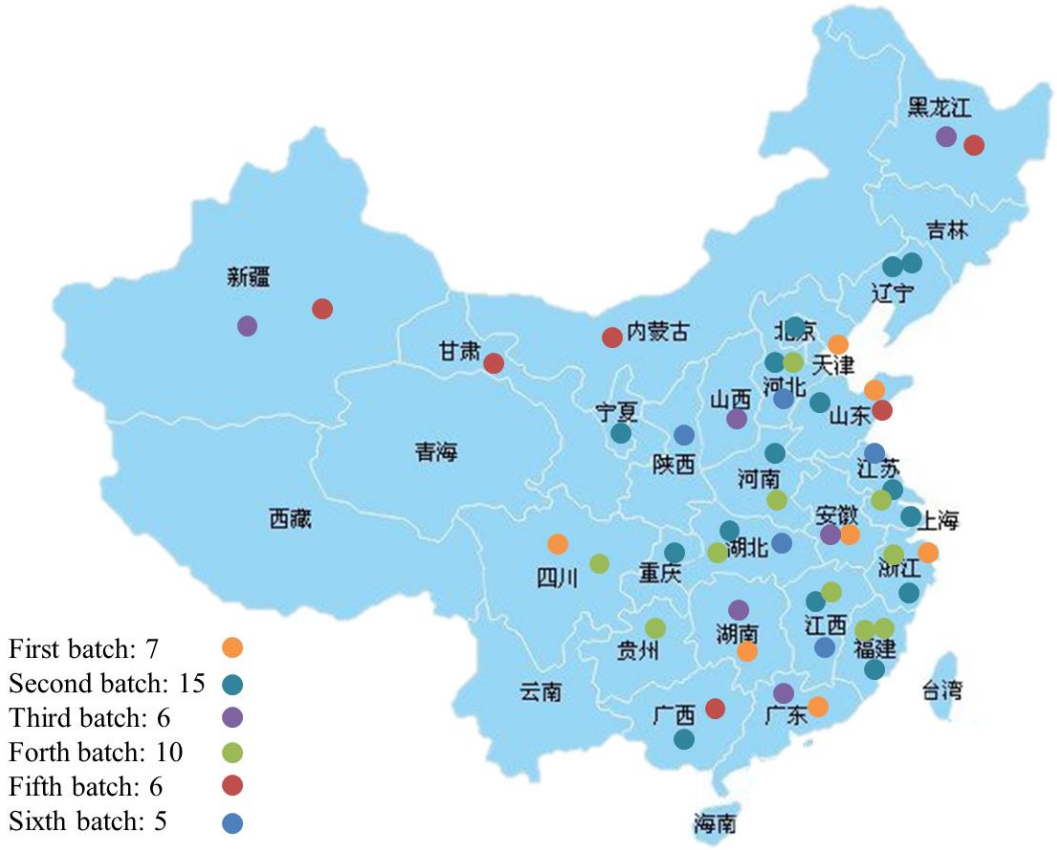

Figure 5.2 Location of 49 urban mining demonstration bases in china.

■ Waste Electrical and Electronic Equipment (WEEE) recycling

The WEEE recycling was a relatively good field of circular economy implementation. Except for Regulation on the Administration of Collection and Treatment of Waste Electrical and Electronic Equipment, there are few documents to facilitation and regulation of WEEE recycling, such as Guidelines for the Preparation of Development Plan of WEEE Treatment and Catalogue of WEEE Treatment. Administrative Measures on License of WEEE Treatment make WEEE recycling more normalized, and Administrative Measures on Collection and Use of Treatment Fund of WEEE stipulate that authorized enterprises can obtain subside when doing WEEE recycling. Until 2015, 109 WEEE recycling enterprises have obtained the license of the WEEE Treatment and been included in the list of WEEE Treatment Fund of e-waste. The authorized products increased from 5 categories to 14 categories in 2014. It is clear shows that the recycling rate of TV, Refrigerator, Washing Machine, Air Conditioner, Computer significantly increasing during since the WEEE fund was applied in 2012.

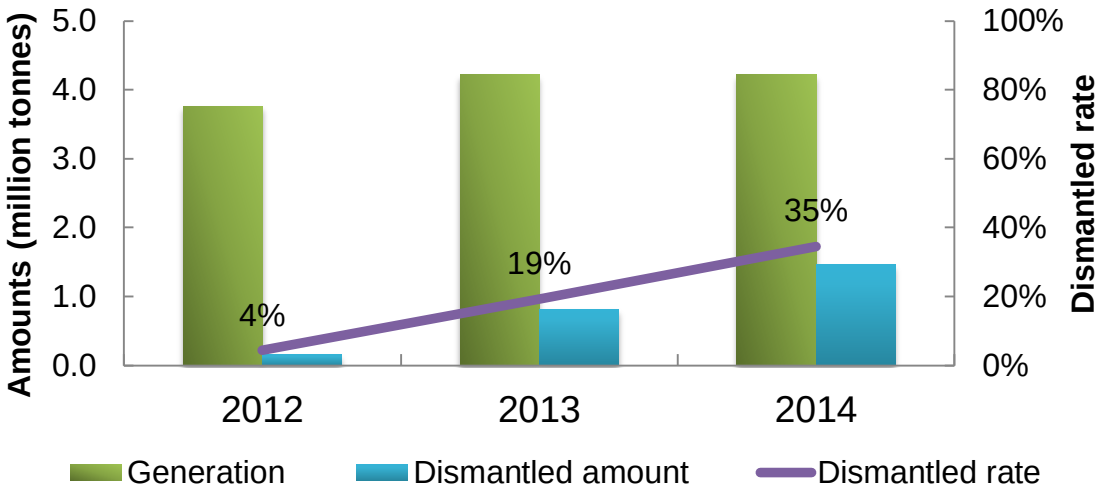

Figure 5.3 Recycling rate of total number of TVs, Refrigerators, Washing Machines, Air Conditioners and Computers during 2012 to 2014.

■ Re-manufacture industrialization

During 2008- 2014, total 42 enterprises were chosen as auto parts pilots to promoting the remanufacture industry in China. The remanufactured product “ old for

remanufacture" pilot project was launched in 2013, and then in 2015, 10 enterprises were chosen as pilot unit and the list of promoted products was given, which mainly included gearbox and engine (NRCD, 2015).

- **Kitchen waste pilot development**

The state council issued Opinion on Strengthening the Management of Illegal Cooking Oil and Kitchen Food Waste in 2010, and national authorities started to carry out pilot work of urban kitchen waste recycling and environmental sound disposal, China has organized five batches of kitchen waste recycling pilot projects since 2010, to explore the establishment of conditions on the registration of kitchen waste, authorized recovery, evaluation and supervision management system of centralized treatment and resource-based product. This project also included building kitchen waste recycling and safe disposal demonstration projects, guide scientific consumption and reduce the generation. At present, the number of kitchen waste demonstrative city has reached 100 in China. NDRC and Ministry of Finance has established five batches of pilot city of utilization and harmless treatment of kitchen wastes in 2011, 2012, 2013, 2014, and 2015, and city number of each batch is 33, 16, 17, 17 and 17, respectively.

- **5.2 Contribution of circular economy to SDGs and its outcomes.**

The overall aims of SDGs include thriving lives and livelihood, improving food security and water security, universal clean energy, healthy clean productive ecosystem, and to build sustainable societies (Griggs et al., 2013). By implementation of circular economy, a part of SGDs can be accomplished to benefit economy, society and environment and to achieve human well beings for both current generation and later generations. The contribution of circular economy in achieving SDGs in China was concluded in the following.

5.2.1 Significantly reduce impact of economic development on environment and resource.

The traditional economy development strongly relies on environment and economy. To decouple economic development with environment and resource, higher resource efficiency, resource recycling and using renewable resource are promoted in China.

- **Improvement of resource efficiency**

Higher resource efficiency means that a higher GDP can be generated using less resource, raw material and energy. In general, resource productivity have been significantly increasing sine 2005 which indicated from efficiency of mineral resource, energy and water. It is reported that per tons of coal can generated 12.4 thousand RMB product value in 2010 compare with 10 thousand RMB per ton of coal in 2005, and energy intensity is estimated to increase to 1.47 thousand RMB in 2015. Water intensity has increased by 59% from 2005 to 2010, and is estimated to increase by 118% till 2015. A remarkable progress of reduction on energy efficiency is also noticed. Energy consumption for generating 10,000 RMB GDP decreased from 1.22 tons of coal to 0.76 tons of coal. From 2011 to 2015, the energy consumption per GDP decreased by 2.0%, 3.6%, 3.7%, 4.8%, and 5.6% respectively(NBS, 2016a). According to the newest report, energy consumption for the first half year decreased by 5.2% compare with energy consumption in 2015 (NBS, 2016c). In terms of water efficiency, water consumption for generating 10,000 RMB GDP declined 70% in the last decade (Figure. 5.4). Higher energy efficiency can reduce the coal consumption when generating the same GDP, and therefore make contribution to carbon emission reduction. Higher water efficiency can mitigate water scarcity to some extent.

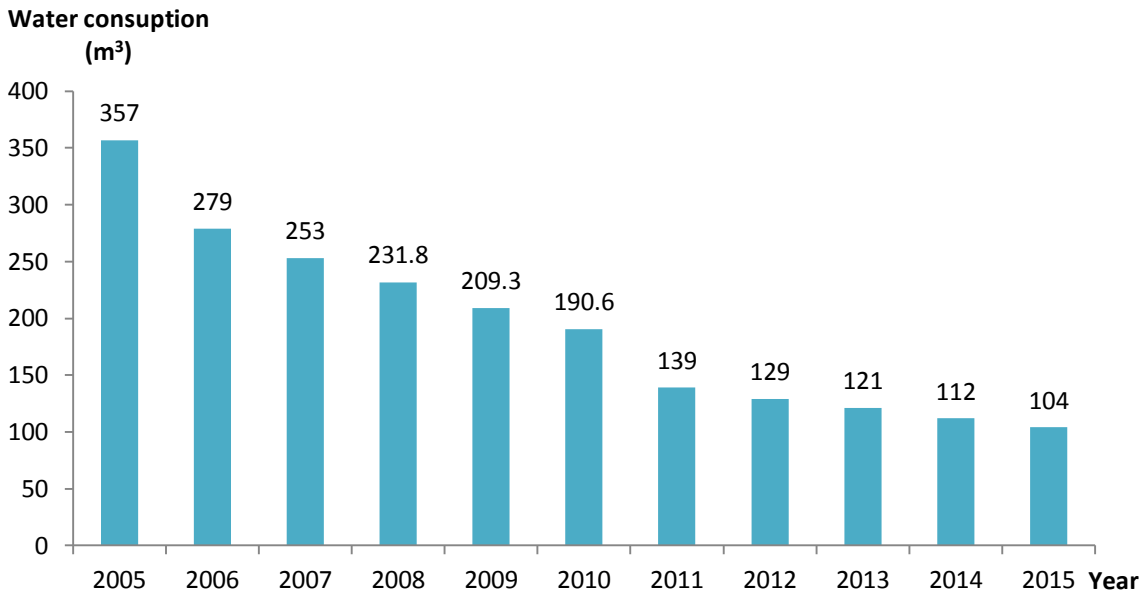

Figure 5.4 Water consumption for generating 10,000 RMB GDP from 2005-2015. Source:(NBS, 2016b).

■ **Achievement in resource comprehensive utilization**

The price of primary energy, raw material and resource keep increasing due to the resource scarcity problems. Solutions to the rising cost of production are resource comprehensive utilization and renewable resource recycling. Those approaches can directly cut down the input of raw materials and primary resources.

The most direction effect of implementing circular economy is rapid development of comprehensive utilization of resource, including mineral resource, waste and renewable resource. Generally, comprehensive utilization rate of all resources grows at annual rate of 1% since 2005 to 2013 (the State Council, 2013). By developing comprehensive utilization of resource, approximate 6700 hectare of land for storing solid waste was decreased.

By using renewable resource such as steel and non-ferrous metals, it is estimated that 0.25 billion tons of coal can be saved every year, and waste water discharge, carbon emission and solid waste production can reduce 17 billion tons, 0.6 billion tons and 5 billion tons, respectively, compare with using primary resource (NDRC, 2014). By recycling waste textile, 3.8 million tons of oil and over 220 thousand hectare of agricultural land was saved.

Waste comprehensive utilization

The dressing reclaiming rate of non-ferrous minerals is up to 85%. Mining recovery rate of coal and Iron can reach 95%. Recovery rate of byproducts during mining keeping increasing, and the recovery rate of Au, Ag, S and Mo was 66.7%、71.4%、76.7% and 47.0%, respectively. The annual recycling amount of mining waste was 0.3 billion ton in 2013, which took up 18.9 of mining waste production. 3% of recycled waste was used to produce valuable metals, and the annual productivity exceeds 10 million tons. Total product value of mining waste utilization was 90 billion RMB. The electricity generated by waste or byproducts produced during coal production can reach 30 million KWH, which is equivalent to electricity generated by 450 million tons of primary coal.

Industrial solid waste was also well recycled (table 5.2). 62.3% of the total amount of industrial solid waste produced in 2013 has been comprehensive utilized (NDRC, 2014). Gypsum, as a byproducts of industrial activities, its utilization rate approximated 50% in 2013 and 10% was increased since 2009. Waste residues from steel and non-ferrous metals smelting is 67% and 17.5%, the total utilized amount reach 0.36 billion tons. Those residues are mainly used as construction production and chemical materials. Comprehensive utilization rate of chemical industrial residues vary among different types. Some solid waste can achieve 100% recycling such as calcium carbide and chromium waste. However, Comprehensive utilization rate of some industrial solid waste is lower than 20%, including soda ash and barium waste. The cycling rate of construction waste was only 5%.

Table 5.2. Comprehensive utilization of industrial solid waste in 2013.

	Comprehensive utilization amount (ton)	Comprehensive utilization rate (%)
Total industrial solid waste	2,590,000,000	62.3
Gypsum	88,300,000	48.1
Steel smelting waste	230,000,000	68
Non-ferrous metals smelting waste	130,000,000	17.5
Calcium carbide	20,100,000	100
Chromium waste	900,000	100
Soda ash	3 000,000	16
Barium waste	96,000	20
Construction waste	50,000,000	5

- **Renewable resource recycling**

The achievement in renewable resources recycling is also negligible. There are ten main renewable resource identified by Ministry of Commerce. According to statistics by Ministry of Commerce, the total recycling volume in the past 5 year is 977 million tones, and annual volume of recycling has been significantly increased in 2014 and 2015, which is 1.5 times of previous level (figure 5.5). In 2014, amount of ten categories renewable resources in China reached to 245 million tons, the recovery approximate 64467 hundred million Yuan. The recycling details of ten main renewable resources are showed in Table 5.3. Iron and steel, paper and plastic are most recycled renewable resource in China, which compose about 90% of total recycled volume.

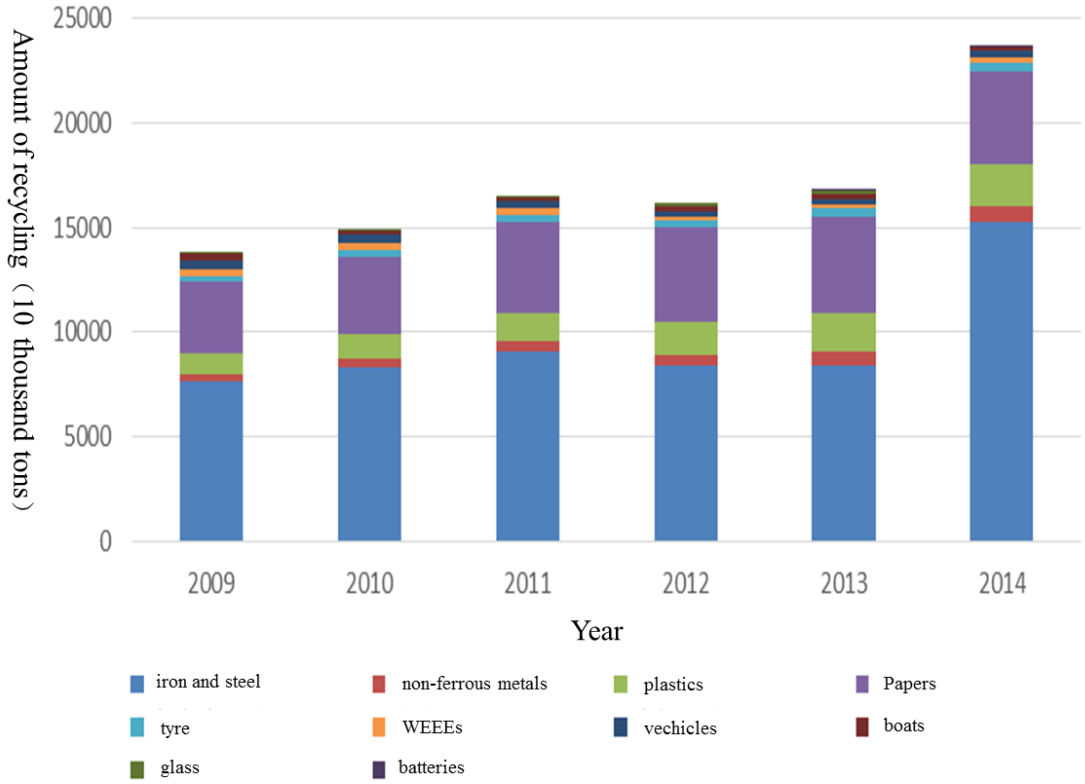

Figure 5.5 Total recycling volumes of 10 main renewable resources since 2009-2014.

Table 5.3. Recycling volume of 10 main renewable resource from 2011-2015. (Unit: million ton, Source: Commerce, 2016, Commerce, 2015, Commerce, 2014, Commerce, 2013)

	2011	2012	2013	2014	2015
Iron and Steel	91	84	85.7	152.3	143.8
Non-ferrous Metals	4.55	5.30	5.56	7.98	8.76
Plastic	13.50	16.00	13.66	20.00	18.00
Paper	43.47	44.40	43.77	44.19	48.32
Tire	3.29	3.70	3.75	4.30	5.01
Electric and electrical product	3.71	1.91	2.64	3.14	3.48
Vehicle	2.85	2.49	2.74	3.22	8.72
Boat	2.25	2.55	2.50	1.09	0.91
Battery				9.5	10
Gasses				8.55	8.50

The advantages of resource comprehensive utilization and recycling of renewable resource is embodied from three aspects. Firstly, circular economy calls for using of

byproducts, waste and renewable resource to instead of primary energy and resource. This can directly reduce abstraction of resource, including minerals, wood, fossil fuels, from environment by human beings, and less damage will be caused to environment. Secondly, the recycling of metals, such as steel and non-ferrous metals, can reduce the coal consumption that used to smelting metals, and therefore can also make contribution to carbon emission reduction. Thirdly, by using those waste and byproducts as resource, less solid waste requires to be disposed. If industrial solid waste cannot be deposed properly, contamination will posed to soil, water and air. Thus, circular economy also makes contribution to improvement of waste management. It is also mentioned above that land for restoration of solid waste is saved, which can relieve city from land stress. Overall, those advantages play important roles in building up inclusive, safe, resilient and sustainable cities.

- **Carbon and water recycling**

In addition, recycling of waste water is also encouraged. Numerous volume of water is used in industrial activities every year, which aggravates water shortage problems. Recycling of waste water can remarkably reduce the extraction of water resource. For example, the annual recycling rate of min water was estimated to be 62% during 2010-2013, and the annual recycling amount of mine water was above 6 billion tons m^3 (NDRC, 2014). Recycling of water can also prevent contaminated water discharged into surface water system and groundwater, and therefore can improve water security to a certain extent.

The CO_2 recycling capacity approached to 10 million tons in 2013, which is doubled compare with carbon recycling capacity in 2000 (NDRC, 2014). The national carbon emission in 2010 was 7.2 billion tons and keeps rising until 2015. Thus, it is estimated that carbon recycling can reduce 0.1% carbon emission every year. If the carbon recycling can be further promoted, more achievement can be down on carbon emission reduction.

- **Agricultural and forestry waste recycling**

Agricultural and forestry waste was also included. It is clearly stated in the Circular economy development strategy, and the recent action plan that the national task of transforming agriculture into a circular mode (the State Council, 2013). In 2013, over 600 million tons of straw was comprehensive utilized, accounting for 77.1% of straw production. About 95% of forestry waste was used, which mainly used for papermaking and biomass energy. Over 40% of livestock waste was recycled to generate methane.

5.2.2 Sustainable economic development

Circular Economy as a national development strategy, the first priority will still be developing economy, but in a more sustainable way. The sustainable economic development is achieved by higher resource efficiency and higher proportion of renewable resource in production. Actually, emerging industry related to circular economy can also create considerable economic benefit. The product value of resource comprehensive utilization was up to 1300 billion RMB in 2013 (NDRC, 2014). However, promoting of circular economy does have impact on economic development. The economic growth from 2010-2015 shown a steady decline trend, but the GDP is still increasing. A slower economic growth might be more sustainable and suitable for China (Green and Stern, 2016).

In addition, circular economy was regarded as sustainable development model because CE is able to extent industrial chain and therefore to create more employment opportunities (Sun, 2010). It is reported that 18 million people are engaged in resource recycling industries.

5.2.3 Sustainable society

Building sustainable societies means eliminating poverty, ensuring healthy lives and promoting well-being for all at all ages, and providing safe, resilient and sustainable citied. A prerequisite of economic development is required for building up a sustainable society. The construction of 3R infrastructure can improve resilience of a city by better recovery abilities of external impact. Circular economy also reduces negative environmental effect by reduce resource extraction, carbon emission and pollutions, therefore to provide a better environment for human beings. Last but not least, higher employment rate created by CE can increasing the safety and stability of the society.

6. Lessons from circular economy practice

6.1 Constraints, barriers and challenges of transition towards circular economy in PR China

Through 10 years practice of CE，several challenges and constrains that can slow down or restrict the implementation of the CE have been recognized numbers of scholars. Those challenges and constrains reflects from following aspect: poor information system, insufficient advanced technology, weak economic incentives, weak enforcement ability of legislation, immature leadership and management, incomplete system for performance assessment and shortage of public awareness.

Systemic information is very crucial to decision making, because it enable decision maker to find more financially beneficial and environmental friendly plan and management for their resources structures to design the a specific scenario for its optimal reduction, reuse and recycle activities (Geng and Doberstein, 2008). For an enterprise, not only internal information would be necessary, but information of a larger economic system or web is also required. However, fragmented management frameworks, different kinds of information are from different agencies, and the information exchange will be in efficient. Therefore, creating systematic information net will be a huge challenge in China. As development of Internet based platform, this situation might be improved in the future.

Science and technology are always the primary productive forces and have been playing a key role in the national economy development in China. Although economic development model is transforming, the importance of science and technology does not change. 3R principles require advanced technology and development and the updating of facilities and equipment (Su et al., 2013). However, the technology level in China is still backward especially in environmental field due to lack of financial support. For example, the resource efficiency is still much lower than OECD countries (Mathews and Tan, 2016).

Economic incentives are always the useful to guide the development direction.

However, there is unwillingness for the government to take economic and financial measures to take management (Wang et al., 2008). Higher price of resource and energy might not be useful as the producer can lift sale prices, hence the economic incentives might be more effective in this situation. Lack of economic incentives will also confine the innovation of environmental friendly technologies (Su et al., 2013)

Another constrain is that poor enforcement of The Law of Circular Economy Promotion, the only legislation about circular economy. Punishment for noncompliance is inadequate, injured parties are not properly compensated, and volunteer compliance is not rewarded. This will lead to poor compliance of legislation, and effectiveness of law is very limited (Wang, 2006).

Fifth, government's management system has been questioned in China due to the complex structure of government agencies, poor accountability of local governments and straight-forward corruption. The implementation of the CE over a sustained period required integrated management efforts, including the top leadership, pro-active participation from major actors at all levels of government, and transparency and predictability in both the administrative and economic policy instruments (Ma and Ortolano, 2000). As a result, failures in the management of energy, materials and environment in China to a greater extent can be attributed to deficiencies in these respects.

In terms of public awareness, practices of Germany and Japan indicate that public participation is crucial to the development of circular economy. It could be more important for China due to spectacular effect can be created by numerous population (Geng and Doberstein, 2008). In fact China lacks the human and institutional capabilities to encourage public participation in a CE. Also, environmental management programs and facilities at many Chinese academic institutions are limited (Su et al., 2013).

Finally, more systematic assessment standards should be established with consideration of process of data collection, calculation and submission, prevention-oriented and absolute energy/material consumption reduction indicators, to setting specific and quantitative goals in each local government (Geng et al., 2012).

The data collection and evaluation by local government can result in lack of transparency monitoring and inter-city inequity of auditing. The accuracy and validity of data are also problems. Yong (2011) pointed out that regional-specific indicators should be provided as the regional imbalance on economic development, resource endowment, technology level and public awareness on CE, and this might be stimulate poor western region to implement circular economy.

6.2 Disadvantage of circular economy in China

During the implementation of circular economy, some problems have also been noticed. Reduce is the first priority among 3R concepts, but it has not been reflected from practice of circular economy. This requires a good design and accurate calculation for every single step to reduce the waste during production. In addition, there is also lack of indicator to assess the performance of reduction measures. The achievement in reduction was rare mentioned in national report and industrial report. Enterprises prefer to make contribution to reuse and recycling because it is easier to be assessed and accepted by government. Importance of reduction should be emphasized and reward mechanism should be established to encourage reduction.

7. The Way Forward:

In concluded, a solution to the world's resource-security problem is to transform linear economy to a circular economy (Mathews and Tan, 2016). China's circular economy strategy is a significant step forwards in bridging the global gap between economic and ecological sustainability and promoting achievement of sustainable development goals. However, more effort need be made to facilitate regional 3R development in Asia and Pacific region. China as a representative country in Asia, hold large population and is one of the major world manufacturing bases. The lessons and experience of implementing circular economy in China can be references for other Asian countries.

As the importance of legislation and economic initiative in China realized, corresponding institutions, including legislation, policies, regulations, guidelines and strategies, are recommended to be established in a national level in other similar counties to promote circular economy in national level. In addition, the economic initiatives and financial measures should be enhanced. Circular economy funds and extended producer responsibility institution might be a good practice.

There are already some regional organizations and platforms existing, which play an intermediary role among countries. Fully make use existing of organizations, regional platform, and centre under specific convention, to achieve information exchange, technology transfer and technology support among countries. Consulting service can also be provided to give necessary information and advice on decision making.

A standard assessment system should also be development nationally and internationally to evaluate recirculation potential and performance of a production process. Unified indicators can also be developed to assess 3R performance of enterprises, cities and countries. A standard reporting guideline can be drawn up by international originations, such as UNCRD, for all member countries. This will benefit corporations and competitions among countries.

Make use of existing corporation relationships, such as South- North Cooperation South–South Cooperation, and land and maritime Silk Road initiative, to achieve 3R cooperation. Country who wishes to develop circular economy can seek technology support, financial support from cooperated countries and create more business opportunities. Therefore, the collaboration and communication among counties within Asia and Pacific region, or even in a wider range, can be enhanced to promote implementation of circular economy.

Last but not least, encourage the development of Public-private Partnership (PPP) to make more stakeholders, including governments, Inter-government organizations, NGOs, Industrial Association, Academic Institutions, enterprises and others to engage with 3R infrastructure construction. . In addition, different type of enterprises, including large company, SMEs, WEEE and Metal recycling and Equipment manufacturers should also involve in 3R implementation and explore different cooperation modes to maximizing their functions for promoting 3R development.

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