

**FLEXIBLE PACKAGING:
SUBSTITUTION
TO PAPER-BASED
FLEXIBLES:
Design and circulation**

Deepdive



This document is a strategy deepdive with detailed insights, analysis and actions. For a high-level overview of the work, see the executive summary.

WEBSITE

Easily digestible overview of the different strategies for flexible packaging, and the key insights and actions for each.

[Click here](#)

EXECUTIVE SUMMARY

Short, high-level strategy document. Doesn't contain any analysis, reasoning or details for the key actions.



STRATEGY DEEPLIVES

Detailed insights and analysis, and detailed key actions for the different strategy options.



SUPPLEMENTARY INFORMATION

Supporting data and references.



OVERARCHING STRATEGY

(this deepdive relates to only one part of this overall flexible packaging strategy)

[Click here for the executive summary.](#)

CONTEXT

Flexible packaging is the fastest-growing plastic packaging category. Because it is almost uniformly single-use, with very low recycling and high leakage rates, it is also by far the most challenging market segment to address on the journey towards a circular economy for plastics.

OVERARCHING STRATEGY

Eliminating and innovating away from single-use flexible packaging must be the first and foremost part of any flexible packaging strategy — because as soon as single-use flexible waste is generated, regardless of material or geography, it is very hard to deal with. Current efforts are only just scratching the surface and a step-change in the level of commitment and effort across direct elimination of unnecessary packaging and exploration of upstream innovation solutions, such as reuse, is required from ALL stakeholders.

For the single-use flexible packaging items that cannot currently be eliminated without unintended consequences, unprecedented efforts are required to ensure they can be circulated. This can include staying with a conventional plastic and scaling recycling systems, or substitution to a different material (such as paper or compostable plastics where relevant) and then scaling those systems. Either way, what is clear is that unless simultaneous, unprecedented efforts across packaging design, infrastructure, and policy are begun immediately — efforts that push far beyond the level of activity we are currently seeing — the circulation of flexible packaging in practice and at scale is unlikely to happen in the foreseeable future.

While they are currently a necessary part of the solution, the inherent quality and yield limitations of recycling and substitution strategies mean that staying with single-use flexible packaging will always present a challenge from a circular economy perspective. This is why we need to keep driving a strong upstream innovation agenda (in line with the first part of the overarching strategy) in order to find ways to eliminate ever-increasing single-use flexible packaging over time.

URGENT ACTIONS

This work has identified 21 specific and urgent actions for flexible packaging that need to be commenced immediately by businesses and policymakers in order to make significant progress towards 2025 targets and beyond.



KEY ACTIONS FOR PAPER-BASED FLEXIBLES

PAPER-BASED FLEXIBLES: flexibles made from regeneratively sourced paper (uncoated or with a coating that has the same biodegradation profile as paper), designed for recycling and composting, collected, sorted and recycled or composted in practice and at scale

PAPER-BASED FLEXIBLES KEY ACTIONS

POTENTIALLY APPLICABLE FOR ~15% OF FLEXIBLES

Businesses to:

For your organisation's entire paper-based packaging portfolio, put in place a robust reduction, virgin reduction, and regenerative sourcing strategy

Improve paper packaging design so that all paper-based packaging fits into both recycling and composting systems

[See page 6 for details](#)

Policymakers, collaborative cross-sector initiatives, and businesses (through advocacy) to:

Increase collection and recycling rates for paper-based flexibles

[See page 7 for details](#)

Businesses to:

For your organisation's entire paper-based packaging portfolio, put in place a robust reduction, virgin reduction, and regenerative sourcing strategy

Businesses with paper-based packaging in their portfolio to develop a robust reduction, virgin reduction, and regenerative sourcing strategy following the guidance for sourcing of paper as specified on [page 17](#)

Businesses with paper-based packaging in their portfolio to actively engage in collaborative initiatives/consortia to:

- Maximise the amount of recycled content used in flexibles.
- Investigate the use of alternative fibres (e.g. agricultural residues and other by-products) and their compatibility with current recycling infrastructure.
- Ensure best-practice sourcing for virgin wood-pulp (e.g. avoidance of deforestation and sourcing from ancient and endangered) through improving and scaling existing certification schemes for virgin fibres.
- Explore the possibility of moving towards next generation 'outcome-based' regenerative sourcing approaches and certification schemes for all agricultural products.

Improve paper packaging design so that all paper-based packaging fits into both recycling and composting systems)

Businesses with coated paper-based packaging in their portfolio to actively improve design by:

- Engaging in collaborative initiatives/consortia to further develop coatings and lamination materials that have the same biodegradation profile as paper to improve the barrier properties of paper while allowing for integration of paper-based flexibles across BOTH recycling and composting systems (and to avoid hindering the biodegradation properties of paper should it end up in the environment). Innovation programmes to be commenced immediately, with elimination of conventional plastic coatings to be undertaken by 2025.
- Ensuring inks, glues, etc. are compatible with BOTH recycling and composting processes.

Policymakers, collaborative cross-sector initiatives, and businesses (through advocacy) to:

Increase collection and recycling rates for paper-based flexibles

Businesses with paper-based flexibles in their portfolio, national governments, municipalities, recyclers, and financial institutions to collectively identify and then implement actions to improve the capture and recycling rate of paper-based flexibles. Although the recycling rate of paper is higher on average than for plastics, high-quality recycling of B2C paper flexibles is still quite low, particularly for food-contact paper packaging and needs to markedly increase. How EPR fees can be used to achieve this should be a core part of the discussion, as should how to ensure that any system put in place is inclusive (see the [informal recycling deepdive](#)).



PAPER-BASED FLEXIBLES

SECTORS AND GEOGRAPHIES OF PARTICULAR RELEVANCE

Due to current technical limitations (particularly if looking to avoid coatings that don't have the same biodegradation profile as paper), substitution to paper is most often appropriate for applications that require low/medium barrier properties.

For example:



BREAD



E-COMMERCE TRANSPORT
parcels



DRIED FOOD & CEREALS
pasta, rice

Once direct elimination and innovation opportunities have been pursued, pursuing substitution to paper for flexibles is likely to be of most relevance in geographies where recycling systems for plastic flexibles are still many years away.

Note: sourcing issues will differ between geographies (and in some of the geographies where recycling of plastic flexibles is furthest away, sourcing issues for paper may also be greatest). In any geography considered, sourcing issues need to be addressed prior to substitution.

Geographic Archetype 1: Geographies with low volumes of mismanaged packaging waste, and advanced waste management systems.

For example: Established recycling systems producing high-quality recyclate; mandatory EPR.

Proxy geography: Europe

Geographic Archetype 2: Geographies with low volumes of mismanaged packaging waste, but less advanced waste management systems.

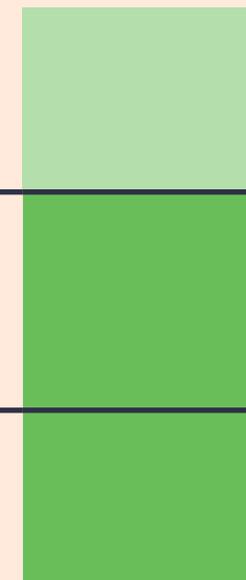
For example: Recycling systems are limited in scale or have considerable loss of material quality; emerging, limited or voluntary EPR.

Proxy geography: USA

Geographic Archetype 3: Geographies with high volumes of mismanaged packaging waste and limited/no waste management systems.

For example: Limited systems even for collection; No/limited EPR

Proxy geography: South and South-East Asia



4 KEY INSIGHTS SUPPORTING THE KEY ACTIONS

PAPER-BASED FLEXIBLES

4 KEY INSIGHTS

1 In certain contexts, substitution from plastic to paper* appears to be a relevant strategy for flexibles and could result in higher recycling rates compared to plastics and allow for synergies with food composting systems. Paper-based flexibles potentially also have a reduced persistence in the environment compared to plastic flexibles (although this is of course not a long-term solution). This strategy, with existing technology, has been estimated to be applicable for ~15% of plastic flexibles.

2 However, significant sourcing challenges mean substitution to paper-based flexibles must be very carefully considered.

3 If pursuing a paper substitution strategy for flexibles, a strategy based on reduction, virgin reduction and regenerative sourcing needs to be put in place — and not just across an organisation's paper-based flexibles portfolio, but across an organisation's entire paper-based packaging portfolio. This is to ensure that substitution of flexibles does not contribute towards growing the global demand for virgin wood.

4 Importantly, substitution to paper should never be undertaken in place of direct elimination, innovative elimination, or reuse solutions — inherent limitations of substitution solutions mean that moving away from single-use flexibles needs to remain the first and foremost part of any flexible packaging strategy.

*Uncoated paper or paper with a coating that has the same biodegradation profile as paper.

PAPER-BASED FLEXIBLES

4 KEY INSIGHTS

1

In certain contexts, substitution from plastic to paper* appears to be a relevant strategy for flexibles

Substitution to paper for flexibles could result in a higher recycling rate compared to plastics (although the majority would still be recycled into lower quality applications, not flexible-to-flexible) and allow for synergies with the food composting system. Paper-based flexibles potentially also have a reduced persistence in the environment compared to plastic flexibles (if well designed, in terms of additives and coatings, although this should not be seen as a long-term solution). This strategy, with existing technologies, has been estimated to be applicable for **~15%** of plastic flexibles.

See following page for details and references

*Uncoated paper or paper with a coating that has the same biodegradation profile as paper.

It is estimated that substitution to paper could be relevant and technically possible for as high as 15% of the B2C flexibles market by 2040.

*Breaking the plastic wave*¹ report highlighted flexible packaging as the category for which substitution to paper is most relevant — and in particular for formats that have low plastic recycling rates and high rates of food contamination.

In complement to elimination, innovation and recycling, it was estimated that substitution to paper could be relevant and technically possible for ~15% of the current B2C flexibles market.¹

However, the majority of this substitution potential relies on coated paper (hindering the packaging's ability to fit into BOTH recycling and composting systems), and is mainly relevant to packaging formats that have low barrier property requirements.

Engaging in collaborative initiatives/consortia to further develop coatings and lamination materials that have the same biodegradation profile as paper and improved barrier properties will be of key importance to:

- Allow for integration of paper-based flexibles across BOTH recycling and composting systems, and avoid hindering the biodegradation properties of paper should it end up in the environment.
- Potentially open up a broader range of applications for paper.

Proportion of a B2C flexibles category that can be substituted to paper according to the *Breaking the plastic wave* report¹

	Paper	Coated paper*
Mono-material Films	6.5%	25.5%
Sachets and Multi-layer Films	2%	2%
Carrier bags	3%	10%

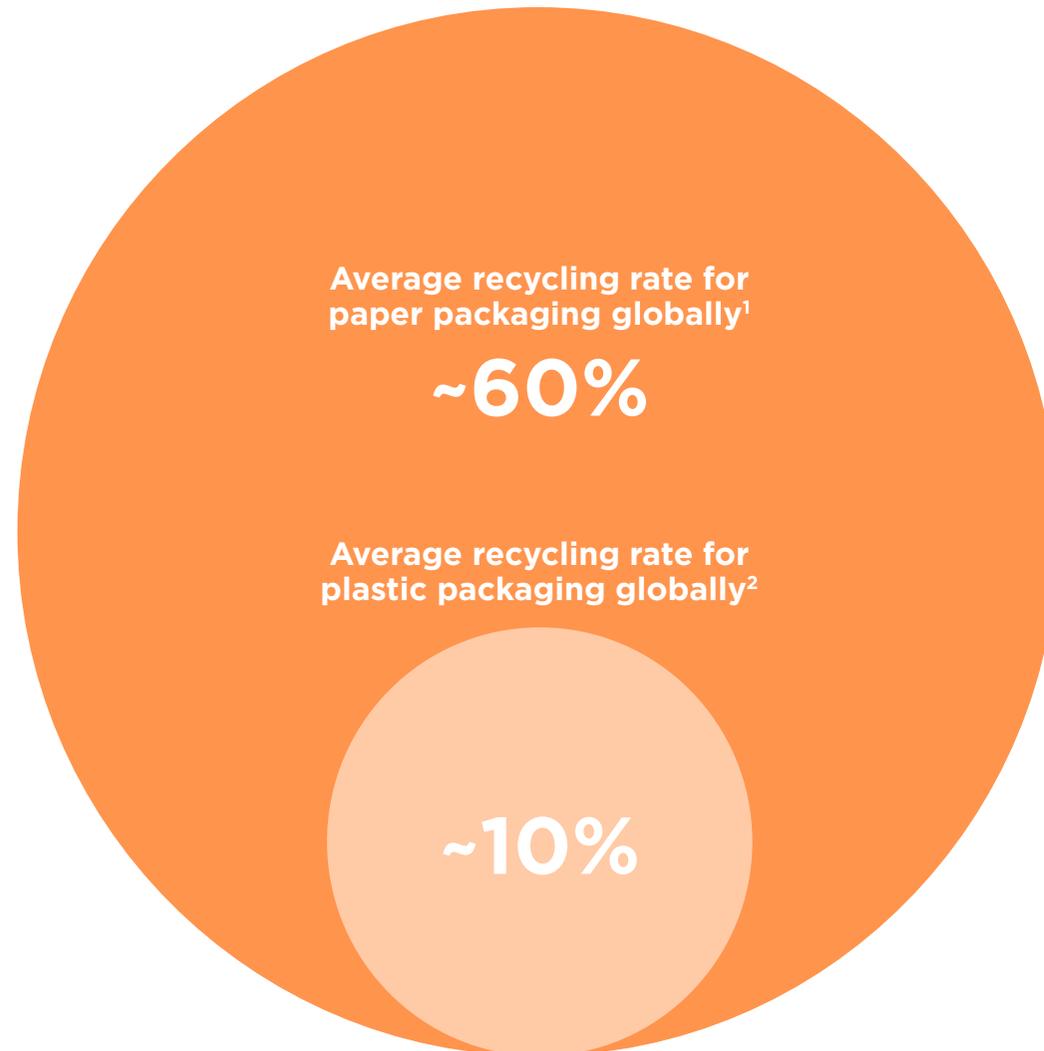
*Refers to paper that has a maximum of 5% by weight of conventional plastic coating, which is currently considered acceptable by recyclers. As discussed in this document, our recommendation is that moving forward, any coatings for paper should have the the same biodegradation profile as paper.

1. **The PEW Charitable Trust and Systemiq**, *Breaking the plastic wave: a comprehensive assessment of pathways towards stopping ocean plastic pollution* (2020), p. 58.

Substitution to paper could potentially offer higher recycling rates compared to plastic.

Infrastructure for collecting, sorting, and recycling of paper is on average far more advanced than for plastics.

This said, more data is certainly still needed to better understand the picture for flexibles specifically, as well as how this differs by geography.



Note: For the European context, the [4evergreen](#) cross-industry alliance is working towards raising the overall recycling rate of fibre-based packaging to 90% by 2030. Intermediary targets have been set for 2025.

¹ **European Declaration on Paper Recycling**, *Monitoring Report* (2020), p.5;

² **Ellen MacArthur Foundation (New Plastics Economy)**, *Rethinking the future of plastics* (2016), p. 27.

PAPER-BASED FLEXIBLES

4 KEY INSIGHTS

2

Significant sourcing challenges mean substitution to paper-based flexibles must be very carefully considered

Evidence suggests that a significant share of virgin wood-pulp for paper is sourced from problematic sources making 'blind' substitution to paper a poor choice for flexibles. Of the 190 million tonnes of virgin wood-pulp used for paper and paperboard globally, it is estimated that up to **50% originates from problematic sources such as ancient and endangered forests** — a significant issue from both a climate and biodiversity perspective. Switching an estimated ~15% of current plastic B2C flexibles to virgin wood-pulp paper could result in up to a **10% increase in virgin wood-pulp demand**. This is a problem as it would be adding to the ever-growing global demand for wood caused by many major industries (such as construction and fuel industries) shifting towards wood in a bid to source 'sustainable' raw materials.

See following page for details and references

Evidence suggests that a significant share of virgin wood-pulp for paper is sourced from problematic sources making ‘blind’ substitution to paper a poor choice for flexibles.

The global production of wood pulp for paper and paperboard already far exceeds ecological boundaries, with up to **~90 million tonnes** of wood pulp (**up to 50%** of global virgin wood-pulp for paper and paperboard demand) originating from problematic sources such as ancient and endangered forests.¹

With the role that forests play in combatting climate change and supporting biodiversity well recognised, any loss of ancient and endangered forests is a major concern.

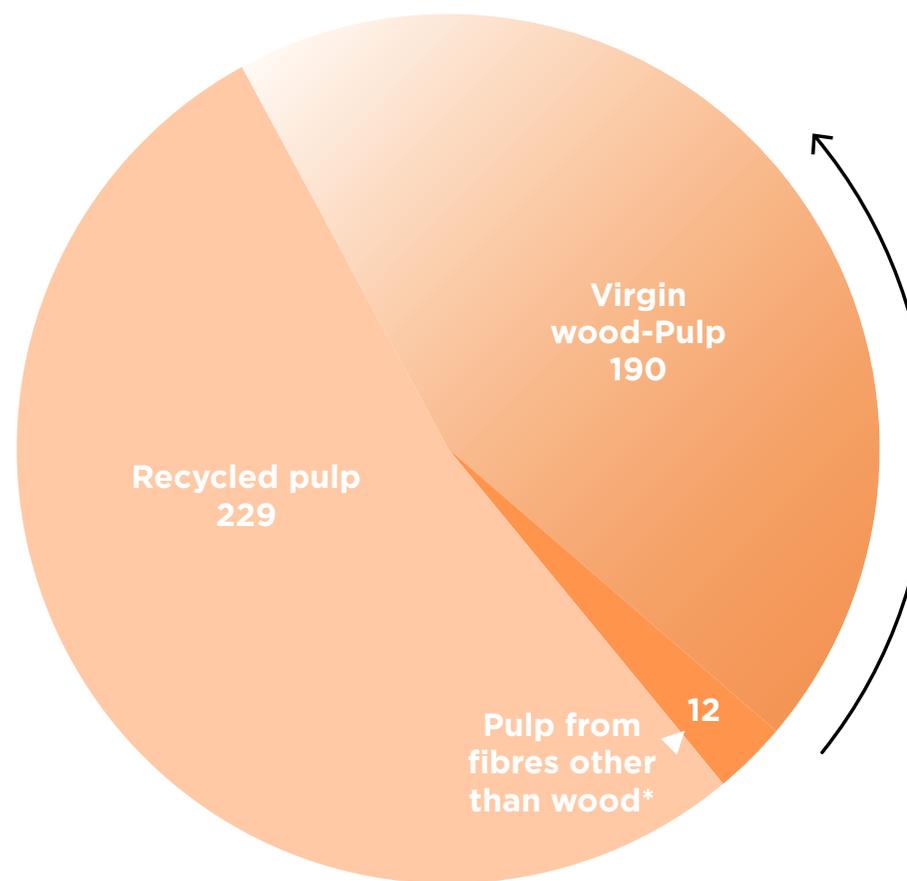
Substitution of flexibles would add to this already strained system. Given the technical requirements of the fibres required to make paper B2C flexibles, a high-virgin content is required, meaning substitution of **15%**³ of plastic B2C flexibles to paper would potentially require an extra **12 million tonnes**⁴ of virgin wood-pulp (an ~10% increase in global virgin wood-pulp demand).

While sourcing issues do vary by geography, due to significant trading of wood between continents, no particular geography can be deemed as ‘safe’.⁵

¹Includes bamboo and all other non-wood dedicated pulp fibre crops.

²Proportion of agricultural residues and bamboo and other crops going into ‘Pulp from fibres other than wood’ is unknown.

³For additional information and references (1-5) see the [Supplementary Information: Paper B2C flexibles: “Material Sourcing”](#)



Up to 50% of global virgin wood-pulp supply is estimated to originate from problematic sources such as ancient and endangered forests¹

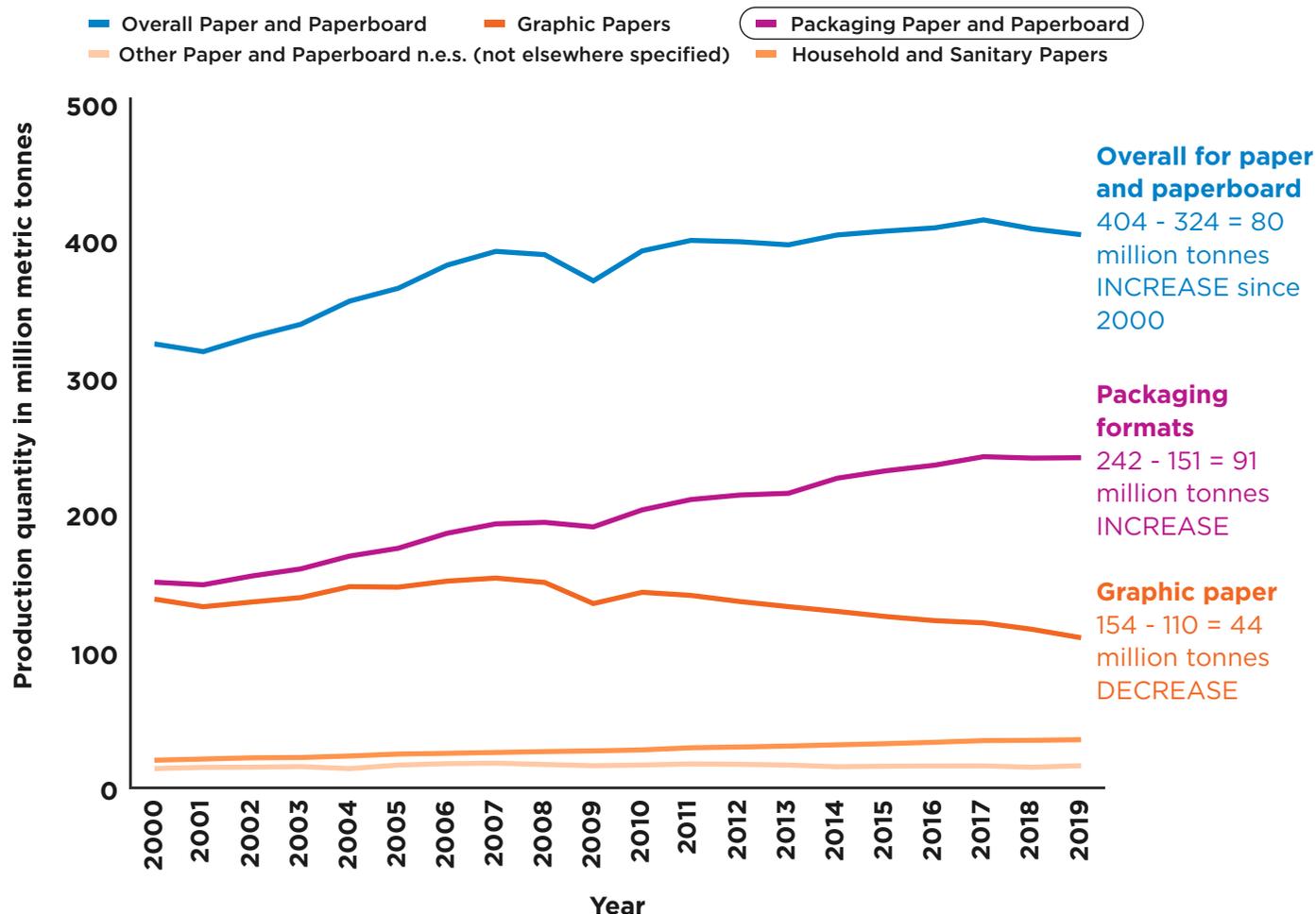
Pulp for paper and paperboard²
431 (Million tonnes)

Demand for paper and paperboard has steadily grown over the past 20 years. The growth is primarily driven by an increased demand for packaging that has vastly outpaced the decline in newsprint, printing, and writing papers (see right).

This growth is adding strain to an already strained system.

Paper and Paperboard - Global Production Volume - Primary Formats¹

Chart produced by EMF from FAO data



Definitions: [FAO definitions](#)

¹ Food and Agriculture Organisation (FAO), [FAOSTAT Data](#) (2019).

PAPER-BASED FLEXIBLES

4 KEY INSIGHTS

3

If pursuing a paper substitution strategy for flexibles, a strategy based on reduction, virgin reduction, and regenerative sourcing needs to be put in place — and not just across an organisation's paper-based flexibles portfolio, but across an organisation's entire paper-based packaging portfolio

This should ensure that substitution of flexibles does not contribute towards growing the global demand for virgin wood.

See following page for details and references

If substitution to paper is pursued as a strategy for flexibles, a robust sourcing strategy that would prevent the growth of global demand for virgin wood needs to be in place

(i.e. a substitution strategy for flexibles can not be undertaken in isolation, but needs to be accompanied by a broader reduction, virgin reduction, and regenerative sourcing strategy for paper and paperboard that encompasses an organisation's entire paper-based packaging portfolio)

1 Reduction

Where possible prioritise reduction e.g. by removing packaging or switching to reusable packaging.

2 Recycled Content

If reduction is not possible, prioritise recycled content where possible.

3 Agricultural residues or other byproducts

Where virgin content is needed, prioritise using fibre from agricultural residues or other by products where possible.

4 Diversified and certified wood pulp

Where virgin content is needed and agricultural residues are not an option, avoid sourcing from ancient and endangered forests, ensure highest possible certification standards for all wood used (current best practice is generally considered FSC 100%) and use a diversified range of dedicated crops (e.g. sourcing from a mix of certified wood, bamboo, papyrus)

3 & 4 Shift towards regenerative principles

Go beyond sustainable sourcing and aim to improve soil and ecosystem health and enhance biodiversity through regenerative practices.

Eliminating unnecessary packaging and switching to reuse models is the most effective way to reduce the use of virgin-pulp. Many opportunities exist e.g. for B2B, multibuy, transport packaging. see more in the [Upstream Innovation Guide](#)

Maximising the use of recycled fibre is an effective way to reduce the need for virgin fibre. While there is a limit to the amount of recycled content that can be used in flexibles (e.g. estimated up to 50% for non-food contact B2C flexibles), other packaging applications with lower fibre performance requirements can be made almost entirely from recycled fibres.

Using byproducts (e.g. agricultural residues from food production) could reduce the amount of land needed to produce virgin pulp for paper. While the opportunities for using fibre from byproducts vary (e.g. by application, by technical properties of the byproduct fibre, by geography) and current capacity of paper mills that use agricultural residues is low, the availability of agricultural residues far exceeds the demand for paper, making this an important avenue to continue investigating.

Where virgin wood-pulp is required (sourcing strategies 1-3 should always be considered first) ensuring appropriate sourcing is key to avoid further accelerating biodiversity loss and climate change.

PAPER-BASED FLEXIBLES

4 KEY INSIGHTS

4

Importantly, substitution to paper should never be undertaken in place of direct elimination, innovative elimination, or reuse solutions

Inherent limitations of substitution solutions means that moving away from single-use flexibles needs to remain the first and foremost part of any flexible packaging strategy. Regardless of the material a single-use flexible is made from, the inherent limitations of recycling and composting systems means that staying with a single-use flexible will always present a challenge from a circular economy perspective.

See following page for details and references

For paper recycling systems and composting systems there is significant unavoidable material quality and quantity losses and therefore considerable virgin input requirements.

RECYCLING of paper-based flexibles: Significant and inherent quality losses

- Mechanically recycled fibres have reduced fibre strength compared to virgin fibres.
- Given the material properties required to produce high-performance paper flexibles, an average of 10-50% mechanically recycled content is generally agreed to be the upper limit for paper B2C flexibles.
- In addition, some use cases for paper B2C flexibles require 100% virgin content for safety (such as in food-grade).
- **As is the case for plastics, loss of quality within a mechanical recycling process limits the amount of mechanically recycled content that can be used in paper B2C flexibles and means that substitution to paper comes with significant, unavoidable virgin input requirements (e.g. between 50-100% of the fibres used in paper B2C flexibles will need to come from virgin sources).**

COMPOSTING of paper-based flexibles: Inherent loss of the packaging material from the packaging system

- Composting a material involves breaking it all the way down into fundamental building blocks — for the most part, carbon dioxide and water.
- This means that for any packaging that is composted, the equivalent amount of virgin material is then required to make new packaging.
- Compostable packaging is most often designed as single-use.
- **Compostable packaging, while relevant in some applications, means shifting towards 100% virgin input requirements and is still ‘single-use’ in the same way that conventional plastic B2C flexibles are.**

See the executive summary for details of the limitations of conventional plastic recycling systems.

For additional information and references, see the [Supplementary Information: Paper B2C flexibles: “Material Sourcing”](#) and [Deepdive: Substitution to compostable B2C flexibles](#).

This work has been developed in collaboration with an expert panel consisting of more than **100 organisations** including relevant expert organisations and NGOs, [Plastics Pact](#) lead organisations, and members of the [New Plastics Economy](#) initiative (which includes many of the leading producers of packaged goods, and many of the largest retailers and packaging producers).

We are deeply grateful to all collaborators and contributors for the time and expertise they have dedicated to this project.

These organisations are not responsible for any of the recommendations presented in this work. This report is the work of, and solely reflects the views of, the Ellen MacArthur Foundation. The Foundation's views have been formed on the bases of existing literature, expert interviews, workshops with the expert panel, and in-house analysis.

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ABOUT THE ELLEN MACARTHUR FOUNDATION

The Ellen MacArthur Foundation develops and promotes the idea of a circular economy.

The Ellen MacArthur Foundation is committed to the creation of a circular economy that tackles global challenges, such as climate change, biodiversity loss, waste, and pollution.

The Ellen MacArthur Foundation is an international charity that develops and promotes the circular economy in order to tackle some of the biggest challenges of our time, such as climate change, biodiversity loss, waste, and pollution. We work with our network of private and public sector decision-makers, as well as academia, to build capacity, explore collaborative opportunities, and design and develop circular economy initiatives and solutions. Increasingly based on renewable energy, a circular economy is driven by design to eliminate waste, circulate products and materials, and regenerate nature, to create resilience and prosperity for business, the environment, and society.

Further information:

www.ellenmacarthurfoundation.org | [@circulareconomy](https://twitter.com/circulareconomy)

ABOUT THE PLASTICS INITIATIVE

Since 2016, the Ellen MacArthur Foundation's New Plastics Economy initiative has rallied businesses, governments, and other organisations behind the vision of a circular economy for plastic, in which it never becomes waste or pollution.

Focused on ambitious targets for 2025, the Global Commitment addresses plastic waste and pollution at its source, beginning with plastic packaging, while the Plastics Pact network of local and regional (cross-border) initiatives, endorses and implements circular economy solutions that work towards the vision.

Further information:

www.emf.org/plastics | [@circulareconomy](https://twitter.com/circulareconomy)

[Explore the vision for a circular economy for plastic](#)



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