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EU-CHINA BENCHMARK BASELINE STUDY

Transition to Circular Economy in Textile & Apparel MSMEs along the Lifecycle in Huzhou & Shaoxing

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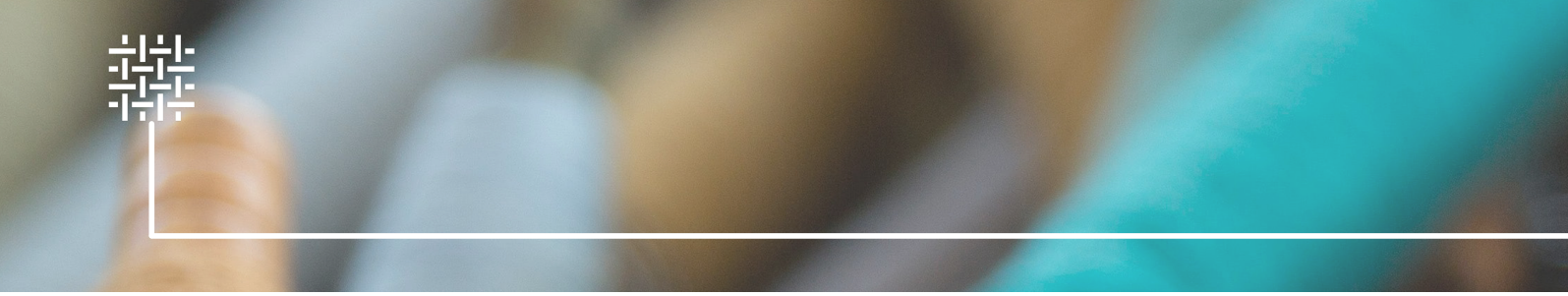

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Executive Summary

This publication is a product of the SWITCH-Asia project: *Transitions to circular economy practices in textile and apparel MSMEs along the lifecycle in Huzhou and Shaoxing.* The project is funded by the European Union (EU), and implemented by China National Institute of Standardization, China Textile Development Center, ICLEI – Local Governments for Sustainability and Regional Activity Center for Sustainable Consumption and Production.

The transition to a circular economy will reduce pressure on natural resources and will create sustainable growth and jobs. The project will contribute to providing future proof and skills training for the transition to circular economy and make available to consumers in the EU sustainable textile products from China.

The objectives of this SWITCH-Asia project is to facilitate the transition to circular economy practices in the textile and fashion industry in Huzhou City and Shaoxing City, People's Republic of China (China).

The specific objectives of the SWITCH-Asia project include:
- Improved sustainable management, resource efficiency and adoption of circular economy principles by the local textile and fashion industry;
- Conditions enabled for a conducive policy environment among key stakeholders for circular textile industry in Huzhou and Shaoxing; and
- Increased access of textile and apparel industry to financing for eco-design, recycling investments and clean technology transfer.

This Benchmark Baseline Study is structured to provide a multi-dimensional analysis of the textile industry's current state and practices in EU and China, followed by an introduction of policy frameworks relating to circular economy in the EU and China. Thereafter practical applications and key insights for utilizing circular textile strategies are discussed and provide Chinese Micro-, Small and Medium sized Enterprises (MSMEs) with actionable steps. It also presents a circular transition suggested list and encourages readers to explore relevant chapters for detailed guidance on implementing circular economy principles throughout the textile industry life-cycle.

There are four chapters/stages in this Benchmark Baseline Study, according to the order of the textile life cycle:
1. Circular design and product development;
2. Sustainable production;
3. Responsible supply chain; and
4. End-of-life management.

In accordance with the principles of the circular economy, several key parameters are identified as evaluation parameters at each stage. An analysis of these parameters is essential to accurately reflect the current industry landscape and identify a roadmap for

future circular transition. This Benchmark Baseline Study outlines ten key parameters, which are examined across four stages: circular design and product development; sustainable production; responsible supply chain; and end-of-life management. However, given that these parameters span multiple stages and are interdependent, the following clarifications are necessary:

Figure 1 outlines the correlation between circular textile industry parameters and four stages of the life cycle. The impact of each parameter is represented by the intensity of the color; for instance, a term like 'chemical control and traceability' predominantly pertains to 'sustainable production', as they focus on raw material selection and chemical management across the manufacturing. However, this does not negate the relevance or importance of other stages. The choice of materials by product designers for textile garments is also important. As a result, the bar illustrates an extension of influence represented in a lighter shade. The objective of this diagram is to assist MSMEs in referencing the parameters following their specific circumstances, enabling them to identify pertinent regulations and policies in China and the EU. This facilitates targeted enhancement and circular transition in a focused manner.

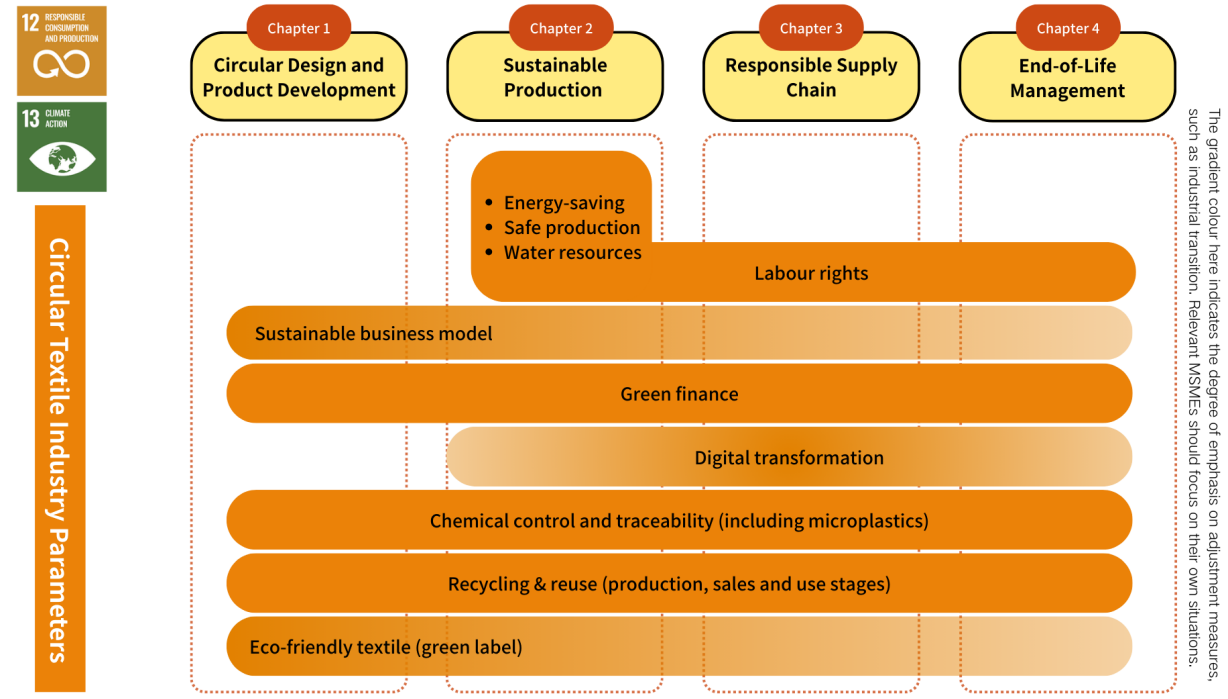


Figure 1 Circular Textile Industry Parameters in Four Stages

Actionable Steps

To serve as a basis for developing a future roadmap, this guide offers readers an actionable pathway from a MSMEs perspective and encourages them to consult the relevant chapters for detailed guidance on implementing circular economy principles throughout the textile industry life cycle. The guide's last chapter concludes with a suggested list for circular transition. To ensure its relevance and timeliness, MSMEs are strongly encouraged to participate actively. Based on the suggested list and actionable steps, invitation-only workshops will be organized in the subsequent phase of the project.

1. MSMEs conducting self-identification within the sustainable textile industry chain (circular design & business model, sustainable production, responsible supply chain management, recycling, and end-of-life management).

Objective: To assist in pinpointing relevant EU policies and regulations, and introducing circular transition tools to focus on key areas of concern.

2. Selecting sustainable textile indicators.

Objective: (1) To use the indicators to search for related policy matrix diagrams at the end of relevant chapters within the benchmark study, and then to look up pertinent European Union policies and regulations. (2) To select sustainable textile indicators based on the enterprise's near-future circular transition strategy. It is advised to choose one or two key indicators (not too many) for enterprise upgrading and transformation according to self-capacity. Attempts can be made by incorporating related technological commercialization, financial tools, and other means.

3. Actively participating in relevant industrial ecosystem communities and platform.

Objective: To facilitate exchanges with upstream and downstream industry partners, as well as domestic and international institutions and organizations, thereby mutually exploring pathways for the transition to a circular economy.

4. Continuously tracking related information and shared data.

Objective: To ensure that the enterprise remains up-to-date and informed.

Textile Industry in China and the EU: Environmental Impact and Market Dynamics

The textile industry has a significant environmental impact. The major processes of textile production, such as dyeing, printing, and finishing require a wide variety of chemicals (roughly 8,000 chemicals are used[1]) and a substantial amount of water (statistics as of 2024 show that it accounts for nearly 17%-20% of global consumption, ranking second behind agriculture[2]), resulting in the release of large volumes of chemical-laden wastewater. Additionally, processes such as spinning, weaving, dyeing and finishing consume substantial energy. If it is sourced from fossil fuels, it can emit a considerable amount of greenhouse gases (accounting for nearly 10% of global emissions annually[3]). Another critical aspect is that supply chains also generate a vast amount of greenhouse gas emissions due to transportation. Meanwhile, textile waste is another intractable issue to deal with, involving incineration, landfills, plastic pollution, etc.

In China, the 2023 annual greenhouse gas emissions of textile and apparel industry are about 230 million tons[4], accounting for about 2% of the country's total emissions. In the EU, the figure for 2020 is 121 million tons[5].

The annual water intake of the textile industry of China in 2022 was approximately 3 billion m3, ranking among the top four industrial industries, and wastewater discharge, chemical oxygen demand (CODCr), and ammonia nitrogen emissions ranked second in all industries[6]. In the EU, textile production, which includes cotton farming, consumes approximately 93 billion m3 of water annually, representing 4% of global freshwater withdrawal[7].

The textile industry has a significant environmental impact both in China and the EU, as they are two major economies and participants in the textile supply chain, they play important roles in driving environmental sustainability based on their market dynamics. In turn, the effectiveness of environmental protection efforts directly affects market development as well.

China is currently the largest manufacturer and exporter of textile goods globally. China's textile exports generate an annual revenue of $293.6 billion (Nearly €271 billion based on the annual average exchange rate in 2023), accounting for 8.7% of the country's Gross Domestic Product and providing employment for approximately 8 million people[8]. The EU is a major consumer of textiles, and has long been one of China's primary export destinations. According to official data released by the European Commission, as illustrated in Figure 2[9], the total value of textiles and clothing imported by EU countries from China far exceeds the amount exported from the EU to China. However, it's noteworthy that since 2021, the EU's textile imports from China have decreased by half, and by 2023, they had dropped to just €10 billion, which is only one-third of the 2020 level.

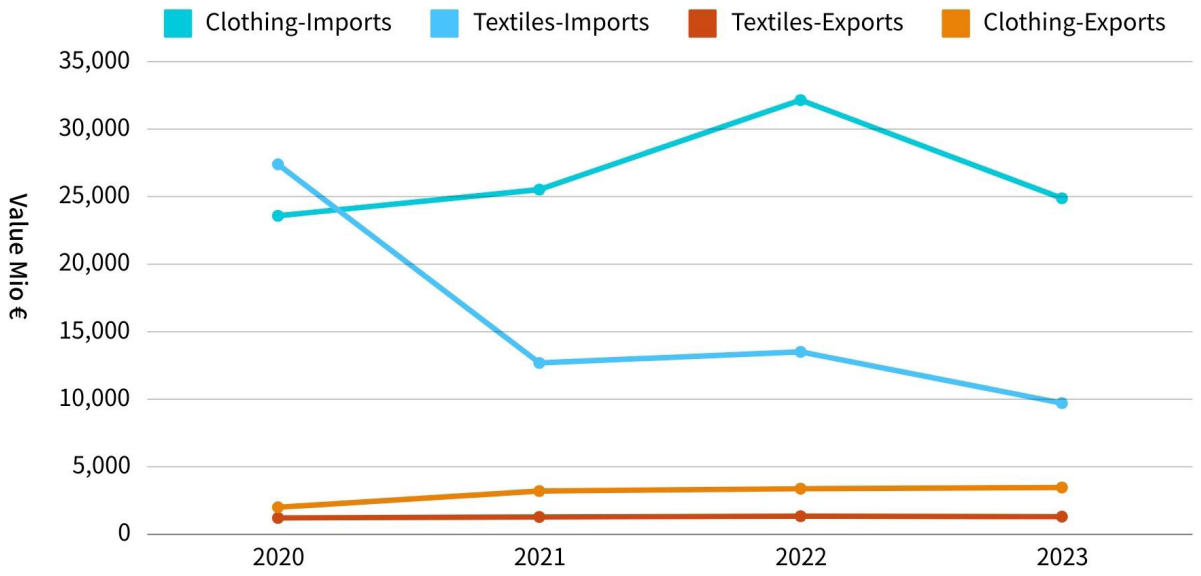


Figure 2 Trade Flows by SITC (Standard International Trade Classification) Product Grouping 2020 - 2023

Figure 3 Trade Flows by SITC Product Grouping 2023

% Growth: relative variation between current and previous period
% Total: share in total: total defined as all products
% Extra-EU: imports/exports as % of all EU partners i.e. excluding trade between EU member states

Figure 3 presents data on textile and clothing imports and exports between China and EU countries in 2023[10]. The term "% Extra-EU" refers to the total trade value between China and the EU, relative to the total trade value among EU countries. It is also evident that China's market share for textile products in the EU is significantly declining, while the trend of self-production and consumption within EU countries is rebounding.

This Benchmark Baseline Study will analyze the textile industry's current state both in China and the EU, followed by an introduction of EU's policy frameworks based on the current environmental protection needs and EU-China market dynamics.

Definition of Circular Economy in the EU and China

At the outset of this Benchmark Baseline Study, it is essential to establish a clear correlation between the concept of the circular economy and the comprehensive life cycle of goods. China's most recent interpretation of the circular economy, as articulated by the National Development and Reform Commission, underscores that 'a modern economic system must inherently prioritize efficient resource utilization and recycling'. Furthermore, it highlights that 'the typical characteristics of circular economy encompass the optimal utilization of materials, comprehensive utilization, recycling, and the capacity to achieve more with fewer resources'. These defining characteristics of a circular economy entail the ability to generate higher value-added and more sustainable products and services while concurrently reducing energy and resource consumption, and mitigating emissions. At its core, this concept seeks to enhance the efficiency of resource utilization[11].

In the EU, the European Parliament puts forward: 'an economic model based inter alia on sharing, leasing, reuse, repair, refurbishment, and recycling, in an (almost) closed loop, which aims to retain the highest utility and value of products, components and materials at all times'[12]. It follows that a circular economy inherently involves a closed-loop feedback system that encompasses 'resource use – product manufacture – commodity consumption – resource reuse', which pertains not only to the flow of material but also to the flow of value within economic products.

1. Circular Design and Green Consumption

Key Parameters

- Sustainable business model.
- Green finance.
- Chemical control and traceability.
- Recycling and reuse.
- Eco-friendly textile.

In addition to natural materials such as cotton, flax or silk etc., a large proportion of textile raw materials are synthetic fibers, because they are cheap, durable and can be mass-produced without restrictions on agricultural land (cotton), planting seasons, or breeding locations (silkworm). However, the production of synthetic fibers involves extensive emissions of chemicals and microplastics. Moreover, numerous chemical additives are also used in printing, dyeing, post-processing, and other stages. Without strict control measures, large-scale production can result in irreversible pollution of water sources, soil and ecosystems in general. Therefore, the circular design should be taken into consideration in the initial design stage.

In China, designers in the apparel industry possess a foundational understanding of sustainability in textile production. However, constraints imposed by prevailing business models, cost considerations, and the existing industrial structure have led to a noticeable lack of motivation to extensively apply these principles. This includes the impact of fast fashion on market and designers. It blindly pursues the rapid changes from consumer tastes and low price, leading to low profits, and explosive production. As a result, there is a high degree of competition for fashion trends, design and production speed, rather than environmental concerns.

The driving force behind design on the initial phase comes from market demand. For example, whether consumers are willing to pay for high-priced green-dyed clothes (the cost of green dyeing is generally higher), or still prefer cheaper products with questionable sustainability. In China, much work remains to increase public awareness of green consumption. The influence on public awareness of green consumption is largely attributed to the efforts of non-governmental organizations (NGOs) and industry associations. There is relatively minimal intervention from policies.

Due to the inertia of market demand and the reluctance of changing from merchants, environmental pollution issues are often overlooked at the beginning of the process, with compensation measures delayed until the end of the textile life cycle. For example, designers may opt for inexpensive but environmentally harmful clothing materials, which forces waste disposal companies to seek equipment that can purify the toxic gases released during incineration. However, making significant remedies at the last stage is

extremely challenging (which will be explained in the last chapter), and the responsibility should not be solely placed on the end-of-life cycle management.

China continues to seek practical solutions to these challenges. While the EU may not be the primary hub for comprehensive textile production, its deep understanding of the circular economy, as a major market, positions it as a pioneer in shaping the industry. This chapter explores the EU's Circular Economy Action Plan (CEAP)[13] and Extended Producer Responsibility (EPR), which corresponds to the green consumption and sustainable design principles based on efficient and safe use of chemical materials.

It should be noted that sustainable design in the textile industry spans the entire life cycle of the industry, ranging from initial product design, the business model design and the industrial production design to recycled products design. These design stages are interdependent. This chapter focuses primarily on the initial phase – the design of the product itself (including reused textile design) – and the accompanying business model design, which means that it addresses the design considerations that are critical before the product's first use.

1.1 The EU's Circular Economy Action Plan and Extended Producer Responsibility

The EU's CEAP includes specific measures and objectives related to textiles with the aim of promoting a more sustainable approach to textile production, consumption and waste management. The CEAP emphasizes the importance of promoting eco-design principles in the textile industry. This includes designing textiles and garments with durability, recyclability and resource efficiency in mind. Initiatives may involve promoting the use of sustainable materials, such as organic cotton, recycled fibers and bio-based alternatives, as well as reducing the environmental impact of textile production processes.

The CEAP encourages the implementation of EPR schemes for textiles[14]. EPR requires producers to take responsibility for the environmental impact of their products throughout their life cycle, including collection, recycling and disposal of textiles in the EU, in line with the EU strategy for sustainable and circular textiles[15]. This addresses the problem described at the beginning of this chapter, where the responsibility often falls to end-of-life recycling management due to initial product design and business models not considering sustainability factors.

EPR is an environmental policy approach aimed at compelling producers to expand their responsibility for their products into the post-consumer phase of the product life cycle[16]. On 5 July 2023, the European Commission issued a public letter proposing the introduction of a mandatory and standardized EPR scheme for textiles in all EU member states. This proposal aligns with the objectives outlined in the EU strategy for sustainable and circular textiles[17]. The primary goal of these initiatives is to generate economic advantages in the

realms of collection, sorting, reuse, preparation for reuse and recycling. Furthermore, these measures are intended to incentivize producers and brands to ensure that their products are designed in line with recycling principles. Subsequent phases will involve the implementation of an evaluation process and the allocation of a portion of the funds contributed by the EPR program towards preventive measures for textile waste and the enhancement of preparation for reuse practices. Common EU EPR rules will also make it easier for member states to implement the requirement to collect textiles separately, starting in 2025, in line with current legislation.

The Execution Status of EPR in EU Member States

- France, as the pioneer in introducing an EPR system for textiles, took a significant step in November 2022 by publishing a regulation that expanded the liability of producers for designated textiles, footwear and household textiles (TLC). This regulation targets not only producers but also operators engaged in the reuse, repurposing and repair of textile products. Additionally, the code is directed at individuals involved in the collection and sorting of textile products, as well as local authorities and their affiliated entities responsible for public waste management service[18].

- Italy, a significant player in the textile industry, took a noteworthy step on 2 February 2023. The Ministry of the Environment and Energy Security (MASE), in collaboration with the Italian Ministry of Enterprise and Manufacturing, announced the drafting of a decree outlining new responsibilities for producers within the textile sector[19].

- In Sweden, a significant move towards EPR for textiles was made in 2020. The government develop a national report aimed at reducing the volume of discarded textiles[20].

EPR in China

The implementation of EPR in China is in the early stages. In December 2016, the General Office of the State Council of the People's Republic of China issued a notice outlining the implementation program of the Extended Producer Responsibility System (EPRS). This Notice specified a range of key tasks, with a particular focus on addressing waste generated by packaging and electronic equipment products. The EPRS system, combined with China's earlier legislative acts, including the Circular Economy Promotion Law[21], the Cleaner Production Promotion Law[22] and the Solid Waste Pollution Prevention and Control Law[23], essentially laid the groundwork for the recovery and recycling of electrical and electronic waste products. Since then, there has been a notable surge in the volume of waste electrical and electronic equipment being handled in China. There is currently no EPR-related document in China for the textile sector.

Despite efforts, the implementation of the EPR in China has faced challenges, particularly regarding recycling responsibility and the lack of clarity regarding information disclosure obligations. To address these issues, China has proactively taken measures to leverage policy incentives to promote the development of recycling technologies and socially responsible enterprises. These initiatives aim to devise solutions tailored to the nation's production industry and value chain.

1.2 Practices in Textile Sustainable Design: EU and China

Clear Fashion

Clear Fashion[24], focuses on the evaluation of garments. It introduces products to consumers, scores various ecological impacts, and enables fashion brands to communicate the scores, thus bringing more transparency to the fashion industry. The aim is to help people know more about what is behind the clothes they buy.

Consumers have the power to shape the industry and help a sector evolve. They can guide the textile industry towards more sustainable production models.

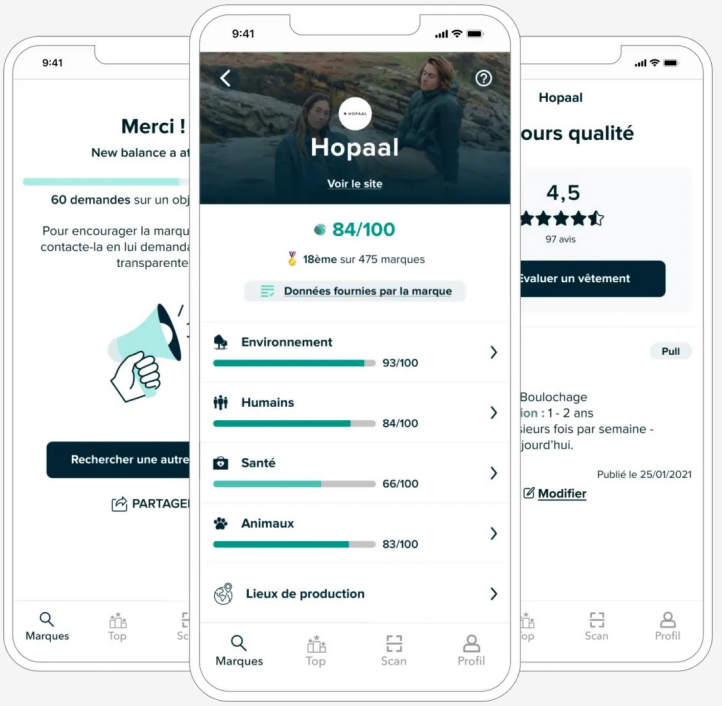


Image 1 Clear Fashion (from the official website)

The Fabric Sales

Fabric Sales[25] is a Belgian designer fabric outlet equipped with an online database for managing textile inventory, storage logistics, and both online and offline sales.

This store offers 10,000 fabrics and 5,000 accessories for young designers and emerging brands. These fabrics are sourced from high-end fashion brands such as Dries Van Noten, AF Vandervorst, Christian Wijnants, Raf Simons, Kris Van Assche, Filles A Papa, Celine, Rue Blanche, Ines De La Fressange, Lanvin, Essentiel, and others.

By managing and reselling the unsaleable fabric stocks of these high-end brands, the environmental impact is reduced and resources are better allocated.

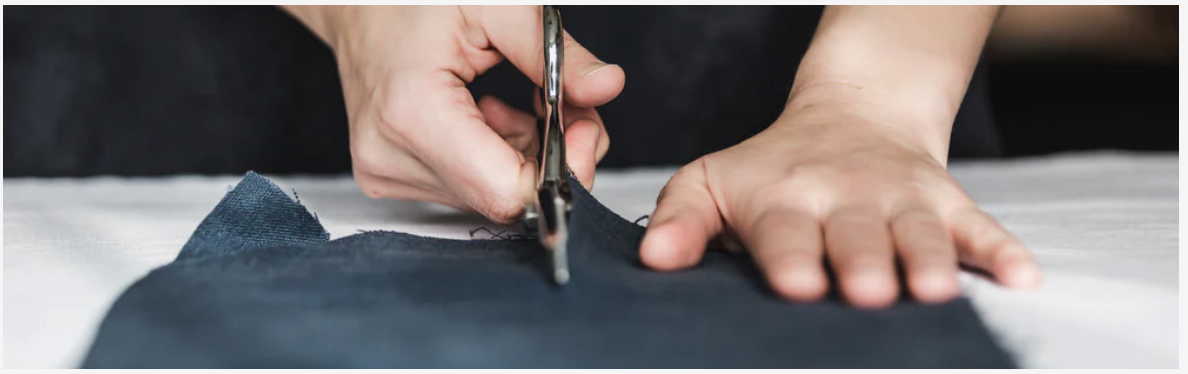


Image 2 The Fabric Sales (from the official website)

Zīle

Latvian fashion brand Zīle[26] uses the concept of upcycling by reselling second-hand clothing, especially jeans and men's shirts, with unique designs. The clothing is sourced from vintage shops or donated by their partner charity shop Otrā Elpa.

Image 3 Zīle (from the official website)

JNBY

JNBY[27] is a Chinese fashion company established in 1994. In 2020, JNBY created a sesame lab in search of innovative ways to reuse its inventory fabric. Unlike conventional practices in which fabrics are selected before design, JNBY's Sesame Lab operates in reverse. It prioritizes existing stock fabrics and designs to craft unique pieces based on the distinct characteristics of these fabrics. Through secondary design, the Sesame Lab transforms inventory fabric into lifestyle crafts, offering a fresh approach to sustainability and creativity in the fashion industry.

Furthermore, JNBY integrates the concept of inventory fabric reuse across all its brands. For instance, the sub brand Croquis[28] employs the 'single-cut' technique to maximize the use of a single piece of cloth. In the process of making T-shirts, the extra clothes are crafted into tote bags to achieve 100% zero waste. This innovative design not only meets consumers' demand for unique fashion but also positively influences the sustainable fashion industry. In October 2021, JNBY joined the 30–60 plan (an acceleration plan for climate innovation carbon neutrality of Chinese fashion brands).

It supports the China Green Carbon Sink Foundation Fashion Climate Innovation Special Fund, which promotes the industry's low-carbon transformation.

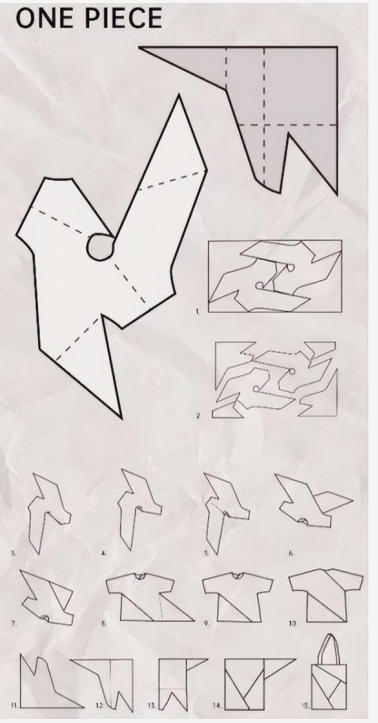


Image 4-1 JNBY (from the official website)

Image 4-2 JNBY (from the official website)

1.3 Summary

The textile industry, known for its high resource consumption and pollution, urgently needs strategic planning and redesign. Annually, 'fast- fashion' can generate 92 million tons of waste textiles from the 100 billion garments produced, which end up in landfills[29]; besides, there is an uncertain amount incinerated. The complex chemicals in these textiles can contaminate soil, and the toxic emissions from incineration pollute the air. Without prompt intervention, the earth's ecological resilience will be increasingly strained.

The prioritization of social and environmental sustainability with a circular economy lens is increasingly imperative. One of the important factors driving the direction of the economy is market demand and consumer choice. Therefore, promoting green consumption is a necessity.

While the EU market has demonstrated an earlier transition towards green consumption, bolstered by comprehensive policy frameworks, progress in China has been comparatively slower. This can be seen through the adoption of the EPR approach in the EU in the early 1990s[30], versus EPR in China in 2016. The implementation of EPR can effectively enforce the sustainable responsibility of industry participants while also subtly attracting consumers' attention. At first, both the EU and China basically targeted automobiles, batteries, and electronic products, and now the EPR in the EU is gradually expanding to the textile field. In China, due to specific characteristics of the textile industry—such as a large number of MSMEs as the major production and a focus on low-end product manufacturing—implementing EPR in this sector will take time. After all, performing EPR will increase the cost of MSMEs. Thus, there is a pressing need to intensify efforts to promote sustainable consumption, and make consumers willing to pay. To achieve this goal, various strategies can be employed, including advertising campaigns, initiatives by industry associations and NGOs, and foundational education programs.

Aligning with the new business models envisioned by the circular economy concept progressively enhances the entire ecological supply chain. During the effective green product design or sustainable business model development, designers can anticipate recycling and reuse challenges and address them early in the textile industry life cycle. This approach helps ease the challenges of the end-of-life management. The Chinese market currently faces challenges in implementing similar measures to those in the EU due to the different economic base and industrial attributes. Nevertheless, there are lessons to be gleaned from European successes, and exploring novel approaches tailored to China's unique market dynamics is paramount. This endeavor requires collective involvement from governments, manufacturers, retailers, consumers and broader societal institutions to drive meaningful progress towards a sustainable and circular economy.

2. Sustainable Production in Textiles

Key parameters

- Energy-saving.
- Water resources.
- Safe production.
- Labor right.
- Sustainable business model.
- Green finance.
- Digital transformation.
- Chemical control and traceability.
- Recycling and reuse.
- Eco-friendly textile.

In production, the textile industry has a profound environmental impact, primarily driven by its substantial consumption of water and energy and the emission of chemical pollutants and microplastic particles.

The 2023 annual greenhouse gas emissions of China's textile and apparel industry are about 230 million tons, accounting for about 2% of the country's total emissions. In 2020, the average textile consumption per person in the EU was 9 cubic meters of water, 400 square meters of land, and 391 kilograms of raw materials, and around 270 kilograms of carbon footprint[31]. Every year, between 200,000 to 500,000 tons of microplastics are discharged into the sea[32].

According to the European Environment Agency, of all consumption sectors in textile industry, the largest percentage – roughly 85% of these fundamental materials and 92% of the water – were consumed abroad[33], which highlights that the primary environmental impacts are concentrated in the countries where production occurs. This includes China, a major textile exporter. When compared with EU companies, Chinese small and medium-sized enterprises face greater pressure under the same strict EU regulations due to the lack of technical accumulation and sufficient information.

Due to the significant environmental impact of the textile industry, China and the EU, as key participants, are actively working to address the resulting ecological challenges. Their strategies vary because of the difference in resource categories, industry attributes and market characteristics. Therefore, this chapter primarily examines the current state of the industry in China and the EU, while highlighting relevant policies or regulations of the EU on imported products in the context of the circular economy.

2.1 Energy Management & Carbon Emissions

The Chinese textile industry, like most of other industries in China, heavily depend on fossil fuels for energy production, with coal being a predominant source. This reliance on coal is due to its widespread availability and cost-effectiveness, facilitated by China's abundant coal reserves. As a fossil energy source, it significantly contributes to carbon dioxide, creating substantial ecological pressure. In 2022, the textile industry in China consumed 72.68 million tons of standard coal, accounting for approximately 1.3% of the country's total energy consumption[34]. To balance cost considerations with the goal of Dual Carbon, China has implemented extensive upgrades to energy-saving equipment. For example, in February 2023, nine departments, including the National Development and Reform Commission, jointly issued 'guiding opinions on coordinating energy saving, carbon reduction, and recycling to accelerate the renewal and upgrading of products and equipment in key areas'[35], etc.

In contrast, the EU has made substantial strides in transitioning to a more sustainable energy mix. As of 2022, the source of Europe's industrial energy is composed of 40% renewable energy sources, 38.6% fossil fuels, and 20% nuclear power[36]. Textile production relies significantly on natural gas, which is known for its thermal efficiency compared to coal. Among the EU's industrial sectors, chemical and petrochemical reported the highest shares of final energy consumption in 2021 (2,159 petajoules [pj] or 21.5%), followed by nonmetallic minerals (1420 pj or 14.1%); paper, pulp and printing (1361 pj or 13.6%); food, beverages and tobacco (1168 pj or 11.6%); and iron and steel (1027 pj or 10.2%). At 1.3% (129 pj), the textile and leather industry had the lowest share of the overall final energy consumption[37].

However, Europe faces challenges, including dependence on natural gas imports. In 2022, the energy crisis had a severe impact on the entire European textile supply chain. For example, Botto Giuseppe e Figli Spa, an Italian textile company, experienced an eightfold increase in its electricity and gas bills compared to the previous year due to surging gas prices[38].

The latest EU policy related to industrial energy was announced in February 2023, and the EU's Green Deal Industrial Plan[39] will adopt a 'net-zero' industrial plan, which will establish Europe's leadership in the adoption of clean energy by 2030. The CBAM series, a strategy that imposes a carbon tax on imports of carbon-intensive products into the EU countries, is set to be implemented in 2026 as part of the European Green Deal. The mechanism aims to address 'carbon leakage', which happens when businesses relocate from the EU to non-EU countries with lower environmental standards to avoid the cost associated with the EU Emission Trading System (ETS), which means global emissions do not decrease overall and the competitiveness of the EU industry is impacted. To prevent carbon leakage, most carbon allowances are allocated for free. However, free allocation in the long term may contradict the 'polluter pays' principle and potentially hinder the EU's decarbonization efforts. The CBAM will make the EU ETS more effective and mitigate

carbon leakage, while encouraging third countries to reduce emissions. Currently, the textile industry is not covered by CBAM, but it is likely that this will change in the future.

2.2 Water Conservation and Waste Management in Textile Production

Textile production consumes large amounts of water and releases harmful chemicals and microplastics during the waste water discharge, significantly impacting the environment. This section will focus on these effects.

Water Conservation

Textile production entails significant water usage across multiple stages, starting from raw material production, spinning, weaving and the printing and dyeing processes.

The water consumption patterns of the textile industry are mainly influenced by factors such as the type of product, manufacturing processes, availability of water sources and capabilities in wastewater management. Water requirements can vary significantly across different textile products, with corresponding differences in the water quality supply. Certain product categories may not require fresh water, which can lead to a wide range of improvement measures. Furthermore, considering the textile industry's substantial demand for steam and heat exchange, there is potential for optimizing the creation of new units alongside energy management strategies. However, due to the diverse combinations of water intake and discharge, technical enhancements can lead to a more intricate layout of intake and discharge systems.

Just like the global scenario, in China, the textile sector is the major contributor to water consumption among other industries. According to China's national statistics, in 2020, the textile industry, specifically in yarn knitting and dyeing fabrics, had a unit water withdrawal of 95 cubic meters per ton of product[40]. In June 2022, six Chinese government departments, including the Ministry of Industry and Information Technology and the Ministry of Water Resources, jointly issued an action plan for improving industrial water efficiency[41]. The plan sets a target for the textile industry to reduce water usage per unit of major products by 15% by 2025. It outlines 12 specific tasks spanning six areas, emphasizing key technological research directions and the transformation and upgrading of various sub processes within the textile industry to enhance water efficiency.

Despite not having extensive production compared to China, textiles still rank fourth in terms of water usage in the EU. This is because, while the EU primarily relies on imports for its clothing consumption, it is also a significant manufacturer and exporter of home textiles, automotive seat covers, carpets, medical textiles and specialized technical textiles[42]. As a result, the EU region also attaches importance to water resources

management. Water Europe[43] was launched by the European Commission in 2004 as the European water technology platform. To address water-related challenges, this platform continues to focus on water efficiency, recycling management, collaboration with the industrial emissions directive and the promotion of research and innovation in new technologies. These challenges encompass concerns related to hazardous substances and microplastics in wastewater discharge.

Waste Management (Chemicals) in Textile Production

The substantial amount of drainage during production leads to a significant risk of contaminated sewage discharge. The complexity of the processes and extensive use of chemicals result in technical challenges for many factories, particularly in effectively filtering wastewater.

China's textile industry is characterized by its vast scale, comprehensive system and high proportion of SMEs, making it challenging to effectively track and manage emissions control measures within the sector. Various relevant national departments and local governments have attempted to address this issue through extensive data analysis and comprehensive strategies.

One notable initiative is the implementation program for the pollutant discharge control permit system[44], launched in 2016, which covers all enterprises involved in discharging pollutants. This program establishes a national information platform for managing discharge permits. In 2017, specific technical specifications were introduced for discharging permit applications, including a technical specification for discharging permit applications and technical specifications for the application and issuance of emission permits in the textile printing and dyeing industry (Standard ID: Hj 861-2017)[45] and technical specifications for the application and issuance of emission permits for the chemical fiber manufacturing industry (Standard ID: Hj 1102-2020)[46]. These technical specifications mandate that enterprises engaged in processes related to the Chinese production chain and processes must apply for emission permits, while others can choose to do so voluntarily. Over the years, these policies have incentivized numerous textile enterprises to explore technological upgrades and innovate management practices, resulting in noticeable improvements in environmental outcomes.

The EU's technical guidelines on resource consumption and emissions control primarily focus on specific process steps. For example, the textile industry's best available techniques reference file (text BREF), which was adopted by the EU under the Integrated Pollution Prevention and Control (IPPC) Directive on integrated pollution prevention and control[47], explicitly states that textile processes involve dyeing and surface treatments but not the production of fibers. Alongside specific technical guidance BREF, the EU has implemented the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) program, which was implemented in 2007[48], which signifies a significant regulatory framework for governing chemical usage. This crucial regulatory framework manages chemical use and controls hazardous substances throughout the supply chain.

Currently, Appendix XVII includes 59 categories covering over 1,000 substances, each subject to specific restrictions.

The EU has also introduced updated regulations for nearly 3,000 chemical plants and 300 textile factories in its member states to rigorously monitor and control their industrial emissions. For the textile industry, the new standards place special emphasis on regulating air and water emissions by targeting more than 20 air and water pollutants, including formaldehyde, total volatile organic compounds, dust and ammonia (air pollutants) and metals (water pollutants)[49].

For the Chinese textile export industry, compliance with REACH entails meticulous scrutiny and adherence to chemical safety standards to ensure that exported textiles meet the stringent regulatory requirements set forth by the EU.

Waste Management (Microplastics) in Textile Production

Finally, regarding the issue of microplastics, similar to the use of chemicals, the emission of microplastics is primarily due to the production of chemical fiber textiles, which generates debris and fibers. When wastewater discharge contains these particles, these microplastic particles can be directly introduced into the ocean, thereby exacerbating the issue of marine microplastic pollution.

China's 2021 circular on the issuance of the 14th five-year action plan on plastic pollution control, jointly issued by the National Development and Reform Commission and the Ministry of Ecology and Environment, specifies key objectives for addressing plastic pollution in the country. The plan encompasses several core tasks, including promoting the reduction of plastic production and usage at the source, accelerating standardized recycling and disposal of plastic waste and implementing regional initiatives to clean up plastic waste. However, specific provisions regarding the control of microplastics in the textile production process are currently limited within this plan.

In the EU, statistics reveal that approximately 8% of microplastics discharged into European waters originate from synthetic textiles, with global estimates ranging from 16% to 35%. This translates to an annual input of between 200,000 to 500,000 tons of textile-derived microplastics entering the global marine environment[50]. In 2019, the EU enacted a directive on the reduction of the environmental impact of certain plastic products. This directive imposes stringent controls on nine categories of single-use plastics, including disposable straws, cutlery and cotton swabs. In addition, the EU's CEAP identifies the textile value chain as a key priority due to its significant role in contributing to microplastic emissions, thus underscoring the importance of addressing this environmental challenge[51].

2.3 Ensuring Safety in Textile Production

Ensuring safety in textile production is paramount, given the inherent risks associated with the industry. This section outlines Standards and practices for maintaining a safe working environment and discusses regulatory requirements and effective safety management strategies.

The mass production of textiles encounters numerous challenges. Due to the pressure on profits and the inherent complexity of the process, factories often ignore labor conditions and production safety. For example, mechanical injuries, electrical accidents, fires and long-term health issues arising from exposure to noise and chemicals. However, over the past decades, advancements in the economy and technology, coupled with increased safety awareness among workers and improved management practices, have led to a significant decline in safety accidents within the industry.

In October 2021, the International Labor Organization issued its first code of conduct on safety and health in the textile, clothing, leather and footwear industries[52]. This code of conduct was designed to enhance safety and health conditions in these industries and is based on established international labor standards, sector-specific guidelines and related tools. This pertains to safety considerations in the production of textiles using natural raw materials as primary commodities.

It is also important to note that the sorting process for waste textiles can pose additional safety hazards, mainly due to the presence of pathogenic microorganisms in waste textiles. This is a significant contributing factor behind the domestic ban on the import of waste textiles from abroad. Dealing with the recycling of waste products is often perilous and characterized by a lack of organization, thus ensuring the safety of personnel remains a matter of concern.

The European Federation of Public Service Unions published a report in 2020, 'Health and Safety in the Circular Economy on Waste and Wastewater Management', which addressed the issue of staff safety in such environmental operations[53].

In August 2023, an action program for the construction of a modernized textile industrial system (2022–2035) was issued by the China Textile Industry Federation. This program emphasizes the promotion of a healthy and safe development environment within the printing and dyeing industry and aims to create a modernized textile industrial system that prioritizes integrity, advancement and safety.

Currently, one of the most significant hazards in the textile industry is fire safety because the presence of materials like cotton, wool and chemical fibers which are highly flammable. Additionally, some materials similar to cotton fabrics can easily become airborne, increasing the risk of fire. The textile production process also involves the use of coal and electricity, further elevating the potential for fire incidents, especially

in areas with poor airflow. To mitigate these risks, textile factories must adhere to strict fire-safety standards during their architectural design and construction. Additionally, they need to establish comprehensive fire safety management systems and regularly conduct fire safety training for their staff, including drills. In 2022, the state council's work safety committee issued a notice outlining the 14th five-year plan for national work safety, which underscores the importance of strengthening fire safety management in industrial parks.

2.4 Practices in Sustainable Textile Production: EU and China

Reet Aus

Addressing the issue of waste in the fashion industry, Reet Aus[54] has developed a new certification called UPMADE®, adhering to Reet Aus' production standards. This approach maximizes sustainability by utilizing pre-consumer leftovers for full production.

Reet Aus enables brands and manufacturers to implement industrial upcycling and achieve UPMADE® certification. In 2020, the brand collaborated with the European Commission Representation in Estonia, the Ministry of the Environment, Uuskasutuskeskus, Hoolekandeteenused AS, the Hea Hoog Foundation, and the Ministry of Prisons. This valuable project not only produces upcycled products but also creates a positive social impact.

Image 5 Reet Aus (from the official website)

Jeanologia

Jeanologia[55] is a Spanish company founded in 1994 that is committed to achieving complete dehydration and detoxification in the denim industry.

With Mission Zero[56], the company is transforming the way jeans are made from fabric to finish by minimizing the use of water and chemicals to a close-to-zero target, thanks to disruptive technologies that reduce water consumption in the finishing of garments from 100 liters to just 1 liter.

In addition, the Life Anhidra project[57], coordinated by Jeanologia, has received funding from the EU's LIFE (LIFE2027) Program under the Grant Agreement 101074372, plays a vital role in the Mission Zero challenge. Through the H2 Zero[58] water treatment system developed by Jeanologia, the aim is to reduce water consumption to just 1 liter. The project proposes an innovative, efficient and effective solution for the in-situ regeneration and reuse of water in the textile finishing process.

In partnership with AITEX, the project has developed an industrial-scale demonstrator at Portuguese textile finishing company Pizarro. The system is based on a pilot closed-loop water treatment system that leaves water in optimal condition for reuse in the garment finishing and washing processes without the need to use additional chemicals to treat the incoming water.

Image 6 Jeanologia (from the official website)

RegioGreenTex

RegioGreenTex[59] is a project initiated and led by the European Apparel and Textile Confederation (EURATEX). With 43 partners, EURATEX brings together industry, government, research institutions and the public, to foster R&D collaboration in the textile industry and establish a systematic circular economy business model within the EU.

As part of the European Green Deal, RegioGreenTex features five textile recycling center ecosystems located in northeastern Romania, northern Portugal, the Lowlands (Eastern Netherlands, Flanders, and Hauts-de-France), Italy (Tuscany and Piedmont), and southern France (Auvergne-Rhône-Alpes). These centers aim to support SMEs in scaling up, attracting investments, and creating effective value chains.

Image 7 RegioGreenTex (from the official website)

Huafu

Image 8-1 Huafu (from the official website)

Huafu[60], one of the world's largest manufacturers and suppliers of novel yarns, has achieved over 50% water savings and emissions reduction through its dye-before-spin process. Over the past 27 years, Huafu has sold over 1.8 million tons of colored yarn, saving more than 90 million tons of water—equivalent to the annual consumption of nearly 1 million households. The use of REGENTE™ recycled polyester plays a significant role in the management of plastic pollution.

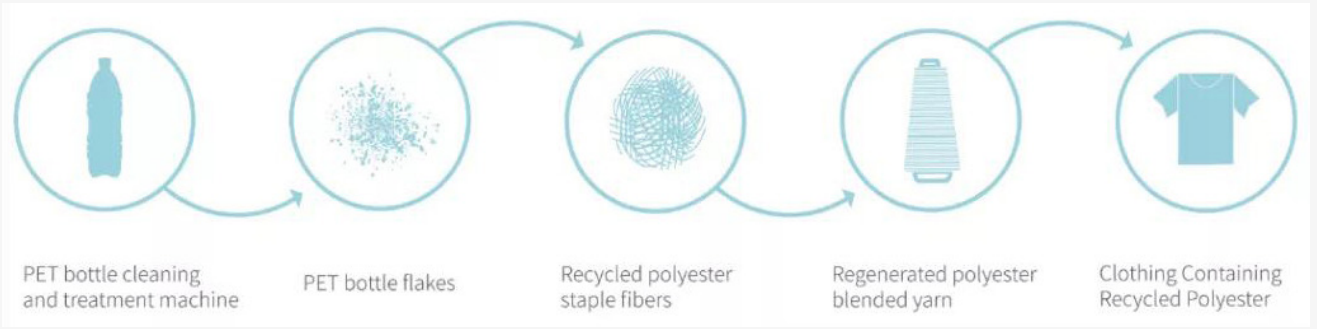


Image 8-2 Huafu (from the official website)

Huafu has invested significant funds and technology in sustainable manufacturing. In 2017, a Huafu subsidiary was awarded the Green Factory honor by the MIIT for the first time. Five products declared by Huafu, including 70% cotton and 30% viscose blended colored spun yarn, were successfully listed in the MIIT's fourth group of green products, making it the company with the most products selected in the colored spinning industry.

RUIMO

Ruimo[61] uses 100% post-consumer recycled food containers in the production of recycled polypropylene textiles, pioneering the breakthrough in high-ratio applications from injection molding to textiles. This innovation not only transforms discarded polypropylene food containers into high-quality recycled textiles but also serves as a latest example of combining technology and environmental protection.

To meet the high standards required by different processes for recycled materials and the everchanging market demands, Ruimo's R&D team has worked tirelessly to achieve equivalent replacements for traditional materials. They have successfully applied a high proportion of recycled materials in various polypropylene textile processes, such as filament yarn, staple fiber, FDY, ATY, POY, and DTY. This innovation meets the diverse needs of the market, with applications covering quick-dry clothing, upholstery fabrics, non-woven fabrics, and more.

Ruimo has introduced a digital carbon footprint platform, enabling full traceability of materials. Companies can monitor and manage the carbon footprint of recycled products in real-time, from raw material sourcing to final products, achieving full process transparency and traceability.

Image 9 Ruimo (provided by the company)

2.5 Summary

Image 10 Jaipur (credit to Terri Bleeker on Unsplash)

This chapter examined the factors influencing the circular economy in textile production and the current situation in EU-China policy, covering three aspects: energy usage and carbon emissions, water management and pollutant emissions during production, and safe production practices.

Apart from luxury products, in terms of the mass consumer textiles, the industry and market attributes of the EU and China are different. China, being a major producer, contrasts with EU countries that primarily rely on imports, leading to distinct policy priorities. In addition, the accumulated experience with the circular economy in these two regions also result in differing influences on the final policy formulation.

There is a significant difference in the energy structures of China and the EU. China relies heavily on fossil fuels and has abundant coal resources. Although it is actively developing renewable energy, the textile industry still produces substantial carbon emissions due to coal burning and electricity consumption. Consequently, China's policies focus on updating energy-saving equipment and reducing carbon emissions.

In contrast, the EU has a higher penetration rate of renewable energy, but the textile

industry primarily depends on natural gas. While natural gas is cleaner than coal, most of the natural gas in the EU is imported. The recent energy crisis has made natural gas or electricity prices unaffordable for many companies, particularly for small and medium-sized enterprises, prompting the government to seek alternative solutions and provide subsidies to sustain the industry.

Production is the most active stage of material exchange in the textile industry, involving raw material extraction from nature and pollutant discharge back into nature within the current linear economy. This is particularly important for water and chemicals (including microplastics). In the EU, textile-related associations strongly advocate for water conservation, and the government also promotes the development of water-saving technologies. However, attention to this issue is relatively lower compared to China, as the EU is not a major producer. The Chinese government provides more detailed guidance on water-saving, focusing on practical measures such as equipment upgrades to address the problem.

Regarding textile pollution management, the EU's sustainable and circular textile strategy emphasizes the importance of incorporating production information into textiles. The EU's Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) program, aims to enhance the protection of human health and the environment from potential hazards associated with chemical substances. For the textile export industry such as China, compliance with REACH entails meticulous scrutiny and adherence to chemical safety standards to ensure that exported textiles meet the stringent regulatory requirements set forth by the EU.

Finally, regarding production safety and measures for on-site operations such as fire prevention and chemical exposure, both the EU and China have comprehensive policies in place to ensure worker safety and reduce the occurrence of accidents.

3. Responsible Supply Chain in Textiles

Key parameters

- Labor right.
- Sustainable business model.
- Green finance.
- Digital transformation.
- Chemical control and traceability.
- Recycling and reuse.
- Eco-friendly textile.

The supply chain of the textile industry is highly globalized, with the production of a single product often traceable to multiple countries and regions before being distributed worldwide. Currently the South Asian and Asian regions centered around China, along with the EU and North America, constitute the three major hubs of the world's textile supply chain. Each of them has different role, based on their respective market attributes, natural resource, economic structure and national circumstances. The production of natural textile materials and synthetic fibers is primarily concentrated in the Asian region and the United States[62], while the processing and manufacturing stages are mainly focused in China, the South Asian and Asian regions and the EU[63]. (For details, please refer to Figure 4).

Developed countries continue to hold competitive advantages in core technology, and advanced equipment etc. In addition, as textile importing countries, they have established higher goals for the development of a sustainable textile industry. However, less developed regions face much challenging issues, such as shrinking profit margins, stricter scrutiny of export products due to green transformation, and a lack of technical capabilities, which contributes to bankrupt enterprises. Asia, the world's major producer, has seen pressure from low factory profits transferred to vulnerable workers, resulting in long working hours, low wages, a lack of fixed-term contracts, and accidents caused by poor working conditions.

China has transitioned from a phase of rapid economic growth to one focused on high-quality development. With robust implementation plans, the industrial structure and economic development model are being reshaped. This shift is evident in rising labor costs and enhanced safety regulations. However, most textile producers in China are still MSMEs, and profitability is still their main drive, rather than corporate social responsibility. To protect profit margins, product prices must be higher compared to other Asian countries, which directly leads to a decrease in orders. Consequently, China's textile MSMEs face a dilemma. They must contend with the fierce international competition, as well as stringent supply chain management and emission control both domestically and

internationally. At a crossroad, they strive to provide resilience across the textile industry in China amid these complex dynamics.

This chapter further examines the current state of supply chain management and relevant regulations in the textile industry in China and the EU, considering the issues previously discussed. It will discuss the complexities of supply chain, the significance of ethical practices, and the potential for innovation.

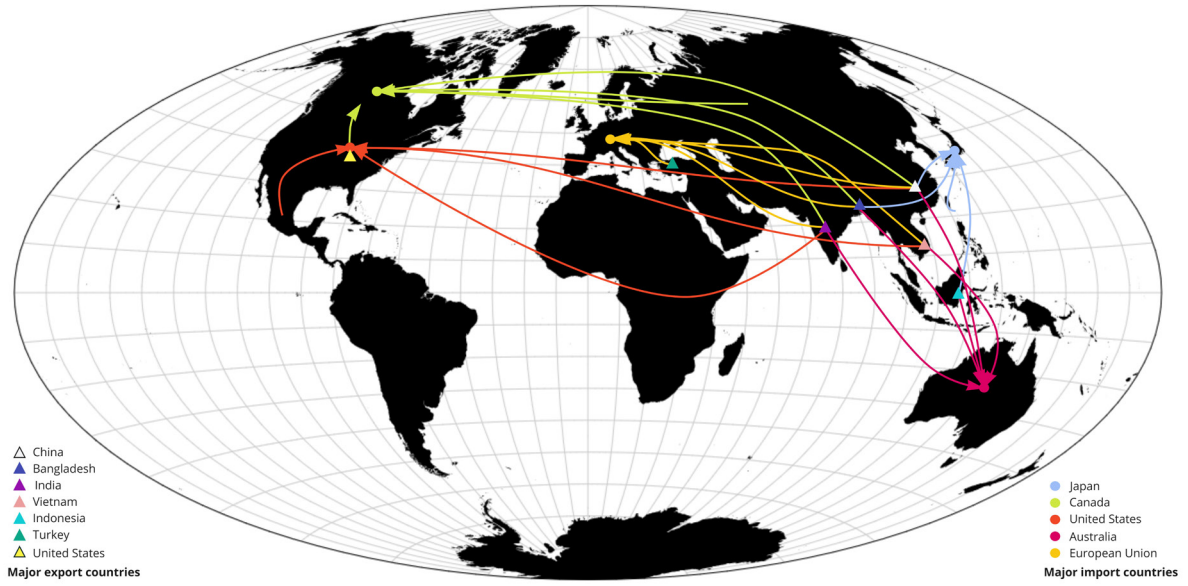


Figure 4 Global Supply Chain in Textile (Main Participants)

The data comes from the following articles or platforms:

1. World Integrated Trade Solution[64].
2. OEC[65].
3. Biggest Textile Exporter Countries Statistics[66].
4. Biggest Textile Importers Statistics[67].
5. Clothing Manufacturing and Exporting Countries of the World: A Review[68].
6. Facts & Key Figures 2022 of the European Textile and Clothing Industry[69].

3.1 Building a Green Supply Chain in the Textile Industry

At the core of the textile industry's entire supply chain are fiber, yarn, fabric and garment production, along with the recycling of discarded textiles generated during and post-consumption into a loop. But the current textile supply chain is predominantly linear, as less than 1% of textile waste returns to main chain at the end of its life cycle.

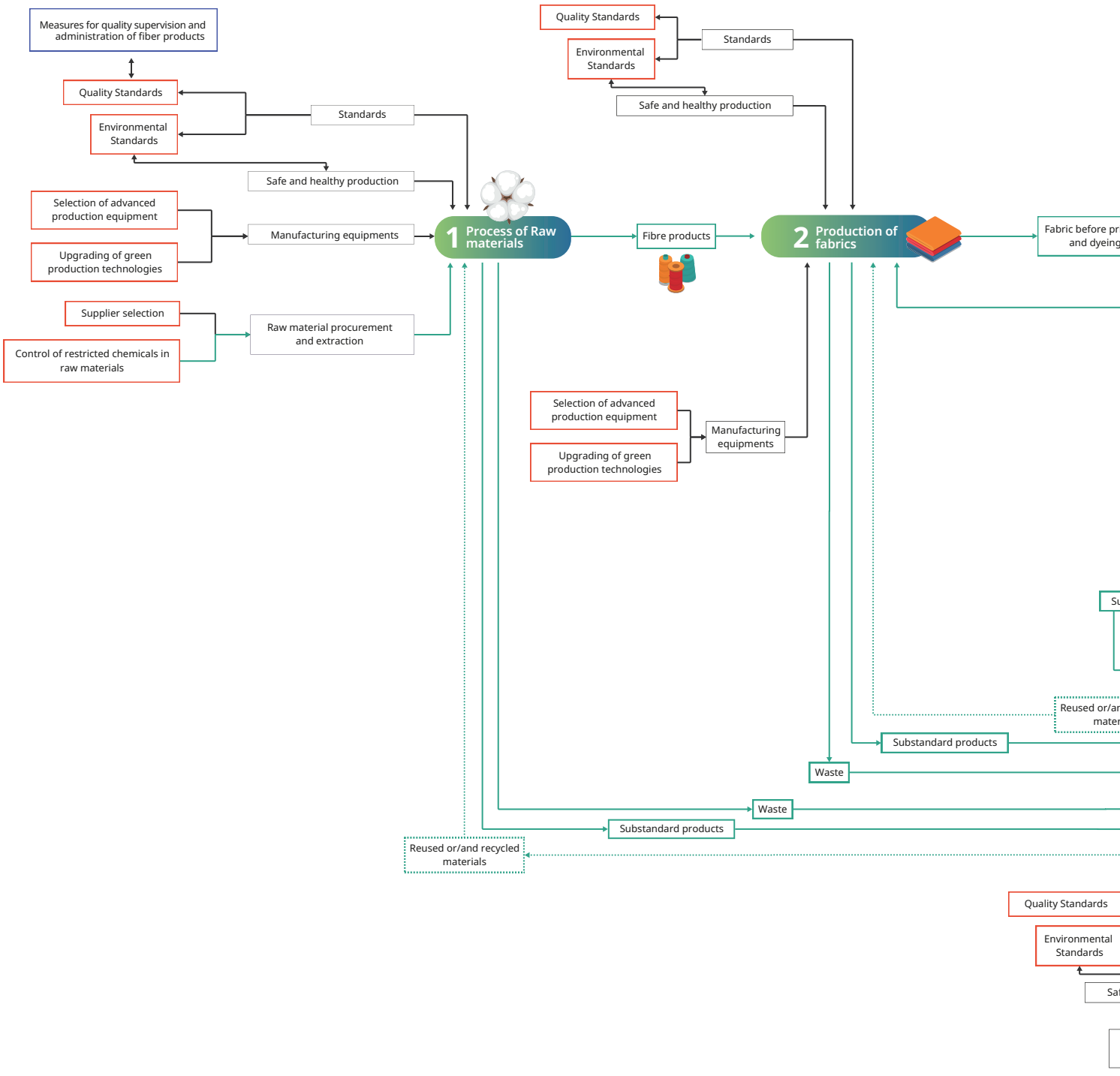
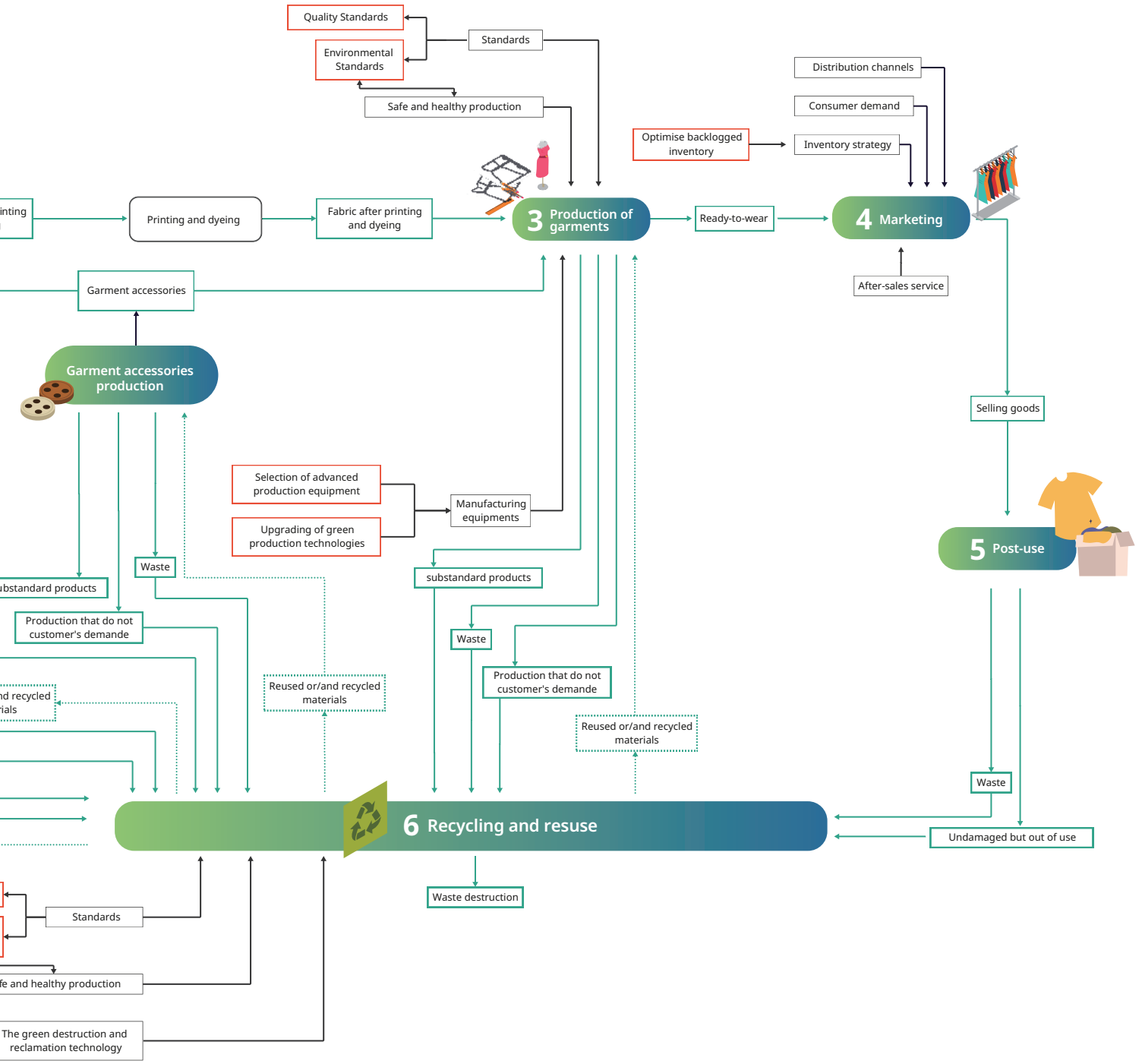


Figure 5 Supply Chain of the Whole Textile Industry


Quality Standards
Environmental Standards
Standards
Safe and healthy production
Distribution channels
Consumer demand
Optimise backlogged inventory
Inventory strategy
inting
Printing and dyeing
Fabric after printing and dyeing
3 Production of garments
Ready-to-wear
4 Marketing
After-sales service
Garment accessories
Garment accessories production
Selling goods
Selection of advanced production equipment
Upgrading of green production technologies
Manufacturing equipments
5 Post-use
Waste
substandard products
Production that do not customer's demande
Waste
Production that do not customer's demande
Reused or/and recycled materials
Reused or/and recycled materials
Waste
6 Recycling and resuse
Undamaged but out of use
Waste destruction
Standards
fe and healthy production
The green destruction and reclamation technology

Taking enterprises as the boundary, they can be divided into the internal supply chain and the external supply chain. Internal supply chain, as the name suggests, is the management within the enterprise, and this is broken down into three categories based on the nature of the enterprise: procurement, production and sales. The external supply chain is relatively more complex, involving different upstream and downstream linkages in the industry, including raw material producers (such as fiber/chemical/fabric producers), garment manufacturers (most of which also have design functions), sellers/clothing brands. With the current industrial structure, the model has been adjusted. For example, some large-scale apparel companies began to consider the storage and sales of subcontracting management as the rapid spread of the market.

This marks a turning point. Seizing the opportunity presented by the model adjustment and prioritizing sustainability will not only enhance the overall efficiency of the supply chain but will also optimize the operational mechanism of the textile sector, marking a qualitative leap towards replacing resource-intensive processes and methods. In the era of rapid information technology development, leveraging digitalization to efficiently integrate the logistics, information flow and capital flow for reasonable control and analysis can effectively transform the existing supply chain into a more circular value-added chain.

3.1.1 Supply Chain Management in Textiles (Resource Management)

Logistics management in the textile sector is embodied in four components: (1) the supply of raw materials; (2) the selection of producers; (3) storage and distribution; and (4) recycling and disposal. Logistics management initially focuses on documenting the distribution of the flow from natural resources to the stage of economic products and, finally, to commodities. Responsible supply chain management, as an indispensable part of the circular economy, which extends to the recycling and processing stage. Additionally, with the advancement of research and the increasing focus on environmental issues, many scholars have refined and enriched the concept of a responsible supply chain. This has made it more structured and has integrated energy saving, low carbon practices, water conservation, and sewage management into the entire production and logistics management process. As a result, supply chain management has been enriched into resource management.

The previous chapter focused on how to improve the green competitiveness of products through process upgrading and responsibility constraints from the point of view of independent production links. In fact, if each link is connected in series and parallel, all of the resources involved in production can be more intuitively understood in terms of resource utilization and pollutant emissions through input and output.

Based on this principle, material flow analysis (MFA) and material flow cost accounting (MFCA) methods gradually appeared in western countries in the early days, and MFCA later gained importance and was put into practice in Japan. Later, as an important analytical tool for the circular economy, MFCA was published as a specification in 2011 (EN ISO 14051:2011)[70] by the International Organization for Standardization (ISO), which

serves most European enterprises, especially for the control of product costs and strategic decision-making.

China has fewer applications at the moment, but these could be further promoted at a later stage. In 2023, the China National Institute of Standardization (CNIS), one of the implementation partners in this SWITCH-Asia project, took the textile and garment MSMEs in Zhuji city as the object of study, targeting 39 cotton textile enterprises and 32 chemical fiber textile enterprises, to gain a deeper understanding of the manufacturing process system, and introduce MFCA into the process. They carried out a material and value chain analysis of the resource metabolism process in the enterprises. The relevant data in this analysis will be cited later.

REACH Regulation & Digital Product Passports (DPPs)

The control of chemicals and the release of hazardous substances in the supply chain management process is also a very serious issue, as the industry requires a large amount of printing and dyeing, which causes water pollution and leads to air pollution caused by the combustion of boiler coal, thus bringing serious harm to the environment. In 1976, the EU adopted a 'restriction of the distribution and use of certain hazardous substances and preparations by member states' directive[71], which will be included in the priority control scope of 132 chemical substances. Later, after many revisions, the REACH regulation was issued in 2007. Currently, there are a total of 59 categories in Appendix XVII, involving more than 1,000 kinds of substances. These hazardous substances are subject to specific restrictions and are therefore not allowed in specific products to avoid unnecessary testing.

As part of the eco-design for the regulation of sustainable products, the European Commission will most likely introduce digital product passports (DPPs)[72] that contain information about the specific product. For example, DPPs will include information about the product's supply chain, materials used, how to take care of the product and how to prolong the life cycle through reparation, recycling and access to product-related services. With that, the EU's new strategy for sustainable and circular textiles will further promote the reshoring or near-shoring of the textile supply chain going forward to a sustainable and circular textile industry in the EU[73].

In China, currently there are no regulation or tool similar to REACH and DPPs. The control of chemicals in the textile production process is primarily guided by various standards, such as GB 18401-2010, the National Technical Code for the Basic Safety of Textile Products[74], which sets forth basic technical requirements for the addition of various dyes, auxiliaries and other finishing agents in the process of printing, dyeing and finishing textile products. And another relevant standard is GBT 39498-2020 the Guidelines for the Control of the Use of Key Chemical Substances in Consumer Products[75]. Unlike regulations, these standards do not require the registration, evaluation, authorization, and notification of chemical substances but instead directly stipulate the prohibition and restriction of their use.

In addition, in March 2016, the China Chemical Fiber Industry Association launched a green fiber certification initiative based on the Technical Requirements for Green Fiber Evaluation (T/CCFA 02007-2019) standard. The first phase of certified products includes solvent-based cellulose fibers, marine bio-based fibers, bio-based synthetic fibers and other bio-based chemical fibers; recycled polyethylene terephthalate (PET) fibers; and colored fibers spun using the dope-dyed method. Obtaining green fiber certification is considered a prestigious accomplishment in the textile industry due to its stringent requirements and high recognition. According to relevant data, as of 2024, only 40 fiber enterprises had achieved certification.

3.1.2 Supply Chain Digitization and Industrial Integration to Improve Response Speed

The initial goal of the supply chain creation is the desire to coordinate resources inside and outside the enterprise to optimize the value of the entire industry. Information exchange is a reasonable match of upstream and downstream supply and demand. The first step in encouraging companies to adopt a responsible supply chain is to address the issues from the company's perspective. Capital, as the basis of value exchange, is the driving force that companies gain in the operation of the entire supply chain. It is a dynamic system that continuously changes according to market demand. Blindly taking a series of expensive measures, such as strictly controlling energy conservation and emission reduction without considering the survival status of enterprises, will inevitably backfire.

The Chinese government and relevant stakeholders aim to assist industrial clusters in integrating their supply chains and emission control. The purpose of integrating the supply chain is to improve the response speed of information flow, logistics and capital flow; reduce inventory backlogs; and improve enterprise financial turnover. For example, in September 2023, China's Ministry of Commerce and eight other units issued a notice on carrying out the declaration of national supply chain innovation and application demonstration cities and demonstration enterprises for the year 2023, to strengthen the upstream and downstream cooperation of the industry chain, maintain the resilience and stability of the supply system and strengthen the exchange and cooperation of the global textile and garment industry chain supply chain[76].

In the EU, the relevant digital incentive policy is mainly the Digital Product Passports (DPPs) mentioned above, which contains specific product information. The goal of the DPP is to increase transparency throughout the entire supply chain lifecycle, aligning with the circular textile strategy.

The differing goals for supply chain digitalization between two regions are influenced by the distinct characteristics of the textile markets. China prioritizes export competitiveness while also focusing on environmental protection. In contrast, Europe places its top priority on a sustainable and high-quality economy.

3.2 Human Rights in the Textile Supply Chain

In the global textile supply chain, labor rights present another significant social challenge alongside environmental conservation. Asia, a major production and export hub, has been reported to experience child labor, discrimination, forced labor, safety issues, and unfair wages. One of the underlying reasons is that factories in this region operate with very low profits, causing them to shift the pressure onto vulnerable groups. The global textile supply chain is intricate and lengthy, with the most complex and resource-intensive processes concentrated in developing countries. Conflicts of interest and disparities in capabilities between large and small enterprises make it difficult to protect the rights of the latter, and consequently, the rights of workers.

In December 2023, the EU Council and the European Parliament reached a provisional agreement on the Corporate Sustainability Due Diligence Directive (CSDDD). This directive aims to enhance the protection of the environment and human rights both within the EU and globally. It will impose obligations on large companies to address actual and potential adverse impacts on the environment and human rights within their business chains, encompassing their upstream business partners as well as certain downstream activities such as distribution and recycling[77].

However, the directive failed to get the support of a majority of member states in February 2024[78]. In the following months, after several rounds of negotiations, the directive was finally approved in May 2024[79]. It is a competition between environmental protection and business interests. Although the directive got the final approval, the directive's scope was loosened, with the number of employees increasing from 500 to 1,000 employees and the turnover requirement expanding from €150 million to more than €450 million.

The adjustments to the directive highlight the complexities of globalization. In the textile industry, for instance, each major company relies on multiple suppliers, who in turn have smaller subcontractors. The refinement of responsibilities requires all companies to thoroughly understand human rights, environmental protection, and labor standards of their suppliers and subcontractors. This burden will ultimately impact both MSMEs and policymakers in Asian countries. As these enterprises operate under diverse national policies and regulations, it demands not only stronger self-regulation from MSMEs but also policy support from governments. If the directive is not properly implemented, it could lead European companies withdrawing from these countries. In addition, since over half of their upstream suppliers are still in the early phases of transitioning to a circular economy, this could disrupt the global supply chain, potentially causing industrial shocks and impeding European industrial development.

As noted at the beginning of this chapter, China has transitioned from high-speed economic growth to a focus on high-quality development. While labor rights and the textile production environment have seen significant improvements, this has resulted in increased labor and other costs. China's textile industry is still dominated by MSMEs.

These companies must navigate intense international competition while simultaneously managing stringent supply chain regulations and carbon emission controls both domestically and abroad.

China has not yet implemented a responsible supply chain directive similar to those in the EU. Instead, the country has established various laws to safeguard human rights. Such as the Constitution, Criminal Law, and General Principles of Civil Law, for fundamental human rights, the Occupational Safety Law, the Law on the Prevention and Control of Occupational Diseases, the Work Injury Insurance Regulations, and the Labor Law for further protection for workers' safety and health. The Law on Regional Ethnic Autonomy for all ethnic groups' equal rights and the Law on the Protection of Women's Rights.

In addition, China keeps demonstrating a proactive stance in engaging with global initiatives for responsible supply chains. It has participated in numerous EU cooperation projects, including the 2017-2021 initiative focused on responsible supply chains in Asia, developed by the EU, the Organization for Economic Cooperation and Development (OECD), and the International Labor Organization (ILO)[80]. This project targeted China's major industries—electronics and textiles—and used the OECD's Guidelines for Multinational Enterprises[81] and the ILO's Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy[82] to support the implementation in China. The China Enterprise Confederation (CEC) and the All-China Federation of Trade Unions (ACFTU) have collaborated to address labor issues within the supply chain.

However, China will soon have to contend with the Corporate Sustainability Due Diligence Directive (CSDDD) issued by the European Union, presenting an unprecedented challenge.

3.3 Practices in Responsible Supply Chain: EU and China

Mingled Hope-fear of Fast Fashion

Fast fashion is driven by both consumers and manufacturers, with the desires of each side often overlooking the climate and social issues. Brands like Shein, H&M and Zara, and Primark are prominent players in this sector. These brands frequently face pressures from consumers and environmentalists. While they celebrate high sales volumes, they also grapple with increasing stress to address environmental concerns. This presents both a chance and a lesson for all involved. This is a battle between capital and humanity.

The following examples illustrate the sustainable measures from fast fashion from China and EU:

SHEIN *In July 2024, SHEIN launches €200 Million Circularity Fund in the UK and the EU and commits to investing €50 million in broader ESG efforts*[83].

SHEIN will invest in initiatives to empower British and European brands, designers, and artisans to grow their businesses online and beyond.

The flagship Circularity Fund will invest in start-ups and other businesses across the UK and EU engaged in advancing circularity solutions.

H&M *In Jun 19 2024, Fashion company H&M Group is partnering with Rondo Energy, the leading provider of zero-carbon industrial heat and power, to explore the potential for heat storage technologies in its supply chain*[84].

Main Goals on Zara's website[85]:

2025 / 100% linen and polyester from preferent sources;

2025 / 25% reduction of water consumption in our supply chain;

2025 / Reaching three million people in our supply chain with our Workers in the Center strategy;

2030 / Protecting, restoring, regenerating or otherwise improving biodiversity across 5 million hectares;

2030 / Reducing our emissions by over 50% (including the design and manufacture of our products, their distribution and their end-of-life management);

2030 / Using only textile raw materials that deliver a lower impact on the environment, so-called preferred fibers; and

2040 / Achieving zero net emissions by reducing our carbon footprint by at least 90% by comparison with 2018.

Primark, the international fashion retailer, is partnering with the Circular Textiles Foundation (CTF), to deliver an advanced training program for its Design and Product teams. The new training will cover advanced circular design principles, with recyclability at its center, which supports Primark's commitment to make more of its clothes recyclable by design by 2027[86].

Mango has joined forces with Materra, a British-Indian company which specializes in designing solutions for growing and sourcing future-proof cotton, including regenerative cotton, in order to move towards a fashion industry that is more respectful to the environment and people[87].

MUD Jeans

MUD Jeans[88] is focused on adopting a circular production model. Customers can rent or buy MUD jeans and then return them to be recycled into new denim products. Then they can get a discount on the purchase of new jeans. Non-MUD jeans are also accepted, the only condition being that the jeans must contain at least 96% cotton. MUD also offers a free repair service.

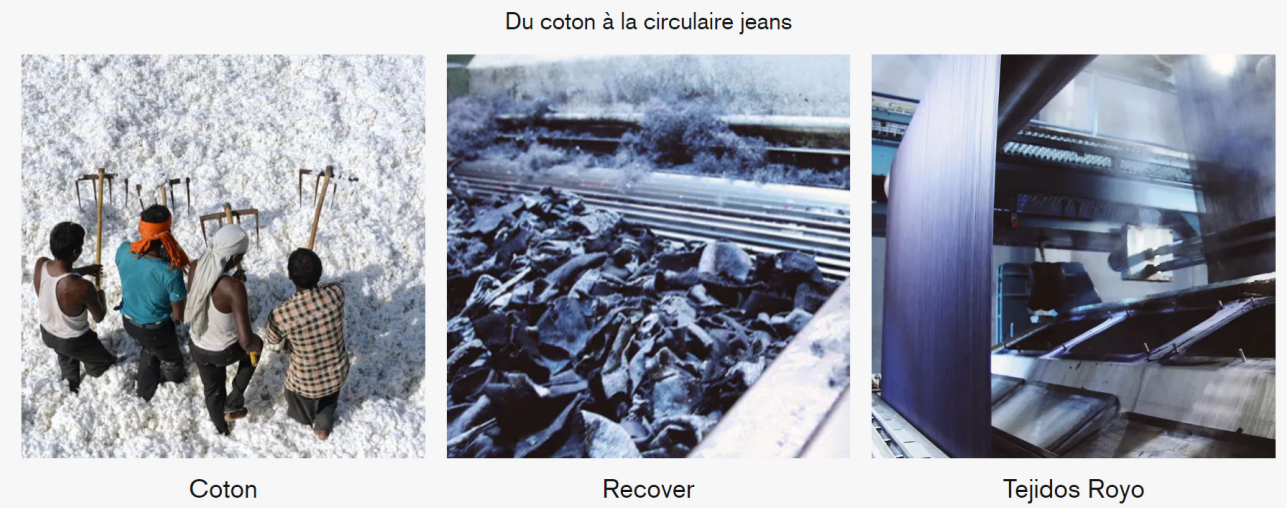


Image 11 MUD Jean (from the official website)

When old (MUD) jeans are sent back to the firm, a small quality check is carried out: if they are still in good condition, they are given a second life through MUD's vintage program. If they are irreparably worn out or from another brand, jeans are mechanically recycled at MUD's recycle factory (recover@). Fibers then go to MUD's fabric manufacturer and then are mixed with organic GOTS certified cotton and yarn is spun from it. The yarns are dyed and woven into fabrics. The resulting fabrics contain between 23-40% post-consumer recycled cotton fibers. Finally, the fabrics go to MUD's jeans manufacturer, where they are cut, sewn into jeans and washed.

Quid Project

Quid[89] is a prominent social organization in Italy dedicated to providing employment opportunities for disadvantaged groups, particularly women. With 133 employees, 67% of whom have faced marginalization at work and 83% of whom are women, Quid has created over 213 jobs since 2013.

The organization collaborates with 50 Italian textile producers, companies, and brands, sourcing raw materials from the Italian fashion and textile industry. They use surplus and discontinued fabrics to develop their own fashion brands. Additionally, Quid serves as an ethical supplier for for-profit companies such as Calzedonia Group, NaturaSì, and L'Oréal, producing co-branded accessories and capsule collections. To date, Quid has extended the life cycle of more than 1,170 fabrics.

Image 12 Progetto Quid (from the official website)

A Series of Supply Chain Tools Emerging in China

As previously noted, China has implemented several measures to encourage textile digitalization, driven by the dual pressures of green industry transformation and international competitiveness. Therefore, a variety of comprehensive supply chain tools have been developed. Here are three platforms with distinct characteristics:

Global Textiles (EN)[90]

GlobalTextiles
Global Professional Textile Market

Global Textile belongs to Shaoxing Keqiao Textile City. It combines functions of information and online fabric trading. Established in October 1988, Shaoxing Keqiao Textile City is the largest textile wholesale market in Asia, renowned for its high turnover and diverse range of products. It attracts customers from over 80 countries, spanning 17 textile fields including raw materials, fabrics, home textiles, and clothing.

The Global Textile Network stands out for its extensive coverage. It employs information experts in major Chinese textile markets to deliver the latest market conditions and industry insights. Additionally, it provides up-to-date procurement information from major domestic and international buyers. This platform is ideal for garment factories seeking fabric partners.

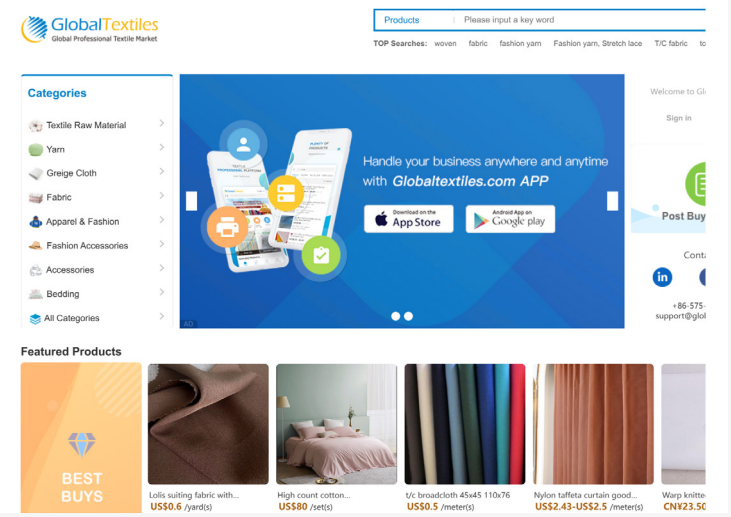


Image 13 Global Textiles (from the official website)

Yunsha[91]

云纱网

Yunsha.com is a cloud management platform also focusing on textile. Yunsha.com emphasizes building an industry mutual-trust system, digitizing the entire lifecycle, and enhancing cost reduction and efficiency across all processes. It offers a range of technological products and solutions, including big data analysis, intelligent order matching, Internet of Things solutions, and artificial intelligence software, as well as blockchain-supervised warehouse outputs for the upstream and downstream of the industrial chain.

Yunsha also establish strategic cooperation with financial institutions such as Ping An Bank, China Construction Bank, Qingyuan Rural Commercial Bank, and Qingyuan Industrial and Commercial Bank to jointly solve the "pain points" such as low level of industry digitalization and funding bottlenecks, and drive efficient operation of the industry.

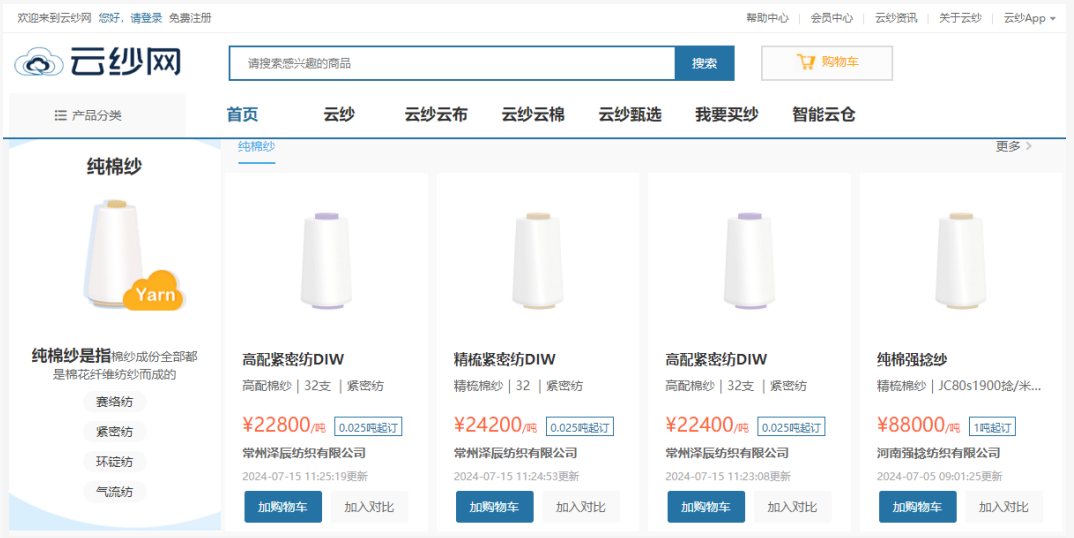


Image 14 Yunsha (from the official website)

Cotton Union[92]

棉联 UnionCotton
纺织数字化供应链服务平台

Cotton Union is also a digital supply chain service platform. While its functions are similar to the previous two platforms, it uniquely focuses on cotton trading. It provides comprehensive e-commerce services for the entire cotton industry chain, combining fast logistics and warehousing services with small-batch factory delivery as its core.

3.4 Summary

When examining the textile industry as a whole, it becomes apparent that various subjects of interest, functional divisions of labor and mechanisms exist across different regions. Upstream and midstream enterprises in the textile industry have the potential to bring value-added effects to downstream users through process improvements in production or by directly reducing material treatment processes at the end of the recycling process. However, if these upstream and midstream enterprises lack awareness of the circular economy concept and prioritize profits, it can pose significant obstacles in the later stages of the supply chain.

Nevertheless, the complexity of the supply chain extends beyond simple positive and negative relationships. Even if upstream and midstream enterprises implement measures to reduce pollutant emissions, strictly control raw materials and invest in advanced environmental management facilities, the resulting high costs may need to be passed on to downstream users. This could lead to a loss of competitiveness, especially in markets where awareness of sustainable consumption is lacking. The industrial supply chain, with its economic attributes, is inherently a complex system, and a simplistic adjustment of any one parameter may not offer a solution but could instead potentially destabilize the entire system.

In this context, both the EU and China are developing tailored solutions and incentive policies. The EU continues to focus on the core principles of the circular economy. For chemical management within the supply chain, the REACH regulations address nearly a thousand substances and establish a comprehensive framework for the registration, evaluation, authorization, and notification of chemicals, effectively controlling harmful substances. Furthermore, the future implementation of Digital Product Passports (DPPs) will include crucial product information to enhance lifecycle management.

In contrast, China prioritizes the resilience of its textile industry, which is largely composed of small and medium-sized enterprises. Given the complexities of international market competition and environmental concerns, China aims to boost the efficiency of information flow, logistics, and capital through digital integration of the supply chain. This approach seeks to reduce inventory backlogs and improve overall enterprise turnover.

Finally, both China and the EU are deeply examining labor rights within responsible supply chains. The ongoing tension between environmental protection and business interests in the global textile industry highlights the need for close collaboration rather than competition. The implementation of the EU Supply Chain Act is expected to significantly impact Chinese textile companies. According to the directive, European firms must assess themselves and their upstream partners, and as a major source of EU imports, Chinese companies must develop comprehensive management systems that adhere to environmental and human rights standards. Otherwise, it could result in substantial fines or the exclusion from EU public procurement opportunities. Therefore, enhancing cooperation with EU companies, understanding EU market needs and standards, improving compliance management systems, and maintaining competitiveness are essential, despite rising costs.

4. End-of-Life Management (Regeneration of Waste Textiles)

Key parameters

- Labor right.
- Sustainable business model.
- Green finance.
- Digital transformation.
- Chemical control and traceability.
- Recycling and reuse.
- Eco-friendly textile.

In the EU, for every 7 to 7.5 million tons of textile waste (predominantly from consumer sources), only 30% to 35% are collected separately, and is only for specific fibers and mixed products, with the majority of unsorted waste textiles being exported outside of the EU[93].

According to official reports from China, of the approximately 22 million tons of textile waste generated in the country in 2020, only about 20% was subjected to recycling efforts. In that same year, China just produced a total of 1.5 million tons of recycled fiber[94].

Textile waste arises not only after consumption but also during the production process. According to the research in 2023 by the CNIS, one of the implementation partners in this SWITCH-Asia project, on the resource metabolism process value chain of textile and garment MSMEs in Shaoxing city, most manufacturers generate a high proportion of waste during the production process. The material cost loss of cotton textile enterprises accounts for 95% of the total loss. Similarly, chemical fiber textile enterprises incur a material cost loss that represents 99% of the total loss.

These statistics highlight the considerable room for improvement in textile waste recycling in China.

This chapter offers an overview of the current state of end-of-life management in the textile industry. While one of the core principles of a circular economy is to establish a closed-loop model through effective end-of-life management, the entire life cycle stages are closely interconnected.

Therefore, some of the content in the last chapter ties back to earlier chapters, such as circular design and green consumption and the introduction of the extended producer responsibility system in Chapter 1. Thoughtful consideration of resource use and

recycling management during the early design stages can greatly ease challenges during later phases. Additionally, raising green awareness and encouraging active consumer participation can enhance end-of-life management as well.

Chapter 3 discussed resource management in responsible supply chains, including REACH regulations and digital product passports. These tools also greatly improve the management of recycling and reuse in the textile industry.

This chapter will only focus on the classification and quality control of textile waste regeneration.

4.1 Classification and Quality Control in Textile Waste Recycling

Sources of Waste Textiles

In terms of defining and categorizing textile waste, the relevant national standards in China currently cover various materials originating from different sources. This includes waste textiles, scrap textiles, old textiles and reprocessed fibers etc. Most of them come from second-hand or outdated clothing generated in the post-consumer segment as well as waste generated during production processes.

It's important to note that in China some of the waste previously came from imported textiles. However, as of 2021, China has fully banned the import of foreign solid waste. This ban encompasses 14 categories of waste textile and products, old clothing, recycled cotton fibers and synthetic fiber waste[95]. China has implemented stringent screening processes for used textiles and introduced measures to reduce waste generation, thereby promoting more efficient and optimized management of textiles at the end of their life cycle.

In terms of China's implementation measures for the entry of solid waste materials, the EU also places significant emphasis on the export of textile waste, as outlined in Section 4.2 of the EU strategy for sustainable and circular textiles[96]. To prevent textile waste from being falsely labelled as second-hand goods when exported from the EU, thereby bypassing the waste framework, the European Commission, under the mandate outlined in the proposal, contemplates the development of specific EU-level criteria to distinguish between waste and certain second-hand textiles. This regulatory approach aims to ensure transparency and accountability.

In addition, many countries in the EU have implemented their own waste management regulations. For example, France enacted the Anti-Waste and Circular Economy Act in 2020, featuring over 130 provisions aimed at reducing waste in various forms. This legislation

promotes strategies for product reuse, recycling and recovery, all intended to transition from a linear economic model to a circular one, thereby enhancing sustainability and resource efficiency[97].

Classification and Quality Control in Textile Waste Recycling

Due to the intricate nature of textile materials, often with unclear original processing methods, the subsequent classification and inspection processes pose a challenge in terms of clearly defining the separation of components. Presently, textile waste is typically categorized into seven groups based on the primary component, which constitutes more than 50% of the material. This highlights the complexity of the post-processing procedures. Importantly, the existing standards do not comprehensively cover all stages of the textile production cycle, and significant improvements may take time.

Quality control of textile waste presents a significant challenge that is currently being addressed. In China, from national standards to local standards and enterprise-specific standards, technical requirements and management guidelines are being developed to enhance the quality control of waste textiles throughout the classification and recycling processes. These include standards such as GBT 39781-2021 on 'technical specification for the recycling of waste textiles'[98] and GB/T 39026-2020 on 'recycled polyester (PET) fiber identification methods'[99], etc.

Concerning technical regulations on recycling, there are relatively few European standards. Instead, the EU places a primary emphasis on quality control of textiles produced from virgin materials, often adhering to ISO standards, or, through fiber naming and labelling regulations. For example, the REACH regulation applies to all products containing chemical substances in the EU market, which includes textile manufacturers and importers, and the REACH audit process typically involves the submission of an analytical report on the properties of the relevant substance[100]. This approach allows for early-stage materials control during production, which helps prevent complications with recycled products due to complex chemicals mixtures.

EU textile eco-labelling is not mandatory but rather voluntary, aligning with the sustainable labelling standards. Certification audits by international agencies predominantly focus on compliance with sustainability criteria and generally exclude chemical and quality testing.

In China, eco-labels are also gaining ground, with some involving collaboration with quality and technical standards bodies. For instance, the Société Générale de Surveillance's (SGS) green mark[101] for recycled content verification is currently implemented in China, illustrating the global reach of such initiatives. This standard is a certification standard introduced by the SGS, a joint venture established in 1991 between the SGS group of Switzerland and the China National Standards and Technology Development Corporation, which is a subsidiary of the former state Administration of Quality and Technical Supervision.

4.2 Practices in End-of-Life Management (Regeneration of Waste Textiles): EU and China

RECIMAP Project

The RECIMAP project[102], led by Bespoke Factory Group[103] and implemented by AIMPLAS[104], the University of Valencia[105], and Consorcio Valencia Interior V3[106], focuses on addressing the challenges of recycling cotton-polyester blends.

These blended cotton and polyester fabrics are difficult to separate and recycle using traditional methods, often resulting in incineration or landfilling, which contributes to soil and groundwater pollution. The project aims to selectively separate these blends through the use of ionic liquids.

The proposed solution involves recycling the polyester component using mechanochemical technology to produce recycled polyester, while the cotton component is converted into lactic acid via a fermentation process.

Image 15 RECIMAP (from the official website)

RECIMAP was initiated in anticipation of a rise in textile waste and in response to European regulations on Extended Producer Responsibility (EPR), emphasizing the need for effective waste management solutions.

The research project is funded by the Valencian Community government through the Valencian Innovation Agency (AVI)[107], with co-financing from the European Union's ERDF Valencian Community Program 2021-2027[108] within the call for Strategic Projects in Cooperation 2022.

SIPTex

SIPTex[109] is the world's first large-scale facility of sorting textiles by color and fiber composition using near-infrared light and visual spectroscopy to handle large flows and produce textile fractions suited to different recycling processes.

Siptex processes three types of textile materials: industrial textiles, pre-sorted textiles, and residual textiles from consumers and industry. The facility is designed to deliver a variety of standardized, quality-assured recycled products with consistent fiber composition and colors, suitable for various recycling processes. These products include cotton, wool, polyester, viscose, polyamide, acrylic, and custom options based on customer specifications.

The Siptex facility has a processing capacity of 4.5 tons per hour, or 24,000 tons per year, and is equipped with three NIR/VIS machines and a 260-meter-long conveyor belt.

Siptex is funded by Vinnova[110], the Swedish innovation agency.

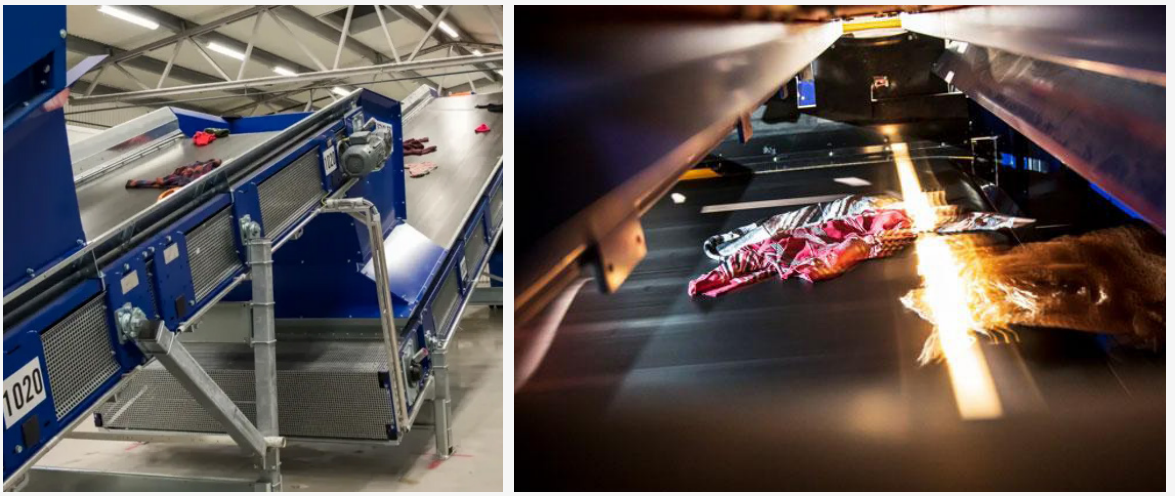


Image 16 SIPTex (from the official website)

A Breakthrough about Separation and High-Value Utilization of Waste Polyester-Cotton Blended Fabrics

The project 'Separation and High-Value Utilization of Waste Polyester-Cotton Blended Fabrics'[111], collaboratively undertaken by Taiyuan University of Technology[112] and Anhui Tianzhu Textile Technology Group[113], primarily focuses on enhancing the recycling technology for waste textiles.

Every year, a significant amount of waste textiles is generated. With landfilling and incineration being the main disposal methods due to the low rate of comprehensive recycling, which significantly contributes to environmental pollution.

Image 17 Project 'Separation and High-Value Utilization of Waste Polyester-Cotton Blended Fabrics' (from the official website)

The reason for this low recycling rate is primarily due to the diversity of textile fibers, making the separation of blended fibers a key challenge. For example, polyester-cotton blended fabrics are among the most common and widely used textiles, composed of cellulose and polyester, which have distinct properties that are difficult to separate. This project focus on the efficient separation of cotton and polyester fibers, enabling their high-value utilization.

Based on the technology, Taiyuan University of Technology has developed microcrystalline cellulose, pure polyester fabrics, and flame-retardant polyester fiber products, which have been successfully promoted, applied, and tested in the market by Anhui Tianzhu Textile Technology Group.

Chemically Regenerated DMT (Dimethyl Terephthalate)

Chemically regenerated DMT (dimethyl terephthalate)[114] *is a unique polyester chemical recycling system developed by Zhejiang Jiaren New Materials*[115]*. This process uses waste textiles, garment factory scraps, and similar materials as the initial raw inputs. The entire procedure involves recycling, sorting, and shredding, followed by a chemical decomposition technology that breaks down waste polyester into small molecules. These molecules are then processed through distillation, filtration, purification, and polymerization to create new polyester fibers.*

Image 18 Project 'Chemically Regenerated DMT (Dimethyl Terephthalate)' (from the official website)

Starting from July 2023, regenerated materials produced through this method were exported globally. The company has the capacity to process 40,000 tons of waste textiles annually, resulting in the production of 30,000 tons of recycled products.

Additionally, Jiaren New Materials is actively involved in building a 'textile recycling system.' Through collaboration with various companies, institutions, recycling agencies, and public welfare organizations to recycle old factory and school uniforms.

4.3 Summary

This chapter primarily focused on the classification and quality control of textile waste regeneration. Topics such as recycling design, green consumption, and recycling-related supply chain were discussed in the previous chapters and were not expanded upon here.

Regarding the source of waste, both China and the EU currently emphasize the strict control of domestic waste generation, with a focus on managing second-hand or obsolete clothing produced at the post-consumer stage, as well as waste generated during production. In addition, China has completely banned the import of solid waste, while Europe continues to export textile waste but has implemented strict regulatory systems.

China and the EU take different approaches to waste classification and quality control. China focuses on the recycling stages, while the EU emphasizes upstream measures.

China's current policies and regulations are aimed directly at improving textile waste classification and recycling, enhancing technical standards, and developing a sustainable recycling model. The EU, on the other hand, places less emphasis on technical specifications for waste classification and quality control. Instead, it shifts the responsibility for managing textile materials and pollutants to the early stages of production through policy and regulatory tools like Extended Producer Responsibility or Digital Product Passports. This approach encourages designers and manufacturers to use chemical raw materials more cautiously. The benefit is that recycling becomes easier, but establishing a well-functioning ecosystem requires significant time for market penetration and stakeholder acceptance. This approach is valuable for China to learn from, but it should be adapted to fit the country's specific conditions and industrial landscape.

5. Conclusion

The development of the textile industry within circular economy principles in China and the EU demonstrates similar trends, albeit with different policy orientations driven by distinct market characteristics and objectives. In China, where the textile sector is predominantly comprised of MSMEs, the focus lies not only on the domestic market but also heavily on exports. Given the challenging international market environment, China's leading policies prioritize enhancing the competitiveness of export enterprises. Conversely, EU countries, which are major importers of non-luxury textile products, tend to adopt a selective approach towards imported products, particularly in the context of escalating climate and environmental concerns.

Sustainable Design and Green Consumption

The fast fashion industry, which dominates the market, produces vast quantities of clothing annually, leading to significant textile waste that is often landfilled or incinerated, causing severe environmental pollution. This underscores the importance of sustainable design and green consumption as critical tools for advancing sustainable development and the circular economy.

The EU has been a frontrunner in promoting green consumption and sustainability concepts, with the successful implementation of policies such as the Extended Producer Responsibility (EPR) system, signaling positive market acceptance.

China has also begun exploring EPR system, albeit with slower progress, as the promotion of green consumption is just gradually extending from major cities. Much of the pressure to adopt these practices comes from international markets. Although China faces challenges in implementing measures similar to those in the EU, it can learn from European experiences to develop strategies tailored to the Chinese market. This requires joint efforts from the government, industry, and consumers.

Sustainable Production

Environmental pollution and safety issues in textile production are highly complex, and the differences in market, industry, and economic structures between China and the EU have led to distinct policy approaches.

Energy Use and Carbon Emissions

China's textile production mainly relies on fossil fuels, particularly coal, due to its abundant coal reserves, resulting in high carbon emissions. China is actively developing clean energy alternatives with policies focused on upgrading energy-efficient equipment to reduce carbon emissions. In addition, China encourages energy companies to enhance R&D and accelerate the adoption of clean energy. In the EU, the textile industry is more dependent on natural gas, but recent energy crises and rising costs have forced governments and businesses to seek alternative renewable energy sources.

Water Management and Pollutant Emissions

Since the EU primarily depends on imported textiles, the policies and regulations related to water conservation in the production process are not as comprehensive as those in China, the main producer. China has implemented more specific guidance and measures for water resource management, including equipment upgrades to address water shortages.

However, regarding the pollutant emissions, the EU has explored this more in-depth than China. For instance, the REACH regulation is employed to enhance the oversight of chemicals. Although China does not have a similar regulation at present, it is still with pressure arising from the scrutiny of textiles exported to Europe.

Textile production also contributes to microplastic emissions, which are acknowledged in relevant documents in both China and the EU. However, due to the complex interactions between ingredients, fibers, and related additives during production, identifying a clear solution for decomposition remains challenging, and as a result, no specific measures have been introduced.

Responsible Supply Chains

The textile industry operates within a global supply chain, where upstream and midstream enterprises can add value for downstream factories and consumers through sustainable management practices. For instance, upstream designers who thoroughly consider the recyclability of textile materials can significantly ease the challenges of downstream clothing recycling. However, these initiatives also tend to increase costs, which may be transferred to downstream users, potentially weakening the competitiveness of upstream companies, particularly in markets with low awareness of sustainable consumption. This dynamic also explains why developing countries, positioned as upstream and midstream players, adopt distinct strategies for their domestic markets and international export markets.

Resource Supply Chain Management:

Resource management in supply chains primarily involves the traceability of raw materials and chemicals. Tools like the REACH regulation and the proposed Digital Product Passport (DPP) in the EU are intended to enhance product lifecycle management, reflecting the EU's current focus.

Supply Chain Digitalization:

Compared with the EU's focus on resource traceability, China prioritizes measures that can improve the resilience of the textile industry. As a major exporter, China has to face increasing international competition and export barriers as well as rising material and management costs. To address these challenges, China is urgently pursuing supply chain digitalization to improve efficiency, reduce inventory backlogs, and increase corporate revenue, thereby enhancing its own strength. These measures also effectively mitigate resource waste. In addition, China is actively developing domestic green product labels that align with international standards.

Labor Rights and International Cooperation

Both China and the EU are increasingly focusing on labor rights within responsible supply chains. The EU's recent supply chain law requires European companies to evaluate their own operations and those of their upstream supply chain partners, which will have a significant impact on Chinese textile enterprises. Chinese companies must meet environmental and human rights standards otherwise they will face the risk of penalties or market restrictions. Therefore, it is crucial for Chinese companies to strengthen cooperation with EU firms, improve compliance management systems, and maintain competitiveness.

End-of-Life Textile Management

Waste Sources

Controlling the generation of textile waste is a top priority for both China and the EU, particularly in managing second-hand, discarded clothing and production waste. China has banned the import of solid waste, while Europe continues to export textile waste under strict regulations.

Waste Classification and Quality Control during the Recycling

China mainly focuses on measures related to the recycling stage, such as waste classification, technical standards for the quality of recycled materials, and sustainable recycling models. In contrast, the EU emphasizes measures in upstream stage, using

tools such as the Extended Producer Responsibility (EPR) program and the Digital Product Passport (DPP) to shift management responsibilities to earlier stages of production. This approach encourages more prudent use of chemical materials thereby facilitates easier recycling, but the full application of this approach requires time to penetrate the market and gain stakeholder acceptance. China can partially adopt this method, adapting it to its own industrial characteristics.

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