Cost Benefit Analysis of Compostable Plastics

For TIPA, lead project manager of ‘Compostable Coalition UK’

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Report For

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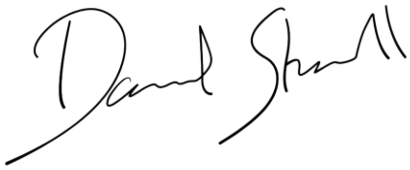

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Executive Summary

This report, commissioned by TIPA, as the lead project partner of 'Compostable Coalition UK', a research project supported by Innovate UK, presents a cost-benefit analysis (CBA) of different options to manage the circularity of compostable plastic packaging in the UK. The study evaluates the feasibility of integrating compostable plastic packaging into existing waste management infrastructure, which currently does not widely accept this waste stream, and future waste management infrastructure. The analysis considers the financial and environmental impacts of compostable versus conventional plastic for certain types of packaging and explores policy interventions to support the adoption of compostable plastic packaging.

The study's findings are particularly relevant in light of the UK's evolving waste and resources policy, including the new Extended Producer Responsibility (EPR) regime and Simpler Recycling reforms. These policies aim to improve recycling consistency and funding for waste management. However, compostable plastics are not yet mandated for collection under these reforms, and this CBA provides evidence to support potential policy changes.

Modelling Approach

The CBA modelled three scenarios to assess the impacts of compostable plastics:

- **Baseline Scenarios**: Reflect the current situation without additional policy interventions.

- **Scenario 1**: This scenario assumes that there is a ban on the use of conventional plastic in the manufacture of lightweight plastic carrier bags, sticky labels, and tea and coffee bags, with these products all being made from compostable plastic. Little penetration of compostable plastics for other types of packaging is assumed to occur.

- **Scenario 2**: Assuming higher penetration of compostable plastics, expanding their use in more packaging applications through switches from difficult-to-recycle conventional plastics to compostable plastics, particularly in the flexibles category. In this scenario, most compostable plastics are assumed to be collected via the dry recycling system along with other flexible plastics. This is achieved using additional near-infrared (NIR) sorting technology installed at plastic recovery facilities (PRFs), with the resulting compostable material directed to composting facilities.

Waste Destinations

The scenarios indicate a net increase in recycling, which includes a significant contribution from increased organic recycling (including food waste). Scenario 1 results in an additional 102 and 207 thousand tonnes of recycling under the low and high baseline respectively. Scenario 2 adds 20 and 22 thousand tonnes for a total net change, relative to the baseline(s), of between 122 and 229 thousand tonnes.

A switch from conventional plastic carrier bags to compostable plastic carrier bags leads to lower contamination of food waste sent to anaerobic digestion (AD), and therefore rejects from AD pre-sorting are sent to in-vessel composting (IVC), instead of to residual waste disposal as in the baseline. These rejects, when removed from AD, drag with them a large quantity of food waste, greater in weight than the weight of the material removed.

This is the major factor affecting final disposal routes in both scenarios and accounts for the majority of the increase in organic recycling achieved. Most (approximately two thirds) of this additional organic recycling is composted food waste.

The modelling also indicates that there is scope for compostable plastic to achieve higher market penetration in flexible plastic food packaging, and for this material to be sorted via the dry recycling system, reducing the potential for consumer confusion and contamination that might otherwise occur. The net result of the modelling is an increase in recycling of between 6–7 thousand tonnes of this currently difficult to recycle packaging waste stream, equivalent to a 22% (high baseline) to 64% (low baseline) increase in recycling of this waste stream. The potential still needs to be further explored, but the material appears particularly promising as an alternative to multi-layer/metallised conventional flexible plastic packaging.

Financial Costs

The analysis shows potential net savings for local authorities, ranging from £3.5 to £6.5 million annually in Scenario 1 and £3.0 to £4.7 million in Scenario 2. These savings are primarily due to reduced gate fees for anaerobic digestion (AD) facilities, as less contaminated food waste leads to lower disposal costs. This is assumed overall to offset the costs incurred as a result of installing the new sorting systems for compostable plastics.

There are expected to be no substantial financial changes for waste management operators, as they are likely to pass on any significant change in their costs to local authorities (whether directly, or eventually, when re-contracting) by proportionate adjustment of gate fees or via other contractual adjustments.

Environmental Impacts

Both scenarios demonstrate reductions in greenhouse gas (GHG) emissions. Scenario 1 achieves a reduction of 53–58 thousand tonnes CO_2e annually, while Scenario 2 results in a reduction of 170–192 thousand tonnes CO_2e benefit. The primary driver of these reductions is the decreased incineration of conventional plastics, which are replaced by compostable alternatives. Additional environmental benefits are likely to also occur but cannot currently be quantified, such as a reduction in microplastic pollution.

Policy Recommendations

At present there is a risk that compostable plastic packaging will be subject to a higher modulated fee under the UK's proposed EPR system – thereby hampering investment into a nascent industry and the potential to realise the benefits outlined above. It is also not clear how compostable packaging will be compatible with the recyclability assessment proposed as part of the system, as it is understood that there is currently no plan for the assessment to consider compostability. These potential issues will need to be resolved if the potential benefits of compostable plastic packaging considered here are to be achieved.

The report outlines a policy roadmap to support the beneficial use of compostable plastic packaging in the UK:

- **Short-term**: Exempt compostables from EPR fees and recyclability assessments for up to five years to protect the compostable plastic industry's development.

- **Medium-term**: Place compostable plastics on a level playing field with conventional plastics and other dry recyclable materials in terms of UK policy. Undertake further research into the environmental impacts of compostable plastic packaging.

- **Long-term**: Maximise the environmental and agricultural benefits that compostable plastics can deliver. Assuming the outcome of environmental research supports this, invest in infrastructure to sort compostable plastics at materials recovery facilities (MRFs). Alongside this provide policy support, where appropriate, for composting over anaerobic digestion to enhance soil health and food security.

Conclusion

The CBA demonstrates that compostable plastics can play a significant role in the UK's waste management system, offering both financial savings and environmental benefits. However, achieving these benefits requires supportive policy measures and further research to address current uncertainties. The report provides a robust evidence base for policymakers to consider the integration of compostable plastics into the UK's recycling and waste management strategies.

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1.0 Introduction

Following a successful application for UKRI funding, TIPA and its partners at the Compostable Coalition UK have delivered an ambitious multi-disciplinary research project exploring the feasibility of recycling compostable plastic packaging waste using existing and upcoming infrastructure, which does not, at large, currently accept this stream in the UK. The research considers the feasibility of options to mainstream the collection and treatment of compostable plastics and any systemic changes that may be needed to realise these options in practice. As part of the research project, a cost-benefit analysis (CBA) was undertaken of different options to manage the circularity of compostable plastic packaging waste in the UK.

This report summarises the methodology and key findings of the analysis, which included:

- Considering what role compostable plastic packaging might play in the future UK packaging market in terms of overall market penetration and share in key applications;
- Examining the financial and environmental impacts of using compostable packaging vs. conventional plastic packaging alternatives in a range of key end-of-life waste management scenarios; and
- Considering actions that could be taken by policy makers in support of compostable packaging to maximise the potential for positive economic and environmental outcomes.

The work is particularly relevant in the context of ongoing changes to resources and waste policy in the UK related to the roll out of a new packaging extended producer responsibility (EPR) regime and improving consistency in recycling collections. While the new Simpler Recycling reforms in England – which will require all local authorities to collect the same suite of packaging materials – do not currently include a mandate to collect compostable plastic packaging, the Government has signalled its intention to review any new evidence in support of such a mandate. The purpose of this CBA study is to provide such evidence.

In the UK, a key element of policy appraisal is to assess both environmental impacts and financial costs in a common metric, through the application of CBA. This allows policy makers to examine the potential effects, trade-offs and overall impacts of a range of options, thereby providing an objective evidence base for decision making. In response to the call for further evidence regarding compostable plastic packaging's suitability for recycling collection, and against the backdrop of emerging UK policy more generally, this report describes the results of a CBA model of different options to manage compostable plastic packaging waste in the UK. The goal has been to provide insight into the economic and environmental impacts of policy interventions necessary to support best practice in compostable plastic packaging uptake and end-of-life treatment, weighing the potential costs and benefits to help inform better policy decisions.

This report presents the approach to and results of the CBA, and is structured as follows:

- **Section 2.0** – provides a summary of the relevant UK policy proposals on packaging waste and analyses the implications of these for the compostable plastic packaging industry.
- **Section 3.0** – presents a summary of the methodology and scenarios underpinning the CBA model, its findings, and the resulting evidence base for compostable plastic packaging in the UK.
- **Section 4.0** – summarises conclusions that can be drawn from the CBA modelling and areas for further research.
- **Section 5.0** – provides a high-level roadmap for policy recommendations based on this study.

This report includes a **Technical Appendix**, starting **Section A.1.0,** which provides full details regarding the data, sources of information, and assumptions that support the analysis.

2.0 Analysis of Key UK Policy Proposals

In 2018, the UK Government set out its overarching environmental goals in its 25 Year Environment plan.[1] Aiming to improve the state of the environment within a generation, this plan covers a range of environmental areas, among them the management of waste and resources, including a target to eliminate all avoidable plastic waste by the end of 2042, and ambitions to meet all existing waste and recycling targets.

However, the UK failed to achieve its initial target of preparing for reuse or recycling 50%, by weight, of household (and similar) paper, metal, plastic and glass by 2020, achieving a household recycling rate of only 44%.[2] Currently, it has future targets of preparing for reuse or recycling 55% of municipal waste, by weight, by 2025, 60% by 2030 and 65% by 2035. There is also a target to send less than 10% of municipal waste to landfill by 2035 – there are no equivalent UK targets to reduce the amount of waste sent to incineration.[3]

The UK Government's Environmental Improvement Plan 2023 also set a target to not exceed 42 kg per capita of residual plastic waste, annually, by 31 January 2028 – a 45% reduction from 2019 levels.[4]

While there is no official, legally enshrined UK plastic packaging recycling target, the UK boasts a world first voluntary initiative in the UK Plastics Pact, which sees businesses from across the plastics value chain working with UK governments and NGOs to work towards a circular economy for plastics. Led by Wrap and Defra, the pact includes the following 2025 targets for plastic packaging: [5]

- To be 100% reusable, recyclable or compostable
- For 70% to be effectively recycled or composted
- 30% average recycled content across all plastic packaging
- To take action to eliminate problematic or unnecessary single-use plastic items

The most recent available data on UK packaging recycling performance is for 2021, in which year the UK achieved a plastic packaging recycling rate of 44%.[6]

It is in this context that emerging UK policy must be understood. Having failed to meet the 2020 household packaging waste target, and with performance on plastic packaging recycling falling short

[1] HM Government (2018), A Green Future: Our 25 Year Plan to Improve the Environment, accessible at https://www.gov.uk/government/publications/25-year-environment-plan

[2] Defra (2022), Progress report on recycling and recovery targets for England 2020, accessible at https://www.gov.uk/government/publications/progress-report-on-recycling-and-recovery-targets-for-england-2020/progress-report-on-recycling-and-recovery-targets-for-england-2020#context

[3] Defra (2023), The waste prevention programme for England: Maximising Resources, Minimising Waste, accessible at https://www.gov.uk/government/publications/waste-prevention-programme-for-england-maximising-resources-minimising-waste/the-waste-prevention-programme-for-england-maximising-resources-minimising-waste

[4] HM Government (2023), Environmental Improvement Plan 2023, accessible at https://assets.publishing.service.gov.uk/media/64a6d9c1c531eb000c64fffa/environmental-improvement-plan-2023.pdf

[5] Wrap, The UK Plastics Pact, accessed 25/06/2024, accessible at https://www.wrap.ngo/taking-action/plastic-packaging/initiatives/the-uk-plastics-pact#:~:text=A%20world%20first%20initiative,the%20scourge%20of%20plastic%20waste.

[6] Defra (2023), UK Statistics on Waste, accessible at https://www.gov.uk/government/statistics/uk-waste-data/uk-statistics-on-waste

of the UK Plastics Pact target, the UK Government has launched the Collection and Packaging Reforms, as part of its Resources and Waste Strategy.[7] This comprises three reforms:

- **Extended Producer Responsibility for Packaging**, to better fund the management of packaging waste and to reduce unnecessary and difficult-to-recycling packaging by making it subject to higher producer fees.

- **Simpler Recycling,** to improve consistency across household and business recycling collections in England.

- **A Deposit Return Scheme** for drinks containers in England, Wales and Northern Ireland, to increase both the amount of and quantity of material collected.

These reforms are intended to improve recycling rates, and it is the first two that impact on the management of compostable plastic packaging waste in the UK.

2.1 Extended Producer Responsibility for Packaging

Background

In 2018, the UK Government first announced its decision to overhaul England's waste system, including a revamp of the existing producer responsibility regime in favour of a new extended producer responsibility (EPR) system.[8] Under this system, producers would be required to pay fees in order to cover the end-of-life management costs associated with packaging they place on the UK market, shifting this financial burden from taxpayers to producers in line with the producer pays principle.

After a number of consultations and delays, the system is due to become fully operational in October 2025 – although producer registration and reporting requirements are in place as of 2023. While the EPR fees payable by producers will be related to the varied costs of managing the different types of packaging waste at the end of life, they will be further modulated in order to incentivise packaging that is more environmentally friendly. Initially, this modulation will be based on the recyclability of the packaging – other criteria for modulation (such as reusability) may be introduced in future years.

The precise methodology for modulating these fees and the approach to assessing recyclability are still in development, and a recyclability assessment methodology (RAM) is being developed to support this. to supersede the "early years" list of packaging types subject to modulation, although the timeline for this has not been finalised.

In addition, Defra had previously planned to require producers to provide clear and consistent recyclability information on packaging in the form of a binary label instructing consumers to either 'recycle' or 'do not recycle', from 2027; however, in September 2024 it announced that this mandatory labelling requirement has now been dropped.

Relevant proposals for compostable plastic packaging

The EPR regulations are still in draft form at the time of writing, and the position of compostable plastic packaging within the final policy is therefore uncertain. However,

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[7] HM Government (2018), Our Waste, Our Resources: A Strategy for England, accessible at https://www.gov.uk/government/publications/resources-and-waste-strategy-for-england

[8] Defra (2018), Our Waste, Our Resources: A Strategy for England, accessible at https://assets.publishing.service.gov.uk/media/5c18f11740f0b60bbee0d827/resources-waste-strategy-dec-2018.pdf

in its 2021 consultation document outlining early proposals around EPR, the UK Government suggested that the majority of compostable or biodegradable plastic packaging would not be considered recyclable and would therefore attract higher fee rates and be labelled ‘do not recycle’ under EPR. This was justified based on challenges associated with the management of compostable plastics at end-of-life, with the Government citing a lack of widespread collection, limited numbers of facilities that can accept this material, and the potential for consumer confusion leading to contamination of the conventional plastic recycling stream.[9]

Despite stakeholder feedback highlighting the potential unintended consequences of this proposal, the Government’s response (2022) reiterated the position, though reference to compostable packaging being eligible for higher EPR fees was removed. The question of whether composting of compostable plastic packaging can be considered equivalent to recycling was also raised:

‘Further evidence is needed to consider the disposal of compostable packaging via composting under industrial conditions as recycling, including independent evidence of the benefit to soils and land obtained by incorporating compostable packaging into compost or digestate. We will consider supporting an alternative approach should the SA [scheme administrator] see a strong, evidence-based, case for doing so.’[10]

Compostable packaging and composting are not mentioned in the more recent UK Government consultation on the draft EPR regulations (July 2023)[11], nor are they mentioned in the draft regulations themselves.[12] However, at a London Packaging Week event in September 2023, “compostable and degradable plastics” were identified as one of 13 packaging items shortlisted for higher fees in the early years of modulation (i.e., before a more formal recyclability assessment methodology is rolled out), again indicating that compostable plastic would be subject to negative fee modulation, as had formerly been suggested in 2001.[13] Stakeholder feedback is still being sought on this list, which has not been finalised at the time of writing.

It is worth noting that the Government’s draft EPR regulations propose that producers will be eligible for offsets from their EPR fee obligations if they can demonstrate that the related tonnage of packaging materials that are not collected by local authorities are collected and recycled in private schemes instead. However, it is not clear whether compostable packaging is eligible for this offset, given that “composting” is not explicitly included in the relevant clause, and given the wider lack of clarity as to whether composting can be considered equivalent to recycling or not as per the 2022 Government consultation response quoted above.

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[9] Defra on behalf of UK government (March 2021), Extended Producer Responsibility for Packaging Consultation Document, accessible at https://consult.defra.gov.uk/extended-producer-responsibility/extended-producer-responsibility-for-packaging/supporting_documents/23.03.21%20EPR%20Consultation.pdf

[10] Defra on behalf of UK government (March 2022), Extended Producer Responsibility for Packaging - Summary of consultation responses and Government response, pp 33/ 69, accessible at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1063589/epr-consultation-government-response.pdf

[11] Defra on behalf of UK government (July 2023), Consultation on the draft Producer Responsibility Obligations (Packaging and Packaging Waste) Regulations[2024 Consultation Document, accessible at https://consult.defra.gov.uk/extended-producer-responsibiity-team/consultation-on-the-draft-producer-responsibility/supporting_documents/Consultation%20on%20the%20draft%20Producer%20Responsibility%20Obligations%20Packaging%20and%20Packaging%20Waste%20Regulations%202024%20.pdf

[12] Draft Statutory Instrument - The Producer Responsibility Obligations (Packaging and Packaging Waste) Regulations 2024, accessible at https://consult.defra.gov.uk/extended-producer-responsibiity-team/consultation-on-the-draft-producer-responsibility/supporting_documents/230720%20consultation%20draft%20PRO%20Packaging%20and%20Packaging%20Waste%20Regulations.pdf

[13] Packaging News (September 2023), Defra outlines materials to be impacted by higher EPR fees, accessible at https://www.packagingnews.co.uk/news/defra-outlines-materials-to-be-impacted-by-higher-epr-fees-22-09-2023

Analysis of implications for compostable plastic packaging

Alongside concerns over challenges associated with managing compostable plastics at end-of-life, an important element informing the Government's current position that they cannot be considered recyclable is the absence of clear evidence of the benefit to soils and land of incorporating compostable packaging into compost or digestate. This position is based on definitions of what counts as recycling within the EU's Waste Framework Directive[14], with which UK policy is currently aligned. The relevant article states:

'…the amount of municipal biodegradable waste that enters aerobic or anaerobic treatment may be counted as recycled where that treatment generates compost, digestate, or other output with a similar quantity of recycled content in relation to input, which is to be used as a recycled product, material or substance. Where the output is used on land, Member States may count it as recycled only if this use results in benefits to agriculture or ecological improvement.'

The Government's consultation response focusses on benefits to soil and land but does not mention other forms of 'ecological improvement' that should be considered when assessing equivalency of composting to recycling. This oversight needs to be rectified if compostable plastics are to be assessed fairly, since their use could result in ecological benefits besides those to soil or land (e.g., potential avoided emissions from incineration and avoided microplastics, which have been explored further in this study).

Despite the lack of conclusive evidence of the benefits (or lack thereof) of compostable plastics, the Government's EPR policy is not being designed with the possibility of compostable plastic packaging in mind. For example, the development of the RAM is focussed only on collection, sorting and reprocessing of dry recyclables, with no equivalent methodology for assessing 'compostability'. Perhaps most problematically, the option for EPR fee offsets available to producers of other types of packaging that are not currently collected by local authorities are not explicitly available to producers of compostable packaging.

Regardless, the establishment of private collection and composting schemes would be costly. This means that whether through increased collection costs or the requirement to pay the higher rate of EPR fees, producers of compostable plastic packaging are likely to face significantly higher costs, and potentially be priced out of the market altogether given that the industry is a small, nascent one. As there is no clear evidence that compostable packaging treatment *does not* result in benefits to agriculture or ecological improvement, this policy impact is disproportionate.

Work is underway to identify novel applications for compostable materials where they provide environmental benefits and to identify end-of-life solutions and pathways. In comparison, conventional plastics are already well-established, having had decades to innovate and invest in waste management solutions. Assessing compostables against this benchmark risks stifling innovation, and UK policy proposals include no safeguards against such unintended consequences, not just for compostable packaging, but for all innovative packaging types. In contrast, the proposed regulations for the recyclability of packaging in the EU[15] specifically identify a need for exempting innovative packaging from recyclability requirements for a period of up to five years for this very reason:

"In order to stimulate innovation in packaging, it is appropriate to allow that packaging, which presents innovative features resulting in significant improvement in the core function of packaging and has

[14] Article 11a, (4), of Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008L0098-20180705

[15] DG Environment of the European Commission (2022), Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC, recital 23, accessible at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC0677

demonstrable environmental benefits, is given limited additional time of five years to comply with the recyclability requirements."

2.2 Simpler Recycling

Background

The UK Government announced reforms to existing waste collections for England in October 2023, aiming to boost recycling rates and dispel confusion around recyclable and non-recyclable materials (which currently vary by local authority). The purpose is to provide greater consistency in recycling practice for households and businesses, with changes due to be implemented by 2026/ 27. While the draft regulation detailing the new requirements is not yet available, the Government's consultation response provides a good indication of the upcoming changes.[16]

These changes will go hand in hand with the rollout of new labelling requirements for packaging waste – so that the recycling information on packaging labels matches the new service provision for household collections – and the gradual introduction of EPR requirements, as detailed in the previous section. While the requirements for labelling and EPR apply only to packaging waste, the Simpler Recycling reforms apply to all municipal waste (not just packaging), including food and garden waste – with implications for biowaste treatment routes and wider food and soil policy.

Although these reforms only apply to England, similar updates to collection systems are also underway in Wales, Scotland and Northern Ireland. Given that England accounts for more than 80% of households in the UK, we only focus on Simpler Recycling proposals in the sections that follow.

Relevant proposals for compostable plastic packaging

In addition to collection requirements for the packaging types that are currently collected by most local authorities – i.e., glass packaging (bottles and jars), metal packaging (such as cans and foil), paper and card (including packaging but also non packaging items like magazines, etc.) and rigid plastic packaging (bottles, pots, tubs and trays) – the proposed reforms require the separate collection for recycling of beverage cartons from households by 2026, as well as plastic film packaging and plastic bags made of mono-PE, mono-PP and mixed polyolefins PE and PP from 2027 onwards.

The separate collection of compostable plastic packaging materials is not being required as part of the Simpler Recycling proposals, due to concerns over suitability for recycling, and the impacts of contamination of the conventional plastic stream if compostables cannot be differentiated in the sorting process. However, the consultation response does appear to support further research and innovation in this area, to inform future guidance as the evidence develops.

The other possible avenue for the separate collection of compostables is via household food waste collections, which are being made mandatory on a weekly basis by 31 March 2026. In this option, they would not be recycled alongside other dry recyclables, but would be treated via the food waste treatment route.

Based on the most recent Government communications at the time of writing – provided in consultation responses in October and November 2023 – indications are that compostable packaging will not be in scope for collection along with food waste, with the exception of food waste caddy liners and tea bags.

[16] Defra (2023), Consultation outcome, Government response, available at https://www.gov.uk/government/consultations/consistency-in-household-and-business-recycling-in-england/outcome/government-response

[17], [18] It should be noted that there is no requirement, however, for food waste to be collected using caddy liners. Meanwhile, coffee pods are explicitly mentioned as being not in scope for collection as part of the food waste stream. Further statutory guidance is forthcoming.

Simpler Recycling's likely exclusion of compostable packaging in food waste reflects the Government's wider stance in favour of anaerobic digestion (AD) over in-vessel composting (IVC), as whereas compostable plastics are considered contamination in the AD process, IVC is better suited to their treatment. This preference is due to AD's potential to generate energy in the form of biogas, thus contributing to the UK's efforts to decarbonise its energy mix. The consultation explicitly notes that the Government's preference is for food waste to be treated by AD, and highlights the subsidies being provided to encourage the construction of additional AD facilities through the Green Gas Support Scheme. It also rejects suggestions to require a post-AD composting phase for plants treating food waste, due to cost, planning and space constraints.[19] This implies that the potential treatment route of recycling compostable packaging alongside food waste in composting facilities will become even less feasible once these policies are in place, creating an additional barrier to collecting compostable packaging with food waste.

There is a proposed exemption to allow food and garden waste to be collected together in one bin, in contrast to previous proposals that suggested mandatorily separating these streams. Co-collection of food and garden waste is common practice for several local authorities, and, typically, the resulting waste stream is sent to in-vessel composting (IVC). One complicating factor is that the consultation response requires food waste collections to be provided free of cost, while garden waste collections may be charged for – this will create challenges in implementation for local authorities that avail of the new exemption to co-collect food and garden waste.

Analysis of implications for compostable plastic packaging

The UK's agricultural soils are suffering from year-on-year erosion, putting at risk our ability to grow food, alongside a range of other essential ecosystems services soil provides, such as water filtration and supporting biodiversity.[20] However, the application of quality compost to soil has been proven to reduce soil erosion by improving soil structure and water retention, as well as improving soil health in terms of nutrient enrichment and pH regulation, aiding plant growth and productivity.[21] Furthermore, it also conveys carbon sequestration benefits.

Defra's stated preference for anaerobic digestion as the preferred form of biowaste treatment fails to recognise the key role that compost has to play in protecting the UK's food security and general environmental health. IVC produces a quality compost capable of locking essential nitrogen into soil thanks to the presence of more robust structural matter (humus) from plant material. By contrast, the digestate produced from the kind of wet AD treatment used in the UK is liquid in nature, making its application to land more difficult and meaning there is a risk of the nitrogen it holds being washed away in wet weather. Furthermore, the carbon sequestration benefits are also absent.

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[17] Defra (2023), Consultation outcome, Government response, available at https://www.gov.uk/government/consultations/consistency-in-household-and-business-recycling-in-england/outcome/government-response

[18] Defra (2023), Consultation on exemptions and statutory guidance for Simpler Recycling in England, accessible at https://brc.org.uk/media/683824/brc-response-to-defra-consultation-on-exemptions-and-statutory-guidance-for-simpler-recycling_november-2023.docx

[19] The benefits of generating more compost (rather than raw digestate) are discussed in a separate piece of research developed as part of this project. See: Carbon Clarity (2024) The Soil-Food-Biowaste Policy Disconnect, final report March 2024

[20] Dr Jane Gilbert, Carbon Clarity (2024), The Soil-Food=Biowaste Policy Disconnect in England: The Case for Policy Coherence, accessible at https://www.biopap.com/wp-content/uploads/2024/05/2024TheSoil-Food-BiowastePolicyDisconnectJaneGilbert.pdf

[21] Ibid.

The application of liquid digestate will only become more problematic once the volume of food waste increases with mandatory collection. The market distortion resulting from the building of even more anaerobic digestion plants in response to Government policy is therefore problematic, because there is no equivalent support to develop composting capabilities to meet the additional demand that mandatory food and garden waste collections imply while also enabling long term soil improvement to ensure UK food security. This suggests that the UK biowaste treatment landscape is not as diverse as it should be, and risks lock in and a stranded asset risk over the longer term with an excess of AD capacity and not adequate composting capacity.

IVC is therefore likely to provide a better long-term solution for treating the UK's food waste than wet AD. IVC would also, as noted, allow compostable plastic packaging to be collected alongside food waste, whereas AD creates another barrier to integrating the material into collection and treatment systems in England, and therefore has a negative impact on the likelihood of their greater uptake as an alternative to conventional fossil plastics.

Making the link between biowaste recycling, soil health and food productivity through further investment in composting and compostables would represent a circular model relative to the linear route of food waste to energy generation. [22]

2.3 Policy Summary

At the time of writing, recent indications are that compostables will be included on an 'early years' list of packaging types subject to negative EPR fee modulation. Furthermore, the Government has also indicated that local authorities will not be required to collect compostable plastic packaging for recycling either with dry recyclables or alongside food waste under the new Simpler Recycling requirements in England.

It is also unclear whether compostable plastic packaging will be eligible for the proposed negative modulation offset mechanism for packaging not collected by local authorities but instead collected through private take-back schemes. However, as private collection would anyhow be costly, compostables producers would end up paying more either way, through funding private collection if not in negatively modulated EPR fees.

The policy approaches the Government are taking to compostable plastic packaging in the Collection and Packaging Reforms are in part motivated by concerns over a lack of collection and processing capacity and how consumer confusion about the difference between compostables and conventional plastics could lead to contamination of the conventional plastic waste stream. Another key factor, however, is that the Government does not consider the composting of compostable plastics to be equivalent to recycling, due to the absence of clear evidence demonstrating that incorporating compostable plastics into compost or digestate delivers agricultural benefits to soil and land.

The Government's consultation response on Simpler Recycling does, however, seem to support further research into compostable plastic packaging, allowing for a change in position based on new evidence. This report provides such evidence, thereby allowing Defra to make a fair assessment of the benefits that compostable plastic packaging can bring to the UK, if the industry is allowed to develop in a supportive policy environment.

[22] Jane Gilbert (2024) The soil-food-biowaste policy disconnect in England: The Case for Policy Coherence

3.0 Evidence Base

As discussed above, while there is no plastic packaging target in UK law, the voluntary UK Plastics Pact – led by Defra in partnership with WRAP – contains a target for 70% plastic packaging recycling or composting by 2025, alongside other targets including for all plastic packaging to be either reusable, recyclable or compostable. Meanwhile, official Government targets include eliminating all avoidable plastic waste by the end of 2042 and reducing annual per capita generation of residual plastic waste to no more than 42 kg by 31 January 2028. However, as of 2021, the UK recycled only 44% of its plastic packaging waste.

The CBA undertaken for this study focusses on three key packaging applications for which plastics are predominantly used while considered to be hard-to-recycle at end-of-life. These plastic applications, which therefore present a challenge for meeting Government and UK Plastics Pact targets, are:

- **Consumer flexible plastic packaging.** Although representing more than a fifth of all consumer plastic packaging consumed in the UK, only 6% of flexible plastic packaging is recycled.[23] In its October 2023 report on progress made towards the circular economy goals of the Global Commitment on plastics, the Ellen MacArthur Foundation cites flexible plastics as a key barrier to signatory organisations meeting the target of plastic packaging being 100% reusable, recyclable or compostable by 2025.[24] Furthermore, it notes it is uncertain whether an effective collection and recycling system can be put in place, and what the timeframe for doing so would be. Elsewhere, the Ellen MacArthur Foundation has also said stated that: "*If we build organic waste collection systems, compostable plastics could potentially be considered for up to 20% of plastic flexibles.*"[25]

- **Small format plastic packaging**. This includes items too small to be detected at materials recycling facilities (MRF), such as tea bags, stickers for fresh produce and coffee pods. It is also very challenging to separate the plastic in tea bags and coffee pods from the food waste they generate end-of-life, making them in effect highly contaminated as a matter of course. Stickers for fresh produce are likely to be discarded in food waste along with the fresh produce, and therefore if made from conventional plastic will contaminate the food waste stream, and to ultimately the resulting compost/digestate as macro/micro plastic after treatment. The EU Packaging and Packaging Waste Regulation (PPWR) is looking to introduce a mandate across the EU that these small format applications be composed of compostable material, while the UK Plastics Pact also recommends that they be compostable. The vast majority of the UK tea industry has already moved to using compostable tea bags and multiple retailers are seeking to replace conventional plastic stickers with compostable alternatives.

- **Single-use plastic tableware for the hospitality sector**. While certain single-use tableware items are already banned in the UK, and there will likely be some movement to reusable alternatives, it is also likely that single-use tableware will continue to service consumer and industry needs. These items are typically made from plastic or cardboard with a plastic liner while also highly likely to be contaminated with food waste and are not capable of being recycling with current technology and infrastructure. Therefore, the CBA considers the impact of substituting these items with

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[23] The UK Plastics Pact, WRAP (2021), Creating a Circular Economy for Flexible Plastic Packaging, available at https://www.wrap.ngo/sites/default/files/2021-05/Creating-a-circular-economy-for-flexible-plastic-packaging-Roadmap-2025-v2May21_0.pdf

[24] Ellen MacArthur Foundation, UNEP (2023), The Global Commitment 2023 Progress Report, accessible at https://emf.thirdlight.com/file/24/E0TR4NIE0M2GH8rE0V7NE8PXj7Z/The%20Global%20Commitment%202023%20Progress%20Report.pdf

[25] Ellen MacArthur Foundation, Learn: Strategies for dealing with flexible packaging in a circular economy, accessed on 01/07/2024, available at https://www.ellenmacarthurfoundation.org/flexible-packaging/learn

compostable alternatives. Global brands such as McDonald's have already declared compostable packaging to be the most sustainable solution for them.

The model developed for the CBA assumes that some of these three key plastic packaging applications transition to compostable alternatives in the UK market and explores the impact of such a transition from an environmental and economic perspective.

3.1 Modelling Approach

The aim of this study is to add to the evidence base by undertaking a CBA that considers the costs and benefits of a significant increase in compostable plastic packaging, relative to the current situation. CBA was selected for this study since it is a method of economic appraisal typically undertaken by Government departments as part of the evidence base when analysing whether a new policy is appropriate. To ensure that these results have maximum credibility in the UK policy context, the methodology therefore aligns with the standard expectations for UK Government CBA policy assessments. [26]

The model attempts to map the different ways in which packaging markets and waste management policy might evolve in the UK, considering the resulting changes in packaging material and waste flows through the system and their economic and environmental impacts. Based on the results, we also provide a set of policy recommendations to support compostable packaging for those scenarios most likely to have positive environmental and economic impacts.

Throughout the project, robust and consistent coordination with the other work packages delivered under the UKRI funded project was undertaken to ensure an efficient approach to the work and to derive the greatest possible benefit from collaboration. WP1 included a review of stakeholder opinions on compostable plastics, considering the challenges of uptake of this packaging from the perspective of local authorities and industry. Outputs from that part of the project were considered when designing the scenarios.

Note that it is not within the scope of the CBA to provide detailed insights on overall waste treatment capacity and efficiency, and the likely levels of investment / employment associated with these. Additionally, reflecting the scope of the proposed EPR policy changes, the CBA model has not been developed separately for each of the devolved nations, but reflects the situation across the UK as a whole.

The CBA involved four main tasks:

1. **System definition** – establishment of mass flows of different packaging materials and waste, as well as collection, sorting and treatment systems in the UK.

2. **Scenario development** – creation of the scenarios to be modelled, based on previous work undertaken at EU level by Eunomia as well as inputs from the other work packages in this project, with desk-based research and expert interviews to support key assumptions and data. These interviews are reflected in the WP1 report developed as part of the project.

3. **Modelling of environmental and economic impacts** – identification, estimation and comparison of the financial and environmental costs and benefits (and monetisation of these where relevant) of the different scenarios relative to the current situation.

[26] These are outlined in the HM Treasury Green Book, accessible here: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1063330/Green_Book_2022.pdf

4. **Policy recommendations** – analysis of the results in light of the current policy situation and resulting recommendations.

In this report, these steps are presented in combination to provide a holistic view of the operational, economic and financial implications for each scenario. A more thorough methodology is set out in the Appendix starting at Section A.1.0 which includes detail on:

- **Current and potential material and waste tonnages** – for both conventional and compostable plastic packaging as well as food waste reflecting relevant market shares and penetration.

- **Waste flows and treatment assumptions** – including assumptions around contamination levels (in both food waste and packaging collected), waste destinations (biowaste treatment, wet AD, aerobic composting and residual disposal) and performance.

- **Unit impacts** – for both financial impacts (e.g., treatment costs, gate fees, material revenues, etc.) and environmental impacts (e.g., carbon and other GHG emissions associated with different treatment routes for both conventional and compostable plastics, based on both efficiency of these processes and their outputs).

The appendix details the data, sources and assumptions used in modelling the costs and benefits of policy changes to increase the uptake of compostable plastic packaging in the two scenarios. Where figures are not directly referenced in this report, they have been given in this technical appendix.

3.2 The Modelled Scenarios

Packaging placed on the market, together with waste flows and treatment routes, and resulting financial and environmental impacts, were modelled under three scenarios:

- **Scenario 0: Baseline scenarios** – reflecting the current situation (i.e., no policy intervention to increase uptake of compostable plastic packaging) and projected out to 2030 to provide a 'business as usual' counterfactual against which the impacts of the scenarios can be assessed over time. Two baselines – low and high – are modelled to reflect a range of potential future outcomes of current/proposed policy measures.

- **Scenario 1: Low penetration of compostables** – reflecting a scenario in which the UK introduces requirements that, for a number of key packaging applications likely to be contaminated by food waste, packaging items should be composed of compostable plastic, while placing such items made of conventional plastics on the market is prohibited. This represents a pragmatic or low ambition scenario.

- **Scenario 2: Higher penetration of compostables** – in addition to Scenario 1, further switches are made from difficult-to-recycle conventional to compostable plastics, particularly in the flexibles category. This represents a high ambition scenario.

Each of these is described in more detail below, with key assumptions provided. Further information provided in the Appendix.

3.2.1 Scenario 0: Baseline Scenarios

Given that UK policy on packaging waste is currently undergoing significant revisions, two baselines were modelled to reflect the uncertainty in the impact of these policies at present. Respectively, these represent the low or high potential capture of dry recycling and food waste under the range of implemented and proposed policies to date. Specifically, the high baseline assumes that all households receive food waste and film collections under the new simpler recycling proposals, while the low baseline assumes that these collections are rolled out to most, but not all households, due to policy exemptions, capital funding and contractual issues among LAs. Data used to inform the baselines was from the years 2019 and 2020, with projections modelled to 2030.

Key estimates and assumptions regarding the total assumed market share of compostable plastics in the UK at present, relative to the overall market size for all materials in the relevant applications are shown below in Table 3-1. Due to significant uncertainty in future market trends, no change is assumed in these placed on market tonnages for the modelled 2030 baseline projections (except for caddy liners, see table notes). Further detail regarding these assumptions, and descriptions of each application category are provided in Appendix A.3.0.

Table 3-1: Total Market Size and Current Penetration of Compostables, Thousand Tonnes

	Packaging / non – packaging	Total packaging placed on the market (all materials), thousand tonnes	Of which compostables based on most recent estimates, thousand tonnes[3]
Carrier bags	Packaging	31	3.0
Caddy liners	Packaging	5.5 – 11[2]	3.9[4]
Tea and coffee bags	Non – packaging[1]	12	4.0
Coffee pods	Non – packaging[1]	3.0	0.2
Sticky labels on produce	Non – packaging[1]	0.7	0.1
Fresh produce flexible packaging	Packaging	46	2.0
Other food flexible packaging	Packaging	203	–
Catering and other food services	Packaging	200	16
Total		**507**	**29**

Note:

[1] Non-packaging conventional plastic is included in the baseline modelling, to enable analysis of switching from conventional to compostable plastic.

[2] Estimate for 2030, based on low/high projections for food waste tonnages.

[3] Based on TIPA's data received from BBIA, unless noted.

[4] Estimate for 2018, based on food waste tonnages.

The majority of compostables (approximately two thirds) are assumed to end up in residual waste collections at present. Of the remaining material, most is assumed to be captured in food waste collections – where local authorities offer these - the majority of which is composed of compostable plastic carrier bags / caddy liners. In addition, it is assumed that at present, a small proportion of compostables end up as a contaminant in the dry recycling stream, varying from 1% to 12% of compostables placed on the market – see Appendix A.3.0 for further details. It should be noted that data on these factors is scarce, and these should therefore be considered 'best-guess' estimates.

In both the low and high baseline scenarios, it is assumed that the coverage of food waste collections across the UK will increase, reflecting the requirement for food waste to be collected separately across the UK by 2026. This results in an increase in overall capture of food waste between now and 2030. Based on our best interpretation of the likely outcomes of Simpler Recycling and EPR regulation proposals, we assume that:

- Compostable carrier bags (and caddy liners) will be allowed to be used as caddy liners in food waste collections (i.e., no change from present).

- Tea bags can be disposed in food waste (based on a specific exemption in consultation response for Simpler Recycling proposals).

- All other compostable packaging is not allowed for disposal with residential food waste. Private closed-loop collections of compostable packaging in hospitality waste may still exist.

- Sticky labels will still enter the food waste stream (even if not allowed, as they are attached to food).

- In both the low and high baseline scenarios, it is assumed that the vast majority of food waste in the UK continues to be treated via wet AD, with treatment via IVC declining slightly as new requirements for food waste collections see greater separation of food and garden waste collections. This means that, given the continued focus on wet AD, most compostables, if captured in this way will be removed as contaminants at the front-end of AD plants in the baseline scenario. Compostables that make their way into IVC are assigned appropriate degradation rates (see Appendix A.7.0 for further detail).

Finally, in the baseline we assume the same composition of conventional plastic packaging in the future as present. In practice some switching from multilayer to more recyclable mono-PE (and other more recyclable materials) is likely, due to modulated EPR; however, the structure of the fees, and therefore the potential extent of switching, is not known, and therefore no switching between (conventional) packaging types is modelled.

It is acknowledged that there is uncertainty around recycling capacity for conventional plastic films in the future. Some investment in capacity is likely (there are some UK facilities in the pipeline and active discussions on investment, as well as some potential capacity in the EU), but whether there is sufficient investment for all collected and sorted films in the UK to be recycled is not known. We capture this uncertainty in our baseline modelling, as follows:

- Under the low baseline we assume that only 50% of conventional flexible plastics (which are successfully collected, and sorted) are sent for recycling, due to constraints on capacity.

- Under the high baseline we assume that 100% of conventional flexible plastics (which are successfully collected and sorted) are sent for recycling.

3.2.2 Scenario 1: Low Penetration of Compostables

In Scenario 1, there is relatively low penetration of compostable plastics. However, it is assumed that **there is a ban on the use of conventional plastic in the manufacture of lightweight plastic carrier bags, sticky labels, and tea and coffee bags**. This is assumed to result in the following:

- A subsequent reduction in contamination of food waste sent to AD. Debagged material (food waste removed from the bags) at the front of AD is now considered to be sufficiently uncontaminated to be set to IVCs. Other contamination material includes the compostable plastic caddy liners used in the collection of food waste, and lightweight plastic carrier bags performing the same role. Previously this material stream would have been sent to incineration as contamination, but this is now sent to IVC.

- Small formats (tea and coffee bags, coffee pods, sticky labels) mostly stay in AD and are digested. There is no change in material treatment destination compared to the baseline, but the contamination rate of the output from AD plants is assumed to be effectively reduced in practice.

- The increases in the use of compostable plastic (arising as a result of the ban) described above are also assumed to result in a modest increase in the use of compostable plastic in the hospitality sector.

- The rationale for these changes is set out below.

Small format items

With an upcoming mandate for UK local authorities to provide food waste collections from March 2026, there will likely be an increase in the volume of sticky labels for fresh produce entering the food waste stream. However, the sortation equipment used in AD plants to remove plastic packaging contamination prior to the digestion process is not capable of detecting such small formats as stickly labels; similarly, these labels will not be detected in the screening process used in IVC plants. Therefore, if made of conventional plastics, sticky labels are highly likely to contaminate digestate/compost, and once this is spread to farmland, to ultimately pollute agricultural soil with macro/micro plastics.

However, Article 9 (1) of the latest version of the proposed text for a revised EU Packaging and Packaging Waste Regulation (PPWR) provides a mandate for these labels to be compostable.[27] The relevant text reads:

> *"…sticky labels attached to fruit and vegetables* ***shall be compatible with the standard for composting*** *in industrially controlled conditions in bio-waste treatment facilities…"*

Meanwhile, the UK Plastics Pact is recommending that those among its members that manufacture and/or place sticky labels for fresh produce on the market should switch to compostable labels.

Following the direction of the PPWR and UK Plastics Pact, in Scenario 1 we have modelled a shift to 100% of sticky labels for fresh produce placed on the market being compostables.

- Other small format items are also likely to form part of the AD feedstock from householders and commercial entities. These include tea and coffee bags – already found in the stream – and other single serve units. Since these small format items tend to be disposed of alongside food waste, banning the use of materials that are not compostable in these applications reduces the risks associated with contamination of the food waste stream.

It is understood (from research undertaken as part of this project) that these small format items cannot generally be removed by debagging processes at AD plants, and therefore stay in the digester. Mandating the use of compostable plastics for these items will therefore reduce the contamination of AD digestate.

Caddy liners and lightweight plastic bags

The latest version of the proposed text for a revised EU Packaging and Packaging Waste Regulation (PPWR)[28] includes a requirement that:

> *"… where* ***Member States allow waste with similar biodegradability and compostability properties to be collected together with bio-waste pursuant to Article 22(1) of Directive 2008/98/EC and*** *appropriate waste collection schemes and waste treatment infrastructure are available to ensure that* ***compostable packaging*** *enters the organic waste management stream, Member States* ***may*** *require that* ***the following packaging*** *shall be made available on their market for the first time only if* ***the packaging is compostable****:*

[27] European Parliament (2024), European Parliament legislative resolution of 24 April 2024 on the proposal for a regulation of the European Parliament and of the Council on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC (COM(2022)0677 – C9-0400/2022 – 2022/0396(COD)) accessible at https://www.europarl.europa.eu/doceo/document/TA-9-2024-0318_EN.pdf

[28] Ibid.

> ***(a)* packaging referred to in Article 3, point (*1)(g)* *composed of material other than metal, very*** *lightweight plastic carrier bags* ***and lightweight plastic carrier bags****."*

France and Italy have already implemented measures prohibiting placing conventional plastic lightweight carrier bags on their respective markets, requiring that all lightweight plastic carrier bags be compostable.

Note that very lightweight plastic carrier bags are bags with a wall thickness below 15 microns, commonly used as primary packaging for loose food items. They are a subset of lightweight plastic carrier bags. The CBA modelling treats lightweight plastic carrier bags as one category and does not differentiate very lightweight plastic carrier bags.

While the PPWR has been successfully voted through and adopted, due to the European election held in June 2024, the EU may decide to vote on the PPWR once again post-election. Therefore, the legislative process is not yet concluded.

A ban on lightweight plastic carrier bags made of conventional plastic (accompanied by a requirement for these to be made from compostable plastics certified to an appropriate compostability standard) would reduce contamination of the food waste stream (with conventional plastics), and also reduces the risk of microplastic contamination. Due to the lower contamination, it is assumed that IVCs (on/off site) would then be more willing to receive the reject stream from wet AD plant pre-sorting processes – the risks associated with screening at the end of the process are reduced, resulting in a removal of some of the current restrictions by the Environment Agency on this. This is the major route for successful composting of compostable packaging.

It is also assumed that these bags will be used as food waste caddy liners, reducing the need for dedicated caddy liners and effectively substituting existing conventional plastic liners with compostable plastic ones.

While the adopted PPWR text does not include a ban on conventional lightweight plastic carrier bags, such a ban was at one time included in a previous PPWR draft.

Single-use tableware used by the hospitality sector

Due to their use, these items are also likely to be contaminated with food waste and so not suitable for recycling. In addition, when composed of cardboard with a plastic lining, this composition makes them challenging to recycle. Despite Government bans on a few applications, it is assumed that some portion of the hospitality sector will need to continue to use single-use tableware. However, a substitution to compostable alternatives would allow for single-use tableware to be brought into the circular economy. This is the model that companies such as Vegware are already using in the UK.

As a result of banning the use of conventional plastics in the key packaging applications considered, it is also assumed that there is greater market acceptance of compostables, specifically in the hotel, restaurant and catering (HORECA) and events sectors. This is associated with an increase in the volumes of compostable material in closed loop collections from these sectors going directly to IVC.

3.2.3 Scenario 2: Higher penetration of Compostables

This scenario is intended to provide a vision for what could be achieved in an encouraging policy environment for compostable plastic packaging, considering the potential of technology to unlock the potential benefits these materials could bring.

In addition to applications listed in Scenario 1 above, this scenario assumes a much higher penetration of compostable plastic packaging in applications in which they are most likely to have benefits relative to alternatives, i.e., where they interface with organic wastes, but also where conventional plastics are not easily recyclable in the UK and also not easily substituted in a particular application from a technical perspective. In particular, **it is assumed that a proportion of flexible plastic packaging applications (for both fresh and non-fresh produce) move from conventional plastics to compostable plastics.**

In line with the Ellen MacArthur Foundation's position that compostable plastic could be used to substitute 20% of plastic flexibles globally, we have assumed a future market share of 20% for compostables in consumer flexible plastics (assumed in the modelling to be predominantly used for packaging fresh produce).

It is assumed that **consumers are advised to dispose of compostable flexible food packaging in the dry recycling stream – i.e., with other (conventional) flexible plastics used for similar applications.** The rationale for this is that, based on evidence gathered by the UK Compostable Coalition, where consumers dispose of compostable flexibles along food waste they are likely to be treated as contamination in wet AD plants, – which are used to treat the vast majority of food waste in the UK (see Section 2.0) – due to these using technologies to remove all packaging as a contaminate, regardless of type. As other evidence from the UK Compostable Coalition's research work shows that flexible compostable plastics can be positively sorted by MRFs in the UK, we have modelled the collection of flexible compostables via the dry recycling stream, alongside conventional plastics.

The collection method is based on the Flexible Plastic Fund's FlexCollect system, which includes two variations: 1) separate collection of flexible plastics in designated bags; and 2) co-collection of flexible plastics with rigid plastics. For the purposes of modelling, we assume the latter, in line with the Simpler Recycling reforms, which deem it likely that most local authorities will choose to co-collect films with rigid plastics, or with a wider selection of materials depending on their collection specifications. If flexible plastics are instead collected separately (from rigid plastics or other materials) they can be sent directly to a plastics recovery facility (PRF) and do not require primary sorting at a MRF, as described below.

This mixed plastic stream undergoes a two-step process. Firstly, the mixed plastic stream is sent to a primary MRF, to sort plastic films (conventional and compostable) from other materials. This initial sorting does not require any additional technology when compostable films are included in the mixed plastic stream. In the second stage, the flexible plastic stream is sent to a PRF for further sorting. Here, NIR sorting technology is used to sort into mono-streams (such as mono-PE, mono-PP, and compostable films). **Additional NIR sorting technology, costed in this study, is required to sort compostable films,** which are subsequently directed to composting facilities for processing.

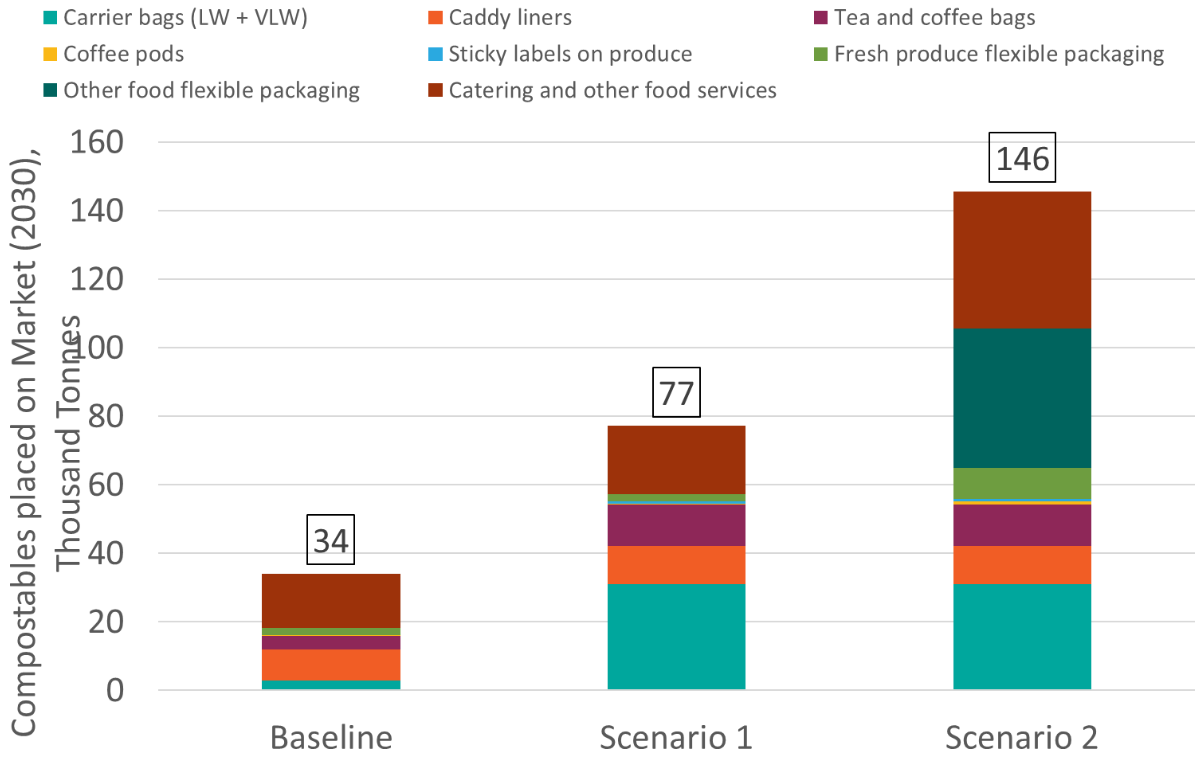
Similar capture rates and sorting efficiencies (in dry recycling) for conventional and compostable plastic flexibles are assumed; however, conventional (mono PE/PP) plastics are subject to further reprocessor losses after sorting, while compostables are not (the full weight is composted, along with any attached food waste). Multi-layer and other 'hard to recycle' conventional films are not targeted in sorting and are sent to incineration. Preliminary analysis of potential substitutions of conventional plastic with compostable polymers (by polymer type and application) indicates that approximately 60% of this switch to compostables is from mono PE/PP flexible plastic, and 40% from multi-layer and other 'hard to recycle' packaging. Furthermore, as discussed in Section 3.2.1, under the 'low baseline' we assume that there is a lack of capacity to recycle all collected / sorted conventional plastic films. Overall, this leads to a net increase in recycling / composting when switching from conventional to compostable consumer flexibles. The detail of these changes is shown in the results section.

We also assume a further increase in compostable market share in the HORECA and events sectors, alongside increased direct 'closed loop' collections from these sectors, as detailed in Section 3.2.4.

3.2.4 Summary of Scenarios

A summary of the assumed penetration rates of compostable plastics in the different packaging applications, under each of the scenarios, is provided in Figure 3-1 below.

Figure 3-1 - Compostables Placed on the Market, 2030



The total market size for these applications (made of all materials) is estimated to be around 674 kT. This means that **in the baseline scenario, compostable plastics are assumed to account for only ~7% of the market for these applications, rising to ~15% in Scenario 1, and ~29% in Scenario 2.** The modelled market share for each application in each of the two scenarios is shown in Table 3-2 below. For further details regarding the data used to arrive at these estimates and the relevant sources of information, refer to Appendix A.3.2.

Table 3-2 Modelled Market Share of Compostables in each Scenario (2030)

Application	Total Market Size (ktonnes)	Compostables Market Share (%)			Compostables Market Share (ktonnes)		
		Baseline	**Scenario 1**	**Scenario 2**	**Baseline**	**Scenario 1**	**Scenario 2**
Carrier bags (LW + VLW)	31	10%	100%	100%	3.0	31	31
Caddy liners	11	80%	100%	100%	8.9	11	11
Tea and coffee bags	12	33%	100%	100%	4.0	12	12
Coffee pods	3.0	5%	5%	30%	0.2	0.2	0.9
Sticky labels on produce	0.7	10%	100%	100%	0.1	0.7	0.7
Fresh produce flexible packaging	46	4%	4%	20%	2.0	2.0	9.1
Other food flexible packaging	203	–	–	20%	–	–	40
Catering and other food services	200	8%	10%	20%	16	20	40
Total	**507**	**7%**	**15%**	**29%**	**34**	**77**	**146**
Note: totals for 'Compostables Market Share (%)' are weighted averages, and as such are heavily weighted by 'other food flexible packaging' and 'catering and other food services' applications, owing to the relatively high tonnages of these applications.							

3.3 Modelling Results

This section presents modelling results for Scenario 1 and Scenario 2, compared to the low and high baselines. The overall change in final waste destinations is presented, and the dynamics of these changes are described in further detail for Scenario 2 / High Baseline results. Financial cost and environmental impacts are then summarised. Note that all presented results include impacts from food waste.

3.3.1 Waste Destinations

3.3.1.1 Overall Results

The change in final waste destinations, including food waste, from the low/high baseline to the scenarios, are presented in Figure 3-2. Tabular results with and without food waste included are shown in Table 3-3.

Figure 3-2: Change in Final Waste Destinations, Thousand Tonnes (Incl. Food Waste)

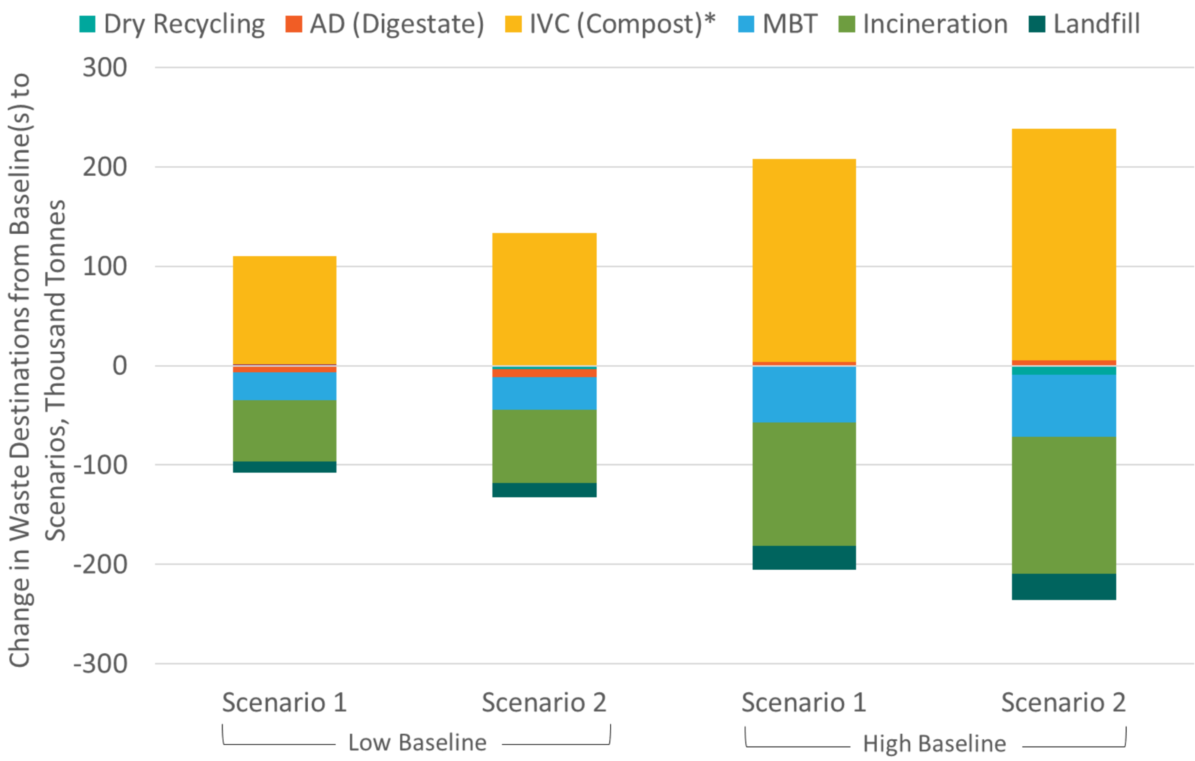


Table 3-3: Change in Final Waste Destinations, Thousand Tonnes

	Low Baseline		High Baseline	
	Scenario 1	**Scenario 2**	**Scenario 1**	**Scenario 2**
Packaging and food waste				
Dry Recycling	-1	-4	-1	-9
Organics Treatment	103	126	208	238
Residual Disposal	-101	-121	-204	-227
Net Increase in Recycling	102	122	207	229
Packaging only				
Dry Recycling	-1	-4	-1	-9
Organics Treatment	34	57	60	90
Residual Disposal	-33	-52	-57	-78
Net Increase in Recycling	34	53	59	81

Overall, the scenarios modelled drive a net increase in recycling (including organic recycling) relative to the baseline, of between 102 and 207 thousand tonnes in Scenario 1. Scenario 2 drives a further increase in recycling (including organic recycling) of around 20 thousand tonnes, for a total net change, relative to the baseline, of between 122 and 229 thousand tonnes. Most of this change in recycling (approximately 2/3 to 3/4 of the total net impact) is due to increased composting of food waste. The specific drivers of this change are described in the below section.

3.3.1.2 Detailed Impacts by Scenario

Ban on conventional plastic carrier bags (both Scenarios)

The ban on conventional plastic bags leads to lower contamination of food waste sent to AD, and therefore rejects from AD pre-sorting are sent to IVC (instead of to residual disposal in the baseline). These rejects, when removed from the AD plant, drag with them a large quantity of food waste, greater in weight than the weight of the material removed (see Appendix A.6.3)

This is the major factor affecting final disposal routes in both scenarios and accounts for the majority of the increase in organic recycling achieved. **Most (approximately two thirds) of this additional composting is food waste.**

Higher penetration of compostables and installation of sorting equipment at PRFs (Scenario 2)

In Scenario 2, 48 thousand tonnes of consumer flexible packaging placed on the market are switched to compostables, with 60% of this switch to compostables being from mono PE/PP flexible plastic, and 40% from multi-layer and other 'hard to recycle' packaging. This has the following impacts:

- For the fraction of multi-layer conventional films switched to compostables, a reduction in incineration is seen, and an increase in composting. Effectively, packaging which cannot be recycled is replaced with compostables which can be collected, sorted and recycled (with rejects sent to incineration, see below) through the dry recycling stream.

- For mono PE/PP conventional films switched to compostables, overall recycling rates (including composting) also increase. While both conventional mono PE/PP and compostable films have viable recycling / composting routes, the net recycling rate per unit of compostables is higher. This is because conventional plastics are modelled as subject to further reprocessor losses after sorting, while compostables are not subject to the same losses (the full weight is composted, along with any attached food waste); therefore, this switch also leads to a small net reduction in waste sent to residual disposal.

Detailed results for this modelled change are shown in Table 3-4. Overall, higher penetration of compostables in flexible packaging and installation of sorting equipment at PRFs results in increased recycling (including organic) recycling of between 6 and 7 thousand tonnes per year for this currently difficult to recycle stream, and a corresponding reduction in incineration. This is equivalent to a 22% (high baseline) to 64% (low baseline) increase in the total tonnage of recycling (including organic) recycling under Scenario 2 compared to the baseline.

Table 3-4: Model Assumptions for Recycling of Consumer Flexibles in Dry Recycling Stream under Scenario 2, Thousand Tonnes

	Baseline	Scenario 2	Change
Consumer flexibles placed on market			
Total size of market for consumer flexibles[1]	249	249	0
Of which conventional	247	199	-48
Mono PE / PP[2]	132	104	-28
Multi-layer / hard to recycle[2]	115	95	-20
Of which compostables	2	50	48
Recycling from Dry Recycling Collections (Low Baseline)			
Recycling rate for conventional packaging (average of mono PE / PP and multi-layer)	4%	4%	0%
Mono PE / PP[3]	7%	7%	0%
Multi-layer / hard to recycle[3]	0%	0%	0%
Recycling rate for compostable packaging[3]	0%	15%	15%
Overall dry recycling rate for consumer flexibles	**4%**	**6%**	**2%**
Total recycling / composting (thousand tonnes)[4]	**9**	**15**	**6**
Recycling from Dry Recycling Collections (High Baseline)			
Recycling rate for conventional packaging (average of mono PE / PP and multi-layer)	14%	14%	0%
Mono PE / PP[3]	25%	25%	0%
Multi-layer / hard to recycle[3]	0%	0%	0%
Recycling rate for compostable packaging[3]	0%	28%	28%
Overall dry recycling rate for consumer flexibles	**13%**	**16%**	**3%**
Total recycling / composting (thousand tonnes)[4]	**34**	**41**	**7**

Notes:

1. Fresh produce flexible packaging and other food flexible packaging

2. Assuming a consumer flexibles composition for applications in scope of this study based on baseline PoM tonnages for all conventional plastic films (53% Mono PE / PP, 47% multi-layer / hard to recycle).
3. Based on collection, sorting and reprocessing assumptions detailed in Appendix A.8.3
4. Note this data focuses solely on collections of packaging through the dry recycling stream, and the impact from switching from conventional to compostable plastic under Scenario 2. Excluded from these outputs are: 1) minor additional collection of conventional plastic consumer flexibles (diverted to dry recycling collection from food waste) as a consequence of reduced contamination of food waste under the ban implemented in Scenario 1 and 2; and 2) minor additional collection of compostable plastic consumer flexibles in organic collections (due to consumers choosing this rather than the advised dry recycling route for disposal), some of which is composted (debagged at AD and sent to IVCs)

Increase in 'closed loop' hospitality collections (both Scenarios)

An increase in 'catering and other food services' compostables placed on the market, and rollout of more 'closed loop' hospitality collections, leads to an increase in tonnage sent to IVC plants. Further increases in market share and composting are achieved in Scenario 2.

Key difference between baselines when considering the switches in the scenarios

Under the low baseline, a lower coverage of food waste collections by 2030 is assumed. This means that, while capture rates of compostable packaging in food waste are the same under both baselines, as not all local authorities are modelled as offering food waste collections, the overall tonnage of food waste captured across the UK is lower. Therefore, the modelled change in waste destinations (from residual disposal to IVC) for rejects from AD plants is also lower.

The capacity constraint for recycling of conventional plastic films in the low baseline drives a greater benefit when switching to compostables, as more of the switch to composting is replacing incineration (rather than dry recycling).

3.3.1.3 Impacts on Recycling Rate

The specific changes in recycling rates for the applications modelled in this study are shown in Table 3-5. This chart shows the final calculated recycling rate for plastic packaging (conventional and compostable) in the UK, including composting as a contributor towards the overall rate. Note, these are estimated **final** recycling rates, accounting for all losses in sorting / reprocessing, and are therefore lower than the modelled EPR target rates for plastic packaging based on the current UK measurement method (which among other factors do not include sorting losses; see Appendix A.2.2 for more details).

Table 3-5: Estimated Final Recycling Rates (Including Composting) for Modelled Applications in 2030, %

	Low Baseline			High Baseline		
	Baseline	Scenario 1	Scenario 2	Baseline	Scenario 1	Scenario 2
Carrier bags (LW + VLW)	7%	51%	51%	26%	77%	77%
Caddy liners	–	61%	61%	–	91%	91%
Tea and coffee bags	–	33%	33%	–	49%	49%
Coffee pods	–	2%	9%	–	2%	14%
Sticky labels on produce	–	59%	59%	–	89%	89%
Fresh produce flexible packaging	5%	5%	7%	17%	17%	20%
Other food flexible packaging	5%	5%	7%	17%	17%	20%
Catering and other food services	7%	9%	15%	8%	10%	16%

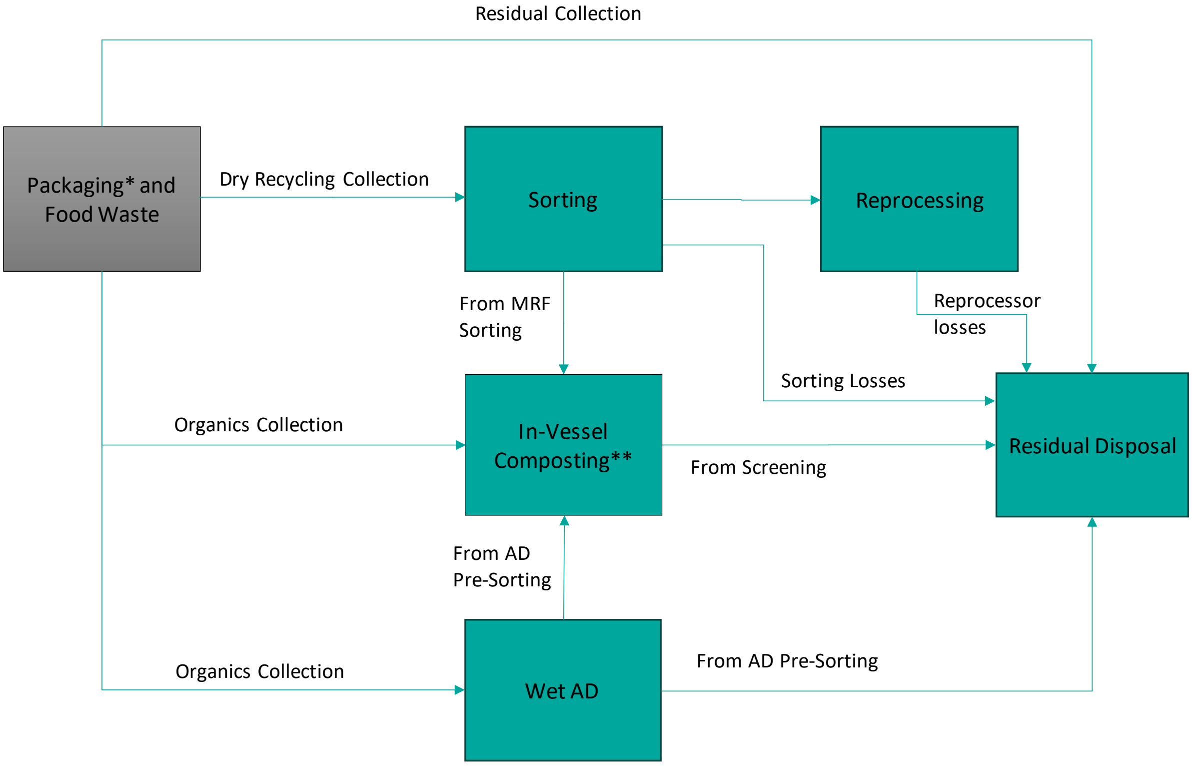
This table demonstrates that under both scenarios there is an increase in the overall recycling rate (including composting) for all applications modelled. As discussed, there is also an increase in food waste recycling, resulting from a decrease in the amount of contamination sent to incineration alongside the removed compostable plastics which occurs in the baseline.

3.3.2 Financial Costs

A simplified schematic of the primary flows of packaging and food waste modelled, from collection to final treatment destinations, is shown in Figure 3-3. Key changes in costs are modelled for each of the operators in this system: MRF operators, IVC facilities, Wet AD plants and residual waste disposal operators (incineration, MBT and landfill facilities).[29]

[29] We do not model any change in collection costs. This is because the quantity of material shifted from one type of collection to another (in the scenarios relative to the baseline) is relatively low, and the cost differential between collection types (residual, dry, organics) is not significant for this modelling. Reprocessing costs are considered only in terms of material revenues paid to sorting plants. Furthermore, we did not account for any County Councils that pay recycling credits for organics and dry recycling, because the extent of such arrangements is not known and beyond the scope of this study.

Figure 3-3: Schematic of the Modelled Waste Management System



The modelling assumes that there are no substantial financial changes for operators, as they are likely to pass on any significant change in their costs to local authorities (whether directly, or eventually, when re-contracting) by proportionate adjustment of gate fees – or via other contractual adjustments.

Gate fees are set by operators (incineration plants, MRFs, AD plants, etc.) based on the costs they bear, including the annualised capex/opex of sorting/treatment processes and any further gate fees they in turn pay to subsequent operators, as well as factoring in income from material revenues. Local authorities pay a set gate fee per tonne of material collected in each waste stream (residual, dry recycling, and organics).

In practice, how and when cost-sharing occurs would depend upon the specific details of the waste management contracts between waste operators and local authorities (including risk sharing agreements etc.). Costs presented here are therefore indicative.

Our approach to modelling the full net costs is:

- AD and IVC gate fees are an input to the model and are adjusted in the scenarios to account for changes in estimated costs/revenues (i.e. savings to AD operators when sending rejects to IVCs rather than incineration plants);
- For sorting facilities, gate fees are not calculated directly; however, all costs/revenues for sorting facilities are passed on in the model.
- Residual disposal costs are based on a gate fee which stays constant in the baseline and scenarios.

The full set of costs, by operator, are shown in Table 3-6. Based on the approach described above, the costs which, when summed together, are equivalent to the net costs of waste management are shaded in orange.

Table 3-6: Overview of Costs Modelled by Operator

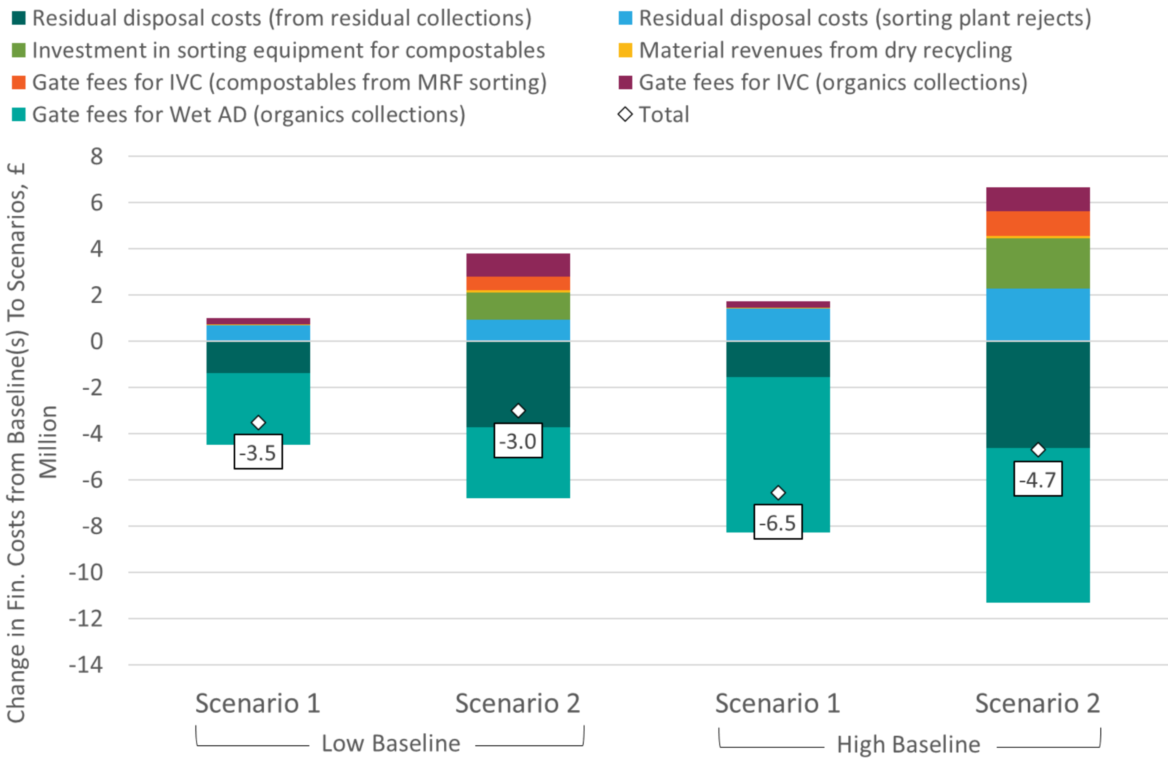
Operator	Cost / Revenue Category
AD operators	Gate fees from organics collection
	Gate fees paid to residual disposal operators (rejects)
	Gate fees paid to IVC operators (rejects)
IVC operators	Gate fees from organics collection
	Gate fees from Wet AD plants (rejects)
	Gate fees from MRFs (sorted compostables)
	Gate fees paid to residual disposal operators (screening rejects)
Sorting facilities and reprocessors	Investment in sorting equipment for compostables
	Gate fees paid to IVC operators (sorted compostables)
	Gate fees paid to residual disposal operators (sorting/reprocessing rejects)
	Material revenues from dry recycling
Residual disposal operators (MBT facilities, incinerators and landfill sites)	Gate fees from residual collection
	Gate fees from IVC (screening rejects)
	Gate fees from Wet AD plants (rejects)
	Gate fees from sorting / reprocessing (rejects)

We first present the net impact of these cost changes in Section 3.3.2.1, modelled as an annualised cost per year.[30] Specific costs falling on each of the operators in the waste value chain are then further detailed in Section 3.3.2.2.

3.3.2.1 Net Costs of Waste Management

The total change in costs modelled is presented in Figure 3-4. These costs are broadly equivalent to the scope of costs that would/could be considered in terms of the 'net costs of waste management' considered under EPR and are presented as the change in costs to local authorities, which are the entities most likely to be impacted by any overall cost change.

Figure 3-4: Change in Financial Costs for UK Local Authorities per Year, £ million



These results demonstrate **potential net savings** for UK local authorities from £3.5 to £6.5 million per annum in Scenario 1, and £3.0 to £4.7 million per annum in Scenario 2. In comparison, Government data for spending on waste services by local authorities in England, Wales and Scotland states a total cost of

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[30] Note that, as a minor proportion of commercial (hospitality) waste is included in the modelling, a small amount of the 'local authority' costs presented are in fact borne by commercial waste collectors (whether LAs or private companies).

£5.98 billion in 2022/23 (no data available for Northern Ireland).[31,32,33] This would suggest these savings are equivalent to 0.1% or less of local authority spending on waste management.

Key drivers of changes in financial costs are outlined below, with further detail provided in Section 3.3.2.2.

Bans on the use of conventional plastics for key packaging applications likely to be contaminated by food waste (both scenarios)

- **The main cost saving in both scenarios is from reduced gate fees paid to wet AD facilities** for treatment of food waste collected separately from households. As discussed, the ban on conventional plastic bags leads to lower contamination of food waste sent to AD, and therefore rejects from AD pre-sorting are sent to IVC (instead of to residual disposal as in the baseline). The modelling assumes that cost savings for AD operators, from switching from paying residual gate fees (at an average of £105 per tonne), to IVC gate fees (£63 per tonne) are passed on to local authorities as a 10% reduction in AD gate fees paid (reduced from £16 in the baseline to £14.40 in the scenarios). This adds up to a considerable saving over the total tonnage of food waste collected by local authorities in the UK.

- There is an increase in sorting rejects from MRFs and associated residual disposal costs. In Scenario 2, consumers are advised to dispose of flexible compostable food packaging via the dry recycling stream, increasing the total tonnage collected via this route. Incineration costs may also have increased by this point due to the implementation of ETS for these facilities; this has not been included in the modelling due to uncertainties surrounding the likely financial impact.

Increase in 'closed loop' hospitality collections (both scenarios)

- There is an increase in total gate fees paid to IVC (from organics collections) and a reduction in residual disposal costs, and a minor decrease in material revenues. This is due to an increase in compostable packaging placed on the market and subsequently collected in 'closed-loop' hospitality collections and sent to IVCs. This compostable packaging replaces conventional packaging, which is mainly sent to residual disposal for these applications. The small reduction in material revenues in Figure 3-4 relates to the minor proportion of conventional packaging that is recycled currently and is switched to compostables in the scenarios (see Appendix A.8.4). The impact is greater in Scenario 2 due to more compostables placed on the market and collected in 'closed-loop' collections.

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[31] HM Government (2023) *Revenue outturn cultural, environmental, regulatory and planning services (RO5) 2022 to 2023*, Accessed 27th August 2023, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1144982/RO5_2021-22_data_by_LA.ods (includes 'waste collection', 'waste disposal', 'recycling' and 'waste minimisation')

[32] StatsWales (2023) *Revenue outturn expenditure summary, by authority (£ thousand)*, Accessed 30th March 2024, https://statswales.gov.wales/Catalogue/Local-Government/Finance/Revenue/Outturn/revenueoutturnexpendituresummary-by-authority (all 'waste' spending)

[33] Scottish Government (2023) *Scottish local government finance statistics (SLGFS) 2022-23: workbooks - 2022-23 LFR 06 – Environmental*, Accessed 30th March 2024, https://www.gov.scot/publications/scottish-local-government-finance-statistics-slgfs-2022-23-workbooks/ (includes 'waste collection' and 'waste disposal')

Higher penetration of compostables and installation of sorting equipment at MRFs / PRFs (Scenario 2)

- Relative to Scenario 1, there is an annualised capex / opex of installing sorting equipment to target compostable plastics at MRFs / PRFs (£1.2–£2.2 million).

- With more compostables placed on the market and collected with dry recycling, there is an increase in gate fees paid to IVCs by PRFs for compostable packaging sorted from the dry recycling stream.

For both scenarios, the change in costs is greater under a high baseline. This is because under a high baseline:

- Much more food waste is collected separately (almost double the amount in the low baseline, due to full rollout of food waste collections). There is a similar increase in the quantity of compostables collected in the organics stream, and therefore the quantity of AD rejects sent to IVC.

3.3.2.2 Costs by Stakeholder

This section presents the change in costs for each of the key stakeholders likely to be impacted by the modelled changes to the waste management system. It is important to note that, as discussed in Section 3.3.2, substantial changes (particularly increases) in costs for facility operators are ultimately passed on to local authorities via changes in contractual arrangements. There is also the opportunity for costs to be covered by EPR fees, depending on how the EPR system is managed. Therefore, actual costs for operators are unlikely to increase substantially, since any potential increases will be covered in one of these two ways.

The costs shown in Table 3-7 to Table 3-10 include all costs that were possible to model. They are not comprehensive and do not show profit, rather only accounting for major changes in turnover and costs paid.

As in Section 3.3.2, rows showing costs that are passed on to local authorities are highlighted in orange. Positive numbers are additional costs / lost revenue to operators in the scenario compared to the baseline, while negative figures are revenues / avoided costs.

Table 3-7: Change in Costs to Sorting Facilities per Annum, £ Million

	Low Baseline		High Baseline	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Gate fees paid to residual disposal operators (sorting/reprocessing rejects)	0.7	0.9	1.4	2.3
Material revenues from dry recycling	0.01	0.1	0.02	0.1
Investment in sorting equipment for compostables	-	1.2	-	2.2
Gate fees paid to IVC operators (sorted compostables)	-	0.6	-	1.1
Total	**0.7**	**2.8**	**1.4**	**5.6**

Notes

Costs passed on to local authorities are shown in the orange rows of the table.

- The key points in relation to changes in costs to sorting facilities are:
  - There are additional gate fees for sorting / reprocessing rejects in all scenarios, primarily due to diversion of contamination (mainly conventional plastic films) from food waste to the dry recycling stream because of the ban on conventional plastic carrier bags.
  - There are lower material revenues from dry recycling in all scenarios, due to a reduction in conventional plastic film packaging placed on the market and collected in dry recycling.
  - In Scenario 2, there is a sorting equipment investment for compostables at PRFs of between £1.2 million and £2.2 million.
  - In Scenario 2, there are additional gate fees for compostables sorted from dry recycling stream of £0.6 to 1.1 million.
  - There is a total change in cost of between £0.7 and £1.4 million per year in Scenario 1, and £2.8 to £5.6 million per year in Scenario 2, with this ultimately passed on to local authorities.

Table 3-8: Changes in Costs to Wet AD Plants Per Annum, £ Million

	Low Baseline		**High Baseline**	
	Scenario 1	**Scenario 2**	**Scenario 1**	**Scenario 2**
Gate fees paid to residual disposal operators (rejects)	-11.5	-11.5	-24.5	-24.5
Gate fees paid to IVC operators (rejects)	9.0	9.4	17.3	17.4
Reduced gate fee revenues from organics collection	3.1	3.1	6.7	6.7
Total	**0.6**	**1.0**	**-0.5**	**-0.4**

Notes

Costs passed on to local authorities are shown in the orange rows of the table.

- The key point in relation to changes in costs to wet AD plants is:
  - In Scenario 1 and 2, rejects are no longer sent to incineration and are instead sent to IVC. This leads to a net saving for wet AD plants, which we assume is passed on to local authorities as a reduced gate fee (shown in the third row of the table). A 10% lower gate fee is modelled.
  - The gate fee saving means that on average there is no change in costs for wet AD operators per tonne even after increased gate fees to IVC operators and changes in gate fees to local authorities are taken into account.

Table 3-9: Changes in Costs to IVC Operators Per Annum, £ Million

	Low Baseline		**High Baseline**	
	Scenario 1	**Scenario 2**	**Scenario 1**	**Scenario 2**
Gate fees from Wet AD plants (rejects)	-9.0	-9.4	-17.3	-17.4
Gate fees paid to residual disposal operators (screening rejects)	1.5	1.6	3.1	3.0
Increased gate fee revenues from organics collection	-0.3	-1.0	-0.3	-1.0
Gate fees from PRFs (sorted compostables)	–	-0.6	–	-1.1
Total	**-£7.8**	**-£9.4**	**-£14.5**	**-£16.5**

Notes:
IVC costs include a minor volume of waste sent to dry AD facilities
Costs passed on to local authorities are shown in the orange rows of the table.

- The key points in relation to changes in costs to IVC operators are:
  - IVC operators gain from a significant increase in revenue in gate fees received for rejects sent by AD plants (for which a 20% higher gate fee per tonne is assumed, to account for the increased contamination and lower food waste content of this stream).
  - The increased input tonnage from a more highly contaminated stream means that there are more screening rejects to treat, which require an additional cost to send on to residual treatment operators.
  - IVCs also benefit from increased revenue from closed loop collections of hospitality waste (both scenarios), and gate fees paid by PRFs for sorted compostables (Scenario 2 only).
  - There is a total increase in revenue of between £7.8 and £14.5 million per year in Scenario 1, and £9.4 to £16.5 million per year in Scenario 2.

Table 3-10: Changes in Costs to Residual Disposal Operators Per Annum, £ Million

	Low Baseline		**High Baseline**	
	Scenario 1	**Scenario 2**	**Scenario 1**	**Scenario 2**
Gate fees from residual collection	1.4	3.7	1.5	4.6
Gate fees from Wet AD plants (rejects)	11.5	11.5	24.5	24.5
Gate fees from IVC (screening rejects)	-1.5	-1.6	-3.1	-3.0
Gate fees from sorting / reprocessing (rejects)	-0.7	-0.9	-1.4	-2.3
Total	**10.7**	**12.7**	**21.5**	**23.8**

Notes

Costs passed on to local authorities are shown in the orange rows of the table.

- The key points in relation to changes in costs to residual disposal operators are:
    - Residual disposal operators experience a relatively significant reduction in revenue from no longer receiving gate fees from rejected material from wet AD plants, as well as from reduced gate fees from tonnages arising from residual waste collection.
    - There is some increase in revenue from increased screening rejects from IVCs and from gate fees from sorting plants paid for disposal of rejects.

The model does not consider the potential change in ETS costs arising from the changes in material composition that will likely occur as a result of the switch to compostable plastic (expected to be made from biogenic feedstocks).

3.3.3 Environmental Impacts

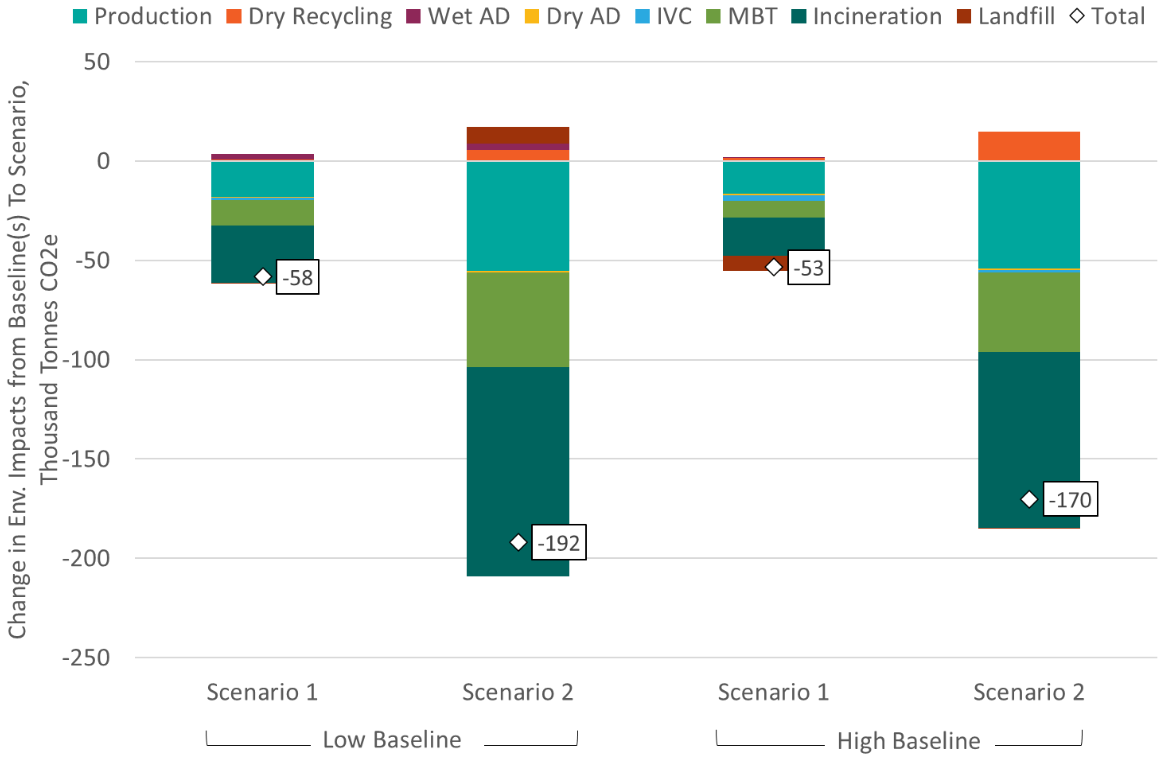
A change in GHG emissions also modelled, relating to production, recycling, biowaste treatment and residual waste disposal. This is shown in Figure 3-5. The most significant benefit seen is that for Scenario 2 under the low baseline, where an emissions benefit of 192 thousand tonnes CO_2e is seen per year.

The most significant driver in benefits by far is the reduction in incineration (combined with MBT) impacts from burning of fossil plastics; compostable plastics are, conversely, assumed to be primarily produced from biogenic feedstocks. By convention in this type of analysis, biogenic CO_2 emissions are excluded from the emissions directly occurring from incinerators as this is considered to be carbon that was recently sequestered into biomass during plant growth. The impact is significantly greater in Scenario 2, as the switch from conventional to compostable flexible packaging (which is associated with a relatively significant quantity of material) leads to a larger net reduction in incineration.

Impacts associated with manufacturing plastic (shown on the graphs as "production" impacts) are also lower for compostables plastics when compared to conventional plastics, as the literature indicates emissions associated with using biomass-based feedstocks are somewhat lower than using fossil-based feedstocks (the ultimate feedstock for the latter being crude oil).

The net reductions in GHG emissions from production and incineration / MBT are significantly greater than the reduced GHG benefit from a reduction in recycling (of conventional plastic) which also occurs under both scenarios. There is, in contrast, relatively little GHG impact from the biowaste treatment system elements. Landfill impacts are also relatively small as relatively little residual waste is now sent via this management route.

Figure 3-5: Change in GHG Emissions per Year, Thousand Tonnes CO_2e



The modelling may underestimate the full benefits that could be seen by a greater switch to compostable plastic packaging. Data on the quantity of packaging arising via the hospitality sector and via events is of relatively poor quality. The model includes indicative impacts but there is likely to be greater scope for the use of compostable packaging in this waste stream than has been modelled here. Equally, however, the modelling of incineration impacts does not consider the potential impact of decarbonisation activities such as might occur incentivised by the potential future inclusion of incinerators in the UK's Emissions Trading Scheme.[34]

In addition, a number of environmental impacts were not included in the assessment, due to a lack of data and / or methodologies with which to assess impacts. The reduction in incineration – and commensurate increase in the use of IVC – for compostable plastic packaging is also anticipated to result in air quality benefits, associated primarily with a reduction in NOx emissions. These have not been included within the modelling as there is currently a lack of data on the air pollution impacts of compostable plastic production.

[34] This might result in the installation of carbon capture and storage at some incineration facilities which would result in a significant decrease in emissions at such a facility. At the time of writing, however, the extent to which this type of pollution mitigation solution might be implemented is highly uncertain.

Furthermore, the benefits arising from a reduction in microplastic pollution cannot currently be accounted for, due to a lack of agreed assessment methodologies. These are expected to arise as a result of the removal of fossil carbon plastic from the biowaste stream resulting in particular from the carrier bag ban assumed to occur in both scenarios. This issue is discussed further in Section 3.4.

3.4 Other Supporting Evidence

The potential for compostable plastics to replace conventional plastic polymers has been considered in work by the Ellen Macarthur Foundation.[35] This considered the global potential for such shifts; compostable plastic could be used to substitute 20% of plastic flexibles. It considered two prerequisites for this to occur:

1. There is a need to consider the design of compostable flexible packaging products such that these can integrate with food composting systems

2. Solutions are needed to tackle the contamination problems that arise from the contamination that might otherwise occur when conventional and compostable polymers exist in the same waste streams.

A key consideration in respect of the increased use of compostable plastic material – reflected in the work of the Ellen Macarthur Foundation and others - is the propensity of such packaging materials to reduce the potential for environmental harms arising from microplastics. Recent years have seen much research undertaken which considers the potential for environmental harm arising from the increased prevalence of such materials in the environment. A recent review paper set out the emerging evidence of the potential effects of these materials on human health – these are understood to include oxidative stress, DNA damage, organ dysfunction, metabolic disorder, immune response, neurotoxicity and reproductive and developmental toxicity.[36] Similar effects are also likely to occur in animal health.

Currently the environmental impacts of microplastics are outside of the scope of appraisal methodologies aimed at environmental impact assessment such as life cycle assessment. Work has, however, now been undertaken on this front as well – publications include work by BASF, where a scientific model has been developed that shows how to integrate the impact of microplastics on marine life into impact assessments within the life cycle assessments of plastic products.[37] Further similar research work may lead to agreed methodologies with which to assess these impacts in the coming years. Were this to become available, this would allow for the potential inclusion of such impacts within the fee modulation of the EPR system.

Work undertaken as part of this project provides promising evidence that most of the compostable plastics assessed in the research would disintegrate and degrade to a significant extent within IVC treatment systems, further indicating that compostable plastics are less likely to cause this type of environmental problem than conventional plastic material – although further research is needed to fully support these conclusions for the full range of compostable plastic polymers available and in respect of the environments in which this needs to occur.

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[35] https://www.ellenmacarthurfoundation.org/flexible-packaging/learn

[36] Li Y, Tao L, Wang Q, Wang F, Li G and Song M (2023) Potential Health Impact of Microplastics: A Review of Environmental Distribution, Human Exposure and Toxic Effects, *Environ Health*, 1, 4; pp249-257, available from https://pubs.acs.org/doi/10.1021/envhealth.3c00052

[37] Saling P, Gyuzeleva L, Wittstock K, Wessolowski V and Griesshammer R (2020) Life cycle impact assessment of microplastics as one component of marine plastic debris, *The International Journal of Life Cycle Assessment*, 25, pp2008-2026

Evidence of the effectiveness of conventional lightweight and very lightweight plastic carrier bag bans in reducing the contamination of compost has been collected over time in Italy, where biowaste collection systems are among the most advanced and well established in the world. The country was one of the first to introduce such a ban – with bags being manufactured from compostable plastic - and published an assessment report of the potential benefits in reducing contamination from plastic carrier bags in compost as a consequence of the continued implementation of the ban over time.[38] Analysis provided sampling data on around half of the country's composting plant. This showed the introduction of the ban on fruit and vegetable bags made from conventional plastic material resulted in a decline in such materials in compost from 9% in 2016-7 to 2% in 2019-20.

Much of UK's biowaste treatment capacity is based on wet AD – which is potentially problematic with regards to the treatment of compostable plastics, as was explored in detail in WP1 of this study. The Simpler Recycling proposals may lead to a reduction in IVC capacity, which is likely to be needed to ensure that compostable plastic packaging can be appropriately treated to maximise the environmental benefits. However, other research undertaken in this project under WP5 confirms that significant benefits could occur in respect of soil health and other associated benefits such as sequestered carbon in soil if the amount of compost produced in the UK were to be increased. This suggests there are important links between biowaste management policy and agricultural policy which need to be maintained if we are to maximise the potential for continued nutrient recycling. IVC capacity may therefore needed for reasons beyond the requirement to ensure that compostable plastics can continue to be treated.[39]

4.0 Conclusions

A ban on conventional plastic carrier bags, tea/coffee bags and sticky labels (as modelled in Scenario 1) would harmonise UK with upcoming European legislation (specifically the PPWR) and reduce contamination in food waste. This, in turn, would increase recycling rates. Evidence of the effectiveness of such bans is available from Italy, where such a policy has been in place for a number of years.

Evidence provided by this project indicates that there is scope for compostable plastic to achieve higher market penetration in flexible plastic food packaging, and for this material to be sorted via the dry recycling system, reducing the potential for contamination that might otherwise occur. This has been a key focus of concerns associated with the use of this type of packaging in the UK and Europe, and is reflected in the work recently undertaken by the Ellen MacArthur Foundation. The net result of the modelling undertaken here is an increase in recycling of between 6-7 thousand tonnes of this currently difficult to recycle stream. The potential still needs to be further explored, but the material appears particularly promising as an alternative to multi-layer/metallised conventional flexible plastic packaging. The extent to which this market penetration may occur will depend on the ability of such packaging products to achieve comparable technical performance to that of the conventional plastic alternatives and the desirability of packaging producers to make that investment. Outside of the UK, investment may be influenced in part by further evidence emerging of the environmental harm from microplastics as discussed above.

The results indicate that there could be net financial savings to local authorities of between £3.5 to £6.5 million under Scenario 1 and £3.0 to £4.7 million under Scenario 2. Savings occur if it is assumed the reduction in contamination costs (from AD plant) is passed on to local authorities. Costs are higher under Scenario 2 as treatment of compostable plastics packaging via materials recycling facilities would require additional sorting equipment to be installed at such plants. Current mechanisms to fund this are unclear, but it is noted that similar (additional) investments are likely required to allow for the sorting of

[38] Consorzio Italiano Compostatori (2020) Ottimizzazione del riciclo dei rifiuti organici: Sintesi dei risultati del programma di monitoraggio CIC – COREPLA (2019-2020)

[39] Carbon Clarity (2024) The Soil-Food-Biowaste Policy Disconnect, final report March 2024

flexible plastic packaging made from conventional polymers. Sorting / reprocessing efficiencies are also potentially greater than conventional flexibles.

Results from the CBA indicate environmental benefits in terms of GHG emissions reductions arising from both scenarios of 53 to 58 thousand tonnes CO_2e under Scenario 1, while Scenario 2 is estimated to result in 170 to 192 thousand tonnes CO_2e benefit. These reductions – particularly associated with a reduction in incineration emissions - are relatively modest. However, the environmental appraisal was not able to account for some potentially significant environmental impacts, including those associated with an anticipated reduction in microplastics. Evidence continues to emerge of the extent to which microplastic may cause harm to human health and other environmental damage. Given the amount of research currently being undertaken, further evidence is anticipated to emerge on this topic in the coming years – including potential assessment methodologies with which to evaluate environmental impacts. This, in turn, might mean that microplastic pollution could be considered within the fee modulation framework for packaging in the future as part of the UK's EPR system.

This analysis has also considered some potential benefits arising from the substitution of plastic used in the hospitality sector. Results from this are highly uncertain due to the lack of data on the quantities of material within the waste stream that could potentially be available for substitution.

Notwithstanding all of the above, at present there is a risk that compostable plastic packaging will be subject to a higher modulated fee in the UK's proposed EPR system – thereby hampering investment into a potential solution to tackle this problem. It is also not clear how compostable packaging will be compatible with the recyclability assessment proposed as part of the system, as it is understood that there is currently no plan for the assessment to consider compostability. These potential issues will need to be resolved if the potential benefits of compostable plastic packaging considered here are to be achieved.

5.0 Policy Roadmap Recommendations

In light of the conclusions presented above, we recommend that the UK Government pursues four policy goals over the short, medium and long term, together comprising a policy roadmap to facilitate the beneficial use of compostable plastics in the UK. The policy goals are presented below, along with accompanying policy recommendations for how to achieve these goals.

1. **In the short term, protect the continued existence and development of the compostable plastics industry in the UK.**

    a. Compostables should be recognised as an innovative packaging type and as such be exempt from both EPR fees and recyclability assessments for up to five years.

2. **In the medium term, place compostable plastics on a level playing field with conventional plastics and other dry recyclable materials in terms of UK policy.**

    a. Where there is evidence that the substitution of compostable plastic packaging products for those made of conventional plastics results in a clear benefit in reducing plastic contamination in compost, there should be a requirement that only the compostable equivalents should be placed on the market (e.g., this could include fruit and vegetable labels, tea bags, coffee pods, and some small flexible plastic packaging products such as sweet wrappers). Such items should be mandatorily collected alongside food waste and, where relevant, labelled with the appropriate disposal instruction to consumers.

    b. Once an appropriate compostability assessment methodology is in place, EPR requirements can be rolled out for compostables on terms equivalent to those for conventional packaging materials.

3. **Alongside goal 2, undertake further research into the environmental impacts of compostable plastic packaging.**

    a. Further analysis is needed to combine emerging data on the disintegration and degradation potential of compostable plastics with emergent environmental assessment methodologies which are better able to consider the environmental impact of microplastic generation. This would enable a full appraisal of the potential benefit compostable plastic packaging has to reduce environmental harms from microplastic in comparison to that seen with conventional plastic packaging.

    b. Work is also needed to understand the potential benefits of compostable plastic packaging to reduce emissions of air pollutants such as NOx and PM. Recent LCA evidence on the production of compostable plastic polymers is currently somewhat lacking beyond assessments of the climate change benefits of such polymers.

4. **In the medium to long term, maximise the environmental and agricultural benefits that compostable plastics can deliver.**

    a. Rectify the current market distortion for biowaste recycling in favour of bioenergy generation (via AD) at the expense of natural capital (soil) enhancement (via composting) by applying similar financial incentives to the use of quality biowaste-derived compost to improve soils. This issue is further discussed in a further research report produced as part of this project.[40] This will also help ensure there remains enough IVC capacity to treat compostable plastic packaging.

    b. Assuming the environmental benefits of the use of compostable packaging can be substantiated, invest in UK treatment infrastructure for sorting compostable plastic packaging from other materials at MRFs such that it can be composted it alongside food / garden waste. Depending on the design of the scheme, EPR fees may cover the cost of the investment required to achieve this aim. Additional research into the sorting of compostables may be needed here, building on the work that has already been done as part of this project.

    c. Once sorting infrastructure is in place at MRFs/PRFs, this will enable compostables to be collected at the kerbside. The UK Government should also then consider a mandate for replacing non-recyclable flexible plastic packaging products with compostable equivalents where there are clear benefits of doing so.

[40] Carbon Clarity (2024) The Soil-Food-Biowaste Policy Disconnect, final report March 2024

Technical Appendix

CBA of Compostable Plastics Technical Appendix

A.1.0 Modelling Overview

This technical appendix presents detailed data and assumptions used in the CBA model. Sections A.1.0 to A.7.0 relate to data and assumptions for the model baselines, Section A.8.0 to modelling parameters for the Scenario, and Sections A.9.0 and A.10.0 the financial and environmental unit impacts.

A.1.1 Material Scope

The model incudes placed on market and waste destination data for packaging (conventional and compostable), a limited set of non-packaging materials (for applications that may be switched to compostables, and food waste. The taxonomy is shown in Table A-1.

Table A-1: Taxonomy of Materials/Applications Included in Modelling

Type	Material / Application
Conventional (packaging)	Plastic
	PET bottles (beverage)
	PET bottles (non-beverage)
	HDPE bottles
	Pots Tubs and Trays (PET/PP/other)
	Mono PE / PP flexibles
	Other flexibles
	Wood
	Aluminium
	Steel
	Paper
	Card
	Glass
Conventional (non-packaging)	Sticky labels on produce
	Tea and coffee bags
	Coffee pods
Compostables	Carrier bags (LW + VLW)
	Caddy liners
	Tea and coffee bags
	Coffee pods
	Sticky labels on produce
	Fresh produce flexible packaging
	Other food flexible packaging
	Catering and other food services
Food waste	Household
	Commercial

The model includes all waste commonly within the scope of an EPR scheme for packaging, that is, municipal packaging waste. The model scope is based on the common definition of municipal waste, as used by Defra, and within the EU, that is, "*waste from households, plus waste from other sources, such as commercial waste, which is similar in composition to household waste*".[41] For the purposes of modelling, the scope is defined as household and (commercial) hospitality waste (the 'household-like' component of packaging waste).

A.1.2 Baselines

Modelling was conducted for the latest year of data (2019 and 2021), with future projections for 2030. By 2030 most policies included in the modelling will have taken full effect.

Two baselines were developed for the model – low and high. These model, respectively, the low/high potential capture of dry recycling and food waste under the range of implemented and propose policies.

[41] DEFRA (2022) *Resource Efficiency and Waste Reduction Targets, April 2022,* https://consult.defra.gov.uk/natural-environment-policy/consultation-on-environmental-targets/supporting_documents/Resource%20efficiency%20and%20waste%20reduction%20targets%20%20Detailed%20evidence%20report.pdf

A.2.0 Plastic Packaging / Non-Packaging

Baseline assumptions for conventional packaging and non-packaging placed on the market, and capture rates in waste collections are outlined in this section.

A.2.1 Placed on Market

Placed on market (PoM) data for packaging waste is based on the most comprehensive source of packaging data available – Packflow Refresh 2023 reports by Valpak.[42] The most recent data, from 2022, was used for the baseline for all material types (see Table A-2).

For both baselines, assumptions for tonnages in 2030 are set to match the 2022 data. It is extremely difficult to predict future PoM tonnages, especially given the current, more volatile and unpredictable economic climate where past trends provide a less reliable indication of what may occur in the future.

The continued global economic challenges, particularly the impact of high inflation and rising interest rates, have broadly dampened consumption. The trajectory of the UK economy going forward is unclear, whether the UK economy will enter a recession, an extended period of stagnated economic growth, or something else is not yet known. Therefore, compared to the 2022 levels, we anticipate a wide range of potential outcomes for PoM tonnages by 2030 and thus have kept tonnages unchanged.

Table A-2: Packaging Waste Placed on the Market (2022), Thousand Tonnes

	Consumer Packaging	**Household-like Non-consumer Packaging (back of store and hospitality)**	**Total**
Plastic (overall)	1,270	209	1,479
PET bottles (beverage)	263	57	320
PET bottles (non-beverage)	75	4	79
HDPE bottles	148	26	174
Pots, tubs and trays (PET/PP/other)	448	71	519
Mono PE / PP flexibles	175	32	207
Other flexibles	161	19	180
Wood	11	1,374	1,385
Aluminium	162	40	202
Steel	246	34	280
Paper	485	23	508
Card	1,162	1,276	2,438
Glass	2,050	512	2,562

[42] Valpak, PackFlow Refresh 2023: A review of the quantity of packaging placed on the market and recycled in 2022 with compliance projections to 2028, July 2024, available at: https://www.wrap.ngo/resources/report/packflow-refresh-2023-reports#download-file. This set of reports includes reports on aluminium, steel, glass, paper and card, plastic, and wood.

A.2.2 Capture Rates

Modelled capture rates for packaging materials in the dry recycling stream are set out below. Further assumptions regarding contamination of organics collections with conventional packaging materials are detailed separately in Section A.6.0.

A.2.2.1 Current Capture Rates

Capture rates, that is the % of waste collected in a dry recycling collection, for the baseline in 2019 are based on various data sources and assumptions.

For plastic packaging, assumptions were based on data within the RECOUP UK Household Plastic Packaging Collection Survey 2021[43], supplemented with Eunomia internal assumptions for the performance of typical UK collection systems. Final capture rates were compiled based on data for average capture rates for dry recycling collection, and the collection coverage by local authorities

For other packaging materials, capture rates are based on the Packflow Phase I reports by Valpak (see Section A.2.1).

In general terms, the measurement method commonly used in the UK for the calculation recycling rates includes the following features:

- Dry weight of materials placed on market are compared with the (wet, including moisture) weight of material presented as waste;
- Does not fully account for losses incurred during the recycling process (commonly accounts for sorting losses, but excludes losses at reprocessors);
- Tends to overstate recycling rates, particularly when it comes to export.

There are intentions stated by DEFRA to alter the current method used in the UK to calculate recycling rates to order to align with the EU methodology.[44] However, there is no defined date for any such change, and furthermore, the targets for recycling as defined in the EPR consultation (see Table A-4) do not appear to be consistent with a potential update in measurement methodology, as, most notably for plastics, they are more ambitious than similar EU targets. For the purposes of this modelling, we have therefore not assumed any change in the UK measurement methodology in the future.

Current modelled final recycling rates for plastic packaging incorporate an estimate of sorting losses, but not reprocessing losses. This approach is expected to provide outputs that are generally consistent with the current measurement method for recycling packaging waste, taking into consideration the limitations of the methodology stated above. For other (non-plastic) materials, final recycling is based on collected tonnages (sorting losses are lower in general for these materials, and an analysis of sorting losses for these materials is deemed not necessary for this analysis, as the focus is largely on plastic packaging).

Final modelling assumptions for capture rates / recycling rates for packaging in the UK are detailed in Table A-3.

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[43] Recoup (2021) *UK Household Plastic Packaging Collection Survey, 2021*

[44] Defra (2021) *Extended Producer Responsibility for Packaging*, March 2021, https://consult.defra.gov.uk/extended-producer-responsibility/extended-producer-responsibility-for-packaging/supporting_documents/23.03.21%20EPR%20Consultation.pdf

Table A-3: Capture Rate and Recycling Rate Assumptions for 2019

	Capture Rate, %	Collection Coverage by LAs, %[1]	Modelled Capture (Collection) Rate, %	Estimated Losses (Sorting Only)	Modelled Recycling Rate, %
Plastics (overall)	–	–	–	–	35%
PET bottles (beverage)	75%	100%	75%	8%	69%
PET bottles (non-beverage)	45%	100%	45%	8%	42%
HDPE bottles	57%	100%	57%	8%	53%
Pots Tubs and Trays	43%	87%	37%	15%	32%
Mono PE / PP flexibles	40%	13%	5%	55%	2%
Other flexibles	5%	13%	0.7%	100%	0%
Wood	–	–	22%	–	22%
Aluminium	–	–	45%	–	45%
Steel	–	–	80%	–	80%
Paper	–	–	64%	–	64%
Card	–	–	84%	–	84%
Glass	–	–	61%	–	61%

Notes: includes consideration of uptake of commercial waste recycling collections by businesses, and other forms of recycling collection (e.g. current plastic film collections by retailers / businesses)

A.2.2.2 Future Projections

Future projections for the high baseline assume that 'modelled' (target) UK packaging waste recycling rates detailed by DEFRA, within the consultation documents for the Extended Producer Responsibility for Packaging [scheme], will be achieved. [45]

These target rates include the combined impacts of:

- Proposed recycling targets (as set out within the consultation) for packaging within the scope of Extended Producer Responsibility (EPR) in England;
- The introduction of a (UK-wide) DRS for beverage containers; and
- Rollout of policies relating to Consistency in Household and Business Recycling in England (particularly mandatory plastic film collections).

The target rates provide a sensible 'high' estimate for capture rates across packaging materials. It is, yet, unclear whether EPR will include commercial waste in scope. For the purposes of modelling, we have assumed that it is included in scope of the targets provided in the consultation.

The low baseline considers the technical, economical, and behavioural barriers to policies having the impact on capture rates intended by policy. For example, we assume that only around half of the population will have access to a separate plastic film collection in 2030 under the low baseline. This could be due to issues with, for example, local authorities that are locked into existing waste collection

[45] DEFRA (2021)

contracts which extend beyond 2030, or lack of access to capital funding for setting up these collections.

The target recycling rates, as set out in the consultation, are shown in Table A-4, which also presents our modelling assumptions for the 'low' and 'high' baseline.

Table A-4: Recycling Rates for UK Packaging Waste in 2030

	Target Rates from EPR Consultation	Modelled	
		Low Baseline	**High Baseline**
Plastic[46]	62%	47%	62%
PET bottles (beverage)[47]	–	93%	98%
PET bottles (non-beverage)	–	57%	77%
HDPE bottles	–	65%	77%
Pots, tubs and trays (PET/PP/other)	–	41%	66%
Mono PE / PP flexibles	–	16%	30%
Other flexibles	–	0%	0%
Wood	39%	31%	39%
Aluminium	69%	57%	69%
Steel	92%	86%	92%
Paper/card	86%	75%	86%
Glass	93%	77%	93%

[46] For plastics, we assign capture rates to each material stream based on the likely contribution to the overall 62% target.

[47] Assumes 85% of beverage containers in a DRS, as set out in Defra's impact assessment, with collection of the remaining 15% through existing municipal collection services.

A.3.0 Compostables

Baseline assumptions for compostables placed on the market, and capture rates in waste collections are outlined in this section.

A.3.1 Compostable Applications and Market Size

The applications for compostable plastic packaging including in the modelling are shown in Table A-5.

Table A-5: Compostable Plastic Applications

Application Types	Definition
Carrier bags	Lightweight carrier bags (<50 microns), provided at the till, intended for single-use to carry home purchased goods Very lightweight carrier bags (<15 microns), intended for single-use to provide primary packaging for loose food (e.g. fruit / vegetables) for hygiene purposes or to prevent food waste)
Caddy liners	Specialised bags designed to line small kitchen compost caddies or bins used in food waste collection
Tea and coffee bags	Single-serving tea or coffee bags, which in practice are disposed of together with the product
Coffee pods	Single-serving packaging for specific coffee machines, which in practice are disposed of together with the product
Sticky labels on produce	Labelling attached to fruit and vegetables
Fresh produce flexible packaging	Flexible packaging used for pre-packed fresh produce (e.g., fruits and vegetables) Includes bags used to pack pre-prepared vegetables such as salads
Other food flexible packaging	Flexible packaging used for pre-packed food that is not fresh produce (e.g., savoury food, confectionery, baked goods, dry food, sachets for condiments) Included within scope – coverings for perishable goods such as meats and cheeses
Catering and other food services	Cups and lids for hot and cold beverages Hot and cold food containers Plates, bowls, trays Cutlery, straws

Estimates for the current market size for each application, that is, the total market size for all packaging materials used in this application are provided in Table A-6. Note that, apart from caddy liners (see note in table), as discussed in Section A.2.1, the market size is assumed to remain unchanged in 2030.

The market share currently captured by compostables, based on the most recent available date, are also provided. Please note that, in general, the data quality is poor, and these assumptions should be viewed as estimates.

Table A-6: Total Market Size and Current Penetration of Compostables, Thousand Tonnes

	Packaging / non – packaging	Total packaging placed on the market (all materials), thousand tonnes	Of which compostables based on most recent estimates, thousand tonnes3
Carrier bags	Packaging	31	3.0
Caddy liners	Packaging	5.5 – 11[2]	3.9[4]
Tea and coffee bags	Non – packaging[1]	12	4.0
Coffee pods	Non – packaging[1]	3.0	0.2
Sticky labels on produce	Non – packaging[1]	0.7	0.1
Fresh produce flexible packaging	Packaging	46	2.0
Other food flexible packaging	Packaging	203	–
Catering and other food services	Packaging	200	16
Total		**507**	**29**

Note:
[1] Non-packaging conventional plastic is included in the baseline modelling, to enable analysis of switching from conventional to compostable plastic.
[2] Estimate for 2030, based on low/high projections for food waste tonnages.
[3] Based on TIPA's data received from BBIA, unless noted.
[4] Estimate for 2018, based on food waste tonnages.

A.3.2 Methodology for Market Size Potential Estimates

The methodology used to estimate the potential total market size for each application (see Table A-6) is described below.

A.3.2.1 Carrier Bags

In the UK, the definition of single-use plastic carrier bags varies across the constituent nations, but they generally align with the scope outlined in the 2015/720 EU Directive on lightweight plastic carrier bags (LPCB). The data, presented in Table A-7, is based on the number of carrier bags (LPCBs, which are bags with a wall thickness of 50 microns or more) sold by large retailers. However, this data does not include very lightweight plastic carrier bags (VLPCBs), which are defined as bags with a wall thickness of less than 15 microns and are exempt from charges. Reported data from England and Scotland is significantly lower than the average number of bags per person, falling between 15 to 50 microns), which is reported as 30 bags per person by 16 EU nations for 2020. Hence, for the purpose of this study, we assumed that an average of 30 bags per person is being used across the UK. By calculating with the assumption that each bag weighs 7 grams[48], the total weight of carrier bags (wall thickness ranging between 15 and 50 microns) in the UK Is estimated to be **14k tonne.**

Table A-7: Lightweight Plastic Carrier Bags in the UK

	Population in 2021[49]	Reported number of bags (million)	Reported bags per person	Assumed bags per person	Calculated number of bags (million)	Total tonnage (ktonnes)
England	56,536,419	49650	8.8	30	1696	
Scotland	5,479,900	5051	9.1		164	
Wales	3,105,410	9452	30.0		94	
Northern Ireland	1,904,563	5153	26.8		57	
Total	**67,026,292**	**691**			**2011**	**14**

Accounting for the VLPCBs in the UK, we used the average of 84 bags per person (less than 15 microns)[54] voluntarily reported by 16 EU nations for 2020. By calculating with the assumption that each bag weighs 3 grams[55], the total weight of VLPCBs (i.e., bags with a wall thickness of less than 15 microns) in the UK is estimated to be **17k tonnes**.

A.3.2.2 Caddy Liners

The estimation of caddy liners was derived from 2030 projections for separately collected household and commercial food waste tonnages (see Section A.4.0), assuming that 80% of the food waste is collected using caddy liners. For this estimation, it was assumed that each caddy liner can accommodate approximately 2.15 kg of food waste and weighs 5.32 grams.[56] As a result, the total weight of caddy liners used is estimated to be **5.5 to 11.1 thousand tonnes**, under the low and high baseline respectively.

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[48] Based on internal measurements at Eunomia - weighing sample bags.

[49] Estimates of the population for the UK, England, Wales, Scotland and Northern Ireland - Office for National Statistics (ons.gov.uk)

[50] Statistics for 2022, single-use plastic carrier bags purchased at check out Single-use plastic carrier bags charge: data for England 2021 to 2022 - GOV.UK (www.gov.uk) Note, very lightweight bags are not included

[51] Based on the assumption that in 2019 Scottish Retail Consortium reported that around £2.5 million had been raised for good causes from the sale of single-use carrier bags when the price was set to 5 p.

[52] Statistics for 2018, any single-use carrier bag The Sale and Use of Carrier Bags in Wales: summary (gov.wales)

[53] Statistics for 2021, any single-use carrier bag NI Carrier Bag Levy Annual Statistics (daera-ni.gov.uk)

[54] Statistics | Eurostat (europa.eu)

[55] Based on internal measurements at Eunomia - weighing sample bags.

[56] Vegware - COMPOSTABLE BIN BAGS

A.3.2.3 Tea and Coffee Bags

Based on a consumer survey conducted in 2020, it was estimated that approximately 61 billion tea bags are consumed annually in the UK.[57] Assuming that a tea bag weighs approximately 0.2 grams[58], the total tonnage of tea bags annually is **12k tonnes**.

A.3.2.4 Coffee Pods

Based on a 2018 report, coffee capsules make up 17% of the UK coffee market, estimating 1 billion coffee capsules consumed in the UK[59]. Assuming that an average coffee pod weighs approximately 3 grams[60] per pod, the total tonnage of coffee pods annually is **3k tonnes.**

A.3.2.5 Sticky Labels on Produce

Based on a previous interview conducted by Eunomia with a trade association (confidential) regarding the usage of sticky labels in the EU, it was estimated that 15 billion sticky labels are being used within the EU-27. Extrapolating this data for the UK, it was projected that approximately 2.3 billion stickers are used annually. Assuming an average weight of 0.3 grams per sticker, the total tonnage of sticky labels used annually across the UK is approximately **0.7k tonnes.**

A.3.2.6 Fresh Produce Flexible Packaging

Fresh produce flexible packaging market size is based on triangulation of various data sources, including flexible plastic packaging market data provided by TIPA, grocery / non grocery data from WRAP Refresh 2023 reports and data from CEFLEX. Based on this analysis, we assume that the total tonnage of flexible packaging on fresh produce is approximately **46 k tonnes**.

A.3.2.7 Other Food Flexible Packaging

Estimates are made for flexible packaging used for other food products, including meat, fish and poultry, savoury snacks, confectionery, baked goods, dried food, cheese and dairy and other food category. These are based on similar data and methods as described above for fresh produce packaging. Annual consumption is estimated at **203k tonnes** annually in the UK.

A.3.2.8 Catering and Other Food Services

The figure of **200 k tonnes** of packaging for catering and other food services was provided by TIPA, with the original estimate made by Vegware. It is important to note, that there is some ambiguity regarding what exactly was included in this category.

[57] Thirst For Better Tasting & Sustainable Tea Drives Change In Tea Habits | JING Tea

[58] Tea bag material - THIE - Tea and Herbal Infusions Europe (thie-online.eu)

[59] Aluminium Coffee Pods & The Impact On The Environment – Halo Coffee

[60] ▷ How Many Grams Are In A Coffee Capsule? ☕ | The Guide 2023 (coffeemaker.top) Dolce Guste 3 g, Nespresso 0.9 g and Tassimo 4.7 g

A.3.3 Capture Rates

Modelled capture rates for compostables in separate food waste collections (i.e. the proportion of compostables placed on the market, that go into compostable collections) are detailed in Table A-8. These should be considered 'best-guess' estimates, as data on which to base these assumptions is mostly not available. Capture rates for 2030 are modified based on our best interpretation of the likely outcomes of Simpler Recycling and EPR regulation proposals (see main report for more information).

Table A-8: Capture Rate Estimates for Compostables in Food Waste Collections, %

Application		Capture Rate
	Now	
Carrier bags	80%	
Caddy liners	95%	
Tea and coffee bags	50%	
Coffee pods	50%	
Sticky labels on produce		90%
Fresh produce flexible packaging		5%
Other food flexible packaging		5%
Catering and other food services	20%	

These assumptions are converted to baseline capture rates for the UK based on the current, and future projected coverage of food waste collections (see Appendix A.4.1). These are outlined in Table A-9. Note that in Scenario 2 consumers are advised to dispose of flexible packaging in the dry recycling stream, so these rates reduce in this scenario (see Appendix A.8.3).

Table A-9: Modelled Capture Rates for Compostables in Food Waste Collections, %

Application	Current	Low (2030)	High (2030)
Carrier bags	40%	53%	80%
Caddy liners	48%	64%	95%
Tea and coffee bags	25%	33%	50%
Coffee pods	25%	33%	5%
Sticky labels on produce	45%	60%	90%
Fresh produce flexible packaging	3%	3%	5%
Other food flexible packaging	3%	3%	5%
Catering and other food services	10%	13%	20%

Modelling assumptions for the current proportion of compostables placed on the market that are collected in the dry recycling stream (as contamination), are detailed in Table A-10. These are estimates.

Table A-10: Modelled Contamination of Compostables in Dry Recycling Collections in Baseline, % of Compostables Placed on Market

Application	Capture Rate
Carrier bags	5%
Caddy liners	1%
Tea and coffee bags	1%
Coffee pods	4%
Sticky labels on produce	1%
Fresh produce flexible packaging	5%
Other food flexible packaging	5%
Catering and other food services	12%

A.4.0 Food Waste

This section describes our approach to modelling a baseline for food waste in the UK, for the baseline year (2021) and projections to 2030.

A.4.1 Household

A.4.1.1 Arisings in 2021

Organic wastes (food[61], garden and other compostables[62]) are by far the largest categories in the UK household waste system, accounting for over a third of collected wastes including residual and recycling across all streams. The food waste arising baseline calculation is based on the latest waste collection data (2021)[63] and national waste compositional analyses (WCAs) (2017)[64]. Both waste collection data and the WCAs for each nation were processed separately.

According to WRAP's report[65], food waste is being captured in the following household waste streams:

- Kerbside residual;
- Kerbside collections targeting food waste (separate food waste and mixed garden and food waste);

[61] Including avoidable food waste, unavoidable food waste and consumable liquids, fats and oils.

[62] Pet excrement and bedding and other organic.

[63] For England, Wales and Northern Ireland https://www.wastedataflow.org/ and for Scotland https://www.sepa.org.uk/environment/waste/waste-data/waste-data-reporting/household-waste-data/ waste generation tonnages were adjusted for recycling rejects

[64] https://wrap.org.uk/sites/default/files/2021-10/WRAP-national-household-waste-comparison-2017.pdf

[65] WRAP (2020) *Synthesis of Household Food Waste Compositional Data 2018*, 2020, https://wrap.org.uk/sites/default/files/2020-11/WRAP-Synthesis_of_Household_Food_Waste_Compositional_Data_2018_0.pdf

- Household Waste Recycling Centre (HWRC); and
- Street sweeping, cleansing and litter.[66]

The tonnage of food waste in the residual waste streams (separately for kerbside and HWRC) was determined by taking the average percentage of the residual waste that is food from each of the national WCAs (see Table A-11) and multiplied by the total amount of residual waste collected (WDF data). The total tonnes in each nation were then summed to produce the national figure. Due to lack of recent waste compositional data for street sweeping, food waste from street cleaning, cleansing and litter was not considered.

Table A-11: Percentage of Food Waste in the Residual Waste Stream, Based on WRAP Report (2017)

	Kerbside				HWRC			
	ENG	WAL	NI	SCO	ENG	WAL	NI	SCO
Food waste	34.7%	24.7%	24.0%	27.9%	7.3%	11.8%	7.3%	7.3%
Garden waste	3.1%	2.7%	1.3%	5.7%	3.3%	2.1%	3.3%	3.3%
Other organic	4.4%	5.1%	2.8%	7.8%	1.6%	1.0%	1.6%	1.6%

The tonnage of food waste in the targeted food waste collection was determined based on data reported to WDF as organic material- waste food only. The tonnages of the organic material stream are reported by LAs quarterly, except for Scotland where tonnages are reported annually. No adjustment for contamination has been made.

A.4.1.2 Captures in 2021

Based on the proportion of authorities with food waste collections, the percentage of households currently having food waste collection is estimated at 31% for England, 100% for Wales, 80% for Scotland[67] and 37% for Northern Ireland. It is understood that within these proportions of households served that there is a proportion of non-participating or lower capture households (such as flats and rural households) and therefore the capture per average housed already reflects these nuisances within the service provision.

Currently, authorities with a household food waste collection service capture on average approximately 68 kg per household per year in England, 49 kg per household per year in Scotland, 107 kg per household per year in Wales and 24 kg per household per year in Northern Ireland.

A.4.1.3 Projection 2030

For the projection to 2030, assumptions were made that the food waste arisings will linearly increase with the increase of the total number of households. The projected number of households is derived from the

[66] WRAP 2012 Synthesis of Food Waste Compositional Data made a separate estimate of food waste arising in street sweepings (91,000 tonnes in the UK in 2012). Due to lack of recent waste compositional data for street sweeping, food waste from street cleaning, cleansing and litter was not considered and modelled in the study.

[67] https://www.gov.scot/publications/scotlands-people-annual-report-results-2016-scottish-household-survey/pages/10/

national statistical office website; ONS for England[68], the National Records of Scotland for Scotland[69], StatsWales for Wales[70] and the NISRA for Northern Ireland. [71] No food waste prevention from households is modelled.

Under the high scenario we assume that approximately 95% of the UK population have access to separate food waste collections by 2030, while under the low baseline we assume that around 60% are covered. This is an increase from current coverage of approximately 50%.

A.4.1.4 Commercial

A.4.1.4.1 Arisings in 2021

Using WRAPs Courtauld Commitment 2025 food waste baseline for 2015[72] and other various sources, commercial food arisings have been calculated for a series of subsectors (see Table A-12). The calculation was based on business size for the commercial sector and then aggregated to produce an average for each subsector. The total arisings were then estimated using the number of businesses within each sub-sector, using Standard Industrial Code (SIC) codes[73], from 2018 ONS UK Business: Activity, Size and Location data set.[74]

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[68]https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/householdprojectionsforengland

[69] https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/households/household-projections/2016-based-household-projections

[70] https://statswales.gov.wales/Catalogue/Housing/Households/Projections/National/2014-Based/householdprojections-by-householdtype-year

[71] https://www.nisra.gov.uk/publications/northern-ireland-household-projections-2012-based

[72] WRAP (2015) Courtauld 2025 baseline and restated household food waste figures, 2015, https://wrap.org.uk/resources/report/courtauld-2025-baseline-and-restated-household-food-waste-figures

[73] Financial Analysis Made Easy. FAME is a database that contains information for companies in the UK and Ireland. FAME contains information on 2.2 million companies, 2 million of which are in a detailed format. Published by Bureau van Dijk, www.bvdinfo.com/Products/CompanyInformation/National/FAME.aspx

[74] UK business: activity, size and location dataset https://www.ons.gov.uk/businessindustryandtrade/business/activitysizeandlocation/datasets/ukbusinessactivitysizeandlocation

Table A-12: Food Waste Arisings per Commercial Business Type

Commercial Sub-Sectors	No of businesses (UK, 2021)	Current Food Waste Arisings (tonnes per annum)
Arts, entertainment, recreation and other services	68,270	0.96
Caterers / food assembly	16,740	16.46
Education	45,495	2.85
Food wholesalers	16,825	1.29
Health & social care	104,540	1.11
Hotels	9,825	25.79
Licensed clubs & pubs	36,550	16.46
Licensed restaurants	95,060	16.46
Office based	1,070,550	0.05
Other	108,270	0.05
Other holiday accommodation	5,285	25.79
Retail food (supermarkets)	31,710	14.03
Retail food (non-supermarkets)	23,725	1.94

A.4.1.4.2 Captures in 2021

The volume of food waste which is currently available for AD treatment within each subsector has been estimated using two factors:

- The estimated percentage of material currently treated separately as food waste; and
- The estimated percentage, of separately captured material which is being treated by means other than AD (for example land spreading, or small on-site treatment facilities).

A.4.1.4.3 Projections to 2030

Growth across all subsectors (prior to prevention) is pro rata using the current GDP forecast of 1.0% for 2022 and 2.3% from 2023 to 2035 based on the long-term trend from the Office of Budget Responsibility from 1960 to the present day.[75]

Commercial capture rates are calculated by revising the percentage of material that is expected to be captured from each subsector to reflect an improve capture, with high and low assumptions applied for each baseline.

A.4.1.5 Modelling Assumptions

Based on the methodology described above, modelling assumptions are detailed in Table A-13

[75] https://obr.uk/efo/economic-and-fiscal-outlook-march-2021/

Table A-13: Modelling Assumptions for UK Food Waste

	2021	2030 Low	2030 High
Food waste arisings (household), thousand tonnes	6,288	6,588	6,588
Food waste arisings (commercial), thousand tonnes	3,714	4,500	4,500
Food waste arisings (total), thousand tonnes	10,002	11,088	11,088
Overall capture rate - food waste in separate collections (household), %	12.1%	13.3%	28.5%
Overall capture rate - food waste in separate collections (commercial), %	32.0%	29.9%	58.4%

A.6.0 Contamination

A.6.1 Contamination of Food Waste Collections

Modelling assumptions are made for the proportion of food waste composed of (non-food waste) contaminants. Our assumptions are based on the Italian scheme, and published data from Scotland.[76,77] Data from these sources are mapped to the application types in our model, with additional estimates applied as appropriate. The assumptions used for modelling are detailed in Table A-14.

Table A-14: % of Total Food Waste Composition

Application	Household Food Waste	Commercial Food Waste
Plastic		
PET bottles (beverage)[1]	0.01%	0.04%
PET bottles (non-beverage)	0.01%	0.04%
HDPE bottles	0.01%	0.04%
Pots, tubs and trays (PET/PP/other)	0.16%	0.56%
Mono PE / PP flexibles	1.0%	0.5%
Other flexibles	0.16%	0.56%
Wood	–	–
Aluminium	–	–
Steel	–	–
Paper	0.14%	0.35%
Card	0.14%	0.35%
Glass	–	–

Notes:
[1] Assumptions for contamination/capture of compostables in food waste collections are calculated separately and detailed in Section A.3.3.

A.6.2 Food Waste Contamination in Packaging

Assumptions for the quantity of food left as contamination in packaging materials are detailed in Table A-15. These set out the average proportion by weight of collected packaging which is food waste.

[76] Personal Communication, CIC March 2021, see https://op.europa.eu/en/publication-detail/-/publication/24bda39e-a0a1-11ed-b508-01aa75ed71a1

[77] Scottish Environment Protection Agency (2019) *Plastic in food waste at compost sites*, https://bbia.org.uk/wp-content/uploads/2019/11/plastic-in-compost-SEPA-report-2019.pdf

Table A-15: Assumptions for Food Waste Contamination of Packaging

Application	% of Collected Weight Composed of Food Waste
Plastic	
PET bottles (beverage)1	0%
PET bottles (non-beverage)	1%
HDPE bottles	0%
Pots, tubs and trays (PET/PP/other)	6%
Mono PE / PP flexibles	2%
Other flexibles	2%
Wood	0%
Aluminium	1%
Steel	1%
Paper	1%
Card	1%
Glass	1%
Note: this table considers the dry weight of food in collected packaging, excluding moisture.	

Source: Eunomia internal assumptions from collections modelling

A.6.3 Food Waste 'Drag Effect' in Debagging Process

The assumptions shown in Table A-16 set out the 'drag effect' of food waste attached to contaminants (packaging and other) which are removed from collected food waste e.g. at the front end of anaerobic digestion facilities. The assumption sets out the modelled weight of food waste which is dragged with packaging relative to the weight of contaminants. For example, a 'drag effect' number of 2 means that for every tonne of contaminants removed, 2 tonnes of food waste are also 'dragged' with the contamination.

Table A-16: Assumptions for Food Waste Contamination of Packaging – Drag Effect in Debagging Process

Application	% of Collected Weight Composed of Food Waste
Plastic packaging (conventional)	
PET bottles (beverage)1	1.05
PET bottles (non-beverage)	1.05
HDPE bottles	1.05
Pots, tubs and trays (PET/PP/other)	1.05
Mono PE / PP flexibles	2.75
Other flexibles	2.00
Plastic packaging (compostable)	
Carrier bags (LW + VLW)	2.75
Caddy liners	2.75
Tea and coffee bags	1.80
Coffee pods	1.80
Sticky labels on produce	1.00
Fresh produce flexible packaging	2.00
Other food flexible packaging	1.30
Catering and other food services	1.20
Wood	1.05
Aluminium	1.05
Steel	1.05
Paper	1.05
Card	1.05
Glass	1.05
Non-packaging	
Sticky labels on produce (conv.)	1.00
Tea and coffee bags (conv.)	1.80
Coffee pods (conv.)	1.80

Source: Eunomia internal assumptions from organics treatment modelling

A.7.0 Treatment Assumptions

A.7.1 Biowaste Treatment

Baseline treatment assumptions for the proportion of food waste treated in wet / dry anaerobic digestion (AD) and in-vessel composting (IVC), are detailed in Table A-17.

Table A-17: Food Waste Treatment Destinations, %

	Wet AD	Dry AD	IVC
Current	86%	2%	12%
2030 low	87%	3%	10%
2030 high	91%	3%	6%

Assumptions for the current treatment destination split are based on estimates derived from municipal waste data reported to WasteDataFlow.[78] The methodology used considered the proportion of waste collected separately vs co-collection in garden waste was considered, and the most likely destinations for these waste streams (i.e., AD for the former, IVC for the latter).

Projections for 2030 take into account the increase in separate food waste collections under current proposed policy measures, and therefore the decrease in food waste co-collected with garden waste. Such a change will lead to a switch in food waste treatment from IVC to AD, although it is likely that some food waste will continue to be sent to IVC, as the proposals include some potential exemptions (the details are not yet clear) for authorities to co-collect food and garden waste.

The dry AD industry handles a very small proportion of UK collected food waste tonnage at present. We model a small increase in dry AD capacity in our projections.

A.7.2 Wet Anaerobic Digestion

For the purposes of modelling, we assume the following assumptions for wet AD facilities:

- 95% of contamination is removed in the debagging phase prior to digestion. Contamination here refers to all non-food waste materials (conventional and compostable packaging and other waste). The exception to this is small-formats (tea and coffee bags, coffee pods and sticky labels), for which it is assumed only 20% are removed, and most of these products go into the digestor.
- Removed contaminants are sent to incineration for disposal.
- All (remaining) material going to the digestor i.e., food waste with a low-level of remaining contaminants, undergoes degradation (whether in the digestor, or subsequent composting phases).

A.7.3 Aerobic Composting

Table A-18 gives the degradation rates assumed for the composting process at IVC facilities:

[78] WasteDataFlow (2023) https://www.wastedataflow.org/

Table A-18: Assumption for Material Degradation in IVC

Material	% of Material Degradation in Composting Process
Non-compostables (all materials except for paper/card)	0%
Paper / Card	85%
Food Waste	100%
Compostables	–
Carrier bags	95%
Caddy liners	95%
Tea and coffee bags	95%
Coffee pods	75%
Sticky labels on produce	95%
Fresh produce flexible packaging	95%
Other food flexible packaging	95%
Catering and other food services	85%

It is assumed that 90% of remaining contaminants (i.e., material which has not degraded) are screened out after the composting process.

A.7.4 Residual Disposal

Assumptions for residual treatment destinations are based on UK-wide data from WasteDataFlow for 21/22 and are given in Table A-19.

Table A-19: Residual Treatment Destinations, %

Treatment Type	% of Waste
MBT	28%
Incineration	61%
Landfill	12%

A.8.0 Scenario Parameters

This section sets out the parameters used for modelling of the two scenarios. Market penetration assumptions are discussed in Section 3.2.

A.8.1 Contamination in Food Waste Collections

A reduction in contamination of food waste with conventional plastic packaging is assumed in both scenarios.

In Scenario 1, as conventional plastic bags are banned this will result in much lower contamination of food waste with conventional plastic films. A 75% reduction in contamination of food waste with all flexible plastic packaging is modelled.[79]

Scenario 2 also has this ban, and additionally, as consumers are advised to dispose of flexible compostable packaging (excl. small formats) with other dry recycling, this will enable lower contamination of food waste with conventional plastic packaging. In this scenario, an 85% reduction in contamination of food waste with all flexible plastic packaging is modelled.

A.8.2 Destination of Rejects from Anaerobic Digestion

Within both scenarios, as noted, the impact of the ban is to reduce contamination of food waste significantly. Due to the lower contamination, it is assumed that IVCs (on/off site) would then be more willing to receive the reject stream from wet AD plant pre-sorting processes - the risks associated with screening at the end of the process are reduced, resulting in a removal of some of the current restrictions by the Environment Agency on this. Therefore, in both scenarios, the destination of all material separated from food waste in the debagging process (at the front end of wet AD facilities) is sent to composting (IVC) facilities, rather than to residual treatment, as is the baseline assumption.

A.8.3 Collection in Dry Recycling Stream

For Scenario 2, it is assumed that consumers are advised to dispose of flexible fresh produce packaging made from compostable polymers in the dry recycling stream, i.e. with other (conventional) plastics used for similar applications. Other compostables (small formats such as tea and coffee bags, and carrier bags used as caddy liners) are still recommended to be put in the food waste bin.

FlexCollect have trialled collection of flexible plastic film in a separate brightly coloured bag; however, this is unlikely to be rolled out to households (according to FlexCollect in discussions). In line with the Simpler Recycling reforms, what is likely to be rolled out is co-collection of films with rigid plastics, or with other dry recyclable streams also, depending on whether councils operate fully comingled or dual/tri stream collection schemes. Similar capture rates as those modelled for conventional flexible plastics collected in the dry recycling stream are assumed for compostable plastics.

Co-collection in the dry recycling stream will require sorting at primary MRFs to separate plastic films from other materials, with the complexity of this sorting operation being dependent on how many material types are co-collected with plastic films. For example, the inclusion of other 2D materials, such as paper/card, will make this sort more difficult / expensive and reduce yields. In reality, it may be cheaper to separate fibres (paper/card) from containers (including film) at the point of collection (i.e., in twin stream collections), rather than collecting them together and paying for more complicated automated sorting. The cost of this is excluded from scope in this modelling, as this is likely to occur regardless of compostables market share (driven by the need to sort conventional films).

Discussion with FlexCollect has confirmed that a second step will be required to separate the plastic film fraction into polymers, including compostable polymers. It is expected that the necessary investment for this equipment will occur at a PRF, and this will require additional NIR sorting equipment. NIR sorters are for one polymer type only – they positively sort and target one polymer type. Therefore, NIR sorters that

[79] Based on data on the general range of reduction in contamination of food waste in countries with a similar scope of ban in place (e.g. Italy)

target compostable polymers specifically will be required to sort for compostables. It is this investment that we have modelled in this project (see Section A.9.4).

Following sorting, compostables are assumed to be sent to IVCs for composting, while conventional plastic films are sent for recycling, where further losses are incurred at re-processors. Furthermore, under the low baseline it is assumed that there is only sufficient capacity for half of the sorted conventional flexible films (see Section 3.2.1).

Assumptions for each of these stages are detailed in Table A-20, Table A-21 and Table A-22 below. The sources for this information are as follows:

- **Collection rates:** Estimated collection rates under low/high baseline, see Appendix A.2.2.2
- **Primary sorting at MRF efficiency:** Based on confidential industry data and discussions with stakeholders with information from MRF operators – at the higher end of 'typical' rates from well-optimised MRFs.
- **Secondary sorting at PRF efficiency:** Eunomia expert assumption based on operational experience of typical sorting efficiencies for food-contaminated mixed plastic film (e.g. DPD-23 plastic film grade).
- **Reprocessor capacity:** Assumption for modelled baselines, see Section 3.2.1
- **Reprocessor losses:** Eunomia expert assumption based on average loss rates reported by a number of plastic reprocessors

Table A-20: Model Assumptions for Conventional (Mono PE / PP) Consumer Flexible Film Capture Rates

	Low Baseline	High Baseline
Collection Rate	35%	65%
Primary sorting efficiency at MRF (into flexible film fraction)	65%	65%
Secondary sorting efficiency at PRF (into separate polymers)	70%	70%
Proportion for which there is reprocessor capacity	50%	100%
Proportion of input to reprocessor that is recycled (after losses)	86%	86%
Total % of PoM recycled	**7%**	**25%**
Total % of PoM sent to residual disposal	93%	77%

Table A-21: Model Assumptions for Conventional (Multi-layer / Hard to Recycle) Consumer Flexible Film Capture Rates

	Low Baseline	High Baseline
Collection Rate	2%	5%
Primary sorting efficiency at MRF (into flexible film fraction)	65%	65%
Secondary sorting efficiency at PRF (into separate polymers)	0%	0%
Proportion for which there is reprocessor capacity	0%	0%
Proportion of input to reprocessor that is recycled (after losses)	0%	0%
Total % of PoM recycled	**0%**	**0%**
Total % of PoM sent to residual disposal	100%	100%

Table A-22: Model Assumptions for Compostable Consumer Flexible Film Capture Rates

	Low Baseline	High Baseline
Collection Rate	35%	65%
Primary sorting efficiency at MRF (into flexible film fraction)	65%	65%
Secondary sorting efficiency at PRF (into separate polymers)	70%	70%
Proportion for which there is IVC capacity	100%	100%
Proportion of input to IVC that is composted (after screening)	95%	95%
Total % of PoM composted	**15%**	**28%**
Total % of PoM sent to residual disposal	85%	74%

A.8.4 'Closed-Loop' Hospitality Collections

In both scenarios 1 and 2, it is modelled that all additional 'catering and food services' packaging placed on the market is consumed in a hospitality environment, with 75% of packaging collected in a 'closed-loop' compostable packaging only collection. These are assumed to occur in various locations, including hospitality venues, some workplace canteens, festivals etc, with the remainder going to residual waste treatment. Compostable packaging is separated at source in its own specific bin at these commercial locations. These collections are modelled to go directly to IVC facilities, for mixing with other compostable streams (e.g. food and garden waste) for composting.

It is assumed that only 10% of existing conventional 'catering and food services' packaging are collected for recycling, as this application are commonly highly food-contaminated, and many collections in these environments are of mixed (residual) waste only. Sorting/reprocessing losses as detailed in Table A-3 are then incurred. The composition of conventional packaging is assumed to be 70% plastic (pots, tubs and trays), and 30% card (including composite card-based packaging).

A.9.0 Financial Modelling and Unit Impacts

Unit cost assumptions for each of the cost components modelled are described in the section below.

A.9.1 Biowaste Gate Fees

Biowaste treatment costs for the baseline are based on mean values from the WRAP Gate Fees report 2022-23.[80] Treatment costs for the scenarios for AD facilities are adjusted assuming savings from switching the destination of rejects from residual disposal to IVC are passed on as reduced gate fees. IVC costs are increased in the scenarios – the magnitude of increases are rough estimates to account for the higher fees likely to be charged for the input materials specified. Table A-23 gives the biowaste treatment costs used in the modelling.

Table A-23: Biowaste Treatment Costs, £ per Tonne

Biowaste Treatment Type	Gate Fee, £ per Tonne	
	Baseline	Scenarios
AD	£16	£14.40 (10% reduction)
IVC (direct from waste collection)	£63	£63
IVC (sorted compostables from MRFs)	£63	£69 (10% increase)
IVC (rejects from AD plants)	£63	£69 (20% increase)

Within the modelling, these are the costs paid by local authorities (and commercial waste operators) to dispose of biowaste. These costs are determined by the internal costs to biowaste treatment operators, including contamination removal at AD facilities.

A.9.2 Residual Gate Fees

Gate Fees for residual waste are based on the average prices from 2021 to 2023, from Letsrecycle. These are shown in Table A- 24. It is important to note that these are current gate fees; future fees may change for incineration as a result of the inclusion of incinerators within the ETS which may result in an increase in such fees. These impacts are highly uncertain and consideration of them is therefore beyond the scope of the research. (The environmental impact of the inclusion of incinerators in ETS is similarly excluded from scope.)

[80] WRAP (2023) Gate Fees report 2022-23, September 2023, https://wrap.org.uk/resources/report/gate-fees-report-2022-23

Table A- 24: Residual Gate Fees, £ per Tonne

Residual Waste Destination	Gate Fee, £ per Tonne (including tax)
MBT	£103
Incineration	£103
Landfill	£123

A.9.3 Material Revenues

Material revenue assumptions – i.e., the price paid for collected waste sold into the market, after bulking / baling – are detailed in Table A-25. Material prices are volatile, and therefore 'average' prices from 2022/23 have been used for modelling.

Prices for Mono PE / PP flexibles and other flexibles (other polymers and/or multi-layer packaging) are not well known, and end markets are at an early stage of development. Based on discussions with industry, current prices for mono PP can range from £15 per tonne to - £50 per tonne (e.g. a gate fee is paid to offload material). We have therefore conservatively assumed no material revenue (or cost) for this material. Potential future prices for other flexible plastic packaging are not possible to determine, as these are dependent on the development of recycling technologies and markets. Thus, a similar material revenue (£0 per tonne) is assumed.

Table A-25: Material Revenues, £ per Tonne

Material	Material Revenue, £ per tonne
Plastic	-
PET bottles (beverage)	£250
PET bottles (non-beverage)	£250
HDPE bottles	£600
Pots, tubs and trays (PET/PP/other)	£30
Mono PE / PP flexibles	£0
Other flexibles	£0
Wood	£0
Aluminium	£950
Steel	£150
Paper	£150
Card	£90
Glass	£24

Source: Letsrecycle (2023) Prices, Accessed 14th August 2023, https://www.letsrecycle.com/prices/

A.9.4 Costs for Compostable Sorting Equipment

Cost and operational assumptions for the capex / opex of installing sorting equipment for compostables at sorting facilities are given in Table A-26. Based on discussions with industry, it seems likely this sorting equipment would be installed at secondary sorting facilities (e.g. plastics recovery facilities) rather than primary MRFs.

These assumptions are based on NIR sorting machines, installed for the purpose of positively sorting for common compostable polymers from a stream of flexible plastics, either collected separately at the kerbside, or as an output from a primary MRF. Each sorting machine has a throughput of ~ 3.8 thousand tonnes of flexible plastics per annum.

Table A-26: Capex and Opex Cost Assumptions for Sorting Equipment

Material	Cost, £ Thousand
Total purchase cost + setup + installation per machine	185
Other capital costs (bunkers, conveyor belts etc)	300
Operational costs (energy / maintenance) – per annum	18.5
Total combined capex[1] and opex per annum per machine	87.5
Notes: *1. Capex annualised with 7% interest rate, 10-year equipment life*	

Source: Estimates based on confidential industry data for similar sorting technology

Final costs per tonne of sorted compostables vary in the model depending on the proportion of the flexible plastic stream sorted that is compostables – the greater the proportion of this stream that is compostables, the lower the per tonne cost per tonne of sorted compostable plastic output.

A.10.0 Environmental Unit Impacts

A.10.1 Compostable Plastics Assumptions

Key assumptions for the manufacture of compostable plastics are given in Table A-27. These are aggregate assumptions, not related to a specific polymer, given the uncertainties in predicting how markets will develop on this aspect over the coming years.

Table A-27: Assumptions for Compostable Plastics Manufacture

Assumption	Parameter
Carbon content (dry)	53% (36% cellulose, 17% simple sugars)
Biogenic carbon content	100%
Production emissions, kg CO_2 per tonne[81]	1,300

A.10.2 Key assumptions applied to all technologies

A.10.2.1 Approach to Biogenic Carbon

Biogenic carbon emissions are those that originate from organic material like food and garden waste, as opposed to the emissions coming from fossil carbon in oil-derived materials. It is often considered that biogenic carbon emissions need not be incorporated into total emissions, because they are 'short cycle', i.e. "only relatively recently absorbed by growing matter".[82] Note that methane emissions from organic material *are* included because they are considered to be anthropogenic in nature, whereas biogenic CO_2 emissions are in effect viewed as similar to or part of the natural carbon cycle.

This perspective follows the approach taken in developing the national inventories for climate change emissions, which countries submit on an annual basis to the United Nations Framework Convention on Climate Change (UNFCCC). Biogenic CO_2 emissions occurring from, for example, the combustion of wood and other organic items, as well as that arising the organic decay in ecosystems, are excluded from these annual inventories. The carbon incorporated within these items is assumed to have been sequestered from the atmosphere into the plant within the previous years' growth. Inclusion of both impacts is therefore considered to result in a double-counting of impacts. A similar approach has been taken in life-cycle assessments, which consider the global warming potential of systems over a 100-year period.

However, application of the above approach is problematic when accounting for landfill impacts, as a significant proportion of the biogenic carbon is not released as biogenic CO_2 (or as methane) but instead remains sequestered in the landfill; in this way, landfills act as an imperfect 'carbon capture and

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[81] Drawn from a range of sources including: Vink E, Glassner D, Kolstad J, Wooley R and O'Connor R (2007) The eco-profiles for current and near-future NatureWorks polylactide (PLA) production; Vink E and Davies S (2015) Life Cycle Inventory and Impact Assessment Data for 2014 Inego Polylactide Production, *Industrial Biotechnology*, 11(3), pp167-179; Suwanmanee U, Varabuntoonvit V, Chaiwutthinan P, Tajan M, Mungcharoen T and Leejarkpai T (2012) Life cycle assessment of single use thermoform boxes made from polysyrene, PLA and PLA/starch: cradle to consumer gate, *Int J Life Cycle Assess*, DOI 10.1007/s11367-012-0479-7; Madival S, Auras R, Singh S and Narayan R (2009) Assessment of the environmental profile of PLA, PET and PS Clamshell containers using LCA methodology, *Journal of Cleaner Production*, 17, pp1183-1194

[82] DEFRA (2014) *Energy from Waste: A Guide to the Debate, Revised Edition*, February 2014

storage' facility. In contrast, all of the biogenic CO_2 emissions are released from incineration at the point of combustion. As such, the two systems are not being compared on a like-for-like basis where this approach is applied to considering emissions from residual waste treatment systems.

Therefore, this omission of short cycle biogenic carbon emissions is acceptable *as long as a carbon credit is applied for the biogenic carbon which is stored in a landfill*. If no adjustment is made, the exclusion of the biogenic CO_2 emissions will overestimate landfill impacts relative to other forms of treatment in which all the biogenic carbon is released as CO_2 into the atmosphere.

The use of such an approach is recommended by authors from the Technical University of Denmark (who developed the EASEWASTE model), and in Defra's modelling guidance. [83, 84] Despite often being omitted from similar analyses in the literature, a carbon sequestration credit is included in this analysis. A similar approach was used in the peer-reviewed EU Reference Model on Municipal Waste as well as Eunomia's work for the Greater London Authority in developing an Environmental Performance Standard for municipal waste treatment. [85,86]

A.10.2.2 Carbon Dioxide Equivalents of GHGs

A CO_2 equivalent (CO_2e) is a unit of measurement that is used to standardise the climate effects of various greenhouse gases. When reported, all GHGs are reported in CO_2e, the values for which are given in Table A-28. The modelling is undertaken on the basis of impacts taking place over 100 years – this is in line with a 100-year Global Warming Potential, which is a standard approach for life cycle assessments.

Table A-28: Carbon Dioxide Equivalents of GHGs

GHG	Carbon Dioxide Equivalents, (CO_2e)
CO_2	1.00
CH_4	34.00
N_2O	265.00

A.10.2.3 Carbon Intensity of Energy Generation

The assumptions for the carbon intensity of energy generation used in the modelling are given in Table A-29 below.

Marginal electricity carbon intensity is in line with UK Government data used for carbon valuation, which is updated periodically over time. The marginal heat supply is a lot more nuanced, however. Ultimately, it is a judgment call for how much decarbonisation might occur over the time periods modelled. We have

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[83] Christensen, T., Gentil, E., Boldrin, A., Larsen, A., Weidema, B. and Hauschild, M. (2009) C balance, Carbon Dioxide Emissions and Global Warming Potentials in LCA-modelling of Waste Management Systems, Waste Management & Research, 27, pp707-717

[84] Department for Environment Food and Rural Affairs (2014) *Energy recovery for residual waste: A carbon based modelling approach*, accessed 31 March 2020, http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=19019

[85] Eunomia Research & Consulting Ltd., Copenhagen Resource Institute, and Satsuma (2019) *The European reference model on municipal waste*, 2019, https://www.eionet.europa.eu/etcs/etc-wmge/products/final-version-of-waste-model-handbook_april-2019.pdf

[86] Eunomia Research & Consulting (2017) *Greenhouse Gas Emissions Performance Standard for London's Local Authority Collected Waste – 2015/16 Update*, Report for Greater London Authority, January 2017, https://www.london.gov.uk/sites/default/files/gla_eps_report_2015-16_final.pdf

based this emissions factor on natural gas supply with some urban decarbonisation accounted for, such as heat pump roll out.[87]

Table A-29: Carbon Intensity of Energy Sources

Parameter	Assumption
Marginal electricity (kgCO_2e/kWh)	0.12
Marginal heat supply (kgCO_2e/kWh)	0.15

A.10.3 Incineration

A.10.3.1 General approach

Incineration emissions are modelled on the basis of the amount of carbon included within each of the constituent categories of residual waste. Biogenic CO_2 emissions are excluded from the analysis because this is assumed to be short cycle carbon, in line with the methodology set out in Section A.10.2.1.

A.10.3.2 Energy Generation Efficiencies

Energy generation efficiency is a measure of how effectively a power generation system converts the energy stored in its fuel into electrical energy. It is usually expressed as a percentage, indicating the proportion of the total energy input that is converted into usable energy. Data are derived from UK data on expected incineration generation efficiencies published during the planning process (data from multiple plant are included in Eunomia's database of expected efficiencies). Table A-30 gives the energy generation efficiency values used in the modelling.

Table A-30: Energy Generation Efficiencies for Modelled Incineration Options

	Electricity	Heat
Electricity Only Generation	29%	–
Electricity Only Generation with CCS	27%	–
CHP Generation	20%	20%
CHP with CCS	19%	20%

A.10.4 MBT

A relatively small percentage of UK residual waste is treated by MBT systems. The MBT system is modelled on the basis of incineration. This is a simplified approach, based on the following assumptions:

- Relatively little recycling of plastic is assumed to occur, in line with current performance of UK plant in this respect.
- The majority of UK MBT plant send an RDF stream to incineration.

[87] BEIS, Valuation of energy use and greenhouse gas. January 2023. Accessed: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1129243/valuation-of-energy-use-and-greenhouse-gas-emissions-background-documentation.pdf

A.10.5 Landfill Specific Assumptions

The assumptions used in modelling landfill emissions are given in Table A-31 below. These assumptions are, for the most part, in alignment with the UK landfill model used by Defra in its submission to the UNFCCC on methane emissions from landfill, which Eunomia helped update.

Table A-31: Landfill Assumptions

Landfill Assumption	Assumption
Oxidation of methane in landfill gas before release to atmosphere	10%
Landfill gas capture	50%
Proportion of gas used to generate energy	60%
Proportion of gas flared	40%
Engine efficiency	35%

A key difference in the Eunomia model compared to many other LCA models used in the UK is that the Eunomia model includes consideration of the storage of biogenic carbon not emitted as CO_2. A biogenic carbon storage credit is therefore applied to adjust the landfill factors. The approach is described in Section A.10.2.1.

A.10.6 Avoided Emissions Through Recycling

Emissions avoided through recycling conventional plastics have been calculated by subtracting the impact of primary production from the recycling process emissions. Primary production values assume that the material is made from 100% virgin inputs. Table A-32 gives the values for avoided emissions from recycling of conventional plastics used in the modelling.

Table A-32: Avoided Emissions from Recycling Conventional Plastic

	Production	Recycling	Dry Recycling
PET bottles (beverage)	2,295	298	-1,997
PET bottles (non-beverage)	2,295	298	-1,997
HDPE bottles	1,874	210	-1,664
Pots, tubs and trays (PET/PP/other)	1,997	217	-1,780
Mono PE / PP flexibles	1,980	266	-1,714
Other flexibles	1,980	266	-1,714

Sources: Plastics Europe ecoprofiles available from https://www.plasticseurope.org/en/resources/eco-profiles ; Chen Y, Cui Z, Cui X, Liu W, Wang X, Li X and Li S (2019) Life cycle assessment of end-of-life treatments of waste plastics in China, Resources, Conservation and Recycling, 146, pp348-357; Campolina J, Sigrist C, Faulstich de Paiva J, Nunes A and Aparecida da Silva Moris V (2017) A study on the environmental aspects of WEEE plastic recycling in a Brazilian company, Int J Lifecycle Assess, March 2017; Franklin Associates (2011) Cradle-to-gate Life cycle Inventory of Nine Plastic Resins and four Polyurethane Precursors, Report for the Plastics Division of the American Chemistry Council

A.10.7 Composting

Assumptions for composting treatment plant are shown in Table A-33 below. Data are largely derived from work Eunomia has undertaken historically with operators of UK composting facilities, with the exception of the carbon sequestration assumption (Eunomia assumption, in alignment with Carbon Clarity assumptions), and the nutrient benefit from compost, which is taken from the Ecoinvent database.

Table A-33: Assumptions for Composting Treatment Plant

Parameter	Assumption
Emission methane g / tonne input	900
Emission N_2O g / tonne input	59
Electricity use, kWh / tonne	30
Diesel use, litre / tonne	0.3
Carbon sequestration credit, compostable plastic, kg CO_2 / tonne input	55
Nutrient benefit from compost, food waste, kg CO_2e / tonne input	40

A.10.8 Anaerobic Digestion

Assumptions for anaerobic digestion facilities are shown in Table A-34 below. Data are largely derived from work Eunomia has undertaken historically with operators of UK AD facilities. No carbon sequestration credit is assumed for AD processes.

Table A-34: Assumptions for Anaerobic Digestion Facilities

Parameter	Assumption
Heat used in the process, % of heat generated	33%
Electricity used in the process, % of electricity generated	10%
Methane generation, compostable plastics, m^3 CH_4 / tonne volatile solids	390
Methane generation, food waste, m^3 CH_4 / tonne volatile solids	351
Methane slip, g CH_4/ kWh energy	1.5
Fugitive methane emissions, % C to CH_4	1.5

A.10.9 Summary of Treatment System Impacts

Table A-35 and Table A-36 show the impact of waste treatment systems for residual waste and selected organic waste streams, respectively. Note that for compostable plastic there is no nutrient benefit assumed (which is the case for food waste). Some carbon sequestration impact is assumed for all materials.

Table A-35: Impacts of Plastic in Residual Waste, kg CO2e / Tonne Input

	MBT	Incineration	Landfill
Conventional plastic	2,129	2,129	0
Compostable plastic	-173	-173	1,750

Table A-36: Impacts of Key Materials in Organic Treatment, kg CO2e / Tonne Input

	AD	IVC
Compostable plastic	-792	-8
Food waste	-287	-34

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