APPENDIX FOUR c

DEVELOPMENT OF A CO_2eq EMISSIONS PERFORMANCE STANDARD FOR THE MANAGEMENT OF LONDON'S MUNICIPAL WASTE

Development of a Greenhouse Gas Emissions Performance Standard for London's Municipal Waste: Revised Appendices

The Greater London Authority

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Acknowledgements

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Contents

A.1.0 Emissions from Transport of Waste

A.1.1 Determination of System Boundaries

It is first important to determine relevant system boundaries for the inclusion of emissions from transport of waste. The principle for determination of these boundaries is set out in the latest version (at the time of writing) of the London Plan.[1] Paragraph 5.73 of this states that for the purposes of meeting self-sufficiency, waste is deemed to be 'managed' in London if:

1. It is used in London for energy recovery (including incineration, gasification and AD,);
2. It is sorted or bulked in London material recycling facilities for reprocessing, composting or AD either in London or elsewhere; and
3. It is solid recovered fuel (SRF) produced in London.[2]

As a result, the following transport movements which take place after these waste streams have effectively been 'managed' within London, have been excluded from the calculation of transport emissions within the EPS:

- Bottom ash from incineration or slag from gasification facilities, which is sent to landfill;
- Recyclable materials from thermal treatment and MBT facilities, which are sent for reprocessing;
- SRF produced at MBT facilities within London (which meets Renewable Obligation (RO) criteria);
- Bulked recyclable materials from either a MRF or transfer station, which are sent for reprocessing (even if this takes place overseas); and
- Bulked food and garden waste from a transfer station, which is sent to AD or composting facilities.

A.1.2 Approach to Determining Transport Distances

The peer review of this study, undertaken by Ove Arup & Partners (Arup) on behalf of the GLA, recommends that the modelling of transport emissions should follow the approach taken within the Scottish Carbon Metric (SCM).[3] The SCM does not, however, clearly split collection (from the kerbside) from onward transport of waste,

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[1] Mayor of London (2011) The London Plan: Spatial Development Strategy for Greater London – Consultation Draft Replacement Plan, October 2009

[2] Provided the SRF is a 'biomass fuel' as defined in the current Renewable Obligation (RO) Order

[3] Zero Waste Scotland (2011) The Scottish Carbon Metric, March 2011

i.e. from a transfer station to a thermal treatment facility or landfill. In London, however, there is a significant split between these two transport activities, i.e. specific collection vehicles pick up both residual waste and source-separated materials from the kerbside whilst larger vehicles, usually Heavy Goods Vehicles (HGVs), are used for onward transfer of bulked loads. As the emissions associated with these different vehicles is significantly different, it is therefore sensible to adopt an approach which takes into consideration this split. Assumptions for collection rounds are therefore detailed in Section A.1.3, whilst those for onward transport are provided in Section A.1.4.

A.1.3 Distances Modelled for Kerbside Collection of Waste

For collection of waste from the kerbside, based on our knowledge of collection rounds in London, we have modelled an average distance of 29km, rather than the 25km assumed for Scotland. For recyclable materials, we have assumed that 80% are collected as co-mingled and sent to a MRF, and 20% as source separated, which are sent to a transfer station.

Table 1: Assumed Transport Distances for Kerbside Collection (prior to Bulking)

Material	Road Transport Vehicle	Payload (tonnes)	Destination	Average Distance of Round (km)
Residual Waste	26 tonne RCV	12	Transfer Station	29
Dry Recyclables	Kerbside Spilt Body RCV[1]	11	Transfer Station	29
	26 tonne RCV	12	MRF	29
Organics (Green and Food wastes)	26 tonne RCV	12	Transfer Station	29

Notes:

1. WRATE has very similar fuel consumptions for a wide range of waste collection vehicles irrespective of payload, and as such the environmental impact reported is not a true reflection of a vehicle's emissions. Our experience of actual fuel consumption of kerbside-sort vehicles suggests that, of those included in WRATE, the chosen vehicle is the closest match to the true impact from such a vehicle

A.1.4 Distances Modelled for Onward Transport of Wastes

In contrast to the very 'raw' approach used in the Scottish Carbon Metric, we have determined the distances associated with the onward transport of waste via analysis of WasteDataFlow (WDF), which records the final destination of all collected residual waste. Using basic GIS, we have determined the distances (from a central point) within each London Borough and WA to each corresponding waste management facility, i.e. landfill or incinerator. This process was undertaken for each mode of transport, i.e. road, rail and water. A weighted average for each mode of transport was then determined by modelling the distances alongside the tonnes of waste involved in each route. The results of this process are summarised in Table 2.

Table 2: Summary of Assumed Transport Distances for Onward Transport

Material[1]	Transport Method	Destination	Proportion (%)	Average Round Trip Distance (km)
Residual Waste	Road (HGV)	Landfill	27%	72
	Road (HGV)	Thermal Plant	28%	18
	Road (HGV)	MBT	9%	32
	Rail	Landfill	20%	166
	Water (Barge)	Landfill	16%	38
Rejects or Stabilised Waste from Pre-treatment (i.e. autoclave or MBT) Facilities	Road (HGV)	Landfill	n/a	72
Solid Recovered Fuel (which does not meet RO criteria)	Road (HGV)	Thermal Plant	n/a	100

Notes:

1. As detailed in Section A.1.4, all onward transport of materials for reprocessing and food and green waste for composting or AD is outside the system boundaries of the EPS

A.1.5 Emissions Factors for Transportation Activities

All emissions factors for different vehicle types (both for collection and onward transport) have been taken directly from WRATE. These are summarised in Table 3 both in terms of emissions per 'tonne.km' and total emissions, i.e. unit emissions multiplied by distance.

Table 3: Emissions Factors used for Transportation Activities

Material / Journey	Road Transport Vehicle	Destination	Emissions ($kgCO_2$/ tonne.km)	Total Emissions ($kgCO_2$/tonne per round-trip)
Kerbside collection of Residual Waste	26 tonne Refuse Collection Vehicle	Bulking	0.27	7.83
Kerbside collection of Dry Recyclables	Kerbside Spilt Body RCV	Bulking	0.36	10.44
	26 tonne Refuse Collection Vehicle	MRF	0.27	7.83
Kerbside collection of Organics (Green and Food wastes)	26 tonne Refuse Collection Vehicle	Bulking	0.27	7.83
Onward transport of Residual Waste	Road (HGV)	Landfill	0.22	15.84
	Road (HGV)	Thermal Plant	0.22	3.83
	Road (HGV)	MBT	0.22	7.04
	Rail	Landfill	0.02	3.34
	Water (Barge)	Landfill	0.03	1.15
Rejects or Stabilised Waste from Pre-treatment (i.e. autoclave or MBT) Facilities	Road (HGV)	Landfill	0.22	15.84
Solid Recovered Fuel (which does not meet RO criteria)	Road (HGV)	Landfill	0.22	22

A.2.0 Capture Rates for Alternative Scenarios

All assumptions relating to capture rates for the core scenarios modelled both for this study and the associated economics report undertaken by Eunomia on behalf of the GLA have been developed using data published by WRAP.[4] The peer review undertaken by Arup highlights that these capture rates, although being the most current at the time at which Eunomia developed the EPS, have now been updated by WRAP to include information from Wales and Scotland. Arup does not recommend, however, that the EPS is immediately updated to take these into consideration.

In addition to the core scenarios, as described in Section 3.3.1 of the Main Report, we have modelled two alternative scenarios to demonstrate the impact on performance against the EPS of focusing either on 'higher' or 'lower' impact materials. Table 4 summarises the capture rates assumed, which are based on schemes being operated in the UK and Europe. These captures are achievable, albeit ambitious, but serve to illustrate the impact on the EPS of the combination of material collected.

Table 4: Capture Rates for Alternative Scenarios (2015)

Material	Focus on 'Higher CO_2 Impact' Materials	Focus on 'Lower CO_2 Impact' Materials
Paper / Card	32%	59%
Glass	20%	80%
Metals (ferrous)	90%	50%
Metals (non-ferrous)	90%	85%
Plastics	90%	14%
Textiles	90%	11%
Wood	16%	50%
Organics (food and garden)	25%	77%

[4] WRAP (2009) *Analysis of kerbside dry recycling performance in England 2007/08,* available at: http://www.wrap.org.uk/local_authorities/research_guidance/collections_recycling/benchmarking.html

A.3.0 Indicative Residual Waste Compositions

Table 5 provides a summary of the residual waste compositions used in the modelling for the EPS, following 25%, 45%, 50% and 60% levels of recycling or composting. It should be noted that the percentage of some materials increases along with the level of recycling. This is because their concentration increases *relative* to other materials, a greater amount of which might be collected to achieve a particular level of recycling.

It should also be noted that the compositions provided in Table 5 are indicative only, and that such levels of recycling may result in many other compositions, depending upon which materials are collected for recycling or composting.

Table 5: Composition of Residual Waste at Different Levels of Recycling

	Recycling / composting rate				Net CV (MJ/kg)[1]
	25%	45%	50%	60%	
Paper / Card	20%	11%	13%	12%	11.35
Plastic Film	5%	7%	8%	10%	21.28
Dense Plastic	7%	4%	8%	8%	23.07
Textiles	4%	4%	4%	5%	14.30
Disposable Nappies	4%	5%	6%	7%	5.53
Wood	3%	2%	3%	3%	16.84
Misc. Combustible	4%	5%	6%	7%	14.06
Misc. Non-Combustible	5%	6%	6%	8%	2.57
Glass	4%	4%	5%	5%	1.50
Putrescibles	36%	45%	34%	28%	3.52
Ferrous	6%	4%	5%	5%	0
Non-Ferrous	1%	1%	1%	1%	0
Fines	2%	2%	2%	2%	3.47

Notes:

1. WRATE default values

A.4.0 Calculating the Carbon Intensity 'Floor'

A.4.1 Using WRATE Outputs within a Bespoke Model

WRATE is a life-cycle assessment (LCA) tool which considers the environmental impact of waste management processes against a set of assessment criteria such as 'Global Warming Potential' (GWP). The type and amount of energy generated by a waste management technology has an important influence upon the results of such assessments. However, 'energy generation' cannot in isolation be considered as a 'lifecycle method'. WRATE therefore presents only a relatively limited amount of information with regard to the energy generation associated with the different elements of waste management processes.

In addition, the calculation of the carbon intensity 'floor' (CIF) requires a more detailed consideration of energy impacts over much narrower system boundaries than those used within the life cycle approach taken by WRATE. Thus, whilst WRATE considers impacts associated with treating one tonne of waste across the entire treatment process, the carbon intensity 'floor' requires a consideration of impacts associated with energy generation in isolation from the rest of the waste treatment process.

WRATE presents information associated with the environmental impacts of waste treatment systems in two ways:

1. *Headline Results*: This includes some information on key environmental aspects beyond that provided within the results of the LCA, such as energy generation and the land-take of facilities. Impacts are aggregated across the whole of the waste system. The headline results associated with a particular MBT process, for example, therefore will include impacts associated with pre-treatment, combustion and landfill; and

2. *Detailed Results*: This gives a breakdown of results with regard to each of the LCA criteria. Here, some information is provided for the different elements of the waste system, such as, for example, the pre-treatment and landfill elements associated with treatment of waste via MBT.

Information with regard to energy generation is only provided in the *Headline Results* section of WRATE, which presents the *total* energy generation associated with each waste management system, expressed in MegaJoules (MJ). There are several difficulties associated with this approach as follows:

- Where combined heat and power (CHP) is generated, the reporting of electricity and heat generation is combined;
- Whilst the breakdown of results produced as part of the GWP assessment makes it possible to determine energy generation impacts associated with the landfill and incineration stages of an MBT process, WRATE neither separately identifies the GHG emissions offsets associated with electricity and heat impacts for CHP facilities nor does it directly present assumptions for carbon intensity of either heat or electricity;
- For mechanical-biological treatment (MBT) scenarios, it is not possible to

separately identify the electricity generation that occurs through the combustion or gasification of solid recovered fuel (SRF) produced by the facility, as distinct from that which occurs at the landfill (via gas engines to processing captured methane) where the stabilised residues are sent; and

- Whilst the efficiency of generation is presented for incineration, this is not the case for gasification facilities, albeit these can be deduced from information contained within the process model.

It is therefore not possible to calculate performance against the carbon intensity 'floor' *directly* within WRATE as currently designed. As a result, for the purposes of this study, Eunomia developed a separate, bespoke model using the data and assumptions contained within WRATE using the following approach:

- Waste characteristics data contained within WRATE was used to calculate the calorific value (CV) of the input waste (whether untreated or treated), the carbon content and the proportion of the calorific value that is from biomass;[5]
- Characteristics data was combined with the efficiencies of generation to calculate the quantities of energy generated;
- Assumptions within WRATE regarding the carbon intensity of the avoided electricity and heat generation from combined cycle gas turbine plant (as the assumed 'marginal' source of energy) were deduced from the calorific value of the feedstock and the avoided emissions given in the 'energy output' column in WRATE within the GWP assessment;[6] and
- The CIF includes impacts associated with fossil CO_2 emissions from the energy generation process, emissions associated with energy use at the incinerator or gasifier (the 'parasitic load'), and any avoided emissions associated with heat generation.[7] These impacts are expressed in terms of g CO_2 equivalent per kilowatt hour (gCO2/KWh) of electricity generated.

A.4.2 Methodology for Inclusion of Heat

The potential use of heat use is included in modeling of performance against the CIF according to the following rationale:

- The starting point is to determine the nature of the heat that any heat generation by waste facilities would be displacing, i.e. what type of heat, in terms of temperatures and pressures, needs to be generated? For the

[5] WRATE attributes the same characteristics (expressed in terms of the dry matter content of the material) to both the SRF from MBT facilities and the fibre produced from autoclave plant.

[6] The energy output column in WRATE gives the total CO_2 emissions avoided through energy generation at the plant.

[7] WRATE also includes impacts associated with the construction and operation of the energy generation facility. As detailed in the Main Report, these are considered outside the system boundaries of the carbon intensity 'floor' for energy generation. These impacts are, however, included within the whole system EPS

calculations used in Tables 4-1 and 4-2 in the Main Report, we have assumed that household space heat is displaced. For each MWh provided, therefore, we have assumed the displacement of domestic gas boilers (which we have modelled have a carbon intensity of 240 gCO_2/KWh thermal);

- The impact of this heat provision on electrical output / efficiency depends upon how well the relevant generation turbines are designed and the level of integration between heat and electrical provision. To provide household heat, we have assumed that when heat demand is 100% of the design basis, electrical efficiency (of incineration in CHP mode) is reduced to 15%;
- However, we have assumed that heat demand is only present 60% of the time (or put another way, that the system has been designed to be 'available' to provide heat 60% of the time), which is based upon 14.5 hours/day 'availability' for 365 days/annum). Therefore, at times when heat is not 'available', we have assumed that steam can be diverted back into electricity generation (albeit this is unlikely to be the case for older plant), which we have assumed gives 19% overall electrical efficiency;
- In the example in Table 3-1 in the EPS report, heat 'efficiency' for incineration is expressed as 30%. This is effectively stating that 30% of the total energy (CV) input to the plant is used to generate heat.

A.4.3 Step-by-Step Guide to Calculating Performance against the CIF

To calculate performance against the CIF, the following steps should be taken:

1. Using an estimated residual composition for London, the starting point is to take the following chemical analysis data from WRATE for each of the 16 composition categories (i.e. paper, plastic film, organic, etc):
   - Net CV;
   - Carbon content; and
   - Proportion of total carbon which is 'biogenic'.
2. Direct emissions from the process are calculated by multiplying the quantity (i.e. weight) of each element within the composition by the fossil carbon content (derived from total carbon content minus the biogenic content) for each composition element;
3. The energy content of the input composition is calculated by multiplying the WRATE data on Net CV by the composition data which is then converted to kWh. This is then multiplied by the efficiency of generation to get the amount of electricity generated (electrical generation efficiencies are gross figures). This is then multiplied by the assumed electricity source which is displaced, which in the revised EPS Study is 400 gCO_2/kWh;
4. Emissions from energy use at the energy generating plant are drawn from WRATE, albeit the default values have been amended for greater accuracy. As detailed within Section 3.1.2 of the Main Report, it should be noted that emissions calculations for the CIF include only direct emissions from the thermal treatment process and those associated with energy use (fuel oil

and electricity) in the process due to the narrower system boundaries set for this standard, i.e. emissions from pre-treatment processes are excluded);

5. Any heat generation (and use) is included in the final EPS calculation as an 'offset' as described in Section A.4.2;
6. The Final Calculation can therefore be summarised as:

[Direct Emissions + Energy Use Emissions – Heat Offset] \ [Electricity Generated]

A.5.0 Considerations Associated with WRATE

A.5.1 Limitations of WRATE

Wherever possible, WRATE considers the environmental impacts of facilities based on actual data obtained from facilities currently operating in the UK. Many of the process models with WRATE, however, contain both information extrapolated from operating facilities and theoretical values supplied by literature sources to fill the gaps that exist.

The tool offers the user some flexibility in the modelling process. Those holding an 'expert' license for the software - Eunomia is one such holder - can modify much of the data contained within the models of individual treatment processes through the creation of so-called 'user defined' processes (UDPs). In many cases it is also possible to create new bespoke models of processes not already included within WRATE. Thus, although the existing 'standard' version of the software does not include process models of some advanced energy generation technologies, such as the use of syngas in a gas engine and the upgrading of biogas (such as would be required prior to its use as a vehicle fuel), the user defined aspects of WRATE allow the standard models to be modified to a significant extent. For example, modifications can be made to generation efficiencies and the choice of energy offsets. This effectively allows for the creation of UDPs that more closely reflect the performance of the advanced treatment technologies.

It is not, however, possible to make changes to the landfill module with WRATE – this forms a part of the background database, and modification of this data is not possible even for 'expert' license holders. Eunomia believes that this presents some limitations to the tool as WRATE currently significantly underestimates the amount of methane emissions that result from the degradation of most wastes sent to landfill; for example, the emission of methane assumed to occur over 150 years from landfilled food waste and paper is about half of what we would expect even given the same landfill gas capture rate (currently fixed at 75% in WRATE).

Further issues occur in the tool's treatment of the 'stabilised' output from MBT facilities. The model assumes that a proportion of the carbon is degraded within the biological part of the MBT process. However, when this stabilised material is subsequently landfilled, the methane emission is assumed to be exactly the same as that of untreated wastes - WRATE only accounts for the reduction in mass which occurs in material which is biologically pre-treated (occurring as a result of moisture loss). The model, therefore, significantly underestimates the extent to which the biological component of the MBT process reduces the biological activity of material subsequently sent to landfill.

These limitations in the model's current datasets have been acknowledged by the Environment Agency, and a programme of updates – updating both in terms of the functionality of the model along with some of the data contained with it –

commenced in 2009. Although the first phase of updates was originally intended for release during 2009, these did not reach the user community until 2010.[8]

Improvements to the front end of the tool have provided the focus for much of the initial updates incorporated into the revised version of WRATE, with the aim being to provide standard users with more control over the models of treatment processes. Substantial revisions have been made to the incineration (energy from waste) module in this regard. The updated model also includes a number of new MBT and gasification processes, although no revisions were made with respect to the autoclave model.[9] The new version of WRATE also includes data from the latest version of the Swiss life cycle database ecoinvent.

The second set of updates currently scheduled for release later during 2011 will include a new 'build your own' MBT process, which will give standard users of the tool the ability to modify some of the assumptions associated with the MBT models, such as the capture rates of materials recovered for recycling. This additional series of updates will also allow users to modify assumptions with regard to landfill gas capture. No other amendments to the landfill module are scheduled at present.

A.5.2 Accounting for Limitations in the Landfill Module

As discussed in Section A.5.1, 'expert' WRATE license holders can modify much of the data contained within the models of individual waste treatment processes, with the exception of the landfill module. It is within this module that the greatest differences exist with regard to the outputs generated in WRATE, and those produced using Eunomia's proprietary model, Atropos.

Atropos calculates the impact of sending one tonne of residual waste to landfill to be 3 - 4 times greater than that of WRATE, depending on the composition of waste being landfilled. WRATE also applies an 'efficiency factor' when calculating the anticipated impacts associated with landfilling larger quantities of waste. The 'efficiency factor' further increases the difference in results between WRATE and Atropos when larger amounts of waste are modelled. Furthermore, in WRATE, the greater the amount of waste landfilled, the larger the 'efficiency factor'. The 'efficiency factor' is such that the CO_2 emissions associated with landfilling 1.8 million tonnes of residual waste (the amount landfilled in London during 2008) are 5.4 times greater in Atropos than in WRATE.

Unfortunately, following related questions from Eunomia, at the time of writing, no details of assumptions behind the derivation and calculation of this 'efficiency factor' have been provided by the Environment Agency. It is acknowledged that it would have been helpful to establish some kind of 'adjustment mechanism' (external to WRATE) that would allow for the results generated in WRATE to be

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[8] This was confirmed in presentations by the Environment Agency at the first WRATE user conference held in Birmingham on the 18th November 2009

[9] We understand that this is because the technology suppliers did not want to provide the Environment Agency with data to be included within the updated tool

modified to reflect the differences between the two models. However, the lack of transparency with regard to this 'efficiency factor' is such that it is not currently possible to determine an appropriate 'adjustment mechanism' to account for these discrepancies.

The model that underpins WRATE with regard to the behaviour of waste in landfill is GasSim.[10] This model produces similar results to another model which is used to prepare the UK's greenhouse gas inventory submitted to the IPCC. Eunomia recently commenced a study undertaken on behalf of Defra which aims to review this existing model.[11] The project includes an extensive review of the literature surrounding the calculation of landfill impacts, and aims to identify errors contained within the existing models.

The Environment Agency has confirmed that any changes made to the Defra model as a result of the aforementioned project for Defra will ultimately be incorporated into GasSim and hence into WRATE, although the timescale associated with such an update process remains uncertain.[12] Eunomia's Atropos model will also be updated with any relevant data identified as a result of this project on behalf of Defra. It is anticipated that these changes will reduce the extent of the discrepancy between the two models, thus hopefully removing any need for the external 'adjustment mechanism' mentioned above.

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[10] Originally developed by Golder Associates

[11] This model uses a similar basis for the calculation of landfill impacts to that of the landfill module contained within WRATE

[12] Personal Communication, Terry Coleman, Environment Agency, July 2010

A.6.0 Modelled Waste Flows

A.6.1 Roll out of Scenarios from 2008 to 2015

As discussed in the Main Report, the modelling undertaken for this study is based upon a related study undertaken by Eunomia on behalf of the GLA with regard to the economics of waste management.[13] The principle behind the modelling for this related study was to focus upon the most cost effective roll-out sequence for new services to meet the recycling / composting targets stated in the Mayor's draft MWMS. As a result, to meet the recycling targets for 2015, 2020 and 2031, the performance of the 'focus on food' and 'focus on dry' scenarios is very similar, as there is a need to collect dry and food wastes to meet these targets without excessive cost.

The difference between these scenarios, therefore, is best expressed between 2008 and 2015. This is to demonstrate the differences between these scenarios, which appear relatively similar in the waste flows expressed within Sections A.6.2 and Section A.6.3. Figure 1 and Figure 2 show that under both 'focus on dry' scenarios (Scenario 1 and Scenario 2), dry recycling services are rolled out first, followed by food and green waste collections to reach the 45% recycling / composting target in 2015. The reverse is the case for the two 'focus on food' scenarios (Scenario 3 and Scenario 4), whereby food waste services are rolled out first.

The abbreviations used along the x-axis in both Figure 1 and Figure 2 are set out in Table 6.

Table 6: Abbreviations for Collection Systems

Abbreviation	Collection System
DS Dry	Dry recyclables from properties with doorstep collection services
Com Dry	Dry recyclables from 'communal' systems (i.e. for flats)
Garden	Garden waste from properties with doorstep collection services
DS Food	Food waste from properties with doorstep collection services
DS Food (Co.)	Food waste, comingled with green waste from properties with doorstep collection services
Com Food	Food waste from 'communal' systems (i.e. for flats)

[13] Eunomia (2010) Economic Modelling for the Mayor's Municipal Waste Management Strategy, on behalf of the GLA, August 2010

Figure 1: Roll out Scenarios 3 and 4 with 'Focus on Dry' (2008 – 2015)'

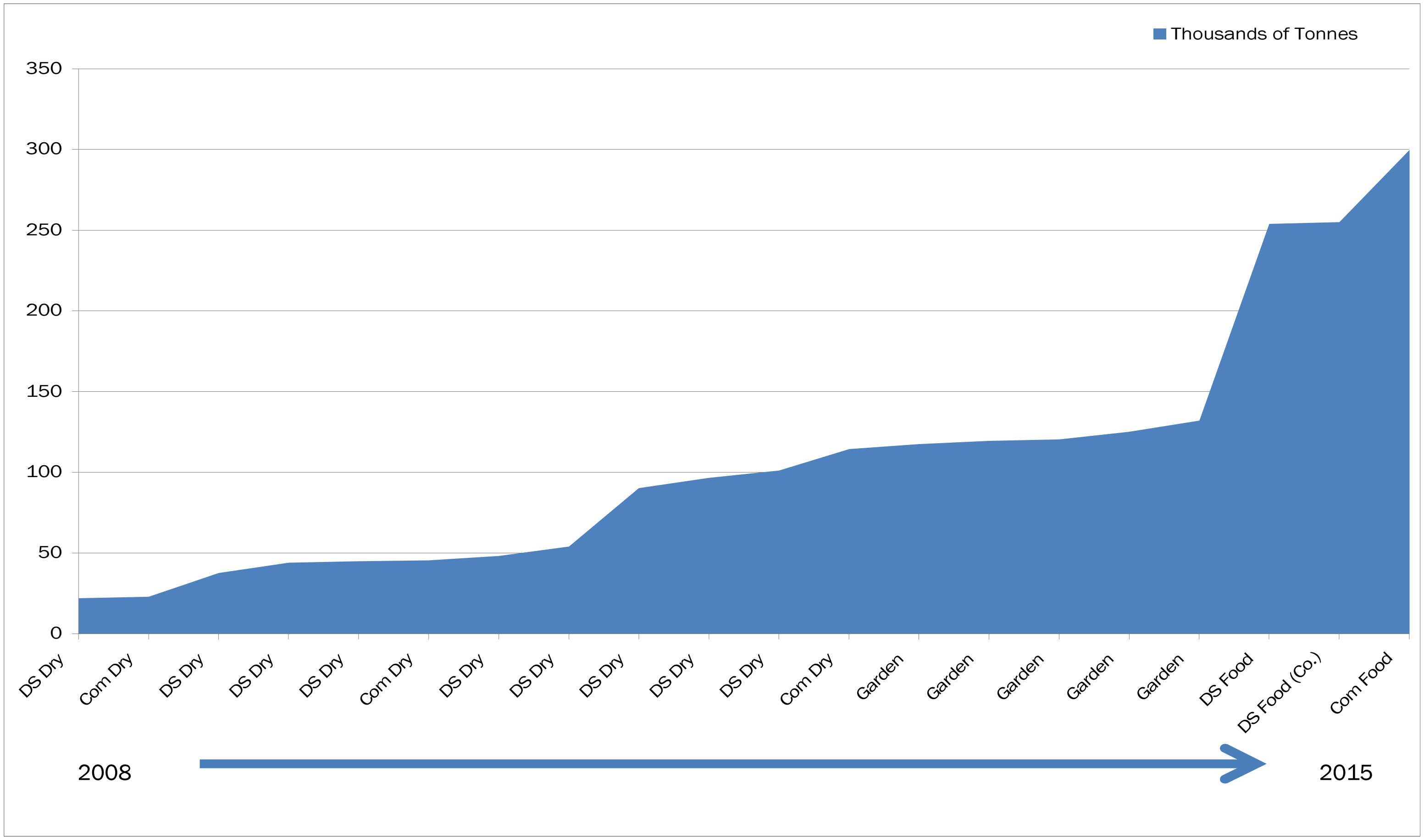
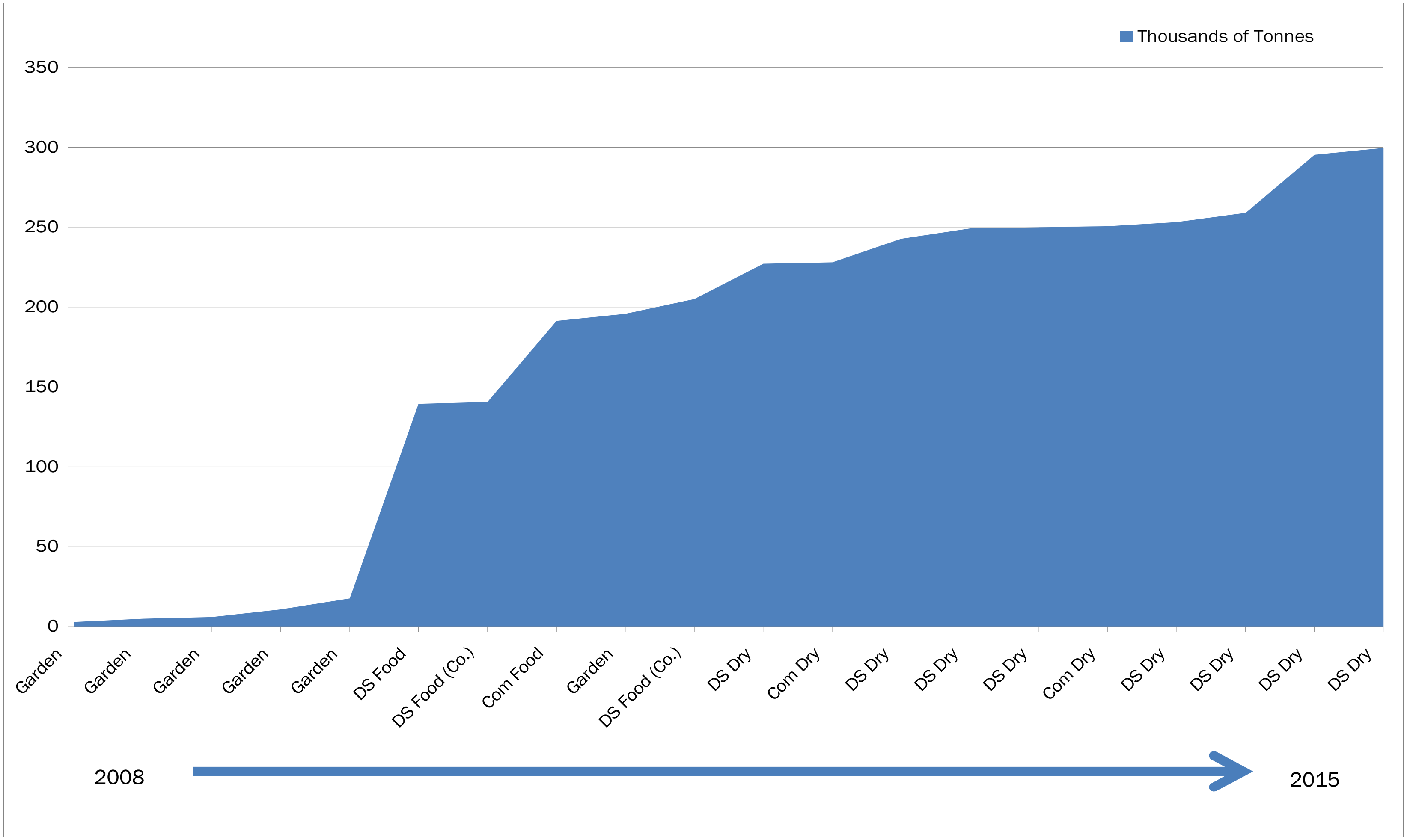


Figure 2: Roll out Scenarios 3 and 4 with 'Focus on Food' (2008 – 2015)'



A.6.2 Flows Expressed in Percentages

Table 7 to Table 12 summarise the waste flows for each of the six scenarios modelled for development of the Emissions Performance Standard (EPS). Waste flows are expressed in each of the recycling target years (2015, 2020 and 2031) expressed in the Mayor's Municipal Waste Management Strategy (MWMS) and the baseline year (2008). In Section A.6.3, the same waste flows are expressed in tonnes per annum.

It should be noted that since the modelling was undertaken for this study, the GLA has since reduced its target for reuse to 1% (or 50,000 tonnes) from 2015 through to 2031. As described on Page 8 of the Main Report, however, reuse is not currently included within the scope of setting the EPS, so this change does not have any impact on this study. The figures listed for reuse in Table 7 to Table 12 have not been updated to reflect this change.

Table 7: Scenario 1: 'Focus on Dry + Low Biomass New Technologies'

<table>
<tr><th colspan="3">Management Method</th><th>2008</th><th>2015</th><th>2020</th><th>2031</th></tr>
<tr><td rowspan="7">Reuse / Recycling/ Composting</td><td colspan="2">Total Reuse, Recycling and Composting</td><td>25%</td><td>46%</td><td>51%</td><td>61%</td></tr>
<tr><td rowspan="4">Dry Recyclables</td><td>Reuse</td><td>1%</td><td>3%</td><td>4%</td><td>5%</td></tr>
<tr><td>Source Segregated Collections</td><td>22%</td><td>23%</td><td>24%</td><td>23%</td></tr>
<tr><td>Comingled Collections (i.e. MRF Input)[1]</td><td>31%</td><td>31%</td><td>31%</td><td>29%</td></tr>
<tr><td>Direct Delivered</td><td>19%</td><td>12%</td><td>11%</td><td>11%</td></tr>
<tr><td rowspan="2">Source Seg. Organics</td><td>Composting (Windrow and IVC)</td><td>26%</td><td>24%</td><td>24%</td><td>24%</td></tr>
<tr><td>Anaerobic Digestion (AD)</td><td>0%</td><td>7%</td><td>8%</td><td>8%</td></tr>
<tr><td rowspan="15">Residual Treatment</td><td colspan="2">Total Residual Treatment</td><td>75%</td><td>54%</td><td>49%</td><td>39%</td></tr>
<tr><td rowspan="5">Direct to Incineration</td><td>Input</td><td>28%</td><td>61%</td><td>68%</td><td>49%</td></tr>
<tr><td>Metals Recycling</td><td>3%</td><td>3%</td><td>3%</td><td>3%</td></tr>
<tr><td>Recycled Bottom Ash</td><td>24%</td><td>24%</td><td>24%</td><td>24%</td></tr>
<tr><td>Landfilled Bottom Ash</td><td>3%</td><td>3%</td><td>3%</td><td>3%</td></tr>
<tr><td>Mass Loss (Combustion)</td><td>70%</td><td>70%</td><td>70%</td><td>70%</td></tr>
<tr><td rowspan="7">MBT / MHT</td><td>Input</td><td>9%</td><td>26%</td><td>25%</td><td>51%</td></tr>
<tr><td>Recycling</td><td>0%</td><td>2%</td><td>2%</td><td>3%</td></tr>
<tr><td>SRF</td><td>22%</td><td>26%</td><td>26%</td><td>27%</td></tr>
<tr><td>% SRF to Incineration</td><td>100%</td><td>77%</td><td>70%</td><td>42%</td></tr>
<tr><td>% SRF to Gasification</td><td>0%</td><td>23%</td><td>30%</td><td>58%</td></tr>
<tr><td>Landfilled Rejects</td><td>36%</td><td>34%</td><td>35%</td><td>34%</td></tr>
<tr><td>Mass Loss (Water)</td><td>41%</td><td>37%</td><td>38%</td><td>36%</td></tr>
<tr><td rowspan="2">Landfill</td><td>Input - Direct to Landfill</td><td>62%</td><td>14%</td><td>8%</td><td>0%</td></tr>
<tr><td>Input - Rejects[2]</td><td>4%</td><td>11%</td><td>11%</td><td>19%</td></tr>
<tr><td colspan="7">Notes:
1) 10% of this input is assumed to be rejected and landfilled.
2) % of 'Total Residual Treatment'.</td></tr>
</table>

Table 8: Scenario 2: 'Focus on Dry + High Biomass New Technologies'

Management Method			2008	2015	2020	2031
Reuse / Recycling/ Composting	Total Reuse, Recycling and Composting		25%	46%	51%	61%
	Dry Recyclables	Reuse	1%	3%	4%	5%
		Source Segregated Collections	22%	23%	24%	23%
		Comingled Collections (i.e. MRF Input)[1]	31%	31%	31%	29%
		Direct Delivered	19%	12%	11%	11%
	Source Seg. Organics	Composting (Windrow and IVC)	26%	24%	24%	24%
		Anaerobic Digestion (AD)	0%	7%	8%	8%
Residual Treatment	Total Residual Treatment		75%	54%	49%	39%
	Direct to Incineration	Input	28%	60%	67%	48%
		Metals Recycling	3%	3%	3%	3%
		Recycled Bottom Ash	24%	24%	24%	24%
		Landfilled Bottom Ash	3%	3%	3%	3%
		Mass Loss (Combustion)	70%	70%	70%	70%
	MBT / MHT	Input	9%	26%	26%	52%
		Recycling	0%	5%	4%	7%
		SRF	22%	21%	21%	21%
		% SRF to Incineration	100%	80%	75%	49%
		% SRF to Gasification	0%	20%	25%	51%
		Landfilled Rejects	36%	34%	35%	34%
		Mass Loss (Water)	41%	39%	40%	39%
	Landfill	Input - Direct to Landfill	62%	14%	8%	0%
		Input - Rejects[2]	4%	11%	11%	19%

Notes:

1) 10% of this input is assumed to be rejected and landfilled.
2) % of 'Total Residual Treatment'.

Table 9: Scenario 3: 'Focus on Food + Low Biomass New Technologies'

Management Method			2008	2015	2020	2031
Reuse / Recycling/ Composting	Total Reuse, Recycling and Composting		25%	46%	51%	61%
	Dry Recyclables	Reuse	1%	3%	4%	5%
		Source Segregated Collections	22%	23%	24%	23%
		Comingled Collections (i.e. MRF Input)[1]	31%	31%	31%	29%
		Direct Delivered	19%	12%	11%	11%
	Source Seg. Organics	Composting (Windrow and IVC)	26%	24%	24%	24%
		Anaerobic Digestion (AD)	0%	7%	8%	8%
Residual Treatment	Total Residual Treatment		75%	54%	49%	39%
	Direct to Incineration	Input	28%	61%	68%	49%
		Metals Recycling	3%	3%	3%	3%
		Recycled Bottom Ash	24%	24%	24%	24%
		Landfilled Bottom Ash	3%	3%	3%	3%
		Mass Loss (Combustion)	70%	70%	70%	70%
	MBT / MHT	Input	9%	26%	25%	51%
		Recycling	0%	2%	2%	3%
		SRF	22%	26%	26%	27%
		% SRF to Incineration	100%	77%	70%	42%
		% SRF to Gasification	0%	23%	30%	58%
		Landfilled Rejects	36%	34%	35%	34%
		Mass Loss (Water)	41%	37%	38%	36%
	Landfill	Input - Direct to Landfill	62%	14%	8%	0%
		Input - Rejects[2]	4%	11%	11%	19%

Notes:

1) 10% of this input is assumed to be rejected and landfilled.
2) % of 'Total Residual Treatment'.

Table 10: Scenario 4: 'Focus on Food + High Biomass New Technologies'

Management Method			2008	2015	2020	2031
Reuse / Recycling/ Composting	Total Reuse, Recycling and Composting		25%	46%	51%	61%
	Dry Recyclables	Reuse	1%	3%	4%	5%
		Source Segregated Collections	22%	23%	24%	23%
		Comingled Collections (i.e. MRF Input)[1]	31%	31%	31%	29%
		Direct Delivered	19%	12%	11%	11%
	Source Seg. Organics	Composting (Windrow and IVC)	26%	24%	24%	24%
		Anaerobic Digestion (AD)	0%	7%	8%	8%
Residual Treatment	Total Residual Treatment		75%	54%	49%	39%
	Direct to Incineration	Input	28%	60%	67%	48%
		Metals Recycling	3%	3%	3%	3%
		Recycled Bottom Ash	24%	24%	24%	24%
		Landfilled Bottom Ash	3%	3%	3%	3%
		Mass Loss (Combustion)	70%	70%	70%	70%
	MBT / MHT	Input	9%	26%	25%	52%
		Recycling	0%	5%	4%	7%
		SRF	22%	21%	21%	21%
		% SRF to Incineration	100%	80%	75%	49%
		% SRF to Gasification	0%	20%	25%	51%
		Landfilled Rejects	36%	34%	35%	34%
		Mass Loss (Water)	41%	39%	40%	39%
	Landfill	Input - Direct to Landfill	62%	14%	8%	0%
		Input - Rejects[2]	4%	11%	11%	19%

Notes:

1) 10% of this input is assumed to be rejected and landfilled.
2) % of 'Total Residual Treatment'.

Table 11: Scenario 5: 'Doorstep Only + High Biomass New Technologies'

Management Method			2008	2015	2020	2031
Reuse / Recycling/ Composting	Total Reuse, Recycling and Composting		25%	44%	49%	59%
	Dry Recyclables	Reuse	1%	3%	4%	5%
		Source Segregated Collections	22%	23%	24%	23%
		Comingled Collections (i.e. MRF Input)[1]	31%	32%	32%	30%
		Direct Delivered	19%	12%	11%	11%
	Source Seg. Organics	Composting (Windrow and IVC)	26%	23%	23%	24%
		Anaerobic Digestion (AD)	0%	6%	6%	7%
Residual Treatment	Total Residual Treatment		75%	56%	51%	41%
	Direct to Incineration	Input	28%	59%	64%	46%
		Metals Recycling	3%	3%	3%	3%
		Recycled Bottom Ash	24%	24%	24%	24%
		Landfilled Bottom Ash	3%	3%	3%	3%
		Mass Loss (Combustion)	70%	70%	70%	70%
	MBT / MHT	Input	9%	28%	29%	54%
		Recycling	0%	6%	5%	7%
		SRF	22%	21%	21%	21%
		% SRF to Incineration	100%	79%	70%	46%
		% SRF to Gasification	0%	21%	30%	54%
		Landfilled Rejects	36%	34%	34%	34%
		Mass Loss (Water)	41%	39%	39%	39%
	Landfill	Input - Direct to Landfill	62%	13%	7%	0%
		Input - Rejects[2]	4%	12%	12%	20%

Notes:

1) 10% of this input is assumed to be rejected and landfilled.
2) % of 'Total Residual Treatment'.

Table 12: Scenario 6: 'Max Greenhouse Gas Abatement'

Management Method			2008	2015	2020	2031
Reuse / Recycling/ Composting	Total Reuse, Recycling and Composting		25%	46%	59%	69%
	Dry Recyclables	Reuse	1%	3%	3%	4%
		Source Segregated Collections	22%	24%	24%	24%
		Comingled Collections (i.e. MRF Input)[1]	31%	32%	31%	31%
		Direct Delivered	19%	13%	11%	10%
	Source Seg. Organics	Composting (Windrow and IVC)	26%	19%	16%	16%
		Anaerobic Digestion (AD)	0%	10%	15%	15%
Residual Treatment	Total Residual Treatment		75%	54%	41%	31%
	Direct to Incineration	Input	28%	60%	79%	60%
		Metals Recycling	3%	3%	3%	3%
		Recycled Bottom Ash	24%	24%	24%	24%
		Landfilled Bottom Ash	3%	3%	3%	3%
		Mass Loss (Combustion)	70%	70%	70%	70%
	MBT / MHT	Input	9%	26%	17%	40%
		Recycling	0%	5%	0%	5%
		SRF	22%	21%	22%	21%
		% SRF to Incineration	100%	80%	100%	66%
		% SRF to Gasification	0%	20%	0%	34%
		Landfilled Rejects	36%	34%	36%	35%
		Mass Loss (Water)	41%	39%	41%	40%
	Landfill	Input - Direct to Landfill	62%	14%	4%	0%
		Input - Rejects[2]	4%	11%	9%	16%

Notes:

1) 10% of this input is assumed to be rejected and landfilled.
2) % of 'Total Residual Treatment'.

A.6.3 Flows Expressed in Tonnes

As mentioned above, Table 13 to Table 18 express the information set out in Section A.6.2 in terms of tonnes of waste per annum (rather than percentages) managed by each specific route.

Table 13: Scenario 1: 'Focus on Dry + Low Biomass New Technologies'

Management Method			2008	2015	2020	2031
Reuse / Recycling/ Composting	Total Reuse, Recycling and Composting		1,007.9	1,869.5	2,071.1	2,525.4
	Dry Recyclables	Reuse	10.2	52.6	73.7	120.0
		Source Segregated Collections	222.7	436.6	490.7	589.8
		Comingled Collections (i.e. MRF Input)[1]	312.3	580.8	636.9	741.6
		Direct Delivered	191.4	219.9	221.4	265.7
	Source Seg. Organics	Composting (Windrow and IVC)	267.0	456.7	493.7	604.5
		Anaerobic Digestion (AD)	4.4	122.9	154.6	203.7
Residual Treatment	Total Residual Treatment		2,947.2	2,166.6	1,958.7	1,595.9
	Direct to Incineration	Input	837.7	1,317.7	1,317.7	777.7
		Metals Recycling	22.4	35.3	35.3	20.8
		Recycled Bottom Ash	203.4	319.9	319.9	188.8
		Landfilled Bottom Ash	28.9	45.4	45.4	26.8
		Mass Loss (Combustion)	278.4	548.2	490.3	817.5
	MBT / MHT	Input	0.0	11.0	8.6	22.0
		Recycling	62.2	143.1	125.8	223.9
		SRF	62.2	110.7	87.6	94.5
		% SRF to Incineration	0.0	32.4	38.1	129.4
		% SRF to Gasification	101.0	188.3	169.6	275.4
		Landfilled Rejects	115.2	205.8	186.3	296.2
		Mass Loss (Water)	1,961.1	534.4	365.7	302.9
	Landfill	Input - Direct to Landfill	1,831.2	300.7	150.7	0.7
		Input – Rejects[2]	129.9	233.7	215.0	302.2

Notes:

1) 10% of this input is assumed to be rejected and landfilled.
2) % of 'Total Residual Treatment'.

Table 14: Scenario 2: 'Focus on Dry + High Biomass New Technologies'

Management Method			2008	2015	2020	2031
Reuse / Recycling/ Composting	Total Reuse, Recycling and Composting		1,007.9	1,842.0	2,062.1	2,497.1
	Dry Recyclables	Reuse	10.2	52.6	73.7	120.0
		Source Segregated Collections	222.7	436.6	490.9	589.9
		Comingled Collections (i.e. MRF Input)[1]	312.3	580.8	636.9	741.6
		Direct Delivered	191.4	219.9	222.5	266.1
	Source Seg. Organics	Composting (Windrow and IVC)	267.0	442.9	489.1	587.3
		Anaerobic Digestion (AD)	4.4	109.2	149.1	192.2
Residual Treatment	Total Residual Treatment		2,947.2	2,194.1	1,984.1	1,629.7
	Direct to Incineration	Input	837.7	1,317.7	1,317.7	777.7
		Metals Recycling	22.4	35.3	35.3	20.8
		Recycled Bottom Ash	203.4	319.9	319.9	188.8
		Landfilled Bottom Ash	28.9	45.4	45.4	26.8
		Mass Loss (Combustion)	278.4	575.7	515.8	851.3
	MBT / MHT	Input	0.0	29.7	23.7	57.3
		Recycling	62.2	121.6	109.7	176.8
		SRF	62.2	97.9	81.2	85.1
		% SRF to Incineration	0.0	23.8	28.5	91.7
		% SRF to Gasification	101.0	197.9	178.3	287.6
		Landfilled Rejects	115.2	226.5	204.0	329.7
		Mass Loss (Water)	1,961.1	543.9	374.4	315.1
	Landfill	Input - Direct to Landfill	1,831.2	300.7	150.7	0.7
		Input – Rejects[2]	129.9	243.3	223.7	314.4

Notes:

1) 10% of this input is assumed to be rejected and landfilled.
2) % of 'Total Residual Treatment'.

Table 15: Scenario 3: 'Focus on Food + Low Biomass New Technologies'

Management Method			2008	2015	2020	2031
Reuse / Recycling/ Composting	Total Reuse, Recycling and Composting		1,007.9	1,869.5	2,065.8	2,526.5
	Dry Recyclables	Reuse	10.2	52.6	73.7	120.0
		Source Segregated Collections	222.7	418.7	470.5	588.8
		Comingled Collections (i.e. MRF Input)[1]	312.3	571.5	634.3	741.6
		Direct Delivered	191.4	219.9	220.9	265.6
	Source Seg. Organics	Composting (Windrow and IVC)	267.0	472.8	505.2	605.9
		Anaerobic Digestion (AD)	4.4	133.9	161.2	204.6
Residual Treatment	Total Residual Treatment		2,947.2	2,166.6	1,955.6	1,592.2
	Direct to Incineration	Input	837.7	1,317.7	1,317.7	777.7
		Metals Recycling	22.4	35.3	35.3	20.8
		Recycled Bottom Ash	203.4	319.9	319.9	188.8
		Landfilled Bottom Ash	28.9	45.4	45.4	26.8
		Mass Loss (Combustion)	278.4	548.2	487.2	813.9
	MBT / MHT	Input	0.0	11.0	8.5	21.8
		Recycling	62.2	143.1	124.8	222.8
		SRF	62.2	110.7	87.2	94.3
		% SRF to Incineration	0.0	32.4	37.6	128.5
		% SRF to Gasification	101.0	188.3	168.6	274.2
		Landfilled Rejects	115.2	205.8	185.3	295.0
		Mass Loss (Water)	1,961.1	534.4	364.7	301.7
	Landfill	Input - Direct to Landfill	1,831.2	300.7	150.7	0.7
		Input – Rejects[2]	129.9	233.7	214.0	301.0

Notes:

1) 10% of this input is assumed to be rejected and landfilled.
2) % of 'Total Residual Treatment'.

Table 16: Scenario 4: 'Focus on Food + High Biomass New Technologies'

Management Method				2008	2015	2020	2031
Reuse / Recycling/ Composting	Total Reuse, Recycling and Composting			1,007.9	1,842.0	2,046.6	2,488.1
	Dry Recyclables	Reuse		10.2	52.6	73.7	120.0
		Source Segregated Collections		222.7	418.7	470.5	567.9
		Comingled Collections (i.e. MRF Input)[1]		312.3	544.0	615.2	724.2
		Direct Delivered		191.4	219.9	220.9	265.6
	Source Seg. Organics	Composting (Windrow and IVC)		267.0	472.8	505.2	605.9
		Anaerobic Digestion (AD)		4.4	133.9	161.2	204.6
Residual Treatment	Total Residual Treatment			2,947.2	2,194.1	1,974.7	1,630.6
	Direct to Incineration	Input		837.7	1,317.7	1,317.7	777.7
			Metals Recycling	22.4	35.3	35.3	20.8
			Recycled Bottom Ash	203.4	319.9	319.9	188.8
			Landfilled Bottom Ash	28.9	45.4	45.4	26.8
			Mass Loss (Combustion)	278.4	575.7	506.3	852.3
	MBT / MHT	Input		0.0	29.7	22.8	57.4
			Recycling	62.2	121.6	107.8	176.9
			SRF	62.2	97.9	80.4	85.1
			% SRF to Incineration	0.0	23.8	27.4	91.8
			% SRF to Gasification	101.0	197.9	175.3	287.9
			Landfilled Rejects	115.2	226.5	200.5	330.0
			Mass Loss (Water)	1,961.1	543.9	371.3	315.4
	Landfill	Input - Direct to Landfill		1,831.2	300.7	150.7	0.7
		Input – Rejects[2]		129.9	243.3	220.7	314.7

Notes:

1) 10% of this input is assumed to be rejected and landfilled.
2) % of 'Total Residual Treatment'.

Table 17: Scenario 5: 'Doorstep Only + High Biomass New Technologies'

Management Method			2008	2015	2020	2031
Reuse / Recycling/ Composting	Total Reuse, Recycling and Composting		1,007.9	1,826.0	2,012.3	2,440.2
	Dry Recyclables	Reuse	10.2	52.6	73.7	120.0
		Source Segregated Collections	222.7	417.5	469.4	566.7
		Comingled Collections (i.e. MRF Input)[1]	312.3	579.8	635.8	740.4
		Direct Delivered	191.4	219.9	222.8	267.4
	Source Seg. Organics	Composting (Windrow and IVC)	267.0	447.6	478.2	574.3
		Anaerobic Digestion (AD)	4.4	108.6	132.5	171.3
Residual Treatment	Total Residual Treatment		2,947.2	2,210.0	2,039.3	1,708.8
	Direct to Incineration	Input	837.7	1,317.7	1,317.7	777.7
		Metals Recycling	22.4	35.3	35.3	20.8
		Recycled Bottom Ash	203.4	319.9	319.9	188.8
		Landfilled Bottom Ash	28.9	45.4	45.4	26.8
		Mass Loss (Combustion)	278.4	591.7	570.9	930.4
	MBT / MHT	Input	0.0	31.3	29.3	65.2
		Recycling	62.2	124.8	120.7	192.6
		SRF	62.2	99.8	85.6	88.3
		% SRF to Incineration	0.0	25.1	35.1	104.3
		% SRF to Gasification	101.0	203.0	196.3	313.3
		Landfilled Rejects	115.2	232.5	224.7	359.3
		Mass Loss (Water)	1,961.1	549.1	392.4	340.8
	Landfill	Input - Direct to Landfill	1,831.2	300.7	150.7	0.7
		Input – Rejects[2]	129.9	248.5	241.7	340.1

Notes:

1) 10% of this input is assumed to be rejected and landfilled.
2) % of 'Total Residual Treatment'.

Table 18: Scenario 6: 'Max Greenhouse Gas Abatement'

Management Method			2008	2015	2020	2031
Reuse / Recycling/ Composting	Total Reuse, Recycling and Composting		1,007.9	1,842.5	2,397.5	2,826.5
	Dry Recyclables	Reuse	10.2	52.6	73.7	120.0
		Source Segregated Collections	222.7	436.6	573.0	673.8
		Comingled Collections (i.e. MRF Input)[1]	312.3	580.8	741.5	862.4
		Direct Delivered	191.4	234.1	263.2	294.0
	Source Seg. Organics	Composting (Windrow and IVC)	267.0	354.8	393.6	443.4
		Anaerobic Digestion (AD)	4.4	183.6	352.5	432.9
Residual Treatment	Total Residual Treatment		2,947.2	2,193.5	1,663.5	1,292.2
	Direct to Incineration	Input	837.7	1,317.7	1,317.7	777.7
		Metals Recycling	22.4	35.3	35.3	20.8
		Recycled Bottom Ash	203.4	319.9	319.9	188.8
		Landfilled Bottom Ash	28.9	45.4	45.4	26.8
		Mass Loss (Combustion)	278.4	575.2	278.4	513.8
	MBT / MHT	Input	0.0	29.7	0.0	23.5
		Recycling	62.2	121.5	62.2	109.3
		SRF	62.2	97.8	62.2	71.6
		% SRF to Incineration	0.0	23.7	0.0	37.7
		% SRF to Gasification	101.0	197.7	101.0	177.7
		Landfilled Rejects	115.2	226.3	115.2	203.3
		Mass Loss (Water)	1,961.1	543.8	213.9	205.2
	Landfill	Input - Direct to Landfill	1,831.2	300.7	67.4	0.7
		Input – Rejects[2]	129.9	243.1	146.4	204.5

Notes:

2) 10% of this input is assumed to be rejected and landfilled.

3) % of 'Total Residual Treatment'.

A.7.0 Emissions Factors for Thermal Waste Treatment

As recommended in the peer review undertaken by Arup, in Table 19 we have provided CO_2e emissions factors for each residual waste treatment route modelled for each of the target years of 2015, 2020 and 2031. In the context of the emissions factors presented in Table 19, it should be noted that:

1. For all residual technologies, the CO_2 impact of each tonne of waste treated changes over time. This is because year-on-year increases in the level of recycling vary across different materials result in the residual waste composition used within the model becoming more 'carbon intense' in each target year. In the case of incineration, for example, this results in a situation whereby in 2031, whilst less tonnage of waste is being treated than in 2020, there are higher total CO_2 emissions;
2. Incineration plant in 2008 and 2015 are assumed to generate electricity only, with efficiencies based on current performance in London, i.e. 21-23%. In 2020, due to assumed market development of heat networks, 50% of waste incineration is assumed to take place at CHP plant with the remainder continuing to be treated at facilities generating electricity only. In 2031, it is assumed that 100% of incineration is undertaken at CHP plant. It is assumed that all such CHP plant operate at 19% electrical efficiency with an additional 30% converted into heat, which is used to displace alternative heat supply at all times of operation;
3. The MBT technology modelled for this study is 'bio-drying', which produces a relatively low-biomass (or 'carbon intense') fuel compared to alternative forms of pre-treatment. Other technologies, such as autoclaving, are often designed to produce a high-biomass fuel, which would result in lower emissions when thermally treated at an incineration or gasification facility; and
4. The WRATE model cannot currently take into consideration the impact of 'biostabilising' reject streams from MBT 'bio-drying' facilities prior to landfill. CO_2e emissions from these streams are modelled by WRATE as if they are untreated waste, which therefore results in significantly higher emissions than would be the case in reality.[14]

As highlighted in the Main Report, the EPS is set at the level of the *poorest* performing of the six key scenarios ('Low Biomass – New Tech') modelled within the Waste Economics study undertaken by Eunomia on behalf of the GLA (which was also published in October 2010 as an Appendix to the Mayor's Draft MWMS).[15] As a result,

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[14] See Appendix 5.0 for further discussion of this issue

[15] Eunomia (2010) Economic Modelling for the Mayor's Municipal Waste Management Strategy, on behalf of The Greater London Authority, August 2010

not all residual treatment technologies, for example, autoclaving or alternative forms of MBT (aside from bio-drying), were used to set the level of the EPS for 2015, 2020 and 2031. It should be emphasised, therefore, that should such lower carbon pre-treatment technologies be employed, these would provide Boroughs and WAs with a greater chance of meeting the EPS.

Table 19: Emissions Factors for Residual Waste (as modelled to set core EPS)

Treatment	Impact of Activity (t CO_2 e /tonne of waste managed)				Source
	2008	2015	2020	2031	
Landfill	0.26	0.256	0.246	0.232	WRATE Default
Incineration	0.057	0.106	0.107	0.022	WRATE UDP
MBT incineration	-0.012	0.0501	0.051	0.096	WRATE UDP
MBT gasification (steam turbine)	0.041	0.096	0.106	0.155	WRATE UDP
MBT gasification (gas engine)	-0.087	-0.019	-0.028	0.015	WRATE UDP

Table 20 provides 'material-specific' emissions factors associated with sending one tonne of material for treatment at different types of thermal treatment facility. It should be noted that in reality, it is very unlikely, aside from in the case potentially of wood, that such facilities will ever process individual material streams in this way. It is far more likely that they will be combined as part of a wider residual stream, as per the final line of the Table. The information in Table 20 has been extracted from a series of 'user-defined' processes (UDPs) designed by Eunomia, within WRATE. It should be acknowledged that these are deliberately different from the processes used to model the core EPS. For each material treated, however, the data clearly shows the benefits, in terms of lower unit emissions of CO_2, of facilities which use CHP to generate electricity and heat over those which generate electricity only.

Table 20: WRATE Emissions Factors (t CO2e / tonne) for Selected Materials

Material	Incineration		Gasification (Gas Engine)[1]		Gasification (Steam Turbine)[1]		Landfill
	Electricity only	CHP	Electricity only	CHP	Electricity only	CHP	
Paper and card	-0.164	-0.364	-0.36	-0.515	-0.257	-0.288	0.407
Food waste	-0.002	-0.065	-0.088	-0.137	-0.056	-0.065	0.297
Garden waste	-0.019	-0.095	-0.116	-0.175	-0.076	-0.088	0.297
Wood[2]	-0.29	-0.596	-0.572	-0.809	-0.414	-0.462	1.139
Textiles	0.486	0.226	0.245	0.044	0.379	0.338	0.213
Plastic (dense)	1.521	1.069	1.125	0.776	1.358	1.288	0.011
Plastic (film)	1.346	0.959	1.006	0.707	1.206	1.145	0.005
Residual Waste[3]	0.057	-0.093	-0.003	-0.113	0.08	-0.057	0.26

Notes:

1. It should be noted the figures presented are for 'standalone' gasification, i.e. not including any upfront MBT (pre-treatment) of waste, as has been modelled for the EPS
2. Discussions with the Environment Agency have clarified that the emission factor assigned to wood when sent to landfill represents an error within WRATE. It has been presented here, however, as it is what remains in the current version of WRATE
3. Based on a residual waste composition assuming a 25% recycling rate

A.8.0 Summary of Peer Review Recommendations and Actions

Table 21 provides details of actions undertaken in response to the recommendations within the peer review of this study by Arup.

Table 21: Summary of Peer Review Recommendations and Actions

No.	Arup Recommendation	Action(s) Taken	Reference(s)
1	There should not be any immediate requirement to update the Economic Modelling Study with new capture rates information but it should be considered in any future updates to the Whole Waste System EPS.	Need for future update now acknowledged	Page 12 of Appendix 4c to the Mayor's MWMS
2	It has been confirmed the Whole Waste System EPS is based on the associated emissions for Scenario One (Low Biomass - New Tech) but this should be stated explicitly within Appendix 4b to the Mayor' Draft Municipal Waste Management Strategy (MWMS).	Scenario 1 now stated explicitly	Page 10 of Appendix 4c to the Mayor's MWMS
3	As a waste management option, re-use should be included within the scope of associated emissions for the Whole Waste System EPS.	See Action Note 5	n/a
4	It is advised that consideration be given to the system boundaries of the LCA studies used to provide re-use information to ensure that the scope of re-use emissions data used is consistent.	See Action Note 5	n/a

5	Based on the suitability of available data, a decision will need to be taken as to the scope of re-use emissions to be included in the Whole Waste System EPS. In this case, it is recommended that re-use focuses, where possible on the avoided emissions of re-use as a waste management option.	Now stated that this could happen in future but current data is not sufficiently robust	Pages 8-9 of Appendix 4c to the Mayor's MWMS
6	For completeness, composition data for reject materials should be reviewed and reassessed for suitability of modelling associated emissions within the Whole Waste System EPS. This would be consistent with the approach taken by the EPE Protocol, which considers final treatment of residues from MBT and MRF to landfill.	Emissions from rejects (based on WRAP composition data) now included within modelling of the EPS	Page 9 of Appendix 4c to the Mayor's MWMS
7	The statement that waste-related transport emissions typically account for a small percentage (5% to 10%) of the total CO2eq emissions from waste management activities should be verified for London	Text now amended to be less specific about related percentage	Page 10 of Appendix 4c to the Mayor's MWMS
8	It is recommended that the EPS Steering Group revisit its previous conclusion to exclude waste-related transport impacts from the scope of the Whole Waste System EPS, not least so that local authorities can benefit from the potential emissions reductions associated with methods of rail and river transportation.	See Action Note 9	n/a
9	It is recommended waste-related transport emissions are included using an approach similar to that for either the EPE Protocol or Scottish Carbon Metric.	Waste-related transport emissions now included. Bespoke distances for London modelled rather than those used by EPE Protocol or Scottish Carbon Metric	Page 10 of Appendix 4c to the Mayor's MWMS Policy 2 Mayor's MWMS

10	WRATE UDPs created by Eunomia to facilitate the inclusion of a range of technology configurations and related assumptions in the calculation of associated emissions should be subject to detailed peer review as recommended by the Environment Agency.	The WRATE UDPs will be peer reviewed as part of the wider EPS review process at least every three years (see Action Note 20)	Policy 2 Mayor's MWMS
11	The Whole Waste System EPS treats food and garden waste as open loop in the same way as the Scottish Carbon Metric but it is not clear if any consideration has been given to open loop recycling of glass. A similar approach should be adopted as for the Scottish Carbon Metric, which allows for future extension to take account of different recycling methods should sufficient waste data become available	Open-loop glass recycling now assumed to be undertaken for 50% of material captured	Page 11 of Appendix 4c to the Mayor's MWMS
12	The reason for the omission of associated emissions for wood in Table 2.1 of Appendix 4b to the Mayor's Draft MWMS should be qualified in Appendix 4b to the Mayor's MWMS.	Emissions from wood now included (previously modelled, but not included within Table as are close to zero)	Table 3-3 (Page 14) of Appendix 4c to the Mayor's MWMS
13	It is recommended to verify the materials recycling and reprocessing emissions factors for open windrow composting and ferrous metals reported in Appendix 4b of the Mayor's Draft MWMS to ensure that the correct figure has been used and/or reported for the baseline and future target years.	Emissions factors now verified with slight resulting amends	Table 3-2 (Page 7) of Appendix 4c to the Mayor's MWMS
14	It would be helpful to state the exact emissions factors used for residual waste management (and how these have been transposed from Table 14 of Appendix 4b to the Mayor's Draft MWMS) so that the calculation of associated emissions	Emissions factors for residual waste treatment now stated explicitly	Table 19 (Page 32) of Appendix 4c (Report Appendices) to the Mayor's MWMS

	can be replicated to verify the performance levels of the Whole Waste System EPS for the baseline and target years.		Table 3b in the Mayor's MWMS
15	Based on a review of alternative approaches to specifying a performance level for the CIF, it is considered appropriate to continue to use the marginal emissions approach over grid mix and alternative waste management options.	No related action proposed	n/a
16	The specified level of the CIF should be raised to at least 393gCO2/kWh for consistency with DECC's latest IAG guidance (2010). It is also recommended that consideration be given to raising the performance level of the CIF further based on a review of a range of values for the marginal source of electricity generation (CCGT) and as a result of SLR's additional modelling work being undertaken for a range of waste management and energy from waste options.	Following decision by the GLA based on evidence from study undertaken by SLR and on updated Inter-departmental Analysts' Group (IAG) guidance, CIF raised to 400gCO2/kWh	Page 20-21 of Appendix 4c to the Mayor's MWMS Policy 2 of the Mayor's MWMS
17	The additional benefit of allowing biomass to be treated using anaerobic digestion is that it would contribute both to the Whole Waste System EPS (i.e. bulk of emissions reduction to be met through materials recycling and reprocessing, including anaerobic digestion) and the CIF, in terms of off-setting more carbon intense forms of waste to energy generation. It is noted, however, that this approach has not been modelled to date and should be verified in future modelling of CIF scenarios.	Anaerobic digestion can now be used to offset emissions from residual waste treatment	Page 24-25 of Appendix 4c to the Mayor's MWMS Policy 2 of the Mayor's MWMS
18	Appendix 4b to the draft MWMS should be updated to make reference to the inclusion of anaerobic digestion within the scope of emissions to be measured against the CIF.	See Action Note 17	n/a

19	Further clarity is required with respect to how transport fuels are considered within the context of the CIF and particularly in relation to the biomass content that would be required to meet the specified performance level.	Further clarification now provided	Page 25 of Appendix 4c to the Mayor's MWMS
20	An established review process should be set out to reassess the adequacy of the scope, methodology and assumptions used against future changes in policy, technology and data availability. The review process should also consider the use of data quality standards for inclusion of information within the Mayor's EPS at a later date.	London's performance against the EPS will be monitored annually. The EPS including its scope, methodology, and assumptions will be reviewed at least every three years	Policy 2 of the Mayor's MWMS
21	It would be of benefit to the intended audience to set out a step-by-step approach to the methodology used for developing the Mayor's EPS and to show how the Whole Waste System EPS and CIF are designed to be met together.	Step-by-step guidance has now been provided	Pages 9-10 of Appendix 4c (Report Appendices) to the Mayor's MWMS
		Commentary on how the EPS and CIF are designed to be met together has now been provided	Page 27 of Appendix 4c to the Mayor's MWMS
22	Clarity should be provided as to those organisations that are directly and indirectly affected by the Mayor's EPS.	Related ommentary has now been provided	Policy 2 of the Mayor's MWMS
23	Clarity provide as to the organisations that are directly and indirectly affected by EPS	Further clarity has now been provided	Policy 2 of the Mayor's MWMS

24	Confirmation is required as to whether the Mayor's EPS will apply as a benchmark or required standard for waste authorities and the consequences of not being in 'general conformity' with Policy 2 of the Mayor's Draft MWMS. It would help also to explain that the Whole Waste System EPS changes on a trajectory over time whilst the CIF is intended as a static target (or until such time as there might be a strong reason to revise the specified performance level of the CIF)	Confirmation now provided that the EPS will apply as a benchmark for London's waste authorities to work towards. Also see Action Note 20	Policy 2 of the Mayor's MWMS

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