London's packaging footprint

An analysis of packaging material flows, greenhouse gas emissions and levers for climate action in London

October 2024

ReLondon

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ReLondon

ReLondon is a partnership of the Mayor of London and the London boroughs to improve waste and resource management and transform the city into a leading low carbon circular economy. ReLondon's mission is to make London a global leader in sustainable ways to live, work and prosper by revolutionising our relationship with stuff and helping London waste less and reuse, repair, share and recycle more.

Valpak Consulting

Valpak is on a mission to create a sustainable waste-free world. Valpak helps its clients to reduce waste and recycle more, continually innovating and using leading data science and expertise. Valpak doesn't just show customers how to navigate waste regulations; they help them become more sustainable, through their ever-increasing capabilities and pioneering innovations. Valpak is part of Reconomy which is an international circular economy specialist that combines technology, skills and incredible people to build sustainability 'loops' that create circular opportunities for business.

WRAP

WRAP is a climate action NGO working around the globe to tackle the causes of the climate crisis and give the planet a sustainable future. WRAP was established in the UK in 2000 and is now working in over 50 countries.

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Glossary of terms

Carbon footprint Carbon footprint (or greenhouse gas footprint) relates to the total amount of greenhouse gases that are emitted as a result of the activities of a particular individual, organisation, or community. Carbon footprint is expressed in terms of their equivalent warming potential to carbon dioxide (carbon dioxide equivalents, CO_2eq).

Commingled Commingled collections involve different recycling streams being collected together in a wheeled bin, box or bag, and taken for sorting at a materials recovery facility (MRF).

Consumption-based emissions Consumption-based emissions are those allocated to the final consumers or users of goods or services, rather than the producers of those emissions.

They incorporate greenhouse gas emissions that occur over the lifecycle of products and services, as well as the emissions associated with waste management activities. These emissions may occur both within and outside a given territory, and are allocated to the final consumers or users, rather than the producers of those emissions.

Energy from waste (EfW) Burning of packaging and other materials, with heat or other energy captured.

Greenhouse gas emissions Greenhouse gases are gases that are capable of absorbing infrared radiation and re-radiating infrared radiation within the Earth's atmosphere. Common greenhouse gases include carbon dioxide, methane and nitrous oxide.

Grouped packaging Packaging used to bundle one or more articles of retail packaging together.

Lever A lever is a place to intervene in a complex system that can bring about significant changes to that system.

Lifecycle emissions Lifecycle emissions are the greenhouse gas emissions that occur throughout the lifecycle of a product.

Materials recovery facility (MRF) Materials recovery facilities receive commingled recycling and, via a series of mechanical processes, separate this into different materials: ferrous and non-ferrous metals, paper, card, glass and plastics. Some streams may undergo additional sorting on-site or at other sites to separate them into additional streams (e.g. plastic separation by polymer type) or to reduce contamination and increase purity of the stream.

Packaging loss and waste Packaging loss and waste covers packaging that is lost and/or wasted at every step of the supply chain.

Packaging supply Packaging supply refers to the total quantity of packaging that is produced to fulfil the demand of a consumer group citizens, public organisations, or businesses. Total packaging supply includes not only the packaging obtained through imports and primary production but also the packaging loss associated with imports and primary production.

Placed on the market Packaging placed on the market refers to the quantity of packaging that is around or supplied with goods that are provided for sale.

Plastic recycling (or recovery) facility (PRF) Plastic recycling facilities accept mixed plastics from MRFs, or from separate collections, and separate them by polymer types (and by colour for some streams) to sell on for recycling into new plastic products.

Recycling Any operation by which waste is reprocessed into products, materials or substances, for either its original or other purposes.

Refill systems Reuse system in which the user refills a reusable container, either at home with a refill, or on the go via a dispensing point. Users retain ownership of the reusable packaging in this system and are responsible for cleaning it.

Residual waste Waste materials that have not been separated for recycling or composting, and rejected materials from those processes.

Return systems Reuse system in which packaging is collected after use to be professionally cleaned before being refilled and placed on the market for a new use cycle.

Reuse (of packaging) Operation by which packaging is refilled or used for the same purpose for which it was conceived, with or without the support of auxiliary products present on the market, enabling the packaging to be refilled. Reuse models can either use refill systems or return systems (see 'refill' and 'return' definitions).

Sankey diagram A Sankey diagram is a flow diagram used to visualise systems. The width of the flow lines in the diagram is proportional to the flow quantity. In this report, the flow lines indicate material and greenhouse gas emission flows.

Separate collections/ streams	Separate collections involve householders and/or recycling collection crews separating recycling into different material streams that are deposited into assigned compartments on a recycling collection vehicle, or onto different vehicles. Cans and plastics are generally collected together even under separate collections (with other materials being collected as separate streams) and these are then separated at local depots using a mini-MRF to separate the ferrous and non-ferrous metals to leave the plastics.
Territorial emissions	Territorial emissions are the greenhouse gas emissions directly generated within a territory, such as a city.
Waste hierarchy	The waste hierarchy is a ranking of waste management options according to what is best for the environment. It ranks prevention as the most desirable option, then re-use, recycling and other recovery (including incineration) as the next best options, and finally disposal as the least favourable option.

Contents

Executive summary

Packaging production, and especially plastic packaging, has skyrocketed over the last few decades and is now everywhere. Beyond its impact on the natural environment, packaging contributes significantly to climate change.

Global plastics use has quadrupled in 30 years, with 31% being found in packaging.[1] Global production of paper packaging has increased by 60% over the past 20 years,[2] and glass packaging production has increased by 20% over the past 10 years in the European Union alone.[3]

Beyond its widely regognised impact on our natural environment, the production, transportation and disposal of packaging also has a significant climate impact that is less widely understood or mentioned by public media.[4,5] This first-of-its-kind study shows that London's packaging sector has a considerable climate impact, equivalent to half of all transport emissions in London. And plastic packaging is the biggest contributor to London's packaging footprint - accounting for almost half of it, the equivalent of London's fashion footprint.[6]

To better understand the dynamics at play in the capital's packaging sector, this report maps material flows across the city's packaging supply chain and assesses the impact that consumption and disposal of packaging – plastic, paper, glass and other materials – has on London's greenhouse gas emissions. The results demonstrate an urgent need for systemic change and highlight opportunities to lower the city's carbon emissions across the supply chain.

Whether through incorporating more recycled content into our packaging, introducing more reusable and refillable options across the city or collecting and processing more used packaging for recycling – and ideally a combination of all three – cities have the power to reduce the footprint of packaging use. It will require a more transparent and engaged supply chain but collaborative action is urgently needed to help mitigate the climate crisis and make a meaningful contribution to keeping global temperature rises within 1.5°C of pre-industrial levels.

Mapping the material flows and lifecycle emissions of London's packaging system – key findings

London residents and visitors (commuters and tourists), and London-based businesses and institutions consume a staggering 2.21 million tonnes of packaging per year, of which only 36% is recycled. Slightly less than half (45%) of packaging placed on the market in London is used and disposed of by consumers, and 55% is consumed by London-based businesses and institutions.

Of packaging used in London, 42% is paper, 17% plastic, 21% glass, 13% wood and 6% metals by weight. Most of this packaging has a very short life cycle and 2.18 million tonnes of packaging are thrown away every year in London, equivalent to almost 250kg per person. Only a small proportion of this gets recycled - 44% for household waste (including litter and street bins) and 33% for commercial waste.

While visitors account for 30% of consumer packaging use in London, they account for 55% of packaging thrown away in street bins, and 55% of consumer packaging thrown away in the commercial waste stream (hotels, restaurants, offices, etc).

This study links packaging flows for the first time with greenhouse gas emissions in London and shows that London packaging consumption is responsible for 4.1 million tonnes of CO2eq per year, equivalent to half of all transport emissions in London.[7] This takes into account all lifecycle greenhouse gas emissions from packaging consumed in London, from the manufacture of the material through to packing and filling, plus emissions related to waste management.

The vast majority (76%) of greenhouse gas emissions associated with London's packaging supply chain have already arisen by the time the packaging leaves the factory gate, before it is even filled with product. The next largest source of emissions is the incineration of packaging waste – mainly plastic – which contributes to 20% of London's packaging emissions. These two hotspots present the greatest opportunities for reducing London's packaging footprint.

Figure 1. Recycling rates for packaging waste in London

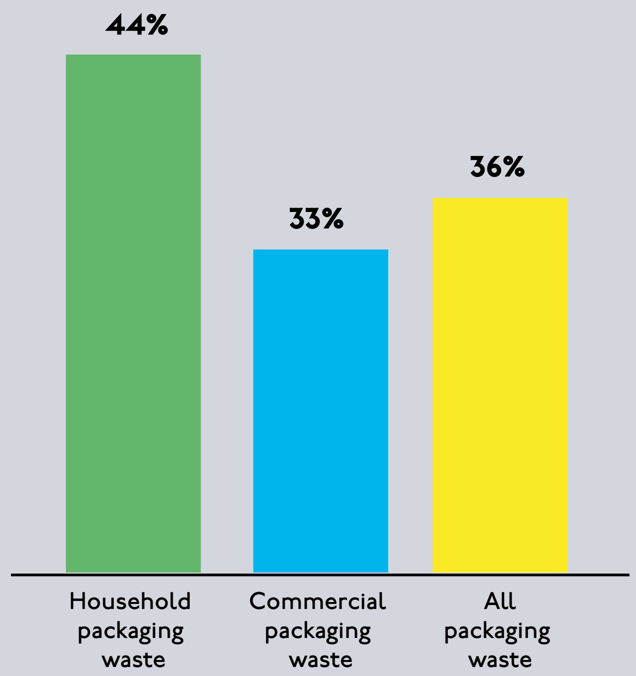
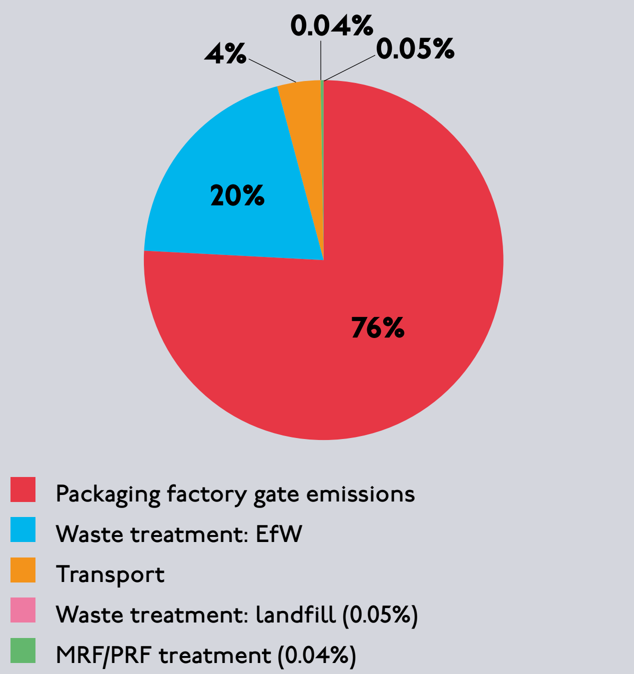


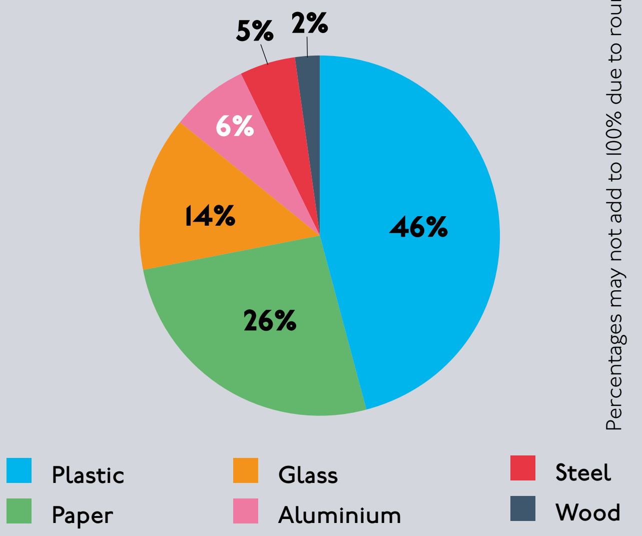
Figure 2. Greenhouse gas emissions associated with London's packaging supply chain, split by activity



Plastic packaging is the biggest contributor to London's packaging-related carbon footprint, due to its widespread use and high number of units placed on the market, its high embodied carbon, and its low recycling rates combined with high incineration rates.

Plastic packaging consumption in London is 379 thousand tonnes and the associated greenhouse gas emissions of this plastic packaging are 1.9 million tonnes CO2eq. This is similar to the emissions generated by London's fashion supply chain (2 million tonnes CO2eq).

Figure 3. Greenhouse gas emissions associated with London's packaging supply chain, split by material



Levers to support a circular and low-carbon packaging system

Through the mapping of materials and emissions associated with London's packaging system, three key levers were identified that have the ability to support London's transition to a circular and low-carbon packaging system.

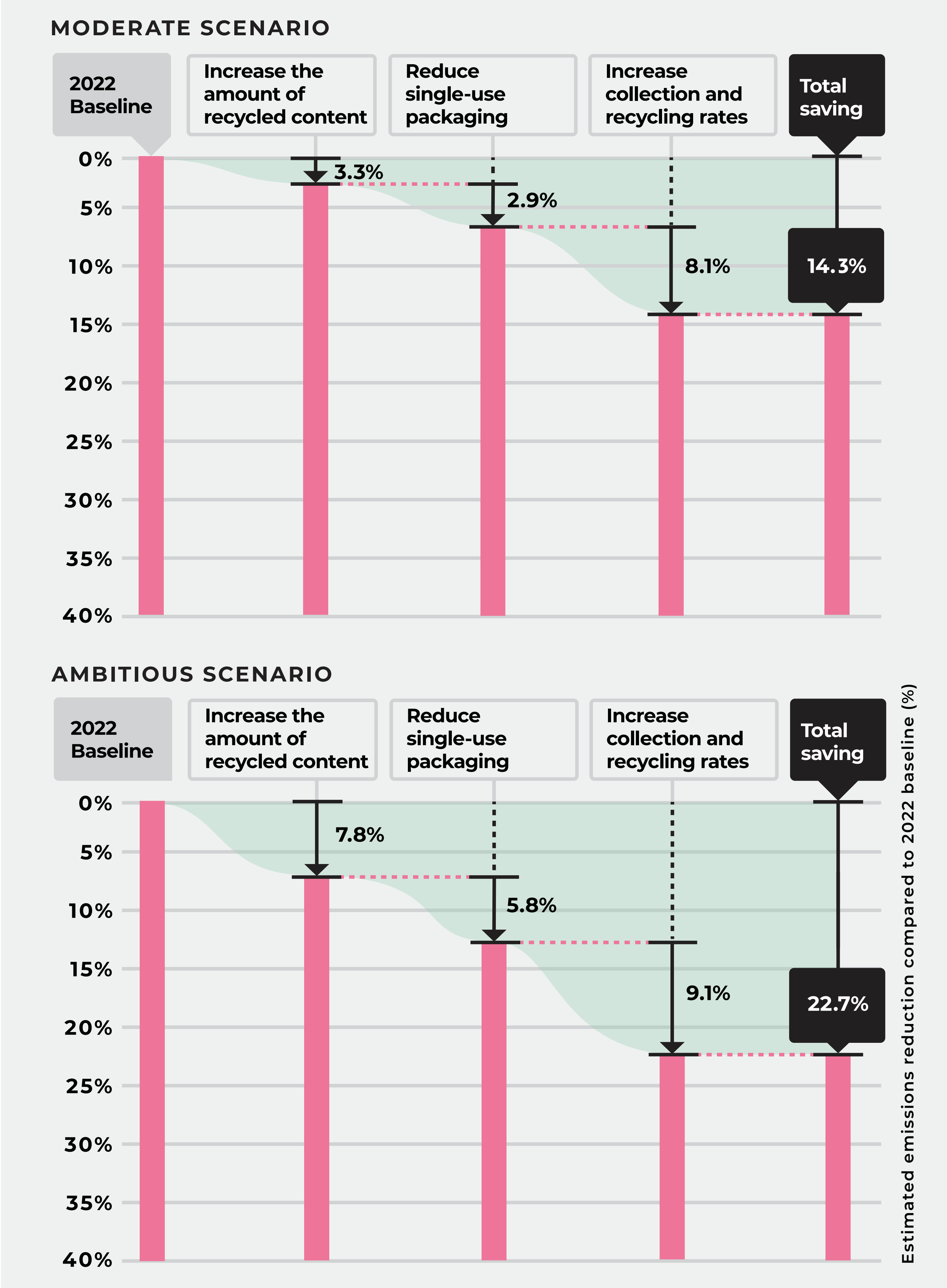
1. Increase the amount of recycled content in plastic packaging.
2. Reduce single-use packaging placed on the market, including through packaging refill and reuse.
3. Increase collection and recycling rates for all packaging waste.

These were modelled across moderate and ambitious scenarios to highlight where the greatest reductions in emissions could be made at different points across the packaging supply chain. The scenarios set out are for illustrative purposes and the percentages have been set in line with a variety of targets, including London Environment Strategy's objectives and the European Union's targets for packaging.

If the sector were to meet the ambitious scenarios against each of the three levers, there is **potential to reduce the carbon emissions associated with London's packaging supply chain by 22.7%**, by delivering the following actions and impacts:

- Increasing the average recycled content in plastic packaging to approximately 60% is estimated to result in a **7.8% reduction in emissions**.
- Reducing the amount of single-use packaging placed on the market by eliminating fruit and vegetable packaging and grouped packaging, and by implementing reuse systems for some consumer packaging categories, is estimated to result in a **5.8% reduction in emissions**.
- Increasing collection and recycling rates to 70% for packaging overall and 55% for plastic packaging specifically is estimated to result in a **9.1% reduction in emissions**.

Figure 4. Summary of the estimated carbon emission reduction of circular levers against the 2022 baseline across moderate and ambitious scenarios



A replicable model for cities around the world

London's packaging footprint is the third in a series of material flow analyses produced by ReLondon and their partners, with the first being '[London's food footprint]' in 2021, and the second '[London's fashion footprint]' in 2023. These three reports have applied similar methodologies to quantify sectors' material flows and associated carbon emissions in London; and all three reports aim to propose replicable models which other cities can use to measure and tackle their own consumption-based emissions.

This is important because most major cities globally are net consumers of products and materials. While they generate greenhouse gas emissions within their own boundaries, they also consume vast amounts of resources which are imported from elsewhere. London's consumption-based emissions are, for instance, 2.8 times higher than its territorial emissions.[8]

What follows in this report represents a practical approach to identify, measure and act on packaging-related waste and carbon hotspots at a city level. It shows the significant potential impact cities can have on carbon emissions by developing the infrastructure and conditions to reduce single-use packaging consumption and increase packaging recycling.

Context and aims of the research

1. Context and aims of the research

1.1 Context

The greenhouse gas emissions that are generated in cities have received a great deal of attention in recent years. Conventionally, cities' efforts to achieve net zero greenhouse gas emissions are focused on reducing the emissions occurring within the city boundaries (often referred to as territorial emissions), such as low-carbon forms of transportation, improving the energy efficiency of housing and improving waste reduction and management measures.

However, the broader climate impacts associated with urban consumption and consumption-based emissions can be overlooked. For many cities (especially those in the global north), the majority of these emissions occur outside of the city's boundaries and are embodied within the materials and products imported.[9] These embodied emissions relate to the greenhouse gases that are emitted and associated with the generation and consumption of energy required for the extraction, manufacture and transportation of materials, products and services which are then consumed by residents.

Developing our understanding of the climate impact of our consumption and waste management model is therefore crucial for the transition towards a sustainable future within the ecological boundaries of our planet; and a consumption-based approach can provide new insights which can prioritise action to reduce greenhouse gas emissions.[10]

The global pollution issues caused by packaging consumption, waste and littering and their impact on the natural environment have also received increasing attention in recent years. Plastic packaging has been the most visible, accumulating in huge subtropical oceanic gyres and being deposited even on remote islands far from human habitation.[11]

A circular economy is a solution for both issues, reducing as it does consumption of virgin materials (and therefore associated emissions); as well as tackling pollution by increasing reuse and recycling. It presents an alternative to the current 'linear' way we produce and consume products and resources, characterised as 'take-make-waste'. In a circular economy, products and materials are kept at their highest value for as long as possible, in order to eliminate waste and pollution and regenerate natural systems. Pursuing a more circular economy not only presents opportunities to reduce ecological degradation, but also provides opportunities to generate new economic value and jobs at a local level through product innovation as well as the development of local material loops, logistics and infrastructure to circulate the material back to new uses.[12] Cities therefore have a crucial role to play in creating a circular economy - for all types of materials and resources but especially for packaging.

Recognising the influential role that cities can play in this transition, the Mayor of London has set ambitious targets for London to become a leading net zero-carbon city by 2030 and a zero-waste city.[13,14] Notably, the Mayor of London is striving for a 65% municipal waste recycling rate by 2030, and to cut food and associated packaging waste by 50% by 2030.[15] Alongside this, three-quarters of London's boroughs have set targets to reach net zero emissions by 2030 and the One World Living theme of London Councils' climate programme is set up to develop an action plan for boroughs to reduce consumption-based emissions by two-thirds by 2030.[16] Such commitments demonstrate London's ambitions to continue to be a frontrunner in the transition towards a more sustainable future.

Supporting this circular transition, London's Circular Economy Route Map identified five priority sectors that should form the core focus of London's circular transition: food, textiles, plastics, electricals and the built environment. However, the evidence base and decision-making tools needed to support this transition at a sector level are currently incomplete. Further evidence is needed to increase understanding of the relationship between material flows and consumption-based emissions. To address this issue, ReLondon commissioned a series of reports to develop an analytical framework for key sectors to support policymaking and inform actions to reduce consumption-based emissions at a city-wide level. The first reports focused on food and textiles flows and their associated emissions, and they were published in 2021 and 2023 respectively.[17,18] This third report in the series focuses on packaging, linking consumption of packaging material to its carbon footprint.

1.2 A focus on packaging

Packaging brings many benefits: protecting our goods from breakage, damage and tampering, keeping food and medicines fresher for longer, providing information about the goods, making shipping easier, enabling global trade, and providing convenience.

Global packaging production and consumption have grown significantly over the past decades, especially for plastic packaging.

- Global plastics use has quadrupled in 30 years, and packaging is the largest plastics application (31%).[19] Global plastic packaging production and consumption are projected to increase by over 2.5 times by 2060.[20]
- Global demand for paper and paperboard has steadily grown over the past 20 years, primarily driven by an increased demand for paper packaging. Between 2000 and 2019, global production of paper packaging increased by 60%.[21]
- Glass packaging production has also increased, with growth in the European Union reported at nearly 20% between 2012 and 2021, an average growth rate of 1.7% per year.[22]

This increase in packaging consumption translates into a growing amount of packaging waste and significant environmental challenges, especially as plastic packaging recycling remains low.

- It was estimated in 2016 that over 90% of plastics produced were derived from virgin fossil feedstock. At the time, plastics already represented about 6% of global oil consumption, equivalent to the aviation sector. It was concluded that if the strong growth of plastics usage were to continue as expected the plastic sector will account for 20% of total oil consumption and 15% of the global annual carbon budget by 2050.[23]

- Other packaging materials can also have unsustainable or problematic supply chains and impacts on land use. For example, the global production of wood pulp for paper and paperboard already far exceeds ecological boundaries, with up to 50% of global virgin wood-pulp supply estimated to originate from problematic sources such as ancient and endangered forests.[24]
- There is also a risk of littering of packaging, and of packaging entering waterways and ultimately reaching the ocean.

London recognises the importance of packaging, particularly plastic, in reducing its carbon footprint and has emphasised plastic as a priority material to focus actions and reduce the city's environmental impact, setting ambitious targets as stated previously in the report.

Recognising the importance of packaging and plastic packaging for London, this report focuses on the flow of packaging materials and their associated emissions in order to support city-wide policy-making and the implementation of localised actions. The insights from this report can help city stakeholders understand where greenhouse gas emission hotspots are across the packaging supply chain and where actions should be focused to reduce emissions stemming from London's packaging system.

1.3 Transition within the packaging supply chain

Given the social and environmental impacts of the packaging industry, there is increasing pressure for more sustainable design, production, consumption and management of packaging – especially plastic packaging - across the globe, with targets, regulations, support and new strategies being put in place to tackle this. For example, at a global level, United Nations member states have committed to ending plastic pollution and have been negotiating since 2022 to develop an international legally binding agreement that addresses the full lifecycle of plastic, including its production, design and disposal.[25] These negotiations build on existing voluntary commitments such as the Ellen MacArthur Foundation's Global Commitment that united more than 1,000 organisations behind a common vision of a circular economy for plastics and a set of 2025 targets.[26]

In Europe, the recently adopted Packaging and Packaging Waste Regulation sets out a comprehensive framework aimed at reducing packaging waste and fostering reuse and recycling of packaging. It sets 2030 and 2040 targets for recycled content in packaging; as well as packaging recycling rate targets of 65% by 2025 and 70% by 2030. The recycling rate targets are in turn supported by specific targets for different packaging materials. The regulations also plan the phase-out of some packaging categories, including some formats of fruit and vegetable packaging and grouped packaging, and sets out reuse targets and recommendations for specific packaging categories such as beverage bottles, take-away packaging, and transport packaging.[27]

At a UK level, the UK Plastic Pact, led by WRAP, brings together businesses from across the entire plastics value chain with UK governments and NGOs to tackle the scourge of plastic waste. This commitment includes four targets: eliminating problematic and unnecessary single-use plastics; ensuring all plastic packaging is reusable or recyclable; reaching 70% plastic packaging recycling rate; and achieving 30% recycled content in plastic packaging.[28]

In London, the Greater London Authority and London's boroughs have been taking a variety of actions to address single-use plastics waste and pollution, including education campaigns and events, schemes to encourage better business practices and create 'Low Plastic' or 'Plastic Free' zones, and projects to eliminate certain types of packaging or provide Londoners with packaging-free solutions. ReLondon's report 'Reducing single-use plastic consumption' provides a comprehensive overview of actions taking place in London, and recommends building on these fragmented efforts to develop consistent and coordinated actions in London to address single-use plastic waste and pollution.

Finally, ReLondon has been working in partnership with the GLA and London's boroughs since its creation to improve waste and resource management in the capital. Most recent and innovative projects include the Flats Recycling Package which supports housing providers, building managers and service providers to make recycling easier for people living in flats, and the Flats Above Shops project which aims to better understand and address the unique challenges that residents who live in flats above shops face with regards to managing their waste and recycling.

1.4 Aims and objectives of this project

Research has been done to map packaging and plastic flows across the UK and other countries, and greenhouse gas lifecycle emissions associated with specific types of packaging are well studied. However, research has not been done that scales these analyses for London, nor do they link packaging flows to lifecycle emissions. ReLondon commissioned Valpak to fill this research gap and adapt to packaging the analytical framework previously developed by ReLondon and Circle Economy to assess London's food footprint in 2021, and already applied to London's fashion footprint in 2023 in collaboration with University College London.

Valpak has mapped packaging moving across the city's supply chain and linked it to their lifecycle emissions, enabling London policymakers and stakeholders to understand where material hotspots and carbon hotspots occur, and the extent to which packaging contributes to the city's overall carbon footprint. This research also identifies key levers for reducing these emissions and provides an evidence base so that decision-makers can focus their efforts on the most impactful actions.

The sections that follow run through the analytical approach used to map the flows of packaging across London's packaging supply chain and estimate the associated lifecycle emissions before showcasing the key findings from the research.

Approach

2. Approach

In this section, we describe the approach and analytical framework that has been developed to explore the material flows and lifecycle emissions of London's packaging system.

2.1 Mapping packaging flows and lifecycle emissions – an overview of the approach

A packaging flow methodology was used in this research to develop a holistic view of how packaging flows through London. This approach examines how resources are purchased, consumed and disposed of within a system. The outcomes of this analysis provide estimates of the quantities of materials and waste generated at key points across London's packaging system, from packaging placed on the market to disposal and end-of-life management.

A carbon footprint assessment was also carried out to examine the packaging-related carbon footprint. The analysis connects the flows of packaging with their associated emissions, including the emissions that are embodied in the packaging and waste recycling and treatment emissions.

The objective of this task is to provide a baseline level of material flows within London's packaging system and identify levers to support a transition. This is achieved by collecting and harmonising the best available data and representing it visually in a Sankey diagram. The analysis offers a static 'snapshot' of packaging flows and their associated emissions within London for a given year, in this case 2022.

2.2 Scope of the analysis

The scope of the analysis focuses on the flows of packaging consumed in London, whether by Londoners, London businesses and institutions or by visitors (commuters and tourists). The analysis estimates packaging placed on the market in London and the packaging waste produced from different packaging users in London. The key flows that are mapped throughout the system are:

Packaging materials (tonnes)	The tonnage of paper, plastic, aluminium, steel, glass and wood packaging placed on the market including consumer retail packaging, hospitality packaging and other business packaging.
Packaging waste (tonnes)	The amount of packaging that is discarded and sent for recycling, energy from waste (EfW) or landfill.
Greenhouse gas emissions (tonnes CO2eq)	Lifecycle emissions related to these packaging flows.

The key steps along London's packaging supply chain are:

- **Packaging production and imports**: Activities related to the extraction of raw materials, packaging production and conversion, and imports of packaging – pre-filled or empty – in London. There is no data on the volume of packaging that is produced or filled within London but industry experts consulted as part of the research confirmed that those activities are marginal, and that most of the packaging consumed in London is coming already filled when imported into the city. Because of this, London-based production, conversion and filling have not been analysed separately in this study. Due to lack of data, it was also not possible to identify the origin country or geography of packaging – pre-filled or empty – imported in London. However, the embedded greenhouse gas emissions from production and conversion stages are included in the analysis to account for the full packaging life cycle.
- **Packaging placed on the market**: This is packaging that is around or supplied with goods that are provided for sale. Packaging placed on the market in London is analysed across three key sectors:
  - **Consumer retail packaging**: This is packaging around goods sold to individuals or households in stores or online, rather than to businesses.
  - **Hospitality packaging**: The hospitality sector includes hotels, pubs, restaurants, cafes, catering and takeaways. In this study, hospitality packaging is split into take-away packaging and packaging retained on the premises.

- **Other business packaging**: This includes any other packaging, such as retail back-of-store packaging, agriculture, construction and all other commercial and industrial packaging, such as from services and manufacturing. Retail back-of-store packaging is packaging around goods that is not passed on to consumers, such as outer boxes, film wrap or display trays.

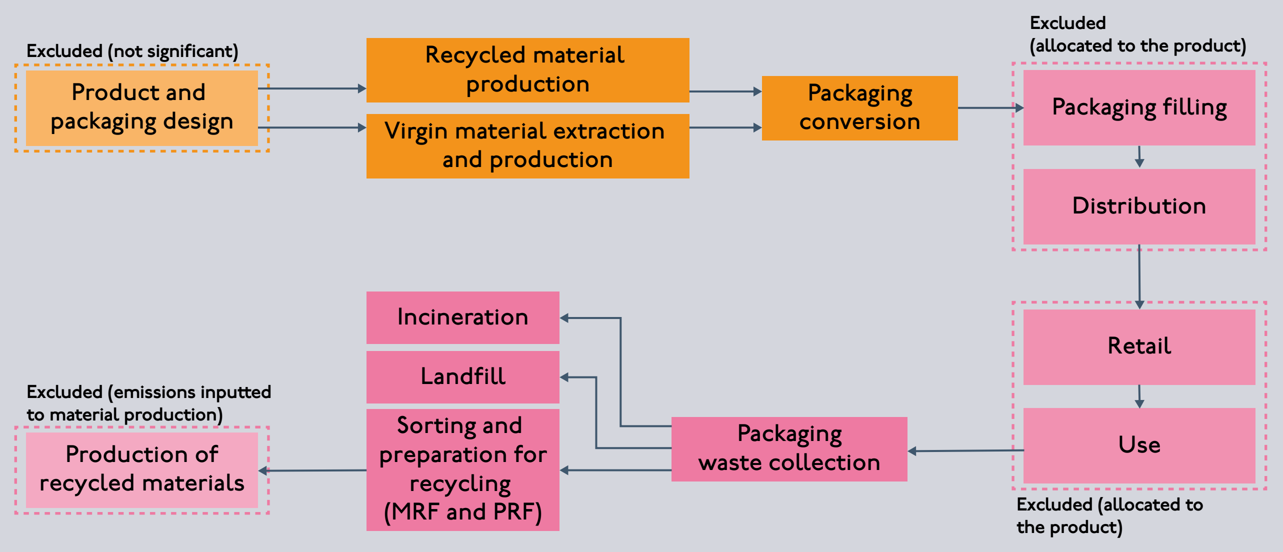
- **Use stage**:
  - **Consumer use**: the consumption of packaging by London residents and visitors (including tourists and commuters). In the vast majority of cases, packaging is single-use and is thrown away after a very short lifecycle. However, some packaging reuse systems might enable the consumer use phase to last longer, and for packaging to go through several use cycles. Due to a lack of data, this study does not provide estimates of the amounts of consumer packaging reused in London.
  - **Business use**: the consumption of packaging by London businesses and organisations. While a large proportion of business packaging is single-use, reusable packaging is common in some sectors such as retail. For example, retail back-of-store packaging include reusable crates and trays used for bread and other baked goods and for fresh produce as well as reusable wooden and plastic pallets. Similarly as for consumer packaging, data was not sufficient to robustly quantify the amounts of business packaging reused in London, but estimates of reused packaging in the retail industry are provided alongside the Sankey diagrams in section 3 (see deep dive I – Example of B2B packaging reuse system: plastic crates in the retail industry).
- **Household waste**: the amount of packaging waste disposed of in household bins. Local authorities are responsible for collecting and disposing of this waste.
- **Street waste and litter**: the amount of packaging waste disposed of in bins on streets and other public spaces, and the amount of packaging littered in the environment. Local authorities are responsible for collecting and disposing of waste in street bins and conduct cleaning operations to collect littered packaging.
- **Commercial waste**: the amount of packaging waste disposed of in business and other non-household bins (e.g. in hospitals and government buildings). This includes packaging waste from industrial and construction activities in London. Businesses and organisations are generally responsible for arranging the collection and disposal of this waste.
- **Waste management**: activities related to the processing of London's packaging waste. Many of these waste management activities occur outside of the city itself, despite the waste being generated within London. The following treatment processes are included in the analysis:
  - **Incineration (Energy from Waste, EfW)**: packaging is burned to generate heat or electricity. Whereas a small fraction of the product's value is captured, most value is lost, although metals are recovered from incinerator bottom ash.
  - **Landfill**: packaging is diverted to a landfill site. Not only is all value lost, but landfilling waste causes additional environmental pressures through greenhouse gas emissions of biodegradable waste and competes with other land uses.
  - **Sorting and recycling**: recycling is any operation by which waste is reprocessed into products, materials or substances, for either its original or other purposes.

Splits by material of both tonnages and emissions are provided where appropriate, to allow more granular analysis of impacts.

2.3 Emissions model

To complement the understanding of the flows of packaging materials, a carbon footprint assessment was carried out to assess the greenhouse gas emissions associated with London's packaging supply chain, at each of its stages. The stages and included and excluded emissions are illustrated in Figure 5.

Figure 5. Carbon modelling scope



This analysis includes upstream emissions up to packaging filling (material extraction from virgin materials or processing of recyclate, intermediate processing, manufacture and conversion of packaging and transport to filling) but excludes emissions associated with packaging filling and filled packaging distribution, retail, and use. These emissions are conventionally attributed to the product rather than the packaging, and limited data on emissions at these life stages is available.

In addition, this analysis includes downstream emissions from waste collection, transport, and sorting. Emissions linked to packaging landfill are included, in line with national emissions accounting. Emissions linked to incineration – including with energy recovery - are accounted to reflect emissions linked with burning packaging waste, especially as research suggests that energy production from waste incineration of plastics (the main fossil component of packaging waste) is more carbon-intensive than conventional energy production (i.e. current UK grid energy mix).[29] Recycling emissions after sorting are excluded from the footprint as they are attributed to the production of recycled materials.

2.4 Data availability and limitations

To provide the most comprehensive picture of material flows and emissions throughout London's packaging supply chain, the analysis builds on various available data sources.

The data used within the packaging-system flow analysis is collected from a variety of sources, including government and other sources. Where possible, reliable London-specific data for the year 2022 was prioritised. Occasionally older data has been extrapolated to the focus year 2022, such as overall commercial and industrial waste arisings, for which the latest year is 2021 for England, which was then scaled to London. Such transformations of data introduce assumptions and uncertainties, and, as such, reduce its overall accuracy. However, this data is required to depict a system-level overview of London's packaging system.

Estimates of packaging placed on the market mainly build on data sourced from Valpak and WRAP's PackFlow 2023 Refresh reports,[30] which provide material tonnages for 2022. These detail flows for each packaging material at the UK level, from being placed on the market to being consumed, discarded into a waste or recycling stream and recycled, incinerated or landfilled. To downscale PackFlow and other national data sources to London, employment data was generally used (this assumes that packaging use efficiencies and characteristics for London are comparable to the UK average). To obtain estimates for Londoner's consumption, distinct from overall consumption including that by visitors, spending data by Londoners was used to downscale UK data for the relevant sectors.

Household waste flows have been calculated using government data sources and ReLondon's household waste composition analysis. To fill out data gaps on commercial waste, the largest commercial waste management companies were invited to provide primary data for London. Estimates of recycling of commercial packaging waste are presented in this report using primary data and the best available national data but should be interpreted with caution as consistent and good-quality data is currently missing to robustly estimate commercial waste flows.

To analyse London's packaging emissions, the report uses detailed emissions factors based on the 2024 Department for Energy Security and Net Zero data and ecoinvent 3.8. These factors, expressed in kg CO2eq per tonne of material, indicate the quantity of emissions generated for a given packaging material.[31] These factors are applied to the packaging materials that flow through and are consumed within London. It is important to note that these emission factors are not London-specific, but based on averages for comparable economies, so their use therefore assumes that these emission factors are comparable to London. However, these emission factors are the most suitable data source for this analysis, and the resulting insights provide a valuable system-wide understanding of emission hotspots.

While the results in this report are prepared using the best data available, the packaging material flow and carbon footprint assessments should not be viewed as complete and comprehensive representations of the material and greenhouse gas emissions within London's packaging system. Nevertheless, the analysis provides an important start in understanding London's packaging system from both a mass and greenhouse gas emissions perspective.

Finally, this research has developed a framework and methodology that can be easily used in future years with more updated data. The framework can be used to monitor the impact of changes and allows for the reassessment of the hotspots previously identified in the material flow analysis.

The material flows and greenhouse gas emissions of London's packaging

3. The material flows and greenhouse gas emissions of London's packaging

This chapter presents the findings from the estimation and mapping of packaging flows throughout London, along with their associated lifecycle emissions. The analysis also showcases the packaging waste treatment methods, which are grouped into recycling, incineration, and landfill.

Firstly, subsection 3.1 presents a summarised view of London's packaging system and plastic packaging system specifically, and emission indicators to highlight characteristics of London's packaging and plastic packaging systems. Subsection 3.2 then provides a more detailed description of each stage of London's packaging system, based on two Sankey diagrams, one for all packaging in London, and one focused on plastic packaging specifically. All data points shown in this chapter have been rounded to the nearest one thousand tonnes. Subsection 3.3 provides a detailed description of the greenhouse gas emissions associated with London packaging consumption. Finally, subsection 3.4 focuses on the contribution of plastic packaging to London's packaging system and emissions.

3.1 London's packaging at a glance

This section introduces key concepts and figures that provide an overview of the scale of the packaging system, in particular for plastic packaging, prior to delving into detail in the following subsections.

London's packaging consumption: 2,214 thousands tonnes

This is the total amount of packaging placed on the market in London across the various sectors. This includes packaging imported from the rest of the UK, the EU and outside the EU, and primary production within London. It includes packaging consumed by Londoners, London businesses and institutions (e.g. councils, schools, hospitals) and London visitors (including commuters and tourists).

London's plastic packaging consumption: 379 thousands tonnes

This is the total amount of plastic packaging placed on the market in London, estimated based on the same scope and methodology as for London's total packaging consumption.

London's packaging lifecycle emissions: 4,121 thousands tonnes of CO2eq

Those emissions refer to the lifecycle greenhouse gas emissions associated with packaging consumed in London by residents, businesses, institutions, and visitors. These emissions occur both within and outside of London, and they are allocated to the final packaging consumers rather than the original producers of those emissions. The estimated 4,121 kt CO2eq of lifecycle emissions generated by London's packaging supply chain is considerably lower than the emissions from food consumption (15,483 kt CO2eq) but higher than emissions generated by London's fashion supply chain (2,009 kt CO2eq).[32,33]

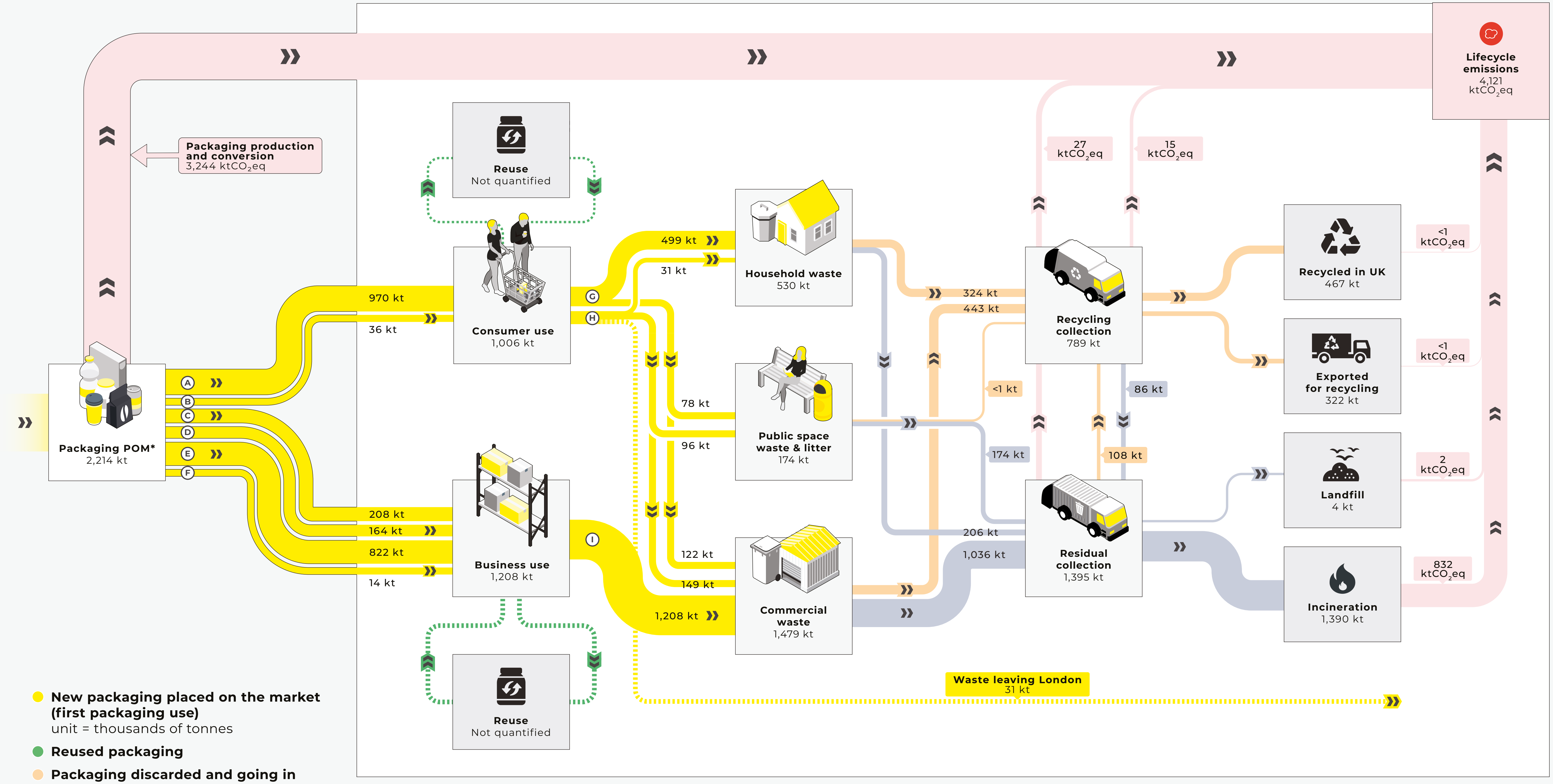
London's plastic packaging lifecycle emissions: 1,913 thousands tonnes of CO2eq

The estimated 1,913 kt CO2eq of greenhouse gas emissions generated by London's plastic packaging supply chain are similar to the emissions generated by London's fashion supply chain (2,009 kt CO2eq).[34]

3.2 Packaging flow

The following Sankey diagrams illustrate the journeys of packaging consumed within London. The diagrams flow from left to right and indicate how packaging flows through the key stages of London's packaging system; from being placed on the market and used by households, visitors, or businesses, to being disposed into a household or commercial waste and either recycled, incinerated, or landfilled.

The Sankey diagrams indicate the quantity of packaging (and plastic packaging) at each stage of the value chain and the emissions associated with each of these stages.

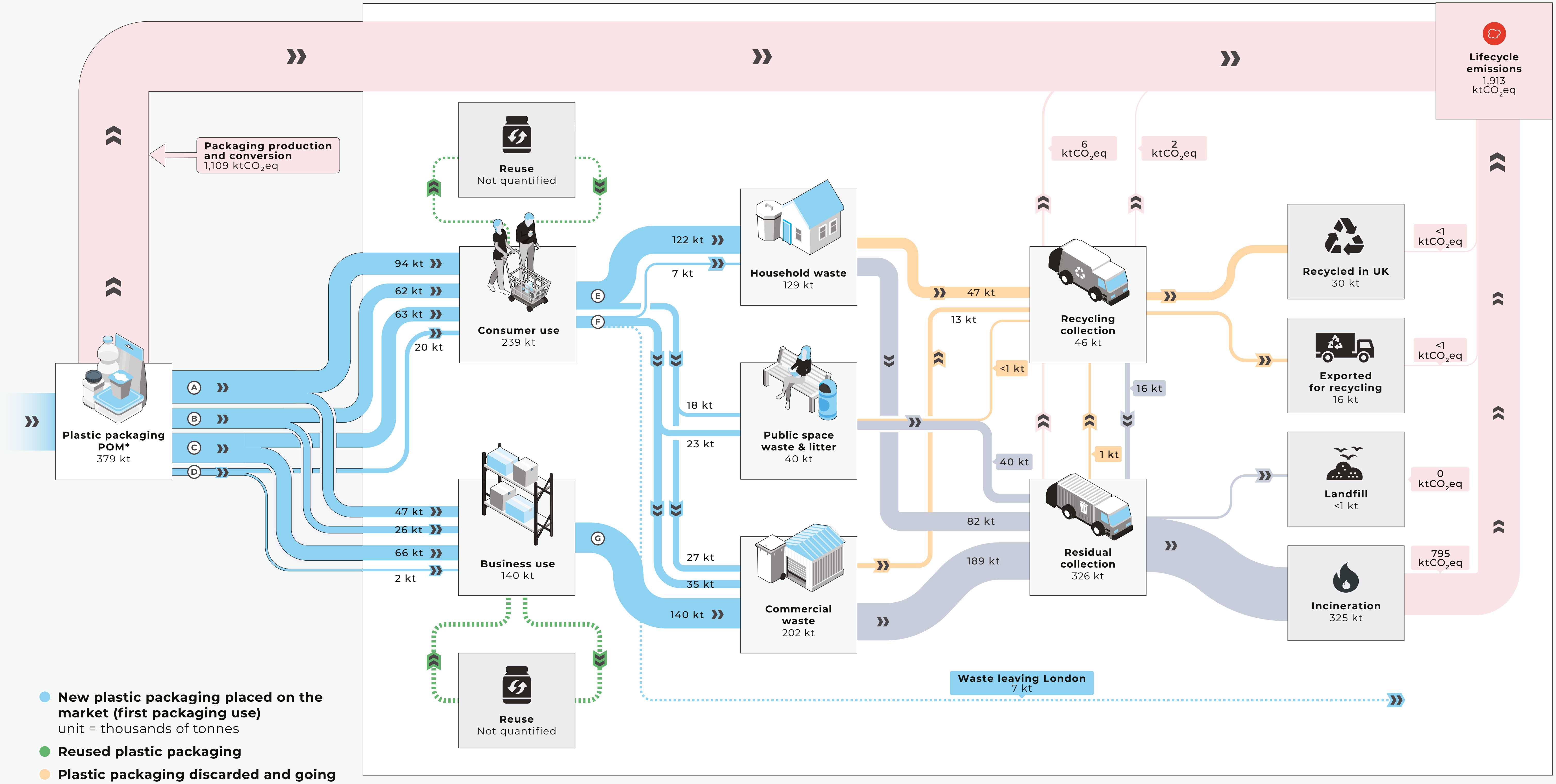


- New packaging placed on the market (first packaging use)
  unit = thousands of tonnes
- Reused packaging
- Packaging discarded and going in the recycling waste stream
  unit = thousands of tonnes
- Packaging discarded and going in the residual waste stream
  unit = thousands of tonnes
- Emissions
  unit = thousands of tonnes CO_2eq

Ⓐ Retail
Ⓑ Take-away
Ⓒ Retail back of store
Ⓓ Hospitality in-store
Ⓔ Other commercial & industrial
Ⓕ Agriculture & construction
Ⓖ Londoners
Ⓗ Visitors
Ⓘ Business

*POM : placed on the market

Note. Numbers have been rounded to the nearest one thousand tonnes. Some totals may not sum due to rounding.



- **New plastic packaging placed on the market (first packaging use)**
  unit = thousands of tonnes
- **Reused plastic packaging**
- **Plastic packaging discarded and going in the recycling waste stream**
  unit = thousands of tonnes
- **Plastic packaging discarded and going in the residual waste stream**
  unit = thousands of tonnes
- **Emissions**
  unit = thousands of tonnes CO_2eq

*POM : placed on the market

Note. Numbers have been rounded to the one nearest thousand tonnes. Some totals may not sum due to rounding.

A **Bottles**
B **Pots, tubs and trays**
C **Flexibles**
D **Other**

E **Londoners**
F **Visitors**
G **Business**

Deep dive 1 – Example of B2B packaging reuse system: plastic crates in the retail industry

Supermarkets have a highly developed system of reusable crates (produce trays) that are used as secondary packaging for transit and display of produce. They have the benefit of being easily stackable while protecting produce and can be placed directly onto shelves in stores rather than needing to decant produce, reducing damage of goods and staff time. They can have ventilated sides and/or bases, which can provide further benefits over solid transit packaging. These trays can be easily stacked inside each other for back-haul to depots or recovery facilities, where they are washed if necessary using tray-wash machines or jet washing, then returned to suppliers for refilling with products. They are also fully recyclable at end of life.

Reusable crates typically have a replacement rate of about 20% per year, i.e. an average lifespan of 5 years, although replacement can be due to thefts, throwing them away unnecessarily or repurposing, rather than them having reached end of life. They are reused on average every fortnight, resulting in an average of 130 uses per crate.

For London, it is estimated that there are currently approximately 7 million plastic crates in use by supermarkets and other grocery stores – nearly one for every resident – with 1.4 million replaced each year, weighing 2,400 tonnes.

Packaging placed on the market in London

- Approximately 2,214,000 tonnes of packaging is placed on the market in London each year. This is across three key sectors: consumer retail packaging (970,000 tonnes, 44% of the total), hospitality packaging (200,000 tonnes, 9%) and other business packaging (1,044,000 tonnes, 47%).
- By weight, 42% of packaging placed on the market in London is paper, followed by glass (21%), plastic (17%), wood (13%), and metal (6%). Business packaging (excluding hospitality) is dominated by paper (56%) and wood (28%) – mostly for pallets. For consumer and hospitality packaging, glass is the largest contributor, followed by paper and plastic. Glass is particularly significant for the hospitality sector, making up 49% of packaging by weight there.
- Around 60% of plastic packaging placed on the market in London is rigid packaging (36% bottles and 23% pots, tubs, and trays) and 36% is flexible film packaging.

Figure 6. Packaging placed on the market in London: percentage split by sector and material

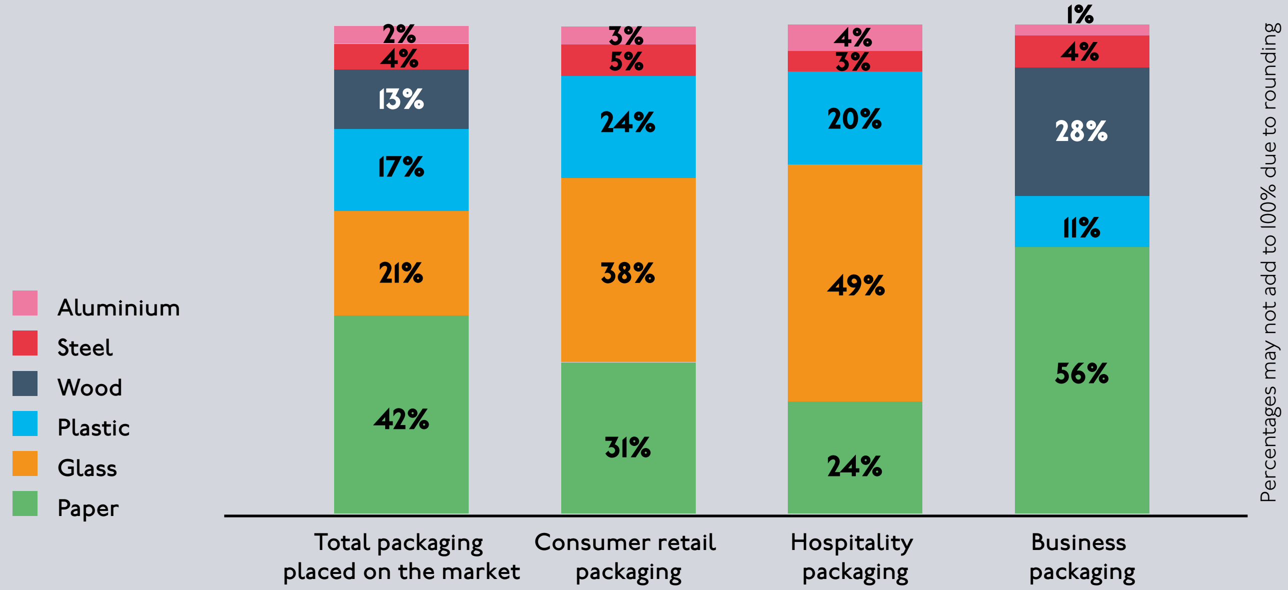
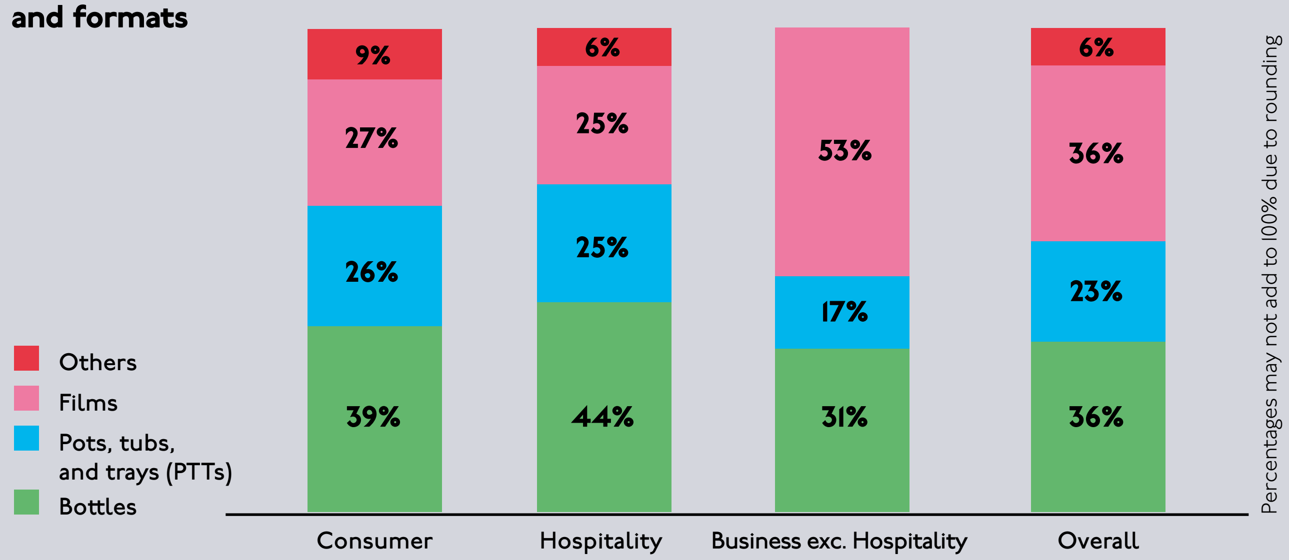


Figure 7. Plastic packaging placed on the market in London: percentage split by sector and formats

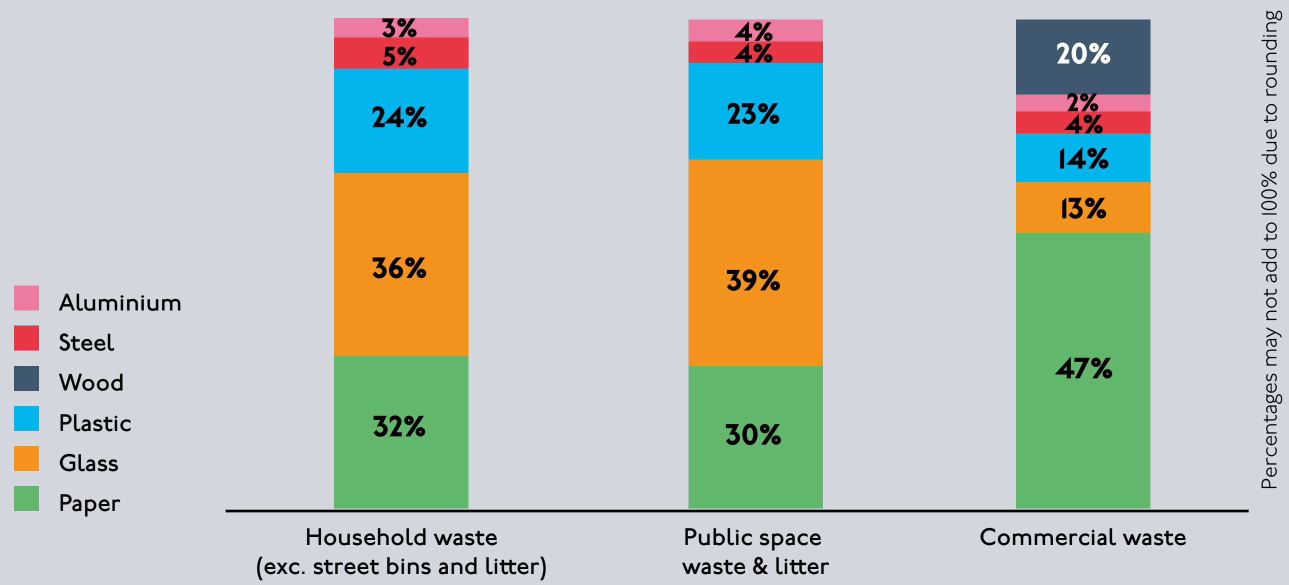


Packaging use and disposal in London

- Londoners and visitors consume 1,006,000 tonnes of packaging per year. 96% is retail packaging, whether from grocery stores or other stores, and 4% is take-away packaging.
- The majority of this consumer packaging (53%) is disposed of in household bins or recycling centres, but another 17% is disposed of in public spaces (bins on streets, in parks etc) and 27% is disposed of in the commercial waste stream (bins in offices, hotels, gyms etc) as 'household-like' waste. Finally, 3% is estimated to leave London with visitors (whether commuters or tourists).
- While visitors account for 30% of consumer packaging use in London, they account for 55% of packaging thrown away in public spaces bins, and 55% of consumer packaging thrown away in the commercial waste stream (hotels, restaurants, offices, etc).
- London-based businesses consume 1,208,000 tonnes of packaging per year that ends up in the commercial waste stream, alongside 272,000 tonnes from Londoners and visitors.

Figure 8 shows the resulting composition of the household and business waste streams.

Figure 8. Composition of household, street, and commercial waste in London



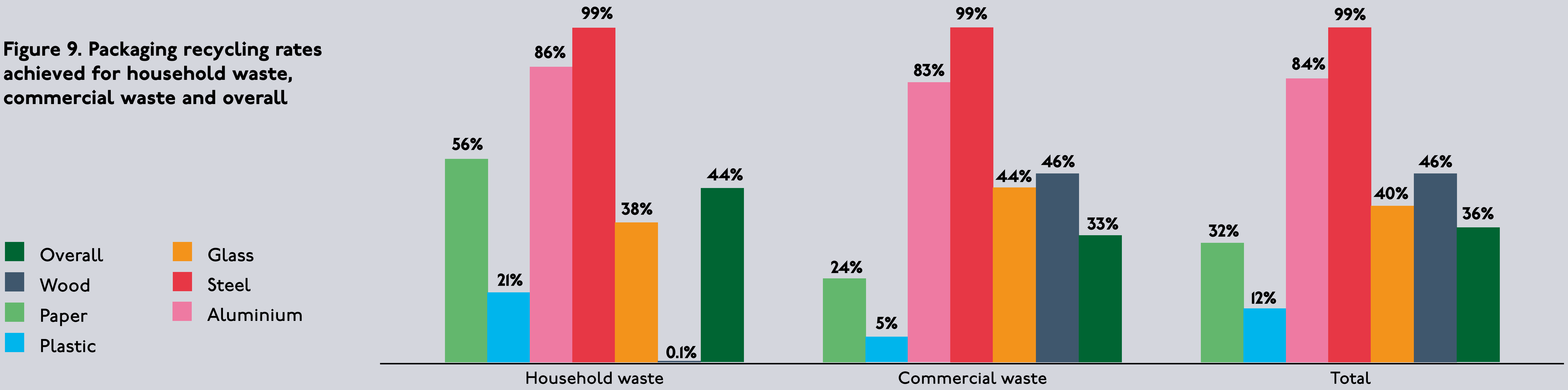
Household packaging waste collection and treatment

- Of the 704,000 tonnes of packaging disposed of in household and street bins, 324,000 tonnes (46%) are collected for recycling and 380,000 tonnes (54%) are collected as residual waste; it is assumed that no significant packaging quantities are collected in food waste or other organic streams.
- Almost none of the packaging waste collected on streets or in street bins is sent to recycling (54 tonnes sent for recycling out of 174,000 tonnes collected). This means that packaging thrown 'on the go', of which a significant proportion comes from visitors, is currently not recycled.
- Out of the 324,000 tonnes of household packaging waste sent for recycling, 61,000 tonnes are lost in MRF processing and other process losses, and 44,000 tonnes are extracted from residual waste (predominantly metals from incinerator bottom ash), resulting in 307,000 tonnes being recycled (44%).
- The resulting recycling rates for household packaging waste are shown in Figure 9 for each material, and compared with commercial waste and overall.
- For packaging in residual household waste in London, 99.7% (396,000 tonnes) is sent to incineration and just 0.3% (1,300 tonnes) of is landfilled.

Commercial packaging waste collection and treatment

- Of the 1,479,000 tonnes of packaging disposed of in the commercial waste stream, 443,000 tonnes (30%) are collected for recycling and 1,036,000 (70%) are collected as residual waste. Similarly to household waste, it is assumed that no significant packaging quantities are collected in food waste or other organic streams.
- In the absence of publicly available data on privately collected commercial waste, these estimates are based on extrapolated primary data shared by waste management companies, completed by public data on local authority collected commercial waste.
- Out of the 443,000 tonnes of commercial packaging waste sent for recycling, 26,000 tonnes are lost during MRF processing and other process losses, and 64,000 tonnes are extracted from residual waste (predominantly metals from incinerator bottom ash), resulting in 482,000 tonnes being recycled (33%).
- Although these estimates of commercial packaging waste should be interpreted with caution due to data uncertainty, these estimates suggest that recycling rates for packaging commercial waste in London are lower than for packaging household waste, and should therefore be a priority focus area to drive London recycling rates up.
- For packaging in residual commercial waste in London, 99.7% (995,000 tonnes) is sent to incineration and just 0.3% (3,000 tonnes) is landfilled.
- The resulting recycling rates for commercial packaging waste are shown in Figure 9 below for each material, and compared with household waste and overall.
- The very high recycling rates for aluminium and steel for commercial and household packaging waste are predominantly due to the high rates of extraction of these metals from incinerator bottom ash.
- While the upcoming changes in regulation (Extended Producer Responsibility, Deposit Return Scheme, Simpler Recycling, digital waste tracking, and UK Emission Trading Scheme) will improve packaging recycling in London, further efforts and collaboration across the industry and policymakers will be needed to increase transparency and data on commercial waste flows, and improve waste services to capture packaging for recycling and ensure it gets recycled.

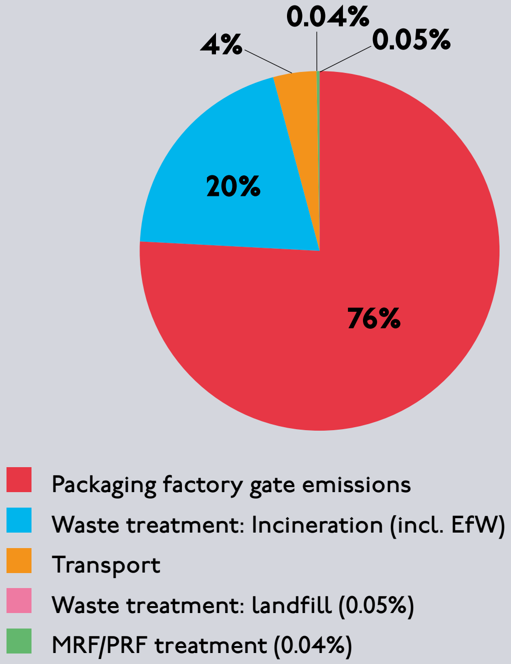
Figure 9. Packaging recycling rates achieved for household waste, commercial waste and overall



3.3 Lifecycle emissions

- Greenhouse gas emissions stemming from packaging consumption in London total 4,121 thousand tonnes CO2eq. Emissions have been considered at the following points along the packaging supply chain: packaging factory gate emissions; transport; MRF and PRF treatment, incineration (including energy from waste) and landfill. These are illustrated in Figure 10 below.

Figure 10. Breakdown of packaging consumption-related greenhouse gas emissions in London



- Packaging factory gate emissions include material production from either raw materials or recycled content, transport to packaging conversion and packaging conversion. These dominate overall packaging emissions, with 76% of emissions, compared with just 4% for transport emissions, 0.04% for MRF and PRF treatment, 20% for incineration (including energy from waste) and 0.05% for landfill.
- Materials contribute differently to emissions at the different supply chain stages as illustrated in Figure 11. Most packaging factory gate emissions are from plastic (35%) and paper (31%), followed by glass (17%). Paper contributes 44% to transport emissions, with glass and paper contributing 19% each. Incineration emissions are dominated by incineration of plastic, which contributes 96% to these emissions. Only paper and wood contribute to landfill emissions since they biodegrade, with paper contributing 83%.
- The high amount of London's packaging waste that is incinerated, and the high plastic content of the incinerated waste stream and therefore its contribution to greenhouse gas emissions, will have a significant impact on local authorities under the forthcoming Emissions Trading Scheme (UK ETS) reporting requirements for incineration. Recycling more of the plastic, or reducing it, will help reduce emissions and potential costs from UK ETS.

Figure 11. Packaging emissions, split per material and per activity type

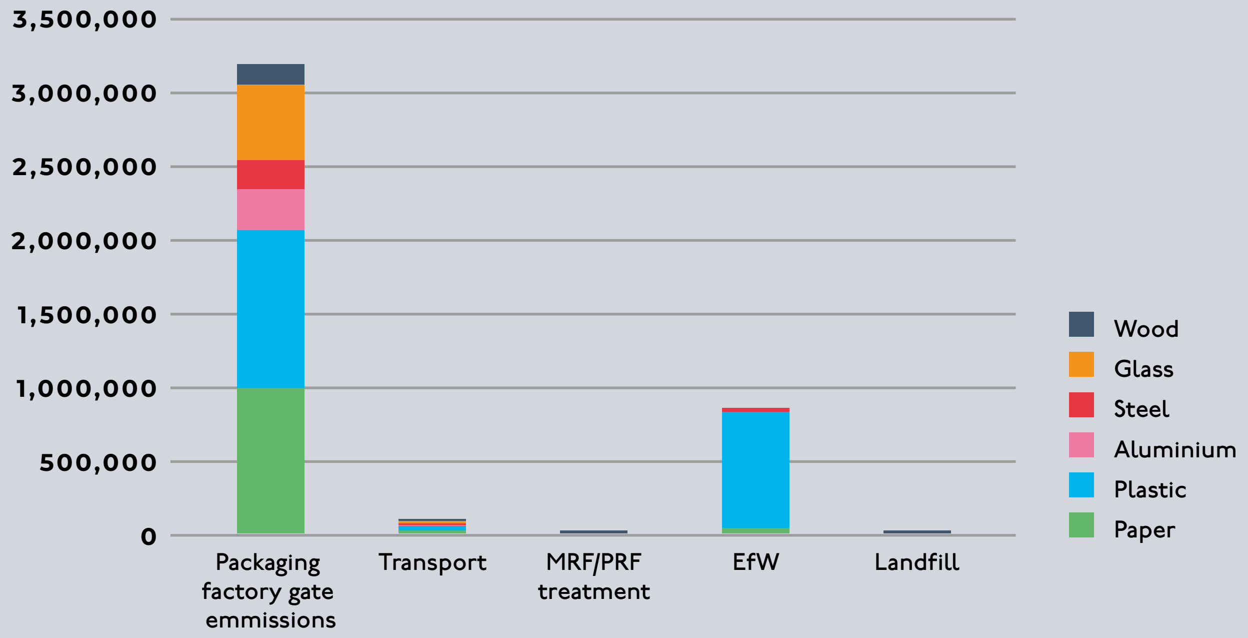


Table 1. Summary of the proportion of tonnages and greenhouse gas emissions associated with London's packaging supply chain*

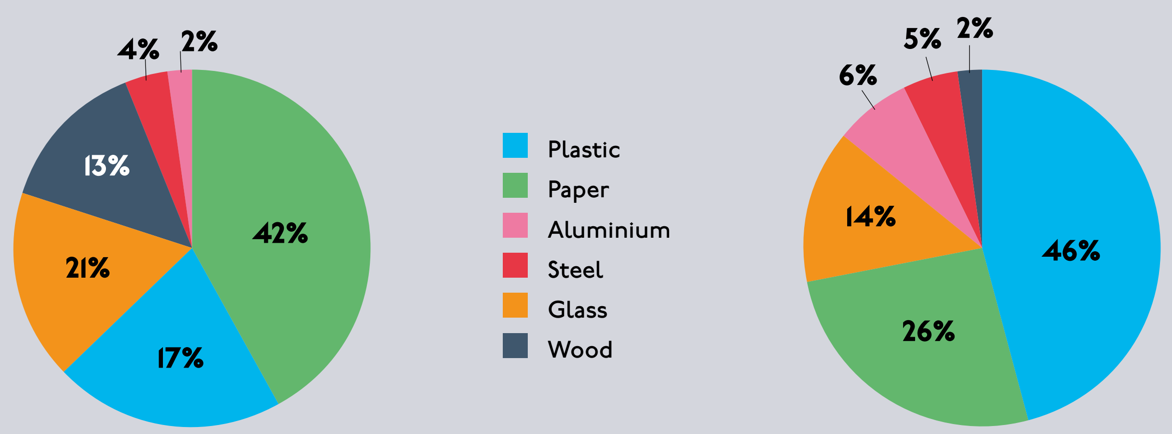
	Total packaging placed on the market (tonnes)	% of packaging tonnages	Emissions (tonnes CO2 eq.)	% of emissions
Paper	934,000	42%	1,071,000	26%
Plastic	379,000	17%	1,913,000	46%
Aluminium	48,000	2%	265,000	6%
Steel	92,000	4%	214,000	5%
Glass	468,000	21%	570,000	14%
Wood	293,000	13%	87,000	2%
Total	**2,214,000**	**100%**	**4,121,000**	**100%**

*Note these figures have been rounded so may not add up to 100%.

3.4 In focus: London's plastic packaging footprint

- Plastic packaging is the biggest contributor to London's packaging footprint, with 46% of London's packaging emissions resulting from plastic. This might be surprising as plastic packaging represents only 17% of packaging placed on the market in London by weight. Conversely, paper represents 42% of packaging placed on the market in London by weight, but only 26% of London's packaging footprint. Figures 12 and 13 below illustrate the share of packaging tonnages placed on the market and emissions for each material. 'Deep dive 2 - Understanding London's plastic packaging carbon footprint' gives further details to understand and interpret these data.
- Although plastic is the biggest contributor to London's packaging footprint, substitution for another material might not always be the right solution. Indeed, substituting plastic packaging for another material could lead to increased material requirements, increased carbon footprint, and have further unintended consequences. 'Deep dive 2 - Understanding London's plastic packaging carbon footprint' explores these trade-offs.
- This study demonstrates the potential of three key levers to reduce London's packaging footprint: increase recycled content in packaging, reduce single-use packaging – in particular through packaging reuse systems – and increase recycling.

Figures 12 and 13. Packaging placed on the market, split by material weights (left) and London packaging footprint, split by material (right).

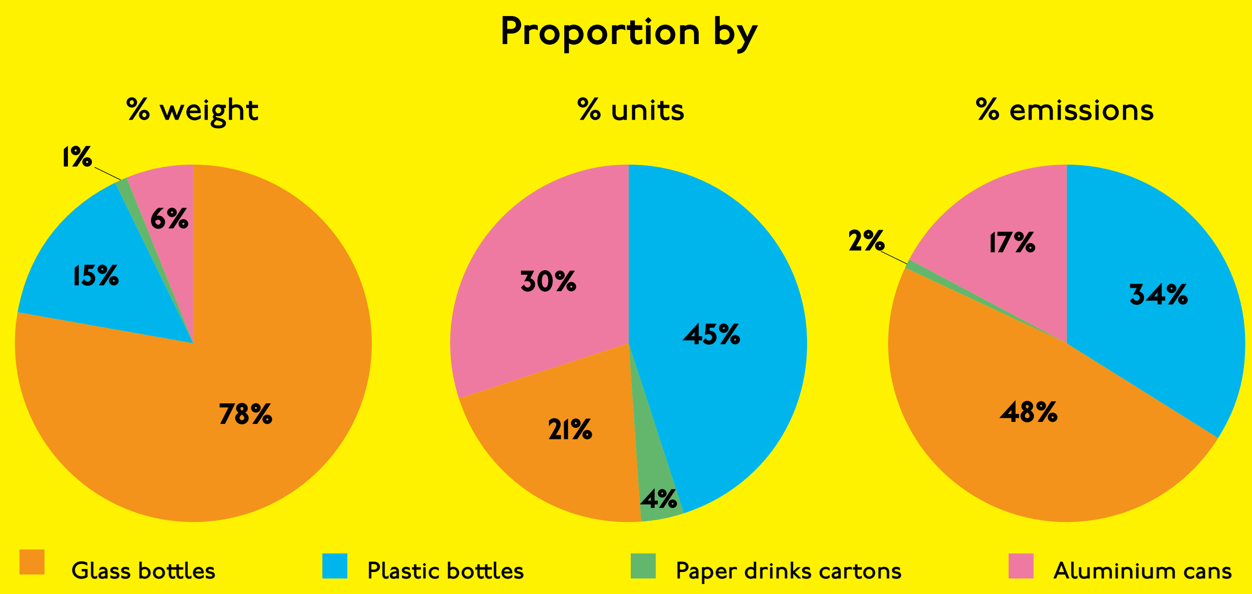


Percentages may not add to 100% due to rounding

Deep dive 2 – Understanding London's plastic packaging carbon footprint

Weight-based data hides the contribution of plastic to London's packaging emissions. Firstly because plastic packaging is often lighter than equivalent packaging in other materials which explains that weight-based data does not reflect the amount of plastic packaging units placed on the market. In addition, plastics have a very high carbon intensity per tonne: the carbon factor for the production of one tonne of plastics is three times the factor for paper, and for incineration (with energy recovery), the carbon factor for plastic is over 50 times the factor for paper. Therefore, the contribution of plastic to London's packaging total weight, units, and emissions is widely different from one metric to another. The graphics below take consumer beverage bottles as an example to illustrate how weight, units, and carbon metrics have markedly different contributions by packaging material.

Figure 14. Proportion of each material by weight, units, and greenhouse gas emissions for beverage containers placed on the market in London.



Percentages may not add to 100% due to rounding

While plastics has both a high greenhouse gas impact per tonne and accounts for the highest proportion of London's packaging emissions, Figure 14 shows that plastics is not a carbon-inefficient packaging material on average for beverage containers. Indeed, while being the material of 45% of bottles' units placed on the market in London, they only represent 34% of bottle carbon footprint. As such, any change in a packaging design should carefully consider the whole lifecycle impact and potential ripple effects, such as potential increase of food waste arising. These design choices should not only consider packaging design but also system design and different strategies such as reduction, reuse, and incorporation of recycled materials.

Levers for action in London's packaging use

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4. Levers for action in London's packaging use

This section presents three key levers to reduce London's packaging footprint and their quantified impact on greenhouse gas emissions reduction.

The analysis of London's packaging supply chain provides a system-level overview of the volumes of packaging waste flowing through the city as well as the quantities of greenhouse gases emitted at each point along the supply chain. This system-level overview enables the identification of levers in London's packaging supply chain, highlighting opportunities to reduce carbon emissions and help achieve London's zero-waste and zero-carbon ambitions.

The three key levers explored in this report are:

1. **Increase the amount of recycled content in plastic packaging.**
2. **Reduce single-use packaging placed on the market, including through packaging refill and reuse.**
3. **Increase collection and recycling rates for all packaging waste.**

For each of these levers, future scenarios were developed which quantify the potential of each lever to reduce the lifecycle emissions associated with London's packaging supply chain. Two scenarios have been developed for each lever:

- **Moderate scenario**: represents a scenario whereby concerted progress has been made on each of the levers.
- **Ambitious scenario**: represents a scenario whereby more ambitious actions have led to much greater progress on each of the levers.

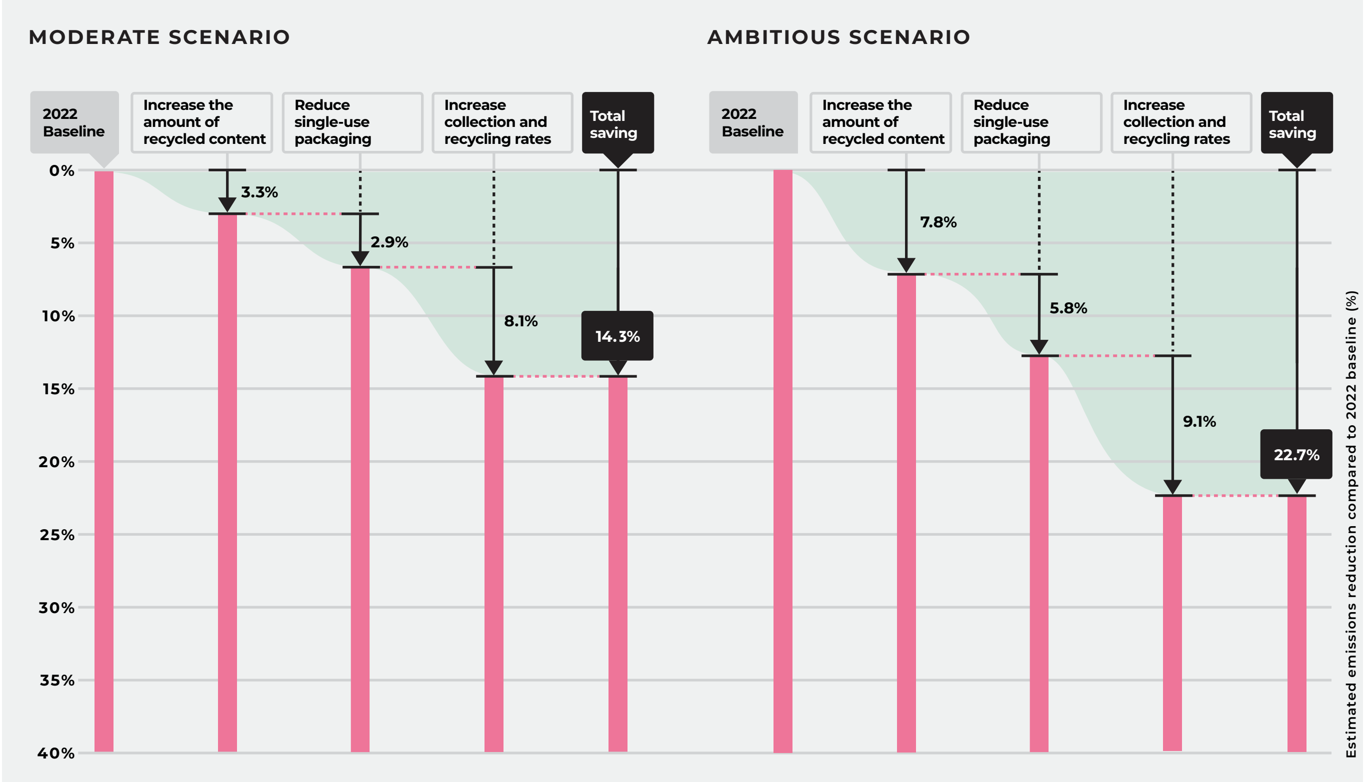
The scenario inputs and results for both the 'moderate' and 'ambitious' scenarios build on the 2022 baseline for London's packaging-related lifecycle emissions, as estimated in section 3 of this report. These scenarios were refined through a stakeholder workshop and discussion with the project advisory group and are intended to serve as illustrative and quantified examples. The ambition level in both scenarios aligns with existing packaging objectives and targets where possible – primarily drawing from the London Environment Strategy and the European Packaging and Packaging Waste Regulation (PPWR). Although these objectives and targets have specific timeframes, this project uses their ambition levels as reference points but does not model the implementation timelines of these levers in London.

It is important to note that the modelling scope for each of those levers varies significantly: lever one applies to all plastic packaging waste; lever two to a smaller selection of consumer packaging categories (see more details in the following sections); and lever three to all packaging. These differences in scope necessarily impact the potential estimated benefits yielded by each lever. The analysis also considers improvements to the packaging supply chain strictly from a greenhouse gas emissions perspective rather than, for example, reductions in littering, water usage or cost. Further analysis would be needed to assess any additional associated environmental or other impacts.

If implemented in tandem, the three levers could lead to a cumulative impact of **14%** across the moderate scenarios and **23%** across the ambitious scenarios against the 2022 baseline.

Figure 15 presents the estimated cumulative impact of the three levers on packaging-related lifecycle emissions. These estimates account for the overlap between levers and avoid double-counting impacts, assuming a sequential order in their implementation. However, levers could also be considered individually, and their isolated impacts are presented in appendix 1. Further detail on each of the levers and their potential to reduce packaging lifecycle emissions is provided in the subsequent sections of this report.

Figure 15. Summary of the estimated carbon emission reduction of circular levers against the 2022 baseline across moderate and ambitious scenarios



4.1 Lever one: Increase the amount of recycled content in plastic packaging

As most of packaging related emissions happen at the production phase, reducing the packaging material footprint represents a significant opportunity to tackle London's packaging emissions. Increasing the amount of recycled content in packaging and innovating to develop low-carbon materials that can be collected and treated with suitable infrastructure are ways to tap into this opportunity. As there is little data on innovative packaging materials and their carbon footprint, this study focused on modeling the impact of increasing recycled content in plastic packaging.

The amount of recycled content used in material production has a major impact on its greenhouse gas emissions: plastic packaging produced with virgin plastic produces on average twice the amount of factory gate emissions of packaging made from recycled plastic.[35] For every 10% increase in the recycled content of plastic packaging, its total greenhouse gas emissions are reduced by between 2.2% and 3.7%, dependent on the polymer.[36]

Current average recycled content for plastic packaging is estimated to be 28.6% for rigid plastic packaging and just 5.3% for plastic film,[37] averaging 20.6% across all plastic packaging placed on the market in London. Other packaging materials tend to have higher average recycled content: 35% to 75% for paper and card packaging, dependent on type;[38,39] 45% for aluminium packaging;[40] 58% for steel packaging;[41] and 50% for glass packaging.[42]

The UK introduced a Plastic Packaging Tax in 2022 to encourage the use of recycled plastic in packaging and to divert plastic away from incineration or landfill.[43] This tax is a levy imposed on plastic packaging that does not meet a minimum threshold of at least 30% recycled content on a per-component basis. All businesses that manufacture or import more than 10 tonnes of plastic packaging per year are liable for the tax. The tax was originally set at £200 per tonne in 2022 for imported or manufactured plastic packaging components and has since risen to £217.85 per tonne,[44] in line with inflation. Returns for the first annual reporting period (2022-23) indicate that the amount of plastic packaging declared to have 30% or more recycled plastic slightly exceeded that which did not.[45]

Businesses from across the entire plastics value chain have signed up to the voluntary UK Plastic Pact to increase recycled content in plastics and have committed to achieving 30% average recycled content across all their plastic packaging.[46] The latest figures indicate that members achieved 24% average recycled content levels in their plastic packaging in 2022.[47]

The **moderate and ambitious scenarios** for lever one are based on respectively achieving the 2030 and 2040 PPWR targets for recycled content in plastic packaging.[48] These targets are shown in table 2, and result in an average recycled rate content in plastic packaging of 30% for the moderate scenario – in line with the UK Plastic Packaging Tax – and 60% for the ambitious scenario.

Table 2. PPWR targets for recycled content recovered from

Type of packaging	2030	2040
Single-use plastic beverage bottles	30%	65%
PET contact sensitive packaging (except beverage bottles)	30%	50%
Non-PET contact sensitive packaging (except beverage bottles)	10%	25%
All other plastic packaging	35%	65%

The modelling inputs and outputs for lever one are shown in table 3, which is followed by the key assumptions used in the modelling. Increasing recycled content in plastic packaging to an average of 30% is estimated to result in a 3.3% reduction in emissions and increasing to an average of 60% is estimated to result in a 7.8% reduction in emissions from London's packaging supply chain.

Table 3. Modelling inputs and outputs related to increasing the amount of recycled content in plastic packaging

Scenario	Increase the amount of recycled content	Change in emissions from London's packaging supply chain
Baseline	Current recycled content in plastic packaging	Not applicable
Moderate scenario	Average of 30% recycled content in all plastic packaging (see Table 2)	↓ 3.3% reduction
Ambitious scenario	Average of 60% recycled content on average in all plastic packaging (see Table 2)	↓ 7.8% reduction

Key assumptions

- The use of packaging types other than plastic remains unchanged in terms of overall tonnages and material splits, with no material or product substitutions.
- The 2022 baseline for plastic packaging used in London is estimated to have 28.6% recycled content for rigid plastics and 5.3% recycled content for plastic films and flexibles, averaging to 20.6% across all plastic packaging placed on the market.
- The moderate and ambitious scenarios are based on the agreed minimum percentage targets for 2030 and 2040 for recycled content recovered from post-consumer plastic waste set in the PPWR, which would achieve on average approximately 30% recycled content in the moderate scenario, and 60% in the ambitious scenario - based on the current packaging placed on the market splits.
- Emission factors used for plastics are based on Department for Energy Security and Net Zero (DESNZ) factors and factors in ecoinvent 3.8.

Case study 1 – Innovative solutions to increase the use of recycled content in packaging

The CleanStream process, developed by Berry, has been conceived to develop the world's first closed-loop system to mechanically process domestically recovered household waste polypropylene (PP) back into food-grade packaging. Berry has already received approval to use their recycled PP in food packaging from the U.S. Food & Drug Administration and is working to get EU approvals. Berry also leverages its capacity and expertise to demonstrate the solution's viability at commercial scale.[49]

COtooCLEAN is an innovative technology that decontaminates post-consumer polyolefins (LDPE, HDPE, PP) films back to food-grade quality, using super-critical CO2 to remove oils and inks. Plastic film recycling is challenging, especially closed-loop recycling into food-grade packaging. In the UK, only 8% of films were recycled in 2021, most often downcycled into low-value products. COtooCLEAN offers a new perspective for films recycling and has received funding from UK Innovation & Research and the Alliance to End Plastic Waste to build a prototype and a demonstration plant.[50]

Case study 2 – Businesses developing innovative packaging materials

Notpla manufactures a range of regenerative packaging materials, made from seaweed and plants, and is on a mission to scale up its technology after having won the Earthshot Prize in 2022. Notpla's product range includes paper food containers with natural seaweed coating that produce up to 70% fewer greenhouse gas emissions than conventional plastic alternatives and can be composted or recycled at the end of life. Notpla has also developed seaweed-based rigid materials, with funding from Innovate UK, and has begun offering alternative solutions to single-use plastic cutlery with the introduction of their seaweed-based ice cream spoons earlier this year. Since 2021, Notpla's packaging has replaced 16 million of conventional single-use plastic packaging, avoiding 900 tonnes of CO2eq - the same as replacing about 570 round-trip flights between London and New York.

Envopap is revolutionising the packaging and paper industry by transforming discarded agricultural fibres into innovative, eco-friendly materials. Compared to traditional methods, which involve cutting trees down for paper manufacturing, Envopap's sustainable approach of utilising renewable resources, which includes a range of waste agricultural fibres, has resulted in reducing packaging carbon footprint by 28% per unit compared to conventional paper packaging. To date, they have saved 2.3 million trees, avoided 375,000 tonnes of CO2eq, and conserved an area equivalent to almost 300 football fields. Envopap's packaging is not only recyclable but also contributes to a healthier planet as it is biodegradable, compostable and marine-degradable.

Data on environmental and economic impacts of the solutions presented above have been estimated by the respective companies, and not by the authors of this report and might not use the same methodology as the one used in this study.

4.2 Lever two: Reduce the amount of single-use packaging placed on the market

As the majority of packaging-related emissions happen by the time packaging leaves the factory's gates – before it is even filled - reducing the volume of single-use packaging placed on the market in the first place is crucial to tackling packaging emissions. The twin tracks of eliminating unnecessary packaging and reusing packaging for as long as possible are the clearest pathways to achieving this.

Plastic packaging produces significant amounts of greenhouse gas emissions over its lifecycle: between 4,500 and 6,600 kg CO2eq per tonne of plastic, depending on the polymer type, at current average recycled contents. Cutting down the need for new plastic packaging – and therefore resource extraction and plastic production – could significantly reduce these greenhouse gas emissions.

The **moderate scenario** for this lever is based on the targets and recommendations for packaging elimination and reuse set out in the PPWR. These include the elimination of some formats of single-use plastic packaging for grouped products and fresh fruit and vegetables. The PPWR recommendation for stores to dedicate 10% of their sales area to refill stations has been translated into a reduction of 10% of single-use consumer retail packaging associated with dried goods such as pasta, rice, and cereals.

Finally, the modelling also includes the 40% reuse target for beverage bottles (for PET bottles only), 10% reuse target for takeaway packaging (e.g. coffee cups and food boxes), and 100% reuse target for all food packaging used in restaurants. Table 4 summarises the components of the scenarios modelled.

The **ambitious scenario** looks beyond the sectors currently included in the PPWR and envisions reuse systems rolled out to glass and personal and home care bottles in addition to just plastic beverage bottles. Research has demonstrated that scaling up reuse systems for these two categories could bring significant benefits. This ambitious scenario also considers reuse systems to be more efficient than in the moderate scenario (e.g. at bigger scale and with more standardisation),[51] and therefore yielding higher greenhouse gas savings compared to single-use.

Finally, this scenario also incorporates a 20% reduction in dried goods single-use packaging – versus 10% in the moderate scenario – to reflect a higher uptake of refill models (in line with the French regulation aiming for 20% of stores' sales area to be dedicated to refill). Table 4 summarises the components of the scenarios modelled.

To best approximate the greenhouse gas emissions and material savings brought by reuse systems, existing reports studying the potential of future scaled reuse systems have been used. In particular, greenhouse gas emission changes and material changes for plastic bottles were based on scenarios modelled in the Ellen MacArthur Foundation (EMF) report 'Scaling Returnable Packaging'.[52] Greenhouse gas emission changes for glass beverage bottles and food packaging in restaurants are based on a study conducted by the European Commission's Joint Research Centre (JRC),[53] and emissions changes for takeaway packaging are based on Eunomia's report 'Assessing climate impact: reusable systems vs single-use takeaway packaging'.[54] As the JRC and Eunomia reports do not provide estimates of the potential material use reduction in the modeled reuse systems, an estimate has been calculated based on packaging weight and return rates assumed in these reports. These reports include details on reuse systems modelled in each of them, key assumptions, and limitations.

Table 4. The packaging applications modelled for lever 2

Packaging category	Moderate scenario				Ambitious scenario				
	Elimination	Reuse	Emissions reduction*	Material use reduction*	Elimination	Reuse	Emissions reduction*	Material use reduction*	*Report source
Beverage PET bottles	-	40%	-19%	-48%	-	40%	-52%	-67%	EMF
Glass bottles	-	-	-	-	-	40%	-70%	-50%	JRC
Home and personal care bottles	-	-	-	-	-	40%	-49%	-51%	EMF
Fruit and veg packaging	80%	-	-80%	-80%	80%	-	-80%	-80%	n/a
Grouped packaging	100%	-	-100%	-100%	100%	-	-100%	-100%	n/a
Dried goods packaging (e.g. pasta, rice)	10%	-	-10%	-10%	20%	-	-20%	-20%	n/a
Take-away packaging	-	10%	From -13% to -75% (depending on categories)	From -67% to -91% (depending on categories)	-	10%	From -13% to -75% (depending on categories)	From -67% to -91% (depending on categories)	Eunomia
Food packaging in restaurants	-	100%	-32%	-26%	-	100%	-32%	-26%	JRC

The modelling inputs and outputs for lever 2 are shown in Table 5, which is followed by the key assumptions used in the modelling. Reducing the amount of single-use packaging placed on the market is estimated to reduce London's packaging emissions by **2.9%** in the moderate scenario, and by **5.8%** in the ambitious scenario.

Table 5. Modelling inputs and outputs related to reducing the amount of single-use packaging placed on the market

Scenario	Reduce single-use packaging placed on the market	Change in emissions from London's packaging supply chain
Baseline	Current amount of single-use packaging (see section 3), and negligible amount of reuse of consumer packaging	Not applicable
Moderate scenario	See table 4	↓ **2.9%** reduction
Ambitious scenario	See table 4	↓ **5.8%** reduction

Key assumptions

- The use of packaging types other than those explicitly in scope for this lever modelling remains unchanged in terms of overall tonnages and material splits, with no other material or product substitutions.
- It is assumed that current quantities of consumer packaging reused in London are negligible, and therefore the baseline against the reuse targets described above is assumed to be 0.
- See greenhouse gas emissions reduction and material use reduction assumed in table 4.
- Emission factors used for plastics are based on DESNZ 2024 factors and factors in ecoinvent 3.8.

Case study 1: Businesses eliminating packaging through direct elimination or refill systems

Stroodles provides an alternative to single-use plastic and paper tableware with an extensive range of eco tableware, including rice straws, edible spoons and stirrers made out of biscuits, wheat cracker bowls, eco plates made from wheat bran, and edible cups made of wafer.

Kind2's award-winning, high-performing solid shampoo and conditioner reduce the need for plastic packaging. Instead of coming in plastic bottles, KIND2's solid bars are packaged in small paper boxes, with each bar equivalent to two 250ml bottles of liquid shampoo or conditioner. Since launch, KIND2 has prevented 50,000 plastic bottles from being produced.

The refill coalition is a UK coalition of retailers and logistics providers who have developed and are testing a standardised solution to deliver refills at scale for both in-store and online. Their solution centres around standardised reusable bulk vessels and has been developed to deliver refills at scale for key food staples (e.g. cereals and pasta) and household products (e.g. cleaning and personal care products), removing single-use plastic packaging when moving goods from supplier to customer and driving efficiencies and cost savings for retailers. The reusable vessels have been designed to be used more than 60 times.

Case study 2: Businesses offering reusable packaging services

Dizzie seeks to solve the problem of packaging waste in groceries with a B2B reusable packaging service. In addition to designing and offering standardised reusable containers, Dizzie's reuse hubs provide the necessary infrastructure to make reusable food packaging a scalable cost-efficient alternative to single-use. Their first reuse hub in Nuneaton provides end-to-end reuse services: filling, labelling, cleaning, sorting and tracking, all under one roof. Since its creation, Dizzie's activities have led to 1.3 million pieces of plastic saved and, in an $11 trillion global grocery industry, Dizzie has grown annual sales thirteen-fold to £3m since 2019.

Caulibox is reshaping the future of food packaging with technology and automation. Their expertly designed Cauli Reuse System (CauliRS) is empowering food businesses to eliminate single-use packaging while easing operations, cutting costs, and reducing waste. Up to March 2024, Cauli is active in over 50 sites, and has prevented 271,244 pieces of disposable packaging from entering landfill, saving 64 tonnes of CO2.

Moree's reusable packaging system makes it easy for food companies to ditch single-use packaging. Moree sells reusable flexible pouches to brands, offers easy returns and digital rewards for their customers, and joins it all up through an online platform for tracking inventory and data on waste, carbon, and cost savings.

Again helps brands to reduce their packaging waste by allowing them to reuse the same packaging again and again. Again's CleanCells provide a supply chain solution to scale reusable packaging. These cells recondition, sort and clean packaging with capacity for 500,000 units per month, and their software platform helps brands monitor and manage return rates and inventories.

Data on environmental and economic impacts of the solutions presented above have been estimated by the respective companies, and not by the authors of this report and might not use the same methodology as the one used in this study.

4.3 Lever three: Increase collection and recycling rates

Packaging recycling rates in London remain low, with only 36% of all packaging waste in London being recycled today. This is especially low for packaging in commercial waste, for which the recycling rate is estimated to be 33% - compared to 44% for packaging in household waste. From a material perspective, plastic achieves the lowest recycling rate (12%), well below other materials that achieve between 32% and 99% recycling rates (see table 6).

Increasing recycling has the potential to reduce packaging emissions, especially those from plastic packaging waste incineration. For plastic, sorting and treatment in a Materials or Plastics Recovery Facility is estimated to emit 3.4 kg CO2eq per tonne of plastic (this does not take into account emissions linked to producing recyclate), whereas energy from waste incineration emits between 2,040 and 3,190 kg CO2eq per tonne of plastic, depending on the polymer. Incineration emissions for other materials (glass, paper, and metals) are comparatively much lower: between 12 and 28 kg CO2eq per tonne of packaging.

The **moderate scenario** for lever 3 is to achieve the packaging recycling targets set out in the PPWR for 2025, also set out in table 6. These targets include a 65% packaging recycling rate overall and a 50% recycling rate for plastic packaging. This is in line with the London Environment Strategy's recycling rate objective of 65% for all municipal waste.

The **ambitious scenario** is to achieve packaging recycling rates as set out in the PPWR targets for 2030, also set out in table 6. These include a 70% packaging recycling rate overall and a 55% recycling rate for plastic packaging. Achieving a 70% recycling rate for packaging could support London in reaching its objective of 65% recycling rate for all municipal waste, as other waste streams such as food are unlikely to achieve recycling rates higher than 65% due to challenges posed by food waste collection and treatment.

It is expected that progress towards London boroughs' Reduction and Recycling Plans, and implementation of upcoming regulations (Extended Producer Responsibility, Deposit Return Scheme, Simpler Recycling, digital waste tracking, and the UK Emissions Trading Scheme) should lead to a significant increase in packaging recycling rates in London and progress against the scenarios described above.

While our model only considers an increase of packaging waste collected and recycled, it is important to highlight that to reach these recycling rates, cross-industry collaboration is also essential to ensure that packaging placed on the market is recyclable – for example by moving away from materials that are difficult or impossible to recycle in current systems, such as black plastic pots, tubs and trays or composite materials. However, there is also a lot of packaging material that could currently be recycled that is not being recycled.

Table 6. Current packaging recycling rates in London compared with recycling targets set in the PPWR for 2025 and 2030

Type of packaging	London 2022	PPWR target for 2025	PPWR target for 2030
Overall	**36%**	**65%**	**70%**
Paper	32%	75%	85%
Plastic	12%	50%	55%
Aluminium	84%	50%	60%
Steel (ferrous metals)	99%	70%	80%
Glass	40%	70%	75%
Wood	46%	25%	30%

The modelling inputs and outputs for lever 3 are shown in Table 7, which is followed by the key assumptions used in the modelling. Increasing collection and recycling rates in line with the targets set out in this section is estimated to result in an 8.1% reduction in emissions in the moderate scenario, and a 9.1% reduction in the ambitious scenario. Although these scenarios model identical recycling rates for household and commercial waste, the baseline rates differ: 33% for commercial waste and 44% for household waste. The challenges in increasing recycling also vary between the two streams. For household waste, London-specific societal and structural challenges include a low level of home ownership, a high proportion of young residents, and a high proportion of flats. For commercial waste, London's dense urban environment also poses challenges, but additional barriers specific to this waste stream include the lack of transparency and data about commercial waste management and a fragmented market operated by many service providers. As such, the strategies and actions needed to boost recycling rates will differ for household and commercial waste, and a greater increase is needed for commercial waste due to its lower baseline rate.

Table 7. Modelling inputs and outputs related to increasing collection and recycling rates

Scenario	Increase collection and recycling rates	Change in emissions from London's packaging supply chain
Baseline	33% recycling rate overall for packaging 12% recycling rate for plastic packaging	Not applicable
Moderate scenario	65% recycling rate overall for packaging 50% recycling rate for plastic packaging	↓ 8.1% reduction
Ambitious scenario	70% recycling rate overall for packaging 55% recycling rate for plastic packaging	↓ 9.1% reduction

Key assumptions

- The type of packaging placed on the market and consumed in London remains unchanged in terms of overall tonnages and material splits, with no material or product substitutions.
- The 2022 baseline is estimated to have a 36% recycling rate overall for packaging used in London and a 12% recycling rate for plastic packaging.
- The moderate scenario is to achieve recycling rates as set out in the PPWR targets for 2025. This includes:
  - 65% packaging recycling rate overall, which is also in line with the London Environment Strategy overall recycling objective; and
  - 50% recycling rate for plastic.
- The ambitious scenario is to achieve recycling rates as set out in the PPWR targets for 2030. This includes:
  - 70% packaging recycling rate overall and
  - 55% recycling rate for plastic.
- Emission factors used for plastics are based on DESNZ 2024 factors and factors in ecoinvent 3.8.

Case study 1: London's work to address recycling challenges

ReLondon's 'Estimates of London household waste composition' report provides the most comprehensive information on household waste currently available. Made possible through collaboration with London's waste authorities, it analyses a huge amount of existing data including waste composition from 6,000 households living in flats in the capital.

ReLondon's 'Flats Recycling Package' is a toolkit for housing providers, building managers and service providers that want to make improvements to the recycling and rubbish services at their flats, by implementing a set of operational and communication guidelines. It has been developed through extensive research on estates in London in collaboration with Peabody, Ecosurety and six London boroughs. It includes guidance on introducing food waste recycling services to flats, as well as making improvements to dry recycling and rubbish services. It provides a full set of downloadable assets including bin stickers, signage, posters and information leaflets, along with guidance for their correct use.

ReLondon's 'Recycling in flats above shops' report is the result of a collaboration between ReLondon and London boroughs to better understand the unique waste and recycling challenges facing residents who live in flats above shops ('FLASH'). Building on previous research on purpose-built flats and houses in multiple occupation, the pilot project involved high level interviews with 30 residents, followed by further in-depth interviews and home visits. Research was also carried out with commercial properties on the same street as the flats as well as with representatives from London Business Improvement Districts. The work explored genuine recycling behaviours amongst residents of flats above shops, identifying factors affecting motivation, opportunity and capability and looking at how existing interventions and guidelines could be applied or adapted, all with the aim of informing recycling policy and practice around these types of property.

Case study 2:
Businesses developing innovative solutions for the sorting and recycling industry

Matoha fights pollution and enables circular economy through their easy-to-use, fast and affordable material identification scanners that enable sorting - anywhere, anytime. Their solution is assembled in London and enables waste managers to sort waste into commonly encountered plastic and textile categories. This technology also improves efficiency with on-site scanning and materials identification and ensures traceability throughout a cloud system.

Greyparrot provides innovative digital solutions to recycling businesses, enabling them to operate more efficiently, accelerate growth and scale-up. Working directly with facilities that process thousands of tonnes of waste a day, Greyparrot's waste recognition software sits on top of conveyor belts, allowing waste to be monitored and sorted at scale. This software uses computer vision and artificial intelligence to examine waste stream contents and shares data specific to each product and material via a live dashboard. This real-time analysis helps waste managers save costs, increase revenue and mitigate against risks.

Sorted builds AI-powered solutions to help waste management companies sort recyclable materials. Their solution for materials and plastics recovery facilities uses computer vision and artificial iIntelligence to detect materials moving through the facilities. It identifies valuable materials, guides the picker with a laser light on what to recover, and provides real-time insights to optimize the sorting process through their live dashboard.

Conclusions

05

5. Conclusions

Transitioning London's packaging supply chain to a circular economy is urgent, not only to reduce the amount of waste generated in London – and its associated costs – but also to tackle the city's consumption-based emissions.

From this research, it is clear that London's packaging system has a significant impact on both quantities of waste generated and the greenhouse gases emitted as part of London's total footprint. Packaging consumption in London remains vastly linear, with only 36% of the 2.18 million tonnes of packaging thrown away in the city every year that gets recycled. London's packaging greenhouse gas footprint is estimated to be 4.1 million tonnes of CO2eq per year, of which plastic packaging is the biggest contributor.

The key levers identified through this research – increasing recycled content in plastic packaging, reducing the need for single-use packaging through elimination and reuse, and increasing recycling rates – are existing solutions that require scaling up and embedding across London to transition towards a more circular economy and reduce London's packaging footprint. These interventions could reduce London's packaging footprint by 23% and demonstrate the importance of an integrated approach with each lever complementing and enhancing the others for increased impact.

To drive action in London, collaboration across stakeholders - including local and national policymakers, private players, and research and academic institutions - is required to:

- Improve waste services to capture packaging for recycling and ensure it gets recycled.
- Deliver initiatives that will reduce single-use packaging placed on the market, including through refill and reuse.
- Deliver change through the procurement practices of large public and private institutions.

The Mayor of London and London's boroughs, supported by ReLondon, are already taking actions on packaging and plastic to accelerate the transition to a low carbon circular economy in the capital. This includes the One World Living theme of London Councils' climate programme, which is enabling London boroughs and their local communities to reduce plastic packaging consumption. This report will help such programmes better target efforts and scope actions in areas with the most impact. The insights of this research will also support London's stakeholders as they collaborate to tackle packaging waste and to deliver a zero waste economy for packaging.

This research is an important milestone in achieving zero carbon ambitions across cities globally, designed as it is to be replicable both in other (non-packaging) sectors and in other cities beyond London. The approach and its findings can help decision makers in cities across the world to identify circular interventions that will reduce consumption-based emissions in their own city. Finally, increased collaboration and knowledge sharing between those cities could help tackle the carbon impacts of packaging across global supply chains.

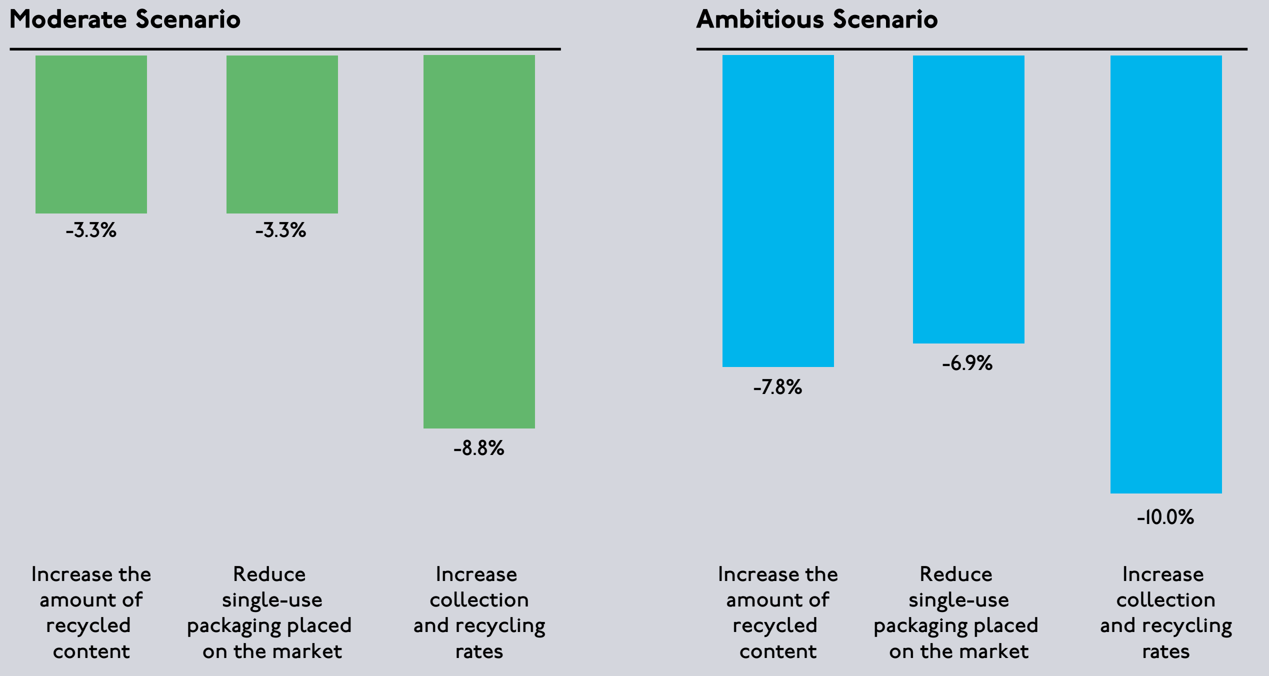
The immediate goal of this report is however to inform and focus attention on the most effective actions in London, actions which will eliminate unnecessary packaging in the city, help design and deploy reuse systems at scale, and improve collection and recycling infrastructure. These levers outline a clear pathway for London to become a leading zero-waste city - one that makes the very best use of our available resources but with better environmental and financial impacts, and a much lower carbon footprint.

6. Appendixes

Appendix 1 – Isolated levers impact

Figure 16 below presents the impact on London's packaging emissions of the three levers studied in this report, when considered in isolation.

Figure 16. Estimated carbon emission reduction of circular levers against the 2022 baseline across moderate and ambitious scenarios, considering these levers in isolation



Appendix 2 – Data quality

The table below qualitatively highlights the degree of uncertainty related to the data within each supply chain node to support the interpretation of the results and values presented in the report.

Supply chain node	Data uncertainty indication
Placed on the market	Very good
Consumer use	Very good
Business use	Very good
Reuse	Not quantified
Household collection volumes	Good
Public space waste and litter	Moderate
Commercial collection volumes	Low
Waste leaving London	Low
Recycling collection (households)	Very good
Residual collection (households)	Very good
Recycling collection (commercial)	Low
Residual collection (commercial)	Low
Recycled in UK	Moderate
Exported for recycling	Moderate
Landfill	Good
Incineration	Good
Emissions	Moderate

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