



Make Fashion Circular

OUTLOOK FOR
A NEW TEXTILES ECONOMY IN CHINA

 中国纺织工业联合会
社会责任办公室
CNTAC Office for Social Responsibility of CNTAC

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Executive summary

The fashion industry is in the process of rethinking how it manufactures, consumes and disposes of textiles and apparel. Circular fashion is an industrial system conceived by various stakeholders as a solution for bringing about sustainable industrial development. The vision is in line with the principles of a circular economy and aims to maximize the value of fiber, textile and apparel in use and recycling, reduce the consumption of natural resources and the generation of waste, and thus reshaping the textile industry towards a more resilient and responsible future.

China's textile and apparel industry plays an important role in the global fashion industry, and its circular economy transition is crucial to the future of global circular fashion and will have a profound impact on its development. On the one hand, China is the world's largest textile and apparel producer and exporter. In 2018, China's total fiber processing volume accounted for more than 50% of the world's total fiber processing volume, and China's textile and apparel export volume accounted for about 35% of the global total.

On the other hand, China is also one of the largest textiles and apparel consumer markets in the world, and one of the top three markets for many well-known fashion brands and companies. With the expanding new middle-class groups and increasing consumption awareness, the potential of China's textile and apparel market to be the industry driver of sustainable consumption will be further boosted.

From the perspective of the industry's entire supply chain, the report for the first time presented the current situation of China's textile and apparel industry, combing through the practices and achievements of circular economy transition in the industry. Furthermore, the

report gave prospects for the vision and opportunities for industrial circular economy transition based on international circular fashion trends. China has been promoting the circular economy since 2005. Under the guidance of China's circular development strategy, the circular economy transition of China's textile and apparel industry has made gradual progress and found its own pace.

The optimization of raw material supply, the improvement of resource efficiency in production and recycling of textile waste are the three main areas of circular economy practices in the industry. The proportion of recycled fiber processing in China has increased from 9.6% in 2010 to 11.3% in 2015, and its output exceeded 7 million tons in 2018. Several bio-based chemical fibers have achieved industrial development, with a range of applications in apparel, home textiles, health and medical products. Levels of energy and material consumption, and resource recycling in production have been significantly improved. A large number of new technologies have been pioneered and subsequently widely adopted. The setting up of an industrial chain of collection, sorting and the comprehensive utilization of textile waste has also been largely completed. "Zero Discarding of Old Clothes" has been carried out, and the Extended Producer Responsibility system has also been introduced at company level. Roughly estimated, China's utilization proportion of textile waste recycled as materials reached 17% in 2018.

At the same time, there are emerging trends in design and in the field of consumption that are favourable to industrial circular development. The practice of green design is gradually increasing; some consumers have begun to turn to green textile and clothing consumption, embracing the concept of sustainable consumption.

New business models such as clothes rental, sharing and resale are emerging.

However, as a whole, due to the large range of product categories, a long industrial processing chain, and large volumes of China's textile and apparel industry, there is still a lot of room for improvement in terms of the substitution scale of non-renewable raw materials, the resource utilization level in production, the recycling and reuse of textile waste, the circular design, and green consumption. With increasing pressure on both resources and the environment, it is imperative to accelerate the circular economy transformation of the industry and expand the scope of practices.

China is building an ecological civilization and accelerating its circular transition. Circular fashion is of great significance for China's textile and apparel industry to cope with various complex resource and environmental challenges. At this stage of development, China's textile and apparel industry has put forward a vision for a new textiles economy in China to keep pace with the nation's circular development strategy as well as the developments in international circular fashion. The vision is to build a green, circular, and low-carbon textile and apparel industry system, so as to improve the resource efficiency of the industry and reduce the resource consumption and the negative impact on the environment. The new textiles economy recommends five goals addressing raw materials, design, production, consumption and after use. The goals include:

Goal 1. Optimize the raw material structure to reduce the consumption of non-renewable resources.

Goal 2. Turn to textile design based on the principles of a circular economy.

Goal 3. Further improve resource efficiency in production.

Goal 4. Innovate business models and expand green consumption.

Goal 5. Upgrade the quality and efficiency of textile waste recycling.

It is obvious that transitioning to a new textiles economy is not only a solution to deal with resources and environmental risks but also provides great opportunities for growth. In recent years, various uncertain factors have accelerated the difficulties and risks of economic recovery. And the outbreak of the COVID-19 Pandemic in early 2020 has impacted the economy particularly hard. The textile and apparel industry, which is highly internationalized, is facing serious challenges, and different stakeholders have been under pressure. A circular economy is an important way for China's textile and apparel industry to achieve high-quality development. In the new era of an increasingly complex environment, different stakeholders in China's textile and apparel industry, including government, enterprises, designers, associations and research institutions, as well as consumers, should be unified by the vision of circular development and embrace the global value chain. All stakeholders should work together to strengthen cooperation in a larger and deeper scope, continue to look for new growth opportunities with the aim of building a more resilient industrial value chain. A circular economy transformation path in line with China's national ambitions will unfold in the future and contribute Chinese solutions to global circular fashion.

In Support of the Report

Sustainable fashion opens up new growth opportunities for the global textile and apparel industry. As an important part of the global fashion industry, China's textile and apparel industry is now in the critical transformation phase toward high-quality development.

We believe this report could help all stakeholders understand the status quo of circular practices for the Chinese textile and apparel industry, so as to accelerate the construction of a green, circular and low-carbon industrial system and jointly promote transformation for more responsible and sustainable growth under the guidance of national strategy on circular development.

— Dapeng Chen, Vice President of China National Textile and Apparel Council

The fashion industry in China is in a critical stage of transformation and green development has been taken as the strategic development goal for the textile and apparel industry. This report for the first time systematically combed through the circular economy practices and achievements of the industry from 2005 to the present, and furthermore expounded in detail upon the prospect of industrial transformation based on international circular fashion practices, providing beneficial solutions and references for the industry to explore circular economy transformation.

— Yan Yan, Director of Office for Social Responsibility, China National Textile and Apparel Council

I'm very delighted to learn from this report that more parties in the value chain are aware of the importance of design for circular fashion. Some designers in China have already been inspired by the principles of the circular economy in their work. We expect that more designers will unlock the innovative potential by thinking more about the circularity and recyclability of materials and shaping the future of responsible production and consumption.

— Qinghui Zhang, Chairman of China Fashion Association

A circular economy for fashion, where clothes are used more, are made to be made again and are made from safe and renewable materials, provides an opportunity to create an industry that can thrive in the long term while tackling issues like waste and pollution.

With momentum towards a circular fashion industry growing globally, this report is an exciting milestone that not only highlights the strong foundations upon which the Chinese fashion industry can build, but also sets practical goals for the industry to follow to accelerate its transition.

— Francois Souchet, Lead, Make Fashion Circular at the Ellen MacArthur Foundation

The fashion industry is the world's second most polluting industry, after oil. China's textile industry plays an important role in the global textile industry through its whole value chain, which means it can contribute a lot to global sustainable development by improving the industrial chain and promoting circular economy practices.

It was an honor for Lenzing Group to be involved in the report. Starting from a global perspective, the report sheds light on the circular economy transformation of China's fashion industry, looks deep into its current status, challenges, and opportunities for circular fashion on the basis of numerous pieces of research as well as case studies and data analysis. It can also provide support and guidance to stakeholders systematically, so as to accelerate the industrial transformation.

— Jian Hu, Senior Vice President, Lenzing Group (North Asia)

Fashion represents an important trend in the global textile industry. It is important to introduce the concept of green development, emphasize the driving role of leading enterprises, incorporate the concept of a green and circular economy into corporate fashion development strategies, and continuously strengthen the management of the green supply chain, so as to reduce the impact of textiles on the environment throughout its life cycle and foster the sustainable development of the textile industry. The report released by the Social Responsibility Office of the China National Textile and Apparel Council (CNTAC) depicts a blueprint for the development of China's textile industry, and provides guidance for the industry's transformation towards circular fashion.

— Tao Mao, Director, Institute of Energy, Resources and Environment, Center for International Economic and Technological Cooperation, Ministry of Industry and Information Technology of P.R. China

The production of green fiber, which adheres to the concept of a circular economy, constitutes an important part of industry's transformation and upgrading. In terms of volume and scale, China is currently the world's largest producer and supplier of fiber raw materials, as well as a major producer of recycled fibers, bio-based fibers, dope-dyed fibers, and other fibers with green properties. As international brands attach importance to sustainability, setting their targets and proposing solutions, the demand for recycled fiber internationally and domestically has been amplified further. China's textile and apparel industry should accelerate technological innovation to meet the market demands. With detailed data and future trends analysis, this report can provide relevant enterprises a systematic overview of the material chain.

— Shidong Lin, Deputy Secretary General of China Chemical Fibers Association, Vice President of the Recycled Fiber Commission of China Chemical Fibers Association

It has become a consensus globally to develop the circular economy and promote social sustainable development. The comprehensive utilization of textile waste contributes to sustainable development and has practical and far-reaching importance to society. The China Association of Circular Economy has a long commitment to building a system for textile waste recycling, establishing a graded utilization mechanism, promoting renewable and recycled products, and developing common key technologies. Circular fashion as proposed in this report is also the focus of the association. We hope that this report will attract more governments, institutions and businesses to jointly promote the industrial development for the comprehensive utilization of textile waste throughout the world.

— Mingming Gu, Secretary General of Technology Innovation Strategic Alliance for Waste Textiles Comprehensive Utilization Industry

A linear, unconstrained model of production and consumption is not sustainable, and we are determined to lead our industry towards a better, circular, way of working. This means driving change throughout our business and our entire value chain. Our close collaborations with organisations such as the Ellen MacArthur Foundation and many others will continue to inspire us, help us find even more solutions to transform ourselves and share best practices with both partners and industry.

— Candice Yip, Regional Sustainability Manager, Far East Asia, H&M Group Production

This report is of great significance in advancing the circular economy transformation of China's textile and apparel industry. It sets out an objective analysis of the importance of promoting the circular economy transformation of the industry in China. It first puts forward the vision, ambitions, and principles of China's new textile economy, then comprehensively reviews the current status and challenges involved in the industry's transformation, and finally provides all stakeholders a systematic path to take action jointly.

— Xiaoyi Gao, Director of the Department of International Cooperation, All China Environment Federation

The report reshapes the future of fashion from the perspective of environmental strategy in a far-reaching way. It can increase the transparency of brands and the “healthy supply chain”, and provide clearer implementation guidance strategically for the green and sustainable development of the industry. As a player in the textile industry, we need to make continuous technological innovations to achieve waste reduction, resources utilization, and harmlessness in production, so that products and the environment can be integrated in an organic way, and contribute to human health.

— Fangsheng Long, General Manager of Zhejiang Mizuda Printing&Dyeing Group Co., Ltd.

Mixing the textile and garment industry with recycling is a path of circular fashion featuring waste recycling, resource reservation and environmental protection. At a time when human society is pursuing ecological civilization, circular development has been in the crosshairs of all industries and sectors. This report reveals the exploration of Chinese textile and garment industry for its transformation towards circular future. It also touches upon challenges and presents an attractive vision for Chinese fashion industry, and provide guidance on the transformation of Chinese textile industry and the development towards circular fashion could drive life style to be greener, and modern life more beautiful, environment-friendlier and healthier.

— Huanzheng Du, Director of the Institute of Circular Economy, Tongji University

No other industry is so closely connected with both the production and consumption ends as the textile and apparel industry. Therefore, the circular economy transformation of the industry will not only promote the construction of a green industrial chain across the industry, but also involve tens of millions of consumers to participate, which can fuel the circular development of the industry through the practices of green consumption. The circular economy transformation of China's textile and apparel industry plays an important role in shaping the future of global circular fashion and promoting a green lifestyle. It is also a best practice in terms of China pursuing green development. With detailed information and data, the report proposes the vision and implementation plan, which is of great guiding significance for the systematic circular economy transformation of the industry, injecting new momentum into its further development.

— Ling Zhong, Deputy Director of the R&D Department, China Environmental United Certification Center

Recent years have seen rapid changes in society and the economy, as well as in the consumption habits, patterns, scenarios, and structure of consumers. To address the new opportunities and challenges faced by the textile industry, all stakeholders including brands, retailers, and manufacturers in the global textile and apparel supply chain should make joint efforts and the industry's leading enterprises should commit to social responsibility, promoting the development of the industry in a technological, green and fashionable way. New opportunities coexist with new challenges, and the latter urgently requires new wisdom. It was an honor for Yuyue Home Textile to be involved in the report, which took more than a year of preparation and exploration through multiple channels online and offline. It presents comprehensively the current situation of China's textile and apparel industry in circular economy transformation based on the analysis of massive quantities of data from stakeholders. Practically, the report also provides an analysis of opportunities. It, in a nutshell, helps the industrial players to make judgments more rationally.

— Yuping Wang, General Manager of Yuyue Home Textile Co., Ltd.

I was deeply moved to see the report. Sustainable fashion is a hot topic globally – one which many companies and brands in the industrial chain, including Sinotytex, are exploring and practicing. Environmental sustainability is a journey that is evolving from 0 to 100. To achieve real gains in sustainability, both the product and the business matter. This means producing fashionable, high-quality, and cheap clothing for ordinary consumers, gaining business success and then encouraging more companies to enter the field of sustainable fashion. Therefore, it far exceeds a story of environmental protection. Sinotytex has made certain achievements in the field of “zero dyeing” color spinning, which will drive more peers to engage in this field and reduce the consumption of water and energy and the discharge of sewage together. This also complies with our mission, which is “Let everyone enjoy sustainable fashion”.

— Pin Dong, Vice President of Hangzhou Sinotytex Co., Ltd.

Publishing organization



Office for Social Responsibility, China National Textile and Apparel Council

China National Textile and Apparel Council (hereinafter, "CNTAC"), formerly known as the Ministry of Textile Industry of the People's Republic of China, is a national organization for China's textile and apparel industry. Established in 2005, Office for Social Responsibility which is directly under the administration of CNTAC, has been the first national permanent establishment dedicated to social responsibility. It aims to develop a public governance platform for the industry to deliver its social responsibility and play a leading role in the sustainable development of the industry.

In 2015, Office for Social Responsibility of CNTAC set a vision of Responsible Development Goals 2025 for the textile and apparel industry in China, covering 12 indicators in three dimensions of social, environmental and economic. It works with the government, institutions and relevant enterprises to carry out stewardship innovation through the industry's value chain, including such areas as environmental management of chemicals, carbon emission and climate change, water resource management and systematic circular transformation, so as to enhance the industry's capacity for and awareness of sustainable development. It also established the Textile Sustainable Manufacturing Coalition to accelerate the innovation and collaboration.

More information, please visit: www.sdgstewardship.org/circular

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Ellen MacArthur Foundation and Make Fashion Circular

In 2017, "Make Fashion Circular" was launched by the Ellen MacArthur Foundation, a British charity, at the Copenhagen Fashion Summit. The initiative brings together leaders from across the fashion industry, including brands, cities, philanthropists, NGOs, and innovators. It is committed to leading the transformation of the global fashion industry into the circular economy to design out waste and pollutants. In a circular economy, safe and renewable resources will be used to produce apparel, new business models will be adopted to increase the durability of clothes and discarded clothing will be recycled into new clothing.

To really Make Fashion Circular, businesses, governments, innovators, and citizens need to join forces. Make Fashion Circular brings together industry leaders including Burberry, Gap Inc., H&M Group, HSBC, Inditex, PVH and Stella McCartney as Core Partners. Make Fashion Circular has been made possible by Laudes Foundation, MAVA Foundation and players of People's Postcode Lottery.

More information, please visit: www.tiny.cc/makefashioncircular



Lenzing Group

Established in Austria in 1938, Lenzing Group is one of the world's leading manufacturers of wood pulp and cellulose fibers. It has expanded its production to major markets across the globe and operates an extensive sales and market network around the world. Lenzing Group's products include dissolving wood pulp, cellulose fibers made from dissolving wood pulp, biobased energy, biorefinery products and co-products. Its product brands include: TENCEL™, REFIBRA™, LENZING™, ECOVERO™ and VEOCEL™.

Lenzing Group adopts a business model that goes beyond any traditional fiber manufacturer. Working with its clients and partners, Lenzing Group is developing innovative products along the value chain and creating added-value for consumers. Lenzing Group is committed to the efficient use and processing of raw materials, and providing solutions to navigate the textile industry towards a closed-loop economy.

More information, please visit: www.lenzing.com/

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Core project team

Kehua Hu, Sustainability Stewardship Director, Office for Social Responsibility, China National Textile and Apparel Council

Shite Li, Sustainability Researcher, Office for Social Responsibility, China National Textile and Apparel Council

Francois Souchet, Lead, Make Fashion Circular, Ellen MacArthur Foundation

Claudia Fan, Senior Programme Officer, China Programme, Ellen MacArthur Foundation

Sandy Liu, Sustainability Manager, Lenzing Fibers (Shanghai) Co., Ltd

Expert committee (listed in no particular order)

Tao Mao, Director, Institute of Energy, Resources and Environment, Center for International Economic and Technological Cooperation, Ministry of Industry and Information Technology of P.R.China

Shidong Lin, Vice President, Recycle Chemical Fiber Branch, China Chemical Fibers Association

Mingming Gu, Secretary General, Technology Innovation Alliance for Waste Textiles Comprehensive Utilization Industry, China Association of Circular Economy

Guoliang Zhao, Professor and Head of School of Materials Science and Engineering, Beijing Institute of Fashion Technology

Huanzheng Du, Director of the Institute of Circular Economy, Tongji University

Huapin Wang, Professor of College of Materials Science and Engineering, Donghua University

Dongfeng Gao, Associate Researcher, China National Institute of Standardization

Fangsheng Long, General Manager, Zhejiang Mizuda Textile Printing&Dyeing Co.,Ltd

Hugo Gao, Manager, Recycled Materials Business Department, Yuyue Home Textile Co.,Ltd.

Ryan Li, Senior Manager, Social and Environment Department, Li Ning

Shawn Li, Supplier Chain Sustainability Responsible, Fast Retailing (Shanghai) Enterprise Management Consulting Co., Ltd

Uta Xia, Sustainability relations responsible, H&M Hennes&Mauritz Sustainability Department

Yinghong Yang, Chairman, Shanghai Yuan Yuan Industrial Limited Company

Stella Liu, CEO, Beijing YCLOSET Technology Co., Ltd

Ling Zhong, Senior Engineer, China Environmental United Certification Center

Xiaoyi Gao, Director, Department of International Cooperation, All-China Environment Federation

Further expert contributors (listed in no particular order)

Yicheng Jin, GM Assistant, Zhejiang Mizuda Textile Printing&Dyeing Co.,Ltd.

Peter Dong, Vice president, Hangzhou Tytexchina Co. Ltd.

Hongdi Lv, Department Manager, Recycled Materials Business Department, Yuyue Home Textile Co., Ltd.

Chuncheng Zhang, Lenzing (Nanjing) Fiber Co., Ltd.

Yong Kuang, Manager, Zhejiang Sunrise Garment Group Co., Ltd.

Huanheng Wang, Director, Sunrise (Shengzhou) Knits Co.,Ltd.

Bei Mao, Sustainability Manager, Changzhou Xurong Knitting Printing & Dyeing Co., Ltd.

Liyang Zhou, General Manager, Hangzhou Benma Chemical Fiber Spinning Co., Ltd.

Liqun Chen, R&D Director, Quanzhou Haitian Material Technology Co., Ltd.

Xiangmei Zhang, Marketing Specialist of klee klee

Wen Shao, Strategy Marketing Manager, Erdos Investment & Holding Group Co.,Ltd.

Jingyun Xu, Director of Science Innovation Center, K-Boxing Co., Ltd.

Wilson Xu, CR&Environmental Manager, Bestseller United China Ltd., Shanghai Representative office

Echo Xu, Chemical&Environmental/Environmental responsible, Shanghai Representative Office, Bestseller United China Ltd.

Songliang Cai, Environmental Sustainability Specialist, Inditex Sustainability

Jing Qu, Vice president, Huimei Group

Andrew Li, Officer Environmental Sustainability, Guangzhou World Cat Information Consulting Services Co., Ltd.

Lixin Zhou, Deputy General Manager, Beijing I:Co Trading Co., Ltd.

Dage Cao, Chief Engineer, Zhejiang Jiaren New Material Co., Ltd.

Xiaofan Lu, General Manager, Ding Yuan (Hangzhou) Textile Technology Co., Ltd.

Lingtao Kong, Founder, Shanghai Greenfortune

Yongqin Hu, Executive Director, TSINCOHUASTANDARD & NITI Co., Ltd.

Zang Lie, General Manager, Shanghai Yuan Yuan Industrial Limited Company

Cheng Li, General Manager, Wenzhou Tiancheng Textile Co., Ltd.

Lifeng Xie, General Manager, Fujian Baichuan Resource Recycling Science&Technology Co., Ltd.

Haiyan Sun, Co-founder&Chief Editor, Business Ecology Studio

Chunlan Liu, Senior Editor, Business Ecology Studio

Chong Li, Officer of Department of Sustainability Promotion, China Chain Store & Franchise Association

Jian Yang, Vice president, China Fashion Association

Zixin Zhang, Secretary, The Collaboration for Sustainable Development of Viscose, China Chemical Fibers Association

Disclaimer

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This Report made the first attempt to systematically study the current situation, vision and opportunities of the circular economy transformation of China's textile and apparel industry from the perspective of the entire industry chain, with the aim to provide stakeholders with information and references. While the transformation of circular fashion still has a long way to go, the release of this report is just the beginning. Restricted by a short research period, a wide research scope and difficulty in obtaining some basic data, this Report inevitably has

some deficiencies and controversial elements. We strongly welcome suggestions and corrections from various stakeholders in the industry, and welcome their participation in accelerating industry circular economy transformation process.

Any comments or suggestions, please contact: Sdg@ctic.org.cn

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Global fashion industry is entering an era of circular development

Facing more and more challenges brought about by the linear development model, the global textile industry is in the process of rethinking how it designs, manufactures, consumes and disposes of textiles and apparel. As the impetus for realizing sustainable and high-quality development, the circular economy has gradually achieved consensus within the fashion industry. More and more stakeholders realize that the circular economy transformation of the global fashion industry is not merely a response to external resources and environmental pressure, but also to the internal demand for upgrading the industrial infrastructure.

The fashion industry, with all its rich connotations, is a collection of industries and enterprises, extending through the value chain of key industries, in which the textile and apparel industry plays an important role.¹ As a result, the circular economy transformation of the textile and apparel industry has attracted the attention of all stakeholders in the fashion industry. It is considered to be key to achieving circular and sustainable development for the industry. In recent years, consumers' concern about resource consumption and the environmental impact on the textile and apparel industry has increased, becoming another important driving force for industry reform.

Different stakeholders in the textile and apparel industry around the world are actively building consensus and introducing best practices at different levels to shift the industry from the traditional linear economy model to the circular development model. In a new textile economy based on the principles of a circular economy, fibers, textiles, and clothes should maintain their maximum value during use and re-enter the economy afterwards, to reduce final waste.

1.1

Circular economy transition of global economy accelerated by active international community

Global crises such as the lack of non-renewable resources, the destruction of ecosystems and climate change have been closely linked to the linear economy ever since the start of the industrial era. The increasing pressure on resources and the environment means that the production model of the "linear economy" which uses natural resources irresponsibly is no longer feasible, and the circular economy is part of a more general trend towards correcting past errors.

At the core of the circular economy is the need to reduce the consumption of resources and the generation of pollution and waste in the entire economic system. This entails reconciling economic growth with the increasingly severe pressure on resources and the environment, and somehow managing to decouple the push for economic growth from the overuse of resources. In the circular system, resources will be redeployed and utilized, waste streams can be turned into inputs for new processes. Compared with the traditional linear model of "take – use – waste", the growth circular model is more inclusive and recoverable, and it is a systematic solution to the complex resource and environmental problems faced by the international community.

Starting in the 1960s and with nearly half a century of practice, the circular economy, as a new model of economic growth, is regarded as key to achieving sustainable development. In 2015, the United Nations proposed Sustainable Development Goals (SDGs) built a common vision and framework for solving social, economic, and environmental problems. One of the core aims of sustainable development is to solve issues relating to resources and environmental

problems. This is also the essence of the circular economy, namely that resources should be utilized more efficiently by reducing consumption at source and improving the efficiency of resource utilization in production and ultimately recycling waste at the end of the whole production process. Meanwhile, artificial capital and natural capital can be increased to promote sustainable development. Research shows that circular practices potentially can contribute directly to achieving a significant number of SDG targets, especially the targets of SDG 6, SDG 7, SDG 8, SDG 12 and SDG 15.²

The circular economy is also an important engine for future economic growth. According to statistics, the circular economy could create economic benefits worth US\$4.5 trillion by 2030 by retaining the value of resources, materials and products as much as possible and creating new value by extending the service life of products through reuse, renovating, re-manufacturing and recycling.³ Taking China as an example, it is estimated that if the circular economy in three key areas is implemented in cities, the overall cost of access to goods and services can be greatly reduced, and about 32 trillion yuan of expenditure for high-quality products and services can be saved by enterprises and households by 2030.⁴

An increasing number of stakeholders are aware of the value of the circular economy and its direct economic benefits and are taking proactive measures to achieve "Circular Advantage". The circular economy has become an increasingly important component in the public policies of different countries and regions, as they have recognized its value for the global economy in terms of accelerating

The strong relationship between circular economy practices and SDGs targets



the transition to a circular future. China and the EU play an important role in leading and promoting the circular economy and have set out their own development priorities and characteristics.

The EU has issued the *Manifesto for a Resource-Efficient Europe (2012)*, the *EU Action Plan for the Circular Economy* and its package implementation agreement (2015) and the *European Green Deal (2019)* to guide the circular development of regional economies in the past 10 years. The goal set in the European Green Deal is to achieve the net zero emission of greenhouse gases among the EU countries by 2050 and realize the decoupling between economic growth and resource consumption. In 2020, the EU issued the new *Circular Economy Action Plan*, which proposes 35 legislative initiatives by the end of 2023 to comprehensively promote the development of the circular economy. The new Action Plan works on applying circular economy principles throughout the entire life cycle of products and creating a sustainable product policy framework covering design, consumption, manufacturing, etc. Textiles is one of the seven key product value chains addressed as a matter of priority.⁵

China has vigorously promoted a circular economy since 2005. In 2008, the *Circular Economy Promotion*

Law was issued, providing a legal guarantee for developing a circular economy. In 2013, China promulgated the *Circular Economy Development Strategy and Near-term Action Plan*, which was the world's first national plan for a circular economy.⁶ In recent years, China has accelerated its circular development, transforming both the economy and society at all levels in a more systematic way. At the same time, a series of policies have been developed, including strengthening the management of solid waste, comprehensively promoting the classification of urban household waste, and launching the pilot project of "Waste-free Cities", etc. In 2020, China issued the *Guiding Principles on Building a Modern Environmental Governance System*, the *Implementation Instructions on Promoting Consumption Expansion and Upgrading Quality and Accelerating the Formation of a Dynamic Domestic Market*, and the *Guidances on Accelerating the Establishment of a Regulatory and Policy System for Green Production and Consumption*; the 13th National People's Congress Standing Committee has integrated the study on the comprehensive utilization of resources law into its legislative plan. The circular economy has become a new driving force for China's economic development.

1.2

External pressure and internal demand for global fashion industry's circular economy transition

The fashion industry is the seventh largest economy in the world, largely as a consequence of Mankind's unceasing pursuit of new fashions in the search for beauty. By 2018, the market size of the global fashion industry had reached US \$2.5 trillion, providing jobs for one sixth of the global population.⁷ Despite the fact that growth has started to slow, the world's population is projected to reach 8.5 billion by 2030, 9.7 billion by 2050 and exceed 11 billion by the end of the century, according to a UN population forecast in 2019.⁸ Population growth means more demand for fibers, textiles, and clothes. If the fashion industry continues to develop in the traditional linear way of "mass production - mass consumption - mass waste", it will consume more resources and bring about irreversible environmental pollution and economic losses. The fashion industry needs to innovate and

come up with a development model to achieve new growth at a time when the global economy is facing a downturn. In the face of this double threat a circular economy appears to offer the best solution.

1.2.1 External pressure: an increasing call for circular economy transformation

With the rise of environmental awareness, consumers are increasingly concerned about the depletion of resources and the environmental impact of the textile and apparel industry. The global textile and apparel industry consumes 98 million tons of non-renewable resources. The industry consumes oil to produce synthetic fibers, fertilizers to grow cotton, and chemicals to produce and dye fibers and textiles. The industry also uses about 93 billion cubic meters

of water resources annually. However, globally, clothing use dropped by 36% between 2000 and 2015, and more than 50% of fast fashion clothes will be discarded within one year under the influence of "Fast Fashion". Moreover, only 13% of the total raw materials in the whole textile and apparel industry have been recycled to some extent. This means that a large number of waste clothes are buried or burned, resulting in huge losses of resources and secondary environmental pollution. Worldwide, this material loss represents more than US \$ 100 billion worth each year.⁹

The world is reconsidering the way we source fibers and how we produce, consume and dispose of our clothes. The international community is calling for the fashion industry to face up to the circular economy transformation agenda as well as sustainable development, which requires the industry to take real and effective actions to reduce its environmental impact.

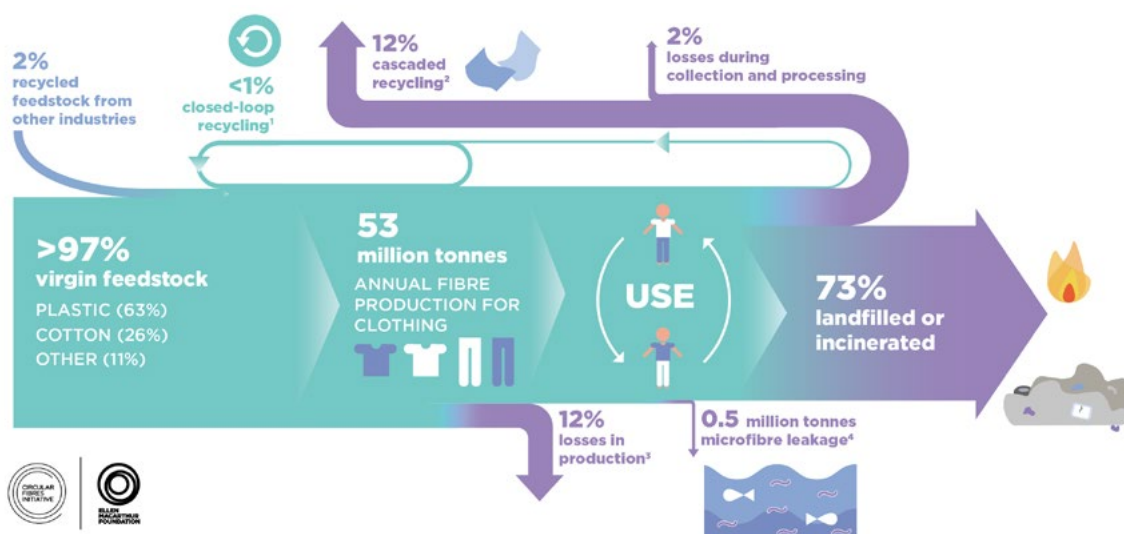
1.2.2 Internal demand: a clear opportunity for circular economy transformation

In a sluggish global economy, the pace of development of the fashion industry is also slowing down. In 2019, the International Monetary Fund

(IMF) lowered its global economic growth forecast four times in succession. The sluggish growth of the global economy quickly spread to the fashion field, especially after the outbreak of the COVID-19 Pandemic in 2020, and the industry is now facing a greater growth crisis. According to statistics, in April 2020, U.S. apparel and clothing retail sales fell 89.3% year-on-year, while Japanese and EU textile and apparel retail sales fell 53.6% and 62.8%, respectively. The industry's supply chain has been directly impacted due to cancelled orders by many brands and traders. Global corporate turnover is expected to fall by an average of 32% in 2020. Both traditional department stores and fashion retail are under tremendous pressure.¹⁰

The global fashion industry urgently needs new opportunities to reshape its industrial development and promote long-term sustainability. The circular economy has proven that it can bring new and innovative revenue streams to the fashion industry, stimulate innovation and enhance brand competitiveness. Globally, more and more brands and enterprises have recognized this fact and have taken action actively. The practices include resale and reuse, fiber recycling, material innovation, circular production practices to eliminate toxic chemicals and dyeing processes, biodegradable products, upcycling, etc.

Global material flows of clothing in 2015



1 Recycling of clothing into the same or similar quality applications

2 Recycling of clothing into other, lower-value applications such as insulation material, wiping cloths, or mattress stuffing

3 Includes factory offcuts and overstock liquidation

4 Plastic microfibres shed through the washing of all textiles released into the ocean

Source: A New Textiles Economy: Redesigning Fashion's Future¹¹

1.3

New textile economy: redesigning fashion's future

The circular economy transformation of the global textile and apparel industry is accelerating, but for it to be a success will require different stakeholders in the industry chain to reach consensus and carry out large-scale, pre-competitive, cross-value-chain collaboration. As sustainable development and circular fashion have started to gain momentum, a number of governments and international institutions have begun to explore and promote forward-looking solutions for system-level change. And some leading industry brands and enterprises have also begun to take action firstly by promoting consensus among the various stakeholders on issues relating to sustainable fashion, environmental protection and circular development and secondly, by setting goals for circular development and starting to implement them. Meanwhile, consumer awareness of the need for green consumption is also growing, especially among the young. Green consumption is likely to be widely adopted by consumers in the future, and this in turn will force the industry to accept change.

1.3.1 Solutions for system-level change to accelerate industrial transformation

Accelerating industry transformation will require system-level change. Based on in-depth research and analysis, some forward-looking international organizations have tried to highlight challenges and opportunities, clearly outline the transformation path towards a circular fashion future, and put forward suggestions to different stakeholders in the industry. The most representative initiatives come from *A New Textiles Economy: Redesigning the Fashion's Future* (2017) and *Textiles in Europe's Circular Economy* (2019).

A New Textiles Economy: Redesigning Fashion's Future

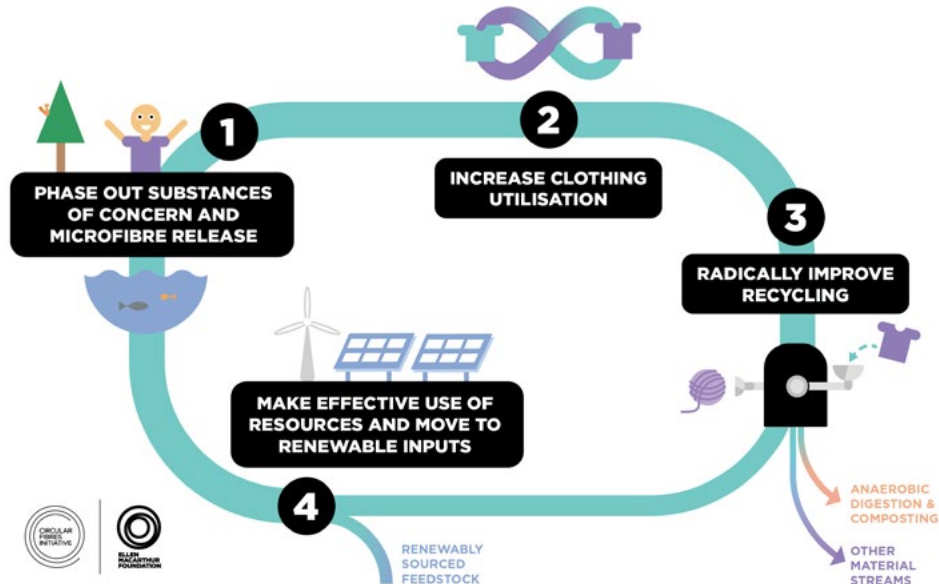
In 2017, the Ellen MacArthur Foundation (EMF) launched the "Make Fashion Circular" initiative at the Copenhagen Fashion Summit, with the aim of leading the circular economy transformation of the global textile industry in order to avoid waste and pollution from the start. The initiative proposed the three principles of a circular economy – design out waste and pollution; keep products and materials in use; regenerate natural

systems. At the same time, EMF jointly released the report *A New Textiles Economy: Redesigning Fashion's Future* with H&M group, Lenzing group and other famous fashion brands and enterprises. The report proposed a vision for a new textiles economy aligned with the principles of a circular economy: one that is restorative and regenerative by design and provides benefits for business, society, and the environment. The report also proposed four ambitions and analyzes in-depth and innovative business opportunities likely to be available when these ambitions are implemented. With the vision and ambitions, EMF wanted to invite core industry stakeholders to work together, carry out systemic reform and make unprecedented investment, cooperation and innovation to accelerate the shift to a new textiles economy. In the same year, EMF and IDEO, a famous global design company, jointly released the *Circular Design Guide*, with the aim of helping design for a recoverable and regenerative economy framework and overcome the linear production system.

Textiles in Europe's Circular Economy

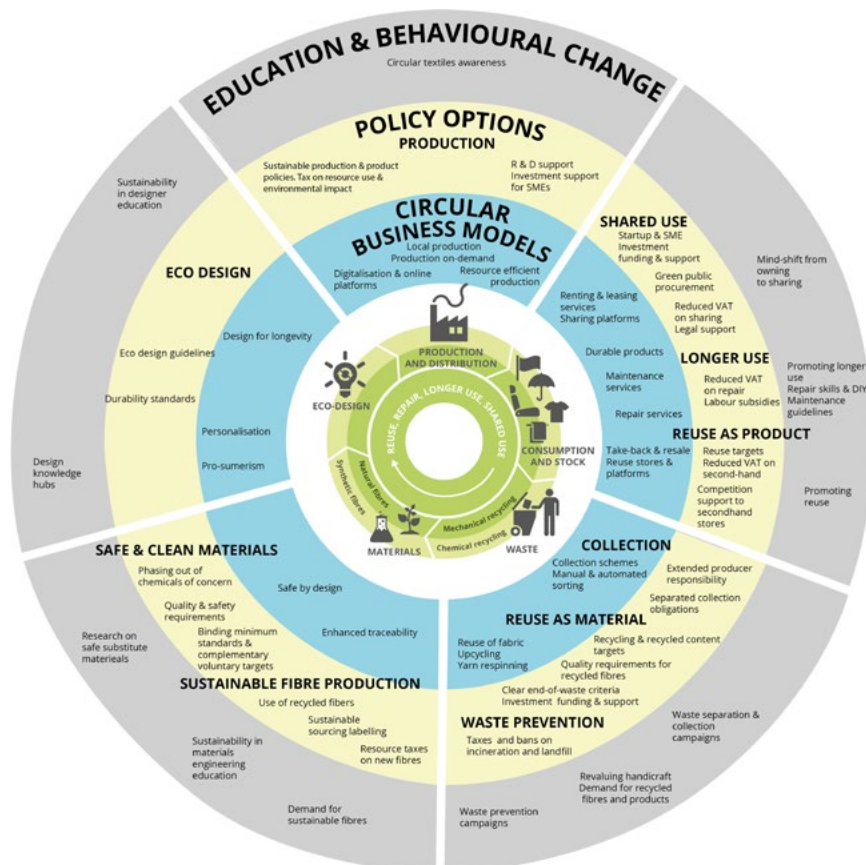
In November 2019, the European Environment Agency (EEA) issued *Textiles in Europe's Circular Economy*, proposing to carry out systematic reforms towards circularity to reduce environmental and climate impact caused by textile production and consumption while maintaining economic and social benefits. The report points out that achieving the goal will require wide-scale implementation of circular business models supported by effective policies addressing materials and design, production and distribution, use and reuse, collection and recycling. This includes product policies such as green public procurement, eco-design, extended producer responsibility, labelling and standards. In the circular textile economy envisioned by EEA, circularity is ensured in all phases of the lifecycle, including materials, eco-design, production and distribution, consumption and stock, and waste. In addition, EEA emphasizes that education and behavioral change is an important part of the shift towards circular textiles to bring about behavioral change across the entire system – from production and processing to transport, consumption, and waste.

Ambitions for a new textiles economy



Source: A New Textiles Economy: Redesigning Fashion's Future ¹²

The role of circular business models, policy options, education and behavioural change in circular textiles systems



Source: Textiles in Europe's Circular Economy ¹³

1.3.2 Industrial practice gradually enriched



Joint action by Industry

Leading global brands and enterprises have begun to take action to encourage different stakeholders to reach consensus on sustainable fashion, environmental protection and circular development through the joint issuance of charters, initiatives, and reports.

In December 2018, 43 large fashion brands, manufacturers, and industry organizations jointly signed the *Fashion Industry Charter for Climate Action* to accelerate the fashion industry's response to climate change. The charter contains a vision for the fashion industry to reach zero emissions by 2050 and defines issues that should be addressed by signatories, including decarbonization of production stages, use of sustainable materials, low-carbon transportation, enhancing consumer awareness, exploring circular business models together with the financing community and policy makers.¹⁴ By May 27, 2020, 103 fashion brands had joined the Charter.¹⁵

In September 2019, 32 globally influential fashion companies including Kering, Adidas, BESTSELLER, Burberry, CAPRI HOLDINGS LIMITED, Carrefour, and CHANEL, signed the *Fashion Pact* to form a global coalition of companies in the fashion and textile industry, committed to a common core of key environmental goals in three areas: stopping global warming, restoring biodiversity, and protecting the ocean.¹⁶



Fashion brand and enterprises' practices

Some well-known global textile and apparel enterprises have successively set their 2020/2025/2030 sustainable development goals and implemented the corresponding practices over the past few years. Circular economy practice is an integral part of fulfilling these goals. The practices include sustainable material usage and innovation, sustainable design, supply chain management, production process innovation, green packaging, trading second-hand clothes and recycling textile waste.

Material innovation is one of the strategic priorities for brands. More and more well-known brands have made clear commitments and shown great interest in research and development to look for alternatives to traditional fibers – including bio-based fibers, recycled fibers, special function or high-tech fibers, etc. For example, NIKE used recycled materials in 76% of its footwear and apparel in fiscal year 2019 and issued a circular design guide to innovate new ways of reclaiming materials; H&M group promises to source 100% recycled or other sustainably sourced materials by 2030, including recycled fibers; Inditex (Zara) plans that 100% of the cotton, linen, viscose and polyester used in their products will be recycled or will have a more sustainable origin by 2025.^{17, 18, 19} Some leading sustainable material supply brands are seeking system-level change of the industry through the innovation of raw materials. For example, Lenzing group from Austria uses renewable wood as a raw material to produce regenerated cellulose fiber – the main large-scale industrialized bio-based fiber at present.

There are more and more sustainable fashion or circular fashion products on the global market, and new product series are constantly emerging. At the same time, new service models based on consumer demand such as recycling old clothes, shared wardrobes, second-hand transactions, upgrading and repair have also been explored and practiced around the world.

1.3.3 Awareness of sustainable consumption emerges globally

With global environmental issues such as climate change and marine plastic pollution attracting worldwide attention and the popularization of the UN's SDGs, global consumers have gradually come to recognize the value of sustainable consumption, especially the younger generation. Fashion industry research shows that 75% of consumers believe that sustainability is extremely important; more than 1/3 of consumers are willing to choose brands that help environmental and social improvement, even if they may not be their preferred brand; if another brand is more environmentally friendly than the one consumers like, more than 50% of consumers will plan to change in the future and a growing number of young consumers say they are willing to spend more on certain products in order to mitigate any negative impact on the environment.^{20, 21}

Leading global brands and enterprises have begun to take action. They have launched new products and services to meet the needs of consumers; at the same time, they have taken various marketing measures to cultivate a new generation of young consumers loyal to their brand's sustainability image. It is also an important strategy for fashion brands and enterprises to cope with the economic downturn and sluggish growth, namely, to ensure brand revenue by fostering the acceptance of new brand concepts by the younger generation to achieve continuing consumption.

There is no doubt that many stakeholders in the global fashion industry have realized that the textile and apparel industry is undergoing an important transformation period from a linear economy to a circular economy. Different participants are actively seeking focal points and breakthroughs to achieve a new textile economy.

02

Circular economy transition of China's textile and apparel industry is crucial to global circular fashion

China's textile and apparel industry plays an important role in the global fashion industry, and its circular economy transformation is crucial to the future of global circular fashion. In the past decade, the industry has made gradual progress in circular economy transformation with the support of national circular economy development strategies, policies and pilot projects, as well as relevant policies such as clean production, environmental governance, renewable resource utilization and green manufacturing, etc. China has started to accelerate the construction of an ecological civilization, by constantly improving the strategic position of the circular economy and supporting policies. As a traditional pillar industry, China's textile and apparel industry has moved into the strategic critical period of accelerating circular economy transformation.

2.1

China's textile and apparel industry is an important part of global fashion

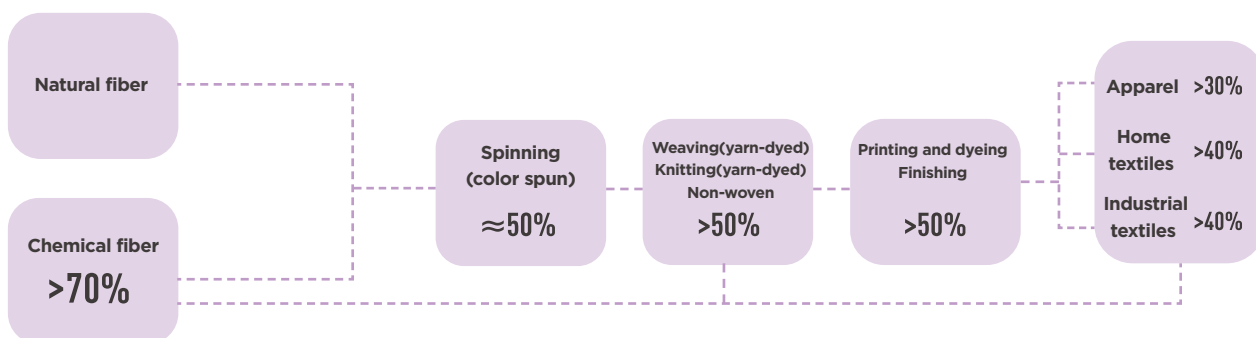
2.1.1 Complete whole industry chain system

China is the world's largest textile and apparel producer and exporter with the world's largest and most complete industrial system from raw material supply, design and R&D to textile printing, dyeing and processing, as well as retail. China's manufacturing capacity and level in all links of the industrial chain are firmly at the forefront of the world. According to statistics from China's National Textile & Apparel Council (CNTAC) in 2018, China's total fiber processing volume reached 54.6 million tons, accounting for more than 50% of the world's total fiber processing volume. At the same time China's textile and apparel export volume reached US\$276.73 billion, accounting for about

35% of the global total. More than 80% of the world's production of high count yarn (more than 60S) comes from China, more than 90% of the world's color-spun yarn production comes from China, 60% of the world's high-grade yarn-dyed shirt fabric production comes from China, 30% of the world's high-grade denim production comes from China, and the production technology of high count and high density fabric is mainly in China. China's textile industry still maintains an obvious international competitive advantage in the complex and changeable international trade environment.

Complete whole industry chain system of China's textile industry

Proportion of China's processing capacity in the world



Source: China's National Textile and Apparel Council (CNTAC)

2.1.2 One of the largest textile and apparel consumer markets

China is also one of the largest textiles and apparel consumer markets in the world, and one of the top three markets for many well-known fashion brands and companies. Data shows that in the past decade, China's market has accounted for 38% of the total growth in all areas of the global fashion industry. Since 2012, China's market has accounted for 70% of the growth in the luxury industry, attracting the attention of the world.²²

With the continuous improvement of people's living conditions, the expansion of new middle-class groups and the upgrading of consumption concepts, the potential of China's textile and apparel consumption market will be further boosted. According to data

issued by China's National Bureau of Statistics, per capita expenditure on clothes reached RMB 1238 yuan in 2017 and RMB 1289 yuan in 2018.^{23, 24} However, this consumption level is far lower than that of developed countries' which is more than \$US 1000. Taking the US as an example, the personal spending of American consumers on clothes and related services was US \$1,885 in 2017, accounting for 3.1% of total consumer expenditure.²⁵

Rising consumer awareness and green textile and apparel consumption will provide a greater market driver for circular and sustainable development.

2.2

Industrial circular economy transition accelerated by China's circular development strategy

2.2.1 China's national circular development policy system

Developing the circular economy is fundamental for China's ambition to construct an ecological civilization and achieve sustainable development.²⁶ China made the circular economy a national strategy in 2005 and has continuously improved its strategic role over the past 15 years.²⁷ The pressure on natural resources has increased during the "13th Five-Year Plan" period, and China has entered a new era of ecological civilization construction. This involves promoting the circular economy more systematically as well as promoting innovation in science and technology, mechanism and mode with the aim of moving to a green, circular, and low-carbon economy.



Laws governing circular development in China

The *Law on Promoting Clean Production* (implemented in 2003/revised in 2012) and the *Circular Economy Promotion Law* (issued in 2008/revised in 2018) are the two main laws and regulations for the development of the circular economy in China. The former is the first law in China to regulate the clean production of companies for the purpose of improving resource efficiency; the latter defines the core principles and scope of circular economy development. Other environmental laws such as the *Environmental Protection Law*, *Law on Evaluation of Environmental Effects*, the *Water Pollution Prevention and Control Law* and the *Law on the Prevention and Control of Environmental Pollution by Solid Waste* reflect the requirements of developing a circular economy in terms of environmental protection and pollution prevention. The authorities have promoted clean production and pollution controls for many years and introduced a raft of support systems and strict standards. Clean production audits and emission permits which are important supports for building the national circular economy have been improved and enforced vigorously.



Normative documents of the State Council of China and all ministries and commissions

Since the "12th Five-Year Plan", the State Council of China and various ministries and commissions have issued a number of normative documents concerning the replacement of non-renewable raw materials, green production and consumption, recycling and utilization of renewable resources, as well as industrial restructuring to guide the circular economy transformation of the economy and society (see Appendix for details).

The *Circular Economy Development Strategy and Near-term Action Plan* and the *Leading Action Plan on Circular Development* are the main strategic plans for circular development in China. The former was compiled by the National Development and Reform Commission (NDRC) of China and issued by the State Council of China in 2013. It was the first special plan for the development of a circular economy in China. It not only clarifies the basic principles of a circular economy, but also defines the development ideas, models, technical routes and means to achieve a circular economy in key industries. The latter was jointly issued by the NDRC of China, the Ministry of Science and Technology, the Ministry of Industry and Information Technology (MIIT) and 12 other ministries in China in 2017. Together these bodies arranged for the overall deployment of a national circular economy during the "13th Five-Year Plan" period. The plan lays out the requirements for strengthening innovation in science and technology, mechanism and mode, stimulating new momentum for circular development, accelerating the construction of a green, circular, and low-carbon economic system and a pollution control system with the aim of promoting the green transformation of the economy and society.

The development of a renewable resources industry is an important part of the transformation towards a circular economy. The Ministry of Commerce of China, together with NDRC and other departments, have constructed a recycling system of renewable resources. The drive for circular industry as part of a

macro industrial transformation is guided by several important government directives. One is that the NDRC of China governs industrial restructuring policies and the development plan for emerging strategic industries. Another is issued by the Ministry of Finance regulates the imposition of a value-added tax on products and services as an incentive for better use of resources. In addition to these important documents in 2017, the State Council of China promulgated the *Plan for Prohibiting the Entry of Foreign Garbage and Advancing the Reform of the Solid Waste Import Management System* and later, in 2019 a *Work Plan for the Pilot Construction of "Waste-free Cities"*. These directives will improve the management of domestic solid waste and help develop the renewable resources industry, and ultimately accelerate the establishment of the circular economy in China.

During the "13th Five-Year Plan" period the government issued directives including setting out an Extended Producer Responsibility (EPR) system and promoting green consumption with pilot projects. The aim was to accelerate supply-side structural reform by stimulating green production and consumption and encouraging an upgrading of the industrial infrastructure. In 2015, taking the EPR system as an example, the *Overall Plan for the Reform of Ecological Civilization System* by the State of Council of China aimed to encourage producers to recycle and dispose of waste products. In 2017 the *Implementation Plan for Extended Producer Responsibility System* was issued by the State Council of China, which applied the EPR system to four categories of products: electrical and electronic products, automobiles, lead-acid batteries and packaging materials.

In recent years, China has introduced policies to encourage a green, circular, and low-carbon economy. In March 2020, in order to solve the problems of green production and consumption such as insufficient incentives, the NDRC of China, together with other ministries and commissions, issued the *Opinions on Accelerating the Establishment of Green Production and Consumption Law and Policy System*. This document defined how green production and consumption should develop through various ways, as well as establishing clear timelines for green production and consumption at a national level. In April 2020, the Standing Committee of the 13th National People's Congress promulgated a legislative plan for comprehensive utilization of resource. All of which indicates China are entering a period of practicing circular economy and green production and consumption on a full scale.

2.2.2 Industrial policies and practices for accelerating system transformation

In 2013, China issued the *Circular Economy Development Strategy and Near-term Action Plan*. It outlined the basic model of circular economy development in the textile and apparel industry, and its future direction. It accelerates the replacement of raw materials, promoting energy conservation and consumption reduction, strengthening the utilization of waste resources, promoting the standardized development of textile waste recycling, as well as building the circular economy industrial chain in the textile industry. Its key areas of work include:

Replacement of raw materials

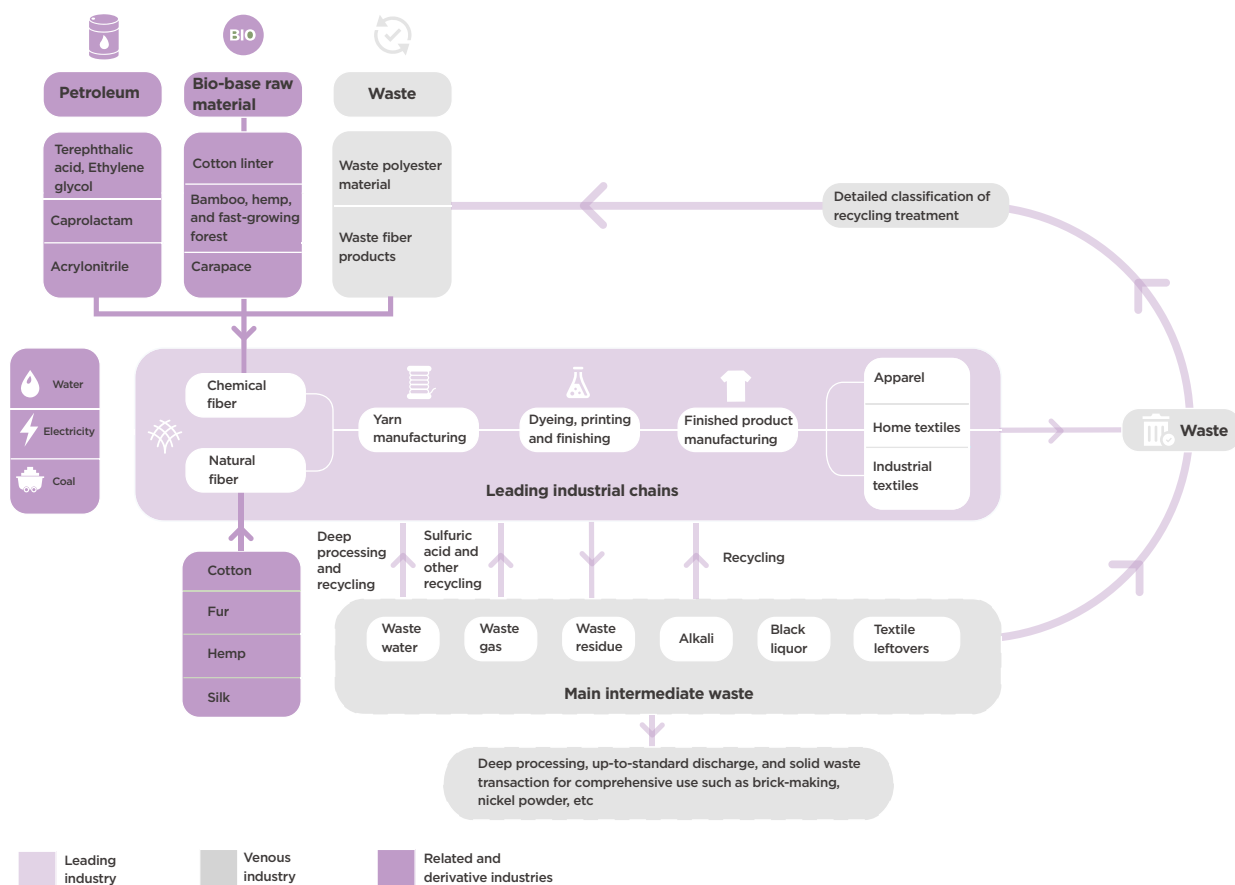
The industry should accelerate the development of bio-based textile fiber materials to replace petroleum, encouraging the production of high value-added recycled fibers made from waste polyester bottles, waste polypropylene fibers, waste natural fibers, etc., to reduce the consumption of primary resources. Potential raw materials of bio-based textile fibers include cotton linter, bamboo, hemp, fast-growing forest and carapace, etc.

Consumption reduction, energy conservation and resource recycling in production

The industry should promote energy conservation and consumption reduction. Backward production capacity should be eliminated faster and the energy- and water-saving transformation of equipment should speed up. The industry should promote the application of high-efficiency energy-saving motors and automatic climate controls to optimize energy systems. The industry should promote the use of biodegradable slurry and clean liquid phase heat transfer fluids to reduce the use of toxic and harmful substances at source. The printing and dyeing industry should comprehensively promote highly efficient short-flow pretreatment techniques, as well as processing techniques such as cold-pressing stack dyeing, airflow dyeing and digital printing.

The industry should strengthen the recycling of waste resources. The approaches include: the recycling of waste water and the recovery and utilization of heat energy from waste water and exhaust gases; the recycling of dyeing and printing chemicals and auxiliaries from waste water; the recycling of alkali from waste alkali liquor from dyeing and printing. waste gas from chemical fiber production should be used to produce acid; and there should be recycling and

Basic development model of circular economy in China's textile industry



Source: Circular Economy Development Strategy and Near-term Action Plan ²⁸

reusing of solid waste (such as production waste and leftover materials).

Standardization of textile waste recycling

The industry should take the recycling of used professional clothing as a breakthrough for the improvement of the recycling system of textile waste. The industry should also promote the safe and environmentally friendly processing of textile waste through choosing economic technical routes, and encourage the use of textile waste to produce building insulation materials and other products.

Build typical circular industry chain in the textile industry

The industry should build industrial chains such as: printing and dyeing – waste liquid – alkali; chemical fiber production – waste gas – acid production; textile – waste water, waste gas – thermal energy – textile; textile – leftover – textile; textile – textile waste – regenerated products – textile; textile – textile waste –

insulation material; waste polyester – chemical fiber – textile.

In 2017, the *Leading Action Plan on Circular Development* proposed to accelerate the construction of a green, circular, and low-carbon industry system and laid out two ways in which a circular economy transformation of the industrial system could be achieved. The first approach consists in reconfiguring the entire industrial chain through optimizing the raw materials structure, promoting eco-design, encouraging green consumption, and enforcing comprehensive utilization of renewable resources. The other approach involves building a circular industrial system through circular production of companies, circular development of industrial parks and circulation between industries.

In 2012 CNTAC issued the *Outline for Building a Strong Textile Country (2011-2020)*, which proposed enhanced development of textile recycling. To do this it proposed building the indicators to be met by the industry in terms of resource consumption, pollution emission

and recycling system by 2020. The *Textile Industry Development Plan During China's "12th Five-Year Plan" Period* and the *Textile Industry Development Plan (2016-2020)*, respectively issued by the MIIT of China in 2013 and 2016, specified standards for the resource recycling of the industry, in key areas, as well as specifying key technologies for implementation. It focused on the optimization of raw material use, cleaner production, comprehensive utilization of renewable resources, etc.

Guided by China's national strategy and industrial policy, China's textile and apparel industry has made step-by-step progress in circular economy transformation by adjusting the industry structure, eliminating backward production capacity and promoting technological innovation. It lays a solid foundation for accelerating the transformation.

Awareness of the importance of circular development among leading companies in the textile and apparel companies has increased. In 2019, the Office for Social Responsibility of CNTAC conducted a survey of the circular practices of 40 companies. The results showed that all these companies had included circular economy into their long-term development strategy, and the

driving force has gradually changed from the traditional ones of cost reduction and increased efficiency, to improving the core competitiveness of companies and seizing market opportunities.

As far as industrial practice is concerned, China's textile and apparel industry has fully completed the planned goals during the "12th Five-Year Plan" period. The proportion of recycled fiber processed has risen from 9.6% in 2010 to 11.3% in 2015,²⁹ and the estimated processing volume reached 7 million tons in 2018. The industrial development of bio-based chemical fiber has been realized with an increased variety of products. Energy consumption has been reduced and recycling in textile manufacturing has improved significantly, with a large number of new technologies being pioneered and put to wide use. The industrial chain of recycling, sorting and comprehensive utilization of textile waste has been basically completed. "Zero Discarding of Old Clothes" has been widely adopted, and the EPR system has also been put into practice at company level in a small scale. Awareness of green design and sustainable consumption has risen, and some exploratory practices have emerged.

Industrial plan for the development of a green, circular, and low-carbon textile industry

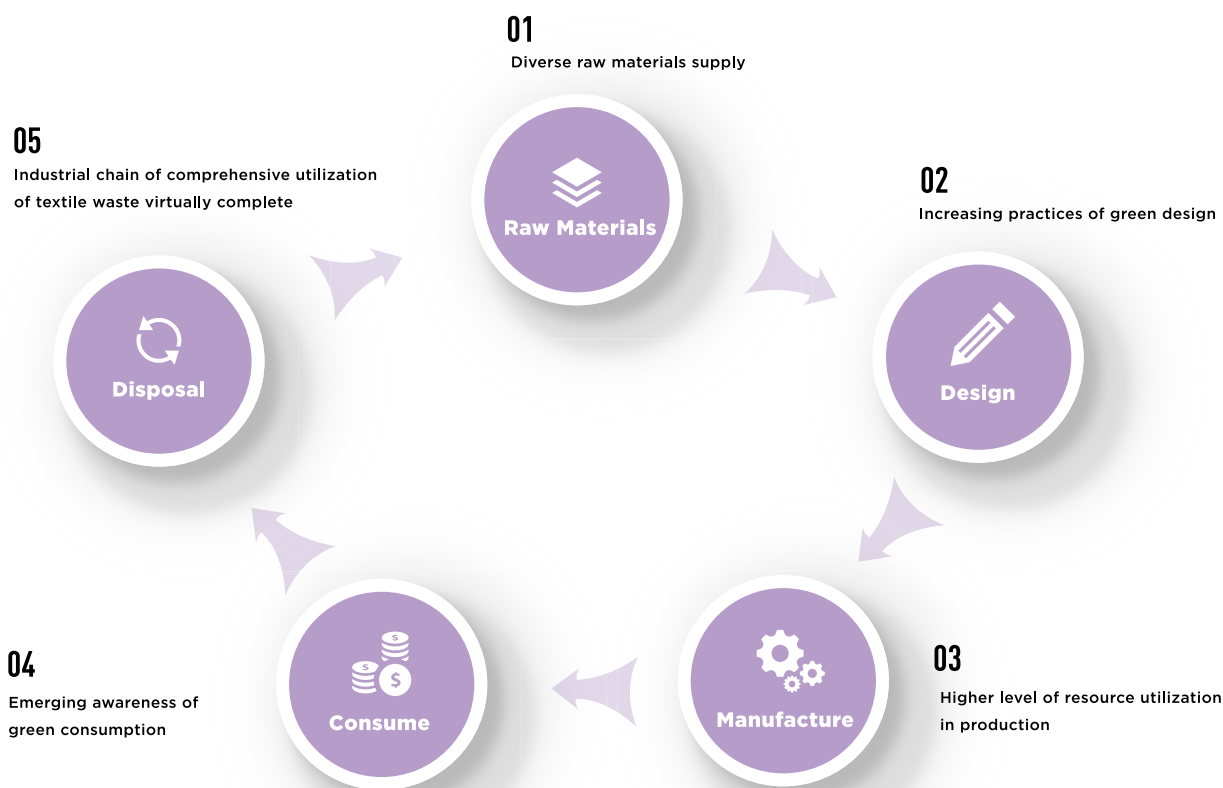
Industrial Plan	Main Goals
Textile Industry Development Plan During China's "12 th Five-Year Plan" Period	<ul style="list-style-type: none"> • The energy consumption per unit of industrial added value is 20% lower than that in 2010. • The emission of industrial carbon dioxide is 20% lower than that in 2010. • The water consumption per unit of industrial added value is 30% lower than that in 2010. • The emission of main pollutants is 10% lower than that in 2010. • The recycling system of textile fiber has been preliminarily established, and the total amount of reused textile fiber has reached about 8 million tons.
Textile Industry Development Plan (2016-2020)	<ul style="list-style-type: none"> • The green manufacturing system of the textile industry has been formed and the cleaner production technologies has been widely used. • By 2020, the energy consumption per unit of industrial added value of the textile industry has decreased by 18%, the water intake per unit of industrial added value has decreased by 23%, and the total discharge of main pollutants has decreased by 10%. • A number of key common technologies for textile waste recycling have made breakthroughs and the proportion of recycled textile fibers in the total fiber processing volume continues to increase.

03

**Main progress and
core challenges of
China's textile and
apparel industry's
circular economy
transition**

3.1

Main Progress



3.1.1 Diverse raw materials supply

According to CNTAC's statistics, in 2018 about 54.6 million tons of fiber were processed in China, about 45.62 million tons of which were synthetic fiber, more than 83% of the total. The main categories included polyester, nylon (polyamide fiber), polypropylene and acrylic (polyacrylonitrile fiber), etc.

It is strategically important for China's textile and apparel industry to diversify its raw materials to reduce the industry's dependence on petroleum resources. As the demand for fiber continues to increase, challenges such as rising costs, and resource exhaustion caused by the shortage of petroleum resources are likely to have a negative impact on the high quality and stable development of the industry. As more and more sustainable fashion practices emerge, the first key issue for the industry is to consider the raw materials used from the whole life cycle perspective so as to reduce resource consumption and the environmental footprint.

Recycled fiber and bio-based chemical fiber are the two main raw materials which are considered to have the potential to be developed as sustainable materials in China. Recycled fiber is very efficient in terms of the utilization of waste resources, offering obvious benefits for the environment. Bio-based chemical fiber, partly or entirely made of biomass, can reduce the use of non-renewable resources.

The proportion of recycled fiber processing in China has been increasing from 9.6% in 2010 to 11.3% in 2015. It is estimated that the output of recycled fiber in China exceeded 7 million tons in 2018, which is widely used in apparel, home textiles, and other fields; while the use of bio-based chemical fiber has become industrialized and the range of product categories has diversified considerably.



Increase proportion of recycled fiber

Recycled fiber, also known as regenerated fiber, can be divided into three categories: recycled chemical fiber, recycled cotton fiber, and recycled wool fiber.

Recycled chemical fiber refers to the fiber which goes through the process in which recycled polymer materials and textile waste are used again after being physically opened and loosened, or are melted and dissolved for spinning. The recycled polymer materials may be further decomposed into small molecules for re-polymerization and spinning. Recycled chemical fiber includes recycled polyester, recycled nylon, recycled polypropylene, etc., of which recycled polyester is the most important, accounting for more than 90% of the total. The main sources of recycled polyester are bottle chips, polyester foam, waste silk, waste fluid, and textile waste. The products include recycled polyester staple fiber and polyester filament.³⁰ In 2018, China's recycled polyester fiber production capacity was about 9.5 million tons, and the actual production is about 5.5 million tons, accounting for 10% of China's total fiber processing volume.³¹

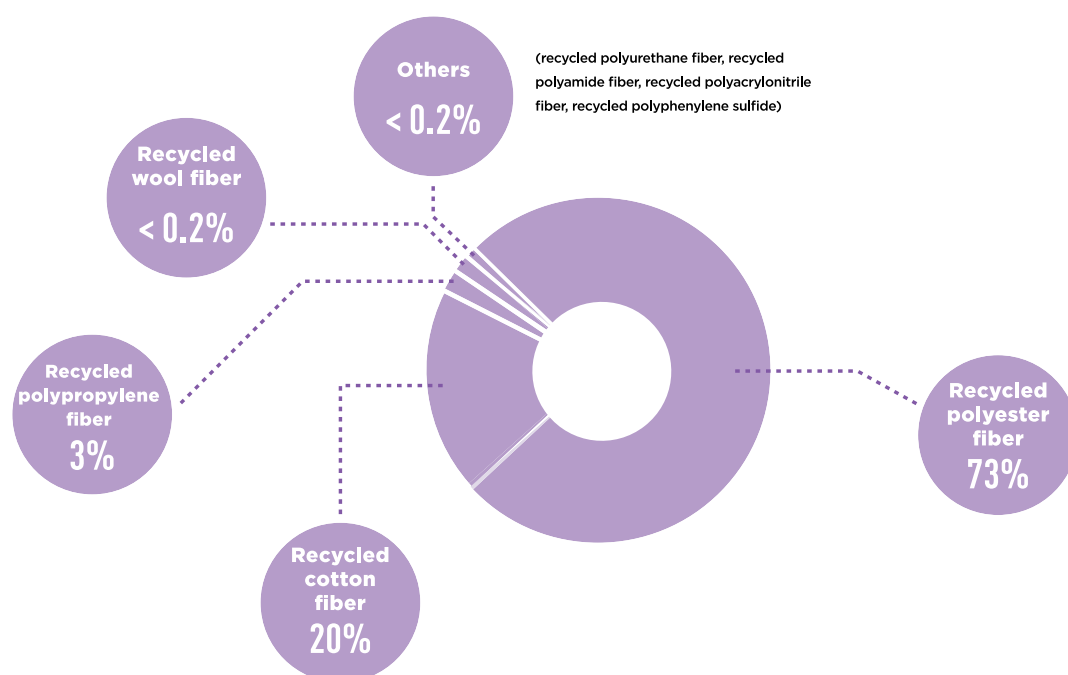
Recycled cotton fiber and recycled wool fiber mainly come from waste cotton textiles, wool textiles, and blended textiles, including leftover materials, waste apparel, and home textiles. After recycling, sorting and physical opening and loosening, they are directly processed into recycled fiber and then spun into yarn to produce textile products. Their main places of production in China is Wuxi city and Nantong city of Jiangsu province and Cangnan county and Jiaxing city of Zhejiang province. In 2018 the output of recycled cotton fiber was about 1.5-2 million tons, and that of recycled wool fiber about 200,000 tons.³²

At present, China is the world's largest producer of recycled polyester fiber. With the development of

technology and product innovation, the quality and performance of recycled polyester products (especially staple fiber) have been able to replace traditional fiber. During China's "13th Five-Year Plan" period, the industry's scale and standardization has been further improved, forming characteristic industrial clusters in Cixi city of Zhejiang province, Jiangyin city of Jiangsu province, Jinjiang city of Fujian province, and Jinning city of Guangdong province. A number of excellent companies have emerged. Zhejiang Cixi mainly provides polyester staple filler and recycled polyester filament with Dafa Chemical Fiber (Ningbo) Co., Ltd. as its leading company; Jiangsu Jiangyin mainly offers cotton-type non-ferrous recycled polyester with Elite Color Environmental Resources Science&Technology Co.,Ltd. as its leading company; Fujian Jinjiang mainly produces non-woven polyester staple fiber with Jinjiang City Gangyi Fiber Products Co., Ltd. as its leading companies; Guangdong Puning mainly provides the cotton-type, semi-dull, high-strength, low-stretch recycled polyester staple fiber with Guangdong Qiusheng Resources Co., Ltd. as its leading company.³³

In 2017, the recycled polyester industry was greatly impacted by the *Plan for Prohibiting the Entry of Foreign Garbage and Advancing the Reform of the Solid Waste Import Management System (2017, the State Council of China)*, causing shortages of raw material and slightly decreased industrial capacity. By extending the processing and collection system of waste bottle chips and strengthening the utilization of waste silk and polyester leftovers, the company basically achieves material re-balancing. As the global fashion industry seeks sustainable development, the global market demand for high-quality, differentiated recycled fiber is increasing, which provides optimistic opportunities for the industry.

China's main categories of recycled fiber and estimated production in 2018



Note: The sum does not exactly equal 100% because of rounding.

Note: The total amount is about 7.2-7.7 million tons based on published data and empirical estimations.



Industrial production of bio-based chemical fiber

Bio-based chemical fiber refers to fiber whose raw material at least in part comes from a biological source, which is then processed via polymer chemistry, physical method, and spinning. It has the advantage of having renewable sources and part of it can degrade naturally after use. It thus can contribute greatly mitigating the crisis of resources and reducing environmental pollution.

The main sources of bio-based chemical fiber are waste crop, bamboo, hemp, fast-growing forest, marine biological resources, etc. The bio-based chemical fibers include new cellulose fiber, bio-based synthetic fiber, marine bio-based fiber, and bio-protein fiber. Most of them are in the early period of industrial development or R&D stage. Lyocell, bamboo pulp fiber, hemp pulp fiber; polylactic acid (PLA) fiber, polytrimethylene terephthalate (PTT) fiber; protein composite fiber, chitosan fiber, and alginate fiber have been

industrialized, and have been applied in different fields such as clothing, home textiles, and medical products. According to China Chemical Fibres Association statistics in 2018 China's bio-based fiber capacity was about 300,000 tons.^{34, 35}

Lyocell, a new solvent-spun cellulose fiber, is the most widely used degradable bio-based fiber and is appreciated on the market because of its excellent quality and performance, and its properties such as the fact that it comes from renewable resources, is produced by environmentally friendly processes, and is completely degradable. China's production capacity of Lyocell in 2018 has reached 60,000 tons, and it has been widely used in haute suits, knitted apparels, casual wear, and underwear, and its use has gradually expanded to decorative textiles and other industrial textiles.

Main bio-based fibers and their industrial production capacity in China in 2018

Fiber varieties			2018 Production capacity Unit (ton)	Main application scenarios
New cellulose fibre	New solvent-spun cellulose fiber	Lyocell	61,000	With natural cellulose as the raw material, the new cellulose fiber is prepared by direct dissolving spinning process with organic solvent. It is mainly used in haute suits, knitted apparel, casual wear, and underwear. In recent years, it has also been used in industrial textiles for decoration.
		Low temperature alkali/Urea solution cellulose fiber	1,300	
	New resource regenerated cellulose fiber	Bamboo pulp regenerated cellulose fiber	120,000	With bamboo slices as the raw material, the bamboo pulp is made into fiber by wet spinning. Suitable for close-fitting fabrics, non-woven cleaning products, and home textiles.
		Hemp pulp regenerated cellulose fiber	1,000	The fiber is made of natural jute and kenaf, which is suitable for close-fitting fabrics, non-woven cleaning products and home textiles.
Bio-based synthetic fiber	Degradable bio-based synthetic fiber	Polylactic acid (PLA) fiber	35,000	The fiber uses corn, tapioca starch and sugar beet as raw materials to produce lactic acid through fermentation, and then it is made into a completely bio-degradable synthetic fiber through advanced polymerization technology and melt spinning. The product is bacteriostatic, flame retardant, is bio-compatible and bio-absorbable, and has been successfully applied in apparel, home textiles, health and medical products.
		PHBV and PLA blend fiber	1,000	Used in nonwovens in recent years.
	Non-degradable bio-based synthetic fiber	PTT fiber	120,000	PTT fiber is prepared by polymerization of bio-based 1,3-propanediol (PDO) and terephthalic acid (PTA). The former comes from non-food raw materials such as cassava starch and glycerin. The fiber is widely used in carpet, fashion, T-shirt, jeans, swimwear, etc.
		PA56 fiber	30,000	Using pentanediamine and adipic acid as raw materials, this new type of bio-based polyamide fiber is synthesized biologically and is widely used in apparel, decoration, and industry field.
Marine bio-based fiber		Alginate fiber	5,000	The fiber is made from alginic acid extracted from brown algae in the ocean. It has started to be used in medical dressings, hemostatic gauze, industrial apparel, etc.
		Chitosan fiber	2,500	The fiber is made from shrimp and crab shell, and is naturally antibacterial, super absorbent, and hemostatic. It is mainly applied in the field of medicine.
Biological protein modified fiber		Soybean protein fiber	10,000	Biological protein modified fiber is a kind of modified chemical fiber, which is produced by adding soybean, milk, wool, and silk fibroin through blending, grafting, and other means during chemical fiber production. It is widely used in underwear, home textiles, women's special sanitary materials, and also in biology, medicine, and other fields.
		Wool protein fiber		
		Milk protein and acrylonitrile grafted fiber		
		Silkworm chrysalis protein fiber		

Source: Development and perspective of bio-based chemical fiber industry ³⁷



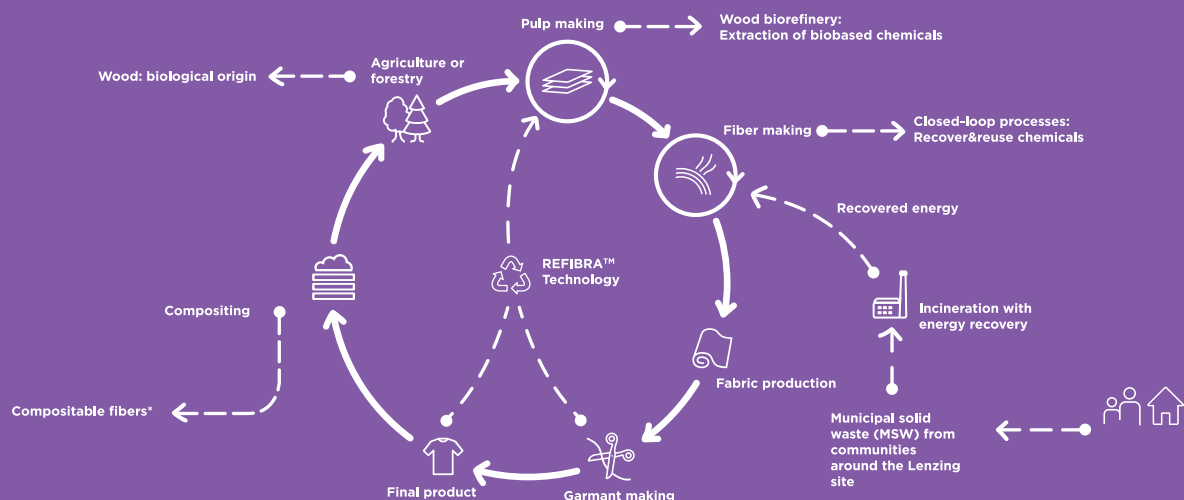
Lenzing's solution to promote systematic industrial change

Based in Austria, the Lenzing Group is one of the world's leading producers of wood-based pulp and cellulosic fibers – Viscose, Modal, and Lyocell. With sustainability and innovation as its core values, Lenzing integrates the circular economy into its business.

- Lenzing produces wood-based cellulosic fibers, which are biodegradable or compostable, and become part of the natural cycle after use.
- Water, chemicals, and energy are recovered and recycled through a closed-loop production process in manufacturing.
- The REFIBRA™ technology is an innovative breakthrough in the production of TENCEL™ Lyocell fibers that are partly based on recycled raw material – cotton waste before and after use.
- Lenzing traces its fibers through Blockchain technology to improve the brand's transparency and traceability, allowing end consumers to obtain information about the fiber when they scan the QR code in clothes.

Lenzing Nanjing Fiber Co., Ltd., a wholly owned subsidiary of Lenzing Group in China, is a mature viscose staple fiber manufacturer with the most advanced technology and non-woven products. By recycling raw materials, chemicals and waste, Lenzing Nanjing demonstrates how to realize highly efficient circular production. The company has obtained EU Ecolabel certification and meets the requirements of EU BAT (European Union Best Available Technology standard). Lenzing Nanjing's main practices include:

- Extracting high purity sodium sulfate from the acid bath process to produce sodium sulfate.
- Reusing waste high-concentration CS_2 through CAP activated carbon adsorption and condensation.
- Generating H_2SO_4 by processing the CS_2 and H_2S in the waste gas in a WSA wet sulfuric acid unit and reusing it.




*All standard fibers from Lenzing are compostable and biodegradable in marine and soil conditions. The compostability and biodegradability of final consumer textile and nonwoven products depend on the material composition (fiber blend) and processing in the value chain.

3.1.2 Increasing practices of green design

Since the 1960s, the public has become increasingly aware of environmental problems caused by accelerated industrialization. Various solutions have been put forward, and the approach has gradually changed from "terminal governance" to "pre-prevention", that is, reducing the impact on the environment at source. Research shows that 80% of resource consumption and environmental impact depends on the design phase of a product.³⁸ In the second half of the 1990s, green design appeared and became mainstream in the field of industrial design.

China's *Circular Economy Promotion Law* clearly states that the design of techniques, equipment, products,

packaging, and services should comply with the requirements of reducing resource consumption and waste, which means priority should be given to the use of materials and design solutions with characteristics like easy to recycle, easy to disassemble, easy to degrade, non-toxic and harmless, or low toxic and of low harmfulness, and meet the requirements of relevant national standards. In recent years, under national policies' guidance the industry has trended in the direction of sustainable development, and some leading textile and apparel companies have been paying more and more attention to green design and related practices as have designers.



Green design, also known as "ecological design", refers to the systematic consideration of a product's impact on resources and the environment within its lifespan including choice of materials, production, sales, use, recycling, disposal, etc. in the perspective of whole life cycle. Efforts are made to minimize resource consumption and reduce waste, using as fewer materials containing toxic and harmful substances as possible so as to protect the environment.^{39, 40}



Awareness and practices of companies

Companies play the main role in green design, and some leading textile and apparel companies in China have started its journey. According to research into 40 textile and apparel companies conducted by the Office for Social Responsibility of CNTAC in 2019, most of the 25 companies involved in product design will consider ecological design in the product design phase: 24% of them will consider ecological design for all their products, and 52% of them will consider it in most of their products.

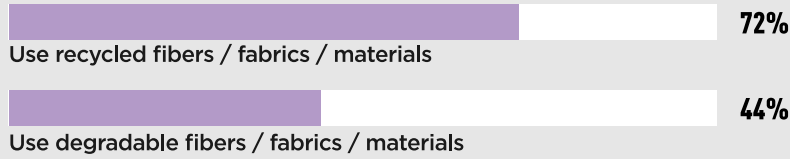
Green design implemented by the interviewed companies is mainly reflected in two aspects: choice of materials and more environmentally friendly production technologies or processes. According to the data, 72% of companies surveyed will choose recycled fibers/

fabrics/materials. The production technologies or processes mainly refer to technologies that use less harmful substances, consume less energy and water resources or do not even consume water at all.

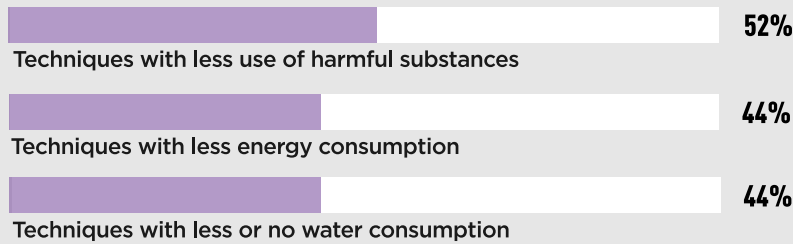
During China's "13th Five-Year Plan" period, the MIIT of China launched a demonstration pilot program of green design. As of November 2019, six textile and apparel companies had received MIIT approval, and have been selected as the first batch of demonstration companies in green design for industrial products. The six companies are: Erdos Group, Pacific (Panyu) textile printing and dyeing Co., Ltd, Wensli Group, Consinee Group, Fujian Baichuan Resources Recycling Science & Technology Co., Ltd., and Dragon Fuhuan Technology Co., Ltd., and their products include textiles, silk products, cashmere, etc.⁴¹

Practices adopted by companies in implementing green design

Raw materials



Production process



ErDOS' green design practices⁴²

Product design and development

Established a basic database for the product life cycle in the cashmere industry.

Raw material selection and use

Implemented a cashmere goat capture program to combine ecological protection and cashmere goat breeding; selected high-quality environmentally friendly dyeing additives and auxiliary materials.

Manufacturing

Achieved water-saving and upgraded green-dyeing technology through research and the application of efficient combing technology, dyeing technology using plant dyes and edible pigments, and green cashmere decolorization technology without the use of phosphorus.

Product recycling

Built a recycling system of waste products by using sales channels, strengthened waste cashmere products recycling by "old for new" activities, reuse, etc.; active R&D into processes and equipment for renovating, and re-manufacturing to develop a new recycling model for precious cashmere resources.

WENSILI's green design practices⁴³

Product design and development

Built a life cycle database for each product in the upstream supply chain, and then, based on the database, initially established the first green design management system in the silk industry.

Raw material selection and use

Selected high-quality suppliers of green dye auxiliaries based on the requirements of safety and environmental protection (e.g. excluding banned chemicals).

Manufacturing

Used independently-developed green digital printing design and manufacturing technology to effectively address the problems of traditional silk printing and dyeing, including high resources consumption, high manpower levels, high costs, etc.

Product recycling

Conducted high-quality silk recycling activities



Awareness and practices of designers

The fashionable nature of the textile and apparel industry determines the important role of designers in leading green design and circular fashion.

In 2019, the Office for Social Responsibility of CNTAC investigated 50 designers' awareness of green design practices. Most of the designers interviewed were independent designers, essentially avant-garde designers who had early contact with the concept of green design and some experience out of it in China.

The survey showed that about 58% of the interviewees will try their best to apply green design; 7.8% of them have adopted green design in all their design, and 13% of them have given little or no thought to the issue. Most designers adopt sustainable design because it is how the market is trending, but some because of their personal commitment to sustainable development.

The designers' green design practices basically cover the product's life cycle. They choose to use environmentally friendly materials and lower carbon and energy-saving production processes and procedures. They attempt to increase the connection between people and products through design to extend the product lifetime. They also take account of the recoverability and recyclability of the product, as well as sustainable packaging solutions, etc. But essentially, designers focus on the choice of materials and the extension of the product's life cycle.

Choice of Materials

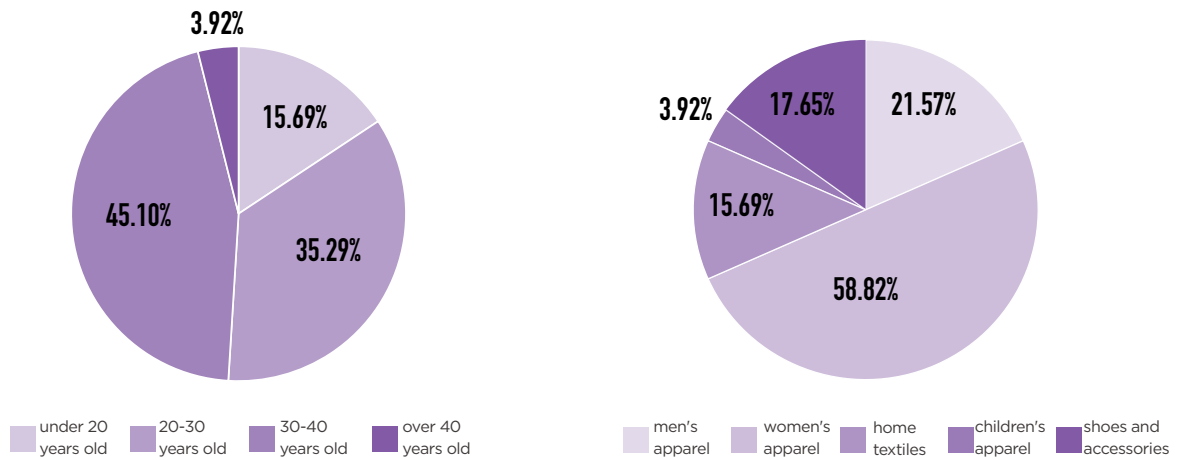
Green materials used by designers mainly include recycled materials and bio-based materials. Recycled

materials include recycled cotton, wool, polyester, and waste clothing, while bio-based materials include bio-based cellulose fiber, bio-based synthetic fiber, marine bio-based fiber and protein fiber materials. According to the survey, the most widely used material is bio-based cellulose fiber, which accounts for about 60.78%, followed by recycled materials (about 54.9%), and upgraded materials from recycled waste clothing (about 45.1%). The proportion of bio-based synthetic fiber, marine bio-based material, and protein fiber material is relatively small, which is basically consistent with the state of the industry's current supply of materials.

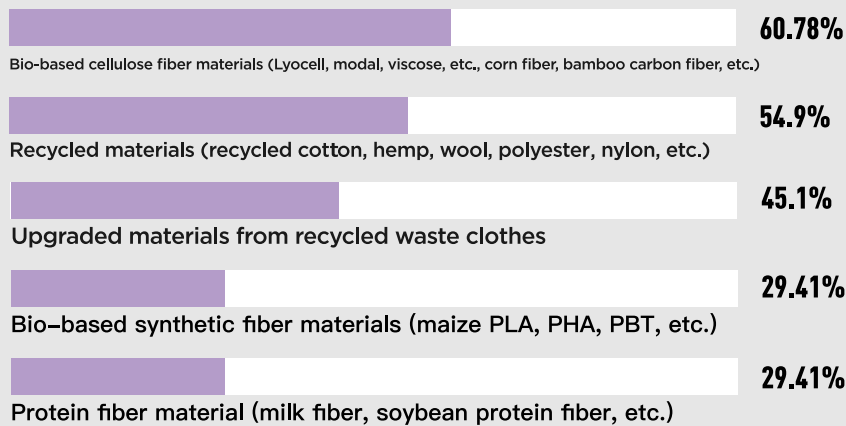
Extending product life cycles

The most direct way to reduce waste and pollution in the textile and apparel industry is to increase the time clothes are used by consumers by improving product quality and connotation. Research shows that two of the top three environmental factors most often considered by China's designers are related to this aspect: 58.82% of designers will try to increase product durability by the choice of materials and manufacturing methods; 54.9% of designers will increase the use time of products by adding cultural, innovative, and other factors.

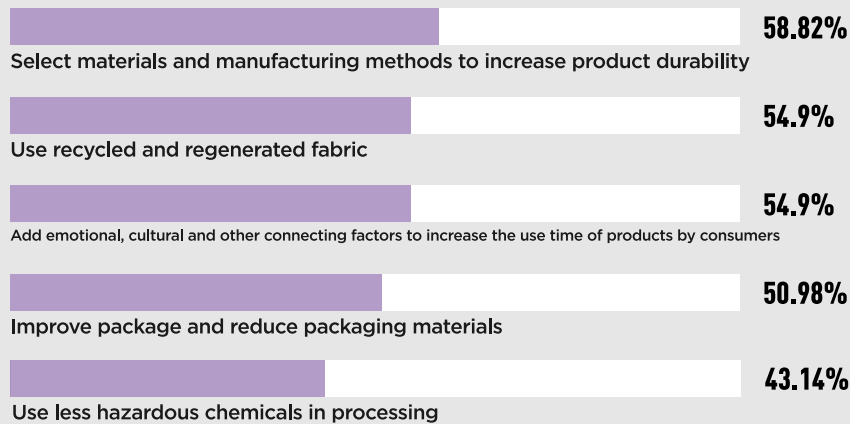
Age and domain distribution of designers interviewed



Top six sustainable/green material categories designers focus on



Top five sustainable / green factors designers will consider when designing



3.1.3 Higher level of resource utilization in production

China has carried out cleaner production and environmental management of water, air, and solid waste since its "10th Five-Year Plan" period and has built relatively sound supporting policies (such as industry access conditions, cleaner production audits, emissions permits). As a key industry, the textile and apparel industry has made progress in cleaner production, energy saving, and emission reduction. During the "12th Five-Year Plan" period, a large number of new energy-conservation and emission-reduction technologies were widely used. The fresh water intake for printing and dyeing of 100 meters of cloth decreased from 2.5 tons to less than 1.8 tons, and the water recycling rate increased from 15% to more than 30%. Restrictive indicators such as the reduction of energy consumption per unit of value-added, the decrease of water intake, and the reduction of total pollutant emissions are all completed. That is energy consumption, water consumption, and emissions of major pollutants per unit of industrial added value decreased by 20%, 30%,

and 10% respectively compared with the "11th Five-Year Plan" period.⁴⁴

Standardized management in key sectors of the industry has been improved in terms of pollution and resource consumption of the industry. From 2015 to 2017, China's MIIT issued specifications for the recycled chemical fiber (polyester) industry, the viscose industry and printing and dyeing industries. The specifications define indicators for key products in terms of industrial water reuse rates, comprehensive energy consumption, and fresh water intake; these indicators are set higher than the standards in the industry development plan and represent the leading level of the industry. For example, the water reuse rate in the recycled chemical fiber (polyester) industry should reach 86%, far higher than the 30% required in the industry development plan. There are 87 enterprises that have reached the standard requirements and passed the evaluation criteria of MIIT.

Progress in Standardized Management of Key Resource Consumption and Environmental Pollution in China's Textile and Apparel Industry

Industry norms	Key products	Industrial water reuse rate	Comprehensive energy consumption	Fresh water intake	Number of compliant companies
Specification Conditions for the Printing and Dyeing Industry (Edition 2017)	Cotton, hemp, chemical fiber and blended woven fabric.	≥40%	≤30 Kg standard coal/100m	≤1.6 tons water/100m	22
	Yarn, knitted fabric		≤1.1 tons standard coal/ton	≤90 tons water/ton	
	Silk woven fabric (including scouring white)		≤36 Kg standard coal/100m	≤2.2 tons water/100m	
	Worsted wool fabric		≤150 Kg standard coal/100m	≤15 tons water/100m	
Specification Conditions for the Viscose Fiber Industry (Edition 2017)	Viscose filament yarn	≥95%	≤4000 Kg standard coal/ton product	≤235 tons/ton product	31
	Viscose staple fiber	≥90%	≤1000 Kg standard coal/ton product	≤55 tons/ton product	
Industrial Specifications Conditions for the Recycled Chemical Fiber (Polyester)	Raw material of recycled polyester staple fiber	≥40%	≤35 Kg standard coal/ton product	≤1.2 tons/ton product	34
	Recycled polyester staple fiber		≤180 Kg standard coal/ton product	≤0.65 tons/ton product	
	Raw material of recycled polyester filament		≤40 Kg standard coal/ton product	≤1.5 tons/ton product	
	Recycled polyester filament		≤320 Kg standard coal/ton product	≤0.70 tons/ton product	



Circular industrial system basically formed

One of the main tasks to be completed in terms of constructing China's circular industrial system is to promote circular production in companies, industrial parks, and industries.⁴⁵

Circular production of companies

This involves companies organizing production according to a circular model, improving utilization efficiency and reducing waste. Textile and clothing companies benefit a lot from their continuously growing practices of circular production. The evaluation system of cleaner textile production has been improved; audits evaluating cleaner production have been implemented in key industries such as printing and dyeing, chemical fibers, etc. In addition, a large number of advanced technologies in terms of energy conservation and emissions reduction have been promoted.

Printing and dyeing is an important intermediate link in the textile and apparel industry and plays an important role in enhancing the added value of the industry, but it is also the link faced with the greatest environmental problems, which limits the move towards sustainable development. Waste-water discharge by the printing and dyeing industry accounts for 80% of all textile waste-water, and the energy consumption involved accounts for more than 60% of total energy consumption.⁴⁷

During its "13th Five-Year Plan" period, energy conservation, emissions reduction, and resource recycling in China's printing and dyeing industry were improved significantly. Low temperature bleaching of cotton fabrics, continuous open-width pre-processing and washing of knitted fabrics, salt-free dyeing of cotton fabrics, yarn coating dyeing, and other technologies have made breakthroughs and been adopted on an industrial scale. There have also been breakthroughs made in terms of research into enzyme refining, short wet steam dyeing, foam dyeing, knitted fabric open-width dyeing, ultrasonic dyeing, plasma technology, and non-aqueous medium dyeing. The industry's cleaner production and automated control systems have been greatly improved. Technology for online collection and automatic control of process parameters, for automatic weighing and transportation of chemicals, and the digital printing technology represented by digital ink-jet printing and color printing

Building a circular industrial chain system

Circular integration of industries

This involves encouraging companies in different industries to build symbiosis and connections through material flow and energy flow, and organize the mutual supply of raw materials and resource sharing, so as to establish a cross-industry circular chain

Circular development of industrial parks

This involves creating circular parks to achieve circular connection between companies and industries, enhancing the flow management of energy and resources, as well as improving the management of the environment.

Circular production of companies

This involves promoting ecological design of products and the "3R" production method

Source: Leading Action Plan on Circular Development⁴⁶

have all also been put to industrial use.^{48,49}

In recent years, dope-dyed fiber has emerged as one of the important solutions to solving the problems of high energy consumption, high water consumption, high carbon dioxide emissions, etc. faced by the industry. Dope-dyed fiber is also called color spinning fiber and pre-spinning dyed fiber. It refers to the colored fiber made by adding colorant into a spinning solvent or melt. Using dope-dyed fiber to produce textiles can reduce energy consumption, and also greatly reduce waste water and carbon dioxide emissions. Due to the environmentally friendly characteristics of the production process, dope-dyed fiber is considered as a kind of "green fiber" by the industry. Since 2010, the annual growth rate of China's dope-dyed fiber has reached more than 10%, and the annual output in 2017 was about 5 million tons, accounting for about 10% of all chemical fiber. At present, polyester fiber, polyamide fiber, regenerated cellulose fiber, and polyacrylonitrile fiber can be manufactured through dope-dyeing technology, and their products are widely used in embroidery thread, sewing thread, vehicle textiles, outdoor textiles, socks, etc.⁵⁰

Main circular economy practices in China's Textile and Apparel Industry

Production phase	New process or technology		Circular economy performance
Fiber production	Dope-dyeing		Mitigate the subsequent dyeing process, reduce energy consumption, and greatly reduce waste water and carbon dioxide emissions.
Spinning	A new bleaching process with low energy consumption and pollutants emission		Save energy and reduce waste
Weaving	New clean size (deep denatured modified starch, grafted starch size, multiple modified starch size, compound modified starch size, etc.) and clean sizing technology (solvent sizing, pre-wet sizing, foam sizing, hot melt sizing, high pressure sizing, cold sizing, etc.)		Reduce the use of toxic and harmful substances and reduce waste water pollution
Printing and dyeing	High efficient water saving technology	Ecological pre-processing technology	Save more than 1/3 of energy and time; reduce 2/3 of sewage.
		Ecological enzyme pre-processing technology	Non-toxic and harmless with low dosage, and the waste water produced is biodegradable.
	Energy saving and emission reduction technology	Biological enzyme de-sizing technology	Simplified technical process with less sewage and naturally-degraded enzyme
		Biological enzyme refining technology	Less usage of the amount and time and less toxicity of refining sewage
		Catalase bleaching	High efficiency, energy saving, and no pollution
		Ultrasonic de-sizing technology	Energy saving
	Ecological dyeing/printing technology	Supercritical carbon dioxide dyeing	Fast dyeing efficiency
		Reactive dye cold rolling stack dyeing technology	Less energy consumption, less dyeing waste water.
		Micro-suspension dyeing	Shorten dyeing time and save energy
		Micro-capsule dyeing	Improve the utilization rate of dyes; being beneficial to the purification of waste water; dyeing without auxiliaries and water washing.
		Salt-free or salt-less dyeing technology	Reduce the use of reactive dyes and the salt content of waste water.
		Digital ink-jet printing	Less waste of dyeing materials, and resources saving.
	Disposal of waste gas	Heat recycling and purification of waste gas of shaping machine	Reduce waste emissions; recycle heat and save energy.
	Lye recycling	Recycle the alkali from waste liquid, which can be used for de-sizing, boiling, mercerizing processes after treatment	Reduce the alkali consumption; decrease the alkalinity and discharge of waste water; reduce the amount of waste water treated to save energy and reduce consumption
	Waste water recycling	Biological processing method, physical method, and chemical method	Reduce water consumption
Apparel manufacturing	Recycling of leftover materials	The leftover materials of textile companies are comprehensively used in various fields by various ways, which can reach a rate of 90%.	Improve resource utilization; and reduce waste.

Source: Textile Industry and Circular Economy ⁵¹

Circular development of industrial parks

The industrial park is an important element in China's industrial development system, and also a major way to promote material exchange and resource sharing among companies. The circular development of the park refers to the construction or transformation of the new park or the park to be upgraded in accordance with the "3R" principles (reduce, reuse, and recycling), so as to achieve the efficient use of resources and energy, reduce pollution, and make the park fully ecological. The characteristics of an eco industrial park are: all companies in the park should actively adopt cleaner production; companies exchange their waste and reuse it to maintain a symbiotic relationship; material resources and energy between companies should be used in cascade fashion; and finally, there should be environmental infrastructure sharing.

China's textile and apparel industry has formed many clusters during its development, and this has become one of its most important characteristics. In 2002, CNTAC launched the joint construction of textile industry clusters and established pilot relationships with 209 textile industry clusters nationwide by the end of 2017.⁵² Since the "12th Five-Year Plan", relying on industrial clusters, the development of Eco industrial parks or circular economic parks has become an important means to restructure and transform the industry.

Taking the printing and dyeing cluster as an example, since the "12th Five-Year Plan" period, China has pushed the printing and dyeing companies into parks to promote the structural adjustment, transformation, and upgrading of this industry. In 2017, China issued the *Specification Conditions for the Printing and Dyeing Industry (Edition 2017)* and the *Interim Measures for the Specification Announcement Management of Printing and Dyeing Companies*, which clearly put forward the requirements that "Companies outside the industrial park should gradually move into the park", "There should be centralized construction in the industrial park to realize centralized heat supply and pollutant treatment". With the implementation of these directives, cleaner production and circular production by the industry has improved.

Circular integration of industries

Industrial circular integration means that companies in different industries obtain symbiosis through material flow and energy flow and achieve the mutual supply of raw materials and resource sharing, so as to establish a cross-industry chain of circular economy. At present,

the common practice in textile and apparel industry mainly concerns two areas: one is the reuse of recycled resources from other industries, such as waste polyester bottles, becoming the raw material for chemical fiber production (See 3.1.1 for details); the other is that after processing textile waste is reused in automobiles, home appliances, agriculture, etc. (See 3.1.5 for details)

Intelligent manufacturing helps the industry's circular economy development

Intelligent Manufacturing refers to informative, smart, customized, and sustainable production through advanced technologies such as big data, artificial intelligence, internet of things, etc.

Intelligent manufacturing helps to enhance the digital and information management of textile companies, improving production efficiency, and reducing operating costs. It helps significantly to improve the resource utilization rate of the whole industry, reduce waste and resource consumption. During the "13th Five-Year Plan" period, guided by China's key national programs relating to textile science and technology innovation, intelligent manufacturing in the industry has progressed. The pilot demonstration of intelligent factories covers the whole industrial chain. The digital textile weaving technology has made significant breakthroughs. The large-scale customization and collaborative textile manufacturing have been developed.^{53,54}

Take the "package technology and equipment for digital automatic dyeing of cheese" as an example. The technology and equipment are jointly owned by Shandong Companion Group Co., Ltd., China Academy of Mechanical Science and Technology Group and Lutai Textile Co., Ltd.. The technology was also the first one in the world to pioneer the whole automatic dyeing process. Lots of innovations have been made in dyeing technology, equipment, and system such as a central automatic control system suitable for the automated dyeing of cheese. A highly efficient automated production for dyeing cheese was established, and a digital dyeing workshop was established, which represents a leap from manual mechanization and single machine automation. Compared with traditional dyeing, 70% of water can be saved per ton of yarn, 45% electricity, and 58% gas. There is also an 28% increase in production efficiency, and a reduction of 30% in overall cost. The technology won the first prize at the 2014 State Science and Technology Progress Award in China.

3.1.4 Emerging awareness of sustainable consumption

Sustainable consumption refers to the services and products that meet the basic needs of human beings and do not jeopardize the needs of future generations. It improves the quality of life with a minimum of natural resources and toxic materials, and minimizes the waste and pollutants generated in the life cycle of services or products.⁵⁵ Green consumption refers to the consumption behavior aimed at saving resources and protect the environment. It mainly involves advocating thrift, reducing losses and waste, choosing efficient and environmentally friendly products and services, and reducing resource consumption and pollution emissions in the consumption process.⁵⁶ These two concepts both emphasize resource conservation and environmental protection.

Social changes and developments in technology have brought about huge changes in people's consumption of clothes. Big data, VR technology, 3D printing, and other technologies make personalized customization and flexible production possible; internet finance and modern logistics have made possible a new format of textile and apparel sales that integrates online- and offline-sales; the prosperity of online social networking has given birth to economic phenomena like internet celebrity and WeChat business. Nowadays, the resources and environmental footprint behind textiles are of increasing concern to consumers. Some consumers have begun to turn to green textile and clothing consumption, and have embraced the new consumption model, and forward-looking brands and companies have also begun to accelerate action to meet the needs of consumers.



Consumers' awareness of sustainable consumption

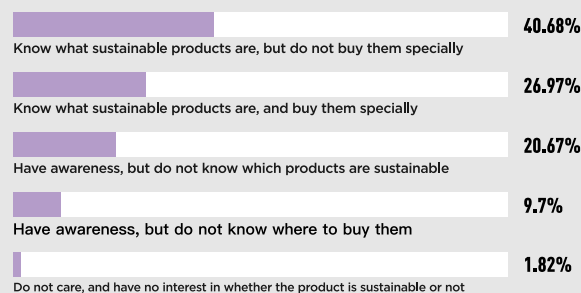
In 2019, the Office for Social Responsibility of CNTAC conducted a random survey into consumers' awareness and practice of sustainable textile and apparel consumption with a total of 5002 Chinese consumers participating in the survey. The results show that:

Consumers' awareness of sustainable consumption has improved, and most of them are willing to act.

More than 67% of consumers pay attention to sustainable products, and about 26% of consumers not only pay attention to sustainable products but also will purchase them intentionally; about 30% of consumers are aware of sustainable consumption, but they aren't aware of what products are sustainable and where to buy them. However, less than 2% of consumers are not interested in sustainable products.

Regarding the characteristics of sustainable clothes, consumers' awareness covers all aspects ranging from raw materials, production, and use right up to disposal. When informed that the production, consumption, and disposal of clothes are closely related to the environment, most consumers are willing to make certain changes in favor of sustainable consumption. Some are willing to reduce the frequency with which they buy new clothes; some are prepared to choose formal recycling channels to dispose of used clothes; some are willing to buy garments with sustainable properties; some are ready to continue to use clothes by repairing, renovating, and altering them. There are also some consumers willing to rent clothes or buy second-hand clothes.

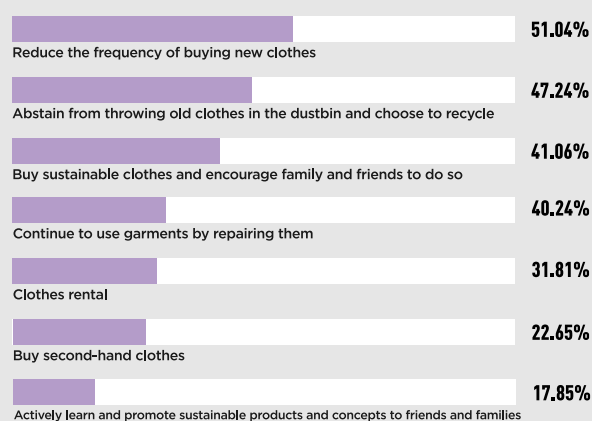
Whether consumers understand and buy sustainable products?



Factors that mark the sustainability of clothes



Changes that consumers try to make to favor sustainable consumption

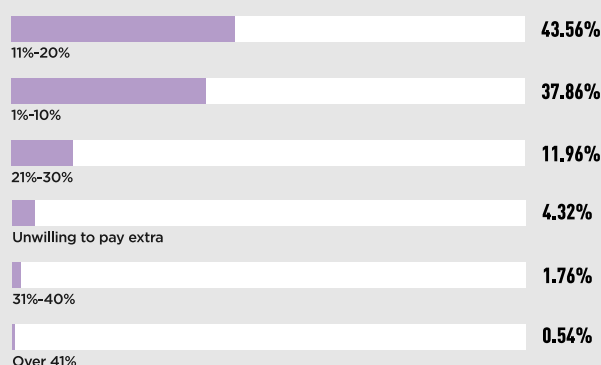


More than 90% of consumers accept a price premium, and quality first.

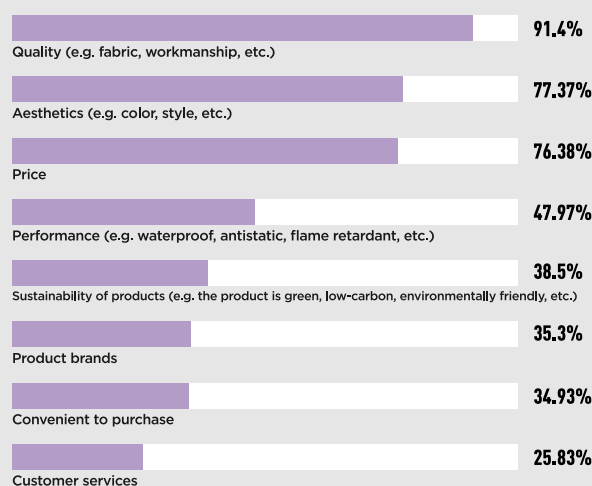
More than 90% of consumers are willing to accept a certain price premium for sustainable products, but quality is still the first factor consumers consider when they buy clothes, followed by aesthetics, price, performance, and then the sustainability of products. It is worth noting that although the proportion of consumers who pay attention to the sustainable

characteristics of products and are willing to accept a premium is not low (67% and 90%, respectively), only 27% of consumers buy sustainable products intentionally. This result shows that there is still a big gap between consumer awareness and actual consumer behaviors. It is necessary for brands and companies to take into account the quality, fashion and comfort of clothes when designing, producing and selling green clothes at a reasonable price to make consumer behaviors change.

Premium consumers are willing to pay for sustainable clothes



Factors consumers will focus on when buying clothes

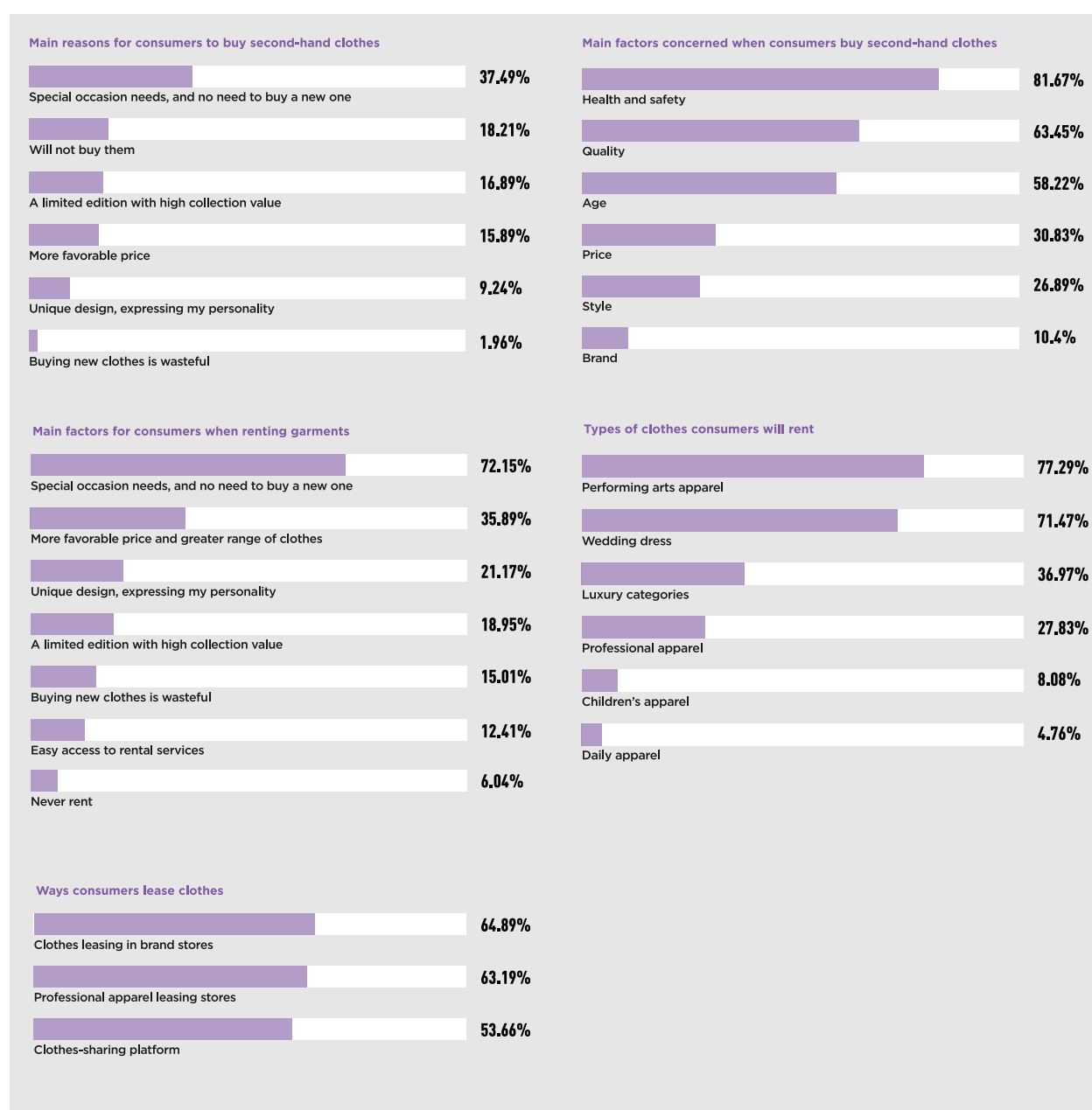


Rising awareness of second-hand clothes and clothes rental, especially for special occasions

Only 18% of consumers said they would not accept second-hand clothes. 34% of consumers opt to buy second-hand clothes for wearing on special occasions. Other reasons include: limited edition garments with collection value; price preference; and unique design to express personality. More than 80% of consumers said health and safety were the factors of greatest concern when choosing second-hand clothes; and the secondary factors are as follows: quality, age, price and style.

Only 6% of consumers said they would not rent

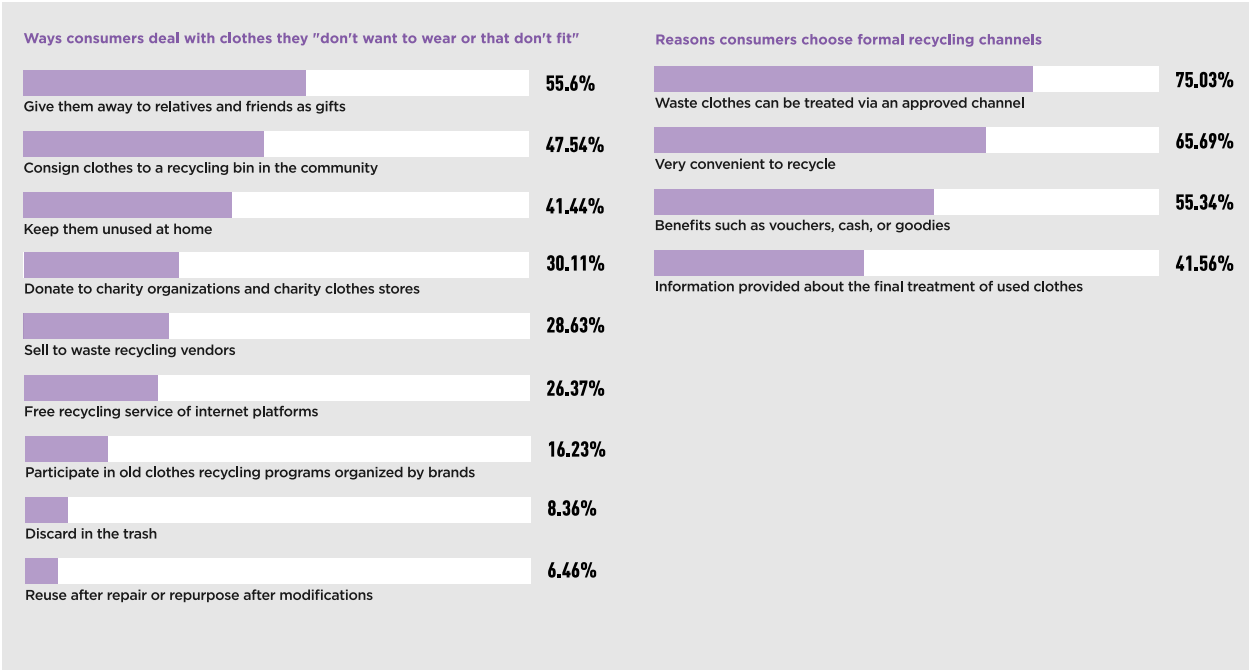
clothes. 72% of consumers choose to lease clothes for specific occasions such as a wedding or a performance. Regarding leasing channels, both clothes leasing in brand stores and professional clothes leasing stores are the primary choices of consumers, while more than 53% of consumers choose a clothes-sharing platform, a service which emerged in the last few years. Consumers' choices involve many factors such as the clothes that consumers need (e.g. special occasions, day-today clothes, children's clothes), the convenience of leasing services, etc.



Consumers have become more aware of the economic value of textile waste

As China has implemented an urban waste sorting policy, citizens have gained awareness of the value of textile waste. The different ways consumers deal with their old clothes includes firstly, gifting them to relatives and friends, but also consigning them to recycling bins in the community, donating to charity stores, or selling them to waste collecting vendors. In

addition, some consumers like to try new recycling models, such as free collecting through internet platforms and brand recycling activities, etc. 75% of consumers want waste clothes to be treated through some form of approved channel. Convenience benefits like vouchers, cash or goods are the main factors which encourage consumers to use formal recycling channels.





Exploring the sustainable consumption market

Sustainable consumption needs support from both end-users and stakeholders in the supply chain. It is important for consumers to be guided consciously in the practice of sustainable consumption; but it is also essential to increase the production of sustainable products.⁵⁶ Therefore, the market needs more diversified, high-quality, and sustainable products to fulfill consumers' demand for a larger range of accessible, high-quality, and low-cost clothes. In recent years, international brands and some national brands have launched more new lines of clothing in order to build connections with more consumers.

Leading international brands have launched environmentally friendly series in China. These include H&M's Conscious Exclusive collection, which uses recycled cashmere and velvet made from recycled polyethylene; Adidas' Infinite Hoodie made from recycled fabrics. Some Chinese companies have also begun to launch their own lines or independent sustainable brands. For example, "Nature's Way", ICICLE's capsule line made from natural materials which uses natural dyes; ErDOS' "SHÀN" line made from recycled cashmere, and yak cashmere fabric, non-dyed cashmere; RECLOTHING BANK's "Basic", "Ready TO WEAR", and "Haute Couture" lines made with fabrics from old clothes.

International brands move faster with more products and on a bigger scale, especially in the use of recycled materials and the development of new materials. In addition, international brands pay special attention to consumer participation and actively involve consumers in their products' circular journey. Most Chinese brands are still at the wait-and-see stage or are just beginning to explore the opportunities because of hesitation linked to cost, market size, etc.

Exploring new business models










The new innovative business models mainly focus on finding new ways to design, sell/buy, wear, recycle, and remanufacture clothes, improving product quality, increasing the number of times clothes are worn, extending product life span, and increasing the recycling rate after use. Brands, companies, and designers are now exploring these new models actively, seeing them as important opportunities. The new models include services such as maintenance, leasing, sharing, second-hand resale, etc.

1) Clothes repair/altering services

Repairing is the most economical and direct way to maintain the value of clothes and extend their life span when damaged, especially for high-grade, durable, and functional clothes. In recent years, some brands have launched repair services to enhance their products' added-value, increase consumer loyalty, and improve their brand image. For example, the outdoor brand Patagonia and down-market brand Bosideng provide recycling and repairing services for worn clothes.

Clothing alterations involves altering or modifying old clothes or clothes that don't fit firstly to meet consumers' new needs, but also to reduce waste. In fact, altering clothes has a long history in China, and used to be the preserve of tailors. But over the last 20 years the tradition has gradually declined as fast fashion came to dominate the market. However, the demand for clothing alterations has taken off again; nowadays it has been combined with internet technology to create a new model to meet modern consumers' needs. For example, "eTailor", an online clothes-altering brand, has devised a new form of tailoring using internet and digital technology; it has developed an SOP for online clothing alterations, and also provides services such as a door-to-door service for body measurements and clothing alterations.

Some environmentally friendly clothes series on the China market

International brands	Product series	Features
	Conscious Exclusive Collection	Recycled cashmere and velvet made from recycled polyethylene
	JOIN LIFE Collection	Fabrics made from recycled clothes
	BOSS SUSTAINABLE Collection	S.Café® eco-friendly coffee yarn
	Stretch Rainshadow Jacket	100% Econyl fabrics woven from recycled nylon
Domestic brands	Product series	Features
	"Nature's Way" capsule series	Natural raw materials; natural plant dyes
	"SHÀN" series	Regenerated cashmere, yak wool, and non-dyed cashmere
	REVERB	Recycled polyester fabrics
	kleee klee	Materials with low impact on the environment; eco-friendly dyes with fewer pollutants
	"Basic", "Ready TO WEAR", and "Haute Couture " series	Fabrics from old clothes

Source: Brands' office website and public information^{57, 58}

2) Clothes sharing

In recent years, the sharing economy has sprung up in different industries around the world, and Airbnb, Uber, and other sharing platforms are well known to consumers. This business model provides a platform to connect product owners with individuals or organizations that would like to use their service, letting multiple customers use the same resources which improves product utilization. And it is also good for promoting durable design. These services also play an important role in the circular economy.

Clothes-sharing platforms represent the sharing economy in the field of clothing consumption. The platforms obtain the right to use the garment from the provider (usually brands) through cooperation, and then provide them to consumers by leasing or borrowing. In the past five years, several clothes-sharing platforms, have emerged on the Chinese market, notably, "YCLOSET". These new brands are mainly located in first-tier cities such as Beijing and Shanghai. Their target users are urban young women in their early twenties. In addition to leasing dresses for special occasions, these women also use fashion brands. The clothes-sharing service has two models: the monthly rental model and the special occasion model.

Cooperating with fashion brands is the main way clothes-sharing platforms obtain a large number of high-quality fashion garments. Almost all the clothing on the YCLOSET platform comes from brands through cooperation. Brands have also tried to explore the possibility of clothes rental through such cooperation. At the end of 2019, H&M Group's innovation department The Laboratory, COS, and YCLOSET teamed up to test subscription rental in China via a three-month project.

3) Second-hand resale

Second-hand transactions are an effective way to give full play to product value and improve its utilization. According to the survey conducted by the e-commerce research center of WJS, an internet economy services platform, China's second-hand trading market expanded by 450% from 2014 to 2018, creating a market of 100 billion US dollars.⁵⁹

China has not yet opened the second-hand clothes market for health reasons. But the resale and exchange of clothes has always existed, especially the exchange

of expensive luxury garments. In recent years in China the resale of second-hand unused luxury goods has exploded and second-hand luxury goods trading platforms such as Hongbulin, Feiyu.Live, and Goshare2 are developing rapidly, particularly in the capital. Offline second-hand luxury stores or C-end buyers and sellers sell their products or unused luxury goods through the platform. After the goods are sold, the platform takes a commission and the consigned products are priced by the platform or the buyer. Clothing is basically the standard category of product found on this kind of platform.

In 2020, e-commerce live broadcasting has experienced a blowout type growth. The transactions of major platforms have exceeded RMB 400 billion yuan, accounting for 4% of online retail sales and 1% of total retail sales. Among them, the transaction growth rate of Taobao live for three consecutive years has exceeded 150%. As the online shopping festival becomes more and more popular, it is very important for brands to understand consumers' consumption preference and conduct effective online communication.⁶⁰ Live broadcasting has become a main business for these resale platforms to promote the sale of second-hand luxury goods in the last two years. Feiyu.Live started Taobao live back in 2016, and then Hongbulin started its live broadcasting business in 2019.^{61, 62}

The second-hand exchange of unused goods is also the main service of internet platforms such as IDLEFISH, Aihuishou, etc. IDLEFISH, for example, is Alibaba's unused goods trading platform. Users upload photos of second-hand unused goods and do online transactions on IDLEFISH through their mobile phones. According to statistics, second-hand clothes and digital products are the two categories with the highest trading frequency on IDLEFISH.

3.1.5 Industrial chain of comprehensive utilization of textile waste virtually complete

Textile waste is a general term for textile materials and products that are discarded either in production, distribution, or consumption. It can be divided into two categories: textile scrap and used textiles. Textile scrap refers to the textile materials discarded in production including spinning, weaving, dyeing, cutting, etc. Used textiles refers to waste apparel, home textiles, industrial textiles and other textiles that have been discarded.⁶³ China's industrial chain of recycling, sorting, and comprehensive utilization of textile waste has been basically completed and a multi-channel collection system has been formed. In addition, a number of recycling technologies have made breakthroughs. The recycling supply chain in the form of "textiles - textile waste - textile", or "textiles - textile waste - thermal insulation materials" has gradually developed, and a number of leading model companies have emerged. The industry has reached a new level in terms of cleaner production and industrial standardization.



Diversified "online + offline" collection system

Collection is not just the primary link whereby textile waste enters its circular journey, but also the link that has the greatest impact on the scale development of the resource utilization industry. Textile scrap generated in production has fewer impurities, and similar quality and performance to raw materials; and it is also easy to sort. Because of this, it has been widely used in various fields since China's "11th Five-Year Plan" period. Used professional clothing from specific industries, such as military, police, school and work uniforms, can be recycled and reused through cooperation with professional institutions. As they are made in a similar style and in the same fabric and color they are relatively simple to recycle and sort. However, clothing and textiles discarded from homes come in a vast range of styles and colors and quality. And as they are scattered in thousands of different homes it is a very complex operation to collect and sort this kind of textile waste.

This is therefore the key challenge facing textile waste collection.^{64, 65}

China has now created a diversified textile waste collection system, including traditional models such as collection bins, private market, charity donation, as well as innovative models such as the company EPR collection model, household waste collection systems and "Online + offline" collection. EPR collection is usually initiated by clothing companies, which encourage consumers to recycle clothes by providing coupons and souvenirs, etc.; the "Online + offline" collection model provides consumers with convenient recycling channels and benefits such as door-to-door collection, shopping with accumulated reward points, etc.

China has announced the implementation of an obligatory waste sorting policy. With the development of household waste sorting systems and renewable resource recycling systems, the household waste sorting and recycling model, integrating digital technology, is becoming one of the main channels for recycling textile waste at scale. By building offline chain service outlets and online mobile internet platforms, companies provide residents with convenient recycling channels and professional collecting services. Companies also try to integrate the whole industrial chain of front-end fine sorting, back-end resource utilization and nontoxic processing, so as to improve the efficiency of resources recycling.

Because of rising urban living standards, improved infrastructure and other factors, the collecting and recycling of China's textile waste is mainly concentrated in the first-tier cities or coastal provinces, such as Beijing, Tianjin, Shanghai, Zhejiang, Jiangsu, Guangdong, etc. As consumer awareness of environmental protection in cities has increased and urban waste sorting policy has progressed, the collection market has expanded. The citizens have gained more awareness of the value of textile waste both in terms of its use as a resource and its impact on the environment, and this has contributed to an increased collection rate.

Typical collection model of textile waste in China

 Waste collection bin	<p>Put textile waste boxes in communities, streets, schools, etc., to recycle waste clothes, shoes, and hats. Case: "The Giant Panda" program of Shanghai Yuanyuan Industrial Co., Ltd., "Yi Yi Bu She" charity program, "Yi Jiu Qing Shen" charity program, etc.</p>
 Private market	<p>In most areas of China, there are textile waste collecting organizations or individual groups formed spontaneously, and they collect a certain amount of textile waste through door-to-door recycling or street recycling outlets, and then send it to recycling centers. Finally, the textile waste is delivered and sold to professional companies at different clusters.</p>
 Charity donation and collection	<p>Programs carried out mainly by public service organizations or charities encourage residents to participate in the donation of used clothes. The clothes collected are sent to underdeveloped areas or sold to companies involved in the comprehensive utilization of resources. And, the revenues are used for public welfare.</p>
 Household waste sorting and collecting	<p>Professional recycling companies set up outlets in residential areas to recycle textile waste and build a unified collection system of classified delivery, classified collection and transportation and resource recycling with the help of internet platforms. Case: "E-Resource Waste Intelligent Classification Cloud Platform" of Beijing Huanwei Group, "Bangbang Station" of Shanghai Mulin Environmental Protection Technology Co., Ltd., etc.</p>
 The EPR collection model	<p>This model refers to companies conducting the practices of EPR. Companies or brands collect old clothes through sales outlets. Case: "Old Clothes Recycling" program of H&M and UNIQLO, Zara's "Join Life" campaign, Inman's "Yi Qi Rebirth" program, etc.</p>
 "Online + offline" collection model	<p>This model integrates online platforms and offline service to collect textile waste through online booking and door-to-door recycling. Case: Feimayi, Oou Yan, Lüdai Environmental Protection, Hainan Greenergy Technology Co., Ltd. of China, the used clothes recycling service platforms of Alibaba, JD and other e-commerce platforms.</p>



Main utilization technologies and product categories

The comprehensive utilization method of textile waste in China are mainly reuse and recycling.^{66, 67} Reuse refers to using textile waste as products directly or after repair, renovation, and remanufacture without changing the original properties. Recycling, also known as regenerated utilization, refers to the process of using textile waste to produce other products after physical and chemical processing, which makes them lose their original basic properties.

After collection, textile waste is first identified and sorted according to conditions, fiber composition, color, and weaving method. Clothes that can be worn again can be donated for resale or export; the textile waste which can't be reused directly can be reused in different ways according to the fiber composition, color, and other differences.

As the technology improves a relatively complete closed-loop industrial chain has been formed to treat textile waste with single fiber components such as pure cotton, pure wool, and pure polyester. These can produce high-quality recycled fibers by physical

or chemical recycling technology. The products are used in clothing, home textiles, medical gauze, and other fields. For blended textile waste, because of their complicated composition blended textile waste contains fibers, they are difficult to separate and therefore difficult to achieve high value utilization. In recent years, companies, research institutions and industry associations have carried out experimentation to derive high-value utilization from blended fabrics, and the range of products from recycled textile waste has expanded.^{68, 69}

Below we list the main technical achievements and product categories derived through textile waste recycling and reuse in China:

Textile waste sorting

Some Chinese companies have introduced the high-speed near-infrared online identification and sorting system of textile waste developed by Valvan Baling Systems, and some Chinese companies have cooperated with universities to develop the system by combining near-infrared technology with automatic sorting equipment. For example, in 2018, the research group into comprehensive reuse of textile waste formed jointly by the Beijing Institute Of Fashion Technology and Jiangsu wool textile companies developed an online rapid identification and sorting system of textile waste with near-infrared spectroscopy. The system improves the accuracy and speed of identification and sorting of textile waste from wool.

Recycling technologies and main product categories of textile waste

At present textile waste utilization technologies in China mainly depend on physical and chemical methods, although the physical method is the primary one.

A. Physical recycling

The physical method refers to the process of remanufacturing products through physical processing such as cutting and shredding, loosing, spinning, thermal mechanical processing, etc. without destroying the chemical structure of textile waste. This includes the physical loosing and thermal melting.

The physical loosing mainly deals with textile waste, such as waste cotton, wool, hemp, and blended textiles. Wenzhou Tiancheng Textile Co., Ltd., one of the leading companies in the sector, directly processes textile

scraps into recycled fibers physically and then spins them into yarn, which is used in clothing production again. The company sorts the textile waste by color – textile waste with similar colors are put together through loosing, spinning, and weaving to obtain recycled yarn of the same color. This helps minimize resource waste and environmental pollution caused by de-coloring and secondary dyeing. Yuyue Home Textile Co., Ltd. sorts the scraps of hemp and cotton products according to their colors, and reuses them after loosing, spinning, and dyeing.

Companies are now exploring the high-value utilization of blended textile waste of uncertain composition. For example, it can be used to produce flame retardants by cutting and crushing; it can be pressed into air conditioning sound insulation material by moulding; it can also be cut and made into wall insulation material, etc. The products can be used in home appliances, automobiles, building insulation, agriculture, etc. Leading companies such as Guangde Tianyun New Technology Co., Ltd. use textile waste to produce air conditioning sound insulation and heat insulation, automobile shock absorbers, and interior decoration products, as well as industrial pallets and thermal insulation materials for the logistics industry. Zhenjiang Junya Air Conditioning Parts Co., Ltd. and Zhenjiang Meida Plastic Co., Ltd. use textile waste to process air conditioning sound insulation products, automobile interior decoration and shock absorption products, etc.⁷⁰

The thermal melting physical method mainly deals with synthetic waste fibers with single components, such as polyester, polypropylene, etc. Leading companies include Ningbo Dafa Chemical Fiber Co., Ltd. and Fujian San-hong Renewable Resources Co., Ltd., which produce recycled polyester staple fiber and recycled polypropylene fiber through cutting, drying, melting, spinning, etc., and the products are used in the production of clothing, luggage, and other products.

In recent years, some companies have also adopted physical-chemical methods for textile waste with high impurity content to produce recycled products through melt molding and by adding chain extenders, plasticizers, compatibilizers, and other additives to improve the fluidity and molecular weight of the fibers.

B. Chemical recycling

Under certain conditions a chemical method is used to depolymerize textile waste into small molecules or monomers, and then re-aggregate them into polymers.

Main recycling technologies and products of textile waste in China

Recycling technologies	Main fiber categories to process	Products and applications	
Physical recycling	Waste cotton, hemp, and woolen textiles Blended textiles Waste synthetic fiber textiles of single-component	Recycled fiber, yarn and textile and apparel products	Textile and apparel industry
		Agricultural greenhouse facilities Soundproof and heat insulation products for air conditioners Automotive shock-absorbing materials, interior products Building insulation materials, waterproof membranes, etc. Pallets, transportation anti-bump non-woven fabric felt Medical yarn and other products	Agriculture Appliance industry Automobile industry Building industry Logistics industry Healthcare industry
Chemical recycling	Pure waste polyester textiles Waste polyester-cotton blended textiles	Recycled fiber, yarn and textile and apparel products	Textile and apparel industry

The chemical method requires high level purity of raw materials, so it is mainly used for processing pure polyester textile waste and waste polyester cotton blended fabrics (with high polyester content). Zhejiang Jiaren New Material Co., Ltd. is a leading company in China in the field of recycling polyester textile waste chemically. The company has introduced Eco Circle™ technology to recycle polyester. Using waste polyester materials such as waste clothes and scraps as raw materials to obtain polyester monomers through thorough chemical decomposition, the company produces recycled fiber products which have a performance level close to that of the raw materials through polymerization. They are used in high-end apparel, home textiles, automobile interior decoration,

and other fields. Donghua University, Fujian Huafeng Co., Ltd., Ningbo Dafa Co., Ltd., Zhejiang Gerial Environmental Protection Co., Ltd., and Shanghai Juyou Chemical Co., Ltd. have also conducted a lot of relevant researches into chemical methods.

For recycling blended textile waste chemically, some Chinese researchers are trying to dissolve polyester/cotton fabrics to separate the components of polyester and cotton. Some Chinese engineering companies and universities are also doing research to develop polyester/cotton separation equipment, but the technology, and equipment do not currently meet the standard required for industrial production.



Collaborative industrial chain & innovation

Textile waste has many complex components which makes it difficult to sort and reuse. Given the limitations of existing technology, industrial collaboration offers a good opportunity to improve the efficiency of comprehensive waste utilization by integrating all acts of collection, sorting, processing, production, disposal, etc. This permits the development of a hierarchical utilization mechanism bringing about added value through cooperation by multiple stakeholders.

In 2014 CNTAC launched "Zero Discarding of Old Clothes" initiative. It has cooperated with brands and leading companies to carry out nonprofit recycling activities, aimed at establishing a closed-loop model with a standardized mechanism for collecting, sorting and recycling waste clothes.

Dingyuan (Hangzhou) Textile Technology Co., Ltd., is one of the companies that has participated in this collaboration. In order to extend its industrial chain, Shanghai Yuanyuan Industrial Co., Ltd., a clothes recycling company, invested in this activity together with Huabeina Woolen Dyeing and Finishing Co., Ltd., a subsidiary of Zhejiang Huading Group. The company uses leftovers and scraps in production and recycled waste clothes as raw materials to produce products through physically loosing, spinning, and weaving. The products include textile fabrics, non-woven materials, ecological matrix, fillers, fuel rods, and other products.

Wenzhou Tiancheng Textile Co., Ltd. has cooperated with national and international clothing companies, to directly recycle scraps from factories, and process them into recycled yarn with primary colors through physical loosing, spinning, weaving, etc. The resulting material is used to produce new products for the brands. The company created a closed-loop recycling system: "recycled fabric – clothes – scraps – recycled fiber – recycled yarn – recycled fabric". It established a GRS management system to ensure the traceability of the scraps.



Cleaner and standardized industry development

One of a big problems facing China's textile waste recycling industry in the early development stage are: low entry threshold, small scale of companies, backward technology and equipment, lack of professional and technical personnel, low degree of automation and intelligent management, disordered industry competition, extensive management, etc. As governments at all levels speed up the closing down of "small, disorderly, and polluting" companies, clean production and operational standards of the industry have both improved.

Some leading companies, such as Wenzhou Tiancheng Textile Co., Ltd., Guangde Tianyun non-woven Co., Ltd., Dingyuan (Hangzhou) Textile Technology Co., Ltd. and Zhejiang Jiaren New Material Co., Ltd., have showcased best practices of standardized development with market competitiveness. These companies lead the industry in integrating recycling channels, research into comprehensive utilization technology, market development, standard setting for recycled products, etc.

The typical textile waste recycling industry cluster has begun to explore the development model of the industrial park, so as to achieve high-quality development through infrastructure co-construction and sharing, centralized pollution control, and unified and standardized management.

Cangnan in Zhejiang province is one of the first pilot bases for the comprehensive utilization of textile waste in China. It deals with about 80% of the textile scraps in China every year and produces about 2 million tons of recycled cotton yarn. It has a full industrial chain from textile waste collection to recycling, as well as a number of leading companies such as Wenzhou Tiancheng Textile Co., Ltd., Wenlong Group Co., Ltd., and Cangnan Dahua Textile Co., Ltd., etc. In recent years, due to the disordered development of the recycled textile industry, the local government requires companies to enter the park and develop a circular model. Three industrial parks have been built so far and two are under construction in Cangnan. After the industrial park was put into operation, the standardization and clean production of recycled textile industry in Cangnan has improved significantly.

3.2 Core Challenges

3.2.1 Main issues relating to linear industrial development

Guided by China's circular development strategy, China's textile and apparel industry has carried out many innovative circular economy practices in a range of aspects and made progress over the past 15 year. However, as a whole, the industry is still in the initial stage of circular economy transformation due to the large range of product categories, a long industrial processing chain, and large volumes. There is still a lot of room for improvement in the substitution scale of non-renewable raw materials, the resource utilization level in production, and the recycling and reuse of textile waste.



The substitution scale of non-renewable raw materials

China is a major textile and apparel manufacturing country with a large demand for fibers with a high proportion of petroleum-based synthetic fibers. In 2018, China produces 45.62 million tons of synthetic fibers, accounting for over 80% of the total. The production scale of recycled fibers and bio-based chemical fibers is still limited. Survey showed that, in 2019, China's production capacity of recycled polyester was about 9.5 million tons, and the output of Lyocell, the most popular bio-based chemical fiber in the market, was around 30,000 tons.



Resource consumption and environmental pollution in production

During its "13th Five-Year Plan" period, China's textile and apparel industry has continuously improved its energy conservation, resource consumption, and emissions, and implemented a large number of advanced technologies. The energy consumption, water consumption and emissions of major pollutants per unit of industrial added value decreased by 20%, 30% and 10% respectively compared with the "11th

Five-Year Plan" period. However, due to the large volumes the application of advanced manufacturing techniques, technologies, and equipment, especially for key industry sectors such as printing and dyeing, is still limited to a few leading companies. There is still a lot of room for scaling up so as to improve the resource level of the whole industry.

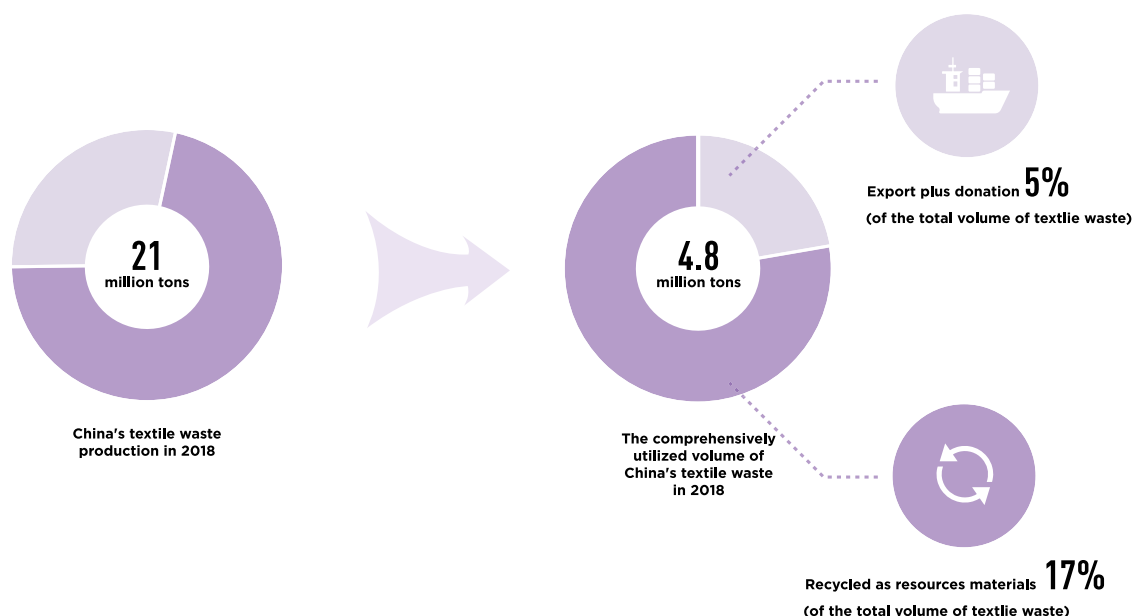
The standardization and clean production of the textile waste recycling industry is also an important issue for the green, circular, and low-carbon development of the industry. Some textile waste recycling companies (including front-end collecting companies and back-end remanufacturing companies) still face challenges such as rough production and operations, non-standard management, environmental pollution, etc.



The comprehensive utilization rate of textile waste

At present, there is no data collection system for the production, collecting and recycling of textile waste. According to statistics from the China National Resources Recycling Association, the recycling volume of textile was 3.8 million tons in 2018, an increase of 8.6% compared with 2017.⁷¹ The *2014/2015 Research Report on Recycling and Reuse of Textile Waste*, issued by CNTAC in 2015, estimated China's production of textile waste in 2014 based on the production and consumption of fibers, industry experience and expert opinions. According to this estimation method, as well as considering the main recycled product flow of the market and the annual output of major recycling companies, China produced about 21 million tons of textile waste in 2018, of which about 5% were reused through donation and export, and about 17% were recycled as materials. The comprehensively utilized volume was 4.8 million tons. There is still a lot of room for improvement in the recycling of China's textile waste, especially as regards the resale of second-hand clothing. Take Europe as an example, European countries mainly recycle their textile waste through second-hand clothing resale, accounting for over 50% of the total recycling volume.^{72, 73}

China's textile waste production and comprehensive utilization in 2018



Note: The sum may not equal 100% due to rounding

3.2.2 Core challenges faced by the industry to accelerate circular economy transformation

China's textile and apparel industry has made progress in transitioning to a circular economy. But the industry still faces various challenges in achieving a complete transformation.



Insufficient innovation in technology, techniques, and equipment

Insufficient innovation in key technologies, techniques, and equipment restricts the large-scale development of recycled fibers and bio-based chemical fibers, the promotion of circular production, and the economic benefits of the textile waste recycling industry.

First of all, a lack of technological innovation directly limits the supply of high-quality, high-performance, and diversified recycled fibers and bio-based fibers, affecting the effective supply and price competitiveness, which makes it difficult to drive the market effectively.

On the one hand, there are many key sectors and technical difficulties in the long process of developing bio-based chemical fiber, so companies face challenges

like technical confidentiality, repeated R&D and immature key technologies that affect the quality and performance of products. On the other hand, diverse raw materials and textile weaving methods, as well as the use of various additives in processing, affect the purity and spinnability of fiber components after recycling, which limits its application in end products. Moreover, with the notable cost advantage of domestically sourced primary raw materials, the price competitiveness of recycled fiber and bio-based chemical fiber has further declined, which increases the need for technological innovation in the industry.⁷⁴

Secondly, the application of advanced manufacturing techniques and equipment is still limited to a few leading companies in the industry. Textile and apparel companies are mainly small and medium-sized private companies, so problems such as shortage of funds, and difficulty in financing make it difficult for companies to carry out the necessary technological transformations. At the same time, the printing and dyeing technology transformation programs are facing increasing requirements for loans because of environmental risks; and this poses a major challenge in terms of scaling up of advanced manufacturing techniques.⁷⁵

Thirdly, the bottleneck in the development of key technologies has led to a dilemma regarding the scale of the textile waste recycling industry. On the one hand,

the components of textile waste are complex, and key technologies such as rapid component detection, efficient sorting, and blending separation puts limits on the efficiency and scale of the comprehensive utilization; on the other hand, fast, safe, and non-destructive disinfection technology has limited the second-hand clothes resale market. This means a large number of re-wearable second-hand clothes cannot be used effectively.



Incomplete systematic and more industry-specific policies, systems and standards

China has issued a series of guiding policies concerning the industry circular development, raw material use optimization, green/clean/circular production, textile waste recycling, etc., which help form the basic model of the industry's green, circular, and low-carbon transformation. In recent years, China's national macro policies on green design and green consumption have also been important in promoting markets for green textiles and new business models.

However, the establishment and enforcement of existing policies and standards in different parts of the industry is unbalanced, systematic supporting systems and standards, especially as regards textile waste recycling, green design, and green consumption need to be further developed.

Take the textile waste recycling as an example. The harmless recycling of textile waste is seen as a strategically emerging industry in China. China's policies, such as *Guiding Opinions on Comprehensive Utilization of Resources During the "12th Five-Year Plan" Period*, *Opinions on Accelerating the Construction of Ecological Civilization*, the *13th Five-Year Plan for the National Economic and Social Development of the People's Republic of China*, the *Circular Economy Development Strategy and Near-term Action Plan*, etc., all encourage the recycling of textile waste and promote research, development, and application of corresponding technologies. China's NDRC carried out the "Double Hundred Program" of comprehensive utilization of resources in 2012. China's Ministry of Finance and the State Administration of Taxation issued the *Catalogue of Value-added Tax on Products and Services for Comprehensive Utilization of Resources* in 2015 to guide the development of the industry with the aim of building bases of resource utilization as well as financial support. China's Ministry of Civil Affairs has issued *Guidance on Strengthening*

and Innovating the Creation of Charity Supermarkets, actively promoting the recycling of donated apparel. The Ministry of Environmental Protection and five other ministries have issued the *Plan for Cleaning Up and Rectifying the Recycling Industry of Electronic Waste, Waste Tires, Waste Plastics, Waste Clothes, Waste Household Appliances, etc.*, to promote the development of standardization and aggregation of the industry. However, the industry still needs more efforts on top-level planning, and set up special regulations and supporting policies to help explore the second-hand clothing market, promote the construction of regional recycling, sorting, and recycling systems. The standards, certification and identification system of recycled products also need to be further improved.



Circular design as a solution still at the stage of concept advocacy

Increasing the use of sustainable/green material, choosing single fiber component rather than complex at the design stage, as well as considering solutions as to how to recycle a product (e.g. using clarifying the fiber composition and providing labelling), will greatly help to solve the difficulty of sorting textile waste at the back end. However, current green design practices in the industry are more related to choices of material and production techniques, lacking sufficient consideration of the product's circularity.

The reason lies in the insufficient awareness of companies and independent designers of the need to carry out circular design and the lack of a systematic circular design methodology. For example, many lack knowledge of potential material categories, and it is difficult to find the right material suppliers that meet the quality and performance requirements; the choice of material types and colors is still limited. Therefore, in addition to a supply of raw material with better quality and more diversity, more support and guidance are needed to promote circular design, including guidelines, training, and knowledge hubs of circular design, and platforms for circular, recyclable and degradable materials.



Insufficient market driving force from green consumption

The green consumption market is not mature enough to drive the development of the industry. Consumer awareness of green consumption has improved, but

consumer behavior lags behind. First of all, consumers' acceptance of second-hand goods and recycled products is not high; secondly, the market of green textiles and clothing is still small, and cannot meet the various demand of consumers; thirdly, current mainstream consumers are still price sensitive, and their actual purchasing power for green textiles and clothing with a certain premium price is limited; fourthly, problems such as an imperfect product certification system, opaque information, and weak traceability also make some consumers reluctant to buy.

As a bridge between industry and consumers, brands/retailers play an important role in providing green products, exploring new business models, and guiding and educating consumers. Currently, it is mainly internationally well-known brands who have taken the lead in circular fashion and a few forward-looking Chinese brands have carried out some practices, most Chinese brands have not yet taken action due to various factors such as lack of awareness, cost, technology and so on. Therefore, it is important for China's textile and apparel industry to further tap the potential of its local brands in guiding and developing the green market, and leading green consumption and



Lack of a unified vision and industrial synergy to drive systematic transformation

With the development of sustainable and circular fashion globally, companies' awareness of the importance of circular economy transformation is growing. Some leading manufacturers and brands have seized the opportunities and adjusted their business strategically. Some entrepreneurs have taken the plunge and opened up new markets based on the principle of a circular economy. However, up to now, stakeholders in the industry still lack of unified and clear understanding of the vision and goal of circular fashion; and also the core issues of the industry's systematic transformation, the roles and responsibilities of various stakeholders and possible new business models; for common definitions in terms of core concepts like sustainable materials, circular and recyclable materials, circular design, etc., confusions and controversy still exist. Meanwhile, there is still a certain insufficiency in the communication between upstream and downstream companies and the industry lacks practical tools for tracing. The industrial synergy for transformation hasn't yet been formed.

To accelerate systematic transformation, the industry should first come up with a unified vision for circular fashion, clarify the transformation objectives and responsibilities of various stakeholders, and establish a standard system. Existing practices show that complex problems need systematic solutions: strengthening industrial collaboration would be an effective way to accelerate solutions. Industrial collaboration can help optimize the allocation of resources, jointly overcome obstacles in key technologies, and solve the common development problems faced by the industry. Taking bio-based fiber materials as an example, the industry can break through the technical barriers (such as the spinnability and dyeability of fabrics) that restrict the industrial production of fibers through the collaborative innovation of fiber producers and spinning, weaving, printing and dyeing companies, and ultimately improve the quality of end products and achieve the large-scale and industrial development of the industry.



Lack of know-how platform and professionals to promote circular fashion

Talent is the first strategic resource for the sustainable development of the industry. To realize circular economy transformation, it is necessary for talented professionals who fully understand the concept to work in different sectors of the industry and carry out circular practices. For example, circular design requires designers equipped with a good understanding of the whole life cycle of products, material choices, processing techniques, disposal methods of waste materials, as well as consumer demand.

At present, China's textile education system covers subjects such as textile science and engineering, dyeing, fashion management, art design, etc. focusing on developing interdisciplinary engineering and technical personnel who can engage in technologic development, textile and process design, production and management, business trade and scientific research in the field of textiles. An interdisciplinary and systematic education system, which can combine textile science and engineering, should be established within the framework of the circular economy. It will contribute to the education of stakeholders in the circular economy and support the green, low-carbon, and sustainable development of the industry in the long term.⁷⁶

04

Outlook for circular fashion in China: accelerating a systematic transition pace

With the growing pressure on natural resources and the environment, it is imperative to accelerate the circular economy transformation of the industry and expand all relevant practices. To accelerate this transformation, the industry needs to unify the vision and goals supported by targeted measures from different facets such as technology, policy, market, and awareness. The measures include strengthening top-level design, developing systematic and specific policies and standard systems, and clarifying the main responsibilities of all stakeholders. This involves promoting collaboration between the upstream and downstream, and pioneering technological innovation, so as to create an environment propitious to circular economy transformation.

4.1

Circular fashion: outlook for a new textiles economy in China

4.1.1 Characteristics and direction of China's textile and apparel industry's circular development

The global textile and apparel industry has basically formed two camps: the consumption end, represented by Europe, the United States, Japan, and other developed countries, is the most important textile and apparel consumption market, while the production end, distributed in a large number of developing countries, is the world's major textile and apparel supply market.⁷⁷ As a result of the increasing trend towards a circular future, the textile and apparel industry in a large number of countries is developing a distinctive role in the global production network.

The model and direction of circular economy development of China's textile and apparel industry are closely related to China's status as a major textile and apparel manufacturing and consumption country.

Firstly, as the world's largest textile and apparel producer, China's textile and apparel Industry has a huge demand for raw materials, and consumes a lot of water, chemicals, and energy in production. So the question arises as to how it might be possible to improve the utilization rate of materials, maximize the value of materials and products, reduce the consumption of water, chemicals and energy in production, and improve the level of resource recycling as part of industry's transformation.

Secondly, the characteristics of the centralized development of China's textile and apparel industry as well as the complete manufacturing system in China provide the foundation and rich possibility for the symbiosis of sectors, mutual supply of raw materials and resource sharing among companies, industrial parks, and industries. In addition to recycling within the industry system, the material flow can also be recycled between industries, and finally realize the efficient and comprehensive utilization of resources. For example, textile waste have become one of the raw materials in the fields of automobile, household appliances, and agriculture, and the recycled chemicals in production can be used as the primary raw materials in other chemical industries.

In addition, green design and green consumption are becoming important driving forces to accelerate the systemic transformation of the industry. Stakeholders are becoming more aware of green design as a primary solution; that is to design out waste and pollution from the beginning. Green consumption is the core market driving force for the sustainable development of the recycling industry. It is important for the industry to expand the supply of green products and promote green consumption.

4.1.2 Vision, goals and principles of China's new textiles economy

This report proposes a vision and goals for China's new textiles economy in line with the guidance of China's national *Leading Action Plan on Circular Development* and based on global fashion industry trends towards a circular future.



Vision for a new textiles economy in China

The vision is to build a green, circular, and low-carbon textile and apparel industry, so as to improve the resource efficiency of the industry and reduce the resource consumption and the negative impact on the environment.



Five goals of China's new textiles economy

China's new textile economy recommends five goals to achieve the green, circular, and low-carbon transformation of the entire industry, and balance the benefits for the economy, society and the environment.

Goal 1

Optimize the raw material structure to reduce the consumption of non-renewable resources.

This can be achieved by taking into account pollution and resource consumption of the whole life cycle of the fiber, including sourcing, producing, recycling, etc. It will involve improving the use of bio-based chemical fiber and recycled fiber.

Goal 2

Turn to textile design based on the principle of a circular economy.

The industry should promote textile design based on the principle of a circular economy, encouraging designers and companies to systematically consider at the product design phase the impact on resources and environment in the whole product life cycle. Companies and designers are also encouraged to take various measures such as extending the life of products through choosing materials, techniques, and solutions. They should also improve the recycling rate after use, and consider the packaging materials or even the use of less packaging, so as to minimize resource consumption and environmental pollution.

Goal 3

Further improve resource efficiency in production.

To improve energy conservation and resource recycling in production (from fibers to textiles; from textile waste to recycled fibers and products) the following will be necessary: improving the proportion of waste water recycled; increasing heat recycling in waste water and waste gas; realizing the efficient recycling of chemicals in waste water and waste gas; strengthening the recycling of industrial solid wastes such as scraps and leftovers; and improving the utilization ratio of renewable energy.

Goal 4

Innovate business model and expand green consumption.

The industry should encourage the consumption of green products and improve the market supply of green textile products. A certification system is needed to ensure the circulation of green products. Companies are encouraged to implement green procurement and build a green supply chain. It is also necessary to encourage new business models aiming at extending the product life, for example, repair, sharing, renting etc.; and encouraging consumers to adopt proactive green consumption behavior.

Goal 5

Upgrade the quality and efficiency of textile waste recycling.

The industry should improve the recycling system of textile waste and establish a recycling mechanism in cascade fashion, so as to increase the level of resource utilization. The textile waste should be collected, transported and recycled collectively. The synergy with other solid waste treatment facilities should be strengthened.



Basic principles of China's new textiles economy

Economic rationality, technical feasibility and environmental friendliness⁷⁸ are the basic principles for the circular economy development of China's textile and apparel industry. China's new textiles economy should progress in an orderly and effective

manner, taking into consideration of the real situation of the industry and the principle of reduction first. Consideration should be given to economic rationality, technical feasibility, resource conservation, and environmental protection, so as to explore a circular economy transformation path in line with China's realities, and contribute Chinese solutions to global circular fashion.

4.1.3 The main responsibility of key stakeholders



Government: improving top-level design and supporting policies, and strengthening supervision

The government plays an important role in guiding, supporting, regulating, and supervising the systematic transformation of the industry towards a green, circular, and low-carbon future. On the one hand, it is the responsibility of the government to design at a top-level and to improve the relevant laws and regulations in line with the various needs of the industry at different stages of development, and must create an environment which provides clear guidance, scientific decision-making, effective incentives, and positive interaction between multiple stakeholders; on the other hand, the government also needs to strengthen supervision and management to ensure the effective implementation of its policies.

China has established a relatively comprehensive circular economy policy system, which has advanced the circular economy transformation of the industry. However, the existing policies, supporting systems, and standards are not well balanced. There is a lack of systematic and more industry-specific supporting policies, systems, and standards, which need to be further improved to provide strong guarantees for the industry to enable it to accelerate the transformation. In view of the core challenges facing the industry as it attempts this transformation, the following suggestions are put forward:

Improving textile waste recycling regulations, and promoting the standardization, scale-up, and cleaner development of the industry.


- Strengthen top-level design, study sustainable recycling models, plan regional recycling & sorting and reuse systems, and establish circular industrial parks for dealing with textile waste.
- Promote the establishment of disinfection systems for second-hand textiles, improve standard systems, and explore the opening of the second-hand textiles market.

- Improve industry access mechanisms and the standard system covering the whole process of collecting, sorting and reuse, so as to promote the standardization and cleaner development of the industry.
- Establish a standard system for recycled products, including quality standards, certification and identification systems for recycled products.
- Introduce policies to stimulate the development of the textile waste recycling industry through measures such as tax reductions, discount loans, special funds, etc.
- Develop special laws and regulations on the recycling of textile waste, clarify the responsibilities of various regulatory departments, as well as the responsibilities of stakeholders such as producers and processors of textile waste, so as to implement the EPR system.

Developing product design standards based on the principles of a circular economy and promoting synergy between the circular design and the green product.

- Based on the *Opinions on Establishing Unified Green Product Standards, Certification, and Labeling Systems*, as well as the existing standards, the evaluation methods of green fibers and green textile products should be unified so as to build unified green textile product standards and a system of certification and identification, and finally effective supply of green textile products should be promoted.
- Promote the green design based on principles of a circular economy. Consideration should be given to the synergy with green design standards and green product systems. Relevant design principles, content, core requirements and evaluation indicators for recyclable green products should be clarified, with focuses on indicators such as material selection, easiness to recycle, reuse, etc. Meanwhile, measures such as market access requirements, green procurement, etc. are also necessary for forming a market for circular and green products.

Establishing standards, certifications and technical guidelines for circular production in companies, parks, and industry.



EPR refers to the system that extends the resources and environmental responsibilities of producers for their products through the whole life cycle including design, consumption, recycling, and waste disposal. It is an effective system for companies to implement their main responsibilities through the whole life cycle of the industry.

- Measures should be taken to strengthen the implementation of cleaner production audits and an emissions permit system and expand the scope of pilot programs for green factories, green parks and a green supply chain, with the aim to improve the green development of the industry.
- Based on existing systems and evaluation standards of cleaner production and green manufacturing, the standards and evaluation system of circular production should be established for textile and apparel companies, industrial parks and products. Meanwhile, it is necessary to improve the relevant technical guidelines to encourage more companies to manage production according to 3R principles, so as to increase the use of renewable energy and improve resource recycling in production.

Clarifying the main responsibilities of companies and promoting the implementation of the EPR system.

- EPR refers to the system that extends the resources and environmental responsibilities of producers for their products through the whole life cycle including design, consumption, recycling, and waste disposal. It is an effective system for companies to implement their main responsibilities through the whole life cycle of the industry. At present, China's national *Promotion Plan for Extended Producer Responsibility System* defines the scope of EPR in four aspects: carrying out ecological design, using renewable raw materials, standardizing recycling, and

strengthening information disclosure. In line with the plan measures have been taken to start pilot applications in the fields of electrical appliances, automobiles, lead-acid batteries, and packaging materials. It is necessary to launch a plan for the textile and apparel industry implementing the EPR system as soon as possible. The plan should clarify the objectives, the main responsibility of various companies, and the implementation scheme.



Companies: carrying out circular practices and model innovation

Companies are the main bodies practicing circular economy. Companies' responsibilities for resources and environment runs through the whole life cycle of their products. Circular economy practices and innovation can help companies to improve their competitiveness, and obtain sustainable profitability. Companies in the textile and apparel industry can be mainly divided into three categories: manufacturers (of fiber, yarn, textile and final product), retail brands, and textile waste recycling companies. According to the position in the industrial chain, they are somewhat different in carrying out circular economy practices and pioneering new models.

Manufacturers

- Manufacturers should consider the impact of all materials selected, production, packaging, sales, use, recycling, processing etc. on resources and the environment, and design their products ecologically.
- Implementing production methods based on 3R principles throughout the whole manufacturing process. This involves reducing the consumption of non-renewable resources, using clean energy or renewable energy, improving the recycling rate of resources and energy in production, improving the recycling rate of waste products and materials, and reducing the generation of waste.
- Adopting advanced information technology such as big data, cloud computing, artificial intelligence, etc., to digitalize the manufacturing process, so as to improve the management and production efficiency.
- Enhancing the use of renewable, circular and recyclable materials in products.
- Recycling waste products and packaging materials in formal and standard ways through independent recycling, joint recycling or commission recycling and waste products and packaging must be standardized; and treating them directly or indirectly like collaborating with professional companies for disposal.
- Labeling components, and providing sufficient information about recycling and disposal of fibers, yarns, fabrics, and finished products, so as to provide necessary information support for the collection, recycling, disposal of textile and clothing.

Retail brands

As a bridge linking production and consumption, retail brands play an important role in promoting circular green design, green supply chain management, green product supply, green consumption, and textile waste recycling.

- The impact of raw material selection, production, sales, use, collecting, and recycling on resources and environment must be taken in account systematically.
- Increasing the use of bio-based chemical fiber and recycled fiber in products, and using less packaging.

- Promoting green supply chain management through measures such as improving the substitution of non-renewable resources/energy, improving the resources utilization efficiency, and reducing waste generation in the supply chain.
- Increasing the design and sales of circular green products by establishing transparent and traceable product labeling system and clarifying the fiber composition of products, relevant resources and environmental information, nursing methods and recycling solutions, so as to provide convenience for consumers and back-end recycling companies.
- Actively participating in the construction of textile waste recycling networks, promoting the collecting and recycling of textile waste, and exploring the establishment of a closed-loop model of "fiber – textiles – recycled fiber".
- Actively guiding sustainable consumption through measures such as enhancing consumers' awareness of green consumption, exploring new consumption patterns based on consumer demand, and involving consumers' participation in the circularity of products, so as to enhance confidence in sustainable textile and apparel and relevant products and services.

Waste recycling companies

- Strengthening the research and development of key technologies in collecting, sorting, and comprehensive utilization to improve industrial efficiency and increase the added-value of recycled products, so as to achieve the high-efficiency and high-value recycling of textile waste by quality classification.
- Comprehensively considering the impact of re-manufactured products on resources and environment in terms of collecting, redesign, manufacturing, use, and disposal, and carrying out circular green design, circular production, packaging reduction, waste recycling, and other practices to ensure the efficient utilization of resources and environmental friendliness in production.
- Using traceable tools to clearly mark the components and sources of recycled materials in the products, so as to provide necessary information for production, sales, and disposal.



Designers: leading green design and circular fashion

The designer's decision in the design stage, to a large extent, determines the environmental impact of the product in production, sales, use and recycling. In the circular economy transformation of the industry, designers can have a positive impact on the following areas:

Choices of raw materials

- Use fibers and fiber products, such as yarns, fabrics, textiles, etc., with no toxic and harmful chemicals, and less resource consumption and fewer emissions in production.
- Consider the recycling of materials after use and increase the use of recycled fibers and fiber products (such as yarn and fabric) and recycled fabrics in the design.

Improve resource efficiency

- Reduce the use of textile materials through reduction design.
- Improve the material efficiency in apparel proofing and cutting through intelligent cutting, 3D technology proofing, etc.
- Apply production techniques with low resource consumption and less environmental pollution, while considering the whole process of fabric processing.
- Optimize the packaging solutions by material reduction and using circular, recyclable, and degradable packaging materials.

Extend product life

- Enhance the durability design and improve the service life of products;
- Enhance design of products with cultural and innovative elements to strengthen bonding with consumers.

Product recyclability

- Consider the recyclability of materials after use, use easy-to-recycle fiber and reduce the use of multi-fiber blending
- Identify fiber components and build traceability and rapid identification of fiber by using electronic radio frequency chips, Blockchain, and other technologies.
- Explore modular design which helps separate products for easy recycling.

Guide the consumer

- Increase consumers' purchases of green textile products through style, color, and other designs;
- Provide consumers with textile product information through labels and logos detailing green properties of materials etc., to guide consumers and help them make informed choices.



Associations and research institutions: empowering the industry development

In addition to the government and companies, industry associations, research institutions and scientific research institutes also play an important role in promoting the circular economy transformation.

Industry associations

Industry associations play a very important role as a bridge between the government and companies and between companies. They provide information support and suggestions for policy makers based on the current situation and practice in the industry. They also further the implementation of national strategies and industrial development policies, and guide the transformation, upgrading, and healthy development of the industry. Industry associations can play a pivotal part in establishing databases, building cooperation platforms, enhancing industry transparency, building up industry capacity, and promoting international exchanges.

As a public governance platform for the sustainable development of the industry, the Office for Social Responsibility of CNTAC is actively building the infrastructure for the circular economy transformation of the industry and building a multi stakeholder engagement mechanism in the value chain, so as to promote the consensus of all parties in the industry, stimulate cooperation at different levels, accelerate industrial collaboration, promote the systematic circular transformation of China's textile and apparel industry, and lead the future of global circular fashion.

In 2019, the Office carried out a baseline survey on the industry circular economy transformation based on the whole industry chain level, and organized events such as "Clothes Remake" and Sustainable Fashion Week to promote the consensus of key stakeholders on the advantages of a circular economy. The manufacturing industry evaluation information system for consumer goods (textile and apparel), data platform for life cycle management, and innovation platform for sustainable technology initiated by the Office will further enable the industry's transformation.

Research institutions

The technology bottleneck is the core challenge to the circular economy transformation in the textile and apparel industry. R&D and innovation of key technologies requires a large amount of capital investment. Reliance on the independent R&D of companies means these companies have to face huge financial pressure, and it will also cause technological barriers and redundant repetition of research programs. Therefore, the role of research institutions is very important in tackling challenges in the common technologies.

The Leading Action Plan on Circular Development also clearly encourages: "supporting the R&D of common technologies of the circular economy through the national science and technology plan (special projects, funds, etc.), and accelerating R&D in key technologies, techniques and equipment in the fields of reduction, reuse and remanufacturing, waste resource utilization, industrial symbiosis; supporting companies in resource recycling, scientific research institutes, and universities to establish research innovation alliances; publishing publication of the state encouraged list of circular economy technologies, techniques, and equipment; improving the selection and promotion mechanism of circular economy technologies and equipment, and establishing an information platform for applications.

Meanwhile, technical exchange is conducive to the promotion and pioneering of key technologies in the industry. R&D institutions should actively exchange experience with the international counterparts.



Consumers: practicing sustainable consumption

Consumers are not only important stakeholders in the circular economy transformation of industry, but also the core driving force for it. First of all, consumers are the main users of green products, as well as the main actors in new business models such as clothes leasing, maintenance, and second-hand resales. Secondly, consumers are the supervisors of the circular development of the industry.

However, the sustainable consumption behavior of China's mainstream consumer groups is still lagging, and most of them have no clear awareness of their role as the supervisor. In order to give full play to the consumption

driving force and supervision power of consumers, different stakeholders in the industry should invest appropriate resources, unite more social forces, carry out consumer education at different levels, help consumers understand their role and function in circular fashion, and actively guide consumers to buy, use, and dispose of their clothes.

The government, industry and company, as well as schools, social organizations and third-party professional institutions play different roles in consumer education.

Government

In 2016, China issued the *Guiding Opinions on Promoting Green Consumption*, which clearly aimed to encourage green consumption, expand the green consumption market, promote supply side reform, and cultivate new economic growth points. In recent years, the implementation and promotion of policies such as the urban household waste sorting and the construction of “waste-free cities” have further created a good policy environment for green consumption.

The industry and companies

The industry and companies are playing a leading role in consumer education. In particular, retail brands that are in direct contact with consumers need to further strengthen their communication around the ideas and practices of circular fashion through various ways such as large-scale industrial exhibitions, fashion weeks, brand programs/activities, competitions, etc., and at the same time, innovate their ways of communicating with consumers.

Schools, social organizations, and third-party professional institutions, etc

Consumer education is a gradual process, during which the roles of schools, social organizations, third-party institutions, and other organizations are also crucial. The industry should work actively with these organizations in designing innovative programs and taking joint action to bring about changes in consumer behavior.

4.2

Mapping the opportunity of circular fashion for China's new textiles economy

Circular economy transformation is both a challenge and an opportunity for China's textile and apparel industry. On the one hand, limited resources and the environmental impact of industry, the green barriers to international trade, the rise of green consumption, and the call for sustainable development urgently require different stakeholders in the industry to take practical actions to accelerate the development of a circular economy; on the other hand, as an economic development model, a circular economy can bring about innovation opportunities, which offer new economic growth to industries in a slowing global economy.

Driven by both pressures and opportunities, in the future, the supply of green fiber products, the recycling of textile waste and the new business model based on consumer needs will start a new journey of rapid development, further releasing the potential of international and domestic markets. At the same time, innovations in key industrial technologies, as well as the mutual stimulation of new technologies such as big data, AI technology, 3D printing, and Blockchain with the textile and apparel industry, will promote a deeper transformation and shape the future of the industry.

4.2.1 Effective supply of green fiber and fiber products

With more and more strict environmental policies at home and abroad, and increasing consumer awareness, the demand for green fiber/fiber products in the international and domestic markets will continue to rise.

First of all, the domestic and foreign public policy environment is good for the development of the industry. Internationally, taking the *European Green Deal* as an example, textiles is listed as one of the key areas for implementing a circular economy, in order to achieve the goal of climate neutrality by 2050. Obviously, the policy will stimulate the demand for green fiber/fiber products in the European market. Europe is one of the important markets for China's textile and apparel industry. The demand for green fiber and fiber products in this market will be an important development opportunity for China's fiber suppliers and apparel manufacturers. Domestically, China's national policies such as a diversified raw material strategy, supply side reform, and the promotion of green consumption provide a favorable development

environment for the large-scale supply of green fiber and fiber products.

Secondly, the active commitment of fashion brands directly conveys a demand signal to manufacturers at the upstream end of the supply chain. So far, Nike, H&M group, Adidas, and other world-famous fashion brands have made a clear commitment to sustainable materials. Data shows that although the number of mass-market retailers using sustainable materials for production is still low, it has increased five-fold in the past two years.⁷⁴ With more and more fashion brands and companies aware of the opportunities brought about by a circular economy and making a commitment to circular economy transformation, the market share of green fiber and fiber products will gradually increase.

In addition to the demand from the textile and apparel industry, the demand for green fiber/fiber products also comes from aerospace, aircraft manufacturing, rail transportation, medical and health, beauty care, automobile interior decoration, and other fields.

Therefore, fiber manufacturers should seize the opportunity of fashion brands to explore alternative materials, accelerate technological innovation, make breakthroughs in product performance and cost, expand the scale of production, and make green fiber a reliable choice for designers and fashion brands. Fashion brands or companies should optimize their product structure, expand their design, production and sales of green collections to meet future consumer demand, and at the same time, improve their brand reputation and create new income streams in the context of an economic slowdown.

4.2.2 Recycling of textile waste

According to statistics, less than 1% of the materials used for apparel production in the world can be recycled and made into new clothes, and only about 12% of textile waste is used to produce other products.⁷⁹ With the increasing market demand for recycled products, large-scale development of recycling textile waste is bound to follow.

First of all, the textile waste recycling industry has a long chain, involving collecting, transportation, component identification, sorting, disinfection, resale or resources utilization, and sales of recycled products. With the scale-up, all sectors of the industry will gain opportunities for standardized and large-scale development, which will also drive the development of relevant equipment and service industries.

Taking collection as an example, different models of collecting will have the opportunity to further expand their market scale, especially the emerging "Internet + Recycling" online model. By using internet technology, online recycling platforms provide door-to-door collecting, which greatly reduces consumers' difficulty in dealing with their textile waste, and consumers in many first-tier

cities in China have gradually become fans. Currently in China, there are several existing online platforms such as Feimayi, Baijingyu, Idle fish, Paipai, Zhuanzhuan, etc. China has a huge stock of textile waste. New companies are still entering the field one after another, innovating in online recycling services, such as Aobag Environmental Protection and Hainan Greenergy Technology.

Secondly, brands and companies will have more space to explore more innovative textile waste recycling systems, such as building recycling systems around a certain fiber, or building their own recycling system. Large international clothing brands have started this journey. For example, UNIQLO launched their "All-Product Recycling Initiative" in 2006 to freely recycle apparels of UNIQLO's own brands. H&M Group began to implement garment collecting programs in 2011 to recycle all clothing (including other brands) by issuing coupons to customers who donate their old clothes. With the value of textile waste increasing, more and more brands have begun to rethink their strategy in terms of textile waste and design their brand recycling system. The clothes collected are mainly utilized through donation, second-hand trading, and reuse.

Case Aobag Environmental Protection⁸⁰

Founded in 2017, Aobag Environmental Protection Co., Ltd. launched its recycling method, which includes 14 categories of waste. The system involves classification, replacement of full bags with empty bags, concentrated delivery points, and cashback depending on price. Aobag's recycling bag is the core of its entire service. Aobag connects residents, communities, logistics systems, and remanufacture systems through QR codes on recycling bags, the WeChat app, the website, and drop-in points, which can reduce the overall cost of recycling. The company aims to recycle the recyclable professionally, and generate sales revenue by transacting with the remanufacture industry. Fabric is one of 14 categories of waste recycled by Aobag.

Case Greenergy Technology⁸¹

Hainan Greenergy Technology Co., Ltd. is a mobile internet service platform for textile waste remanufacturing companies. The company has innovated the recycling system of renewable resources, and improved the traditional recycling industry through innovative technology achievements in the mobile internet, big data, cloud computing, and Internet of things. Its business covers door-to-door textile waste collecting services for urban residents, information management of urban textile waste recycling outlets, intelligent recycling boxes for urban solid waste, flow monitoring of the Internet of things for waste material processing, and big data systems for urban residents' environmental protection activities. "5tan Planet" is the recycling program of Greenergy Technology, which combines Blockchain technology innovatively to create a new clothes recycling model.

4.2.3 New business model based on consumer demand

In the circular economy, the growth of the textile and apparel industry will no longer rely on the original model "Mass Production - Mass Consumption". Instead, the industry will innovate in terms of business services to meet the various demands of existing and future consumers for fibers and fiber products with the same or even less resource consumption. New business models such as sharing platforms, rental services, second-hand trading, online recycling, maintenance services, and re-design services offer ways to explore new possibilities. These new

business models, which take the principles of the circular economy and the new needs of consumers into account, are important driving forces to promote the circular economy transformation of the industry and explore new economic opportunities, especially when they develop on a large scale.

The current international and domestic policies provide a powerful environment for brands and companies to explore new business models. Obviously, these new business models will have a profound impact on shaping the future industry.



**Sharing
platforms**

Globally, clothes sharing platforms have developed very fast in the past few years, favored by the capital market. Rent the Runway, an American e-commerce platform established in 2009, is the earliest clothes sharing platform which aimed to integrate offline leisure apparel products and provide them to consumers at a lower price. At the beginning of 2019, Rent the Runway received a new round of financing of US \$150 million, and its market valuation was close to US \$1 billion.⁸² Another well-known clothes sharing platform in the United States is Le Tote, which was established in 2013 and entered China in 2018. It was the first international clothes sharing platform to enter the Chinese market.

In addition to Rent the Runway and Le Tote in the United States, Myonbelle in Germany and AirCloset in Japan are also early emerging sharing platforms globally. In the last five years, with the rising call for sustainable development globally, increasing awareness of sustainable consumption and technological progress, there has been a rise in the number of clothes sharing platforms. More and more companies have entered the field and created their own angle. For example, My Wardrobe HQ, a leasing platform set up in the UK in December 2019, focuses on high-end fashion to meet the demand in the European market for leasing of clothing for special occasions, which is more popular than day-to-day wear. According to media reports, My Wardrobe HQ's ski apparel leasing business has performed well.

From 2015 clothes sharing platforms have been active on the Chinese market and there once were several platforms such as YCLOSET, MSParis, Meilizu, Le tote, and E-COOL competing on the market. However, in 2017, this market started to decline, mainly because the clothes sharing service chain is long and complex, involving multiple sectors such as clothes selection, logistics, cleaning, wear-and-tear processing. Any problem in any sector will affect the user experience and lead to the loss of users. Therefore, the key issues, such as hygiene, style, customer demand, supply chain management, etc., still need to be improved in order to deliver the service on a larger scale.



**Brand apparel
leasing service**

Brand apparel leasing means that the brand moves away from the traditional sales model and provides apparel for consumers by providing leasing or rental services, thus creating market value. The difference between brand apparel leasing services and clothes sharing platforms is that a company involved in the former owns the product, while the latter does not necessarily own it.

Apparel leasing is not new, but with the expansion of the sharing economy and the rise of clothes sharing platforms, brands and retailers have begun to see the opportunities offered by the rental market and have started to explore its possibilities. There are

three main ways for brands and retailers to practice. The first is that the brand or retailer establishes the entire leasing business within the company. For example, Urban Outfitters, a traditional retailer in the United States, launched its own member leasing service in 2019. The second is to cooperate with clothes sharing platforms, which is a common way for brands to enter the leasing market. Especially for those small-scale brands, cooperating with a more mature platform can reduce the risk, but it also prevents the brand or retailer from establishing their own infrastructure. The third way is to cooperate with a third party to establish the brand and the retailer's own leasing platform. In other words, the third-party organization provides services related to leasing such as logistics, cleaning, delivery, and inventory, but shares data with brand customers. This is a feasible solution for brands that want to start leasing business quickly. Continuous Fashion, a Danish company, is such an agency.⁸³

As an important means to improve the utilization rate of clothes, apparel leasing has great development potential in the fields of high-end apparel, special occasion clothing, special function clothing and so on. Brands and retailers own plenty of clothes in various categories and quantities and have vast experience in supply chain logistics and marketing, which is helpful to develop service-oriented products for consumers such as leasing in the future.



Second-hand trading/ resale

In Europe and the United States, the second-hand clothes market is very active, and consumers are used to dealing with their old clothes through resale, especially children's wear, durable apparel, luxury apparel, and other categories of better quality. In addition to offline stores and second-hand goods markets, the platform is also an important space for second-hand clothes trading in European and American markets, such as ThredUp, The Real Real, and POSHMARK in the United States, and Vestiaire Collective and Vinted in Europe.

Second-hand resale platforms generally operate within either a peer-to-peer or consignment model, though some have both. In the peer-to-peer model, companies provide an online marketplace for buyers and sellers, but the authentication services vary by platform. POSHMARK is typical, adopting P2P model. In the consignment model, the platform provides an online marketplace full-service offering (photos, listing, shipping, inspection, authenticity). The platform makes a profit by charging a listing fee. Generally speaking, the P2P model is suitable for mass products, while the consignment model is suitable for luxury goods.⁸⁴

Based on the price point addressed, the second-hand resale market can be divided into three segments: luxury, midlevel, and mass market. Platforms usually choose to focus on a particular market segment. For example, The Real Real and Vestiaire Collective are mainly engaged in second-hand luxury trading. These two companies are also the leading companies in this field internationally. But there are also comprehensive platforms, such as ThredUp, where consumers can find second-hand apparel in different price ranges.

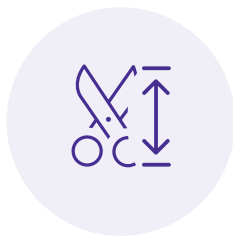
With the rapid development of online second-hand trading, the trend toward online and offline integration is gradually emerging. ThredUP, founded in 2009, is the largest second-hand clothes resale platform in the United States. Eight years after its establishment, ThredUP opened an offline smart store to provide customers with an offline experience.⁸⁵ The Real Real has also opened its own offline stores.

Apparel brands and retailers have also begun to enter the resale market. Patagonia opened a second-hand resale website *WornWear.com* in 2017. Patagonia buys used products in

good condition from consumers and then resells them on the website, while consumers can obtain certain store sales points. At the end of 2019, the brand also tried to sell second-hand apparel through offline POP-UP stores. In 2019, H&M group kicked off a pilot project in Sweden to sell second-hand and antique apparel; Burberry also announced a partnership with The Real Real. At the end of May 2020, Walmart announced its online partnership with ThredUP, which means ThredUP are available on *Walmart.com* and customers can find nearly 750,000 pre-owned items on it.⁸⁶

To some extent, the activity of brands and retailers reflects the promising prospects of the resale market, which is predicted to reach up to US\$ 51 billion in 2023.⁸⁷

Counterfeit goods have always been a pain point for all second-hand trading industries, especially luxury goods. In November 2018, there was a dispute between The Real Real and Chanel because Chanel believed that the former sold counterfeit Chanel handbags on its website. But when it comes to second-hand clothes resale, issues such as style and cleanliness are important. Establishing a mechanism to gain consumers' trust is the key to building a successful clothes resale platform.



Apparel repair/ altering/ redesign services

Besides sales and leasing, brands and retailers will also expand their services to clothes maintenance, altering, and redesign. This is another field that fashion brands and designers have actively explored and practiced in recent years.

Maintenance service has always been a value-added service provided to consumers by some luxury apparel brands or high-end outdoor brands, but this phenomenon has changed. Brands are exploring how to turn the service into a practicable business model of a circular economy. Taking Patagonia as an example, maintenance service has always been at the core of the brand's business model. It has 72 repair centers around the world (as of November 2019). In 2013, Patagonia launched the Worn Wear program, which encourages consumers to reuse and recycle products by buyback and promotes repairing. Based on this, Patagonia launched an online website in 2017 to provide resale of second-hand clothes from the Worn Wear program, thus creating a model from repair service to second-hand clothes trading. In addition to Patagonia, some other brands have also launched maintenance programs. For example, The North Face launched a pilot program named Renewed in 2018, cooperating with The Renewal Workshop, which is responsible for cleaning and inspecting the returned, damaged and defective clothing, then repairing the worn item and replacing the zipper. After this, The North Face evaluates the clothes' quality before resale.

Clothes altering or redesign refers to reconditioning defective clothes, which is also known as upgrading. RECLOTHING BANK in China is a typical case. Designer Zhang Na redesigned the old clothes obtained from different channels (used clothes from recycling companies, brand stock fabrics, public donations) into fashionable apparel, and achieved mass production to a certain extent. In the clothes altering and redesign business, the designer's ability in sustainable design or circular design is very important. Some brands have also begun to provide their designers relevant training. For example, The North Face launched the "RenewedDesignResidency" program in October 2019, aiming to improve the circular design ability of their designers.⁸⁸

However, whether it is repair services, or apparel altering/redesign services, there are still challenges to tackle in the future. For example, maintenance is still mainly regarded as a value-added service of fashion brands, not as a service model. As for clothes redesign, the main problems are sourcing fabrics and mass production.

4.2.4 Key technology innovation and new technology implementation

Advanced technology is fundamental to the textile and apparel industry breaking through the bottleneck of resources and environment. This includes resource recycling technology, environmentally sound technology, and equipment with high added-value and fewer emissions. At present, the technology support system of circular economy development for China's textile and apparel industry is still to be improved. In particular, it is important to make breakthroughs in the high-quality and low-cost technology of high-performance bio-based fiber and the high-efficiency and high-value utilization technology of textile waste.

Against the background of the industry actively developing intelligent manufacturing, the application of new digital technologies such as 5G, artificial intelligence (AI), Blockchain is expanding in the industry. Some digital technologies contribute to improving the industry's position with respect to the circular economy. For example, Blockchain technology can help anti-counterfeiting and traceability, and improve transparency in the industry; AI technology can make an important difference in accurate demand analysis and inventory reduction; 3D printing can effectively enhance material efficiency.



High efficiency and high value utilization of textile waste by quality and classification

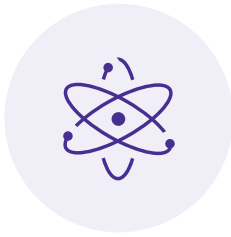
The components of textile waste are complex. At present in China, there are still bottlenecks in key textile waste recycling technologies, such as rapid component detection, efficient sorting, rapid disinfection, and blending separation. This limits the efficiency of the resource utilization industry chain, as well as the quality and performance of recycled fibers and products, which is not yet up to the high-quality standard of fibers that the market demands.

Companies and scientific research institutions should increase the pace of technological research and make breakthroughs in establishing an efficient and high-quality utilization system of textile waste in cascade fashion. These should include: on-line rapid identification and sorting technology which does no damage to composition, coloring and weaving structure of textile waste; remanufacturing and spinning industrialization technology for impure synthetic fibers; technology for the automatic removal of foreign matter in waste clothes; efficient opening technology and product manufacturing technology of hybrid textile waste.



Bio-based chemical fibers with high quality, high performance, and market competitiveness

Bio-based chemical fiber has great potential, but currently, it still can't compete with synthetic fiber in quality and performance, and the cost of production is high, making it rather uncompetitive. Therefore, breakthroughs in key technologies and equipment are still needed. For example, in terms of polylactic acid fiber, it is necessary to improve the technology used in preparing low-cost and high-gloss pure lactic acid and lactide; in terms of bio-based polyester, it is necessary to promote the efficient preparation of bio-based polyalcohols to meet the requirements of the fiber molding process; in terms of bio-based polyamide, it is necessary to start to build a 10,000 tons production line of long-chain diacids and diamines; in terms of new cellulose fiber, it is necessary to promote green pulping and fiber production integration technology to achieve high-quality, large-scale, and low-cost production.⁸⁹



Internet of things: improving resource allocating and production efficiency

The Internet of things (IoT) is designed to collect data from any object or process that needs monitoring, connection and interaction in real time through intelligent sensors, radio frequency identification (RFID), and other technologies. The technology collects all kinds of information such as sound, light, electricity, heat, location, etc., and uses network access to achieve an extensive link between things and things, between things and people, and achieve the intelligent perception, identification and management of objects, so as to improve resource utilization and productivity.^{90, 91} With the automation and intelligent development of the textile and apparel industry, IoT technology has been applied in production, research and development, management, storage, logistics, and other aspects of the industry.

RFID for example is a kind of non-contact automatic identification technology, which can identify high-speed moving objects and obtain data through RF signals, which is one of the core technologies for data acquisition in the Internet of Things. By embedding RFID chips into products and recording product information, the industry can realize "Ubiquitous Perception" of the whole manufacturing process, including detection, real-time parameter collection, equipment and product monitoring management, material consumption monitoring, etc. in production, so as to improve product quality and production efficiency, and reduce product inventory by establishing data feedback mechanisms. Some large domestic apparel companies have begun to apply this technology in the supply chain.

With the development of big data, cloud computing, mobile internet, AI and other new information technologies, IoT, as an infrastructure and platform solution, will realize the optimal allocation of resources through the collection and perception of data throughout the whole value chain. Taking Smart Fabric as an example. Based on SaaS cloud ERP system, Smart Fabric accepts customer orders from apparel brands and apparel factories at the downstream end, while connecting with spinning factories, printing and dyeing factories and weaving factories at the upstream end, and then disassembles the orders. Through IoT and the scheduling system, it organizes the factories in the system to cooperate with each other to complete the manufacturing of fabric, in order to realize the effective docking and optimization of resources.



Data traceability: building a transparent supply chain

Transparency is the foundation of trust. Trust is the foundation of cooperation and consumption. The textile and apparel industry is highly international and has a long and complex supply chain. And the opaque supply chain has always been a problem that has plagued the industry's healthy and sustainable development. With rising consumer awareness and the increasing concern for environmental friendliness and the sustainability of clothes, the demand for all information about products from production to sales and even resale will continue to increase. In the past few years, some stakeholders of the industry have actively used data traceability technologies, such as RFID technology, bar code technology, QR code technology, etc., to build a transparent supply chain. Since 2019, Blockchain technology, the new data traceability technology, has been applied in the industry.

All the fiber information, environmental attributes included, can be stored on the Blockchain, which means giving the fiber a digital identity at the very beginning. This can help to improve the traceability of textile fabrics at source. At present, some international companies are already taking these steps. In May 2019, Lenzing group announced its cooperation with Textile Genesis, a Blockchain company in Hong Kong, China, to integrate Blockchain technology into its fiber business, and plans to launch

a supply chain traceability platform in 2020. At the international fashion and textile show *Première Vision* in France in September 2019, Waste2Wear, a Dutch company, demonstrated a batch of recycled fabrics whose production information can be traced through Blockchain technology, showing that all its fabrics and textiles were made from plastic waste collected from the ocean.

The important derivative function of traceability is anti-counterfeiting. With the rise of the luxury second-hand trading market, it has become increasingly important to identify the authenticity of luxury goods. Through Blockchain technology, luxury brands can give their products block chain codes, control the authenticity themselves, and effectively prevent the counterfeiting of their goods.



Artificial intelligence:
accurate demand analysis and inventory reduction

One of the pain points of the textile and apparel industry is inventory. In recent years, reports about apparel companies' improper handling of inventory have been reported in newspapers from time to time. Companies cannot predict market demand and consumer preferences, leading to difficult inventory issues everywhere, which not only place a heavy burden on companies but also produce waste in the industry. With the development of AI technology, textile and apparel companies are extending their efforts to automate the supply chain and implement intelligent management on the consumer side, that is to accurately identify the needs of consumers through AI technology, such as introducing consumer interaction behavior through face recognition technology to establish their personal consumption habits and preferences, and then feedback these data to the production and design end to achieve inventory control and accurate production.

At present, more and more Chinese apparel companies have begun to carry out the reform of building an intelligent and flexible production line. For example, Qingdao Red Collar Clothing Co., Ltd. has realized both personalized customization and mass production through their C2M personalized customization platform with low inventory or even zero inventory.^{92, 93}



3D printing:
improving textile materials efficiency

3D printing, also known as additive manufacturing technology, can be combined with circular fashion in material, design, production and other aspects. PLA (polylactic acid fiber), one of the main materials for 3D printing, is also a kind of textile fiber and is used more and more often nowadays. It is considered to be the bio-degradable fiber that is most likely to be commercialized in the future. The combination of PLA and 3D printing technology is one of the sectors worth exploring in the industry.

In addition, 3D printing materials can be recycled after use. Whether in the design stage or in the production stage, it helps to improve materials' efficiency, reduce waste, help designers and manufacturing companies maximize the use of textile materials, so as to improve resource efficiency in design and production.

4.3

Strengthening industrial cooperation and accelerating towards circular fashion

Driven by the increasing call for sustainable fashion and the urgent need for new development opportunities, circular fashion has outlined a vision different from the traditional linear economy model for the global fashion industry, that is to reshape a more responsible and resilient industry according to the principles of a circular economy. This means innovating in terms of material choices and design, maximizing the value of the fiber and textile during production, and reducing the consumption of resources and waste.

China's textile and apparel industry is an important part of the global fashion industry and will also be the main supply market and consumption market of the circular fashion in the future. To speed up the transformation, the industry should set forward-looking goals, unify the agenda, and strengthen the industry's cooperation at different levels, such as technological innovation, business model, and information communication, so as to form a win-win industrial community and accelerate the development towards high-quality.

First of all, technological collaboration is the key. Industry stakeholders should harness their competitive relationship and promote the development and large-scale application of key generic technologies in key areas through resource integration and collaborative research. Secondly, policy coordination is the guarantee. Based on industrial practice and demand, government should strengthen policy coordination, unify standards, clarify the roles and boundaries of different stakeholders, avoid adverse and vicious competition, protect the rights and interests of all parties, and guide and encourage cooperation among all parties.

Thirdly, information collaboration is the foundation. The industry should strengthen communication between the upstream and downstream ends, establish effective dialogue mechanisms and platforms, encourage all parties to seek consensus on common challenges and visions for the industry, stimulate bolder and innovative cooperation models on a larger scale, and jointly create solutions.

At the same time, the circular economy transformation of China's textile and apparel industry must be planned against the background of the international economy seeking accelerated transformation towards a circular economy, as well as sustainability. The industry needs to actively dialogue with partners in the global fashion value chain, open cooperation, work together to meet the common challenges of the industry, and provide industrial solutions for global circular fashion.

At present, global economic growth has slowed down, and various uncertain factors have accelerated the difficulties and risks of economic recovery. The outbreak of the COVID-19 Pandemic in early 2020 has impacted the economy particularly hard. The whole value chain of the fashion industry has been affected, and all stakeholders will have to move forward with difficulty. In this new era of an increasingly complex environment, the global textile and apparel industry should share one common value and carry out larger scale and deeper coordination and cooperation in the global value chain, so as to look for new growth opportunities given the uncertain prospects offered by the world economy, and build a more resilient value chain.



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Appendix

Appendix I: Circular economy transformation policy system of China's textile and apparel industry*

Name	Date of issue/ revision	Policy categories
National law		
Water Pollution Prevention and Control Law of the People's Republic of China	Issued in 1984 / revised in 2008	Law
Environmental Protection Law of the People's Republic of China	Issued in 1989 / revised in 2014	Law
Law of the People's Republic of China on Evaluation of Environmental Effects	Issued in 2002 / revised in 2018	Law
Cleaner Production Promotion Law of the People's Republic of China	Issued in 2003 / revised in 2012	Law
Law on the Prevention and Control of Environmental Pollution by Solid Wastes of the People's Republic of China	Issued in 1995 / revised in 2016 and 2020 respectively	Law
Circular Economy Promotion Law of the People's Republic of China	Issued in 2008 / revised in 2018	Law
Circular economy development strategy and leading action Plan		
Several Opinions of the State Council on the Development of the Circular Economy	In 2005	Normative Documents of the State Council
Outline of China's "11 th Five-Year Plan" for National Economic and Social Development	In 2005	Working paper of the National People's Congress
Outline of the 12 th Five-Year Plan for National Economic and Social Development of the People's Republic of China	In 2011	Working paper of the National People's Congress
Notice of the State Council on Issuing the Circular Economy Development Strategy and Near-Term Action Plan	In 2013	Normative documents of the State Council
Opinions of the Central Committee of the Communist Party of China and the State Council on Accelerating the Construction of Ecological Civilization	In 2015	Normative Documents of the State Council
Outline of the "13 th Five-Year Plan" for National Economic and Social Development of the People's Republic of China	In 2016	Working paper of the National People's Congress
State Council Circular on the Issuance of the Comprehensive Work Program for Energy Conservation and Emission Reduction during the "13 th Five-Year Plan" Period	In 2016	Normative Documents of the State Council
Notice of the National Development and Reform Commission, Ministry of Science and Technology, Ministry of Industry and Information Technology, Ministry of Finance, Ministry of Land and Resources, Ministry of Environmental Protection, Ministry of Housing and Urban-Rural Development, Ministry of Water Resources, Ministry of Agriculture, Ministry of Commerce, State-owned Assets Supervision and Administration Commission of the State Council, State Notice of the State Administration of Taxation, the National Bureau of Statistics, and the State Forestry Administration on Issuing the Leading Action Plan on Circular Development	In 2017	Departmental Regulatory Document
Notice of the General Office of the State Council on Issuing the Implementation Plan for Prohibiting the Entry of Foreign Garbage and Advancing the Reform of the Solid Waste Import Administration System	In 2017	Normative document of the State Council
Notice of the General Office of the State Council on Issuing the Work Plan for the Pilot Construction of "Waste-free City"	In 2019	Normative document of the State Council
The Guiding Opinions on Building a Modern Environmental Governance System issued by The General Office of the CPC Central Committee and the General Office of the State Council	In 2020	Guiding Opinions of the State Council

* The system is a compilation of policies and regulations related to the circular economy, including all the key points as far as possible, please correct any inadvertent omissions.

Non-renewable raw material substitution

Notice of the National Development and Reform Commission on Issuing the Biological Industry Development Plan during the “13 th Five-Year Plan” Period	In 2016	Departmental Regulatory Documents
Notice of the Ministry of Industry and Information Technology, the Development and Reform Commission, the Ministry of Science and Technology, and the Ministry of Finance on Issuing the Guidelines for the Development of New Material Industries	In 2016	Departmental Regulation
Catalogue of Industries for Guiding Foreign Investment (Revised in 2017) by National Development and Reform Commission and Ministry of Commerce	In 2017	Departmental Regulation

Green Design, production, and consumption

Guiding Opinions on the Ecological Design of Industrial Products by the Ministry of Industry and Information Technology, the Development and Reform Commission, and the Ministry of Environmental Protection	In 2013	Departmental Regulatory Document
Notice of the Ministry of Industry and Information Technology on Organizing the Establishment of Industrial Product Ecological Design Demonstration Companies	In 2014	Departmental Regulatory Document
Notice of the Ministry of Commerce, the Ministry of Environmental Protection and the Ministry of Industry and Information Technology on the Issuance of the Enterprise Green Procurement Guide (Trial)	In 2014	Departmental Normative Document
Notice of the State Council on issuing the Made in China 2025	In 2015	Normative document of the State Council
Guiding Opinions of the State Council on Actively Playing the Leading Role of New Consumption and Accelerating the Cultivation of New Supply and New Power	In 2015	Normative document of the State Council
Notice of The National Development and Reform Commission, the Central Propaganda Department, the Ministry of Science and Technology, the Ministry of Finance, the Ministry of Environmental Protection, the Ministry of Housing and Urban-Rural Development, the Ministry of Commerce, the General Administration of Quality Supervision, Inspection and Quarantine, the National Tourism Administration, and the State Administration of Affairs on Issuing the Guiding Opinions on Promoting Green Consumption	In 2016	Departmental Regulatory Document
Cleaner Production Auditing Measures by National Development and Reform Commission and Ministry of Environmental Protection	In 2016	Departmental Regulation
Notice of the Ministry of Industry and Information Technology on Issuing the Industrial Green Development Plan (2016-2020)	In 2016	Departmental Regulation
Opinions of the General Office of the State Council on Establishing Unified Green Product Standards, Certification, and Labeling Systems	In 2016	Normative document of the State Council
Notice of the General Office of the State Council on Issuing the Implementation Plan for the Extended Producer Responsibility System	In 2016	Normative document of the State Council
Notice of the National Development and Reform Commission and the Ministry of Justice on Issuing the Opinions on Accelerating the Establishment of Green Production and Consumption Laws and Policies	In 2020	Departmental Regulatory Document

Recycling of renewable resources

National Development and Reform Commission on the Issuance of Guidance on the Comprehensive Utilization of Resources and the Notice on the Implementation Plan for the Comprehensive Utilization of Bulk Solid Waste During the "12 th Five-Year Plan" Period	In 2011	Departmental Normative Documents
Opinions of the General Office of the State Council on Establishing a Complete and Advanced Waste Goods Recycling System	In 2011	Normative document of the State Council
Measures for the Management of Renewable Resources by the Ministry of Commerce, National Development and Reform Commission, the Ministry of Public Security, the Ministry of Construction, State Administration for Industry and Commerce and State Environmental Protection Administration	Issued in 2007 revised in 2019	Departmental Regulation
Notice of the General Office of the National Development and Reform Commission on the Construction of the "Double Hundred Project" for Comprehensive Utilization of Resources	In 2012	Departmental Regulatory Document
Opinions of the Ministry of Civil Affairs on Strengthening and Innovating the Creation of Charity Supermarkets	In 2013	Departmental Normative Documents
Notice of the Ministry of Commerce, the Development and Reform Commission, the Ministry of Land and Resources, the Ministry of Housing, Urban and Rural Construction, and the Supply and Marketing Cooperative Headquarters on Issuing the Middle- and Long-Term Planning for the Construction of Renewable Resource Recycling Systems (2015-2020)	In 2015	Departmental Regulatory Document
Guiding Opinions of the Ministry of Industry and Information Technology, the Ministry of Commerce and the Ministry of Science and Technology on Accelerating the Development of Renewable Resources Industry	In 2016	Departmental Normative Documents
Guiding Opinions of the General Office of the National Development and Reform Commission, the General Office of the Ministry of Finance, and the General Office of the Ministry of Housing and Urban-Rural Development on Advancing the Construction of Resource Recycling Bases	In 2017	Departmental Regulatory Document
Notice of the General Office of the State Council on Forwarding the Implementation Plan of the Household Waste Classification System of the Ministry of Housing, Urban and Rural Construction and the National Development and Reform Commission	In 2017	Normative document of the State Council
Notice of the Ministry of Finance and the State Administration of Taxation on Issuing the Catalogue of Preferential Value-Added Tax for Products and Labor Services of Resources Comprehensive Utilization	In 2015	Departmental Regulatory Document

Industrial structure adjustment

Decision of the State Council on Accelerating the Cultivation and Development of Strategic Emerging Industries	In 2010	Normative document of the State Council
Guiding Catalogue of Key Products and Services for Strategic Emerging Industries (2016 Edition)	In 2016	Departmental Regulatory Document
Guidance Catalogue for Industrial Structure Adjustment (2019 Edition) by National Development and Reform Commission	In 2019	Departmental Regulatory Document
Guiding Catalogue of Green Industry (2019 Edition) by National Development and Reform Commission	In 2019	Departmental Regulatory Document

Industrial development planning

Outline for Building a Strong Textile Country (2011-2020) by China National Textile and Apparel Council (CNTAC)	In 2012	Industrial Development Planning
Textile Industry Development Plan During the "12 th Five-Year Plan" Period by Ministry of Industry and Information Technology	In 2013	Industrial Development Planning
Textile Industry Development Plan (2016-2020) by the Ministry of Industry and Information Technology	In 2016	Industrial Development Planning



Office for Social Responsibility, China National Textile and Apparel Council
www.sdgstewardship.org/circular

Ellen MacArthur Foundation
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