

# **Research Series on the Chinese Dream and China's Development Path**

## **Project Director**

Xie Shouguang, President, Social Sciences Academic Press

## **Series editors**

Li Yang, Vice president, Chinese Academy of Social Sciences, Beijing, China

Li Peilin, Vice president, Chinese Academy of Social Sciences, Beijing, China

## **Academic Advisors**

Cai Fang, Gao Peiyong, Li Lin, Li Qiang, Ma Huaide, Pan Jiahua, Pei Changhong

Qi Ye, Wang Lei, Wang Ming, Zhang Yuyan, Zheng Yongnian, Zhou Hong

Drawing on a large body of empirical studies done over the last two decades, the *Research Series on the Chinese Dream and China's Development Path* seeks to provide its readers with in-depth analyses of the past and present, and forecasts for the future course of China's development. Thanks to the adoption of Socialism with Chinese characteristics, and the implementation of comprehensive reform and opening, China has made tremendous achievements in areas such as political reform, economic development, and social construction, and is making great strides towards the realization of the Chinese dream of national rejuvenation. In addition to presenting a detailed account of many of these achievements, the authors also discuss what lessons other countries can learn from China's experience. This series will be an invaluable companion to every researcher who is trying to gain a deeper understanding of the development model, path and experience unique to China.

More information about this series at <http://www.springer.com/series/13571>

Jianguo Qi · Jingxing Zhao · Wenjun Li  
Xushu Peng · Bin Wu · Hong Wang

# Development of Circular Economy in China



 Springer

The Springer logo, which consists of a stylized chess knight piece above a horizontal line, followed by the word 'Springer' in a serif font.

Jianguo Qi  
Chinese Academy of Social Sciences  
Beijing  
China

Xushu Peng  
Chinese Academy of Social Sciences  
Beijing  
China

Jingxing Zhao  
Chinese Academy of Social Sciences  
Beijing  
China

Bin Wu  
Chinese Academy of Social Sciences  
Beijing  
China

Wenjun Li  
Chinese Academy of Social Sciences  
Beijing  
China

Hong Wang  
Chinese Academy of Social Sciences  
Beijing  
China

ISSN 2363-6866                      ISSN 2363-6874 (electronic)  
Research Series on the Chinese Dream and China's Development Path  
ISBN 978-981-10-2464-1              ISBN 978-981-10-2466-5 (eBook)  
DOI 10.1007/978-981-10-2466-5

Jointly published with Social Sciences Academic Press

Library of Congress Control Number: 2016951685

© Social Sciences Academic Press and Springer Science+Business Media Singapore 2016

This work is subject to copyright. All rights are reserved by the Publishers, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publishers, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publishers nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

Printed on acid-free paper

This Springer imprint is published by Springer Nature

The registered company is Springer Nature Singapore Pte Ltd.

The registered company address is: 152 Beach Road, #22-06/08 Gateway East, Singapore 189721, Singapore

# Foreword I

China's economy has been rapidly growing since reform and opening up began more than three decades ago. Meanwhile, China's consumption of natural resources has also increased nearly 20-fold, raising environmental concerns, including ecological degradation, serious pollution, and the resource depletion. Despite these, China has made tremendous improvements over the last 10 years to address these issues and started to pay more attention to energy conservation, emissions reduction, and environmental protection. At the 18th National Congress of the Communist Party of China, top priority was given to developing a strategic plan guided by the concept of ecological progress to tackle such issues. The reform package which covers economy, politics, culture, and society aims not only to promote sustainable development in China, but also fulfill the "China Dream", and building a beautiful nation for its people.

To construct a sustainable ecological civilization in China, a feasible circular economy needs to be developed. My experience working as an official at the State Environmental Protection Administration in 2000, did not only give me the opportunity to learn about China's complex environmental issues, but also led me to look for ways to tackle them. Although China is still a developing nation with the largest population in the world, it is also quickly becoming the world's largest economy. The country is facing an enormous task to keep up with its economic growth, while also trying to protect its environment. In light of this, China's *Environmental Protection Initiative* was launched to enforce a solid environment legal framework that would prevent further damage at the source, while simultaneously strengthening its role in the legal system to tackle major issues such as pollution, in a systematic way. The circular economy framework also serves as an alternative model for economic development. Benefits such as lowering consumption levels of natural resources and energy, providing a safe and efficient way to recycle waste, and overall reducing emission levels. Most importantly, all of this can be achieved without interfering with the country's economic growth, and or putting harsh constraints on its resources.

Considerate efforts have been made to promote China's circular economy development by taking it from theory to practice among its local population. With the concept of circular economy becoming more widespread over the last decade, the Chinese government and a large number of its state enterprises have also recognized the importance of informing the public about the initiative. As a result, the *Circular Economy Promotion Law* was the first of its kind to be implemented in the country to provide the legal, regulatory and policy framework for promoting circular economy nationwide. Under the leadership of the central economic authority, pilot-demonstrations were used to do the following: (1) organize recycling programs and upgrade its industrial parks and demonstration zones; (2) promote its national demonstration centers into "city mining" programs on a trial basis, where resources from kitchen waste would be recovered and handled appropriately; (3) promote the remanufacturing industry; (4) come up with policies that support the financing and investment of projects in the development of circular economy; (5) promote and raise public awareness of circular economy; (6) set up a funding program that would provide financial support to pilot-demonstration projects in related fields with the help of the central government; (7) come up with a comprehensive development plan of circular economy that includes the production, distribution and consumption of remanufactured materials to all levels for all enterprises, industrial parks and cities.

Since it was first adopted, China's circular economy model has been steadily making progress. In 2012, statistics from various industrial associations showed that the volume of eight major renewable resources, including steel and nonferrous metals, amounted to 160 million tons. To put this into perspective, this was an energy saving equivalent to 170 million tons of standard coal. As a result, it also reduced a total discharge of 11.27 billion tons of waste water, 3.746 million tons of sulfur dioxide, and 3.39 billion tons of solid waste. Reports also indicated that the volume of reclaimed copper reached 2.75 million tons during the same year, accounting for 45 % of China's copper output. In addition to this, over 600 million tons of crop straws and more than 1.1 million tons of kitchen waste were reclaimed for comprehensive utilization. Consequently, with the help of circular economy, the use of waste material utilization can foster sustainable economic growth in China.

Although circular economy has become a more widely known concept in China, it is still in its initial stages of development and continues to face enormous challenges ahead. China's difficulties lie in finding ways to maintain its economic development, while consumption of natural resources and energy continues to soar. China's reform package also aims to improve its market mechanism in order to meet the country's increasing rate of urbanization growth.

Environmental laws and policies would also need to be improved to allow the funding and use of innovative technologies that can implement, support and maintain resource recycling in a safe and efficient way. Social service management programs should also be established to oversee key areas where development of circular economy is still needed. In its *Twelfth Five-Year Plan (2011–2015)*, the Chinese government announced that the output efficiency for resource utilization would need to be increased by 15 % within the plan's time frame, but so far this goal has been too difficult to achieve due to the people's lack of knowledge about

the initiative. Therefore, promoting and raising public awareness of circular economy, and the importance of constructing an ecological civilization has become a key objective during this period. The aim is to inform local communities and how individuals can step up to protect the environment and develop circular economy as a nation. The Chinese government must also step up its efforts to ensure its circular economy framework will go according to plan by providing relevant legal and regulatory policies, revising and improving economic measures, enhancing supervision on its environmental management, speeding up its technological innovation, increasing its ability to provide public service and administration when needed, and finally, furthering the development of circular economy.

Academic institutions such as the Institute of Quantitative and Technical Economics under the Chinese Academy of Social Sciences, and the Center for Studies on China's Circular Economy and the Environment, are places where scholars in China engage in circular economy research and consultation. For more than a decade, they have done extensive research on the development of circular economy in China and in other countries which has been instrumental to the success for its own circular economy framework so far. With the help of the researchers, the Chinese government and its state enterprises are given the theoretical consultation and decision support they need to implement and improve its circular economy model. Written by a dedicated research team under the leadership of Prof. Qi Jianguo, the deputy director of the *Institute of Quantitative and Technical Economics* and director of the Center for Studies on China's Circular Economy and the Environment, it is my hope that this book will not only provide readers a general overview of China's development of circular economy, and the Chinese government's continuous efforts to facilitate its progress and future direction, but also inspire readers from developing nations, who can learn from China's experiences for their own industrialization, including using circular economy to reduce conflicts arising between the pursuit of economic growth and protecting the environment and resources, in order to achieve a sustainable economy.

China's plan to develop a viable circular economy and construct a sustainable ecological civilization is a grand undertaking that would not only generate immediate, but also long-term benefits for the nation. As president Xi Jinping once stated during a visit to an event promoting circular economy:

*Turning waste into treasure, cyclical utilization promotes an emerging industry. Wastes are misplaced resources. Turning waste into resources, and making use of discarded things is a kind of art. Let us persevere on this path.*

I am convinced that China's path towards industrialization through the development of circular economy will make a positive impact on improving the efficiency of utilizing resources, fighting against global climate change, promoting industrialization in developing countries, and ultimately developing a sustainable economy for all.

# Foreword II

To avoid repeating the West's mistake of "polluting first, cleaning up later" that was made during the industrialization process, China has been facilitating the development of a circular economy framework for more than a decade. As China's economy continues to grow, strategies are being used to prevent further deterioration of the environment, to limit wastewater discharge, and to conserve resources and energy. Despite criticisms concerning China's environmental progress, including tackling its severe levels of pollution, the country has been actually making progress in this area since the middle stages of its industrialization. The introduction of circular economy in 2000 was not only critical to improving the state of China's environmental affairs, but it also provided a gateway to making large-scale improvements in just 5 years after its initial implementation.

This book is written with four aims. Firstly, to study and analyze the background on China's development of circular economy. Secondly, to tell its readers about the history of China as a developing nation, its progress on catching up with the rest of the world, and the government's role in making effort to promote circular economy nationwide. Thirdly, to unveil the current practices and breakthroughs of China's circular economy development through the use of story-telling. Lastly, to build readers' confidence in China's economic sustainability through the development of circular economy as well as the wisdom of the Chinese people.

All compilers of this book are researchers from the *Institute of Quantitative and Technical Economics under the Chinese Academy of Social Sciences*, and the *Center for Studies on China's Circular Economy and Environment*. All of them have at least 5 years of experiences in China's circular economy research and are major authors of the *Development Report on China's Circular Economy*, the only book that introduces China's development of circular economy to readers at home and abroad. I hope you enjoy reading this book.



## Series Preface

Since China's reform and opening began in 1978, the country has come a long way on the path of Socialism with Chinese Characteristics, under the leadership of the Communist Party of China. Over 30 years of reform efforts and sustained spectacular economic growth have turned China into the world's second largest economy, and wrought many profound changes in the Chinese society. These historically significant developments have been garnering increasing attention from scholars, governments and the general public alike around the world since the 1990s, when the newest wave of China studies began to gather steam. Some of the hottest topics have included the so-called "China miracle", "Chinese phenomenon", "Chinese experience", "Chinese path" and the "Chinese model". Homegrown researchers have soon followed suit. Already hugely productive, this vibrant field is putting out a large number of books each year, with Social Sciences Academic Press alone having published hundreds of titles on a wide range of subjects.

Because most of these books have been written and published in Chinese, however, readership has been limited outside China—even among many who study China—for whom English is still the lingua franca. This language barrier has been an impediment to efforts by academia, business communities and policy-makers in other countries to form a thorough understanding of contemporary China, of what is distinct about China's past and present may mean not only for her future but also for the future of the world. The need to remove such an impediment is both real and urgent, and the *Research Series on the Chinese Dream and China's Development Path* is my answer to the call.

This series features some of the most notable achievements from the last 20 years by scholars in China in a variety of research topics related to reform and opening. They include both theoretical explorations and empirical studies, and cover economy, society, politics, law, culture and ecology, the six areas in which reform and opening policies have had the deepest impact and farthest-reaching consequences for the country. Authors for the series have also tried to articulate their visions of the "Chinese Dream" and how the country can realize it in these fields and beyond.

All of the editors and authors for the *Research Series on the Chinese Dream and China's Development Path* are both longtime students of reform and opening and recognized authorities in their respective academic fields. Their credentials and expertise lend credibility to these books, each of which having been subject to a rigorous peer review process for inclusion in the series. As part of the Reform and Development Program under the State Administration of Press, Publication, Radio, Film and Television of the People's Republic of China, the series is published by Springer, a Germany-based academic publisher of international repute, and distributed overseas. I am confident that it will help fill a lacuna in studies of China in the era of reform and opening.

Xie Shouguang

# Acknowledgments

After a relatively short gestation period, the *Research Series on the Chinese Dream and China's Development Path* has started to bear fruits. We have, first and foremost, the books' authors and editors to thank for making this possible. And it was the hard work by many people at Social Sciences Academic Press and Springer, the two collaborating publishers, that made it a reality. We are deeply grateful to all of them.

Mr. Xie Shouguang, president of Social Sciences Academic Press (SSAP), is the mastermind behind the project. In addition to defining the key missions to be accomplished by it and setting down the basic parameters for the project's execution, as the work has unfolded, Mr. Xie has provided critical input pertaining to its every aspect and at every step of the way. Thanks to the deft coordination by Ms. Li Yanling, all the constantly moving parts of the project, especially those on the SSAP side, are securely held together, and as well synchronized as is feasible for a project of this scale. Ms. Gao Jing, unfailingly diligent and meticulous, makes sure every aspect of each Chinese manuscript meets the highest standards for both publishers, something of critical importance to all subsequent steps in the publishing process. That high-quality if also at times stylistically as well as technically challenging scholarly writing in Chinese has turned into decent, readable English that readers see on these pages is largely thanks to Ms. Liang Fan, who oversees translator recruitment and translation quality control.

Ten other members of the SSAP staff have been intimately involved, primarily in the capacity of in-house editor, in the preparation of the Chinese manuscripts. It is time-consuming work that requires attention to details, and each of them has done this, and is continuing to do this with superb skills. They are, in alphabetical order: Mr. Cai Jihui, Ms. Liu Xiaojun, Mr. Ren Wenwu, Ms. Shi Xiaolin, Ms. Song Yuehua, Mr. Tong Genxing, Ms. Wu Dan, Ms. Yao Dongmei, Ms. Yun Wei and Ms. Zhou Qiong. In addition, Xie Shouguang and Li Yanling have also taken part in this work.

Ms. Zhou Li is the SSAP in-house editor for the current volume.

Our appreciation is also owed to Ms. Li Yan, Mr. Chai Ning, Ms. Wang Lei and Ms. Xu Yi from Springer's Beijing Representative Office. Their strong support for

the SSAP team in various aspects of the project helped to make the latter's work that much easier than it would have otherwise been.

We thank Ms. Wang Xiao'e for translating this book and Ms. Jiang Lin for her work as the polisher. The translation and draft polish process benefited greatly from the consistent and professional coordination service by Beijing Zhong Huiyan Information Services Co., Ltd. We thank everyone involved for their hard work.

Last, but certainly not least, it must be mentioned that funding for this project comes from the Ministry of Finance of the People's Republic of China. Our profound gratitude, if we can be forgiven for a bit of apophrisis, goes without saying.

Social Sciences Academic Press  
Springer

# Contents

<b>1</b>	<b>Origin and Background of Circular Economy Development</b> . . . . .	1
1.1	China's National Conditions . . . . .	2
1.1.1	China's Population and Demographic Distribution . . . . .	3
1.1.2	A Vulnerable Foundation for Development . . . . .	10
1.2	Staged Characteristics of China's Economic Development Since the Reform and Opening-up Initiative, as Well as Its Impacts on Resources and the Environment . . . . .	10
1.2.1	The Background of Economic Development at the Initial Stage of Reform and Opening-up . . . . .	10
1.2.2	Characteristics of China's Economic Development in 1980–1995 and Its Impacts on the Environment . . . . .	11
1.2.3	Main Features of China's Economic Development from 1996 to 2010 and Its Environmental and Resource Impact . . . . .	14
1.3	From Environmental Protection to Circular Economy . . . . .	17
<b>2</b>	<b>The Role of Government and China's Policy System for Circular Economy</b> . . . . .	21
2.1	Why Did the Chinese Government Facilitated the Circular Economy Development . . . . .	21
2.1.1	Free Market Economy in Britain: The First Generation of Industrialization Featured by the Difficulty in Resource Recycling . . . . .	21
2.1.2	Free Market Economy in the United States: The Second Generation of Industrialization in Which the Government Played a Role . . . . .	22
2.1.3	Capitalist Market Economy in Japan: The Third Generation of Industrialization Under the Leadership of the Government . . . . .	23

- 2.1.4 Socialist Market Economy in China: The Fourth Generation of Industrialization Dominated by the Government . . . . . 25
- 2.2 How Has China Promoted the Circular Economy . . . . . 28
- 2.3 Legal and Regulatory Policy System for Circular Economy Development in China . . . . . 34
  - 2.3.1 History of China’s Legal and Regulatory Policies on the Circular Economy . . . . . 34
  - 2.3.2 Characteristics of China’s Legal and Regulatory Policies on Circular Economy . . . . . 45
- 2.4 Development Strategy and Immediate Action Plan of Circular Economy During the 12th Five-Year-Plan Period . . . . . 48
  - 2.4.1 To Focus on the 10 Circular Economy Demonstration Projects . . . . . 48
  - 2.4.2 To Cultivate 100 Circular Economy Demonstration Cities (Counties). . . . . 51
  - 2.4.3 To Cultivate 1000 Circular Economy Demonstration Enterprises (Industrial Parks) . . . . . 52
- References . . . . . 52

**3 The Fundamental Modes and Achievements of China’s Circular Economy Development . . . . . 55**

- 3.1 Fundamental Modes of China’s Circular Economy Development . . . . . 56
  - 3.1.1 The Top-Down Dynamic Model and Addressing the Crux . . . . . 56
  - 3.1.2 To Enable “the Visible Hand” to Cooperate with “the Invisible Hand” . . . . . 58
- 3.2 To Build a Model for the Circular Economy-Oriented Practice with Chinese Characteristics . . . . . 60
  - 3.2.1 To Set up the Mechanisms of Leadership and Coordination at Different Levels . . . . . 60
  - 3.2.2 To Provide Institutional Guarantee at Different Levels . . . . . 61
  - 3.2.3 Fiscal Means to Directly Carry Out Circular Economy Pilot Projects . . . . . 62
- 3.3 To Set up a Microscopic Circular Economy Model with Chinese Characteristics . . . . . 66
  - 3.3.1 Microscopic Models of the Circular Economy in Key Industries . . . . . 66
  - 3.3.2 The Composite and Cross-Industry Circular Economy-Oriented Models in Agriculture . . . . . 70
  - 3.3.3 Circular Economy-Oriented Models for Industrial Parks . . . . . 71
  - 3.3.4 Models of Remanufacturing and Resource Recycling . . . . . 74

3.4	Remarkable Achievements Harvested in the Decade. . . . .	75
3.4.1	Census of the Whole Society and National Strategic Action . . . . .	76
3.4.2	Circular Economy and Technological Innovation . . . . .	76
3.4.3	Wastes Recycling . . . . .	77
3.4.4	Recycling of Renewable Resources . . . . .	79
3.4.5	Efficiency and Benefits of Resource Utilization . . . . .	81
	References. . . . .	83
<b>4</b>	<b>China's Steel Industry Transformed by Circular Economy . . . . .</b>	<b>85</b>
4.1	Amazing Size and Technological Structure. . . . .	85
4.1.1	The "Steel Dream" for the Rejuvenation of the Chinese Nation. . . . .	85
4.1.2	An Amazing Superpower in Steel Output . . . . .	86
4.1.3	A Museum Showcasing the Technologies Adopted by the Steel Industries from Across the World. . . . .	87
4.2	Circular Economy Transforming Steel Plants into "Power Plants" . . . . .	89
4.2.1	Importance of Energy Conservation in the Steel Industry . . . . .	89
4.2.2	Taking Advantage of Technological Innovations to Reduce Primary Energy Consumption. . . . .	89
4.2.3	Recovering Secondary Energy and Building Distributed Generation Assemblies . . . . .	90
4.3	Circular Economy Transforming Steel Plants into "Mineral Treasures" . . . . .	92
4.3.1	With the Magic Phrase of "Open Sesame", Wastes Transforming into Resource Treasures . . . . .	92
4.3.2	Maximizing the Performance of Ferrous Resources . . . . .	92
4.3.3	Steel Enterprises Transforming into "Building Material" Producers. . . . .	93
4.3.4	Embarking on a Path Towards Diversified Utilization for Higher Value. . . . .	94
4.4	Combination of Water Conservation and Utilization of Reclaimed Water . . . . .	95
4.4.1	Giving Top Priority to Water Conservation . . . . .	95
4.4.2	Steel Enterprises Transforming into "Reclaimed Water Plants" . . . . .	97
	References. . . . .	97
<b>5</b>	<b>The Circular Economy-Oriented Practice in the Nonferrous Metal Industry. . . . .</b>	<b>99</b>
5.1	The Necessity to Develop Circular Economy in the Nonferrous Metal Industry. . . . .	100
5.1.1	Characteristics of the Production in the Nonferrous Metal Industry . . . . .	100

5.1.2	Development of China's Nonferrous Metal Industry . . .	101
5.1.3	Problems Concerning the Environment and Resources for the Nonferrous Metal Industry . . . . .	103
5.2	Major Measures to Develop the Circular Economy of the Nonferrous Metal Industry. . . . .	106
5.2.1	Technological Upgrading and Innovations for Reduction in Energy Consumption. . . . .	106
5.2.2	Enhancing the Comprehensive Utilization and Environment-Friendly Disposal. . . . .	109
5.2.3	Facilitating the Utilization of Secondary Metals . . . . .	111
5.2.4	Improving the Policy and Regulation System . . . . .	113
5.3	Major Achievements in Circular Economy Development in the Nonferrous Metal Industry. . . . .	115
5.3.1	Steady Increase in Resource Utilization Efficiency . . . . .	115
5.3.2	Brilliant Achievements in Energy Conservation and Emission Reduction. . . . .	117
5.3.3	Remarkable Achievements in Secondary Metal Development . . . . .	119
5.3.4	A Long Way to Go for Circular Economy Development in the Nonferrous Metal Industry. . . . .	119
	References. . . . .	121
<b>6</b>	<b>The Circular Economy-Oriented Practice in the Cement Industry. . . . .</b>	<b>123</b>
6.1	Soul of China's Building Material Industry, the Largest Emitter of Greenhouse Gases . . . . .	123
6.1.1	Soul of China's Building Material Industry . . . . .	124
6.1.2	Largest Emitter of Greenhouse Gases . . . . .	124
6.1.3	Circular Economy Development Within the Industry. . . . .	126
6.2	Co-processing of the Solid Wastes in the Cement Industry. . . . .	131
6.2.1	Comprehensive Utilization of Fly Ash. . . . .	133
6.2.2	Comprehensive Utilization of Blast Furnace Slag . . . . .	133
6.2.3	Comprehensive Utilization of Converter Slag . . . . .	134
6.2.4	Comprehensive Carbide Slag Utilization. . . . .	135
6.2.5	Comprehensive Utilization of Nonferrous Metal Smelting Slag. . . . .	136
6.2.6	Comprehensive Utilization of Sludge . . . . .	137
6.2.7	Comprehensive Utilization of Municipal Solid Wastes. . . . .	138
6.3	Circular Economy-Oriented Technological Innovations in the Cement Industry. . . . .	139
6.3.1	Circular Economy-Oriented Technologies Await Improvement . . . . .	139
6.3.2	Accelerating the Efforts for Circular Economy-Oriented Technological Innovations . . . . .	140
	References. . . . .	141



<b>7</b>	<b>The Circular Economy-Oriented Practice in the Electric Power Industry</b> . . . . .	143
7.1	Development of China's Electric Power Industry . . . . .	143
7.1.1	World's Largest Electricity Generator . . . . .	143
7.1.2	Thermal Power-Centered Electric Power Structure . . . . .	144
7.1.3	A Huge Interconnected Power Grid . . . . .	144
7.2	Origin of the Circular Economy-Oriented Development in the Electric Power Industry . . . . .	145
7.3	Legal and Regulatory Policies on Circular Economy Promotion. . . . .	146
7.4	Circular Economy-Oriented Practice in the Electric Power Industry . . . . .	154
7.4.1	Technological Path to Circular Economy-Oriented Development in the Electric Power Industry . . . . .	154
7.4.2	Models of Circular Economy-Oriented Development. . . . .	159
7.5	Achievements of Circular Economy-Oriented Development in the Electric Power Industry . . . . .	163
7.5.1	Remarkable Reductions in Coal Consumption for Power Generation . . . . .	163
7.5.2	Remarkable Reductions in Water Consumption for Power Generation . . . . .	163
7.5.3	Sharp Reductions in Air Pollutant Emissions . . . . .	164
7.5.4	Considerable Reductions in Waste Water Discharge . . . . .	166
7.5.5	Increasing the Ratio of Comprehensive Utilization of Solid Wastes. . . . .	166
7.6	Prospects of the Circular Economy Development in China's Electricity Power Industry . . . . .	167
	Reference. . . . .	168
<b>8</b>	<b>The Circular Economy-Oriented Practice in the Petrochemical Industry</b> . . . . .	169
8.1	Overview of the Industrial Development . . . . .	169
8.2	Necessity to Develop the Circular Economy in the Industry. . . . .	170
8.3	Achievements of Circular Economy-Oriented Development in the Industry . . . . .	172
8.4	Major Policies and Measures for the Circular Economy Development in the Industry . . . . .	174
8.4.1	Formulating Laws and Regulations and Implementing the Policies on Circular Economy Development. . . . .	174
8.4.2	Readjusting the Industrial Structure and the Product Mix and Increasing the Efficiency of Comprehensive Utilization of Resources. . . . .	175

8.4.3	Making Positive Efforts in Promoting and Applying Technological Innovations for Circular Economy Development. . . . .	175
8.4.4	Giving Play to the Industrial Parks and Facilitating the Pilot Demonstration of Circular Economy. . . . .	176
8.5	Typical Models of Circular Economy Development in the Industry . . . . .	177
8.6	Case Study on Circular Economy Development in the Industry . . . . .	179
8.7	Prospects of Circular Economy Development in the Industry . . . . .	181
<b>9</b>	<b>The Circular Economy-Oriented Practice in the Papermaking Industry . . . . .</b>	<b>183</b>
9.1	Overview of the Industrial Development . . . . .	183
9.2	Necessity to Develop the Circular Economy in the Industry. . . . .	185
9.2.1	Firstly, It Is Necessary to Develop the Circular Economy to Transform the Energy-Intensive Industry. . . . .	185
9.2.2	Secondly, It Is Necessary to Develop the Circular Economy to Protect the Environment. . . . .	186
9.3	Major Policies and Measures for the Circular Economy Development in the Industry . . . . .	188
9.3.1	Promoting the Circular Economy Development with Policies and Regulations . . . . .	188
9.3.2	Strengthening the Guiding Role of Industrial Policies in Developing the Circular Economy . . . . .	189
9.3.3	Taking Advantage of the Role of Intermediary Organizations in Facilitating Circular Economy Development. . . . .	191
9.3.4	Popularizing Advanced Equipment, Making Technological Innovations, and Promoting Circular Economy Development . . . . .	192
9.4	Achievements of Circular Economy Development in the Industry . . . . .	192
9.5	Case Study on Circular Economy Development in the Industry . . . . .	193
9.5.1	Group Profile . . . . .	193
9.5.2	Enterprise's Circular Economy-Oriented Practice . . . . .	194
9.5.3	Enterprise's System of Circular Economy Development. . . . .	197
9.5.4	Enterprise's Achievements in Its Circular Economy Development . . . . .	199
9.5.5	Revelations from the Enterprise's Circular Economy Development . . . . .	199

<b>10</b>	<b>The Circular Economy-Oriented Practice in the Food Manufacturing Industry</b> . . . . .	201
10.1	Overview of the Industrial Development . . . . .	201
10.1.1	Overview of the Development of the Food Industry . . .	201
10.1.2	Overview of the Development of the Fermentation Industry. . . . .	204
10.2	Necessity to Develop the Circular Economy in the Industry. . . . .	206
10.3	Major Policies and Measures for Circular Economy Development in the Industry . . . . .	207
10.3.1	To Guide Circular Economy Development in the Industry with Policies and Regulations . . . . .	207
10.3.2	To Set Industrial Development Goals Through Defining Binding Standards for Cleaner Production and Discharge Reduction of Major Pollutants . . . . .	209
10.3.3	To Carry Out Pilot Projects for Circular Economy Development and Bring the Demonstration Effect of Industrial Parks into Full Play . . . . .	210
10.3.4	To Promote Technological Innovations, and Enhance Core Competitiveness . . . . .	211
10.3.5	To Establish the Mechanism of Environmental Scrutiny, and Strengthen the Guidance for and Supervision on Enterprises . . . . .	212
10.4	Achievements of Circular Economy Development in the Industry . . . . .	213
10.5	Case Study on Circular Economy Development in the Industry . . . . .	216
10.5.1	COFCO Biochemical (AnHui) Co., Ltd. . . . .	216
10.5.2	Luzhou Bio-Chem Technology Ltd . . . . .	218
10.6	Future Development of the Circular Economy in the Food Industry . . . . .	221
10.6.1	To Improve the Policy and Law System and Increase the Operability of Policies. . . . .	221
10.6.2	To Carry Out Industrial Restructuring . . . . .	222
10.6.3	To Cement the Building of the Industrial Chain . . . . .	222
10.6.4	To Further Improve Technological Capabilities Through Developing the Key Technologies . . . . .	222
<b>11</b>	<b>Circular Economy-Oriented Agricultural Practice</b> . . . . .	223
11.1	Driving Force for Agricultural Circular Economy Development . . . . .	223
11.2	Definition and Features of China's Agricultural Circular Economy . . . . .	225
11.3	Operation of China's Agricultural Circular Economy . . . . .	225
11.4	China's Policies and Measures to Promote the of Agricultural Circular Economy Development . . . . .	227

- 11.5 Case Study on Agricultural Circular Economy Development . . . . 228
  - 11.5.1 The Model of Agricultural Wastes Recycling . . . . . 228
  - 11.5.2 Internal Recycling Models of the Agricultural  
Production Sectors . . . . . 231
  - 11.5.3 Models of the Composite Industrial  
and Agricultural Circular Economy . . . . . 235
- 11.6 Technological Support System for Agricultural Circular  
Economy . . . . . 241
  - 11.6.1 Technologies of Biomass Development  
and Comprehensive Utilization . . . . . 241
  - 11.6.2 Technologies of Animal Wastes Recycling . . . . . 241
  - 11.6.3 Technologies of Energy Crop Development  
and Utilization . . . . . 242
  - 11.6.4 Technologies of Efficient Utilization of Major  
Agricultural Inputs . . . . . 243
- 11.7 Achievements of China’s Agricultural Circular Economy  
Development . . . . . 243
  - 11.7.1 Lowering Costs, Increasing Revenues,  
and Raising Agricultural Productivity . . . . . 243
  - 11.7.2 Reducing Non-point Pollution in Agriculture,  
and Guaranteeing Food Safety . . . . . 244
  - 11.7.3 Enhancing Energy Security in Rural Areas  
Through the Development of Biomass Energy . . . . . 244
  - 11.7.4 Reducing Greenhouse Gas Emission Through  
Agricultural Circular Development . . . . . 244
  - 11.7.5 Improving the Living Environment in Rural Areas . . . . 244
- References . . . . . 245
- 12 “Urban Mining” . . . . . 247**
  - 12.1 The Concept and Implications of “Urban Mining” . . . . . 247
  - 12.2 Development and Utilization of Urban Minerals in China . . . . . 248
    - 12.2.1 The Policy and Regulatory Systems Concerned . . . . . 248
    - 12.2.2 Technical Standards of Products and Criteria  
for Industry Access . . . . . 252
    - 12.2.3 Development of the Comprehensive Waste  
Reutilization Industry . . . . . 252
  - 12.3 Development of the “Urban Mining” Demonstration Bases . . . . . 253
    - 12.3.1 Buildup of the “Urban Mining” Bases in China . . . . . 253
    - 12.3.2 The Urban Mining Base of Miluo Industrial Park . . . . . 255
    - 12.3.3 Tianjin Ziya Circular Economy-Oriented Industrial  
Park . . . . . 258
    - 12.3.4 Tianying Circular Economy-Oriented Industrial  
Zone in Jieshou, Anhui Province . . . . . 259
    - 12.3.5 Sichuan Southwest Resource Recycling  
Industrial Park . . . . . 260

12.3.6	Ningbo Jintian Industrial Park . . . . .	260
12.3.7	Qingdao Xintiandi Venous Industrial Park. . . . .	261
12.4	Specific Development and Utilization of Urban Minerals. . . . .	262
12.4.1	Scrap Steel . . . . .	262
12.4.2	Scrap Tyres . . . . .	265
12.4.3	Waste Plastics . . . . .	270
12.5	Inspiration from China's Urban Mining for the Comprehensive Utilization of Resources. . . . .	273
	References. . . . .	273

# Introduction

## Will China's Environment Collapse?

China's rising pollution levels have been a major concern for not only the Chinese, but for scholars worldwide studying China, and those who have a stake in the development of the country. Since the 1990s, China's growing pollution problem has continued to rise. In January 2013, severe smog plagued Beijing, the capital city of China, for nearly the entire month, averaging 25 out of 31 days. The situation remained mostly unchanged for the rest of the year. In January 2014, a year later, reports showed the ratio of days and up-to-standard air quality among 74 cities in China was considerably low, standing at merely 37.6 % on average, while days with substandard air quality accounted for a much larger percentage, at 62.4 % on average. This included days where pollution levels were reported to be slight (26.8 %), intermediate (14.4 %), heavy (16.2 %) and severe (5.0 %).

Beijing and its neighboring areas were considered to have some of the worst pollution levels recorded in the country. In the Beijing-Tianjin-Hebei Province, out of a whole year the number of days with up-to-standard air quality in 13 cities accounted for an average of 25.4 %, whereas the number of days with heavy and severe pollution levels accounted for an average 23.0 and 17.8 %, respectively, out of a whole year.<sup>1</sup>

In 2012, industrial solid waste output in China increased to 3.29 billion tons, while its utilization and disposal volume was 2.02 billion tons and 710 million tons, respectively. The amount of wastewater and chemical oxygen demand (COD) discharged into the ocean totaled 68.48 billion tons and 24.237 million tons,

---

<sup>1</sup>Qi Jianguo and You Wan, *Analysis on China's Energy Conservation, Emission Reduction and Environmental Protection*, published by the *Analysis on China's Economic Prospect*, the spring issue of the *Blue Book of China's Economy* (Economic Science Press, April, 2014).

respectively.<sup>2</sup> Such high volumes of wastewater generated and discharged every year have placed increasing pressures on the environment.

In 2010, China took over Japan to become the second largest economy in the world. However, the country is still in the process of industrialization and urbanization, heavy and chemical industries continue to use excessive energy resources and be a source of serious pollution, and many other environmental problems persist. In 2013, studies<sup>3</sup> showed world crude steel production amounted to 1.607 billion tons, in which China accounted for nearly half of the output at 48.48 % from a total output of 779 million tons. During the same year, another report<sup>4</sup> indicated that Chinese cement production accounted for more than half of the global output at 60 % from a total output of 2.414 billion tons. Although China's per capita consumption of resources is considerably low, the country is heavily dependent on imports. Mineral resources, such as iron ore and aluminum oxide are heavily dependent on imports. In 2013, China's crude oil imports reached 280 million tons, when its output accounted for only 209 million tons.<sup>5</sup> This represented more than half of the total consumption volume standing at 57 %.

China's ecological environment has become a worldwide concern leading many to believe that the economy may collapse with any development deemed to be unsustainable. Due to this, the Chinese government and the public has also been trying to find ways to tackle these issues.

Since the 1990s, China has felt increasing pressure to clean up the country's environment and limit its resources consumption, while also trying to maintain its rapid pace of economic growth. In order to do this, the Chinese academic society eventually introduced the concept of circular economy from Germany in 2000. Although China invented a model agricultural circular economy—mulberry fish pond<sup>6</sup>—over 1,000 years ago, a modern version designed for industrial use simply did not exist. China's development of a modern circular economy model was an inspiration from Germany's *Closed Substance Cycle Waste Management and*

---

<sup>2</sup>*Environmental Statistical Bulletin of China (2012)* issued by the Ministry of Environmental Protection of the People's Republic of China on November 4, 2013.

<sup>3</sup>[http://www.csteelnews.com/bjtj/201401/t20140124\\_229723.html](http://www.csteelnews.com/bjtj/201401/t20140124_229723.html).

<sup>4</sup><http://www.askci.com/news/201404/15/1514159233284.shtml>.

<sup>5</sup>*2013 Statistical Bulletin of China's National Economy and Social Development* issued by the National Bureau of Statistics on February 24, 2014.

<sup>6</sup>Mulberry fish pond complex is a sustainable system developed by farmers in the Pearl River Delta Region. The close integration in mulberry cultivation, sericulture and fish farming is one of the models of integrated fish farming to fully exploit the production potentials of the ecosystem. The development of the integration of mulberry cultivation, silkworm rearing and fish farming has promoted the development of silk reeling and other processing industries. It is a more complete, scientifically based man-made ecosystem.

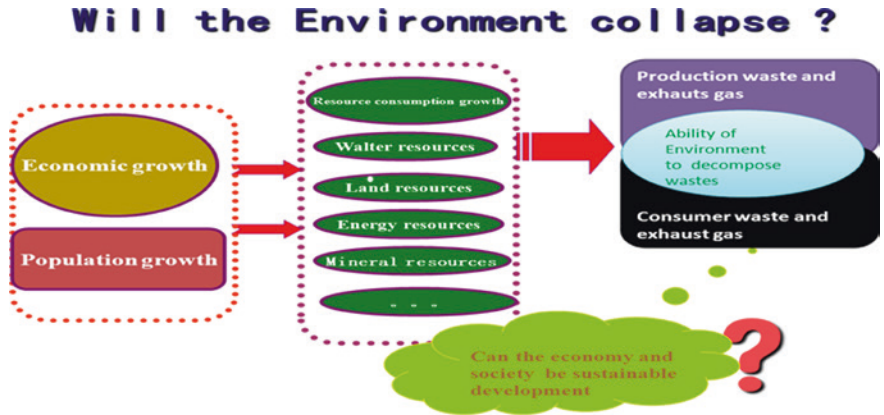


Fig. 1 Can China’s economic growth be sustained?

*Ensuring Environmentally Compatible Waste Disposal.*<sup>7</sup> Kalundborg Eco-Industrial Park is an industrial symbiosis network located in Kalundborg, Denmark, approximately 100 km west of Copenhagen. The park has served as a model for China. In terms of circular economy, the significance of Kalundborg to China is just like Mecca to Jews. To the Chinese, the place is regarded as the origin of a modern circular economy.

Since 2000, when China first introduced the concept of circular economy, the Chinese environmental protection authorities have been promoting its circular economy development as one of the most effective ways to reduce waste generation and discharge, while also trying to find ways to protect the environment. In 2004, it eventually became a national undertaking to develop circular economy, with the government stepping in to find ways to maintain its rapid pace of economic growth without depleting resources and negatively impacting the environment. A year later, in 2005, the State Council issued policies, which has been continuously updated ever since, to develop circular economy nationwide. Its National Development and Reform Commission, Ministry of Finance, Ministry of Industry and Information Technology, *Ministry of Environmental Protection*, and *Ministry of Science and*

<sup>7</sup>Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal (Kreislaufwirtschafts- und Abfallgesetz—KrW-/AbfG), Waste Avoidance, Recovery and Disposal Act\* of 27 September 1994, as amended by the Act on the Expedition of Licensing Procedures (Genehmigungsverfahrenbeschleunigungsgesetz) of 12 September 1996 (Federal Law Gazette I p. 1354), the Act for the Conservation of the Soil (Gesetz zum Schutz des Bodens) of 17 March 1998 (Federal Law Gazette I p. 502), the Act on the Reform of Road Haulage Law (Gesetz zur Reform des Güterkraftverkehrsrechts) of 22 June 1998 (Federal Law Gazette I p. 1485) and the Act on the Implementation of the Protocol of 7 November 1996 to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter of 1972 (Federal Law Gazette I p. 2455).



*Technology*, have all jointly issued policies to carry out government-initiated pilot projects for the development of circular economy at enterprises, industrial parks and cities. During the same year, circular economy was officially added as a key objective in China's national strategy, stated in its *Eleventh Five-Year (2006–2010) Plan*, and the *Twelfth Five-Year (2011–2015) Plan*. The *Circular Economy Promotion Law of the People's Republic of China* was promulgated on August 29, 2008, and came into force on January 1, 2009. It was a sign that China's circular economy development has finally been legally implemented and enforced.

In Hu Jintao's report to the 18th CPC National Congress in November 2012, a proposal to making ecological progress as one of the country's key policies in the future was made. It pointed out that, *promoting ecological progress is an extremely important and long-term task to the People's wellbeing and China's future. Faced with increasing resource constraints, severe environmental pollution and a deteriorating ecosystem, we must raise our ecological awareness and the need to respect, accommodate to and protect nature. We must give high priority to making ecological progress and incorporating it into all aspects of our lives. This include advancing economic, political, cultural, and social progress, as well as working hard to build a beautiful country, and achieving lasting and sustainable development for the Chinese nation. We should remain committed to the basic state policy of conserving resources and protecting the environment as well as the principle of giving high priority to conserving resources, protecting the environment and promoting its natural restoration, and strive for a green, circular and low-carbon life-style. We should preserve our geographical space and improve our industrial structure and ways of production, in the interest of conserving resources and protecting the environment. We should address the root causes for the deterioration of the ecological environment and to find ways to reverse this trend, to create a sound working and living environment for the people, and to contribute as a nation to global ecological security. We should develop a circular economy to reduce waste and resource consumption, as well as reuse resources and recycle waste in the process of production, distribution and consumption.*

These quotes are from a report issued on a plenary by the *Central Committee of the Chinese Communist Party*, China's most authoritative and highest level of policy orientation. Therefore, the above-mentioned report signals that circular economy development has even caught the attention of the highest authority in China.

China has made circular economy development its national strategy, which is directly related to its model of modernization development. China's modernization drive is apparently different from that of developing countries, as shown in Fig. 1.

Apparently, most developed countries advanced into a modernized society in a successive and orderly manner by being agricultural-based first. For example, Britain, a representative of developed countries, entered into the process of industrial revolution only in the mid-seventeenth century, while the USA, Germany and France followed its suit, and completed their urbanization and industrialization from 1973 to 1980. This was all done within a span of 150–200 years, before being quickly ushered into a post-industrial society. There are several notable points: per capita GDP exceeded 10,000 US dollars; annual steel consumption per

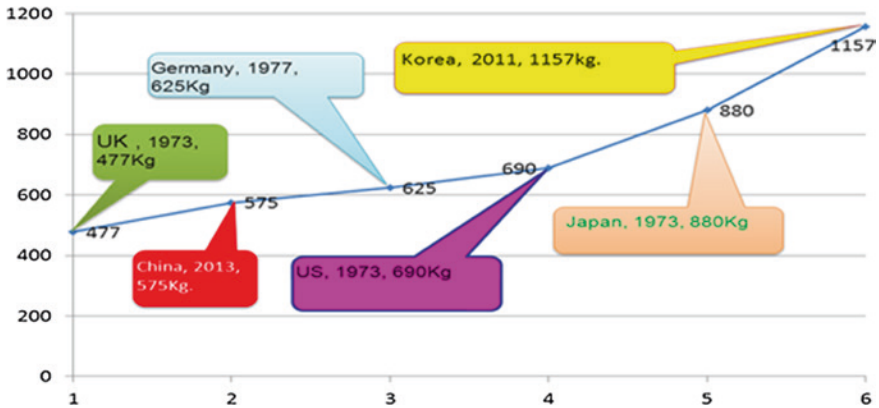


Fig. 2 Progress in industrialization in China and select countries

capita began to see a decline (as shown in Fig. 2); their manufacturing industries, featuring excessive energy and resource consumption and heavy pollution, were moved to developing countries; after environmental pollution reached a peak in the 1970s, they imposed control and management on a large scale and saw gradual improvement. Starting from the late 1980s, developed countries were stepping to an information-based society, and made a shift to becoming low-carbon economies for making ecological progress. Although the USA used to boycott the Kyoto Protocol, which required developed countries to reduce their carbon emissions, it eventually announced its own carbon emission reduction plan in 2014.

On the other hand, China has been realizing its modernization in an all-round way, facilitating industrialization, urbanization, informatization and ecological modernization synchronously. The country initiated the opening up and reform drive in 1978. Therefore, it could be said that China began its reform from rural areas and agriculture. China's industrial reform started in 1984, and has been accelerating ever since. Due to the lack of basic accumulation of capital, China's industrialization started with a characteristic of anti-urbanization. A slogan was proposed at that time, *shift from farming to other trades within the rural area*, trying to promote industrialization in rural areas and keep farmers to stay by developing township and village enterprises. The contradictions between industrialization and urbanization in this policy was implemented until 2000, and led to large-scale problems, such as scattered resource distribution, outdated technologies adopted by these enterprises, and unreasonable industry layouts that did not conform to the principles of Industrial Ecology. During the last three decades, the rapid development of industrialization caused the following: (1) heavy and chemical industries featuring excessive resource and energy consumption leading to severe pollution have continued and increased considerably; (2) heavy and chemical industries were and continues to be aimlessly developed across the country; (3) low efficiency of resource consumption and reckless discharge of pollutants led to resource restraints and grim environmental pollution and ecological degradation.

As shown in Fig. 2, China's annual steel consumption reached a peak in 2013, at around 575 kg per capita, surpassing that of Britain's while staying close behind Germany's and the USA's highest points. Even so, there was still a wide gap when comparing with industrialized countries that are in the process of catching up, such as Japan and South Korea. Hence, China's industrialization is only at the beginning stages. In the future, around 10–20 years from now, China will see a sharp decline in its heavy and chemical industries growth, represented by the steel industry, even though it will still continue to grow at a slower pace. If China fails to accelerate its model for transformation on economic growth, increase its resource and energy consumption efficiency, implement cleaner production of, and more advanced technologies, as well as speed up its efforts of closing down outdated production facilities featuring low efficiency of resource consumption and heavy pollution, China's environment might really collapse.

## How to Avoid an Environmental Collapse?

To improve living standards and raise public awareness, the Chinese people have been embracing an increasing level of awareness of their resources and environment. This can be seen not only from senior leadership of the Chinese government and the academic community, but also more and more from the local population and the general public. Officials from various levels of governments have also began to take interest in learning about the environment and resources around them. To acknowledge that goals for economic growth need to be in place, that ignoring these issues will lead to an unsustainable economy, and that protecting the environment and learning how to transform economic growth will become a crucial part of their future.

In terms of the model for circular economy shown in Fig. 3, economic growth could be achieved by reducing resource and energy consumption and waste generation by virtue of high efficiency of resource utilization, while pollutant discharge could be reduced by virtue of waste reuse. Therefore, pressure from resource and environment restraints can be relieved, and contrasts between economic growth and resources and environment can be lessen, which would increase resource efficiency and economic efficiency by X times.<sup>8</sup> Therefore, the concept of circular economy was introduced in China in 2000. Due to the overwhelming response to tackle the urgency of China's economic transformation, the concept has been widely recognized by the Chinese government and the public. It had been defined by the government as a key developmental strategy and policy, and has become a national undertaking in which enterprises and average citizens also play a role. Nowadays, circular economy has become a household name, with everyone taking part in circular economy, it has been integrated into enterprises and households.

---

<sup>8</sup>It refers to enabling the economy to grow by  $x + 1$  times with twice the amount of resource consumption.

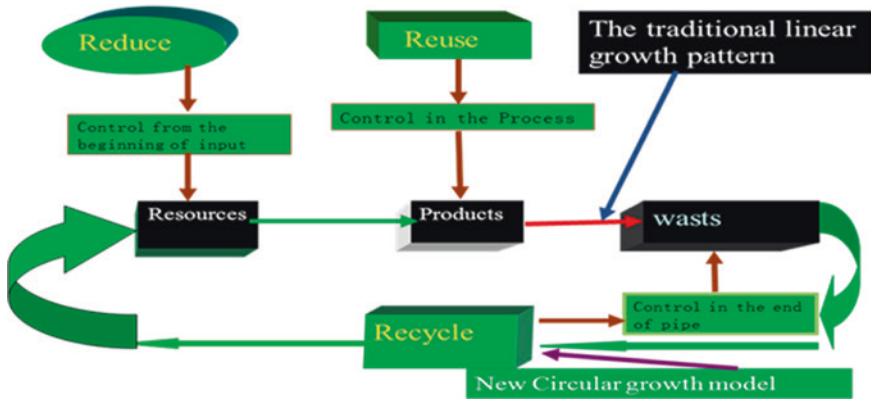


Fig. 3 Model of circular economy in China

A key difference between China and developed countries focuses on its end-of-pipe disposal and comprehensive utilization of waste. China has attached more importance to circular economy development in production because it is still in the process of industrialization and urbanization, while its advantage in low-cost labor and comparatively advanced manufacturing technologies make the nation the world’s manufacturing hub. Industrial production is primarily responsible for both resource and energy consumption, which is still growing in a continuous way, and pollutant discharge. Therefore, China’s government and enterprises have paid special attention to the establishment of industrial symbiosis networks and waste recycling.

With 10 years of high-speed development, China has figured out several circular economy models suitable to Chinese conditions in various industrial fields, including agriculture, industry, and service sectors, at different levels, covering enterprises, industrial parks and cities.

In terms of China’s rural areas and agricultural fields, with most of its land being either state or collectively owned, farmers are only entitled to use the land in which they live and work on. Every household is allowed to manage their plot of land, which is typically considered to be quite small. In many regions, farmers have joined together to form associated entities, with large-scale households who are capable, technically savvy and good at management, to take the lead and promote circular economy to increase the utilization efficiency of agricultural resources and reduce wastes from agricultural production. They have integrated together farming, breeding, processing of agricultural products, agriculture, comprehensive utilization and recycling of wastes from processing of agricultural products, organic fertilizer manufacturing, biomass energy utilization and water-saving technologies, in order to establish a circular production system conforming to the principles of industrial ecology. These efforts have been made with the aim to overcome the disadvantages of a small-scale peasant economy, and to significantly improve the resource and environment efficiency of agricultural production

and processing of agricultural products, reduce the consumption of fertilizers and pesticides in agricultural production, increase the safety of agricultural products, raise the economic benefits and the agricultural output per unit area of land, and alleviate agricultural pollution.

Industries, within enterprises, or across them, that feature excessive resource and energy consumption and severe pollution, including steel and nonferrous metallurgy, thermal power generation, coal chemical industry, petrochemical industry, building materials manufacturing, and food production, have found various models of circular economy to be useful. The practice has not only considerably improved resource utilization efficiency, but has also significantly reduced waste generation and discharge. When comparing with advanced enterprises in developed countries, Chinese enterprises still achieve lower efficiency in resource utilization and discharge lower amounts of wastewater. In contrast, they have increased resource utilization efficiency by at least 30 % and reduced waste emission by at least 30 % during the last 10 years. Let us take the steel industry as an example. In 2000, the overall energy consumption per ton of steel of major steel enterprises was 885 kg of standard coal,<sup>9</sup> while that figure was lowered to 592 in 2013 with a decrease of 33.1 % in 13 years, which is closer to the international advanced level. There are three major reasons for the significant decrease in energy consumption: (1) coke oven gas, blast furnace gas and converter gas have all been recovered and then utilized as fuel or for electricity generation; (2) top pressure recovery turbine unit (TRT); and (3) various kinds of waste heat and pressure have been recovered for reuse. The fresh water consumption per ton of steel has declined by over 40 %. In the past, about 0.4 ton of slag waste had to be disposed in landfills after smelting one ton of steel, while all the smelting slag has been recovered for manufacturing building materials. From 1994 to 2014, a span of 20 years, prices of iron ore, various kinds of energy, water and labor have generally risen by more than five times in China's market, but the steel prices used in building has nearly remained unchanged from 1994. Faced with such difficulties, steel enterprises' survival depends on circular economy development, in which waste has been transformed into resources and energy, costs of resource consumption and waste disposal have been declining, and increasing costs brought by increased prices of production factors have been offset. Ultimately, synchronized increases of economical efficiency, environmental friendliness and resource-saving techniques will reflect the characteristics of the Chinese model of circular economy.

With the world's largest population, China is going through big changes such as urban-rural development and income inequality. As the number of people who are unable to work or find a job continues to grow, most of them end up going into cities and make a living through recovering wastes at market value. After being classified, the recovered wastes are then fed into waste recycling enterprises.

---

<sup>9</sup>Wang Taichang and Chi Jingdong, *Analysis on and Recommended Measures for Chinese Steel Industry's Energy Conservation and Consumption Reduction*, (Steel & Management, Vol. 3 (2007)).

For a long period of time in the past, domestic waste has been classified by these specialized waste collectors, rather than residents in their households. However, the remaining domestic waste without market value were left in garbage dump sites in communities, picked up and sent away by municipal administration departments. As a result, the municipal waste in China is generally kitchen and other kinds of wastes that has no market or low combustion value. Thus, from the perspective of material flow alone, China can be considered as one of the countries with the highest ratio of recycled material.

## **China Needs to Put More Effort to Develop Its Circular Economy Framework**

It should also be noted that China is still in its initial stage of circular economy development, facing lots of problems.

To begin with, resource utilization efficiency is still relatively low in some disadvantaged regions where enterprises tend to lag in production and technology. Waste recycling using low efficiency initial resource utilization is more effective when compared to the traditional linear resource utilization model where exploitation of resources take place by producing the products for consumption and discarding them as waste. However, there is still potential to reduce resource consumption. Only when initial resources are fully and efficiently utilized can a circular economy be developed at the source to lower the dependency of economic growth on resources and reduce damages to the ecological environment.

Due to the lack of proper management and advance technologies, some recycling enterprises are taking advantage of this and reaping the economic benefits by generating secondary pollution. Unfortunately, this runs counter to the original purpose of circular economy development.

The cost of China's waste recycling enterprises can also be extremely high. Rather than paying for waste disposal, "producers" of the waste prefers to sell it for its recycling value, making the material flow of waste run counter to the currency flow. These enterprises have to pay money to get waste, leading to increased costs. Without enough financial support from governments, they are less able to invest in newer technologies and prevent secondary pollution, which hampers the sound development of these recycling enterprises. This provides a striking contrast with the extended producer's or consumer's responsibility in developed countries.

As for domestic waste generated by consumers, including those generated by producers, it is mostly recovered by scavengers, most of whom are low-income peasants without a regular job, and in line with the market mechanism. It is impossible for governments to impose scientific and safe management on waste because of the lack of effective information support. Under the structure of such a market-based mechanism, waste would mainly go to the recyclers who are technologically weak and are willing to pay more to get them as they would not have to bare any costs for the prevention of secondary pollution. Governmental authorities have

also failed to impose effective environmental supervision of such issues arising. There are also many more hidden problems in the scientific classification, safe delivery and clean utilization of waste.

Before 2005, a large number of industrial parks were built and their infrastructure and corporate layout did not conform to the principles of the industrial ecology that we have today. Problems such as: (1) the absence of a sound waste recovery system in the parks; (2) the negative symbiosis occurring between enterprises; (3) the difficulty to form an effective waste recycling system; and (4) the cost of waste recycling is still comparatively high.

In addition to this, land has been scattered aimlessly in agricultural fields across China, and farmers are nearly incapable of making investment in resource recycling, which makes the development of agriculture-based circular economy fall behind that of industry-based circular economy. Rather than being used for their high added-value, tons of waste from agricultural production, including crop stalks, have been incinerated directly without the recovery of reusable elements such as heat, leading to environmental degradation.

The government authorities are also lagging behind in terms of environment-related planning and policy-making. Although China has formulated a series of laws and regulation on environmental protection and waste disposal, their enforcement has been hampered by many obstacles. Enterprises who tend to generate a larger amount of waste would always manage to adopt various measures to avoid legal liability, and commit illegal acts such as discharging waste secretly. The environmental law enforcement departments often fail to set up appropriate laws and regulations in a thorough way, which makes the comparative advantage of waste recycling not as obvious. Meanwhile, government authorities have announced some preferential policies for waste recycling in terms of finance and taxation, yet as China's economy begins to decline since 2010, local governments have also felt increasing fiscal pressures, which make preferential policies for waste recycling harder to implement.

Facing such obstacles, the Chinese government has introduced a number of measures to improve the environment for circular economy development through reforming its waste management and environmental protection systems and institutions. They include the following: (1) building up waste-recycling-oriented industrial parks (called "city mining" in China) in a clustered way which will get financial support from governments; (2) upgrading old industrial parks to make their operations more circular with the assistance from governments; and (3) establishing waste recovering systems in urban communities under the leadership of governments. The goal is to form a sound circular economy system across the country, in order to make the national economy transform toward a circular one. Doing so could perhaps ease the contradiction between pursuing economic growth and protecting the country's resources and environment in order to achieve economic development and fulfill a greener, circular and low-carbon economic lifestyle.

If China can successfully develop its national economy in a clean and effective way, solve the contradiction between pursuing economic growth and protecting its

resources and environment, including increasing its resource and energy efficiency by  $X + 1$  times through the all-round development for a circular economy, a new path to industrialization will soon be realized for developing countries, and significant contribution will be made to solve this problem worldwide as well as to cope with climate change.

This book analyzes in detail the historic background of China's circular economy development, discusses the Government's measures to promote circular economy development in a market-oriented economy, and introduces China's policies for circular economy development. Successful models for circular economy development in the industrial fields of agriculture, steel smelting, non-ferrous metallurgy, cement manufacturing, thermal power generation with coal as fuel, chemistry, paper making, fermentation industry, and city mining are summarized in technical terms. It is my hope that readers from developed countries can get an idea of what China has done to transform its economic development model and prevent environmental collapse in the future. It is also my hope that they will be inspired, gain some insight, and learn from China's experiences in their industrialization phase to solve the increasing contradiction between its pursuit of economic growth and the restraints it puts on resources and the environment in a better way by making their economies transform towards resource conservation and environmental friendliness, it is my hope to achieve such goals and contribute to the sustainable development of humanity.