

The background of the cover features a blurred image of several clear plastic bottles, likely PET or HDPE, arranged in a row. The scene is illuminated by warm, golden-yellow string lights, creating a bokeh effect. The overall aesthetic is clean and modern, with a focus on the materials being discussed in the report.

# **PET and HDPE Packaging in China's Household Chemicals and Food Sectors: Material Flow and Recycling Prospect (Condensed Edition)**

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## Imprint

“Waste to Resource: Upgrading the Value Chain of Packaging Waste Through Improving Collection and Recycling in China” project is commissioned by the German Federal Ministry of Economic Cooperation and Development (BMZ) developPPP.de Programme, is implemented by GIZ in cooperation with Henkel AG & Co KGaA, Tetra Pak (Kunshan) Co., Ltd., Tomra System ASA, UPM Raflatac Oy, and Nongfu Spring Co., Ltd. The project aims to increase the recycling rate of packaging waste in China by promoting an advanced waste segregation and collection system and to upgrade the value chain of packaging waste (plastic and carton) by exploring different recycling approaches.



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Waste to Resource: Upgrading the Value Chain of Packaging Waste Through Improving Collection and Recycling in China

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100600, No. 14, Lingmahe South Road, Chaoyang District, Beijing

Tayuan Diplomatic Office Building 2-5

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Office of Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH in China

Address: 1100, Sunflower Tower, No. 37 Maizidian Street, Chaoyang District, Beijing, China

Postcode: 100125

Tel.: +86 10 8725 5180

E-mail: [giz-china@giz.de](mailto:giz-china@giz.de)

Website: [www.giz.de/china](http://www.giz.de/china)

Waste to Resource: Upgrading the Value Chain of Packaging Waste Through Improving Collection and Recycling in China

Address: Tayuan Diplomatic Office Building 2-5, No. 14, Liangmahe South Road, Chaoyang District, Beijing, China

Postcode: 100600

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## preface

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China's economic takeoff comes with an extensive use and discarding of packaging materials, especially plastics. Data show that more than 30% of China's plastic products are used for packaging, and packaging waste alone accounts for at least one-third of the municipal waste produced daily. Against this backdrop, the project "Waste to Resource: Upgrading the Value Chain of Packaging Waste Through Improving Collection and Recycling in China" ("Waste to Resource Project") aims to increase the recycling rate of packaging waste in China by promoting an advanced waste segregation and collection system and to upgrade the value chain of packaging waste (plastic and carton) by exploring different recycling approaches.

**PET** (polyethylene terephthalate) and **HDPE** (high-density polyethylene) are the two widely used **rigid packaging** materials in the **household chemicals and food** sectors and a primary type of packaging waste. The recycling of PET and HDPE packaging—and the high value-added re-cycling instead of down-cycling in particular—is attracting industry attention and is the focal point of the Waste to Resource Project. This Report, a collaborative effort between the Project team and industry associations and experts, is designed to present a full picture of the generation, recycling of PET and HDPE packaging wastes in China's household chemicals and food sectors, analyze their collection and recycling prospects, and offer recommendations on how to enhance the recycling value chain.





## Material Flow Analysis

In this report, “**rigid packaging in the household chemicals and food sectors**” (“target sectors”) refers to the **bottles and drums** for personal care products (e.g., shampoo, shower gel, laundry detergent, and liquid hand soap), beverages (e.g., water and soft

drinks), dairy products, cooking oil, condiments (e.g., soy sauce and vinegar), chewing gums, and similar products. It does not include the packaging for medical/pharmaceutical products and health care products.

### ■ Packaging Production and Packaging Waste Generation



- The raw material for PET packaging in the target sectors is **bottle-grade PET flakes**, representing approximately 14% of the total supply of PET raw materials in China.
- In 2022, the domestic consumption of PET flakes was 6.94 million tonnes, down 0.6% year-on-year (YoY) but up 18% from 2019. Almost all were sourced domestically, and most were used in the target sectors.
- In terms of the consumption structure, 71% of the PET flakes were made into packaging of drinks, in particular 42% for bottled water and followed by 29% for beverage (packaging bottles). The sheet packaging sector (e.g., fruit and vegetable containers, egg box and beverage cups) accounts for 14%; cooking oil and condiments 11%; and household chemicals a relatively small share at less than 2%.
- In 2022, the target sectors generated 5.10 million tonnes of end-of-life PET bottles, same as in 2021.



- The raw material for HDPE packaging in the target sectors is **HDPE granules for small hollow blow-molded container** (no larger than 50 L), usually marked as 5502, 6200, 5831D, and 5621D, accounting for around 22% of the total virgin HDPE production in China.
- In 2022, China consumed 3.50 million tonnes of such HDPE; 34% were imported. Consumption in the target sectors was around 2.00 million tonnes, down 9% from 2021 and 7% from 2019. This drop was due to the pandemic, reduced export orders, and a high stock of finished or semi-finished products such as bottles and drums.
- From the perspective of consumption structure, most of such HDPE was used in the packaging of personal care products and chemical products (e.g., automotive lubricant bottles and urea drums), each representing 25% of the consumption mix. Packaging for dairy products and beverages, and that for condiments, accounts for 17% and 15%, respectively. The remainder was used in the packaging of pharmaceutical products and health care products.

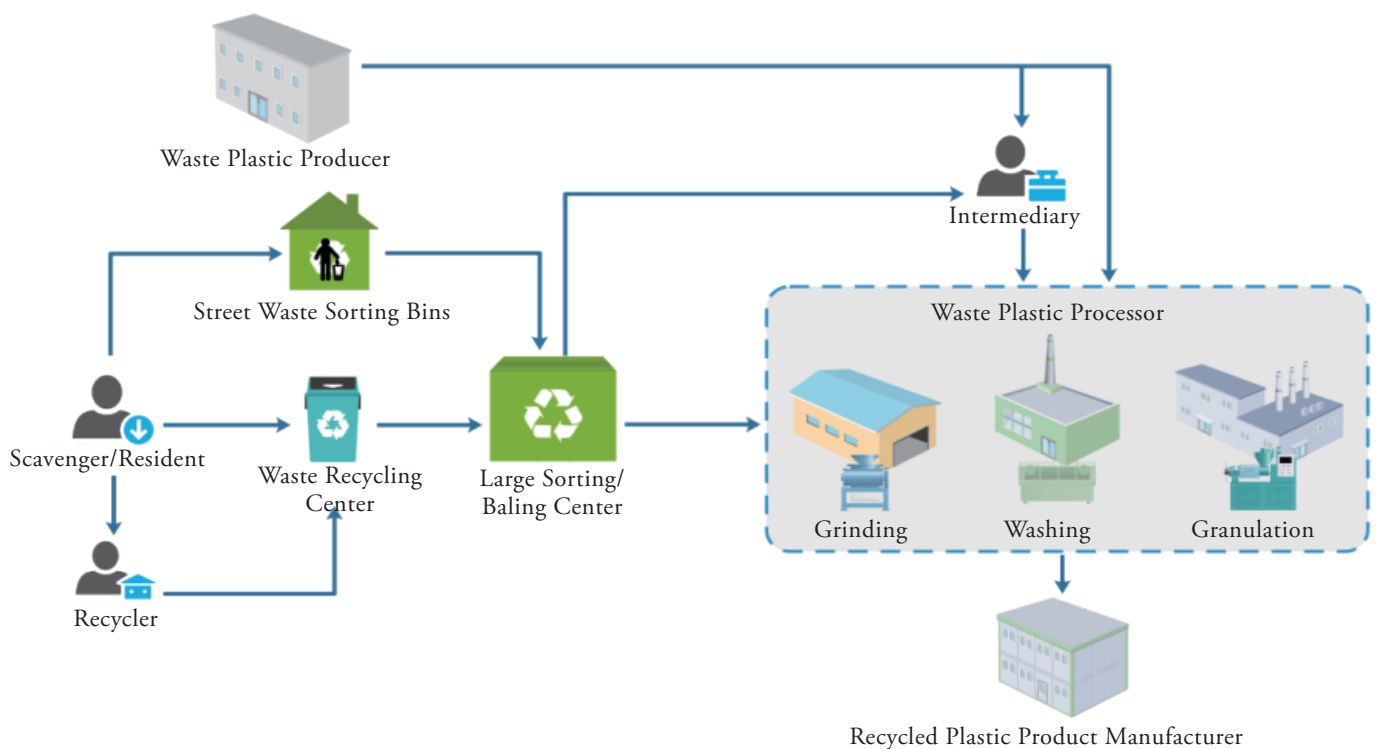
- In 2022, 1.60 million tonnes of HDPE packaging in the target sectors were discarded, a decline of 15% YoY but a growth of 14% from 2019.

## ■ Recycling of Packaging Waste

The recycling system in China varies greatly from sector to sector. Encouragingly, recycling rate in the target sectors far exceeds the overall recycling rate for plastics, thanks to the relatively homogeneous raw materials, their recycling value, and high recycling awareness among the public. As is true for the majority of plastic wastes, three recycling methods predominate in the target sectors: voluntary recycling by

individuals (including households and small recycling centers), recycling by businesses, and integrated dual-network model combining sanitation systems and recycled resource systems. Currently, most waste in the recycling bins are low value; PET bottles, which are comparatively valuable, tend to be picked up by custodians and scavengers to be sold to recyclers.

Figure: Recycling of Waste PET/HDPE Bottles





- **PET bottles and drums** have the highest recycling rate among plastics, despite a pandemic-induced decline in the past three years. The recycling rate of **water/beverage PET packaging** is the highest at 93%, followed by **condiment and dairy product packaging**. A lower rate, of around 70%, is seen in the packaging for **household chemicals and personal care products**, mainly because those packaging solutions come in various colors, making them ill-suited for recycled use with lower recycling value, which diminishes the collection enthusiasm from recyclers and residents. .

- Recycling companies sort PET bottles by color into **clear** (i.e., colorless), **blue, green, and mixed-color** bottles based on downstream needs. Among these, clear bottles are the most common and have the widest applications and therefore the highest recycling value. Next are the blue bottles, mainly used for making home textile products. Green bottles often come from carbonated drinks like Sprite and are mostly repurposed into strapping and covering nets. Oil bottles have a low recycling value due to their high cleaning costs but are still one of the main sources of PET flakes during winter when the waste volume of beverage bottles drops off.

- In the past five years, the average price of end-of-life PET bottles has rebounded after a modest decline. The main reasons for the falling price between 2017 and 2019 were the decrease in raw material prices and the insufficient market demand of chemical fiber manufacturers. In 2020-2022, the pandemic made it difficult to recover waste products from factories, businesses, and households; transportation was also affected from time to time. This pushed up the price level of waste bottles, albeit to a limited degree as terminal market demand also fell.



- The recycling rate of **HDPE bottles and drums** is similarly high at around 70%. The figure has fallen somewhat in the last three years due to external factors such as COVID-19, as waste bottles from certain streams could not enter the recycling system for risk of contamination. **Small packaging** (net weight of less than 8 grams) in the household chemicals and food sectors has a comparatively low recycling rate, but it only accounts for a small proportion of the total waste volume.

- Recycling companies sort waste HDPE bottles according to downstream applications and market price levels. The main categories are **nature HDPE** (natural-color translucent), which has the highest value, **white HDPE** (opaque white), and **mixed-color HDPE** (blue, red, amber, etc. and mostly from the household chemicals sector). Some further classify natural and white bottles based on whether they are sourced from food or non-food sectors, to supply **food-grade rHDPE** factories. Some baling centers also separate out bottles of a certain color (such as blue or green).

- The purchase price of HDPE bottle bales has fluctuated significantly in the past five years: falling in 2018-2020, recovering in 2020-2022, and trending downward again thereafter. The higher-quality grades show frequent and large price swings, mainly due to how closely natural bottles (in partial sectors) relate to HDPE applications, and the fluctuation of raw material prices. By contrast, white and colored bottles have limited room for sharp price declines due to their inherent lower pricing, 14% from 2019.

## ■ Recycling of Packaging Waste



- The production of rPET flakes reached 3.4 million tonnes in 2022, almost on par with the level in 2021 and returning to the 2019 level.

- The price of rPET flakes has been rising on the whole in the past three years. The main driver was the rising recycling cost of end-of-life bottles coupled with the industry's short value chain, which led to a fast transmission of costs. Recycled flakes and virgin polyester flakes show similar price trends on longer time scales but may diverge momentarily as their different applications create different supply-demand dynamics.

- The main uses for rPET flakes are **recycled chemical fibers** (accounting for 80%, including recycled filament for textiles, recycled fiber for spinning and non-woven fabrics, and recycled hollow fiber for fills), **polyester strapping at 8%**, **bottle-to-bottle** (commonly for pesticide and household chemicals) at 5%, **sheets** at 5%, and miscellaneous. Some domestic manufacturers have obtained a “no objections” letter from the U.S. FDA or scientific opinions from the EFSA for the use of rPET in food-contact applications.



- The HDPE recycling volume in the target sectors in 2022 was 0.86 million tonnes, falling to the 2020 level.

- Apart from food-contact uses, rHDPE pellets (primarily the natural color variety) and small virgin hollow HDPE pellets have intersecting applications and thus are mutual substitutes, giving them convergent prices. But recycled material tends to respond more slowly. Thus in 2022 when the uptick in virgin HDPE pricing drove up the price of recycled materials, there was a large differential between the two, making the recycled kind more appealing to buyers. In May 2023, the price of virgin HDPE continued to fall, pushing the price of rHDPE down to near the cost level. The narrowing price gap reduced the use of rHDPE in downstream applications.

- In terms of the consumption structure, 60% of rHDPE pellets are used for **pipes/blow molding and injection molding** (producing containers for industrial and household chemicals); **film blowing** (e.g., plastic bags) and **drawing** (e.g., dust filters and ropes) account for 20% and 10%, respectively. Some Chinese companies also produce the higher-value **food-grade** rHDPE pellets for export or for household chemicals such as cosmetics and have obtained a “no objections” letter from the U.S. FDA.

## Outlook

### ■ Prospect of Collection and Recycling

- **Rising waste volume.** Conferences, exhibitions, and tourism are recovering following the end of the pandemic, which is a boon to the beverage, dairy, and personal care industries. Because the rigid packaging in the target sectors is mostly consumable products and quickly discarded, the overall waste volume is expected to rise on an ongoing basis.
- **Rising collection rate.** China's policies on the circular economy and garbage classification have also improved the collection system for plastic waste. With rising public awareness, the collection rate of plastic packaging in the target sectors will continue to improve. By 2027, the collection volume is expected to hit 7 million tonnes for PET bottles and 1.75 million tonnes for HDPE packaging.
- **Rising recycling volume.** The recycled plastics industry will continue to grow in size and sophistication. Increasing output from upgraded machinery, coupled with the expected rising market demand from downstream sectors, will fuel long-term growth in the supply of recycled materials in the target sectors. By 2027, the recycling volume is expected to reach 6.10 million tonnes for rPET flakes and 1.45 million tonnes for rHDPE in the targeted sector.
- **Subtle changes in consumption structure contribute to increasing the share of potentially high value-added applications.**



• The consumption structure of rPET flakes is not expected to change notably in the coming five years. While **recycled chemical fibers** will remain the largest application area, their share will come down slightly as intra-industry recycling gains momentum. The entry of large enterprises (such as in the household chemicals sector) will further expand the range of **bottle-to-bottle** applications for high-quality products, with their proportion expected to rise to 6%.



• As virgin HDPE manufacturers continue to expand capacity, the next five years will see an appreciable increase in the output for small virgin hollow HDPE pellets, most of which will be used for **pipes and blow molding and injection molding**, a market expected to be fiercely competitive. Because rHDPE is mainly used for its cost-saving benefit, it has a minor influence in that market and its market share there could fall to 59%. However, its application as **high value-added rHDPE film for secondary packaging** may rise to 22% following the entry of leading manufacturers.



## ■ Impacts of the Latest European Policies

Europe has introduced a flurry of plastics and textile policies in recent years which, in the long run, will affect the recycling and reuse of rigid packaging in the target sectors in China.

- **Growing demand for recycled plastics in the packaging industry**

On April 1, 2022, the UK introduced a Plastic Packaging Tax of £200 per tonne on plastic packaging and products exceeding 10 tonnes with less than 30% recycled plastic content. The tax was increased to £210 per tonne in 2023, reflecting a strong determination to replace single-use plastics in favor of recycling. In 2022, the European Commission proposed the Regulation on Packaging and Packaging Waste, hoping to reduce the environmental impact of packaging by mandating a minimum amount of recycled plastic in new packaging products, in particular requiring a minimum 30% recycled content in all plastic packaging used in the EU market by 2030. This mandatory rule poses challenges to the local supply of recycled plastics—high-end recycled plastics especially—and primarily affects Chinese exports to the UK and

the EU. It also indirectly stimulates the demand for high-end recycled plastics in China, thereby promoting high value-added and bottle-to-bottle recycling of PET and HDPE packaging. However, due to the modest size of this sub-market, its overall impact on the recycling market is limited.

- **Reduced demand for rPET flakes in an increasingly self-recycling textile industry**

In 2022, the EU strengthened the regulation of textiles with the EU Strategy for Sustainable and Circular Textiles and subsequently introduced a range of directives and regulations aimed at using more recycled fibers in consumer goods. In 2023, the European Commission amended the Waste Framework Directive to mandate Extended Producer Responsibility (EPR) schemes for textile producers. In the long run, textile manufacturers will progressively replace rPET flakes with recycled fibers. This will compel the rPET flakes industry to align with other recycled applications such as bottle-to-bottle, thereby encouraging greater industry standardization and sophistication.



## ■ Present Challenges

- **Informal channels remain standing.** The high recycling value of rigid packaging in the target sectors has encouraged its unregulated collection and transactions by scavengers and informal recyclers, and even recycling by mom-and-pop workshops, all without paying for the environmental costs and taxes. The quality of the recycled materials from these channels is also highly variable, leading to short-supply and low-capacity utilization at formal enterprises as well as general market disorderliness.
- **Lack of leading collection and recycling companies.** The collection and recycling industry is dominated by small and medium-sized enterprises that have a generally low R&D investment, limited quality control, equipment, and technology capabilities, and poor output efficiency and quality. Their lack of innovation power and competitive edge and severe product homogeneity also add to the waste of resources.
- **Inadequate standardization of packaging design.** Hard-to-remove appendages and PVC labels are a

prevalent problem in the design of rigid packaging in the target sectors as they make recycling more difficult. Furthermore, high value-added recycling is facing headwinds from the lack of standardized guidance during the recycling and sorting of waste packaging.

- **Narrow applications for high-end recycled granules.** Currently, plastic recycling and reuse generally take place in low-end (or downgrading) cycles, giving a limited supply of high-end recycled plastics. This has two implications for brand owners. First, their stringent requirements for manufacturing validation and product quality make finding qualified recycling facilities a difficult process. Second, without policies compelling the use of recycled plastics, they have little interest in favoring recycled plastics over the lower-priced virgin plastics. In addition, China, through regulatory restrictions, is maintaining a cautious stance on recycled materials in food-contact applications, which further slows market development.

## ■ Recommendations to Industry

- **Strengthening full-lifecycle oversight of plastic waste and establishing a whitelist of recycling companies.** China should continue to build its recycling system; better integrate the classification and collection of municipal wastes with the recycling of resources; and improve the governance of garbage classification, transport, and recycling. It should further engage the public, in both awareness and action, for garbage sorting at the source, and prevent contamination during the intermediary stages. It should also boost industry regulation to deny market entry by informal, poorly managed, and polluting enterprises, in order to prevent unnecessary environmental degradation and resource waste and the sale of non-compliant recycled plastics.
- **Supporting leading enterprises and enhancing industry automation and standardization.** China should encourage collection and recycling companies to improve their production management, technologies, and equipment, and issue guidelines for advanced recycling technologies. It should also encourage the replacement of manual sorting, which is still commonplace today, with automated sorting, and establish quality classifications and other standards for the sorted waste. This helps ensure the supply of standardized raw materials for the downstream users, who can improve efficiency and reduce costs by expanding and automating their production. China should also encourage vertical integration within the industry and raise the product standards, such that recycled plastic

companies will become more competitive as capacity expands rapidly and price continues to fall. Moreover, China can build on the existing preferential tax policies on the use of recycled plastics by expanding them to other sectors of the industry, in order to support the recycling and circular use of plastic products.

- **Expanding the scope of extended producer responsibility and improving packaging eco design.** Prominent household chemicals and food companies are both numerous and eager to engage in the circular use of waste plastics. Through the design of the EPR system and preferential policies, major plastic users can be encouraged to take the lead and adopt specific metrics for recycled plastics in the design phase and make packaging more recyclable from the start. While meeting the

functional requirements of products, companies are advised to choose natural colors and minimize the use of chemical additives, either use labels and appendages that can be easily removed or separated or practice environmental design philosophies through water-soluble ink printing, and introduce labels indicating recycle-friendly packaging.

- **Expanding high value-added recycling and high-end applications.** China should issue policies, such as reduced taxes and green procurement lists, to encourage the use of recycled plastics in the industry. The focus should be on the potential high-value applications, such as rPET bottle-to-bottle, rPET strapping, and rHDPE film for secondary packaging. China should also actively study the use of plastics in food-contact applications and other future usage scenarios.



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## Contact us

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH



## Address

No. 14 Liangmahe South Road,  
Chaoyang District, Bei jing Tayu-  
an Diplomatic Office Building  
2-5



## Contact Info

Contact: HOU Jingyue  
Phone:+86 010 8527 5589 ext. 185  
E-mail: jingyue.hou@giz.de

Website



Wechat

