

FLEXIBLE PACKAGING:

SUBSTITUTION TO COMPOSTABLE 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.

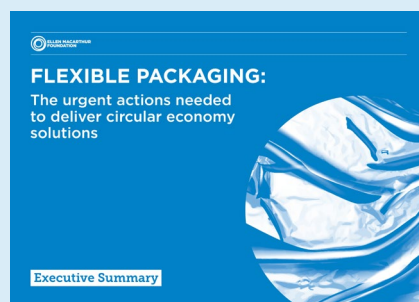
WEBSITE

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 DEEPDIVES

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 COMPOSTABLE FLEXIBLES

COMPOSTABLE FLEXIBLES: flexibles made from regeneratively sourced compostable plastics, designed for composting, and collected, sorted and composted in practice and at scale.

COMPOSTABLE FLEXIBLES

KEY ACTIONS

POTENTIALLY APPLICABLE FOR ~20% OF FLEXIBLES

Businesses to:

For applications supporting the collection of food waste or addressing existing contamination in composting systems: implement compostable materials

Before pursuing compostables as a broader strategy for flexibles: demonstrate the mechanisms that would need to be in place to prevent contamination of both the composting and recycling systems)

[See page 6 for details](#)

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

Define and implement best practices for composting of food waste and align compostable packaging standards with this

Roll out collection and composting infrastructure for food and organics

[See page 7 for details](#)

Businesses to:

For applications supporting the collection of food waste or addressing existing contamination in composting systems: implement compostable materials

Policymakers to mandate that applications that support the collection of food waste (e.g. food waste collection bags, tea bags), and common contaminants within the composting system (e.g. fruit stickers) be made from compostable materials. All businesses with these items in their portfolio (e.g. retailers and FMCGs) to voluntarily make the shift by 2025.

Before pursuing compostables as a broader strategy for flexibles: demonstrate the mechanisms that would need to be in place to prevent contamination of both the composting and recycling systems

Organics recyclers, brands, and policymakers to collectively identify the mechanisms that would need to be in place to allow compostable and non-compostable packaging formats to be put on the market alongside each other without causing contamination of either the composting or recycling systems. The mechanisms investigated should include technical mechanisms (e.g. what sort of sorting technology would be required at organics processing plants?); financial mechanisms (e.g. what EPR fees would need to be in place to ensure a system was economically viable?); and governance mechanisms (e.g. what sort of labelling protocols need to be in place and who governs this?) This would allow a better informed decision to be made as to what role compostable plastics should play in a broader flexibles strategy (i.e. what role they should play in applications that don't either support collection of food waste or directly reduce contamination in a composting system). These mechanisms would need to be put in place alongside any flexibles that are shifted to compostables. (See the [Upstream Innovation Guide](#) pp. 138-143 for details of further mechanisms to be explored)

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

Define and implement best practices for composting of food waste and align compostable packaging standards with this

Organic recyclers and farmers to engage with standards setting organisations to, by 2023, align on what best practice looks like for composting of food waste to produce high-value compost that can support regeneration and maintenance of soil health. Based on existing and potentially new evidence, the aim would be to determine conditions such as optimal retention times for food and organics, temperatures, etc. All composting systems would then need to adhere to these practices. Subsequently, all standards for compostable packaging need to be fully aligned with the agreed best practices for composting systems (if not aligned already) to ensure that industrially compostable plastics meet the requirements of composting systems producing high-value compost.

Roll out collection and composting infrastructure for food and organics

Organic recyclers, financial institutions, and governments to invest in infrastructure for the collection and composting of food and organics. This action exists independently of the introduction of compostable packaging — there is a pressing need to roll out collection and composting infrastructure for food and organics in order to create a circular economy for the food system. While compostable packaging will benefit from this infrastructure development, it will not be the primary driver.

COMPOSTABLE FLEXIBLES

SECTORS AND GEOGRAPHIES OF PARTICULAR RELEVANCE

Currently, compostable flexibles are mostly relevant in a few specific applications related to the food system. (Note: These are of relevance across all geographies.)

For example:



FOOD COLLECTION BAGS



FRUIT STICKERS



DRIED BEVERAGES
tea bags, coffee pods

If substitution to compostable materials was to be of relevance more broadly for flexibles (for those where direct elimination and innovation opportunities cannot be identified), it is likely this will be in geographies where waste management systems of plastic flexibles are still many years away (with one reason being that composting infrastructure anyway needs to develop for food and organics waste so there could be an opportunity to only develop one rather than two new systems, for further comments see [page 19](#)).

Note: Before any substitution is undertaken fundamental questions need to be answered (as elaborated on within this document). Furthermore, the type of compostable material (home or industrially compostable) needs to be carefully considered.

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

| |
|--|
| |
| Likely materials would need to be industrially compostable |
| Likely materials would need to be home compostable |

4 KEY INSIGHTS SUPPORTING THE KEY ACTIONS

COMPOSTABLE FLEXIBLES

4 KEY INSIGHTS

- 1** **Clear candidates for substitution to compostable flexibles are currently limited to a few distinct applications.**
- 2** **However, there are reasons to believe that for B2C flexibles specifically, the opportunity for compostable materials could be broader — given that plastics recycling systems, and paper systems for flexibles are also still nascent solutions and face their own limitations, and organic waste collection and recycling systems anyway need to expand globally to support a circular food system.**
- 3** **Before compostable packaging is pursued as a broader strategy for flexibles, active involvement to address some fundamental questions is required**
 - What are the design requirements for compostable flexibles in order to integrate with the food composting system?
 - What mechanisms (e.g. technology, financing, governance mechanisms) would need to be in place to allow compostable and non-compostable packaging to simultaneously exist on the market without causing contamination of either the composting or recycling systems?
- 4** **Crucial to remember when investigating these questions, is that substitution to compostables should never be undertaken in place of direct elimination, innovative elimination, or reuse solutions — Shifting to compostable packaging means shifting towards 100% virgin input requirements and is still ‘single-use’ in the same way that conventional Plastic and Paper B2C Flexibles are.**

COMPOSTABLE FLEXIBLES

4 KEY INSIGHTS

1

Clear candidates for substitution to compostable flexibles are currently limited to a few distinct applications

Substitution of conventional plastic flexibles to compostable flexibles is currently limited to a few applications. For example, items that facilitate the collection of organic materials, items frequently found contaminating organic waste streams (e.g. tea bags, fruit stickers) and food packaging likely to remain highly contaminated with food (e.g. sauce sachets).

See following page for details and references

As previously pointed out in the Upstream Innovation Guide:



TRENDS

Using compostable packaging to improve the value of compost:

Applications that commonly end up contaminating the organic waste stream are redesigned to be fully compostable (e.g. tea bags and fruit stickers) and compostable packaging is used to facilitate the collection of food waste (e.g. food waste collection bags).



WHERE TO START

A good place to start when identifying opportunities for compostable plastics is to consider applications in which they can help to create a more effective system overall. Three broad categories that currently could make sense are:

- In applications that facilitate the collection and composting of organic materials thus helping to return nutrients to the soil (such as tea bags or organic waste collection bags).
- In a closed system (for example, an event or stadium) if reuse is not an option.
- In applications that are frequently found contaminating organic waste streams (such as stickers on fruit and vegetables).

Yorkshire Tea from Bettys and Taylors Group: using compostable tea bags (p146)

PG tips from CVC Capital Partners: using compostable tea bags (p146)

Ooho: using compostable sauce sachets (p58)

Bostock: using compostable fruit labels (p146)

COMPOSTABLE FLEXIBLES

4 KEY INSIGHTS

2

There are reasons to believe that for B2C flexibles specifically, the opportunity for compostable materials could be broader

There are reasons to believe that for some of the single-use B2C flexibles that cannot be moved away from, compostable materials could be an option. Organic waste collection needs to expand globally to support a circular food system, providing a potential end-of-life route for compostable flexibles. In addition, both recycling and substitution to paper for B2C flexibles being nascent solutions and facing their own significant challenges and limitations, solutions such as substitution to compostable materials have been estimated to be relevant and technically possible for as high as **~20% of the B2C flexibles market by 2040.**

See following page for details and references

There are suggestions that substitution to compostable materials could be relevant and technically possible for as high as 20% of the B2C flexibles market by 2040.

*Breaking the plastic wave*¹ highlighted flexible packaging as the category for which substitution to compostables 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 compostable materials could be relevant and technically possible for ~20% of the current B2C flexibles market.¹

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

| | Compostables* |
|--------------------------------------|---------------|
| Mono-material Films | 25.5% |
| Sachets and Multi-layer Films | 2% |
| Carrier bags | 10% |

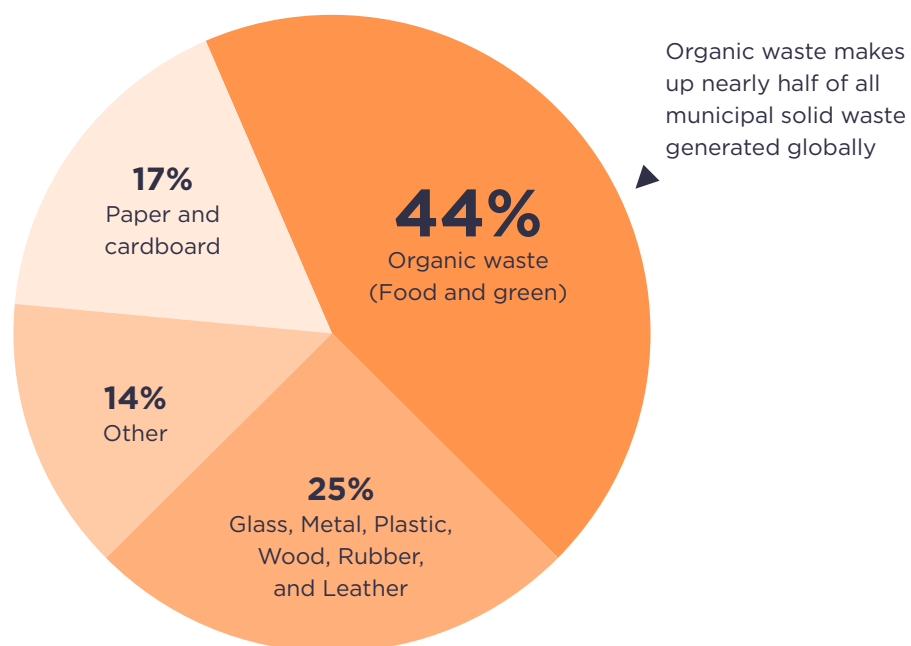
* Existing materials and new formats under development: this includes more common materials such as PLA, less common materials such as PHA, as well as materials in development such as seaweed, algae, and edible packaging.

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

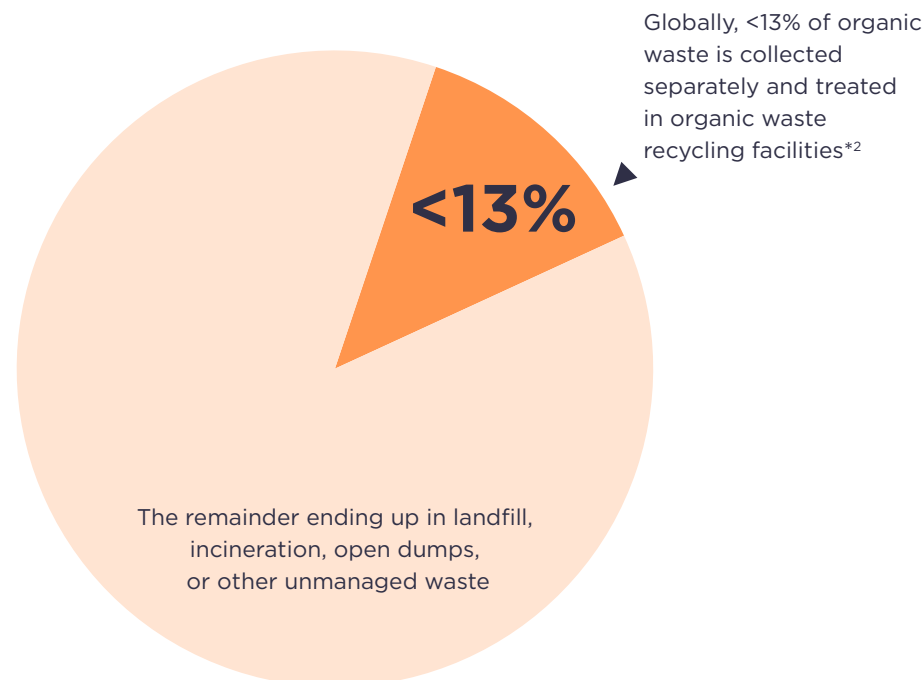
Organic waste collection needs to expand globally to support a circular food system, providing a potential end-of-life route for compostable flexibles.

Organic waste collection and recycling facilities **need to** be developed due to the pressing need to reduce greenhouse gas emissions from landfill and capture and circulate the nutrients contained in food waste to regenerate soils and support a circular food system. This development of organic waste collection and recycling could provide the infrastructure for compostable flexibles.

Global Municipal Solid Waste Composition¹



Fate of organic waste



* This data predominantly includes the organic solid waste that passes through the municipal waste system and in some instances the hospitality, restaurant and catering sectors, not the agricultural system at large.

¹ World Bank, *What is Waste 2.0* (2018), p. 29;

² International Solid Waste Association, *Global assessment of Municipal Organic Waste Production and Recycling* (2020), p. 54.

See our [Big Food Redesign](#) report for more information about a circular food system

Both recycling of B2C flexibles and substitution to paper for B2C Flexibles are themselves nascent solutions and have their own significant challenges and limitations.

Recycling for PLASTIC flexibles: Significant and inherent quality and yield losses

MECHANICAL RECYCLING comes with significant and inherent **QUALITY** losses:

- Even if radical design changes are made across all flexibles, a mechanical recycling process will always produce non-virgin quality recycle.
- Given the material properties required to produce high-performance flexibles, it was broadly agreed by our expert panel that an average of 30% mechanically recycled content is pushing the upper limit for B2C flexibles.
- **This quality loss thus limits the amount of mechanically recycled content that can go back into B2C flexibles.**

CHEMICAL RECYCLING, comes with significant and inherent **YIELD** losses:

- Even if radical design changes are made across all flexibles, a chemical recycling process will always have significant yield losses.
- Polymer yield from a chemical recycling process (i.e. the amount of polymer obtained after polymerisation relative to the amount of polymer going into the pyrolysis unit) is generally found to be between 30-50%, (i.e. there is a 50-70% loss of material from the plastic packaging system).
- While it is technically possible to make a food contact B2C flexible from 100% chemically recycled plastics, to do so across all B2C flexibles would require significant chemically recycled content to be brought in from other sectors/ industries, simply transferring rather than solving the issue of 'yield losses'.

Recycling for PAPER-based flexibles: Significant and inherent quality

- 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, many use cases for Paper B2C Flexibles require 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).**

COMPOSTABLE FLEXIBLES

4 KEY INSIGHTS

3

Before compostable plastic packaging is pursued as a broader strategy for flexibles, active involvement to address some fundamental questions is required

Before a judgement can be made as to what role compostables should actually play in a broader flexibles strategy (i.e. whether they should be used for flexibles that do not directly relate to food waste collection or addressing common contaminants in the composting system), two questions need to be answered:

- 1** What are the design requirements for compostable flexibles in order to integrate with the food composting system? (see [page 19](#) for details)
- 2** What mechanisms (e.g. technology, financing, governance mechanisms) would need to be in place to allow compostable and non-compostable packaging to simultaneously exist on the market without causing contamination of either the composting or recycling systems? (see [page 20](#) for details)

There is also a third, still very open, question that needs to be investigated — What role could home compostable materials play in geographies with very little access to any sort of formal infrastructure? (see [page 21](#) for details)

See following page for details and references

Deciding to pursue compostable plastic packaging for flexibles first requires active involvement in addressing two fundamental questions.

For all flexibles applications that aren't either applications that facilitate composting (e.g. tea bags), or applications that are common *contaminants* of the organics waste stream (e.g. fruit and veg stickers), two key questions need to be answered before substitution to compostable plastics is undertaken:

- 1** What are the design requirements for compostable flexibles in order to integrate with the food composting system?
- 2** What mechanisms (e.g. technology, financing, governance mechanisms) would need to be in place to allow compostable and non-compostable packaging to simultaneously exist on the market without causing contamination of either the composting or recycling systems?
- ?** What role should home compostable materials play in geographies with very little access to formal infrastructure?

1 What are the design requirements for compostable flexibles in order to integrate with the food composting system?

For all flexibles applications that aren't either applications that facilitate composting (e.g. tea bags), or applications that are common *contaminants* of the organics waste stream (e.g. fruit and veg stickers), two key questions need to be answered before substitution to compostable plastics is undertaken:

Composting systems are built primarily to process food and organic waste to produce high-quality, mature compost — meaning compostable packaging needs to be designed to fit best-practice composting systems for food and organics, not the other way around.

- A majority of experts spoken to agreed that the primary aim of a composting system should be to circulate nutrients from food and organics waste to support the development of healthy soils, limit climate impacts and promote a circular food system.
- Even if 20% of all B2C flexibles were shifted to compostables, compostable flexibles would still only comprise ~3%¹ by weight of the material within a composting system.

Currently, composting practices differ widely across geographies and are not always optimised for producing high-quality, mature compost. This variation and lack of agreed protocols for composting systems means that existing certification schemes for compostable materials don't always guarantee compostability in practice and at scale.

Key actors (including organics recyclers, farmers, waste management companies, policymakers, and packaging producers) need to jointly align on what best practice looks like for composting of food waste to support soil health.

All composting systems then need to adhere to these practices.

Standards for compostable packaging need to be aligned with agreed best practice for composting systems and all compostable flexibles need to be designed to meet these requirements.

2 What mechanisms (e.g. technology, financing, governance mechanisms) would need to be in place to allow compostable and non-compostable packaging to simultaneously exist on the market without causing contamination of either the composting or recycling systems?

For all flexibles applications that aren't either applications that facilitate composting (e.g. tea bags), or applications that are common *contaminants* of the organics waste stream (e.g. fruit and veg stickers), two key questions need to be answered before substitution to compostable plastics is undertaken:

- For items extremely likely to end up in the organics system (e.g. food waste bags, tea bags) it has been demonstrated how compostable materials can improve both the composting and recycling systems.
- For items that are not as obviously linked with the organics system (e.g. sweet wrappers, snack wrappers, crisp bags), this is less clear. (Note: While these are food contact applications, they are unlikely to contain food when discarded.)
- There is justifiable concern that having both compostable and non-compostable versions of such items on the market at the same time could lead to increased contamination of composting systems — with the introduction of compostable versions increasing the likelihood of non-compostable versions also being discarded in the composting system.

See the [Upstream Innovation Guide](#) pp. 138-143 for details of some key mechanisms to be explored

Key actors (including organics recyclers, packaging producers, brands, and policymakers) need to collectively identify the mechanisms that need to be in place to allow compostable and non-compostable versions of packaging to be put on the market alongside each other without causing contamination of either the composting or recycling systems.

These could be technical mechanisms (e.g. sorting technology), financial mechanisms (e.g. EPR), or governance mechanisms (e.g. legislation on which items can be compostable).

These mechanisms then need to be put in place alongside any flexibles that are shifted to compostables.



What role should home compostable materials play in geographies with very little access to formal infrastructure?

- There are many regions around the world where there is still little to no waste management infrastructure — with scaled infrastructure likely still many years away.
- There is an open question as to whether materials being home compostable could allow for localised, community-based waste management — as this is likely to be quicker and cheaper to establish than large-scale, centralised infrastructure.

This is still a very open question, and whether it is a reasonable strategy to consider needs to be investigated by initiatives with an understanding of the relevant geographies.



COMPOSTABLE FLEXIBLES

4 KEY INSIGHTS

4

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

Shifting to compostable flexibles, while relevant in some applications, means shifting towards 100% virgin input requirements and is still ‘single-use’ in the same way that conventional plastic and paper B2C flexibles are. Composting a material involves breaking it all the way down into fundamental building blocks — for the most part, carbon dioxide and water — which means that for any packaging that is composted, the equivalent amount of virgin material is then required to make new packaging. This is why moving away from single-use flexibles still needs to remain the first and foremost part of any flexible packaging strategy. Where shifting to compostable flexibles IS selected as a strategy, prioritising regeneratively sourced virgin-feedstock is crucial.

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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