Community Paper
Design Guidelines Working Group

Consumers Beyond Waste
An initiative of the Future of Consumption Platform, World Economic Forum

Design Guidelines

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Acknowledgments

Consumers Beyond Waste (formerly Consumers Beyond Disposability) is a multistakeholder initiative hosted by the World Economic Forum's Future of Consumption Platform in collaboration with Kearney. The initiative engages an informal coalition of diverse stakeholders committed to empowering consumers to, by 2030, access innovative consumption models at scale that offer aspirational, affordable, and more sustainable alternatives to single-use. Consumers Beyond Waste works in close collaboration with related World Economic Forum efforts, such as the Global Plastics Action Partnership and the Platform for Accelerating the Circular Economy. The project's 2020/21 Steering Group comprised members from Algramo, Closed Loop Partners, the Ellen MacArthur Foundation, Greenpeace International, Paris City Hall, Nestle, the New York Mayor's Office of Sustainability, PepsiCo, P&G, TerraCycle/Loop, Unilever, WWF and the UN Environment Programme. Erin Simon from WWF and Tom Szaky from TerraCycle/Loop have served as 2020/21 project co-chairs.

The present guidance document is part of the Consumers Beyond Waste 2020/21 work program. The project's Design Guidelines Working Group laid the foundations for the document. In a series of virtual meetings between June and November 2020, members of this informal, ad hoc multi-stakeholder group exchanged best practices, insights and research, as well as advised on the purpose, scope and structure of the document. Jonathan North from CHEP and Erin Simon from WWF served as co-chairs of the working group. The working group co-chairs played a leading role in synthesizing and structuring the working group findings. Following further editing by the World Economic Forum project team, the draft was shared back to the Working Group and other interested stakeholders for additional comments.

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I. Introduction

Single-use packaging systems have been in place for many decades, and their manufacturing, distribution, retail, and consumption models have matured to such an extent that these have become extremely affordable and integrated into daily business/consumption. However, today's economies of scale and rates of adoption and integration have reached a point where, under a business-as-usual scenario, they are creating waste at an alarming rate. There may be some situations in which single-use will make sense given the existing recycling streams, requirements of the product being delivered, scale, and operational model. However, reuse should be prioritized as the preferred strategy wherever possible.

Virtually all Consumer Packaged Goods (CPG) packaging, with a few minor exceptions, is designed for single-use. In order to maximize the benefits of reusable packaging systems, a mindset shift in packaging design will need to occur. As reuse systems transition from pilot to scale there will be a need to shift away from light-weighting and minimizing packaging costs, towards using higher quality packaging materials that provide longevity and optimized user experience. Refill/reuse models will enable materials like metals, higher quality glass and high-performance plastics that were not previously economically viable as single-use packaging.

Beyond achieving higher durability, reusable packaging needs to be designed for the reuse loop and its distinct steps related to refilling, cleaning and sanitization, collection, and return. In addition, reusable packaging design needs to deliver against broader societal imperatives, in particular public health and safety, net-positive environmental impacts, and consumer engagement. To succeed and scale, reuse systems therefore require improved guidance on safety questions and need to be informed by new or revised environmental criteria. Finally, innovative design for reuse opens an exciting world of opportunities to rethink how consumers can engage with and derive value from products and packaging.

Reuse thus offers the design community a massive opportunity and responsibility to dream and lead the way in developing the packaging and delivery systems of the future that can enable truly sustainable production and consumption models.

II. About the guidelines

Purpose and audience

The present guidelines are intended to inspire and support designers, materials scientists, packaging engineers and reuse system providers in their efforts to design, develop and implement new consumption models that provide consumers with scalable alternatives to single-use. They seek to do this by pulling together in one resource the key design criteria and considerations practitioners should account for in order to participate in this space.

Format

The present document is a static snapshot of insights, recommendations and resources compiled by the Consumers Beyond Waste project community of the World Economic Forum. It is the intent to generate updated issues of the document in the future, to allow for continuous updates, improvement, and further additions to this body of collective knowledge over time. As such, the present document should be considered as a starting point, an initial foundation upon which the reuse community can build in the months and years ahead.

Scope

The following scope considerations were made in developing these Design Guidelines:

- **FMCG focus**: The Guidelines focus on supporting the development of reusable packaging systems for fast-moving consumer goods (FMCG), such as food and beverage, personal care and other common household products used in daily life. Per the EMF, FMCG accounted for about ~60% of consumer spending and 35% of material inputs into the economy, but also ~75% of municipal waste. Note: It may be worth expanding from FMCG to also include the packaging associated with quick serve restaurants (coffee cups, wrappers) which are not a normal part of FMCG but interlinked. Reuse of other product categories (clothing, durable goods, cars, etc.) as well as B2B packaging are not considered, though in some cases the design criteria and considerations outlined here may be relevant.

- **Material agnosticism**: The Guidelines do not take a position in favor of or against broader material categories such as glass, metals, or plastics. Rather, it supports efforts by designers to move from single-use to multiple-use formats. This entails implications on material choice which will be guided by a wide range of factors, including functional requirements, environmental performance, economic considerations, and consumer preferences.

- **Guidelines, not standards**: The Guidelines do not intend to set technical standards of any kind. This is the domain of regulators and standards setting bodies. Instead, the guidelines compile high-level criteria, considerations and recommendations shared by a diversity of stakeholders engaged in developing reuse solutions.

- **Reusable container vs. reuse system design**: Reuse-systems are complex and require the design of multiple system components, including for example logistics and transport systems, cleaning infrastructure, data platforms or adapted retail spaces. Moreover, different reuse modalities share certain design requirements but differ in others. For example, 'refill-on-the-go' solutions (such as bulk-dispensing in supermarkets) require the design of new retail spaces and processes, while 'return-from-home' solutions (reusable containers shipped to customers' homes) do not. To keep the scope manageable, the focus of these initial Design Guidelines lies on the design of the *reusable container* and how it interacts, throughout its journey, with some of the *key reuse system components*. The following section 'Design Guidelines Framework' discusses this approach in greater detail.

- **Reuse-specific considerations**: As much as possible, the Guidelines focus on design aspects that are unique to reuse. Many, if not most, design considerations are of universal character – for example the imperatives that packaging materials need to be free of harmful toxins, or that the packaging needs to be designed to protect the product inside. These are examples of considerations that designers need to heed irrespective of whether the packaging is designed for single or multiple use applications and therefore fall out of the scope of the Guidelines.

- **Design criteria related to environmental sustainability and public health and safety**: Environmental and safety considerations are essential for the design of any packaging. That said, they take on particular meaning in the context of reuse design. As regards environmental considerations (See dedicated section in this document), the premise that reuse models are more environmentally friendly than their single-use alternative serves as a primary motivator for stakeholders to advance reuse in the first place; in fact, they present a new environmental calculation to designers that spreads the environmental (and economic) footprint of packaging across multiple product usages. As regards public health and safety, the cleaning and refilling of reusable containers – above all in the food and beverage space – present unique challenges and solutions that merit particular attention, not least in today's COVID pandemic context. The Consumers Beyond Waste's Safety Guidelines for Reuse provide additional details on public health and safety questions.

III. Overview: Design Guidelines framework

		Reuse system							
		Container life-cycle							
			Reuse cycles						
		Production of container	(Re)filling	Use	Collection	Storage/ transport	Cleaning***	End-of-life / recycling of container	Other
Container	Materials								
	Design								
	Artwork/labelling								
	Technology								
	Other								

To succeed, reuse models require the design of complex systems that involve many different stakeholders from the ecosystem. In order to develop a first foundation and provide designers with actionable tools to advance reuse solutions, the present document proposes a simple framework designed to cut through the complexity without falling into a myopic or siloed approach.

The proposed framework is based on two interdependent design dimensions: the design of the reusable container and the design of the reuse system (see figure above).

Container design

The reusable container serves as a first starting point and lens into the broader reuse ecosystem. The 'reusable container' concept employed here is a very broad one. It can include, but is not limited to, the direct replacement, by the manufacturer or retailer, of a single-use container with a reusable container that is ultimately recovered from the consumer, cleaned, and refilled for the next reuse cycle. It can also include different models, where the reusable container is not directly replaced by the manufacturer or retailer by a reusable container, but rather by a new delivery system, such as a bulk-dispensing system in a retail location. In this case, the reusable container is then handled and/or owned by the consumer and interacts with the delivery system inside a store or cafe.

The Guidelines focus on the following attributes for designing reusable containers:

1. **Materials**: The material from which the container will be manufactured
2. **Design**: The design of the container (beyond the materials)
3. **Artwork/labeling**: Any required artwork of labeling describing the contents, ingredients, legal information, consumer guidelines, etc.
4. **Technology**: Any technology required to support the tracking or reuse of the container to eliminate loss, support environmental or other relevant calculations, enhance the consumers' use of the reusable container, etc.

Reuse system design

The reusable container is only one component of a reuse system. Depending on the modality of reuse, the reusable container needs to be (re)filled, used, collected, cleaned, and transported (usually multiple times). Beyond the reuse loop itself, the container needs to be produced and, at the end of its life cycle, ideally after as many reuse loops as possible, repurposed or recycled.

Reuse and life cycle

The Guidelines therefore divide the reuse and life cycle of the container into the following seven stages which are generally relevant across all reuse modalities (refill at home, refill on the go, return from home, return on the go). Depending on the product and the modality the importance of each of the following stages may vary.

Reuse cycle

1. **Fill/refill**
2. **Use**
3. **Storage/Transportation**
4. **Collection**
5. **Cleaning**

Container lifecycle

6. **Production**
7. **End- of Life**

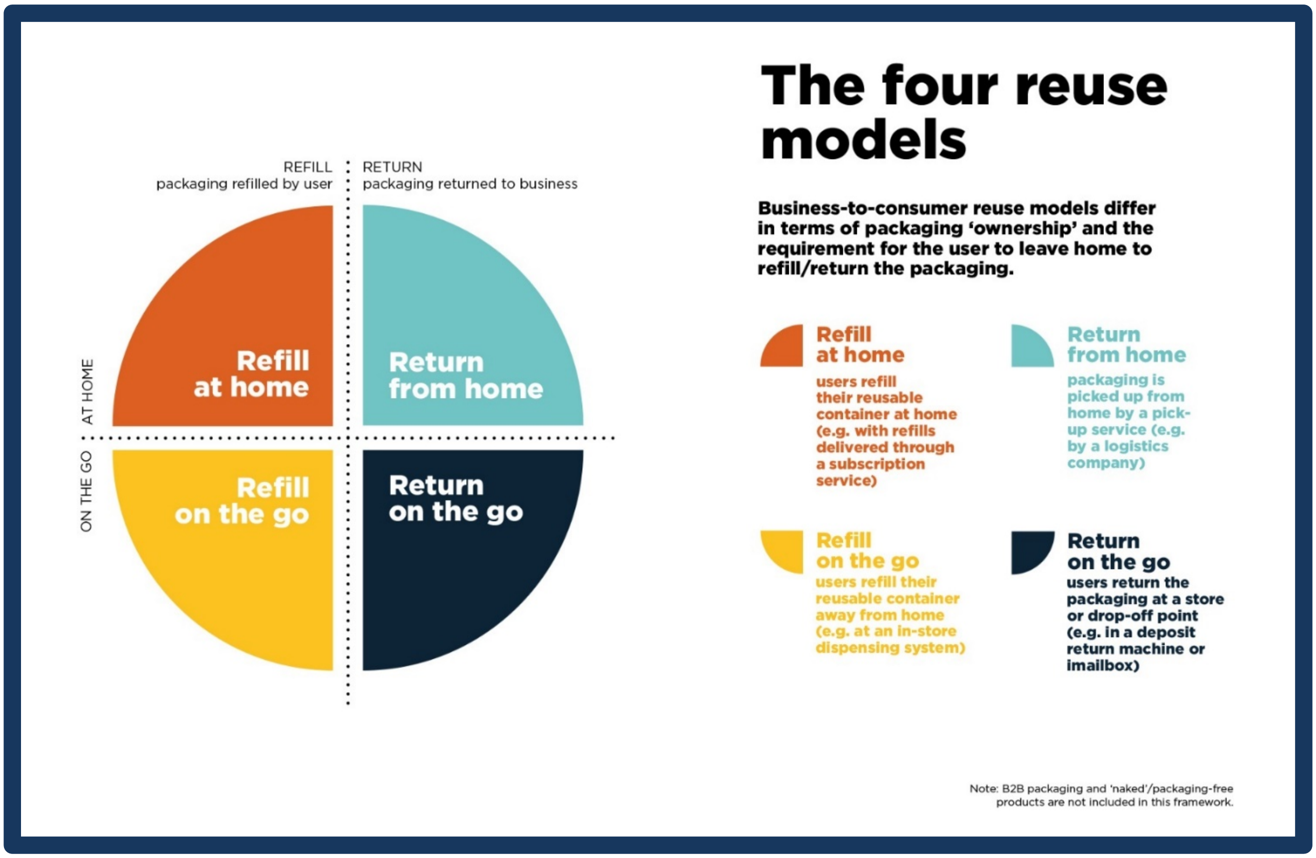
The design of the container has to be informed by these different stages in the reuse cycle and lifecycle. The steps themselves represent entire areas for design, both physically (e.g. refill station design) and in terms of related processes and technologies (e.g. refill station B2B supply design).

Limitations and applications of the framework

The proposed framework acknowledges the full complexity of this wider reuse system. However, in the spirit of a manageable and actionable scope, its focus is limited to system design considerations where the system interacts with the reusable container. As such, many broader design components are not captured by the framework. The initial version of the Guidelines therefore necessarily represents an incomplete treatment of the reuse system. The concluding section on Next Steps seeks to outline some of the key design questions that lie beyond the scope of this document and that deserve dedicated analysis in the future.

The proposed Design Guidelines framework is applicable to different reuse models. The Ellen MacArthur Foundation has classified reuse models into four principal categories, summarized below. However, the relevance of the different design components will vary by model. Generally speaking, the container-related design components (materials, design, artwork/labelling, technology) may be less important for ‘refill-at-home’ applications compared to the other three models, where containers need to integrate into larger-scale collection, cleaning, and refilling operations. Similarly, the collection design component is disproportionately relevant for ‘return-on-the go’ applications, where returning empty containers into a network of publicly accessible drop-off points is a critical piece.

The Ellen MacArthur Foundation’s organization of reuse systems into four distinct modalities allows designers, consumers, and the entire suite of actors involved in reuse to see major differences and similarities between the modalities. The EMF structure divides reuse models across two major lines: packaging ownership and location of packaging return/refill. This structure allows for more tailored improvements to and shared learning within each individual modality.



Source: “Plastics and the Circular Economy”, Ellen MacArthur Foundation

<table>
<tr><th colspan="2">Types of Reuse Models</th></tr>
<tr><td>Refill at home

Refill at home can work in both traditional and online retail. The model works particularly well for e-commerce as the online interface enables communication of an integrated solution and at the same time there is no competition for shelf space from products sold in standard packaging. Current examples of Refill at home include:

• E-commerce for compact refill products that are used at home or in office buildings on a regular basis, e.g. beverages, home care, and personal care products.
• Traditional retail outlets for standard-sized (non-compact) refills, e.g. for home care and personal care products.</td><td>Refill on the go

Refill on the go requires a physical store or dispensing point, which makes it better suited to traditional retail outlets and urban environments. In low-income markets, the model can accommodate customers' needs for small quantities at affordable prices without relying on single-use sachets. Current examples of Refill on the go include:

• Traditional retail outlets for products like beverages, cooking essentials (e.g. grains, flours, oils), personal care, and home care.
• Refill stations in cities for coffee to go or water fountains.</td></tr>
<tr><td>Return from home

Return from home is suitable for e-commerce as the pickup of empty packaging can be combined with the delivery of new products. It is particularly well suited for urban areas with reduced travel distances between deliveries. Current examples of Return from home include:

• E-commerce for products such as groceries, meal delivery, personal care, home care, and beauty.</td><td>Return on the go

Return on the go is widely applicable as it can substitute most single-use packaging without changing the fundamental purchase conditions. Current examples of Return on the go include:

• Traditional retail outlets for beverages where the model has been proven to work at scale in several geographies (e.g. Latin America, Japan, and Europe).
• Permanent and/or temporary stations in cities for products on-the-go such as takeaway coffee, beverages, and food.</td></tr>
</table>

Cross-cutting design imperatives

Finally, the proposed Design Guidelines framework incorporates, where possible, specific design considerations that advance critical overarching imperatives such as:

- Economic viability
    - Design for brand equity as well for a reuse ecosystem

  - Prioritize design standardization across all internal and external touchpoints to increase efficiency and affordability
  - Containers should have both quantitative and qualitative value – for consumer, informal labor sector, brand, or collection company/city
  - Containers should be optimized for local reverse logistics or vice versa
  - Design of reuse should be more desirable than single-use (design, cost, usability)
  - Containers must work for all retail (large and small), and e-commerce

- Social inclusivity and viability + Consumer engagement and adoption
  - Consumer convenience and behavior considered
  - Personal privacy assured in digital platforms
  - Educating consumer is part of design
  - Reuse packaging can hold an emotional connection between the brands and the users

- Public health and safety
  - Containers must be durable to withstand many washings and sterilization
  - Tamper-proofing assured

IV. Design considerations for reuse

Reusable Container Design

Based on the framework outlined in the previous chapter, this section focuses on design criteria and considerations related to the reusable container itself. It will specifically look at four key container design elements: materials, design, artwork/labelling, and technology.

Each of the four elements entails its own set of considerations. However, across all of them, design needs to support the overarching objectives of durability (for optimizing the container's reuse cycle) and recyclability (for optimizing the container's lifecycle).

It is important to note that design choices will have a direct impact on durability and recyclability, which are the key determinants for the social, environmental, and economic viability of any reuse model.

1. Materials

Like their single-use equivalents, reusable packaging materials naturally need to deliver on primary functionality and adhere to existing health, safety, and sustainability standards. Beyond that, what factors should designers consider when making material choices for *reusable* containers in particular?

Reuse cycle considerations

The reuse cycle includes a number of pressure points at which packaging materials are subject to stress and potential damage. The materials need to withstand these pressure points – not only once, but multiple times as the packaging travels through the reuse loop over and over again. The most critical pressure point is cleaning. Other key pressure points relate to use (retail/consumer handling), transportation and collection:

- **Cleaning**: Designers must take into account the ease, affordability, and effectiveness of cleaning reusable containers. Implications for cleaning based on EMF's reuse categories are explored in detail in the Safety Guidelines. The *Safety Guidelines* also explore considerations for cleaning chemistry, environmental considerations of different cleaning processes, and provide general recommendations for cleaning across all modalities. The health and safety of reuse systems depends largely on ability of reusable containers to be effectively cleaned and sanitized between every use. Material choice strongly influences the ability of a container to be cleaned, resistant to degradation, and safe for consumers even after many reuse cycles. The *Safety Guidelines* provide specific recommendations for designers to improve ease of cleaning as well as information on designs and materials that should be avoided. For example, porous materials like cork can harbor bacteria and should therefore be avoided; containers should be designed for ease of assembly and disassembly for easy cleaning, and they should be compatible with household cleaners and utilization in household dishwashers.

- **Use and storage/transportation**: Handling of the reusable containers by consumers, retailers or logistics providers causes wear and tear. The degree to which usual wear and tear depreciates the asset value of the reusable container will depend significantly on material choice. Containers may also fall or get dropped or be subjected to inappropriate treatment or use. Material choice will play an important role in minimizing the probability that damage to the container disqualifies it from remaining in the reuse cycle. The loss of reusable containers during use and storage/transportation therefore represents a qualitatively different design challenge compared to single-use: In the single-use scenario, the packaging is usually a variable cost factor for the owner of the product and its packaging. In cases where single-use packaging breaks or fails, the loss is normally limited to the product inside. In contrast, in the reuse scenario, where packaging is considered an asset by its owner, its loss is much more costly and – at frequent occurrence – undermines the economic (and environmental) viability of the reuse model.

- **Collection**: 'Return-on-the-go' models where empty containers are dropped into collection bins, present a particular risk. Clearly, the design of the collection solution itself is an important factor. That said, material choice may play an important role in ensuring that reusable containers do not suffer significant damage (e.g. dents or permanent scratches) or breakage (e.g. of glass containers).

Lifecycle considerations

- **Reuse-qualifying materials:** The above-mentioned pressure points, in particular the need for proper cleaning, disqualify upfront certain materials from reuse applications. Designers of reusable containers are therefore limited to a shorter list of durable materials generally suitable for multiple uses. Beyond that – and as shown by the collection-related considerations mentioned above – different materials will have distinct advantages and risks associated with particular product applications or reuse models.

- **Composite and combined materials:** e.g. introduce primary vs. secondary elements

- **Material lifespan:** Apart from ensuring that materials perform as required during multiple reuse cycles, designers also need to consider the overall material lifespan. In other words, they should look at both the number of expected reuse cycles and the average duration of each reuse cycle when assessing material choices. Note, a minimum number of cycles is required for environmental and cost reasons, and that the design/material choice should accommodate for that minimum number of reuses.

- **Material production:** The impact of a reuse container and the system it operates in is heavily influenced by the original sourcing and production impacts. Social and environmental impacts of resource extraction and global commodity production pose major risks to humans, nature, and a company's reputation and bottom line. Responsible sourcing of raw materials can reduce the associated detrimental impacts of both resource extraction and agriculture on people and the planet. Responsible sourcing can also increase transparency and accountability. Managing environmental and social risks within supply chains is critical to long-term supply sustainability and security. Material conversion and production also contributes to a reusable container's life cycle impacts; processes may take place in multiple locations and have a range of impacts to water, climate, and land. For more information on the considerations of material sourcing and production please see Environmental Considerations in a Reuse Framework in below section.

- **Material end-of-life/recycling**
  - What is the impact if the material is littered, landfilled, or otherwise disposed of?
  - Can the material be recycled through an established waste stream? Can it be recycled back into itself?
  - What recycling infrastructure exists to support the use of this material?
  - Can the material be effectively recycled in the region of its end use? Are there geographical differences in access to recycling resources that should be considered?
  - Can recycled material be integrated into the container? Is it available in the right location, the right volume and to the right specification?
  - Can recycled content be prioritized?
  - Can bio-based/renewable materials be prioritized?

Other considerations

Other design considerations related to material choice include:

- **Relative benefits of durability**: The choice of material has significant economic and environmental cost implications for the container. Directionally, higher investments in better materials can increase their durability, growing the asset value of the container. However, both the marginal economic and marginal environmental benefits that can be achieved through ever more durable materials (i.e. with each additional reuse loop) will decrease. At a certain point, additional investments in the material's durability will therefore not pay off, especially when the container's initial production cost becomes too high and risky. Material considerations will therefore inform and be informed by an ideal price point of the reusable container that can support the commercial and environmental viability of the reuse model.

- **Consumer perceptions**: How consumers perceive, and experience different materials affect their purchasing and consumption behavior. Sensory, cognitive, and emotional factors play into consumers' experiences and evaluations of a given material and, associatively, the product and brand. For designers, this important consideration offers both challenges (e.g. departure from 'habitual' single-use materials; matching specific convenience factors enabled by single-use materials, such as light-weight or stackability; or strong consumer pre-conceptions related to certain materials) and opportunities (e.g. product innovation/re-imagination; or premium consumer experience through higher-quality materials).

- **Broader systemic considerations related to materials**: It can be expected that shifts from single-use to reuse models entail shifts in the packaging materials used. Such shifts can be significant at the level of a given business or of entire markets, whether local, regional, or global. Although beyond the narrower scope of the product design itself, material choice can have broader implications on stakeholders and the ecosystem. Such implications for example include the availability and market conditions of materials and associated inputs, or sustainability impacts related to their sourcing (such as extraction and transport). In particular when considering the use of certain materials and inputs at larger scale, holistic cross-functional and interdisciplinary assessments related to commercial, social, and environmental risks (and opportunities) must be taken into account in design.

2. Design

This section discusses other design considerations related directly to the primary reusable container, beyond the material questions discussed above.

General design considerations

- Design for longevity & durability
- Design for ease of cleaning (dishwasher safe/designed to be disassembled for cleaning)
- Design for ease of disassembly at end of life
- Design for the environment the product will be used in (e.g., waterproof if used in the bathroom, air sealed if used for food products, microwavable if product is typically heated)
- Optimize design for usage occasions (see below design considerations by reuse modality)

Design considerations for 'Refill at home'

- Determine if it will be a cartridge system or pour system
- Ease of refill using ergonomic considerations (e.g., wide opening)
- Design for plug and play systems that are quick to refill
- Design for ease of delivery (shapes that fit through mailboxes)
- Adaptor/Connector based designs

Design considerations for 'Refill on the go'

- Easy to transport (Handles, collapsible, lightweight etc.)
- Adaptor/Connector based designs
- End of life of refill component needs to be locally relevant
- Design for no mess refilling

Design considerations for 'Return from home'

- Design to optimize transportation
- Stackable
- Optimized for transportation
- Design for durability to withstand shipping

- Internet/E-Comm friendly

Design considerations for 'Return on the go'

- Easy to transport
- Design for convenience
- Nestable designs
- Shelf ready

Other design considerations

- Forward logistics
  - Does it need to fit into retail shelving or other systems?
  - Does it need to be compatible with existing packaging lines and equipment?

- Reverse logistics (for "return" systems):
  - How to design for initial filling and subsequent re-filling? Bulk refilling?
  - Can the containers be part of a modular system?
  - Does the design need to be foldable, collapsible, nestable to optimize collection systems?
  - Does it need to be designed for new collection systems? Reverse vending machines?
  - Does it need to be designed for transportation? How will the containers be transported?
  - Does it need to fit a certain footprint?
  - Does it need to be designed for secondary package considerations (i.e. pallets?)
  - Does it need to be smart (taking into consideration different global contexts)?
  - Are technology/digital IDs needed to assist in sortation/aggregation/redistribution?
  - How to design for washing/sanitization?
  - How to design for manufacturing refill systems? Does there need to be manufacturing standards that enable refill for packaging formats?

3. Artwork & labeling

As in the case of single-use packaging, artwork and labelling on reusable packaging serve to enhance the visual appeal of the product or brand, and to communicate important information to consumers and other actors in the value chain.

As in the case for single-use equivalents, the need for including product-related information on the packaging is strongest for pre-packaged goods due to associated brand differentiation. In a reuse context, 'return-from-home' and 'return-on-the-go' models involving prepackaged goods therefore tend to face more complex artwork/labeling questions than refill-focused solutions with generally fewer informational requirements.

Artwork/labelling lifespans

One of the considerations that is fundamentally different in a reuse context is that the informational elements provided on the container need to be broken down by their optimal lifespan. For example, any information provided to consumers or other stakeholders related to the durable container itself is of permanent relevance, i.e., for the entire lifecycle of the container; in contrast, specific information about the product content for a single usage relates to one of the container's much shorter reuse cycles. In the single-use scenario, this differentiation is generally irrelevant given that the use cycle and lifecycle of the product and container are largely aligned.

Based on this differentiation by information lifespan, designers can consider what combination of permanent, semi-permanent or non-permanent artwork/labeling solutions to deploy. Generally speaking, any information related to the durable container can be permanent. If the container is proprietary to a brand (either a brand of a content manufacturer or a brand of a reuse solution provider) certain branding elements may also be considered permanent. Conversely, if the container is generic, branding elements – if relevant at all – can be of temporal nature. Finally, any information elements directly related to the product's content, such as product descriptions, ingredient/nutritional information, or batch numbers – are the most likely ones to be of temporal nature but take into account local regulative requirements.

The decision on where artwork/labelling elements fall on the permanent vs. non-permanent spectrum, will depend on a number of considerations, including for example:

- How versatile is the reusable container? For example, can it be used for multiple flavors or even product types?
- How stable or dynamic is the product (content) associated with the container over time? Is it expected that new products or product variations will be introduced in the near future or within short intervals of time? Are products (content) expected to change frequently due to seasonality?
- How likely or frequent is the need for updating information (language, regulations, standards, nutrition, etc.) even if the content doesn't change?
- Does the artwork/label have a primary role in branding the product?
- Will the container be a generic one that can be used by different brands? Artwork may also play a role in returns and collection of the packaging item (such as QR codes, deposit information, etc.). In that case, it needs to have a lifespan as long as the lifespan of the packaging item itself.

Reuse cycle considerations

The reuse cycle includes a number of pressure points at which artwork/labelling elements are subject to stress and potential damage.

In some cases, the artwork/labelling is designed to be permanent and therefore needs to withstand these pressure points – not only once, but multiple times as the packaging travels

through the reuse loop over and over again. The most critical pressure point is cleaning. Other key pressure points relate to use (retail/consumer handling), transportation and collection.
In other cases, the artwork/labelling is designed to be non-permanent and needs to be fully removed from the container to make room for new information elements for the next reuse cycle.

To achieve the desired outcome, all key artwork/labelling components need to be designed accordingly, including for example labels, adhesives, inks or etching.

- **Use and storage/transportation**: Handling of the reusable containers by consumers, retailers or logistics providers causes wear and tear to artwork and labelling. The degree to which usual wear and tear compromises artwork and labeling will depend significantly on the choice of materials and technologies. Containers may also fall or get dropped or be subjected to inappropriate treatment or use. Design choice for artwork/labelling will play an important role in minimizing the probability of damage. The stakes are particularly high where damage to the artwork disqualifies the entire container from being reused; at frequent occurrence – the loss of reusable containers undermines the economic (and environmental) viability of the reuse model.

- **Collection**: 'Return-on-the-go' models where empty containers are dropped into collection bins, present a particular risk. Clearly, the design of the collection solution itself is an important factor. That said, design choices for permanent artwork/labelling can play an important role in avoiding unnecessary damage.

Other considerations

- **Supporting consumer engagement**:
  - Education, awareness, instructions related to reuse
  - How will you communicate not only the product but also the systems and behavior to support its reuse?
  - Should artwork be used to differentiate reusables from single-use?
  - How to communicate that the container is clean and the contents are secure?
  - How to communicate to the user where and when it can be reused and refilled?

4. Technology

This section looks specifically at design considerations related to unique identification and advanced track & trace technologies. Such technologies, above and beyond standard barcode technologies existing widely in the market today, can be embedded in reusable containers and link them to integrated data platforms and/or refill systems.

Reuse solutions do not necessarily depend on such advanced technologies to work, and the traditional milkman model – among many others – is a great example of that. At the same time, in many markets, the explosion of choice in products and retail channels over recent decades has meant that 'going back' to reuse will be more complex and that advanced technology solutions can help improve user experience and/or operations related to reuse systems.

From a design perspective, smart technologies, such as those mentioned above, can be an attractive proposition in the reuse context. There are a number of reasons for this:

- The redefinition of the container into a reusable asset justifies higher investments in it, which can include technologies that are more expensive than standard barcode technology.[1]
- The cost of smart chips and sensors is coming down as they are more widely deployed for a wide range of applications.
- The brand owner or retailer can leverage the technology to provide new or better services to consumers, such as packaging-as-a-wallet solutions or customized product dispensing.
- Beyond the consumer, the container can 'communicate' with different reuse loop and lifecycle touchpoints such as logistics, cleaning, refilling, or recycling, facilitating the operation of reuse systems.
- Operators, governments, academics and/or other stakeholders involved in studying the impacts of nascent reuse systems can greatly benefit from relevant data insights.

Integrating technology into packaging may bring improvements to the full reuse cycle but designers should be careful to ensure these changes do not impede recycling of the materials at end of life – designers should ensure that the integrated technology has a clear plan for dismantling and circularity.

Reuse cycle considerations

Below is a list of potential situations in which integrating technology into packaging can improve the functionality and success of the reuse cycle.

- **(Re)fill / use**: Container inspection/removal (after x uses), touchless refill (especially for 'refill-on-the go'); precision dosage or mixing, digital payment, real-time consumption data, loyalty programs, etc.

- **Collection**: identification as reusable, sorting, deposit handling etc.

- **Storage/transport**; real-time inventory tracking, shelf-life tracking etc.

- **Cleaning**: durability of technology; certification of cleaning; etc.

- **Production/recycling**: material passport / recycling instructions / rerouting back to owner and/or manufacturer; data on number of reuse cycles allows measuring environmental lifecycle impact of container.

Other considerations

[1] This is because (a) the technology cost is divided by multiple uses and (b) because some track & trace technologies can help minimize the risk of loss or theft of the container.

- **Track and trace**: Tracking and tracing of individual packaging units have significant costs and complexities. The importance of tracking will vary significantly by business model and/or product type. What value is created by tracking the packaging?

- **Physical vs. digital information**: What information needs to be physically displayed versus being accessible on demand via digital solutions?

- **Data privacy concerns**: open vs. proprietary platforms etc.

Reuse System Design

Again, based on the framework outlined in the previous chapter, this section focuses on reuse system design considerations related to the reusable product. It will specifically look at the big questions designers need to think of at the various stages of the product lifecycle in the context of the reuse system: production, filling, and refilling, use and user experience, collection, transport and storage, cleaning, end of life.

1. Production

- What is the best and most appropriate manufacturing process to use for the container?
- What is the best and most appropriate remanufacturing process to use for the container if it is to be recycled at end of life?
- How to consider the environmental impact of the manufacturing process?
- What is the transportation impact of manufacturing?
- Can the manufacturing process be brought in house?
- How to understand the impact on production of initial volume demand versus longer term? Demand may well decline over time.
- What is seasonality for product?
- What are regional differences?
- Can the production processes be modular and adaptable to future product development opportunities?
- What are the social impacts and implications of the material and manufacturing process?

2. Filling and refilling

- Will the container be refilled during the reuse cycle?
- Who will perform the refilling?
- What implications will filling, and refilling have on container design, for instance size of opening aperture?
- Does the container need to integrate into existing filling and packaging lines?
- Do any of the filling procedures exclude or limit certain materials (pasteurization, hot fill, aseptic, etc.)?
- How can design help ensure filling and refilling happens in a safe and hygienic way for both filler and user? (grip, slip, spillage, temperature, etc.)
- Packaging material and design needs to carefully considered to minimize potential complications, like spills, during the refill process. Intelligent design will minimize the potential for packaging to come into contact with the dispensers. How can we ensure this?

3. Reusable packaging in use/user experience

- Considerations for the weight of the container (and contents) from a user experience?
- Considerations for the dimensions of the container?
- Accessibility for all to be able to use container (weight, shape, ease of removing lids, etc.)?

- Refill at home specific considerations?
- How to prevent counterfeit?
- How does packaging material type impact packaging longevity?
- Does packaging material type increase potential of contamination risk as the material ages-how chemically inert is the material?

4. Collection

- How will the container be collected and consolidated in its use phases?
- How can transport efficiency be maximized?
- Should transport maximization be a consideration (will it be necessary for containers to be nestable, stackable, foldable, etc.? → how to optimize transport efficiency (given environmental considerations, this will be key in most reusable systems)?
- How to deal with theft?
- How will you measure durability?
- How to consider acceptable levels of damage or loss?
- How to assess when a container is not up to standards anymore (esthetic, quality, or safety), and how to take it out of the reuse cycle?
  Note: The factors that determine when a packaging unit needs to be replaced will vary by product type and ultimately should be decided by quality assurance standards of the product providers. One way to responsibly take the packaging out of reuse is having the packaging designed for recyclability and offer the customer a new free packaging if they trade in the old end-of-life packaging (assumes the packaging has a deposit).

5. Transport/Storage

- How can transport efficiency be maximized?
- Should transport maximization be a consideration (will it be necessary for containers to be nestable, stackable, foldable, etc.?

6. Cleaning

- Will the containers have to be cleaned during their use?
- How frequently will the containers have to be cleaned?
- How to design for efficient cleaning and drying?
- Where will cleaning take place? (at home, on premise, off-site) [Depending on the business model and product type, cleaning could take place at home, on premise or off-site. In general, off-site cleaning offers the highest level of sanitization and is most likely to meet more rigorous sanitization standards for refill products with higher risk profiles. This also means off-site refill systems will more likely be able to be used for more product types.]
- What cleaning process will be used?
- What chemicals will be used?

7. End of Life

- Even the best designed and well-intentioned reusable systems will have an end of life; how will end of life be handled?
- How can recyclability be maximized through material and system design choices?
- What is the impact of littering of the container, and how can this be handled?
- How to design system in such a way that returns/number of reuse cycles are maximized? How can customers be incentivized?

Environmental Criteria for Reuse

Introduction

An environmentally beneficial reuse system is one that reduces waste, pollution, and other environmental impacts as compared to single-use packaging. The goal of this section is to cover the main environmental opportunities and risks associated with reusable packaging regardless of material type, production area, and available infrastructure. While this work fits under the Consumers Beyond Waste Design Guidelines, users should also consult the Consumers Beyond Waste Safety Guidelines and City Playbook for a holistic understanding of reusable materials and systems, and their impacts on people and the planet.

This section does not go into detail describing the current environmental impacts of single-use packaging – such as those related to material production, use, and disposal – which are well-documented in the literature. The linear system (take-make-dispose) of single-use packaging has a wide range of negative impacts on people, nature, and economies.

Moving towards a more circular, reuse-based packaging system will allow us to do more with less, getting more value out of the embedded energy and material already in the system. As with all packaging, environmental impacts should be considered through the entire lifecycle - from extraction of raw materials through end of life. Reusable packaging systems hold potential for reduced environmental impacts including but not limited to reduced waste ending up in the environment and lower greenhouse gas emissions as compared to the existing alternative (i.e., the reference system, single-use packaging).

Packaging materials deliver multiple important functions including protecting a product for a given period of time from light, oxygen, humidity, and contamination; delivering a product safely to a consumer; and conveying important information. The nature of the product determines what specifications the packaging needs to meet in order to protect the product inside. Packaging materials can fulfill their needed functions in different ways depending on the nature/technical characteristics of the material used.

The material used for packaging significantly impacts the environmental performance of the packaging, but other factors must be considered as well. Every step of the process from raw material sourcing to final disposal requires some amount of energy and other inputs and has potential to release emissions and generate waste. A multi-indicator approach is necessary to holistically evaluate the environmental performance of a reuse system. Indicators may include but are not limited to: greenhouse gas emissions (from land-use change, agricultural production, machinery, infrastructure, and other sourcing activities; processing, transportation, end of life management); sourcing and/or pollution impacts to areas of high or unique biodiversity, protected areas, and overall ecosystem health; water scarcity; water pollution and consumption; toxicity to humans and non-human species; pollution from sourcing and/or waste management including localized air pollution, solid waste pollution, and chemical pollution; soil degradation. In exploring the environmental impact of reusable packaging, as in most sustainability work, tradeoffs along the value chain and between the indicators are unavoidable.

The fundamental idea of tradeoffs for environmental impacts of reusable packaging can be illustrated by the following example: one material, Material A, may be far heavier and thicker than Material B, causing the former to have a higher greenhouse gas footprint from transportation. If Material A however is reused 100 times while Material B can only achieve 10 reuse loops, Material A may have a lower environmental footprint per package delivered as the environmental footprint is ultimately divided by the total number of reuse loops. Material A may have had any number and combination of drawbacks (higher water footprint, higher energy for extraction, etc.) but depending on the number of loops it achieves, this impact may prove less consequential than an alternative material with a smaller footprint and a smaller number of reuse loops. This is only one example to illustrate a possible combination of tradeoffs to consider. Materials A and B may differ on any number of characteristics such as sturdiness, resistance to scratching and damage, capability of withstanding multiple wash/disinfection cycles, among many others. Tradeoffs must be carefully analyzed to achieve a clear picture of the true sustainability of a material. For more information on potential environmental impacts of packaging please see the World Wildlife Fund's whitepaper *Packaging and the Environment*.

General summary of recommended and available tools

A preliminary list of tools that may be helpful for evaluating the environmental impact of reuse systems include life cycle assessment (LCA), supply risk analysis (SRA), credible third-party sustainability certifications, and individual assessment of company supply chains including purchasing, production, and post-consumer management of packaging materials.

Life cycle assessment (LCA): LCA permits assessing a wide range of environmental impacts associated with the delivery of a product or a service across its entire life cycle. LCA refers to a specific environmental management tool used to evaluate environmental impact, but also serves more broadly as a way of thinking (life cycle thinking). The basis for comparison in LCA is a functional unit--i.e., for a food product, the consumption of a unit of food--that can compare linear delivery models to reuse models while taking into account key reuse factors such as reverse logistics, cleaning and refurbishing, pool size, top-up rates and end of life treatment across a representative set of environmental impact categories. Although LCA does not permit assessing effects of waste leakage into nature for the time being, such impact assessment methodologies are currently under development. LCA is best used in combination with other assessment methods covering economic and social aspects with a life cycle approach as well as other methodologies that permit studying local or specific effects which are not accounted for in LCA. (See Ellen MacArthur Foundation's *The New Plastics Economy: Rethinking the Future of Plastics* for a more detailed discussion of the advantages and the limitations of LCA).

Supply Risk Analysis (SRA): SRA can help companies understand the environmental, social, and supply security and governance risks for material sourcing. Identifying the threats to nature and people in material sourcing and production is the first step in reducing potential negative impacts. See World Wildlife Fund's Supply Risk Analysis page or the SRA Methodology for more information.

Third-party sustainability certifications: Credible third-party sustainability certifications can improve transparency and ensure material sourcers/producers/managers deliver environmental benefits as claimed. Credible standards should be developed in compliance with *ISEAL's Code of Good Practice for Setting Social and Environmental Standards* to ensure transparency is upheld, grievance mechanisms are in place, and stakeholder management is structured and effective. The *WWF Principles for Standards and Certifications* provide an additional 16 principles considered as minimum requirements for standards and certification schemes to be credible and effective.
Additional examples of third-party sustainability standards : Roundtable on Sustainable Biomaterials, Aluminum Stewardship Initiative

Individual assessment of company supply chain: Companies can, either through formal processes or more informal information-gathering, assess the wide range of environmental impacts of their reuse system one indicator at a time. Already existing internal due diligence activities can provide significant insight into supply chain operations, though data typically need to be collected and consolidated across a wide variety of teams. Third-party auditing can also serve as a means to assessing the environmental impacts of a reuse system.

Criteria for assessment: analyzing step-by-step

In evaluating the environmental impacts of a reuse system at least 6 criteria should be assessed: sourcing and materials, production, transportation, durability, use, and end of life. Best practices, tools, and resources for evaluating each of these individual environmental criteria are listed below. However, to determine the true environmental impact of the reuse system, impacts from all criteria must be considered collectively.

1. Sourcing and materials

Why does responsible sourcing matter? Why does it matter which material is used?
Sourcing different materials has different impacts on the environment. Social and environmental impacts of resource extraction and global commodity production pose major risks to humans, nature, and a company's reputation and bottom line.

Responsible sourcing of raw materials can reduce the associated detrimental impacts of both resource extraction and agriculture on people and the planet. Responsible sourcing can increase transparency and accountability. Managing environmental and social risks within supply chains is critical to long-term supply sustainability and security.

The process for managing supply risk and working towards more sustainable systems can be summarized by the table below, beginning with knowledge and awareness as the first step.

Figure: Supply risk analysis, from: WWF, https://supplyrisk.org/

Many factors need to be taken into account in order to assess the sustainability of a material including environmental, social, supply security and governance, and economic and financial. WWF's Supply Risk Analysis covers more than 20 independent factors in exploring production risks of materials such as natural habitat conversion, impact on biodiversity, soil impacts, food security impacts, and many more.

It is important to acknowledge the complex value chain of packaging materials from production of materials through waste management. Material producers and converters come in all shapes and forms, as do waste management operators and infrastructure types; processes take place in multiple locations, adding to the environmental impact of the material before it is used (and well after it is used).

Best practice recommendations, tools, and resources:

- In general, recycled content is preferred over virgin content as it diverts material from the waste management system, prevents new impacts of sourcing, can conserve natural resources, and can be less energy intensive.
- See table 1 (at end of the section) for an overview of high-level risks for specific materials approved by the safety group of CBD for reusable packaging.
- WWF's Supply Risk Analysis, Supply Risk Inquiry, the Water Risk Filter, and BFA Methodology for the Assessment of Bioplastic Feedstocks help users understand the environmental and social risks of sourcing and support supply chain transformation.
- Certification systems such as Roundtable for Sustainable Biomaterials, Initiative for Responsible Mining Assurance, and Aluminum Stewardship Initiative can help ensure accountability in responsible sourcing.
- Forest Stewardship Council Certification is recommended for forest products to ensure that forests are responsibly managed to provide environmental, social, and economic benefits.

- Companies can provide procurement surveys to their suppliers to learn more about risks in their supply chain and whether or not mitigation activities exist. This can lead to a supplier evaluation to compare suppliers.
- *WWF Position Paper on Biobased and Biodegradable Plastic* for additional guidance on bioplastic sourcing
- One or more tools may be needed to fully assess the environmental impacts of sourcing. See Figure 2 below for an interpretation of how several available tools might work together to cover the full life cycle of packaging.

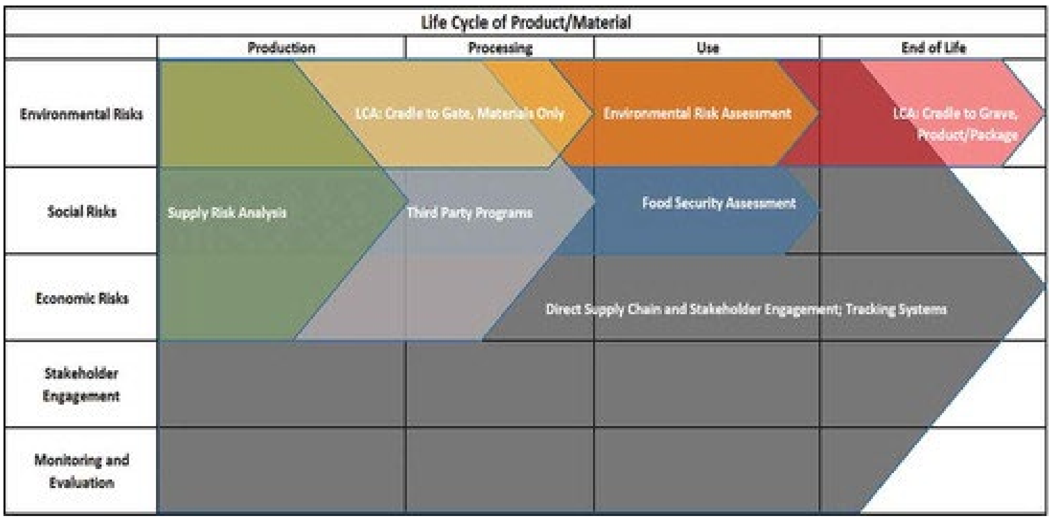


Figure: Sustainable sourcing assessment methods, from: Weisbrod, A., Bjork, A., McLaughlin, D., Federle, T., McDonough, K., Malcolm, J. and Cina, R., 2016. Framework for evaluating sustainably sourced renewable materials. Supply Chain Forum: An International Journal, 17(4), pp.259-272.

2. Production

Extracted raw materials are converted into intermediate materials, which are then processed into a finished product or component. Depending on the material and the final product many different industrial processes including mechanical and chemical processes may be used. During processing materials may be combined or mixed and additives added to ensure the product fits the needed specifications, for example: waterproof, durable, easy to clean, stronger, lighter, etc. The equipment and technology used in processing heavily determine the impacts. Potential environmental impacts from processing include water use, land use, energy use, and pollution (air emissions, water emissions, solid waste). To reduce the overall environmental footprint of a manufactured item, every stage of processing and its impacts must be considered.

Best practice recommendations, tools, and resources:

- Risk assessments and LCAs can serve as helpful tools for evaluating the impacts of material production.
- Key information that needs to be taken into account beyond transport of raw materials to the manufacturing sites are resources consumed and emissions and waste linked to the

manufacturing process, including the fate of generated waste. Such information can be factored into what is commonly referred to as a cradle-to-gate LCA which constitutes one important part of a cradle-to-grave LCA (this assessment covers the full life cycle, from extraction through use and disposal of a product).
- Material scoring tools can help evaluate environmental impacts through all stages of a material's life.

3. Durability

How many uses does it take for a specific material to be environmentally beneficial over its single-use alternative?

Durability is the ability of a material to last through multiple use cycles without significant deterioration and is one of the most important factors in assessing sustainability. Durability has to be paired with a functional, sustainable system of reuse to actually achieve the optimal number of reuse cycles. Reusable, durable materials in this context are those designed with the intention to be reused (i.e., not a material designed for single-use that happens to be reused). A durable material will not need to be replaced or repaired frequently, and ideally should be able to be infinitely recycled without significant losses to quality or quantity.

Compared with disposable items, durable items are designed to last through sturdier design and/or repair. Provided that the number of uses is high enough and that refurbishing operations do not create excessive resource consumption and emissions, this can result in saved energy, resources, and diverted pollution. Regular maintenance required of a durable material must be considered in the design phase, including brand or label changes and minor repairs. An item that can easily be rebranded and repaired is preferable as this material would not abruptly reach its end of life before its break-even point.

Best practice recommendations, tools, and resources:

- LCA is currently one of the best available tools to evaluate the environmental impacts of a packaging material as it relates to how many loops the material achieves. An LCA approach to assessing reuse systems must cover all relevant impacts of that system and in addition all relevant impacts of the reference system, i.e., single use packaging, for comparison.

4. Transportation

Goods must be transported from place to place and reusable packaging materials may require more transportation than their alternatives as the material is transported to and from the consumer to the producer/refiller of the good many times. For example, in a delivery-based/refill from home model, a product and its packaging is moved to and from the consumer's home back to the producer by a third party. In a refill in store model, it is moved to and from the store by the consumer. Therefore, in evaluating the transportation-related environmental impact of reuse systems, this analysis must cover environmental impacts from every step of transportation: raw material geography to processing plants, from processing plant to manufacturing plant, from manufacturing plant to co-packers (if used), from manufacturing plant or co-packing plant to distribution centers, possibly to retail stores, and possibly to and from the consumers home and back to the cleaning station and/or distributor while the packaging is being reused, and finally to disposal. Transportation covers any movement of the packaging pre-use, during use, and after-use (if subscribing to a LCA approach, any process which is a significant contributor to overall impacts of the system must be included in the assessment).

Best practice recommendations, tools, and resources:

- Evaluating the environmental impacts from transportation for a reusable packaging material/system can be pursued through modelling or direct measurement. As no comprehensive assessment for evaluation of transportation footprint is yet available, LCA can serve as a sufficient approach.
- *Environmental evaluation of means of transport*

5. Use (and consumer engagement that enables reuse)

There are a variety of reuse business models, each with specific implementation challenges and potential environmental impacts. Generally, reuse models fit into four categories: refill at home; return from home; refill on the go; and return on the go.

The environmental impact of use depends completely on the number of times the material is used and on characteristics of the systems in place to enable reuse (e.g., cleaning, transportation, refill system). Each reuse model has the potential to be innovative by gathering user insight, customizing user experience, customizing products, standardizing packaging formats and refill systems, and more, all the while encouraging the maximum amount of uses and thereby reducing overall environmental impact of the reuse system. Critically, consumers must be engaged to enable a reuse model, including through incentives (e.g., discounts and promotions), an improved user experience, and clear instruction and guidance to reduce unintended tradeoffs. Without consumer engagement, there is a strong potential for items to be leaked or mismanaged from the reuse system before a break-even point is met. Secondary packaging and transport packaging requirements that enable the reuse system and the corresponding environmental impacts of those materials must also be accounted for.

Regarding the cleaning of materials between use cycles, cleaning may contribute to environmental impact through increased water use and potential chemical use for sanitizing. Procedures and facilities that enable reuse may increase regional water demands and possibly contribute to local pollution of water resources through discharge. Planners should account for these impacts and mitigate these risks as much as possible. Consider that other cleaning and disinfection options that do not rely on the use of water could be selected (e.g., sonic treatments, air cleaning, ozone, and UV application); of course, other impacts could be associated with their use.

Environmental impacts from transportation (e.g., to and from users' homes) between use cycles is also a significant environmental consideration for designers to account for.

Best practice recommendations, tools, and resources:

- Consumer engagement and improved user experience to enable the reuse system
- Life cycle assessment (LCA)
- Promote continued and/or multiple use through convenience (e.g., easy to wash, easy to bring back, etc.)
- Leverage available technology on an opt-in basis (e.g., user preference data, smart packaging with GPS/location)

6. End of life (how to manage the materials when we are done with them)

How is the material managed when it is no longer functional in the system (e.g., once end of life has been reached)? Is the material technically recyclable (almost everything is) or is it actually recycled in practice and at scale?

End of life indicates a product has reached the end of its usefulness for an intended purpose. Inherent to the reuse design itself and to the consumer engagement strategy, a material intended for reuse should reach a maximum or break-even number of uses before reaching end of life. A circular reuse model which recovers end of life materials is environmentally preferable to a linear, take-make-dispose model.

There is potential for material mismanagement or leakage throughout the life cycle and at the end of life of reusable packaging into ecosystems through litter or inadequate waste management systems. Potentially recoverable and recyclable materials may end up incinerated or in a landfill, resulting in harmful emissions and in the loss of valuable resources. In theory, chemically recycled materials can provide some environmental benefit compared to virgin material production but often these benefits do not transpire and are certainly not yet realized at scale (see the journal article *Towards a circular economy for plastic packaging wastes – the environmental potential of chemical recycling*; also, Closed Loop Partners report *Advancing Circular Systems for Plastics* explores the current landscape of advanced plastic recycling technologies). Reusable packaging should be designed so as to be recoverable through one or several recovery options available principally in the place of use, but also at other locations where reusable packaging can be taken out of service (for example, cleaning, filling, collection). End of life options should prioritize choices that divert used packaging from final disposal, i.e., incineration or landfill. The impacts of these management options differ significantly and the pollution to air, water, and land; energy requirements; and impacts to human health and communities should all be taken into account. Recovery effectiveness differs across materials and must be considered in addition to the other tradeoffs when determining the best end of life pathway.

Within the geographical context of a business's operations, it is imperative that adequate waste management and recovery systems are in place and are sufficient in practice. If an adequate waste management system is not in place, businesses should engage with local, state, and federal officials to establish and/or improve such systems.

In addition to the consideration of what physically happens to the material at its end of life, there are secondary items that may affect a material's environmental impacts at end of life. For example, whether one-time labels, shrink plastic labeling, etc. were needed throughout the item's life; whether the container needed to be tamper proof and how that affects potential end of life pathways; and how ink and other secondary packaging contributes to the overall environmental impact of the material. Reusable packaging could be discarded before it reaches the end of its designed useful life (number of reuses) for cosmetic reasons or consumer preferences (scratches, dents, faded labeling and branding), thus pushing for earlier replacement and unnecessary use of materials and inherent environmental impact. Safety and quality requirements could also trigger early replacement of reusable packaging.

Best practice recommendations, tools, and resources:

- WWF's ReSource Footprint Tracker exemplifies how materials may be tracked at end of life. It is a country-level waste management model that can estimate the share of a company's plastic footprint that is recycled, landfilled, incinerated, and mismanaged globally.
- Life cycle assessment (LCA)
    - "LCA is rooted in the comparison of reusable against single-use containers": *Sustainability of reusable packaging – Current situation and trends*
    - For more info on LCA: *Life Cycle Assessment: Past, Present, and Future*

Analyzing the entire reuse system- global indicators for success

Successful reuse systems should deliver a product with lower impacts (social, economic, and environmental) than their single-use counterparts. Although individual components of reuse systems can be analyzed for their discrete environmental impacts, all components and indicators must be integrated into one analysis to develop a holistic understanding of the environmental impacts of the entire reuse system. There are many cases where "success" in one part of the system does not translate into success for the entire system, especially at a global scale.

As this section is intended to guide analysis of environmental impacts for reuse systems/materials, the comparison is always to the traditional linear alternative. An assessment providing a fair comparison between a linear and a reuse system must be based on a functional unit which encompasses the product, e.g., the consumption of 1 portion of food, or one hair wash. In addition to this a number of key points specific to the comparison of a linear to a reuse system have to be accounted for. See WRAP's report *Reusable Packaging - Factors to Consider* for much more information regarding the unique key factors that influence the full environmental performance of a reusable packaging system.

In evaluating the total environmental impact of a reuse system/material a careful analysis of every part of the system should be undertaken, as different parts of the system can disproportionally affect the overall impact of the system. LCA can help identify potential hotspots of impact.

Indicators for success (strong environmental performance) include but are not limited to:

- Trip rates for reusable packaging - The number of trips made by reusable packaging in its lifetime is critical as it determines over how many use cycles the impacts related to the packaging system should be divided. Trip rates are not only related to the durability of the packaging itself, but also to the return rate, i.e., packaging kept by the consumer for other purposes or mistakenly discarded rather than returned.
  - Break-even point where reuse system becomes beneficial compared with a single-use alternative.
  - Retention of users/consumers in the reusable packaging system
  - Inputs and emissions from systems in place to enable use/reuse

- Transport distances and vehicle utilization - As reusable packaging is generally heavier than its linear counterparts and reuse systems involve reverse logistics with empty packaging, evaluation of only transport could favor linear packaging.
  - Miles traveled per consumer use or functional unit in LCA (if only absolute miles traveled by packaging is used, it does not reflect the fact that reusable packaging is used for several cycles and introduces a bias in favor of single-use packaging)

- Reusable pool size - A certain pool size, i.e., the total number of packaging items required to ensure that products can be delivered to a consumer on time, taking into account the quantity of packaging, which is in transit in reverse logistics, i.e., return trip, refurbishing, cleaning, seasonal variations, as well as to cover the fraction of lost packaging per trip due to damages and losses.
  - Attrition rate of packaging items.
  - Ease of rebranding/relabeling: The ability of reusable packaging to stay relevant and be adaptable ensures the packaging can stay in the system for a longer period of time. Improving the ability to rebrand/relabel should not increase impacts in other ways. For example, packaging that requires secondary materials such as plastic shrink sleeves for updated labelling strongly impacts the environmental impacts of the overall packaging.

- Impacts associated with the washing and repair of reusable packaging, including the fate of residual product remaining in the packaging after use.

- In a comparison between a linear and a reuse system, the assessment has to cover all impact categories that are pertinent for both alternatives in order to ensure that potential trade-offs are identified. Whereas indicators such as climate change and resource depletion may be common for both systems, water consumption and emissions related to cleaning and refurbishing are specific to reuse systems and must therefore be included for both systems.
    - Required maintenance, inputs and/or emissions (e.g., water and energy used in washing and repair; effluent discharge from cleaning) should be designed to have the lowest footprint possible and the remaining impacts should be fully mitigated.

- Sustainable and responsible sourcing
    - Sustainable sourcing is a journey of continuous improvement and should be constantly monitored, evaluated, and transparently and publicly disclosed to ensure progress over time. An indication of success in sustainable sourcing is the certification of the material by a credible sustainability standard, (for example, WWF recommends the RSB standard, among others). If credible certification bodies are used to certify, certified materials should still be continuously monitored for adherence to best practices (certification bodies must be held accountable for enforcement and resolution and should be continuously improved by a diverse set of stakeholders as new science and mitigation strategies evolve).
    - Note that mining of metals and other nonrenewable can never be sustainable but addressing all negative impacts can ensure responsible practices.
    - Zero conversion of natural habitat and zero deforestation in the supply chain can serve as high-level key indicators for success of sustainable sourcing.
    - Best practices for sourcing metals/recycled content may include certification schemes/compliance, transparency along metal value chain, circular economy approaches, landscape approach, and responsible mining and rehabilitation practices.

- End of life
    - Recovery potential of material at end of life
    - % material actually recovered at end of life
    - Break-even number of uses achieved before reaching end-of-life. Low break-even number of uses is preferred.

Considerations by material type (common reuse materials)

Each material considered for reusable packaging has its own impacts. The table below provides general considerations for some of the most commonly used materials for reusable packaging. It should be noted that no one material is best for all applications and that, on the whole, using only one material for all reusable packaging would have consequences of its own as high demand could cause unintended/unforeseen issues. Diversifying material types may help mitigate extreme environmental impacts in any one area.

	Stainless Steel
Sourcing Responsible sourcing is a journey; all sourcing activity should be monitored for continuous improvement	-can be made up of many different scrap metals with different impacts -recapturing steel is very important to reduce the need to source more finite raw materials -water risk, see Water Risk Filter Research Series: An Analysis of Water Risk in the Mining Sector -see WWF study on aluminum and steel -see American Geosciences Institute for more on potential environmental impacts of mining -mining impacts depend on the metal(s) used (i.e., iron ore has significant negative environmental impacts - land use change, deforestation, biodiversity loss, water usage, and contamination of air, soil, and water
Production Impacts depend heavily on processes/technologies used	-production impacts depend on the efficiency of the operation and include waste, water, and air impacts -production impacts may also include environmental contamination of local ecosystems and communities -residual byproducts from metallurgical processes should be captured for appropriate other uses -steel production emits significant GHG emissions ,energy use is high, use of coal (or coke) has important impacts to consider
Durability The overall impact of all materials below depends on # of uses (more uses = less impact per functional unit)	-very durable, does not degrade over time
Use All materials below have energy and water impacts from recycling and/or reusing	-has high recapture rates
End of life Recovery in practice and at scale should be measured	-100% recyclable, as long as its recaptured

	Aluminum
Sourcing Responsible sourcing is a journey; all sourcing activity should be monitored for continuous improvement	-responsible sourcing is critical (no such thing as sustainable bauxite sourcing) -significant negative environmental impacts from mining aluminum (bauxite) including CO_2 emissions -community impacts - noise, local water pollution -sourced in high quantities with highly industrial processes, open pit mining -Aluminum Stewardship Initiative (ASI) recommended -water risk, see Water Risk Filter Research Series: An Analysis of Water Risk in the Mining Sector -American Geosciences Institute for more on potential environmental impacts of mining
Production Impacts depend heavily on processes/technologies used	-virgin production is highly energy intensive -GHG emissions from refining/smelting (primary aluminum production is a major source of global perfluorocarbon (PFC) emissions, and smelting water intensive)
Durability The overall impact of all materials below depends on # of uses (more uses = less impact per functional unit)	-highly recyclable
Use All materials below have energy and water impacts from recycling and/or reusing	-reusability at consumer level varies (i.e., demand for BPA-free aluminum bottles)
End of life Recovery in practice and at scale should be measured	-recapturing is critical, reusing aluminum has far less impacts than raw bauxite sourcing

	Glass
Sourcing Responsible sourcing is a journey; all sourcing activity should be monitored for continuous improvement	-raw material: sand/silica -there is high demand for sand as it is used in glass, cement, asphalt -desert sand is typically considered too smooth for use in many applications; sand is extracted from quarries or from river, marine, and coastal ecosystems which may have serious impacts to these landscapes and the wildlife there -illegal sand sourcing is an issue (i.e., from marine ecosystems that lead to coastal erosion) -industrial silica mining has negative environmental impacts (potential for severe land degradation, groundwater depletion, contamination of surface water, noise, air pollution, dust) -*The world needs to get serious about managing sand, U.N. report says* -water risk, see Water Risk Filter Research Series: An Analysis of Water Risk in the Mining Sector
Production Impacts depend heavily on processes/technologies used	-energy intensive -solid waste (minor impacts from glass production) -water consumption for processing -water pollution due to inadequate water processing -emissions during melting activities -emissions and particulate matter from impure raw materials -emission of dust from handling and storage of raw materials can impact neighboring communities (including inhalation of silica sands which can cause silicosis, and glass fibers can cause irritation)
Durability The overall impact of all materials below depends on # of uses (more uses = less impact per functional unit)	-can be endlessly recycled without loss to main functional properties -durability is important (i.e., broken glass)
Use All materials below have energy and water impacts from recycling and/or reusing	-quality of glass will inhibit reuse (scratches, chips) -reuse rate depends on availability of infrastructure for glass recycling -glass recycling can be costly
End of life Recovery in practice and at scale should be measured	-glass bottles and jars can be recycled with no deterioration of quality or purity -broken glass may not be able to be recycled to its previous quality again - broken glass poses a threat to waste management workers and broken glass can cause issues in the recycling stream if facilities cannot separate it out

	Engineered Plastics
Sourcing Responsible sourcing is a journey; all sourcing activity should be monitored for continuous improvement	-majority is fossil-based, made from oil, natural gas, or coal. -fossil-based plastics contribute to the depletion of non-renewable resources, and have range of environmental issues from extraction including contribution to climate change -plastic can be biobased but bio is not always better; the agricultural production must be done responsibly, see the Bioplastic Feedstock Alliance's Methodology for the Assessment of Bioplastics for a description of responsibly sourced bioplastic and for an example of a thorough tool to be used for assessing the impacts of a bioplastic feedstock -production from fossil fuels can have impacts from exploration and establishment of extraction sites causing disruption of migratory paths and damages to wildlife habitat. -Oil spills have severe impacts on surrounding wildlife, habitats, the livelihoods of people in the community, and on human health. -biobased plastic production (as with all agricultural production) can cause large scale issues like habitat fragmentation and biodiversity loss. Cultivation generally also involves the typical agricultural impacts associated with fertilizer, pesticide, and water use. As with most agricultural activities, the severity of these impacts is greatly variable, and depends on both local conditions and the quality of management
Production Impacts depend heavily on processes/technologies used	-pollution to surrounding communities and their air, soil, water -plastic manufacturing results in GHG emissions including carbon dioxide, sulfur oxides, methanol, nitrous oxides, and other volatile organic compounds - effective emissions control devices are necessary -plastic can be re-made from recycled resin which has the advantage of conserving resources, but its quality degrades every time it is re-processed -many different technologies (across mechanical and chemical recycling) exist to reprocess plastic and the water, energy, and waste impacts differ based on the technology and process. The carbon footprint of each process should be taken into account.
Durability The overall impact of all materials below depends on # of uses (more uses = less impact	-plastic comes in a wide range of polymer types and is frequently used for existing packaging because it is light, strong, and customizable. -Long carbon chains contribute to the strength and durability of plastic
Use All materials below have energy and water impacts from recycling and/or reusing	-plastic is easy for consumers to transport (light, flexible) -Plastic deteriorates more quickly from conditions such as high heat, high humidity, extended UV exposure. Deterioration also produces greenhouse gas emissions, extending the climate impacts from plastics throughout their lifecycle -plastic degradation does not mean the material disappears- micro plastics continue to pollute air, soil, water, and food chains. The deterioration of plastic also contributes to pollution through the leaching of chemicals from plastic into food and beverages.
End of life Recovery in practice and at scale should be measured	-some plastics are easily recyclable others are not, especially composite materials or contaminated plastic -even if plastics are technically recyclable, they may not be recycled in practice or at scale depending on many factors including the economic feasibility of recycling in specific geographies. -plastics that are not recycled can be sent to landfill, incinerated, or leaked into nature each of which have consequences to people and nature. -China National Sword, low oil prices, COVID-19 have upended the global plastic recycling market

V. Looking ahead: opportunities for reuse design

Reuse systems can offer enormous social, environmental, and economic benefits but we must pursue a unified, system-wide approach to achieve these benefits. This does not mean creativity or innovation will be stymied, rather the guidelines offered should provide guardrails within which new ideas can achieve their highest potential. As outlined in the recently published report *Future of Reusable Consumption Models*, to achieve scale and the benefits it brings, reuse systems must not require consumers to sacrifice convenience or quality of experience.

This is where designers play a vital role in designing reusable containers and their associated systems in ways that are affordable, easy, and safe to use. The *Design Guidelines* offer an initial attempt to coalesce the most important considerations designers should take into account to achieve this reality. As reuse systems come online and start to scale up, new considerations will need to be added and new questions will be raised. This document is therefore intended to be updated and revised as new opportunities are discovered.

The authors of this report acknowledge there are many upcoming areas of opportunity and many considerations in need of additional work and research. The following list, while not exhaustive, covers some expected areas of future focus.

- Rethinking the role of packaging
    - Consumer experience / value
    - Added functionality
    - E-commerce, etc. (vs. instore-shelf space)

- Circular design
    - Business model innovation/ incentive structures
    - Asset vs costs: designing for durability / packaging as a service
    - Lessons from pallets
    - Design for recyclability (opportunity for design rules – it's early days)
    - Materials as a service model

- Network and scale effects: interoperability and standards
    - Packaging formats, data platforms, etc.
    - C2B, B2B

- Collaborative design
    - Cross-functional, cross-industry/sector, interdisciplinary opportunities