ELLEN MACARTHUR FOUNDATION

FLEXIBLE PACKAGING:

PLASTIC FLEXIBLES:

Design and recycling in the formal sector

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

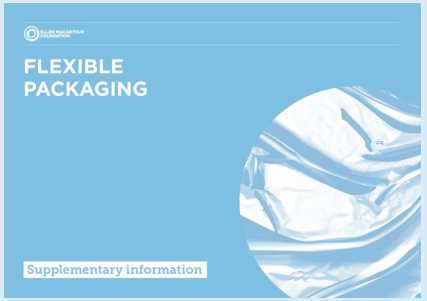
Short, high-level strategy document. Doesn't contain any analysis, reasoning or details for the key actions.

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

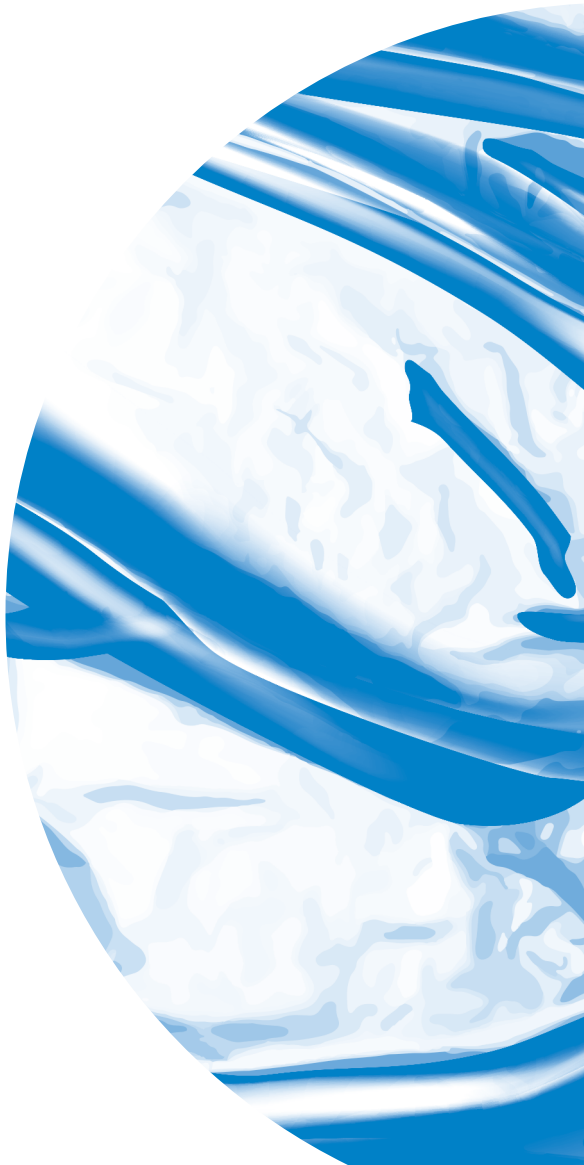
Eliminating and innovating away from single-use flexible packaging must be the first and foremost part of any flexible packaging strategy — because as soon as single-use flexible waste is generated, regardless of material or geography, it is very hard to deal with. Current efforts are only just scratching 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 FORMAL RECYCLING SYSTEMS

FORMAL RECYCLING SYSTEMS: flexibles made from plastic, designed for recycling, and collected, sorted and recycled in practice and at scale in a formal system.

FORMAL RECYCLING SYSTEMS
KEY ACTIONS

Businesses to:

Radically improve packaging design, in particular, shift to mono-materials for the >40% of flexibles that are currently multi-material

See page 6 for details

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

Set separate recycling targets for flexibles (e.g. In Europe the 2030 targets need to be revisited)

Increase EPR fees for flexibles (e.g. In Europe, fees of ~EUR 1,100 per tonne are a good estimate of what may be required)

Expand collection of flexibles for recycling (e.g. In Europe >40% of the population do not have access to separate collection for flexibles)

Invest in infrastructure (e.g. >EUR 2 billion in the case of europe)

See page 7 for details

Businesses to:

Radically improve packaging design, in particular, shift to mono-materials for the >40% of flexibles that are currently multi-material

All flexible packaging producers (converters, FMCGs, retailers, etc.) to transition all multi-material flexibles to mono-material flexibles, eliminate or redesign items less than 50x50mm, reduce non-polymer content (i.e. use of coatings, inks, glues, etc.) to <10% but ideally <5% to enable new end markets, and adhere to local design for recycling guidelines. Eco-modulation within EPR can be used to drive the shift (see the EPR action below). All to be completed by 2025.

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

Set separate recycling targets for flexibles (e.g. in Europe the 2030 targets need to be revisited)

Policymakers to either set separate recycling rate targets for rigids and flexibles, or to set the collective targets for plastic packaging high enough, such that the targets could not be reached through recycling of rigids alone. For example, in the case of the EU the 2030 recycling rate target will need to be increased or granularity will need to be provided in the form of recycling targets for different formats. In the absence of separate recycling rate targets for flexibles at the country/regional level, EPR schemes should independently set and drive towards recycling targets for flexibles.

Increase EPR fees for flexibles (e.g. in Europe, fees of ~EUR 1,100 per tonne are a good estimate of what may be required)

With EPR being the only proven and likely pathway to make the economics of recycling work (see EPR statement), policymakers and EPR organisations to implement appropriate EPR fees for flexible plastic packaging (fees that ensure the true net cost of keeping these formats in circulation in high-quality end-market applications is covered). The true net cost should be determined country-by-country and EPR fees adjusted as required by 2023 (with any fees charged for flexibles explicitly used to collect, sort, and recycle flexibles).

For Europe, an initial estimate of the net cost of keeping mono-material B2C flexibles in circulation is around EUR 1,100 per tonne (see page 17 for further details). This is significantly higher than current fees in most European countries (in many cases, more than 3x higher). Fees for multi-layer films should be even higher to incentivise packaging design changes.

Businesses with flexible packaging in their portfolio (e.g. converters, FMCGs, retailers, etc.), are to support the required changes in EPR fees.

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

Expand collection of flexibles for recycling (e.g. in Europe >40% of the population do not have access to separate collection for flexibles)

Policymakers to implement collection-for-recycling for all flexibles. Even in Europe this is not in place for >40% of the population. Given that actually implementing collection will take some time, it is important that policymakers, as soon as possible, send a clear signal that rollout is being planned. Providing this confidence is crucial to allow investments in sorting and recycling infrastructure and packaging design changes to be started in parallel (saving many years versus undertaking each action consecutively).

Invest in infrastructure (e.g. >EUR 2 billion in the case of Europe)

Recyclers, financial institutions, and governments to invest in sorting and recycling infrastructure. In the case of EU27+4, at least EUR 2 billion CAPEX is needed to achieve a 30% recycling rate by 2025 (See page 17 for further details). Planning, permitting, and financing to be started in 2022 to allow for capacity to be online by 2025.

FORMAL RECYCLING SYSTEMS

SECTORS AND GEOGRAPHIES OF PARTICULAR RELEVANCE

Plastic flexibles are most relevant for applications that require high barrier properties and where reuse or other innovative models seem appear less likely to develop in the near future.

For example:

CONFECTIONERY

CRISPS, BISCUITS, & MOISTURE-SENSITIVE SNACKS

Once direct elimination and innovation opportunities have been pursued, formal recycling systems for flexibles are of greatest relevance in geographies where collection and recycling systems for plastics are already in place, and there is at least some level of discussion ongoing about EPR.

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

FORMAL RECYCLING

4 KEY INSIGHTS

1 Recycling of plastic flexibles has inherent limitations.

2 Despite these inherent limitations, recycling solutions do need to be scaled (bearing in mind that before recycling of plastic flexibles is pursued as a strategy, opportunities for direct elimination, innovative elimination, or reuse solutions should always be implemented).

3 Scaling recycling solutions can't be assumed to be easy — an unprecedented simultaneous effort is required from all stakeholders across design, policy, and infrastructure.

4 Even in Europe, one of the most advanced regions in terms of recycling systems, getting to a mere 30% recycling rate for plastic B2C flexibles by 2025 requires massive efforts across design, policy, and infrastructure to all start by the end of 2022.

FORMAL RECYCLING

4 KEY INSIGHTS

1

Recycling of plastic B2C flexibles has inherent limitations

Even in a maximally optimised recycling scenario for B2C flexibles, there will be significant unavoidable material quality and quantity losses and therefore considerable virgin input requirements. These inherent mechanical limitations are unlikely to be overcome by technical developments and means that only a portion of the flexible packaging that is sent to recycling will make it back into high-quality recyclate. This means that even in a maximally optimised system **~45%** of the plastics going into flexibles would need to come from virgin inputs. Specifically, for food packaging virgin input requirements are likely to be higher due to the lack of availability of recycled materials that can come into contact with food.

See following page for details and references

Even in a maximally optimised recycling scenario for B2C flexibles, there will be significant unavoidable material quality and quantity losses, and therefore considerable virgin input requirements.

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 recyclate.
- 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’.

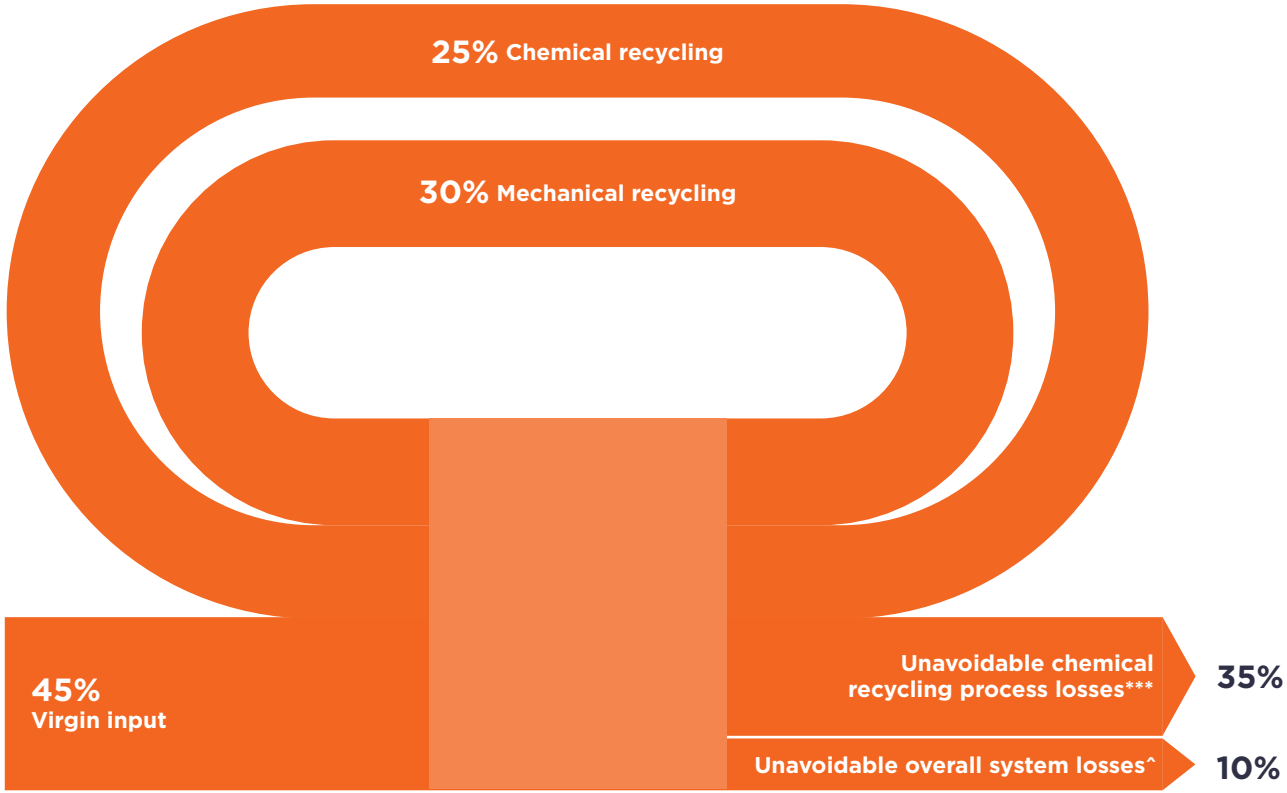
*Expert interviews and Lodestar project publication: https://www.newplasticseconomy.org/assets/doc/Lodestar.pdf

Even in a maximally optimised recycling scenario for B2C flexibles, there will be significant unavoidable material quality and quantity losses, and therefore considerable virgin input requirements.

Maximally optimised recycling system for plastic B2C flexibles**

What the global flows for plastic B2C flexibles would look like assuming:

- All B2C flexibles are collected and recycled via highly optimised mechanical and chemical recycling processes.
- The amount of plastics going back into B2C flexibles is maximised.



NOTES

**What the global flows for plastic B2C flexibles would look like assuming: a) All B2C flexibles are collected and recycled via highly optimised mechanical and chemical recycling processes; b) The amount of plastics going back into B2C flexibles is maximised; c) All flexible packaging (including food packaging) would contain 30% mechanically recycled content; d) The average yield for chemical recycling was 40%.

***Assuming a 60% loss of material from the plastic packaging system (as gasses and waxes) in a chemical recycling process, as per yield discussion above.

^Losses such as those that occur through collection and sorting processes as well as packaging production processes. 10% is highly conservative.

NOTE: Here chemical recycling refers to pyrolysis of polyolefins, this being the predominant technology in use/being considered for scale-up.

For additional information and references see the Deepdive: Plastic B2C flexibles: Design and recycling in the formal sector

FORMAL RECYCLING
4 KEY INSIGHTS

2

Despite these inherent limitations, recycling solutions do need to be scaled (bearing in mind that before recycling of plastic flexibles is pursued as a strategy, opportunities for direct elimination, innovative elimination, or reuse solutions should always be implemented)

Despite inherent limitations, in regions with formal recycling systems in place, recycling solutions do have to be scaled. While moving away from single-use flexibles needs to remain the first and foremost part of any flexible packaging strategy, even with ramping up innovation efforts, it is currently not possible to completely move away from single-use flexible packaging without unintended consequences — meaning recycling does need to form a key part of a flexibles strategy.

FORMAL RECYCLING
4 KEY INSIGHTS

3

An unprecedented, concerted effort is required from all stakeholders across design, policy, and infrastructure to scale recycling for flexibles

Scaling recycling for B2C flexibles can't be considered to be an easy strategy to pursue and will require significant efforts from all stakeholders — and it will be essential that each effort is complementary and coordinated. Even in many countries with established formal recycling systems, the average rates for high-quality recycling of B2C flexibles sit close to 0%. Making recycling work will require massive efforts from all stakeholders and it will be essential that all of the actions are undertaken simultaneously rather than sequentially.

If actions are undertaken sequentially, it could be over a decade before high-quality recycling system are in place — even in Europe which has the strongest starting point in terms of the existing policy landscape and infrastructure.

FORMAL RECYCLING

4 KEY INSIGHTS

4

Even in Europe, one of the most advanced regions in terms of recycling systems, getting to a mere 30% recycling rate for plastic B2C flexibles by 2025 requires massive efforts across design, policy, and infrastructure to all start by the end of 2022

- Key signals on collection rates, EPR fees, and recycling rate targets need to be in place as soon as possible.
- Billions of dollars need to be invested in tripling collection rates and sorting capacity and quadrupling mechanical recycling capacity (as chemical recycling capacity is expected to account for only **3%** of required capacity by 2025).
- All flexibles need to be designed to meet the requirements for both mechanical and chemical recycling (as above, chemical recycling capacity is expected to remain limited).

This task is not impossible, but is not looking likely unless coordinated, ambitious action starts immediately.

See following page for details and references

Even in Europe, one of the most advanced regions in terms of recycling systems, getting to a mere 30% recycling rate for plastic B2C flexibles by 2025 requires massive efforts across design, policy, and infrastructure to all start by the end of 2022.

A few crucial signals absolutely need to be in place ASAP...

- A commitment from governments that **plastic B2C flexibles will be collected for recycling in the first place.**
- A commitment from EPR organisations to put in place an appropriate **EPR fee for flexible plastic packaging to cover the true net cost of recycling these formats — which at first estimate is around EUR 1,100* per tonne.**
- A separate **recycling rate target for flexible plastic packaging** within the 2030 recycling rate targets, to help drive the two above.

... so that stakeholders can confidently invest the required capex of at least EUR 2 bln** in

- **3x** increase in collected-for-recycling volumes of B2C flexibles by 2025 (from 0.8 mtpa currently to 2.5 mtpa by 2025).
- **3x** increase in sorting capacity by 2025 (from 0.7 mtpa currently to 2.1 mtpa by 2025).
- **4x** increase in recycling capacity by 2025 (from 0.5 mtpa currently to 1.9 mtpa by 2025).

In parallel, businesses need to further accelerate packaging design changes, including shifting the **>40%** of plastic B2C flexibles that are multi-material to mono-materials, reducing non-polymer content (e.g. coatings, inks, glues) to <10% but ideally <5% across all flexibles to enable new end-markets, and adhering to local design for recycling guidelines. Items smaller than 50x50mm need to be eliminated or need fundamental redesign altogether.

ALL of this needs to have started by the end of 2022, and happen in parallel, in order to see significant progress towards 2025 targets (given each action has a 3-to-5-year lead time (for example to plan, permit, and build infrastructure)).

Footnotes for previous page

*The indicative EUR 1,100 per tonne fee for mono-material, technically recyclable flexibles is based on the 2022 Fostplus Belgian fee for PE films of EUR 1,159 per tonne — the Belgian system being one of the few EPR schemes specifically attempting to drive the recycling of flexibles.

While the net cost of high-quality recycling of flexibles differs from country to country, based on a variety of local factors, it gives a rough indication of the net cost in a European context.

Given the current average EPR fee in Europe for plastics packaging is ~EUR 350 per tonne1, with few countries having differentiated fees for flexibles, it is clear a significant increase in EPR fees for plastic flexibles will be required in almost all European countries to make the economics of collection, sorting, and recycling of flexibles work.

Multi-material flexibles drive up the cost of the overall process meaning that if they are still on the market, even higher EPR fees would be required to make the economics of the system work (e.g. EUR 1,448 per tonne for other plastic films in Belgium in 2022).

Any fee should be transparent on how the fee is calculated and how it helps to achieve the recycling rate target and the money raised through it should be used to collect, sort, and recycle flexible packaging.

**This number is highly conservative and is based purely on mechanical recycling and achieving a mere 30% recycling rate by 2025. It would likely be far higher if chemical recycling technologies are included and further investment will of course be required to move beyond a 30% recycling rate.[2]

For a globally applicable set of recommendations, the full reasoning and references behind each recommendation and references (1 & 2), see the **Supplementary Information:** Plastic B2C Flexibles - Formal Sector – “What does the system to work towards look like?”

Further details on the required infrastructure expansions

INFRASTRUCTURE - needs to develop for B2C flexibles and see following increases across Europe:

x3
Increase in average COLLECTION rate

The average collection rate of flexibles would need to increase from a current 13% to 40% (from 0.8 mtpa to 2.5 mtpa) through increased access to collection systems and improved performance of existing collection systems.

NOTE: in Europe >40% of the population do not have access to collection of flexibles as part of their predominant household recycling collection and even in countries where there is access, the level of access/success of the system is not always uniform.

x3
Increase in SORTING capacity

The average sorting capacity of flexibles would need to increase from a current 11% to 33% (from 0.7 mtpa to 2.1 mtpa).

The aim would be to produce PE, PP, and mixed PO bales.

Corresponding to a CAPEX investment of EUR 340 million in the next two years.*

x4
Increase in RECYCLING capacity

The average recycling rate of flexibles would need to increase from a current <8% to 30% (from 0.5 mtpa to 1.9 mtpa).

Corresponding to a CAPEX investment of EUR 1.6 billion in the next two years.*

NOTE: Given expected constraints on chemical recycling capacity (see next page) and the timeframes and cost associated with scaling chemical recycling, it is likely that the required increase in recycling capacity will need to be achieved through mechanical recycling.

*This number is highly conservative and is based purely on mechanical recycling and achieving a mere 30% recycling rate by 2025. It would likely be far higher if chemical recycling technologies are included and further investment will of course be required to move beyond a 30% recycling rate.

For additional information and references, see the **Supplementary Information:** Plastic B2C Flexibles - Formal Sector – "What does the system to work towards look like?"

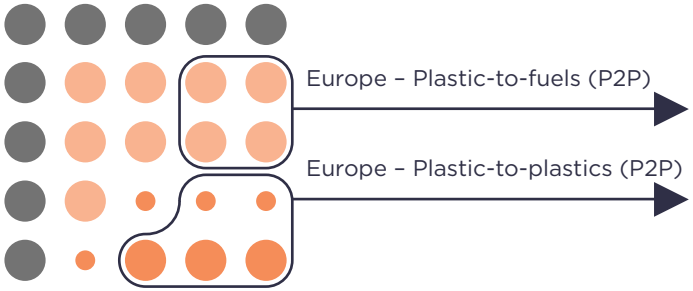
Chemical recycling capacity is expected to account for only 3% of required recycling capacity by 2025.

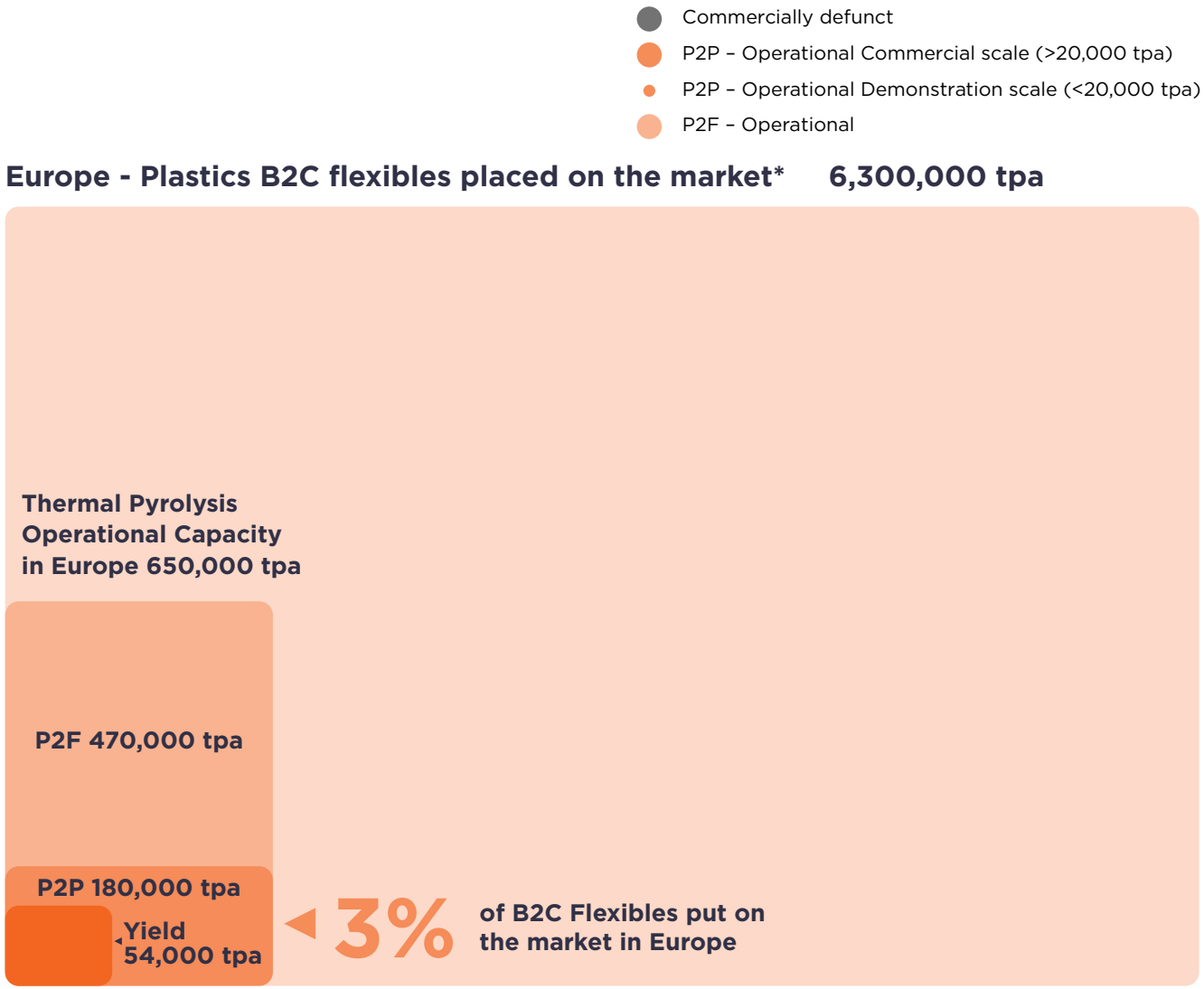
An analysis of chemical recycling projects for polyolefins (the predominant materials used for plastic flexibles) over the past 20 years indicates that polyolefin chemical recycling capacity will not be significant by 2025.

Of the 25 companies, that had announced their involvement in chemical recycling of B2C flexible polyolefins (POs) since 2000, **9 appear to be defunct and another 9 only focus on plastics-to-fuel (projection to 2025). Only 3 are expected to be operational at commercial scale by 2025**, all of which are in Europe.

For Europe, by 2025 **the projected plastic-to-plastic chemical recycling capacity amounts to only ~3% of the mass of B2C flexibles** placed on the market.

Number of Global Thermal Pyrolysis Companies by 2025 (Since 2000)





*Assuming that 2025 volumes of plastics B2C flexibles placed on the market are the same as 2020, owing to significant rollout of elimination efforts

For additional information and references, see the **Supplementary Information:** Plastic B2C Flexibles - Formal Sector – "Recycling"

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

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
Explore the vision for a circular economy for plastic