Design guidance recommendations: rigid packaging

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Consultations: This report is a product of primary and secondary research, based on interactions with stakeholders across the plastics value chain. The India Plastics Pact is grateful to individual experts and specialists for valuable inputs and insights during the preparation of this report. The support of India Plastics Pact Member and Supporter organisations is appreciated and acknowledged.

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INDIA PLASTICS PACT

Introduction

Plastics are widely used because of their many unique properties: plastic products and packaging are light, durable, chemically inert and cheap. Packaging is the largest application of plastics: globally 31% of total volume of plastics consumed were for packaging applications in 2019.[1] In India, 56% of the total plastics placed on the market are used for packaging applications.[2] The primary role of packaging is to protect the product and help eliminate product waste. However, 95% of plastic packaging material is lost to the economy after a short first-use cycle and one-third of plastic packaging remains uncollected globally, polluting the natural environment.[3]

To manage plastic packaging effectively, the search for solutions should be across the plastics value chain: from eliminating unnecessary and problematic plastics, to designing plastics to be reusable, recyclable or compostable, ensuring plastic packaging is effectively recycled[4] and ensuring recycled content[5] is incorporated back into packaging.

In general, packaging should be designed in a way that minimises environmental impact, uses the minimum quantity of resources possible, and is recyclable.

Plastic packaging or a packaging component is recyclable if the post-consumer collection, sorting, and effective recycling[6] of the major component of the entire packaging weight is proven to work successfully in practice and at scale,

and

if the remaining minor components are compatible with the recycling process and do not hinder the recyclability of the main component.

Recycling is a critical part of a circular economy: it ensures that resources are valued by keeping them in the economy for longer and reducing the demand for virgin materials. Recycled content can be used in the same packaging application again, provided the quality meets end-use requirements. However, packaging is often designed in a way that either hampers its recyclability or leads to degradation in quality once recycled. Moreover, poor design can also make an otherwise recyclable packaging, unrecyclable within the existing infrastructure.

The five questions listed below can guide packaging producers and brand owners towards deciding whether their packaging is practically recyclable and not just technically recyclable:[7]

- **Can the consumer recognise the packaging (or product) as recyclable?**
- **Is the packaging (or product) widely collected for recycling?**
- **Can the packaging (or product) be sorted?**
- **Is the packaging (or product) capable of being made into something new?**
- **Is there a commercially viable end-market for the recyclate?**

[1] OECD. (2022). Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options. https://espas.secure.europarl.europa.eu/orbis/sites/default/files/generated/document/en/plastic.pdf

[2] CII analysis based on PlastIndia report 2018-19

[3] Ellen MacArthur Foundation. (2017). The New Plastics Economy: Rethinking the future of plastics and catalysing action. https://ellenmacarthurfoundation.org/the-new-plastics-economy-rethinking-the-future-of-plastics-and-catalysing

[4] Reprocessing, by means of a manufacturing process, of a used packaging material into a product, a component incorporated into a product, or a secondary (recycled) raw material (excluding energy recovery and the use of the product as a fuel) which has proven to work in practice and at scale, i.e., recycling has proven to work across different geographical areas and in that area a significant recycling rate is achieved for that type of packaging.

[5] Proportion, by mass, of post-consumer recycled material in a product or packaging.

[6] Recovery operation by which waste materials are reprocessed, by means of a manufacturing process, of a used packaging material into a product, a component incorporated into a product, or a secondary (recycled) raw material; excluding energy recovery and the use of the product as a fuel.

[7] The tests have been adopted from WRAP. (2021). Defining what's recyclable and best in class polymer choices for packaging. https://wrap.org.uk/sites/default/files/2021-03/WRAP-polymer-choice-and-recyclability-guidance-2021.pdf

Designing packaging to be both technically and practically recyclable ensures that it is collected, sorted and recycled successfully without any degradation in the quality of the recyclate. Hence, improving packaging recyclability through better design is essential for closing the loop and creating a circular economy for plastics.

In 2022, the Government of India notified the new Extended Producer Responsibility Guidelines, under the Plastic Waste Management Rules, placing a statutory responsibility on manufacturers to collect, recycle and reuse used plastic packaging, and use recycled content in new plastic packaging. The Guidelines aim to improve packaging sustainability thorough ambitious targets and promoting improved packaging design.

These EPR Guidelines are expected to lead a surge of interest in closed loop recycling.

The low-hanging fruit for such recycling is **rigid packaging** (bottles, pots, tubs and trays) due to three reasons.

- Nearly one-third of plastic packaging placed on the market in India is used for rigid packaging applications such as bottles used for personal and homecare products, drinking water and carbonated soft drinks.[2]

- Rigid packaging is easier to recycle compared to flexible packaging. One of the main reasons for this is that rigids generally have a mono-polymer mono-layer structure which is easier to recycle compared to the multi-polymer multi-layer structures often used in flexibles.

- The existing collection system for rigids is robust. Additionally, most plastic packaging being recycled in India currently is in rigid formats.

This design guide aims to improve the recyclability of rigid packaging in India by providing packaging producers, designers and brand owners a better understanding on how their design decisions affect recyclability.

The recycling value chain

To improve packaging recyclability, it is helpful to identify the design aspects which affect the ease of recycling and the recyclate quality.

To maximise recycling, it is essential that each stage of the value chain is kept in mind while designing packaging, starting from disposal by the consumer until it is recycled by recyclers.

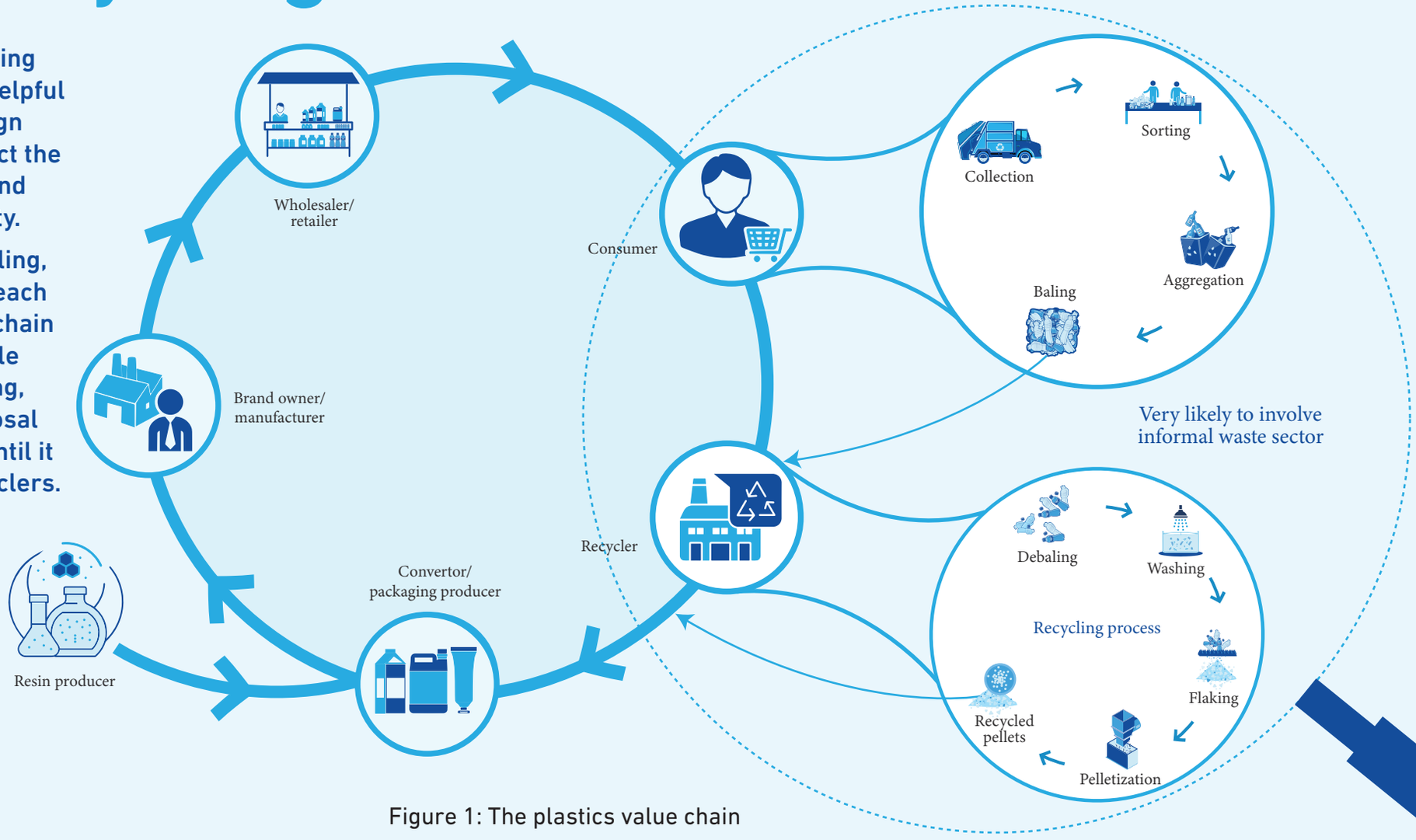
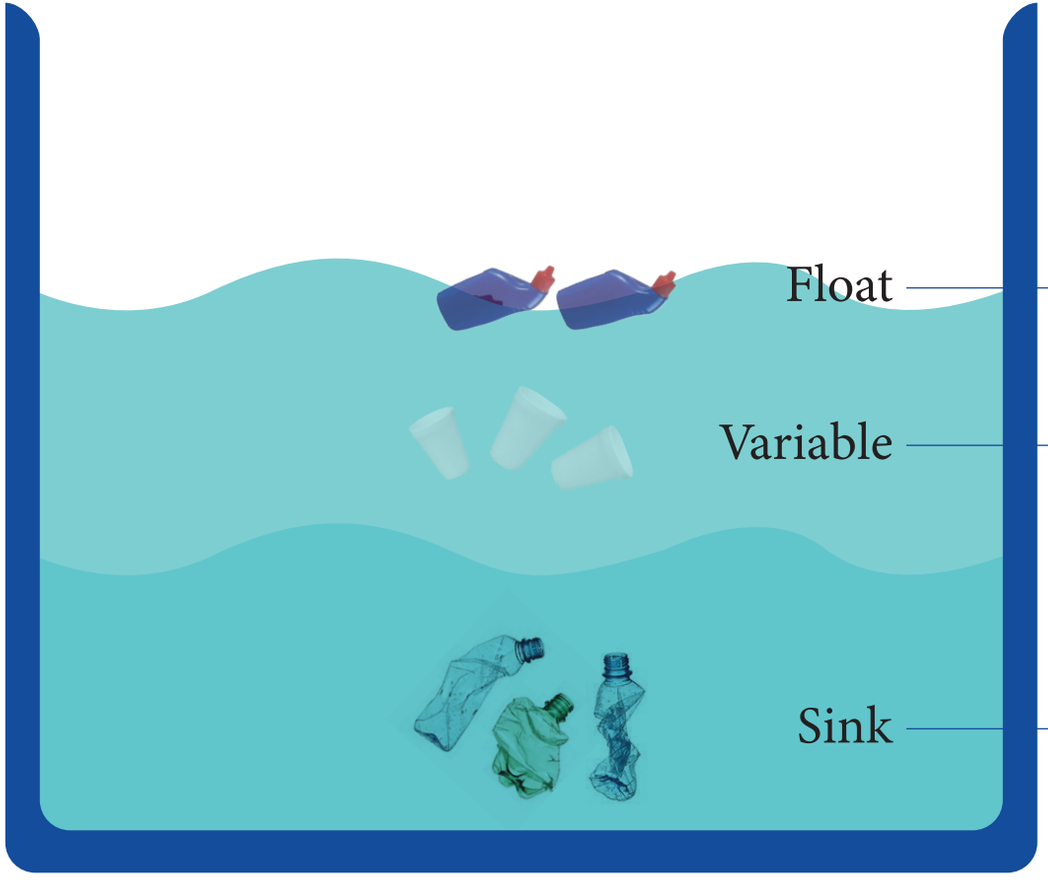


Figure 1: The plastics value chain

First, mixed waste is collected from consumers (household, commercial or industrial). Sorting then occurs at two or more stages starting with the separation of plastics from other materials such as food, metals, glass, paper and cardboard. The plastics are then further sorted by polymer type and by colour (either manually, automatically or a mixture of both). These are then baled and sent for recycling. At the recyclers, the plastics are washed, shredded into flakes and then further sorted to ensure minimal contamination. The flakes may be sorted in various ways such as by colour or by density separation (Figure 2). The washed and sorted flakes may be sold in this flake form or they may be extruded to form pellets, which can be used in new products.

Figure 2: Density* ranges of polymers commonly used to make packaging



Polymer	Density g/cm³
Ethylene vinyl scetate (EVA)	Less dense than water
Polypropylene (PP)	0.90-0.92
Low density polyethylene (LDPE)	0.90-0.92
High density polyethylene (HDPE)	0.94-0.96
Polystyrene (PS)	1.03-1.06
Nylon (PA)	1.13-1.14
Acrylic (PMMA)	1.17-1.20
Polycarbonate (PC)	1.2
Polyethylene terephthalate (PET)	1.30-1.38
Polyvinyl chloride (PVC)	1.32-1.45

* Densities are approximate and relate to virgin unpigmented and unfilled polymer.
Colouring with a 4% pigment can raise density by 0.03 g/cm³ which may cause further overlaps of polymer densities.

Good design adopted at the manufacturing stage will support complete collection, easy segregation and maximize quantities reaching a recycler. This rigids design guide focuses on simple design recommendations which will not require extensive investments or drastic changes in manufacturing lines, but if adopted will improve the overall recycling rate of rigid packaging and further enable the use of recycled content.

While this guidance focusses on design changes that improve recyclability, some additional aspects that should be considered while designing packaging are:

- **optimising the use of plastics:** it is important to take steps to reduce the use of plastics by eliminating excess packaging in the form of excess weight, unnecessary overwraps and excess headspace, and
- **including recycled content:** where technically feasible, it is encouraged to use recycled content in packaging to reduce the demand for virgin plastics and help keep the material in the economy longer.

Communicating the recyclability of packaging is important to encourage the responsible disposal of packaging and to facilitate it's recycling. This may be through the accurate use of the Resin Identification Codes (numbers 1-7) and use of on-pack recycling labelling.

Moving forward, the India Plastics Pact will also develop detailed application specific guidances such as the one developed for food contact grade PET bottles.

Rigid packaging design for recyclability

The design guidelines compiled cover the following aspects of rigid plastic packaging containers:

- Polymer choice
- Colour
- Additives
- Attachments
- Labels and adhesives
- Inks
- Residual content
- Ease of collection

Polymer choice

- Prefer polymers that are recycled at scale
- Prefer single polymer and single layer structures
- Prefer barrier layers that do not hamper recycling
- Identify polymer used in the container and attachments clearly

Polymer selection and combination used; both play a key role in determining the ease of recyclability of any packaging format. In India, polyethylene (PE), polypropylene (PP) and polyethylene terephthalate (PET) rigid packaging are recycled at scale and should be preferred. Certain polymers are known to be not recycled at scale. Polyvinyl chloride (PVC) packaging is problematic in the recycling stream as it generates acidic compounds which can affect the chemical and physical properties of the recyclate. While polystyrene (PS) and expanded polystyrene (EPS) are technically recyclable, they are not practically recycled at scale in India. This can be attributed to the low share of PS in the overall packaging footprint, and bulky but light weight nature of EPS, which results in increased transport costs and hence makes them commercially unviable for recycling. The use of these polymers is only viable when recycling infrastructure is situated close to the source of waste.

Compostable, biodegradable or oxydegradable plastics should be avoided when recyclability of packaging is targeted. Such packaging is not designed to be recycled, rather they are designed to break down. When mixed with conventional plastics, they can affect the recycling process and the quality of recyclate. It is advised that compostable, biodegradable or oxydegradable plastics be used only if they

- are certified according to relevant Indian or international standards,
- do not leave any microplastic residue,
- are clearly labelled, and
- are used and disposed in closed-loop or controlled systems with appropriate infrastructure available for effective treatment.

Conventional plastics which are derived from bio-based feedstock can be considered as alternatives, provided they are recyclable in the recycling stream of their petroleum-based counterparts.

It is preferable to use mono-polymer mono-layer structures for packaging. Where multi-layer structures are needed for functionality, layers of the same polymer are preferred. Preference should also be given to thinner layers, such as those made using vapour deposition. Laminates with incompatible polymers can compromise the quality of the recyclate.

Polymer choice is also equally important for labels and attachments such as caps and closures. As a general principle, where possible, the same polymers should be used for these components as used for the container. Where this is not feasible for functionality (for instance, PP caps have better hinge performance), the polymers used in the components should be easily separable from the container and any residue should not contaminate the recyclate (see Attachments and Labels and adhesives sections).

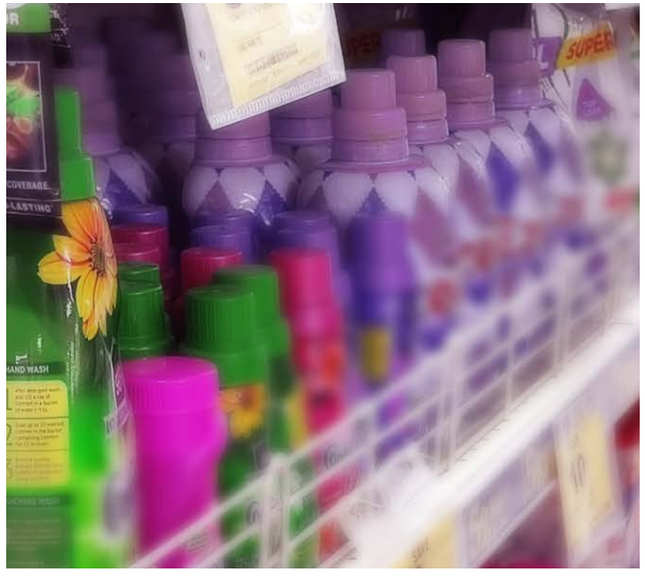
Where barrier layers are necessary for packaging products which are sensitive to moisture and gases, barriers that do not hamper recycling should be preferred, such as EVOH (if less than 5% by weight). Avoid barrier layers of PVdC as they degrade at low temperatures, compromising the quality of the recyclate.

Material identification

In India, the ASTM International Resin Identification Coding System is being used to aid visual identification of the polymer. The polymer being used in both the container and its components (such as caps and labels) should be identified clearly. The codes should be easily visible and the code for the container should ideally be moulded into the container itself. Where multi-layer multi-polymer packaging is used, the number 7 code should be used with the acronyms for the polymers used mentioned below.

Colour

- Minimize use of colour
- Use clear, uncoloured polymers
- Avoid strong colours
- Use colours that are NIR detectable



Use either clear, uncoloured plastics or light tints because the lack of colour in the recyclate allows the plastic to be recycled into a variety of end-products. Avoid strong colours as the recyclate is likely to have limited end-use applications and hence will have low value.

Use colours that are detectable by sorting systems using near infra-red (NIR) sensors. NIR sensors sort the different polymers based on their ability to reflect NIR radiation. Using non-NIR detectable colours hampers the sensors' ability to correctly identify polymers. Carbon black pigment is especially problematic as it absorbs NIR radiation, resulting in the packaging not being detected. As a result, the packaging is classified as waste and is rejected from the stream.

Titanium dioxide, often used to provide white colour, can also be problematic in NIR sorting as the sensors may misdirect it to the waste stream for clear plastics. Although NIR sensors are not used extensively in India currently, the recommendation will help account for any possible future shifts towards NIR-based sorting systems.

Additives

- **Avoid additives that hamper recycling**
- **Avoid additives that promote degradation**
- **Avoid fillers that affect packaging density**

Chemical additives in polymers, such as plasticizers, flame retardants, antioxidants and thermal stabilizers, help enhance functionality. These additives should be used in low quantities and assessed to ensure that they do not affect the quality of the recyclate.

Additives that promote degradation should be avoided as these hamper recycling and contribute to microplastic pollution. This includes bio, oxo- and photo-degradable additives.

Avoid fillers which affect the density of the final packaging. Fillers such as $CaCO_3$, when used in high quantities, increase the density of the plastic. This can affect how the packaging is sorted in the sink-float tank. Similarly, chemical foaming agents which reduce density should be avoided in polymers other than polyolefins.

Attachments (including caps and closures)

- **Prefer polymers that are compatible with recycling of the base container**
- **Prefer attachments that are easily separable**
- **Avoid metal attachments**
- **Minimize colour**
- **Limit the weight of closures**

Rigid packaging often has several attachments such as caps/closures, lids, liners and dispensers. Ideally, these attachments should be recyclable along with the base container. This can be achieved by using the same polymer for the attachments as used in the container. In such cases, uncoloured or lightly coloured attachments are preferred to avoid transfer of colour into the recyclate during recycling.

Where the polymer used in the attachment differs from that used in the container, it should be designed in a way to allow easy separation in the sink-float tank. This can be ensured by using polymers with different densities (for instance, a polymer with a density <1 g/cm^3 and a polymer with a density >1 g/cm^3). The separated attachments should ideally be recyclable in their respective polymer streams. Polymers that are not recycled at scale (described in the Polymer choice section), such as PVC, should be avoided.

Some polymers are compatible with each other to an extent: upto 10% contamination of PP in a HDPE recycling stream is acceptable.[8] To ensure such contamination is minimized, the weight of PP closures on HDPE bottles should be limited.

Closures are preferred which do not contain liners and leave no residual attachments (such as plastic or metal bands around the bottle neck) when removed from the base container. Silicone seals are a potential contaminant in the recycling stream. Seals with a low density are difficult to separate from PE and PP while seals with high densities are difficult to separate from PET.

While it is important for caps to not leave any residual attachments on the bottle neck, caps that are disposed separately tend to be littered. Tethered caps can help minimize litter by ensuring the cap remains attached to the bottle during and after use.

Lastly, attachments made of materials other than plastic should be avoided. Metal closures are more difficult and costly to separate from the container than plastic closures. Residues from metal components, including springs in pumps, that are not separated from the base container can damage recycling equipment and block injection nozzles, and should be replaced with plastic versions. Caustic soda used by recyclers to wash the waste plastics can react with metal residues and contaminate the recyclate, making it unsuitable as a food grade material.

[8] RECOUP. (2022). Plastic Packaging Recyclability by Design 2023. https://www.recoup.org/download/1044/rbd-2022-red

Labels and adhesives

- **Use small and easily removable/separable labels**
- **Label polymer should be compatible with recycling of the base container**
- **Minimize quantity of adhesives**
- **Prefer water soluble adhesives**

Labels are an important component of packaging as they provide information about the product and are key to marketing the product. They can have a large impact on the recyclability of the container. As a best practice, it is good to ensure that the material chosen for the label is compatible with the recycling of the base container and that the label is easily separable from the container. Where separation is difficult, the label material should not affect the quality of recyclate.

It is preferable to use labels made of the same polymer as the base container. This can streamline the recycling process and improve yields. Labels made of incompatible polymers, such as polyethylene terephthalate glycol (PET-G) or PVC labels for PET bottles/containers, can affect the quality of the recyclate.

Labels made of metalized films or paper can hamper recycling. If paper labels are being used, it is important to ensure that they are completely separable from the container. Paper labels can leave residual fibres in the washing process which can then create surface defects when the recyclate is being converted into packaging. While water soluble adhesives allow easy removal of labels, they do not necessarily reduce fibre loss from paper labels.

It is important to ensure that labels also do not hamper the identification of the polymer of the container. Full body sleeves or labels that cover more than 60% of the container's surface can prevent automated sorting systems from identifying the base polymer. In India, the use of automated sorting systems is currently limited to large scale recyclers. However, adoption is expected to increase in the coming years as investments in waste management infrastructure increase.

Removal of labels and adhesives is often an added cost for recyclers. The quantity of adhesive used and the surface area it covers should be minimized to facilitate easy removal of labels. Water soluble adhesives that are removable between 60°C and 80°C, and hot melt alkali soluble adhesives are preferred as they are easily removable and will ensure that no adhesive residue remains.

Inks

- **Avoid inks with heavy metals**
- **Avoid direct printing**
- **Avoid inks that bleed during washing**

Inks used for printing on labels should not hinder the recyclability of the packaging. Inks that bleed and dye the caustic wash solution can discolour the recyclate and also increase the quantity of water required in the washing process.

The density of the inks used should be kept in mind while designing labels: high ink density should not cause a floating label to sink.

Avoid inks which contain heavy metals and other hazardous substances as these can affect the health of workers and also compromise the quality of recyclate. The European Printing Ink Association (EuPIA) publishes a regularly updated exclusion list for printing inks and related products.[9] These are also relevant in the Indian context and it is recommended that inks featuring in this list are not used.

Avoid direct printing on the container. If it is being considered, only use ink removable under hot wash conditions to ensure complete removal before recycling.

Residual content

The presence of residual content in packaging waste can contaminate the recyclate by compromising the colour, odour or mechanical properties. The packaging should be designed so as to allow easy removal of contents before its disposal.

Ease of collection

- **Minimize number of removable components**
- **Mention disposal instructions on label**

In addition to improved recyclability, the packaging design should also enable easy collection and help minimize litter. This can be done by minimizing the number of components that are separated during use. Where such components are necessary, instructions on proper disposal of each component should be printed on the base container/label to encourage segregation by consumer.

[9] EuPIA. (2021). Exclusion policy for printing inks and related products. https://www.eupia.org/wp-content/uploads/2022/09/20210310_-Exclusion_Policy_for_Printing_Inks_and_Related_Products_final_March_2021.pdf

Summary of design guidance

Polymer choice

- Prefer polymers that are recycled at scale
- Prefer single polymer and single layer structures
- Prefer barrier layers that do not hamper recycling
- Identify polymer used in the container and attachments clearly

Colour

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- Use colours that are NIR detectable

Additives

- Avoid additives that hamper recycling
- Avoid additives that promote degradation
- Avoid fillers that affect packaging density

Attachments (including caps and closures)

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Labels and adhesives

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- Minimize quantity of adhesives
- Prefer water soluble adhesives

Inks

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- Avoid direct printing
- Avoid inks that bleed during washing

Residual content

Allow removal of content before disposal

Ease of collection

- Minimize number of removable components
- Mention disposal instructions on label

List of abbreviations

EPS	expanded polystyrene
EVOH	ethylene vinyl alcohol
NIR	near infra red
PE	polyethylene
PET	polyethylene terephthalate
PET-G	polyethylene terephthalate glycol
PP	polypropylene
PS	polystyrene
PVC	polyvinyl chloride

About the India Plastics Pact

The India Plastics Pact, launched in 2021, unites businesses, governments, NGOs and citizens to create a circular plastics economy in India. It was developed by Confederation of Indian Industry (CII) and WWF India. The CII-ITC Centre of Excellence for Sustainable Development (CESD) anchors the India Plastics Pact, within CII. The initiative is supported by WRAP, a global NGO based in the UK.

It is the first Plastics Pact in Asia. As of June 2023, there are 14 Plastics Pacts spread across the globe. As of June 2023, 48 organizations are currently part of the India Plastics Pact. The Pact works on all plastic resins at all stages of the plastics value chain.

www.indiaplasticspact.org

About Confederation of Indian Industry

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering Industry, Government, and civil society, through advisory and consultative processes. For more than 125 years, CII has been engaged in shaping India's development journey and works proactively on transforming Indian Industry's engagement in national development. CII engages closely with Government on policy issues and interfaces with thought leaders to enhance efficiency, competitiveness and business opportunities for Industry through a wide portfolio of specialized services and strategic global linkages.

India's premier business association has around 9,000 members, from the private as well as public sectors, and an indirect membership of over 300,000 enterprises from around 286 national and regional sectoral industry bodies. With 62 offices, including 10 Centres of Excellence in India, and 8 overseas offices in Australia, Egypt, Germany, Indonesia, Singapore, UAE, UK, and USA, as well as institutional partnerships with 350 counterpart organizations in 133 countries, CII serves as a reference point for Indian Industry and the international business community.

About WRAP

WRAP is a UK based international resources and climate action NGO working around the globe to tackle the causes of the climate crisis and give the planet a sustainable future. WRAP is working with businesses across the plastics value chain globally through the Plastics Pact network, transforming how we make, use, collect, sort, reuse and recycle plastics to create a circular economy, capturing the value of plastic, keeping it in the economy and out of the natural environment. Working with key partners internationally, our voluntary agreements are transforming whole systems uniting businesses, governments and citizens behind a shared vision and measurable targets for change.

WRAP set up, and manages, the UK Plastics Pact. Established in 2018, in partnership with the Ellen MacArthur Foundation, it has catalyzed 14 further Plastics Pacts to be developed including South Africa, US, Chile, Kenya and Colombia. WRAP was instrumental in establishing the India Plastics Pact with CII and WWF-India. The Plastics Pact network encompasses over 1000 leading plastics businesses in their membership. WRAP provides operational and technical support to the India Plastics Pact and other Pacts. WRAP also runs a knowledge sharing platform between the various circular plastics initiatives internationally.

About UKRI

UK Research and Innovation (UKRI) was launched in April 2018. It is a nondepartmental public body sponsored by the Department for Business, Energy and Industrial Strategy (BEIS). It brings together the seven disciplinary research councils, Research England, which is responsible for supporting research and knowledge exchange at higher education institutions in England, and the UK's innovation agency, Innovate UK. UKRI's nine councils work together in innovative ways to deliver an ambitious agenda, drawing on our great depth and breadth of expertise and the enormous diversity of our portfolio. Through our councils, we maintain and champion the creativity and vibrancy of disciplines and sector-specific priorities and communities.

Our councils shape and deliver both sectoral and domain-specific support. Whether through research council grants, quality related block grants from Research England, or grants and wider support for innovative businesses from Innovate UK, we work with our stakeholders to understand the opportunities and requirements of all the different parts of the research and innovation landscape, maintaining the health, breadth, and depth of the system.

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