Rural Organic Waste Collection

Carbon and Economic Assessment

The Irish Waste Management Association

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Executive Summary

Introduction & Background

SLR Consulting was commissioned by the Irish Waste Management Association to undertake a study to explore the environmental and cost implications of introducing biowaste[1] collections to rural households in Ireland.

Household waste collection in Ireland is fully privatised, so private companies contract directly with household customers to provide the service. The IWMA is the trade association for waste management companies in Ireland and its members collect about 95% of the household waste presented at the kerbside.

The waste collection system is regulated by a permitting regime that is backed by national legislation plus local bye-laws, in some places. The system is enforced by the local authorities with backing from a regional structure[2] and with national coordination[3]. There are very limited circumstances in Ireland where local authorities collect household waste or directly contract such waste collection services.

Currently, waste collection companies in Ireland are obliged to provide a 3-bin service to all household customers that live in agglomerations of 500 people or more. That includes a residual waste bin, a mixed dry recyclables bin and a brown bin or caddy for the collection of biowaste. In compliance with that obligation, some waste companies have rolled out brown wheelie bins[4] that can take commingled food and garden waste, whilst others have rolled out brown caddies[5] that are sized to only accommodate food waste.

It is Government Policy that the brown bin biowaste service will be rolled out to rural households at the end of 2023 and this will be backed by new legislation and amendments to existing waste collection permits.

This report considers four scenarios in the context of the rural brown bin roll-out and compares each scenario in terms of the impact on MSW recycling rates, carbon emissions/benefits and financial costs. The four scenarios are as follows:

- **Baseline Scenario** where rural households are serviced by a 2-bin system (i.e. a wheelie bin for residual waste and another for mixed dry recycling)
- **Home Composting Scenario** where home composting bins would be provided to householders in rural areas and they would be encouraged to home compost their food[6] and garden waste.
- **Food Caddy Scenario** where rural householders are given a brown food waste caddy and the collected food waste is delivered to anaerobic digestion (AD) plants as feedstock for the production of biogas.
- **Brown Bin Scenario** where rural householders are given a brown wheelie bin and the collected commingled food and garden waste is delivered to composting plants as feedstock for the production of compost, which is a soil enhancer.

[1] Aka organic waste collections. Comprises food waste with or without garden waste.

[2] The Waste Enforcement Regional Local Authorities (WERLAs).

[3] Local Government Management Agency (LGMA).

[4] These vary in size from 80L up to 240L.

[5] Generally 25L to 35L capacity.

[6] Excluding meat, fish and other biowaste that can attract vermin.

Methodology

SLR gathered data from IWMA members via a detailed questionnaire that considered all aspects of household waste collection and treatment in Ireland. The return rate was high and covers about 88% of all kerbside household waste collection in Ireland, so this report is largely evidence-based. Additional data on household waste collection was gathered from the National Waste Collection Permit Office.

SLR used this data when calculating MSW recycling rates and when assessing economic costs. The data also supported evidence-based assumptions for the Life Cycle Assessment (LCA) carried out by SLR using the well-established WRATE software.

A key assumption for the carbon and cost models was that the Food Waste Caddies can be collected in vehicles that are split 3-ways with a food waste pod installed behind the cab of the vehicle with a pumping system from the back of the truck. The rest of the vehicle is split between residual waste on one side and mixed dry recyclables (MDR) on the other. The 3 bins are emptied at the back of the vehicle. This system is already operational in Ireland and is therefore a proven and available technology.

The same assumption could not be applied for the collection of 3 wheelie bins as there are no such vehicles collecting household waste in Ireland and whilst such technology is possible, the brown bin waste is more voluminous, so the capacity of the other two compartments would be significantly reduced and this brings into question its efficiency. Side loaders for wheelie bins are more suitable for material that does not require compaction. None of the waste collection companies in Ireland are considering 3-way split vehicles for the roll-out of brown wheelie bins at this time, so SLR considers that its assumptions in this regard are robust.

The other major assumption in the report is that food waste is treated in AD plants and commingled food and garden waste is treated in composting plants. This is the current situation in Ireland to the best of our knowledge. Some AD facilities in Ireland (north and south) have tried to digest brown bin waste and have failed. New technology may make this possible in the future, but this option is not currently available on the island of Ireland, so it was not considered in this report.

Our analysis suggests that the full roll-out of brown bins/caddies is aimed at c.350,000 rural houses that are currently on a 2-bin system.

Results and Conclusions

Food Waste Caddy Scenario

The assessment suggests that the gross MSW recycling rate for rural houses increases by 8.9% from the baseline scenario (25.2%) to this scenario (34.1%), which is a significant increase. However, it is less than the MSW recycling rate associated with the roll-out of larger brown bins (41.2%).

The food waste caddy scenario performs best in terms of carbon impact when compared against the baseline and the other two scenarios. This is due to the following:

- Data from companies already offering the service suggests that providing a kitchen caddy leads to an increase in total waste collected per household. The collection, transfer and treatment of this waste has a higher impact than the baseline and home composting scenarios, but a lower impact than the brown bin scenario.
- The treatment of the food waste in anaerobic digestion plants has a major carbon benefit as it produces renewable energy that displaces the combustion of natural gas, a fossil fuel.

- There is also a carbon benefit from using digestate to displace soil enhancers and/or fertilisers.

The cost implications of the food caddy scenario are relatively low with an estimated average additional annual cost of €7.77 per house. This equates to c. €2.7 million per annum cost for all 350,000 houses.

Brown Bin Scenario

The assessment suggests that the gross MSW recycling rate for rural houses increases by 16% from the baseline scenario (25.2%) to this scenario (41.2%), which is a very significant increase.

The brown bin scenario performs poorly in terms of carbon impact when compared against the baseline and the other two scenarios. This is due to the following:

- Providing a brown bin is expected to cause an even higher increase in total waste arisings than the foody caddy. Consequently, the collection, transfer and treatment of additional quantities of that waste has a significantly higher carbon impact than each of the other scenarios.
- The treatment of the commingled brown bin waste in composting plants generates significant carbon emissions as those plants use energy to move and aerate the material.
- The composted material emits some methane as it degrades in the composting plant and this has a negative carbon impact, whereas the same material used as fuel in EfW performs better as it provides renewable energy to the national grid.
- There is a carbon benefit from using the resulting compost to displace soil enhancers and/or fertilisers, but this benefit is outweighed by the carbon emissions mentioned above.

The cost implications of the brown bin scenario are high with an estimated average additional annual cost of €76.57 per house. This equates to c. €26.8 million per annum cost for all 350,000 houses.

Overall Conclusions

The study demonstrates that the Food Caddy Scenario performs much better than the Brown Bin Scenario in terms of carbon impacts and cost implications. However, the Brown Bin scenario performs better in terms of increasing MSW recycling rates.

The other two scenarios, Baseline and Home Composting, are not viable options in this jurisdiction as Irish Government policy and legislation requires the roll-out of organic waste collections to rural areas, so householders will be entitled to such a service, even if they home compost their garden waste.

However, it is notable that the Baseline and Home Composting Scenarios perform best in terms of waste prevention with the Food Caddy scenario leading to the collection and treatment of almost 10% additional waste and the Brown Bin scenario leading to the collection and treatment of an additional 25% waste.

As waste prevention sits higher than recycling in the Waste Hierarchy, this is an important observation, but the improved carbon impact associated with the Food Caddy scenario appears to justify the collection of additional food waste. The greater carbon impact associated with the Brown Bin scenario suggests that waste prevention is preferable to recycling in that context.

This study is focussed on carbon emissions and climate change impacts (including benefits). Other Life Cycle Analysis (LCA) parameters, if examined, may prove to be more favourable to the Brown Bin scenario, as returning nutrients to the soil via composting provides a number of environmental benefits and that analysis lies outside the scope of this report.

The study suggests that targeting improved MSW recycling rates is not always the best environmental option in the context of carbon emissions and climate change impacts. Collecting and treating garden waste is a very good way for a country to boost its MSW recycling rate, but this report shows that it has a negative impact in terms of carbon emissions and climate change. The table below shows the additional carbon impact per house and for the overall roll-out to rural areas for each of the scenarios.

Table A Estimated Additional Annual Carbon Impact for Each Scenario

	Home Composting Scenario	Food Waste Brown Caddy Scenario	Commingled Organics Brown Bin Scenario
Number of Houses to be served	350,000	350,000	350,000
Annual Additional Carbon Emissions per house ($kgCO_2e/hh/yr$) Note: minus figure = reduction in carbon emissions	-0.27kg	-6.0kg	+22.4kg
Total Annual Additional Carbon Emissions for all houses in Dataset (tCO_2e/yr)	-93t	-2,100t	+7,825t

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Acronyms and Abbreviations

AD	Anaerobic Digestion
APCr	Air Pollution Control Residues
CCGT	Combined Cycle Gas Turbine
CO_2e or CO_2eq	Carbon Dioxide Equivalent
DECLG	Department of Environment, Community and Local Government
EfW	Energy from Waste
EPA	Environmental Protection Agency
GWP	Global Warming Potential
IBA	Incinerator Bottom Ash
IVC	In Vessel Composting
IWMA	Irish Waste Management Association
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
MDR	Mixed Dry Recyclables
MSW	Municipal Solid Waste
NWCPO	National Waste Collection Permit Office
RCV	Refuse Collection Vehicle
SEAI	Sustainable Energy Authority of Ireland
VAT	Value Added Tax
WRATE	Waste and Resources Assessment Tool for the Environment

1.0 Introduction

SLR Consulting (SLR) has been commissioned by the Irish Waste Management Association (IWMA) to undertake a study to support its members to explore the environmental and cost implications of introducing collections of organic waste from rural households in Ireland.

The support has involved carrying out a carbon assessment assessing the baseline position where rural households are serviced by a 2-bin system (i.e., a bin for residual waste and another for mixed dry recycling) and comparing it with scenario where they are serviced by a 3-bin system (i.e., issued with a brown bin for the collection of food waste, either separately or comingled with garden waste).

The separate collection of food waste is facilitated with the delivery of brown kerbside caddies (c.25L to 35L in volume) emptied fortnightly, whereas the collection of commingled food and garden waste is facilitated with the delivery of brown bins (generally 120L to 240L in volume) also emptied fortnightly.

SLR has also undertaken a high-level economic assessment to determine the potential costs associated with a brown bin or brown caddy roll-out to rural households across Ireland.

1.1 Background and Objectives

SLR understands that Ireland is considering the mandatory offering of an organic waste collection to all households across the country. Whilst this clearly has benefits in terms of offering everyone a uniform service, which can be supported with consistent national guidance, there are questions about the environmental implications, particularly in the deployment of additional services to rural areas where the associated transportation requirements could be significant.

Through discussions with the IWMA steering group, it was agreed that the most appropriate approach to this project would be through the use of data from IWMA members where possible as this would represent relatable operational data with regards to future delivery of the services. This report outlines the findings of the assessment and includes the following sections:

- Legislative overview;
- Data collation;
- Carbon assessment;
- Economic assessment; and
- Conclusions.

2.0 Legislative Overview

This section sets out the principal legislative drivers behind the proposed roll-out of organic waste collections to rural areas in Ireland. European Union (EU) and National legislative measures for waste management are designed to reduce waste generation and to reduce waste disposal in favour of reuse, recycling and recovery.

2.1 The Waste Hierarchy

The EU Waste Hierarchy[7],that puts prevention ahead of reuse ahead of recycling ahead of other recovery (including energy recovery) ahead of disposal, must be implemented through policy and legislation by each Member State of the EU. Ireland's waste policy and legislation actively encourages the management of waste at the higher tiers of the hierarchy and this works against the growth of waste and particularly discourages the growth of residual MSW.

Section 21A(1) of the Waste Management Act 1996 (as amended) addresses the Waste Hierarchy, as follows:

"21A Waste hierarchy.

(1) The following waste hierarchy shall apply as a priority order in waste prevention and management legislation and policy:

(a) prevention;

(b) preparing for re-use;

(c) recycling;

(d) other recovery (including energy recovery); and

(e) Disposal."

This is implemented through the regional waste management plans, soon to be a National Waste Management Plan and through various regulations concerning waste licensing and permitting, as well as food and biowaste regulations. Waste collection permits all include conditions that relate to the waste hierarchy and where relevant, relate to the food and bio-waste regulations. Two such regulations are particularly relevant to this report.

2.2 A Waste Action Plan for a Circular Economy Ireland's National Waste Policy 2020-2025

Ireland's latest National Waste Policy / Action Plan was published in September 2020. On page 18 of that document, the Irish Government made the following commitment:

> *"We will make the provision of an organic waste bin mandatory as part of a waste collection service for all households"*

[7] Article 4 of Directive 2008/98/EC on waste (Waste Framework Directive)

2.3 European Union (Household Food Waste and Bio-Waste) Regulations 2013[8]

This legislation which was passed in 2013 puts an obligation on waste collection companies to roll-out household brown bins to customers by specified dates in the following urban agglomerations:

- 1st July 2013 for agglomerations > 25,000 persons;
- 31st December 2013 for agglomerations > 20,000 persons;
- 1st July 2014 for agglomerations > 10,000 persons;
- 1st July 2015 for agglomerations > 1,500 persons, and
- 1st July 2016 for agglomerations > 500 persons.

A *'Statement of Regulatory Impact Analysis'* (RIA) was commissioned by the Department of Environment, Community and Local Government (DECLG) and was prepared by Indecon, to accompany these new regulations. The RIA suggests that the roll-out to all agglomerations of >500 persons will cover 1,119,178 households in total, which is 67% of occupied houses. However, this assumes that all occupied houses have a waste collection service, which is not the case. Currently, roughly 1.3 million houses and about 200,000 apartments have a waste collection service. Approximately 900,000 of these houses currently have a brown bin and very few of the apartments. We estimate that c.150,000 of these houses are served with a brown kerbside caddy rather than a brown wheelie bin.

These regulations are currently being revised to expand the brown bin roll-out to all areas, including rural houses. At the time of writing, the amended regulations are in draft form and are expected to be finalised at some stage during 2023 and are due to come into effect on 31st December 2023.

The draft regulations require the collection of biodegradable garden waste as well as food waste from all houses, but householders are not mandated to present garden waste. However, placing food or garden waste in the residual wase bins is prohibited. Those waste collection companies that provide brown wheelie bins fulfil the garden waste obligation, but those that provide kerbside brown caddies, must also offer a collection service for biodegradable garden waste at least monthly from March to October, according to the draft regulations. We understand that this can be an 'on-demand' service, for example using skip bags.

2.4 Waste Management (Collection Permit) Regulations

Amended household waste collection regulations were passed in 2015 and 2016[9]. The main thrust of these amended regulations was to require the weighing of all household bins and reporting of all weights. The requirement to charge by weight was included in the 2016 amendment, but this element was later revoked after a political backlash against the proposed mandatory pay by weight system. However, an incentivised charging system has been introduced by way of agreement between the authorities and the IWMA, backed by amended conditions introduced to existing waste permits.

In addition to the requirement to weigh household bins, the revised waste collection permit regulations imposed many additional conditions on kerbside household waste collectors, including conditions relating to the roll-out and use of brown bins. Brown bins must be delivered to householders, rather than just offered, which often involved an additional charge

[8] SI 71 of 2013 as amended
[9] S.I. 197 of 2015 and S.I. 24 of 2016

to the householder and sometimes required the householder to request the delivery of a brown bin.

New measures in these regulations also include Fixed Payment Notices to be applied to householders and to waste collectors for breach of certain waste management requirements. In addition, the regulations require the review and revocation of waste collection permits where waste companies do not fully comply with their obligations, which include the provision of a brown bin service.

2.5 EU Early Warning Report for Ireland

The EU Commission has recently released an Early Warning Report[10] that relates to the prospect of each Member State meeting the targets set in the Waste Framework Directive. The EU considers that Ireland is at risk of missing the MSW recycling rate targets and the report recommends *"Further development of waste treatment infrastructure, including increasing bio-waste treatment capacity and supporting home composting."*

[10] IRELAND 2025 EU waste recycling targets STATE OF PLAY, EU Commission June 2023.

3.0 Data Collation

This section outlines the process followed in gathering data from waste collectors operating in Ireland.

3.1 Development of Questionnaire

In consultation with the IWMA steering group, SLR developed the questionnaire that was used to gather information from the market.

This questionnaire was based on the core elements that in the project team's view were crucial in assessing the environmental and economic cases for the roll-out of organic waste collections to rural households, and expanded on to ensure that a full and comprehensive response was achieved.

Our approach was to develop a questionnaire that was detailed enough to provide the project team with a comprehensive, informative response, but one that was also most likely to provoke a clear and reportable response.

In developing the questionnaire, SLR was aware that the information being requested may have been considered commercially sensitive, so assurances were made that all returns would remain confidential within the SLR project team and that only agglomerated data would be published in the report so as not to expose any individual company data.

The questionnaire developed was presented to the IWMA steering group for review, discussion, revision and agreement – the final version of the agreed questionnaire is included in Appendix A.

3.2 Approach to IWMA Members

SLR issued the questionnaire to members of the IWMA Household Waste Collectors Subgroup on 13/01/2023 with a view to the poll closing at the end of the month. At the end of January, only four responses had been received, so the decision was taken to allow more time for the receipt of responses.

In total SLR received 20 completed questionnaires back, although in some instances there were some unanswered questions. Where significant gaps in the responses were noted, SLR approached the respondents for clarification on their data.

3.3 Collation and Summary of Questionnaire Responses

The responses were collated in a spreadsheet where the data was validated and reviewed for gaps and anomalies. Following this process, the data was agglomerated by question to inform the carbon and economic assessments.

4.0 Carbon Assessment

This section of the report outlines the main assumptions, results and interpretation of a carbon assessment (based on Life Cycle Assessment (LCA) principles) to support the IWMA in understanding the environmental implications of introducing collections of organic waste from rural households in Ireland.

The LCA software 'Waste and Resource Assessment Tool for the Environment' (WRATE) was utilised to model the potential environmental impacts. The WRATE software is an LCA tool specifically designed to model the environmental impacts of waste and waste management processes. In particular, the LCA tool helps with the identification and quantification of the following environmental impacts:

- **Direct Burdens** – defined as emissions from the process itself, for example carbon dioxide as result of a consequence of combustion or aerobic degradation;
- **Indirect Burdens** – associated with the supply of energy and materials to the process, for example construction materials, electrical energy for motors and fans, and chemicals for pollution abatement equipment; and
- **Avoided Burdens** – associated with the recovery of energy and materials from the waste stream resulting in the avoidance of primary energy production and mineral extraction.

A single WRATE model with four scenarios has been developed. Table 4-1 gives an overview of each of the scenarios that have been modelled.

Table 4-1: Overview of Scenarios

Scenario	Summary
Baseline	Models the current assumed baseline waste management
Home Composting	Diversion of garden waste from the residual waste stream to home composting
Food Caddy	Diversion of food waste from the residual waste stream and assumed additional capture of food waste, treatment of food waste via Anaerobic Digestion (AD) technology. (Assumes collection on Split-back Refuse Collection Vehicle (RCV) i.e., no additional collection vehicle added)
Brown Bin	Diversion of mixed organic waste from the residual waste and assumed additional capture of mixed organics, collected via a separate RCV (i.e., dedicated brown bin RCV)[11], treatment of mixed organic waste via In-Vessel Composting (IVC) technology.

The WRATE model and scenario assumptions are presented and discussed in the subsequent sections of this report.

[11] Please note that as far as the WRATE analysis is concerned, the transport impacts are principally assessed on a weight and distance basis. That is to say SLR has not specifically opined on how the capacity of the vehicles is impacted and at what point they might need to return to the transfer station to tip a load. However, the questionnaire responses suggested that operators expect to be travelling a slightly greater distance where brown bins are deployed, and this is accounted for in the analysis.

4.1 Methodology and Assumptions

This section provides an introduction to the WRATE software, provides details of the modelling assumptions and outlines how the results from the WRATE software are presented and interpreted.

4.1.1 WRATE Software

The LCA software WRATE was utilised to model the potential environmental impacts of the scenarios presented in Table 1. The WRATE software is an LCA tool specifically designed to model the environmental impacts of waste and waste management processes.

The software was developed to comply with the International Organization for Standardization (ISO) standards for LCA to ensure studies using the WRATE tool can be delivered to a high technical standard. The WRATE tool utilises a background database supplied by the Ecoinvent centre, a Swiss organisation with unrivalled expertise in the supply of consistent and transparent life cycle inventory data. The use of the WRATE software is endorsed and encouraged by the Environment Agency (EA) and Department for Environment, Food and Rural Affairs (Defra).

As a WRATE model can only be opened and interrogated by users with the WRATE software installed and licensed, this report presents an overview of the key assumptions and the output results.

4.1.2 WRATE Modelling Assumptions

The WRATE model has been developed in the latest available version (Version 4) of the WRATE software. The following is a list of key model assumptions applied:

- **Assessment Year:** 2022;
- **Waste Tonnage:** Varies by scenario, but ranges from 634 kg/hh/yr to 792kg/hh/yr.

	2-Bin System	+ Home Compost	+ Food Caddy	+ Brown Bin
Residual waste collected (kg/hh/yr)	474	463	458	466
MDR collected (kg/hh/yr)	160	160	160	160
Organic waste collected (kg/hh/yr)	0	11[12]	77	166
Combined waste collected per customer (kg/hh/yr)	**634**	**634**	**695**	**792**
Gross Recycling Rate for kerbside collection	25.2%	27.0%	34.1%	41.2%

The assumptions on waste tonnage are based on the data received from IWMA Members in response to SLR's Questionnaire, which is discussed in an earlier section of this report. The returns from 20 No. IWMA members represents about 88% of the household waste collection market in Ireland, so these waste tonnages are based on a fairly comprehensive dataset.

The weights quoted above are based on rural customers. It is notable that rural customers with brown bins produce less biowaste than urban customers with brown bins (rural 166kg per annum versus urban 197kg per annum on average). These weights are based on all customers in the datasets rather than just those that are

[12] This material is not actually collected, but home composted, which is an accepted form of recycling.

actively using brown bins, so we believe this shows that participation rates for brown bins are lower in rural areas compared to urban areas. This could reflect higher levels of home composting in rural settings.

The data suggests that rural customers with brown caddies produce roughly the same weight of food waste as those that live in urban areas.

The Food Caddy and Brown Bin scenarios show significantly higher total weights, which is not surprising as the brown bins and brown caddies attract waste that may have otherwise been home composted. Extra bin capacity often results in extra waste being deposited by householders.

The diversion of food and garden waste from the residual bins, combined with increased capture of food and garden waste[13], results in higher recycling rates as shown on Table 4-1[14]. As expected, the brown bin scenario results in the highest gross recycling rate as well as the highest waste generation rate.

- **Waste Composition:** Waste composition was taken from an EPA Household Waste Characterisation Survey[15]. For the purposes of this study, the key material proportions are as follows:

  Food Waste Proportion of Total Residual Waste: 14%

  Green Waste Proportion of Total Residual Waste: 3%

- **Transportation:** Collection and transport by waste collection vehicles is included in the modelled scenarios. The modelled scenarios also include transport of waste from an assumed waste transfer location to the waste treatment or disposal point. All downstream transportation from the delivery point is included (this includes transportation of process outputs and residues from the EfW treatment to final destination).

- **Electricity Mix:** SEAI publication for Ireland[16].

Electricity Source (2022)	Proportion (%)
Gas	50%
Coal	14%
Peat	2%
Oil	8%
Wastes non-renewable	2%
Wind	18%
Biomass	2%
Renewable Wastes	2%
Hydro	1%
Other renewables	1%

[13] Probably from home composting or other treatment/non-treatment in people's gardens

[14] Note that this is the gross recycling rate for kerbside collections and is not a full reflection of household waste recycling as that also includes material brought to bring banks, civic amenity sites, etc. The gross recycling rate also includes contamination that will be removed during processing and final treatment.

[15] https://www.epa.ie/publications/monitoring--assessment/waste/national-waste-statistics/Household_Surveys_Final_Report1.pdf

[16] https://www.seai.ie/publications/Energy-in-Ireland-2022.pdf

- Waste management facilities utilise electricity (for office/welfare buildings, weighbridge operations and process equipment), therefore an assumed energy mix must be defined in order to calculate the environmental burdens from any energy purchased.
- Where a waste management facility generates energy, the avoided burdens associated with the net electricity generation (i.e., the benefit of not having to produce electricity from traditional generation methods using predominantly fossil based fuels) are offset against an inventory for the marginal grid energy mix – in this instance, 100% Combined Cycle Gas Turbine (CCGT). The use of the marginal energy mix, as opposed to the baseline or average energy mix, is a standard life cycle convention.
- In WRATE for those processes that generate usable heat, the heat energy is offset against the combustion of natural gas.

4.1.3 Global Warming Potential and WRATE Results Presentation

The outputs from the WRATE software are life cycle impact assessments (LCIA). LCIAs present the impacts of a range of solid, liquid and gaseous pollutants on the environment, and compare them to a specific environmental impact. WRATE includes six default environmental impacts: global warming, acidification, eutrophication, aquatic ecotoxicity, human toxicity and resource depletion. This assessment focuses on the emissions of greenhouse gases and therefore the global warming impact of the scenarios.

Greenhouse gas refers to those gaseous compounds that are known to contribute to the warming of the atmosphere, the so called 'global warming' effect. The most common greenhouse gas is carbon dioxide (CO_2) however other types, primarily methane (CH_4) and nitrous oxide (N_2O), are equally important in waste management[17].

Methane is formed by the biological reaction of carbon under anaerobic conditions, and is most commonly associated with landfill gas emissions. Nitrous oxide is formed by the biological breakdown of nitrogen containing material and is therefore closely associated with composting processes. To a lesser extent nitrous oxide may also be formed in combustion processes.

The degree to which a greenhouse gas contributes to global warming is measured by its Global Warming Potential (GWP). This is a relative scale which compares the gas in question to that of the same mass of carbon dioxide (whose GWP is by definition 1)[18]. A GWP is calculated over a specific time interval and the value of this must be stated whenever a GWP is quoted or else the value is meaningless. Life cycle analysis convention dictates that the GWP is commonly measured over a 100-year timespan and consider abiotic (manmade) sources only; results are therefore reported as GWP100a.

A carbon impact (sometimes referred to as a carbon footprint) is expressed in the form of mass of carbon dioxide equivalency (CO_2e or CO_2eq), a concept that describes, for a given mixture and amount of greenhouse gas, the amount of CO_2 that would have the same global warming potential, when measured over a specified timescale. The carbon dioxide equivalency for a gas is obtained by multiplying together the mass and the GWP of the gas.

In this report, carbon impact results (GWP100a) are presented as kilograms of carbon dioxide equivalent per household ($kgCO_2e/hh$). A positive value represents an environmental

[17] The latter types should not be confused with nitric oxide and nitrogen dioxide, both commonly referred to as NOx, and which play no part in global warming but, instead, are powerful contributors to acid rain.

[18] In WRATE Version 4 the GWP for methane and nitrous oxide is 25 and 298 respectively.

burden, whereas a negative value represents an environmental benefit (sometimes referred to as a saving).

4.2 Carbon Impact Modelling, Results and Commentary

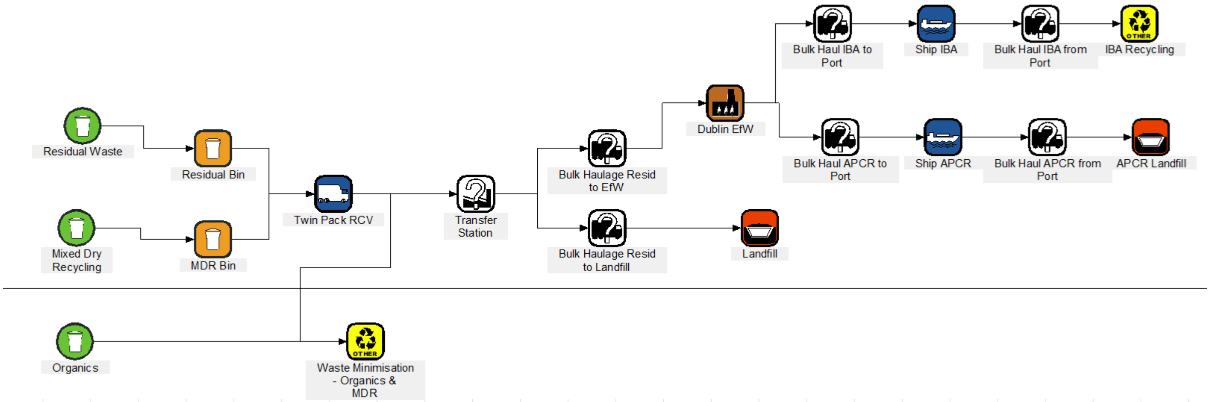
This section provides additional information regarding the scenarios and background assumptions, followed by presentation and interpretation of the carbon impact results.

4.2.1 Baseline (2-bin system)

The Baseline scenario was developed to assess the carbon impact of the collection of 634 kg of waste per annum from each household (474kg of residual waste and 160kg of MDR). The fate of residual waste is assumed to be split between domestic EfW[19] (75%) and landfill (25%)[20]. With regards to the MDR, the analysis takes account of the collection of the MDR only – this ensures the impact of co-collecting kerbside materials in split vehicles is accounted for, although the onward management and recycling of MDR is excluded from the analysis. The scenario map from WRATE is provided in Figure 4-1 – a larger map is provided in Appendix B.

In terms of transportation assumptions, the kerbside collection distance is modelled as 6.6km per household per year by road as determined from the questionnaire responses.

Figure 4-1: WRATE Scenario Map for Baseline Scenario



Note: WRATE icons with '?' symbol identify processes which are User Defined.

The majority of the processes utilised within the WRATE scenario are WRATE standard processes. The process utilised for road bulk haulage is a 'User Defined Process' (UDP). A UDP is where a WRATE standard process is duplicated, and changes are made to the background allocation table to better represent the process or treatment technology.

The WRATE default process for the bulker 'Intermodal Road Transport' assumes a vehicle payload of 17.6 tonnes. Given the passage of time since the WRATE software was developed, haulage vehicles have become lighter are therefore able to transport a greater payload. To account for this increase in vehicle payload, transport UDPs have been developed for the transportation of waste from the waste transfer station onwards. For each, the modelled payload has been assumed using SLR's knowledge from other projects involving haulage of these material types and information from the IWMA members. The modelled vehicle payload for bulk haulage is 22.5 tonnes.

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[19] Although there is a proposed heat network, Dublin EfW understood to be operating in electricity only mode at present with 30.5% electrical efficiency based on 2019 reporting figures, however the flexible EfW process in WRATE has a maximum of 29% so the process has been set to this.

[20] MSW Capacity Report Q 4 2022 projections for 2023 Final

The WRATE scenario assumes IBA is recycled with capability for metals removal and that APCr is disposed to landfill[21].

4.2.1.1 Results – Baseline (2-bin system)

Figure 3-2 below presents the results of the WRATE analysis for the Baseline scenario for the assessment year 2022. The results represent the carbon impacts (GWP100a) of managing 634kg of waste from households each year.

As previously stated, results are presented in kilograms of carbon dioxide equivalent (kgCO_2e); a positive value represents an environmental burden and a negative value presents an environmental benefit.

Figure 4-2: Baseline Carbon Impact of 2-bin System Managing 634kg/hh/yr

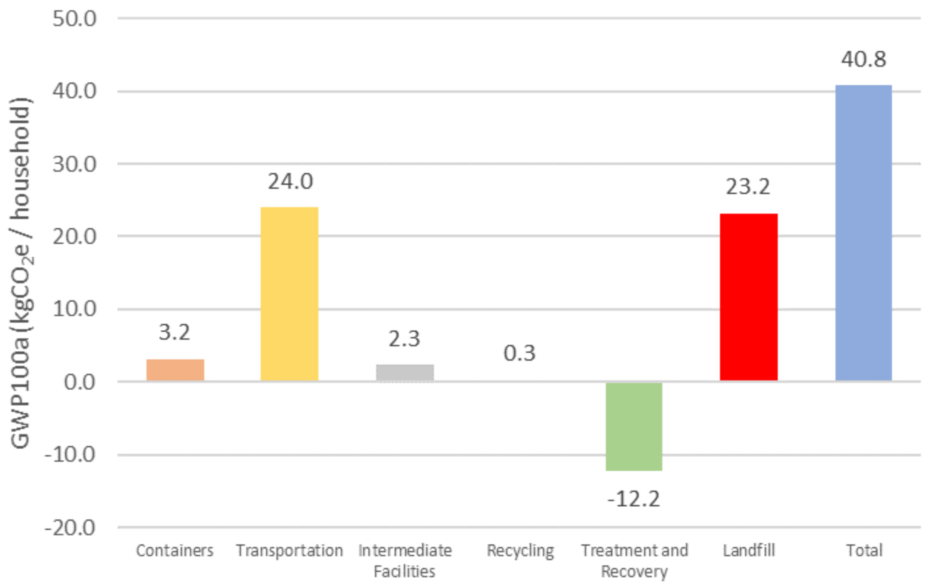


Figure 4-2 shows that for each household there is:

- A small carbon burden of 3.2kgCO_2e associated with the supply of wheelie bins.
- A carbon burden of 24.0kgCO_2e associated with transportation, of which 13.6kgCO_2e is attributable to collection vehicles.
- A small burden of 2.3kgCO_2e associated with the operation of waste transfer stations bulking the collected waste prior to onward management.
- A very small burden of 0.3kgCO_2e associated with the handling and recycling of IBA from the residual waste that is incinerated. While this is an impact, it is more than offset by the benefit of generating electricity from the EfW process, as reported in the 'Treatment and Recovery bar' – see below. This process presents a burden because the waste is assumed to contain no metals that might have been recovered for

[21] There have been technological advancements in the management of APCr which involves the recycling of APCr to generate aggregates for use in dense and medium dense aggregate blocks; however the WRATE software does not currently include an APCr recycling process. The results presented in the report are therefore based on landfill of APCr, and are potentially conservative, as future recycling of APCr will provide further carbon benefits.

benefit – though it also contains no plastics, that would have given rise to fossil CO2 emissions.

- A benefit of -12.2kgCO_2e associated with the treatment of collected residual waste via EfW technology. The assessment assumes that 75% of the collected residual waste is treated at the Dublin EfW operating in electricity-only mode, with the remainder disposed to landfill. If the EfW facility is ultimately connected to a district heating network and/or more waste is diverted from landfill, the overall benefit achieved will be greater.
- A burden of 23.2kgCO_2e associated with the disposal of 25% of the residual waste and the APCr from the EfW process to landfill.
- An overall carbon burden of c.40.8kgCO_2e.

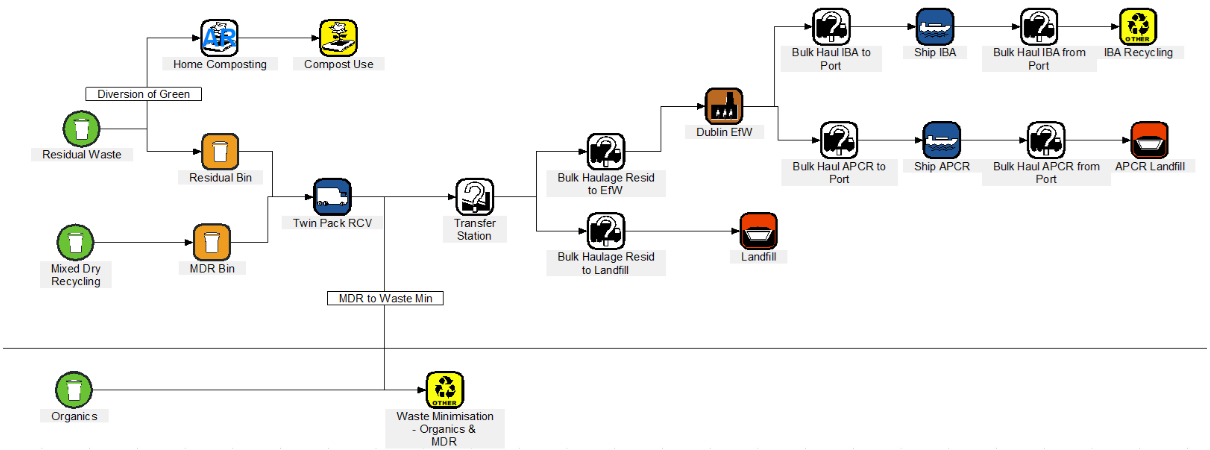
4.2.1.2 Summary Conclusions – Baseline (2-bin system)

The continued use of a 2-bin collection system is shown to result in a significant carbon burden, with transport and landfill impacts being the most significant contributing factors to the overall impact associated with this scenario.

4.2.2 Home Composting

This scenario was developed to assess the carbon impact of diverting a proportion of the residual waste (~11kg/hh/yr) to home composting – all other assumptions remain as per the baseline scenario. The figure of 11kg was derived from an EPA waste characterisation study that showed that the residual waste stream is comprised of c. 3% of green waste, and of this, up to 79% could be diverted where collection services are offered (i.e. 3% * 79% * 474kg/hh/yr). This assumption is conservative as in reality households could also have home composting of food waste such as fruit and vegetable peelings, however the waste characterisation study does not specifically identify this component of the residual waste stream. The scenario map from WRATE is provided in Figure 4-3 – a larger map is provided in Appendix B.

Figure 4-3: WRATE Scenario Map for Home Composting Scenario



Note: WRATE icons with '?' symbol identify processes which are User Defined.

The home composting technology is modelled using a default WRATE process with assumptions applied regarding the use of the compost output for beneficial use.

4.2.2.1 Results – Home Composting

Figure 4-4 below presents the results of the WRATE analysis for the Home Composting scenario.

Figure 4-4: Carbon Impact of 2-bin System Managing 634kg/hh (with Home Composting)

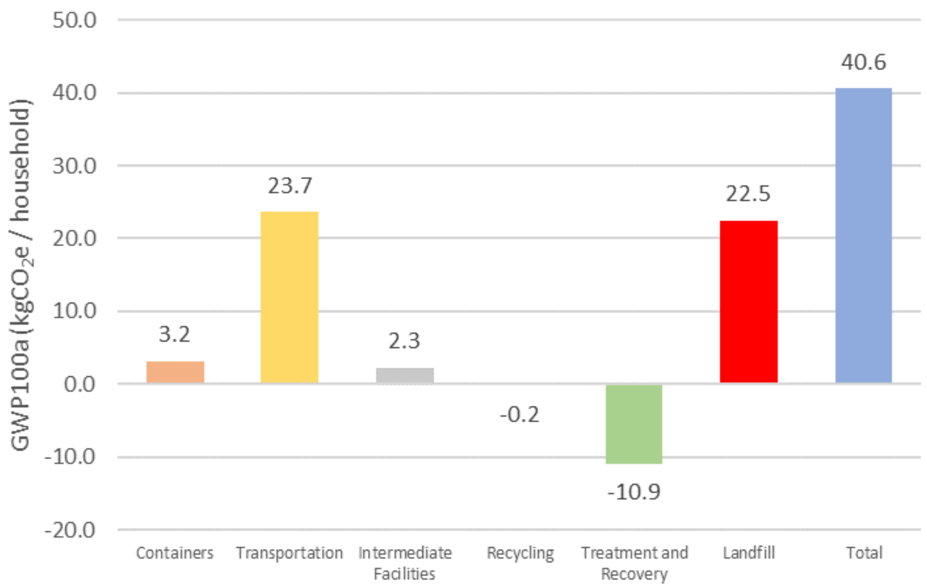


Figure 4-4 shows that for each household there is:

- A carbon burden of 23.7kgCO_2e associated with transportation.
- A very small benefit of -0.2kgCO_2e associated with the recycling of IBA from the residual waste that is incinerated and beneficial use of compost arising from the home composting process.
- A benefit of -10.9kgCO_2e associated with the treatment of collected residual waste via EfW technology.
- A burden of 22.5kgCO_2e associated with the disposal of 25% of the residual waste and the APCr from the EfW process to landfill.
- An overall carbon burden of c.40.6kgCO_2e.

4.2.2.2 Summary Conclusions – Home Composting

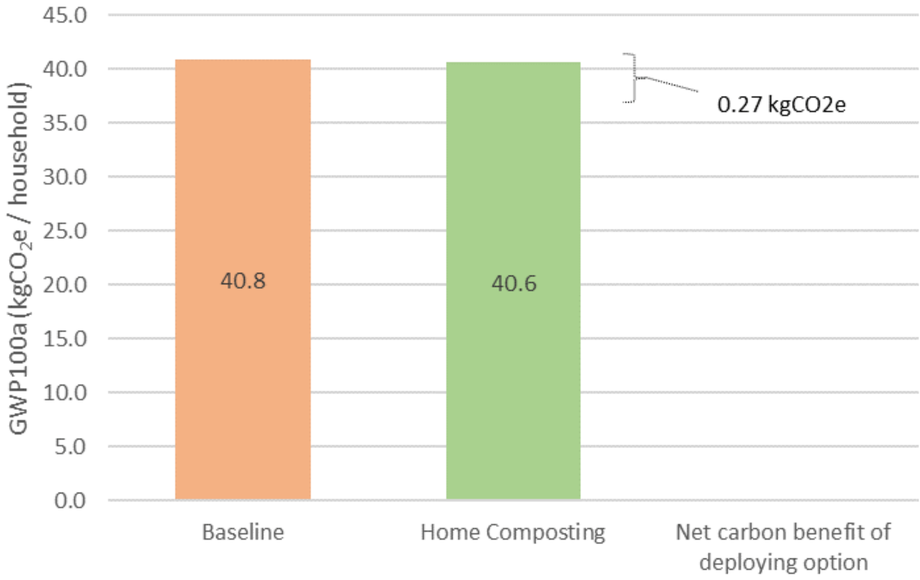
The deployment of home composting alongside the continued use of a 2-bin collection system is shown to result in a significant carbon burden, with transport and landfill impacts being the most significant contributing factors to the overall impact associated with this scenario.

4.2.2.3 The Net Benefit (Comparison of Home Composting to Baseline)

The results in Figure 4-2 and Figure 4-4 present the carbon impact results of the Baseline and Home Composting scenarios respectively. Comparison of the Home Composting impacts to the Baseline impacts derives the overall 'net' carbon impact.

Presentation of results as a net benefit is a common LCA convention. Comparison of the carbon impact of the Home Composting scenario to the Baseline scenario results in a net avoided carbon burden of c.0.3kgCO_2e.

Figure 4-5: Comparison of Home Composting to Baseline Showing Net Carbon Benefit

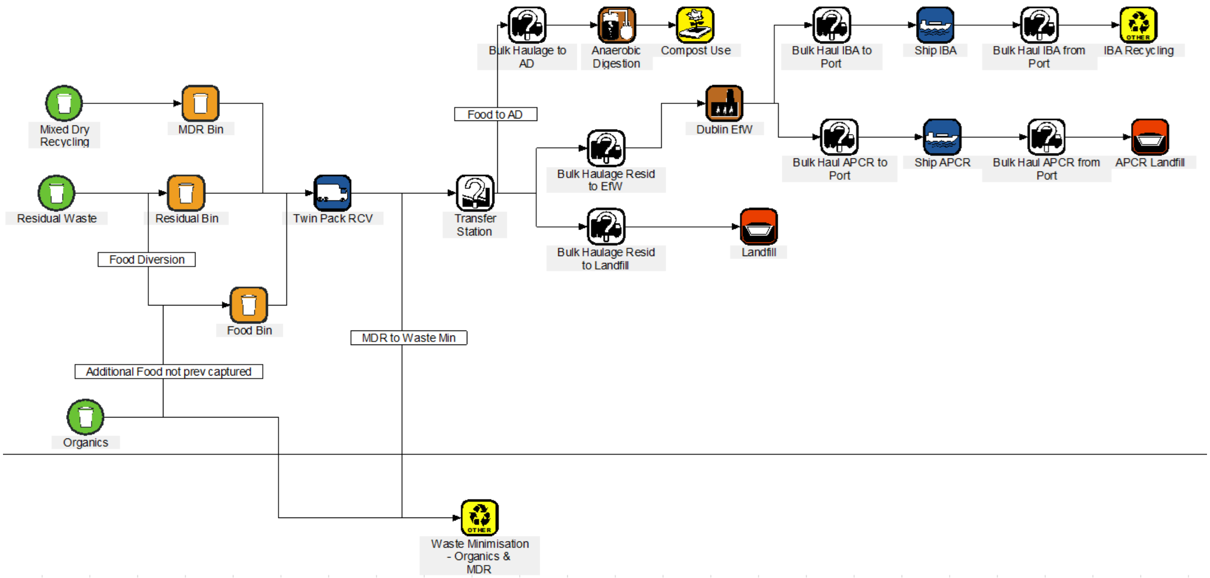


Within the accuracy of the modelling, the above demonstrates that roll-out of home composting bins to households and diversion of 11kg/hh of organic waste from the residual waste stream is at parity with the baseline of the 2-bin system. The garden waste that is removed from residual bins in Ireland in the home composting scenario is no longer contributing to renewable energy at the EfW plant, but the benefit of producing compost and using this to replace soil enhancers or fertilisers is broadly comparable in terms of carbon footprint.

4.2.3 Food Waste Caddy

This scenario was developed to assess the carbon impact of issuing households with caddies for the segregation and collection of food waste – this scenario has more waste in it 695 kg/hh, with 77 kg/hh of food waste collected and processed via anaerobic digestion (AD) technology. All other assumptions remain as per the baseline scenario. The scenario map from WRATE is provided in Figure 4-6 – a larger map is provided in Appendix B.

Figure 4-6: WRATE Scenario Map for Food Caddy Scenario



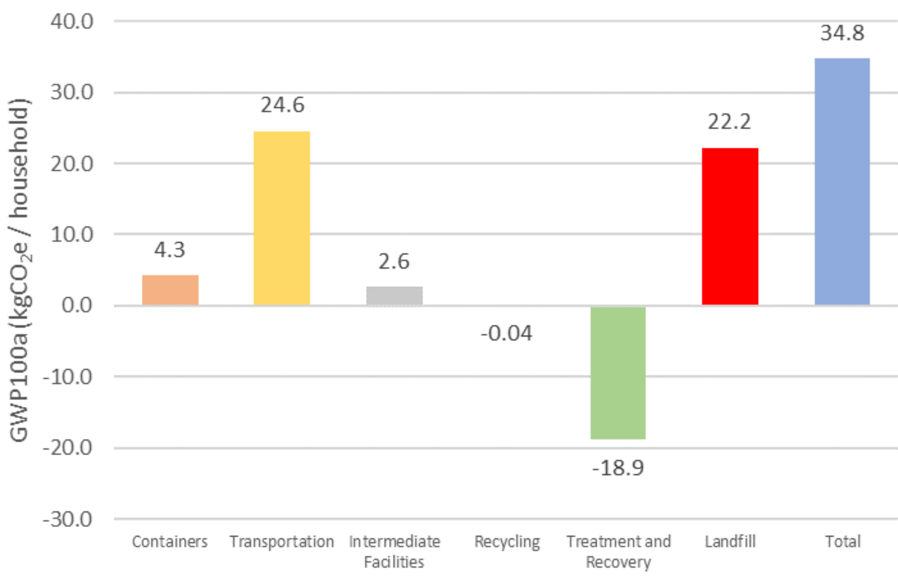
Note: WRATE icons with '?' symbol identify processes which are User Defined.

The AD technology is modelled using a default WRATE process with assumptions applied regarding the use of the digestate output for beneficial use as soil enhancer. The AD process also has benefits associated with electricity generation (offsetting marginal grid electricity[22]) and heat use from the combustion of the biogas that is generated.

4.2.3.1 Results – Food Caddy

Figure 4-7 below presents the results of the WRATE analysis for the Food Caddy scenario.

Figure 4-7: Carbon Impact of 2-bin System + Food Caddy Managing 695kg/hh



[22] Marginal electricity is, simply, the electricity source(s) that will be "turned down" when extra electricity is created. The idea is that, if new electricity is available, it would not be used instead of (e.g.) renewables. In many Western countries, including Ireland, the marginal power source is natural gas.

Figure 4-7 shows that for each household there is:

- A carbon burden of 24.6kgCO_2e associated with transportation.
- A very small benefit of -0.04kgCO_2e associated with the recycling of IBA from the residual waste that is incinerated and use of digestate arising from the AD process as a soil enhancer, offsetting the use of chemical fertilisers.
- A combined benefit of -18.9kgCO_2e associated with treatment and recovery processes comprising benefits of -11.2kgCO_2e from the treatment of collected residual waste via EfW technology and -7.7kgCO_2e from the treatment of food waste via AD where electricity and useable heat are generated.
- A burden of 22.2kgCO_2e associated with the disposal of 25% of the residual waste and the APCr from the EfW process to landfill.
- An overall carbon burden of c.34.8kgCO_2e.

4.2.3.2 Summary Conclusions – Food Caddy

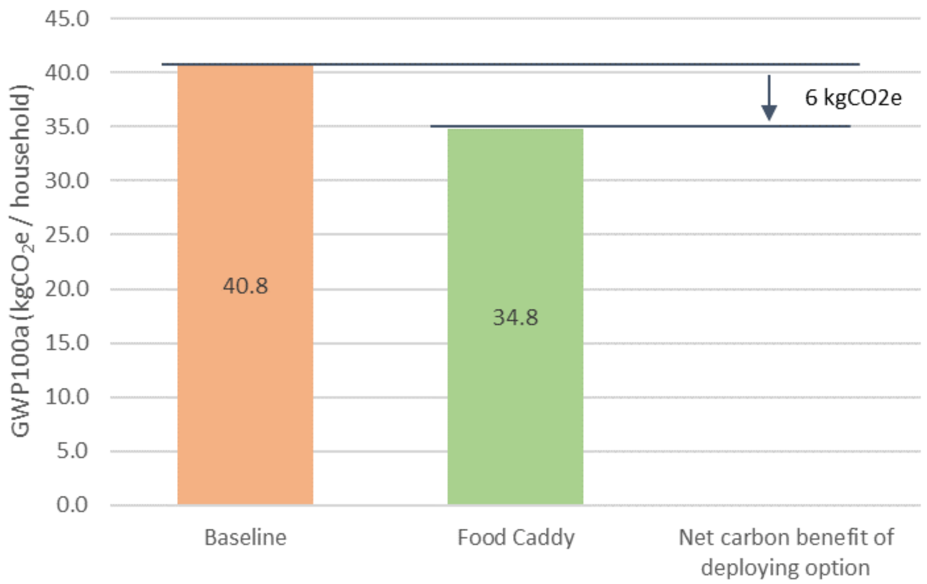
The deployment of a source-segregated food waste collection alongside the continued use of a 2-bin collection system is shown to result in a significant carbon burden, with transport and landfill impacts being the most significant contributing factors to the overall impact associated with this scenario.

There are however carbon benefits associated with electricity production and distribution of heat from the AD process to beneficial use.

4.2.3.3 The Net Benefit (Comparison of Food Caddy to Baseline)

The results in Figure 4-2 and Figure 4-7 present the carbon impact results of the Baseline and Food Caddy scenarios respectively. Comparison of the carbon impact of the two scenarios results in a net avoided carbon burden of c.6.0kgCO_2e/hh/yr.

Figure 4-8: Comparison of Food Caddy to Baseline Showing Net Carbon Benefit

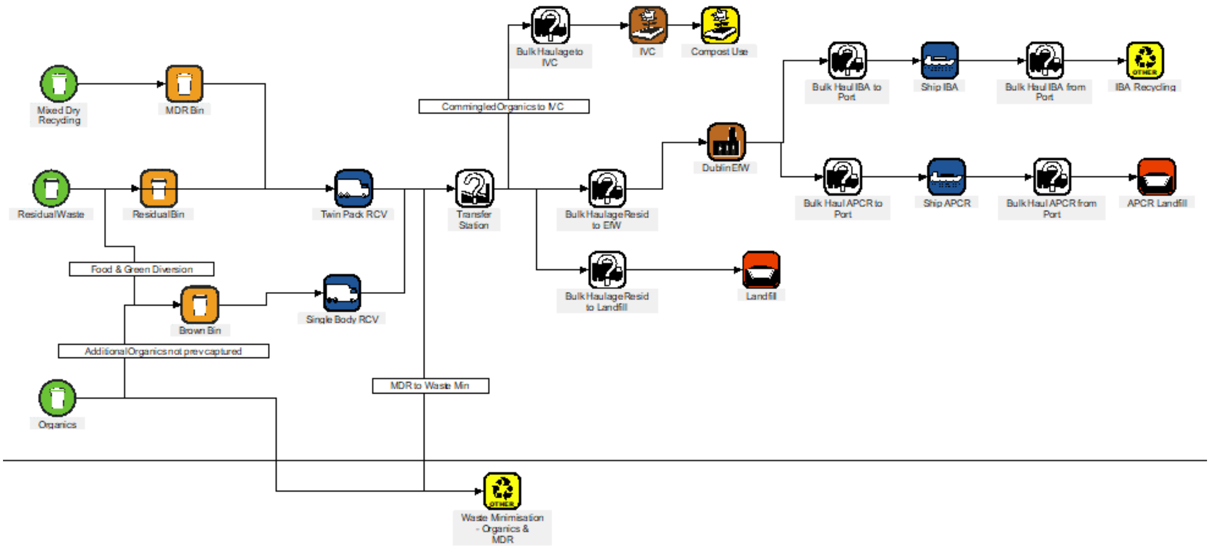


The above demonstrates that roll-out of food waste caddies to households despite yielding an additional 61kg/hh of waste overall could result in the diversion of 77kg/hh of food waste from the residual waste stream, resulting in a modest carbon benefit.

4.2.4 Brown Bin

This scenario was developed to assess the carbon impact of issuing households with a brown bin for the segregation and collection of commingled food and green waste – this scenario has more waste in it 792 kg/hh, with 166 kg/hh of commingled organic waste collected and processed via in-vessel composting (IVC) technology. The questionnaire responses received suggest that waste collectors expect to travel an additional 1.4km to service each rural household. All other assumptions remain as per the baseline scenario. The scenario map from WRATE is provided in Figure 4-9 – a larger map is provided in Appendix B.

Figure 4-9: WRATE Scenario Map for Brown Bin Scenario



Note: WRATE icons with '?' symbol identify processes which are User Defined.

The IVC technology is modelled using a default WRATE process with assumptions applied regarding the use of the compost output for beneficial use.

4.2.4.1 Results – Brown Bin

Figure 4-10 below presents the results of the WRATE analysis for the Brown Bin scenario.

Figure 4-10: Carbon Impact of 3-bin System (incl. Brown Bin) Managing 792kg/hh

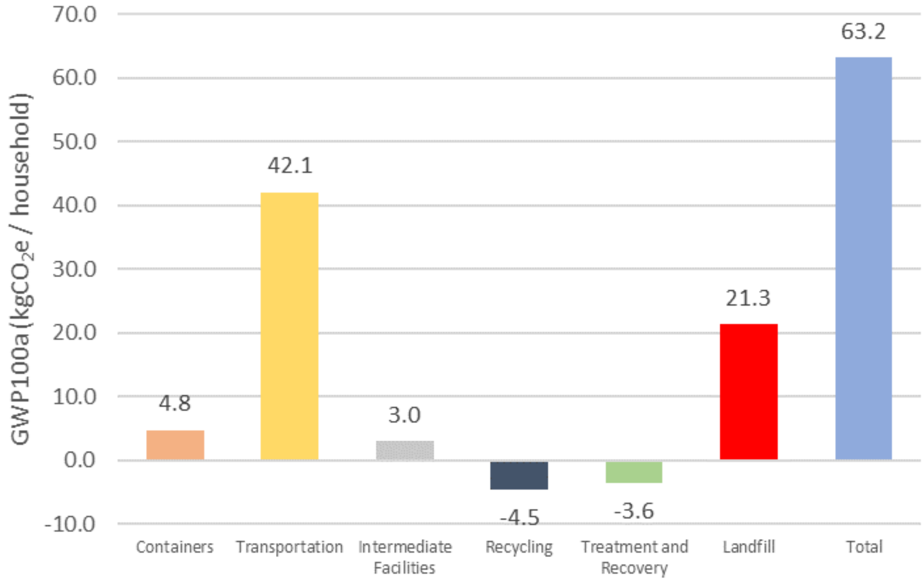


Figure 4-10 shows that for each household there is:

- A small carbon burden of 4.8kgCO_2e associated with the supply of wheelie bins[23].
- A carbon burden of 42.1kgCO_2e associated with transportation.
- A benefit of 4.5kgCO_2e associated with the recycling of IBA from the residual waste that is incinerated and use of compost output from the IVC process for beneficial use offsetting the use of chemical fertilisers.
- A combined benefit of 3.6kgCO_2e associated with treatment and recovery processes comprising a benefit of -10.1kgCO_2e from the treatment of collected residual waste via EfW technology and an impact of 6.6kgCO_2e from the treatment of commingled organic waste via IVC. The IVC process is a net user of energy.
- A burden of 21.3kgCO_2e associated with the disposal of 25% of the residual waste and the APCr from the EfW process to landfill.
- An overall carbon burden of c.63.2kgCO_2e.

4.2.4.2 Summary Conclusions – Brown Bin

The deployment of a 3-bin system and collecting commingled organic waste is shown to result in a significant carbon burden, with transport impacts being the most significant contributing factor to the overall impact associated with this scenario.

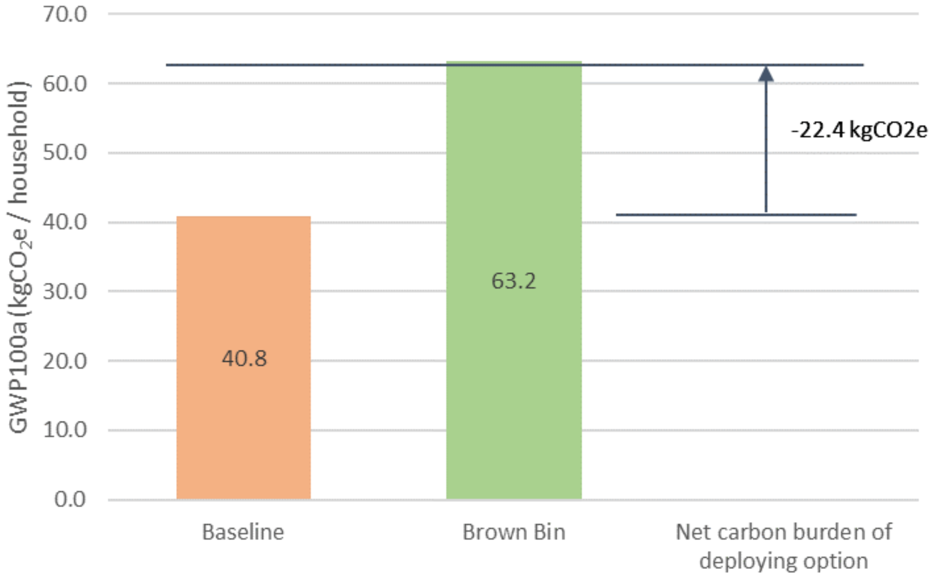
There are however carbon benefits associated with compost use, but these are small in comparison to the overall scenario impacts.

4.2.4.3 The Net Benefit (Comparison of Brown Bin to Baseline)

The results in Figure 4-2 and Figure 4-10 present the carbon impact results of the Baseline and Brown Bin scenarios respectively. Comparison of the carbon impact of the two scenarios results in a net carbon burden of c.22.4kgCO_2e/hh/yr.

[23] Larger containers than the other scenarios.

Figure 4-11: Comparison of Brown Bin to Baseline Showing Net Carbon Burden

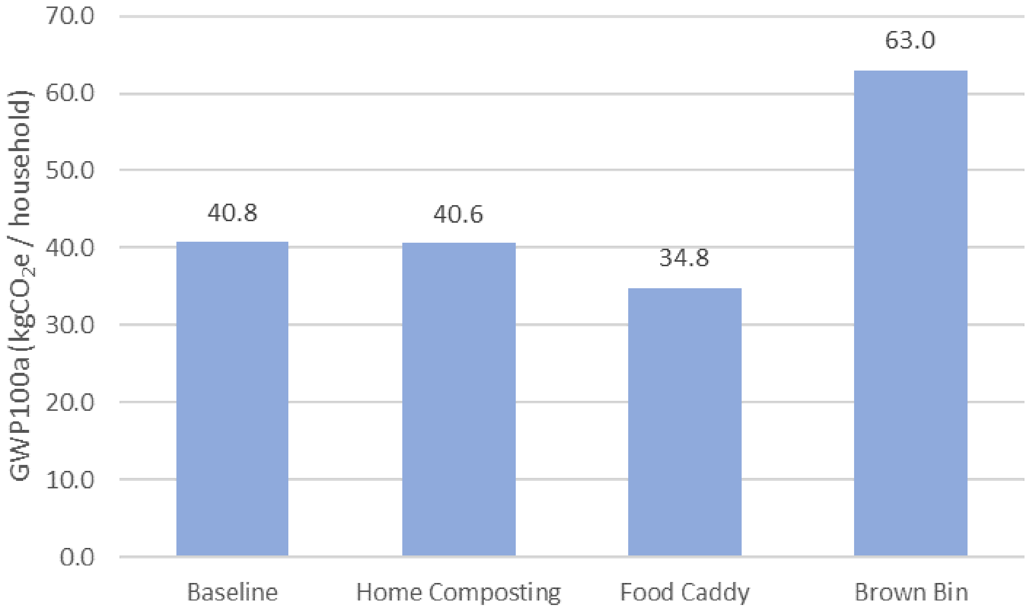


The above demonstrates that roll-out of brown bins to households results in more waste being generated by households – an additional 158kg/hh/yr of waste which results in a significant increase in carbon impacts. In addition to the transport impacts associated with waste collectors transporting more waste, the brown bin scenario is further hampered by the fact that IVC uses energy but does not generate any.

4.2.5 Summary Conclusions

Presented below in Figure 4-12 are the carbon impact results per household ($kgCO_2e/hh/yr$) for the different collection systems in absolute terms.

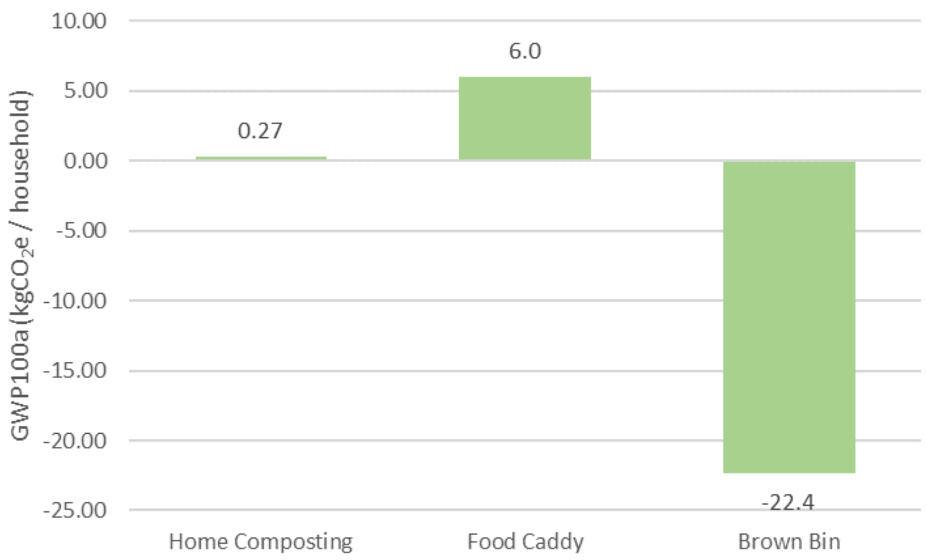
Figure 4-12: Total Carbon Impact Per Household Per Year For All Scenarios



However, it is worth noting that the absolute carbon impact results for each scenario could vary with a different residual MSW composition (i.e. plastics burnt, IBA and metals recycled, etc.), therefore it is useful to compare the absolute results to the baseline, such that the results are only impact above or below the baseline – rather than considering the results in absolute terms (which will take account of processing the non-organic components of the residual waste stream).

Presented below in Figure 4-13 are the net carbon impact results per household ($kgCO_2e/hh/yr$) for the different collection systems relative to the baseline scenario.

Figure 4-13: Net Carbon Benefit Per Household Per Year Relative to Baseline



In summary, it is noted that:

- Within the accuracy of the modelling, the performance of the home composting scenario is at parity with the baseline position of only collecting residual waste and MDR.
- Despite slightly more waste being collected from households, the introduction of a food waste caddy is better still. This is because the food waste that is collected undergoes treatment in an AD facility, generating electricity and heat which can be put to beneficial use, and digestate which can be used as a compost offsetting use of chemical fertilisers.
- The introduction of the brown bin is worse than the baseline position. This is due to:
    - significantly more waste being collected and therefore being transported; and
    - moreover, commingled food and green waste is sent to IVC which consumes energy but does not produce any electricity (unlike AD), although a compost output is produced, offsetting use of chemical fertilisers.
- The brown bin scenario achieves the highest recycling rate, but very clearly has the most negative carbon impact, which shows that pursuing increases in municipal waste recycling rates by collecting more materials is not always the best environmental option in the context of carbon emissions and climate change impacts.

5.0 Economic Assessment

As part of the Brief for this study, SLR was asked to conduct a high-level analysis of the economic cost of the various scenarios. The baseline scenario involves no additional costs, so the exercise just considered the other three scenarios.

5.1 Methodology and Assumptions

The questionnaire that was sent to the IWMA members at the start of the project included questions on costs of various actions that feed into this analysis. The responses were quite varied, so our analysis is based on average data, with outliers removed.

The key costs are considered to be as follows:

- The cost of supplying bins, caddies or home composters to customers in rural areas – these costs can be spread over 10 years.
- The annual cost of providing additional trucks for the brown bin collections.
- The cost of modifying or replacing trucks to allow 3 compartments for brown caddy collections.
- The cost of transfer and treatment of the additional waste collected in each scenario or in the case of the home composting scenario, the reduced costs.

The questionnaire returns suggested that the c.20 IWMA members that responded need to roll out 266,000 new brown bins or brown caddies. Those waste companies represent 88% of the household waste collection market, but they dominate the urban areas. Separate data from the National Waste Collection Permit Office (NWCPO) suggests that about 365,000 houses did not have a brown bin/caddy in Q4 2021. We know that quite a few brown bins/caddies were rolled out in 2022, so we estimate that the number of brown bins/caddies that must be rolled out at the end of 2023 is roughly 350,000.

5.2 Estimated Costs

5.2.1 Supplying Brown Bins

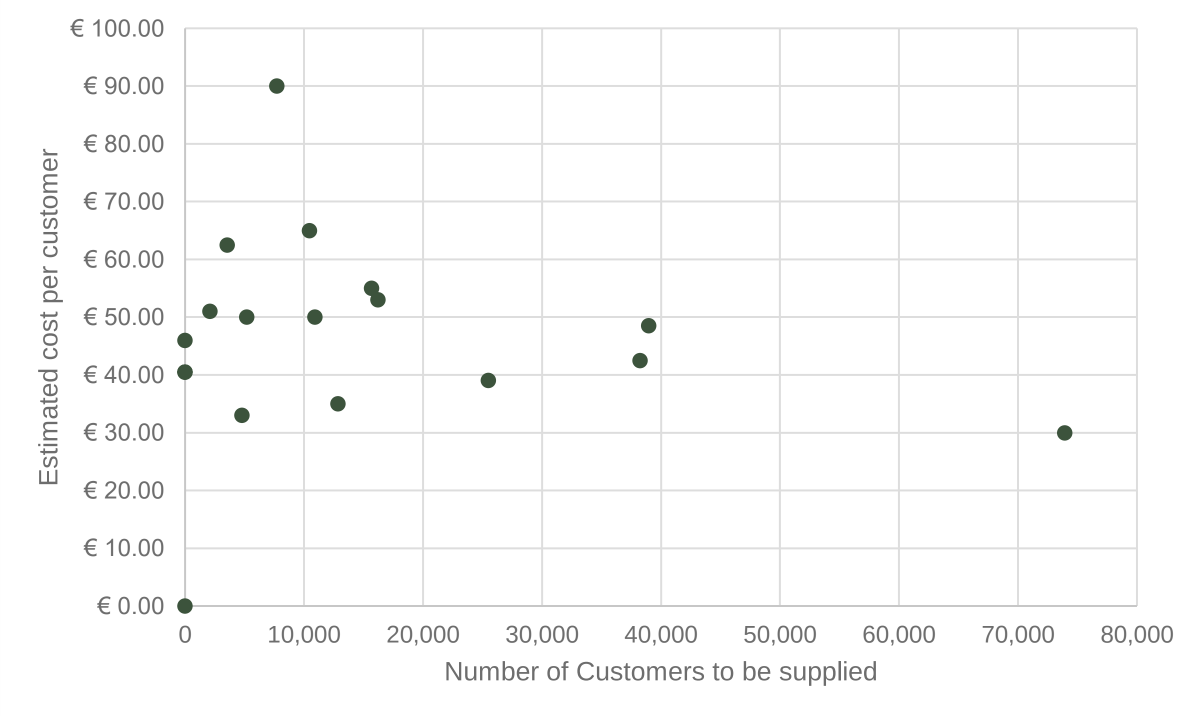
In our questionnaire, we asked the waste companies about the cost of supplying brown bins to their rural customers, as follows:

Please estimate the cost of supplying and delivering new brown wheelie bins and kitchen caddy starter packs to customers that do not currently have brown bins/caddies? Average cost per customer please.

The IWMA has committed to delivering kitchen caddy starter packs to all new customers and those that receive a brown bin or caddy for the first time, so that cost is included also in this analysis.

The responses are graphed below.

Figure 5-1: Cost of Supplying and Delivering New Brown Bins



We considered the €90 figure to be an outlier. The average of the other datapoints was €46 per customer, so we used this figure in our analysis.

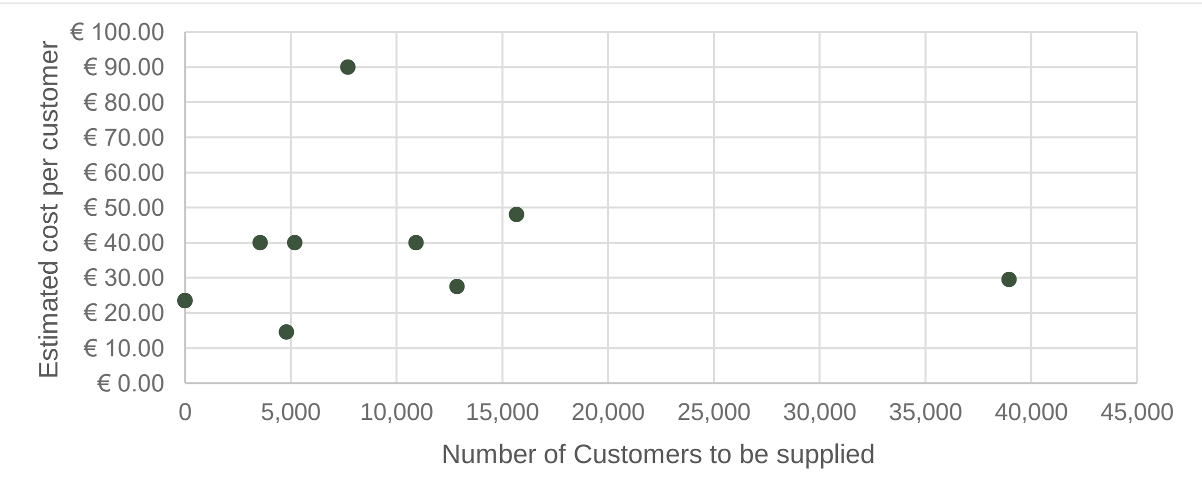
5.2.2 Supplying Brown Caddies

In our questionnaire, we asked the waste companies about the cost of supplying brown caddies to their rural customers, as follows:

Please estimate the cost of supplying and delivering new brown kerbside caddies and kitchen caddy starter packs to customers that do not currently have brown bins/caddies? Average cost per customer please.

The responses are graphed below.

Figure 5-2: Cost of Supplying and Delivering New Brown Caddies



We considered the €90 figure to be an outlier also in this dataset. The average of the other datapoints was €31 per customer, so we used this figure in our analysis.

5.2.3 Supplying Home Composting Bins

In our questionnaire, we asked the waste companies about the cost of supplying home composting Bins to their rural customers, as follows:

Can you provide a cost for supply and delivery of home composters (including kitchen caddy starter pack) to rural customers?

The responses to this question ranged from €60 to €110 for delivery of a single home composting bin. The average cost was €76.

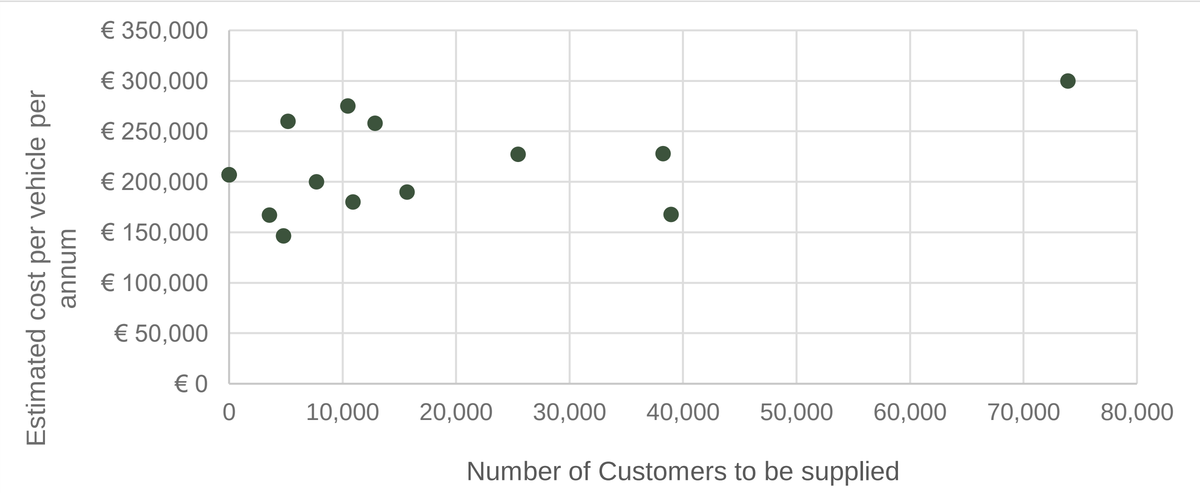
5.2.4 Additional Vehicles and Crews

In our questionnaire, we asked the waste companies about the cost of implementing and operating a new brown bin service for their rural customers, as follows:

Please estimate the annual cost of providing, maintaining and crewing a new vehicle to collect brown wheelie bins from customers that do not currently have brown bins or caddies? Please provide a breakdown of capital costs and operational costs including maintenance, labour, fuel, insurance, etc.

The responses are graphed below.

Figure 5-3: Cost of Providing a New Collection Vehicle and Crew



There were no significant outliers in this dataset. The average of the datapoints was €215,000 (rounded) per vehicle per annum, so we used this figure in our analysis. This includes the cost of fuel, wages, maintenance, insurance, etc, so it is an annual cost, whereby the capital cost of the vehicle has been spread over 7 or 8 years or the vehicles are leased with annual payments.

5.2.5 Three-Way Split Vehicles

For the brown caddy scenario, we need to consider changes to the collection regime and costs associated with that. We assume that the rural areas are generally served by 'two-way' split compartment vehicles where the residual and dry recyclable waste streams are collected simultaneously in two 'side-by-side' compartments. When brown caddies are introduced in rural areas, these collection vehicles can be replaced by specialised vehicles with a longer wheelbase and a food waste pod behind the cab of the vehicle.

The caddies are emptied into a feeder at the back of the truck and the food waste is pumped from there to the pod behind the cab. Figure 5-4 shows how these vehicles are filled with waste.

Figure 5-4: Three Way Split Vehicle in Operation

Data provided, in the response to the SLR questionnaire by an IWMA member with relevant experience, suggests that the additional cost associated with each three-way split vehicle is about €7,000 per annum. This covers the extra capital cost spread over 7 years, additional fuel associated with the pumping action for the food waste and additional maintenance.

As the food waste pod is added to a longer wheelbase vehicle, we are informed that the other two compartments are not reduced in size with the three-way split vehicle, so the vehicle can cover the same routes as before.

Typical capacities of each compartment are as follows:

- 5.7 tonnes – Residual Waste,
- 3.3 tonnes – Mixed Dry Recyclables,
- 1.8 tonnes – Food Waste

Comparing this data with data from rural customers where this system is currently operational, it appears that the food waste pod is the last compartment to fill, so the addition of this pod is unlikely to impact on the capacity of the vehicle to cover existing routes.

The split vehicles can collect from about 400 to 500 houses in a rural route, based on the capacities quoted above and data from a relevant collector using these vehicles. However, with rural routes the travel time to get to the start of the route, the distance between the houses on the route and the travel time to the transfer station are the limiting factors, rather than the fill capacity of the vehicle.

The introduction of the food waste collection reduces the volume of residual waste by about 3% to 4%, based on figures presented earlier in this report, but we do not expect that to have a significant impact on collection efficiencies.

We understand that the food waste caddies can be manually emptied into the vehicle at the same time as the two wheelie bins with MDR and residual waste are mechanically tipped. Therefore, there is no significant delay at each house due to the brown caddy, perhaps a few seconds at each house, which would be about 10 or 15 minutes in total per day or about 2% extra time. So, the reduction in residual waste quantities and the additional time associated with emptying the food waste caddies, more or less, cancel each other out.

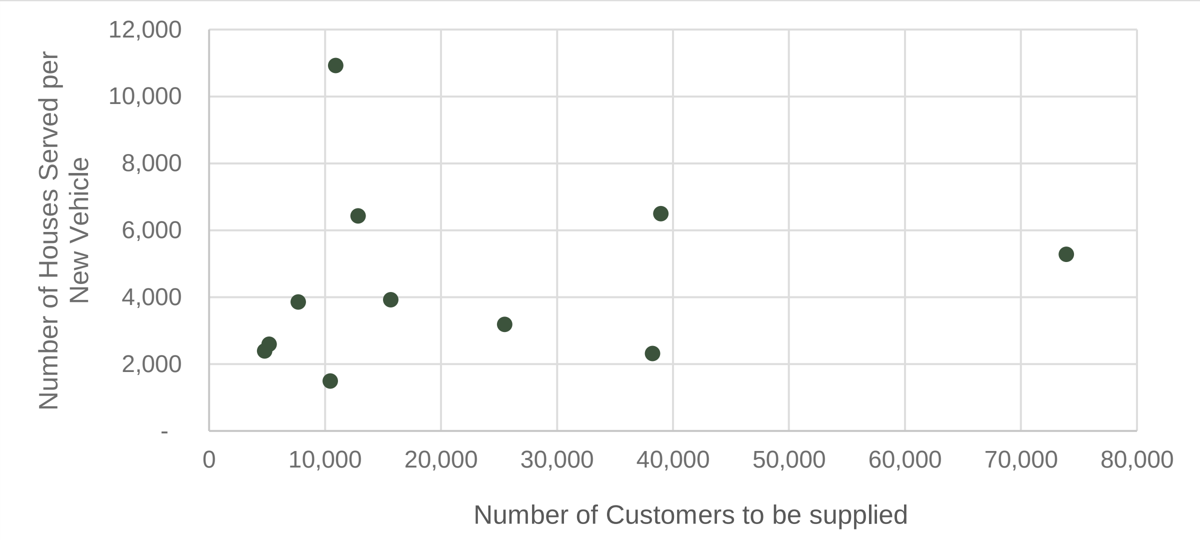
5.2.6 Number of Rural Houses Served per Vehicle

In our questionnaire, we asked the waste companies about the number of rural customers to be served by the new brown bin collection, as follows:

How many new vehicles will you need to provide the brown bin service to customers in rural areas?

The responses are graphed below.

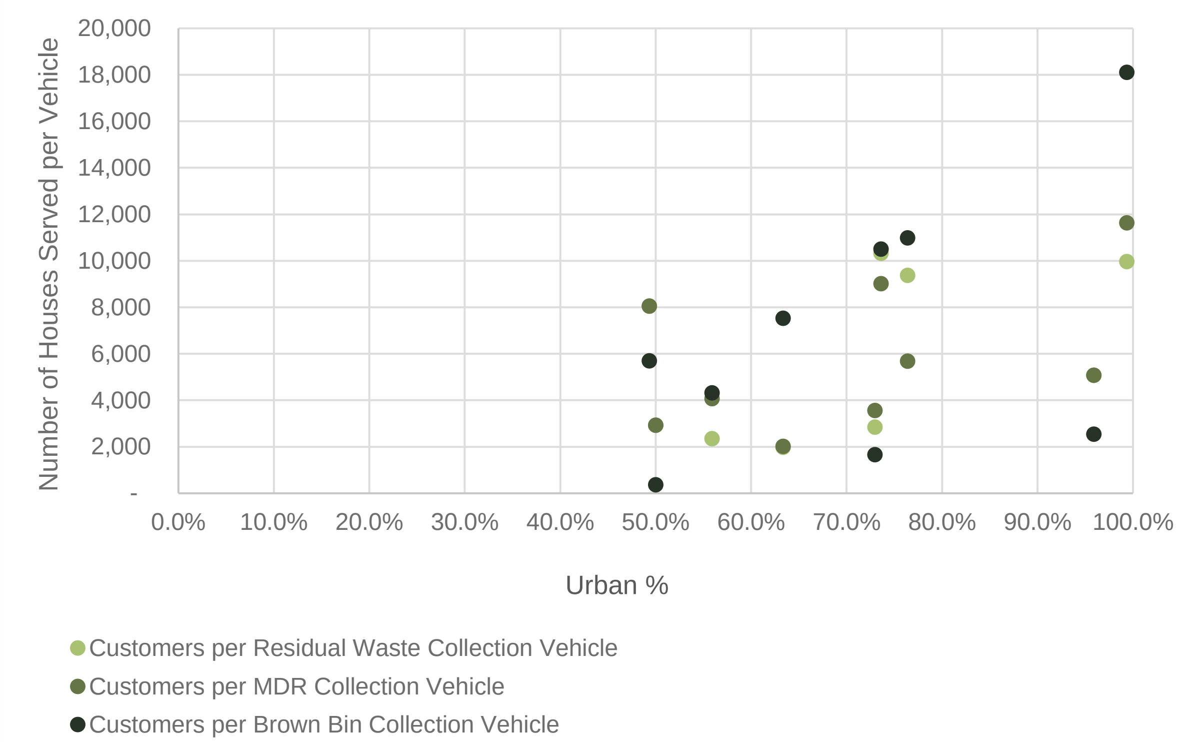
Figure 5-5: Number of Houses Served per New Collection Vehicle



We considered the 10,922 figure to be an outlier in this dataset. The average of the other datapoints was 3,795 households served by each new vehicle, so we used this figure in our analysis.

In order to assess the sensitivity of this assumption, we analysed data in our questionnaire relating to the number of vehicles used to service existing customers. This data is presented below. We excluded collections by companies that rely mostly on brown caddies rather than brown bins, as those collections are not relevant to this section of the report.

Figure 5-6: Number of Houses Served per Existing Collection Vehicle



This data shows quite a wide spread of results as there are a number of variables, including urban vs rural and large company vs small company. There are also split vehicles included in this dataset and our analysis splits the use of those vehicles into the two waste streams that they collect. There are no 3-way split vehicles in this dataset as they relate to brown caddies rather than brown bins.

The data points that show the highest number of houses served relate to the more urban collections, as expected. The figure of 3,795 houses per new vehicle is not inconsistent with the data presented in Figure 5-6 as it relates to rural collections and falls at the lower end of the presented data, as would be expected in rural areas. If anything, it could be considered to be on the high side.

However, the data in Figure 5-6 also suggests that brown bin collection vehicles generally serve more customers than other collection vehicles (collecting residual and MDR streams). This is most likely due to lower presentation rates for brown bins compared with other waste streams. In consideration of this factor, the figure of 3,795 houses served per vehicle fits more comfortably with this dataset.

5.2.7 Transfer and Treatment Costs

Changes in weights of each waste stream from the Baseline scenario to the other scenarios were estimated earlier in this report, based on the questionnaire returns. The projected changes are as follows:

Table 5-1: Changes in Weights per Household from Baseline Scenario

	2-Bin System	+ Home Compost	+ Food Caddy	+ Brown Bin
Residual waste collected (kg/hh/yr)	474	-11	-16	-8
MDR collected (kg/hh/yr)	160	0	0	0
Organic waste collected (kg/hh/yr)	0	0	+77	+166
Combined waste collected per customer (kg/hh/yr)	**634**	**-11**	**+61**	**+158**

We assume the following transfer and treatment costs per tonne on average:

- Residual waste for incineration or landfill: €160 per tonne
- Mixed Dry Recyclables: – not relevant to the study
- Brown Caddy waste for Anaerobic Digestion: €70 per tonne
- Brown Bin waste for Composting: €100 per tonne

Using these ballpark costs, the cost impact per house is estimated in Table 5-2 below.

Table 5-2: Estimated Cost Impact per House for Transfer and Treatment

	+ Home Compost	+ Food Caddy	+ Brown Bin
Residual waste cost impact (€160/t)	- €1.76	- €2.56	- €1.28
MDR cost impact (no change)	€0	€0	€0
Organic waste cost impact (€70/t) AD	€0	+ €5.39	€0
Organic waste cost impact (€100/t) Composting	€0	€0	+ €16.60
Combined waste cost impact	**- €1.76**	**+ €2.83**	**+ €15.32**

5.3 Results and Commentary

Table 5-3 provides the total estimated additional costs for each of the four scenarios considered in this report. This assumes that all waste collectors embrace one scenario when rolling out brown bins or caddies. In reality, each waste collection company will make its own decision on this matter and some decisions will be based on existing systems and infrastructure rather than purely on costs.

Table 5-3: Total Estimated Annual Cost Impact for Each Scenario

Item	Baseline Scenario	Home Composting Scenario	Food Waste Brown Caddy Scenario	Commingled Organics Brown Bin Scenario
Number of Houses to be served	350,000	350,000	350,000	350,000
Cost of supplying bins per house (spread over 10 years or 15 yrs. for home composting bin)	€ 0	€ 5.07	€ 3.10	€ 4.60
Annual cost of one additional vehicle and crew	€ 0	€ 0	€ 7,000	€ 215,000
Houses served by an average vehicle	3,795	3,795	3,795	3,795
Annual cost of additional vehicles and crews per house	€ 0	€ 0	€ 1.84	€ 56.65
Additional Transfer and Treatment Costs per house	€ 0	- € 1.76	€ 2.83	€ 15.32
Total Additional Annual Cost per house	**€ 0**	**€ 3.31**	**€ 7.77**	**€ 76.57**
Total Additional Annual Cost for All 350,000 houses	**€ 0**	**€ 1,157,333**	**€ 2,721,086**	**€ 26,800,722**

The cost of the brown bin scenario is estimated at nearly 10 times the cost of the brown caddy scenario. The need for an additional vehicle to serve rural customers is the biggest factor in this analysis. The responses to our questionnaire suggested that some waste collectors have synergies whereby they will be able to service rural customers with existing brown bin collection vehicles, so their additional costs will be significantly less than projected in this report.

The home composting scenario is clearly the lowest cost, apart from the baseline do-nothing scenario, but does not result in significant improvement to Ireland’s MSW recycling rate.

It should be noted that household waste collection attracts 13.5% VAT.

6.0 Conclusions

In the following sections, we consider each of the four scenarios in terms of MSW recycling rates, carbon impacts and cost implications.

6.1 Baseline Scenario

In the 'Do-Nothing' or 'Baseline' scenario, MSW recycling rates remain constant, there are no new carbon impacts and there are no cost implications. The Baseline scenario is not an option as policy and legislation published by the Irish Government requires the roll-out of brown bins to rural areas.

6.2 Home Composting Scenario

Recycling

In the Home Composting Scenario, the MSW recycling rates increase but are difficult to measure as the organic waste is not collected. Our model suggests that 11kg per house is removed from the residual waste bins to be home composted. In reality, once a householder commences home composting, they are likely to recycle several hundred kg per annum of commingled food and garden organic wastes.

There exists a defined, but complicated, methodology whereby the EPA can count this home composting towards Ireland's MSW recycling rates, so it is possible for that extra recycling to have a significant impact on Ireland's MSW recycling rates.

If 350,000 houses each home composted and average of 250kg per annum of commingled food and garden waste, that would result in 87,500 tonnes of recycled MSW. This is equivalent to 2.73% MSW recycling. It should be noted that the EPA currently allows for 50,000 t/a of home composted organic waste in Ireland's MSW Recycling Rates, so not all of this additional recycling would be added to the National figures.

Carbon Impact

The home composting scenario shows a very small decrease in net carbon emissions compared with the baseline scenario (better off by ~0.3kgCO_2e/hh/yr relative to the baseline), but within the accuracy of the modelling, the results are considered to be at parity. The very small difference in carbon emissions is due to the following:

- The diversion of a small quantity garden waste[24] from residual waste bins resulting in slightly lower emissions from transport, transfer and landfill disposal of this material.
- A small benefit from using the homemade compost to displace soil enhancers and/or fertilisers.
- The composted material emits some methane as it degrades in the garden and this has a small negative carbon impact, whereas the same material used as fuel in EfW performs better as it provides renewable energy to the national grid.

Cost Implications

The cost implications of the home composting scenario are minor with an estimated average additional annual cost of €3.31 per house. This equates to €1,157,333 per annum cost for all 350,000 houses.

[24] In reality both green and food waste would likely be diverted from the residual waste stream, SLR were not advised on what such diversion rate would be for food waste and resultantly the scenario only models diversion of green waste.

A difficulty with this option is that not every rural customer will want to home compost. Some will want a brown bin or food waste caddy and a mix of home composting with the other scenarios would reduce the efficiency of the brown caddy or brown bin collections.

6.3 Food Waste Caddy Scenario

Recycling

Our model suggests that the gross MSW recycling rate for rural houses increases by 8.9% from the baseline scenario (25.2%) to the Food Waste Caddy scenario (34.1%), which is a significant increase. However, it is less than the MSW recycling rate increase associated with the roll-out of larger brown bins (41.2%).

Examination of 2020 data supplied to SLR by the NWCPO shows that one company that extensively uses the brown caddy system achieves a gross MSW recycling rate of 44% nationally, which is not far behind the highest national gross MSW recycling rate of 50%, achieved by a company with an extensive roll-out of 240 litre brown bins. The pattern was very similar in the 2019 NWCPO data, with the brown caddy company achieving 43% gross recycling versus the highest rate of 48%.

Carbon Impact

The food waste caddy scenario performs best in terms of carbon impact when compared against the baseline and the other two scenarios (better off by ~6.0kgCO_2e/hh/yr relative to the baseline). This is due to the following:

- The collection, transfer and treatment of additional quantities of food waste has a higher impact than the baseline and home composting scenarios, but a lower impact than the brown bin scenario.
- The treatment of the food waste in anaerobic digestion plants has a major carbon benefit as it produces renewable energy that displaces the combustion of natural gas, a fossil fuel.
- There is also a carbon benefit from using digestate to displace soil enhancers and/or fertilisers.

Cost Implications

The cost implications of the food caddy scenario are relatively low with an estimated average additional annual cost of €7.77 per house. This equates to €2,721,086 per annum cost for all 350,000 houses.

The modelled cost relies on the use of three-way split vehicles on existing routes that are assumed to be served by two-way split vehicles. We have been assured that the three-way vehicles provide the same capacity as the two-way split vehicles for residual and MDR waste streams, so the existing routes can be maintained. This information has been supplied by a company that has direct experience with that transition from two streams to three streams on rural routes.

The other significant cost relates to the transfer and treatment of additional volumes of collected food waste. We understand that currently in Ireland, AD gate fees for food waste are significantly lower than Compost Plant gate fees for commingled food and garden waste.

The higher demand for AD associated with a major roll-out of food waste caddies could impact on those gate fees if supply exceeds demand. However, the model suggests that 350,000 houses producing 77kg per annum of food waste would generate 26,950 t/a of feedstock for AD plants.

The Huntstown Bioenergy AD plant in Dublin may come on stream in 2024 with a total capacity of c.100,000 t/a, which would ensure continued competitive gate fees for this feedstock. There is some currently available AD capacity in Northern Ireland that could also potentially be utilised. Other AD projects in Ireland have regulatory approvals and could also come on stream in a few years to meet future demand.

6.4 Brown Bin Scenario

Recycling

Our model suggests that the gross MSW recycling rate for rural houses increases by 16% from the baseline scenario (25.2%) to this the Brown Bin scenario (41.2%), which is a very significant increase.

Examination of 2019 and 2020 data supplied to SLR by the NWCPO shows that some companies with extensive collections of large (240L) brown bins achieve gross MSW recycling rates of 40% to 50%. Some companies use smaller brown bins (120L/140L) so the average gross MSW recycling rate for brown bin collections is at the lower end of that range.

The recent extensive roll-out of 240L brown bins across Northern Ireland increased the MSW recycling rate in that jurisdiction from c.40% to c.50%, so the use of large brown bins clearly have a major impact on MSW Recycling Rates. The countries in Europe with the highest MSW recycling rates, such as Germany and Austria rely heavily on the collection and treatment of garden waste, as well as food waste, to boost their recycling rates.

Carbon Impact

The brown bin scenario performs poorly in terms of carbon impact when compared against the baseline and the other two scenarios (worse off by ~22.4kgCO_2e/hh/yr relative to the baseline). This is due to the following:

- The collection, transfer, and treatment of additional quantities of commingled food and garden waste has a significantly higher carbon impact than each of the other scenarios.
- The treatment of the commingled brown bin waste in composting plants generates significant carbon emissions as those plants use energy to move and aerate the material.
- The composted material emits some methane as it degrades in the composting plant and this has a negative carbon impact, whereas the same material used as fuel in EfW performs better as it provides renewable energy to the national grid.
- There is a carbon benefit from using the resulting compost to displace soil enhancers and/or fertilisers, but this benefit is outweighed by the carbon emissions mentioned above.

Cost Implications

The cost implications of the brown bin scenario are high with an estimated average additional annual cost of €76.57 per house. This equates to €26,800,722 per annum cost for all 350,000 houses.

The modelled cost is high as we have assumed that brown bins in rural areas require new vehicles as three-way split vehicles are not commonly used for the collection of three waste streams in three separate wheelie bins.

However, such vehicles are possible, with a side lift for one stream and two lifts at the back for the other two streams, but there would be no compaction on the side. The use of such vehicles could impact on our findings in this regard, but the voluminous nature of brown bin material would reduce the capacity of the vehicle for the other two waste streams, so efficiency would still be significantly reduced from the baseline scenario and costs would be significantly higher.

Some waste collection companies that responded to our questionnaire have indicated that they can collect brown bin material from rural areas using existing vehicles, so these companies will not incur the level of cost increases indicated in our model.

The other significant cost relates to the transfer and treatment of additional volumes of collected brown bin waste. As discussed above, we understand that Compost Plant gate fees for commingled food and garden waste are currently higher than AD gate fees for food waste feedstock.

The cost implications of this scenario could have a further negative impact. If rural dwellers are charged this extra cost plus VAT at 13.5%, there could be a negative reaction leading to a refusal to accept a brown bin or even more concerning withdrawal from the service altogether. That would lead to concerns about illegal dumping and illegal backyard burning.

6.5 Overall Conclusions

The study clearly shows that the Food Caddy Scenario performs much better than the Brown Bin Scenario in terms of carbon impacts and cost implications. However, the Brown Bin scenario performs better in terms of increasing MSW Recycling Rates.

The other two scenarios, Baseline and Home Composting, are not viable options in this jurisdiction as Irish Government policy and legislation requires the roll-out of organic waste collections to rural areas, so householders will be entitled to such a service, even if they home compost their garden waste.

However, it is notable that the Baseline and Home Composting Scenarios perform best in terms of waste prevention with the Food Caddy scenario leading to the collection and treatment of almost 10% additional waste and the Brown Bin scenario leading to the collection and treatment of an additional 25% waste.

As waste prevention sits higher than recycling in the Waste Hierarchy, this is an important observation, but the improved carbon impact associated with the Food Caddy scenario appears to justify the collection of additional food waste. The greater carbon impact associated with the Brown Bin scenario suggests that waste prevention is preferable to recycling in that context.

This study is focussed on carbon emissions and climate change impacts (including benefits). Other LCA parameters, if examined, may prove to be more favourable to the Brown Bin scenario, as returning nutrients to the soil via composting provides a number of environmental benefits and that analysis lies outside the scope of this report.

The study identifies that improvements to MSW recycling rates might not necessarily be the best environmental option in the context of carbon emissions and climate change impacts. Collecting and treating garden waste is a very good way for a country to boost its MSW recycling rate, but this report shows that it has a negative impact in terms of carbon emissions and climate change.

Table 6-1 shows the additional carbon impact per house and for the overall roll-out to rural areas (350,000 households nationally) for each of the four scenarios.

Table 6-1: Estimated Additional Annual Carbon Impact for Each Scenario

	Home Composting Scenario	Food Waste Brown Caddy Scenario	Commingled Organics Brown Bin Scenario
Number of Houses to be served	350,000	350,000	350,000
Annual Additional Carbon Emissions per house (kgCO_2e) Note: minus figure = improvement	-0.27kg	-6.0kg	+22.4kg
Total Annual Additional Carbon Emissions for all houses in Dataset (tCO_2e)	-93t	-2,100t	+7,825t

Appendix A Data Collection Questionnaire

Rural Organic Waste Collection

Questions for IWMA members for Carbon Life Cycle Assessment on Brown Bin Roll Out to Rural Areas

If you have more than 1 household waste collection company in your group, please feel free to submit a return for each company, if that is easier than a single return.
Timeframe - For Q1 and Q2 we are seeking 2022 Calendar Year data.

Q1. Please provide details of your household customers in the following table.
BB = Brown Bin ; BC = Brown Caddy (Kerbside)

	Customer Type	Agglomerations	Bin Types	Number of customers in each category	Size of Residual/ General Waste Bins (Litres)	Size of Mixed Dry Recyclables (MDR) Bins (Litres)	Size of Brown Bins or Caddies (Litres)	Total Annual weight of residual waste collected from these customers (tonnes)	Total Annual weight of Mixed Dry Recyclables collected from these customers (tonnes)	Total Annual weight of organic waste collected from these customers (tonnes)	Number of customers participating in Brown Bin Collections
A	Urban 3-Bin (BB)	More than 500 people	General, MDR, Brown Bin								
B	Urban 3-Bin (BC)	More than 500 people	General, MDR, Brown Caddy								
C	Urban 2-Bin	More than 500 people	General, MDR				not applicable			not applicable	not applicable
D	Rural 3-Bin (BB)	Less than 500 people	General, MDR, Brown Bin								
E	Rural 3-Bin (BC)	Less than 500 people	General, MDR, Brown Caddy								
F	Rural 2-Bin	Less than 500 people	General, MDR				not applicable			not applicable	not applicable

Add rows if necessary

Q2. Travel Distance

	Collection Vehicle Type (for Household Waste Collection only)	Frequency of Collections (weekly, fortnightly, etc.)	Fuel Type	Number of vehicles	Number of Households	Distance Travelled each Year to cover all customers (km)	Quantity of Fuel Used per annum	Unit of Fuel (litres, kWh, etc.)
G	Residual Waste Collections							
H	MDR Collections							
I	Brown Bin Collections							
J	Brown Caddy Collections							
K	Split Residual/Brown Collections							
L	Split Residual/MDR Collections							
M	Split MDR/Brown Collections							
N	3 Way Split Residual/MDR/Brown Collections							

Add rows if necessary

Q3. Please estimate the cost of supplying and delivering new brown wheelie bins and kitchen caddy starter packs to customers that do not currently have brown bins/caddies ? Average cost per customer please.

Q4. Please estimate the cost of supplying and delivering new brown kerbside caddies and kitchen caddy starter packs to customers that do not currently have brown bins/caddies ? Average cost per customer please.

Q5. Please estimate the annual cost of providing, maintaining and crewing a new vehicle to collect brown wheelie bins from customers that do not currently have brown bins or caddies?
Please provide a breakdown of capital costs and operational costs including maintenance, labour, fuel, insurance, etc.

Q6. Please estimate the annual cost of providing, maintaining and crewing a new vehicle to collect brown kerbside caddies from customers that do not currently have brown bins or caddies?
Please provide a breakdown of capital costs and operational costs including maintenance, labour, fuel, insurance, etc.

Q7. How many new vehicles will you need to provide the brown bin service to customers in rural areas?

Q8. Do you plan to use split vehicles to collect brown bin or caddies from customers that do not currently have brown bins or caddies? Please specify.

Q9. Please estimate the total additional distance annually that your collection vehicles will need to travel to provide a brown bin service to all your household customers and explain the logic behind your calculations?

Q10. Do you know how many of your customers have home composters? If so, please provide your estimate.

Q11. Can you provide any data on customers that home compost - for example do you have before and after data from customers that were supplied with home composters that shows a reduction in weights in the collected bins after the home composter was delivered?

Q12. Can you provide a cost for supply and delivery of home composters to rural customers - either to one customer, a group of customers or all rural customers not already served with a brown bin collection (or the cost of all 3 options if possible)?

Q13. Please provide details on Fuel and Energy used at your transfer stations that accept household bins (include all that you operate)

Name of Transfer Station	EPA or Local Authority Ref	Total Waste Processed or Transferred in 2022	Electricity Consumption in 2022	Site Diesel Consumption in 2022	Any Other Fuel Consumption in 2022 (please specify)	Estimated Unit Cost of Electricity Currently	Estimated Unit Cost of Diesel Currently	Estimated Unit Cost of Other Fuel Currently (if relevant)

If 2022 data is unavailable, please provide data from the latest available year.
Add rows if necessary

Q14. How far do you (or your haulier) travel from your WTS to your main outlet for residual household waste treatment? (please specify the outlet and the distance)

Q15. How far do you (or your haulier) travel from your WTS to your main outlet for Mixed Dry Recyclables? (please specify the outlet and the distance)

Q16. How far do you (or your haulier) travel from your WTS to your main outlet for biowaste treatment? (please specify the outlet and the distance)

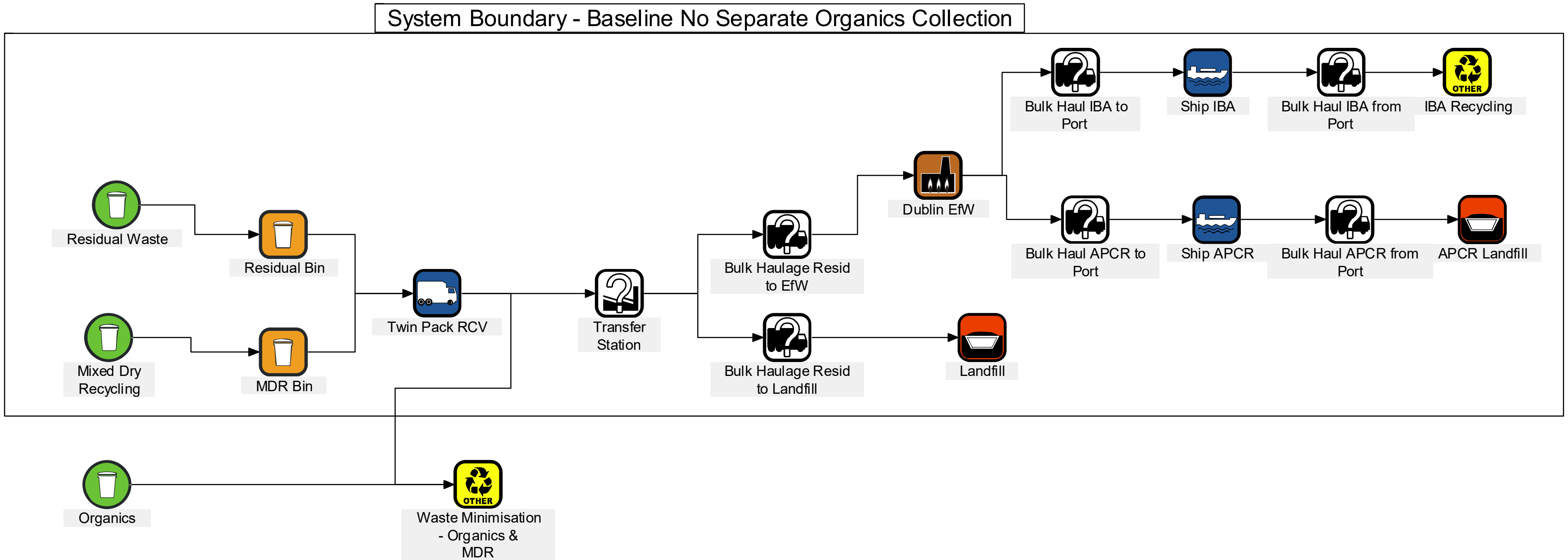
Assumptions:
For the purpose of this study, we are making the assumption that garden waste or mixtures of food/garden waste must be processed at composting plants, not at AD plants.
We are aware that some IWMA Members have plans for pre-processing of mixed food and garden waste prior to AD.
However, that scenario is as yet unproven and cannot be modelled at this time as there is a lack of data around both the pre-processing and the carbon impact of the AD treatment of this feedstock.
Such a scenario can be considered in the future when it is proven and data is available for analysis and inclusion.

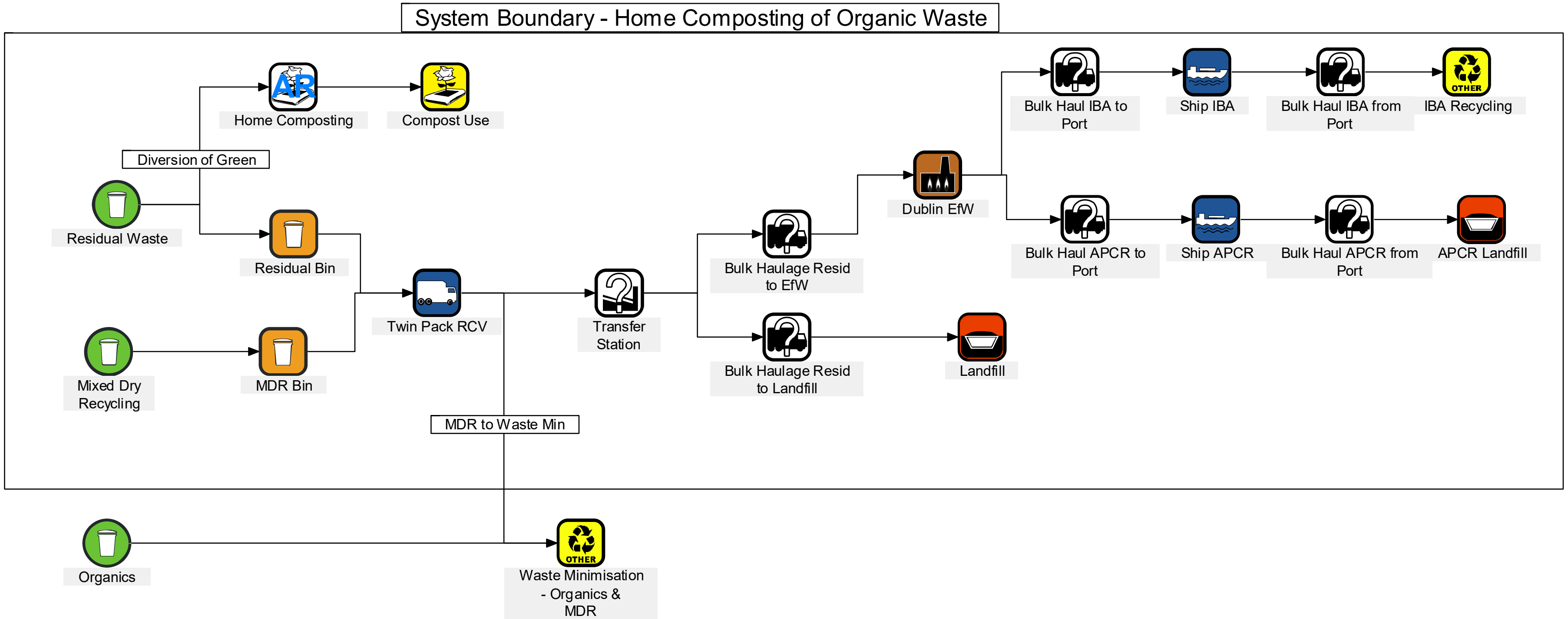
We are also making the assumption that vehicles used for the collection of brown bins in rural areas in the near future will be powered by conventional fuel (diesel).
The use of other fuels in the future is highly likely, but we cannot at this point predict the type of fuel or the likely timeframe for the introduction of alternatives to diesel.

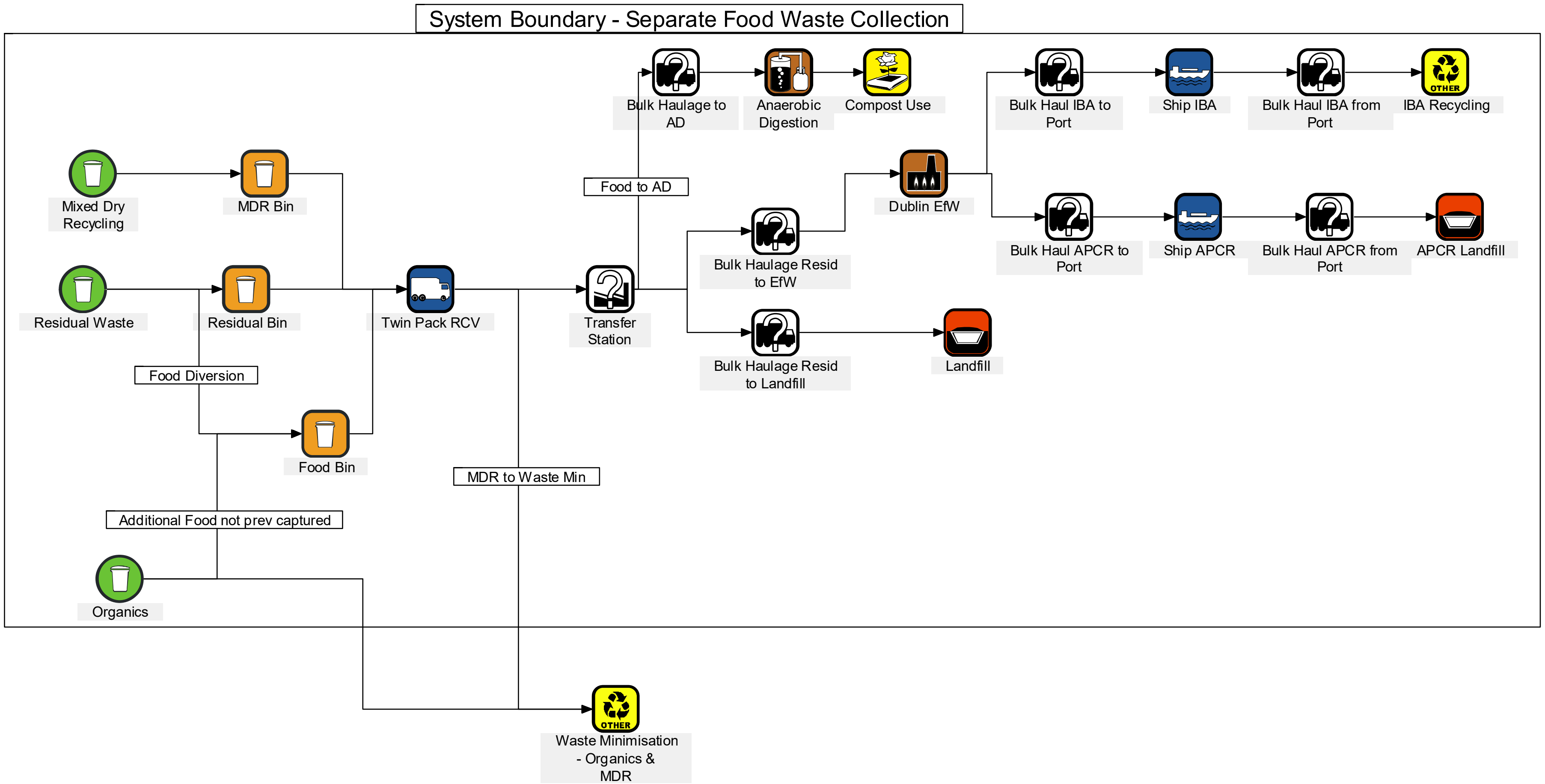
Appendix B WRATE Scenario Maps

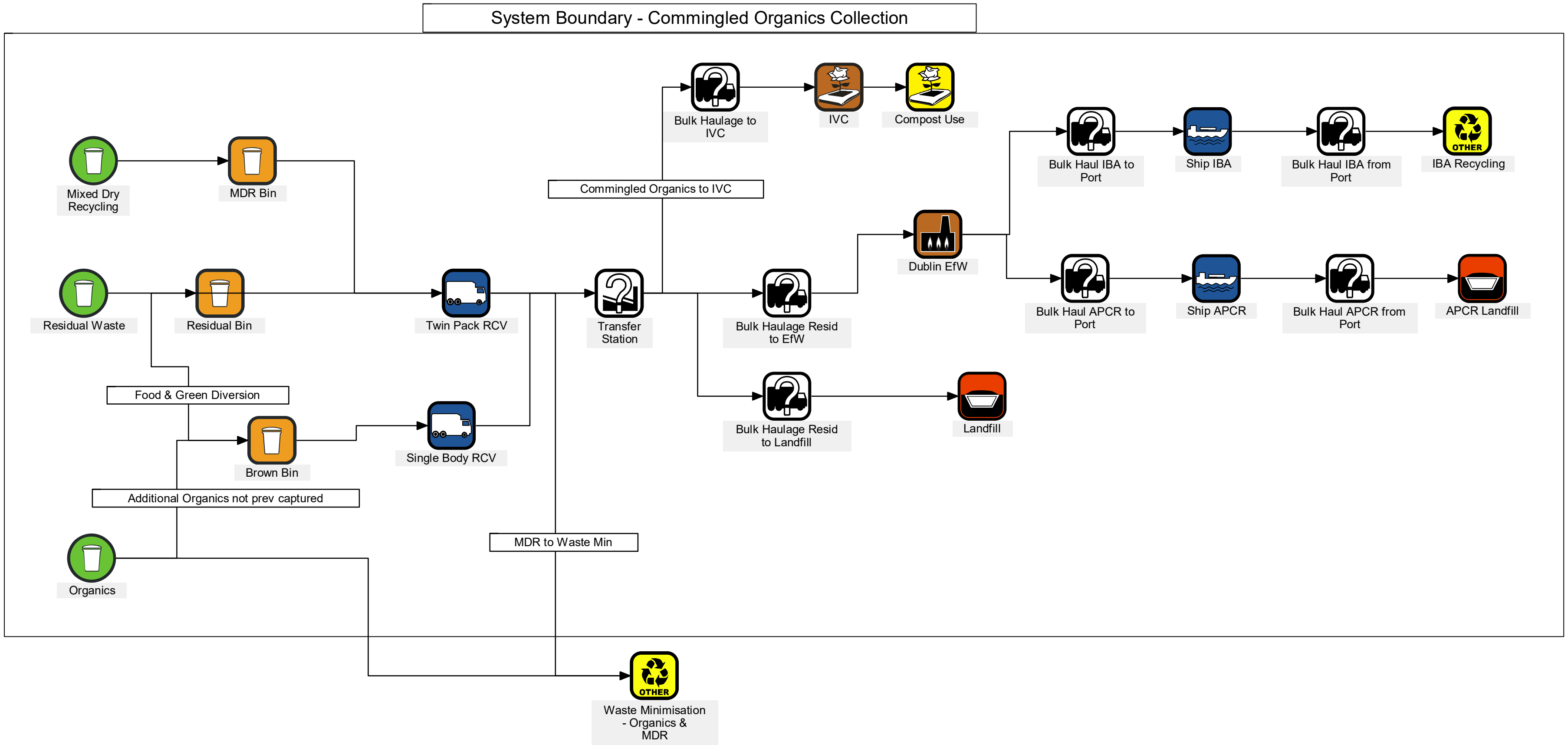
Rural Organic Waste Collection

SLR


System Boundary - Baseline No Separate Organics Collection
Residual Waste
Residual Bin
Mixed Dry Recycling
MDR Bin
Twin Pack RCV
Transfer Station
Bulk Haulage Resid to EfW
Bulk Haulage Resid to Landfill
Landfill
Dublin EfW
Bulk Haul IBA to Port
Ship IBA
Bulk Haul IBA from Port
IBA Recycling
Bulk Haul APCR to Port
Ship APCR
Bulk Haul APCR from Port
APCR Landfill
Organics
Waste Minimisation - Organics & MDR


System Boundary - Home Composting of Organic Waste
Home Composting
Compost Use
Diversion of Green
Residual Waste
Residual Bin
Twin Pack RCV
Transfer Station
Bulk Haulage Resid to EfW
Dublin EfW
Bulk Haul IBA to Port
Ship IBA
Bulk Haul IBA from Port
IBA Recycling
Bulk Haul APCR to Port
Ship APCR
Bulk Haul APCR from Port
APCR Landfill
Bulk Haulage Resid to Landfill
Landfill
Mixed Dry Recycling
MDR Bin
MDR to Waste Min
Organics
Waste Minimisation - Organics & MDR


System Boundary - Separate Food Waste Collection
Bulk Haulage to AD
Anaerobic Digestion
Compost Use
Bulk Haul IBA to Port
Ship IBA
Bulk Haul IBA from Port
IBA Recycling
Mixed Dry Recycling
MDR Bin
Food to AD
Dublin EfW
Bulk Haulage Resid to EfW
Bulk Haul APCR to Port
Ship APCR
Bulk Haul APCR from Port
APCR Landfill
Residual Waste
Residual Bin
Twin Pack RCV
Transfer Station
Bulk Haulage Resid to Landfill
Landfill
Food Diversion
Food Bin
MDR to Waste Min
Additional Food not prev captured
Organics
Waste Minimisation - Organics & MDR


System Boundary - Commingled Organics Collection
Mixed Dry Recycling
MDR Bin
Residual Waste
Residual Bin
Twin Pack RCV
Transfer Station
Food & Green Diversion
Brown Bin
Single Body RCV
Additional Organics not prev captured
Organics
MDR to Waste Min
Waste Minimisation - Organics & MDR
Commingled Organics to IVC
Bulk Haulage to IVC
IVC
Compost Use
Bulk Haulage Resid to EfW
Dublin EfW
Bulk Haulage Resid to Landfill
Landfill
Bulk Haul IBA to Port
Ship IBA
Bulk Haul IBA from Port
IBA Recycling
Bulk Haul APCR to Port
Ship APCR
Bulk Haul APCR from Port
APCR Landfill

Making Sustainability Happen